California ISO
Your Link to Power

July 2, 2010

The Honorable Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Re: California Independent System Operator Corporation
Docket No. ER10-____-000
Tariff Amendment to Modify Interconnection Requirements Applicable to Large Generators and Request for Waiver

Dear Secretary Bose:

The California Independent System Operator Corporation (ISO) submits this filing to modify the provisions of the ISO Tariff relating to interconnection requirements applicable to large asynchronous generators, predominantly wind and solar photovoltaic resources. The proposed modifications ensure the continued reliability and security of the ISO transmission system in anticipation of the significant increase in variable energy resources in California needed to meet aggressive renewable portfolio and greenhouse gas reduction targets.[1] The interconnection requirements are consistent with commercially available technology and reliability mandates in jurisdictions with high penetration levels of variable energy resources. The specific interconnection requirements address: (1) low voltage ride-through and frequency ride-through capabilities; (2) power factor design and reactive power capabilities; (3) voltage regulation; and (4) generator power management. The ISO has also proposed reasonable exceptions to these requirements that seek to minimize disruption to generation development and recognize the impact of previous, targeted financial commitments made by interconnecting generators.

The ISO respectfully requests waiver of the Commission's notice and comment regulations to permit the tariff revisions contained in this filing to become effective as of July 3, 2010 (*i.e.*, one day after the date of this filing), except for the tariff revisions regarding generator power management, for which the ISO requests an effective date of January 1, 2012. As discussed below, good cause exists for this waiver because it promotes reliability by ensuring these requirements will apply to a substantial quantity of renewable generation

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[1] The ISO submits this filing pursuant to Section 205 of the Federal Power Act, 16 U.S.C. § 824d, Part 35 of the Commission's regulations, 18 C.F.R. § 35, and in compliance with Order No. 714, Electronic Tariff Filings, FERC Stats. & Regs. ¶ 31,276 (2009). The ISO is also sometimes referred to as the CAISO. Capitalized terms not otherwise defined herein have the meanings set forth in Appendix A to the ISO Tariff.

capacity in the ISO's current interconnection queue and minimizes the risk of delaying negotiation and execution of Large Generator Interconnection Agreements.

I. Background

A. Reasons for This Tariff Amendment

1. Planning to Meet California's Environmental Policies

The past several years have seen a number of policies, on both a federal and state level, spurring greater reliance on energy from renewable resources. Pursuant to California's renewables portfolio standard (RPS) legislation, as most recently updated in 2006, electric corporations in California are required to increase procurement from renewable energy resources by at least 1 percent of their retail sales annually, until they reach 20 percent by the end of 2010.[2] Further, in 2008 and 2009, the Governor of California issued executive orders that set a target for variable energy resources to supply 33 percent of the power to California by 2020.[3] These targets have already led to a dramatic increase in requests to interconnect renewable resources to the ISO grid. For instance, the ISO's "transition cluster," which consists of the first group of projects to be studied under the ISO's new interconnection procedures approved by the Commission, contains over 8,200 MW of renewable capacity, out of a total of approximately 10,400 MW of capacity in the cluster. This represents a dramatic shift in generator technology trends, and one which the ISO expects to continue over the coming years.

Also, California has a large amount of installed generating capacity (approximately 30 percent) that relies on coastal and estuarine water for power plant cooling. These conventional power plants are the subject of a water quality policy adopted by the California State Water Resources Control Board to adopt best available technology under Section 316(b) of the federal Clean Water Act for power plant cooling.[4] The policy identifies two compliance alternatives for

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[2] See report of the California Public Utilities Commission ("CPUC") entitled *Renewables Portfolio Standard Quarterly Report – Q4 2009*, at 1, 4 ("CPUC Report"). This report is available on the CPUC's website at http://www.cpuc.ca.gov/NR/rdonlyres/52BFA25E-0D2E-48C0-950C-9C82BFEEF54C/0/FourthQuarter2009RPSLegislativeReportFINAL.pdf.

[3] *See* CPUC Report at 1, *referring to* Executive Orders S-14-08 and S-21-09 of Governor Schwarzenegger. A 33 percent RPS target is also a critical component of the California Air Resource Board's plan to implement the greenhouse gas emission reduction requirements embodied in California Assembly Bill 32 as well as the subject of pending legislation in California (California Senate Bill 722).

[4] California State Water Resources Control Board Resolution 2010-0062, available at http://www.swrcb.ca.gov/board_decisions/adopted_orders/resolutions/2010/rs2010_0020.pdf This policy will not be effective until it is reviewed and approved by the California Office of Administrative Law pursuant to California Government Code § 11353.

existing power plants: (1) reduce intake flow rate to a level that can be attained by a close-cycle wet cooling system; or (2) use operational or structural controls to reduce impingement mortality and entrainment for all life stages of marine life for the facility to a comparable level to that which would be achieved under the first compliance option. The ISO anticipates that this policy will force the majority of gas-fired generating units using once through cooling to go offline over the next several years in order to retrofit or repower using alternative cooling technologies, or to retire. Whether the suspension of operation of these power plants is temporary or permanent, during their period of unavailability, California will necessarily lose a portion of its conventional generation fleet that has supported the reliable operation of the transmission system.

The obligation to comply with RPS targets and once-through cooling limitations will lead to the displacement of conventional resources by variable energy generators. However, as variable energy resources increasingly displace conventional generation in the coming years, certain technical characteristics either inherent in, or historically required from, conventional resources will also be increasingly displaced. As a consequence, the extent to which the grid can successfully integrate variable generation will be significantly influenced by the ability and extent to which variable generation contribute basic technical characteristics, such as reactive power capabilities and voltage regulation, that remain critical to support reliable transmission system.

Based on these considerations, the ISO is proposing to require variable energy resources to possess certain technical characteristics that are comparable to those required of conventional generators.[5] This approach is consistent with findings of the Integration of Variable Generation Task Force of the North American Electric Reliability Corporation ("NERC") that anticipate the challenges of integrating renewable resources and the need for interconnection requirements to address the performance of the bulk electric system.[6]

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[5] The ISO relied, in part, on technical analysis performed by General Electric, Inc.'s Energy Applications and Systems Engineering consulting group ("GE"), an expert consultant retained by the ISO to study these issues, GE's analysis and conclusions regarding the appropriateness of the ISO's proposed interconnection requirement revisions are provided in a report entitled *Interconnection Standards Review Initiative* (April 28, 2010). The GE Report was provided as Attachment A to the memorandum to the ISO Governing Board in which ISO management requested authorization to prepare and file this tariff amendment ("Board Memorandum"), and is included with the Board materials provided as Attachment F to this filing. It is also available on the ISO's website at http://www.caiso.com/2793/2793abd91a0a0.pdf.

[6] *Special Report: Accommodating High Levels of Variable Generation* (Apr. 2009), at 2, 11. This report is available on NERC's website at http://www.nerc.com/docs/pc/ivgtf/IVGTF_Report_041609.pdf. The ISO anticipates that the interconnection requirements proposed by the ISO will be superseded by the standards adopted by NERC and the Commission. To the extent such NERC standards are not applied retroactively, the ISO's requirements serve to fill the gap for those asynchronous variable energy resources executing interconnection agreements prior to the effective date of the NERC standards.

2. Balancing of Considerations by the ISO to Address Generator Technology Changes in the Context of Interconnection Requirements

The ISO's current interconnection procedures applicable to large generators, *i.e.*, generators that have gross capacities of more than 20 MW,[7] include technical requirements for conventional generators and variable energy resources. However, these current requirements require refinement and enhancement in order to meet the reliability challenges discussed above.

The need to make these changes is especially urgent due to the considerable amount of variable energy resources in the ISO's interconnection queue. Currently, there are 83 renewable variable energy projects, totaling nearly 20,000 MW of capacity in the "serial group" and "transition cluster" portions of the ISO interconnection queue. Of this total, approximately 14,300 MW are asynchronous wind and solar technologies.[8] Twenty-three of sixty-three asynchronous wind and solar projects – predominantly wind projects – representing approximately 5,400 MW of capacity have either executed interconnection agreements or have been tendered an interconnection agreement for execution. For the remaining approximately 9,000 MW of asynchronous capacity, the interconnection studies are nearing completion or are being accelerated to finish by June 2010 in order to accommodate potential funding opportunities under the American Recovery and Reinvestment Act ("ARRA").[9] The ISO is aware of 4 projects in the serial group and 12 projects in the transition cluster that have applied for ARRA funding, but have not yet executed or been tendered an interconnection agreement for execution. Eligibility for ARRA funding requires that projects commence construction activities by the end of 2010. Project developers have represented that having an executed interconnection agreement is essential to secure project financing. Therefore, the ISO has made it a priority to complete the studies for these projects, and enter into interconnection agreements, as soon as possible, in order to place these projects in the best possible position to begin construction by the end of this year and thereby retain eligibility for ARRA funding.

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7 The interconnection requirements that are relevant to the instant tariff amendment are set forth in the main body of the ISO Tariff, in the Standard Large Generator Interconnection Procedures set forth in Appendix U of the tariff ("Appendix U LGIP"), in the Standard Large Generator Interconnection Agreement found in Appendix V of the tariff ("Appendix V LGIA"), in the Large Generator Interconnection Procedures for Interconnection Requests in a Queue Cluster Window set forth in Appendix Y of the tariff ("Appendix Y LGIP"), and in the Large Generator Interconnection Agreement for Interconnection Requests in a Queue Cluster Window found in Appendix Z of the tariff ("Appendix Z LGIA").

8 Synchronous solar thermal technologies represent an additional 5,530 MW.

9 American Recovery and Reinvestment Act of 2009, Pub. L. 111-5.

The ISO initiated a stakeholder process to consider how best to determine and implement the required refinements and enhancements to its interconnection procedures. In conducting this stakeholder initiative, the ISO balanced the reliability considerations discussed above against the potential disruption to renewable energy development, including those projects seeking financial benefits under the ARRA. This required the ISO to weigh several considerations.

First, the ISO assessed the efficacy of deferring to similar efforts pending at the national level through NERC and at the regional level through the Western Electricity Coordinating Council ("WECC"). The ISO determined that although it is important to ensure consistent industry standards, the expected culmination of the national and regional efforts is incompatible with the timing needs of the ISO and its interconnection customers. As explained above, there is a large amount of variable energy resource capacity (approximately 20,000 MW total and over 14,000 MW of asynchronous generation) in the ISO's current serial and transition cluster interconnection queue, and the ISO anticipates that this trend will continue in future interconnection clusters. Also, due to the fact that eligibility for ARRA funding is contingent on developers beginning construction prior to the end of 2010, which may, in turn, be partly contingent on the existence of an interconnection agreement to obtain project financing, the ISO determined that it was necessary to accelerate the interconnection studies for projects in the current queue in order to provide these developers with a realistic chance of accessing ARRA funding. This resulted in a corresponding need to accelerate the implementation of the revised technical requirements in order to incorporate the requirements into interconnection agreements. Accordingly, absent expediting this initiative and given the uncertainty of retroactive application of future NERC or WECC standards, the ISO is confronted with the very real possibility of losing any future opportunity to require basic interconnection performance capabilities from these resources.

Nevertheless, the ISO recognizes the importance of maintaining consistent standards regarding the technical characteristics of generators, and will work to ensure that its own requirements operate, to the greatest extent possible, in conjunction with those that result from the NERC and WECC processes.

Second, the ISO evaluated the feasibility and timing of compliance with any revised requirements developed by the ISO and stakeholders, in light of the current or impending availability from original equipment manufacturers of the necessary equipment and technology. The ISO's inquiry reasonably confirms that the equipment and technology needed to comply with the revised requirements is available from manufacturers. Third, the ISO determined that any new requirements should not disrupt the timing of the ISO's scheduled completion of ongoing interconnection studies. Lastly, the ISO considered the financial impact of additional interconnection costs on those projects with executed or tendered power purchase agreements, whose terms may not permit recovery of the incremental cost of complying with the new requirements.

As discussed more fully below, the ISO believes its proposed tariff revisions appropriately take these considerations into account. The ISO has limited the scope of the proposed tariff revisions to those interconnection requirements most important to maintaining reliability. The ISO has also maximized reliance on existing requirements where possible, assured the technical feasibility and commercial availability of equipment and systems to comply with the revised requirements, and considered cost implications in designing the requirements and determining the scope of projects subject to the revisions. As a result, the ISO believes it has reasonably mitigated any risk of inconsistency with potential future national or regional mandates and of material impacts to project viability. In this latter regard, the ISO has further attempted to reduce the commercial impact of the revised requirements by excluding from their scope those projects with interconnection agreements executed or that have been tendered, but not executed, or that can demonstrate a pre-existing binding commitment to purchase specific types of non-compliant equipment.

Moreover, while these interconnection requirements are an important and necessary step towards reliable integration of renewable resources, the ISO will continue to conduct stakeholder initiatives to assess the operational impacts of renewable integration. The ISO notes that these efforts could lead to additional or modified obligations placed on variable energy resources, particularly in light of any guidelines that result from the conclusion of the NERC and WECC processes.

II. Proposed Tariff Revisions

The ISO's proposed tariff modifications are set forth in Attachments A and B to this transmittal letter. These modifications include changes to one section in the main body of the ISO Tariff, Section 8.2.3.3, as well as several minor changes to the two versions of the ISO's LGIP.[10] Most of the modifications, however, are contained in two new LGIAs, which will be labeled Appendices BB and CC, respectively, and in Appendix H to those LGIAs, which applies only to wind plants under the current LGIAs, but under the new LGIAs, will apply to all asynchronous generating facilities. Asynchronous generating facilities are defined as those facilities that are induction, doubly-fed, or electronic power generating units that produce 60 Hz (nominal) alternating current. The purpose of creating these new LGIAs is to preserve the ability of interconnection customers, who have entered into or been tendered one of the existing versions

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[10] The ISO Tariff currently contains two versions of the LGIP – one applicable to interconnection requests that are studied serially (Appendix U) and one applicable to interconnection requests studied as part of a queue cluster (Appendix Y).

of the LGIA[11] prior to the effective date of this tariff amendment, to continue to take service under that version of the agreement.[12] In order to facilitate the review of the ISO's proposed technical characteristics for asynchronous generators, the ISO is also including, as Attachment C to this filing, a document that shows the difference between Appendix H to the ISO's existing LGIAs and Appendix H to the new LGIAs.

Only those customers that have interconnection requests in a serial queue or queue cluster window and that have been tendered for execution an LGIA after the effective date of this tariff amendment will be required to enter into one of these new LGIAs. Moreover, the ISO will provide an exemption from these revised criteria for existing individual generator units that are, or have been, interconnected to the ISO Controlled Grid at the same location as of the effective date of the requirements, for the remaining life of the existing generation equipment. Existing individual generator units that are replaced, however, are required to satisfy the requirements.

In addition to these broad exemptions, the ISO is proposing several exceptions to certain of the new technical requirements so as to minimize disruption to generation development and recognize the impact of previous, targeted financial commitments made by interconnecting generators:

- The ISO will exempt from the new low-voltage ride-through requirements those interconnection customers that can demonstrate to the ISO a binding commitment, as of May 18, 2010 (the date on which this amendment was approved by the ISO's Board of Governors), to purchase inverters for thirty percent or more of the facility's maximum generating capacity that are incapable of complying with the revised low-voltage ride-through requirements.

- Generators will have a transition period until January 1, 2012 to comply with the new power management criteria.

- With respect to those generators who have, as of May 18, 2010, purchased equipment that is not compliant with the new power management criteria, the ISO will coordinate with the project to develop

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11 The ISO Tariff currently contains two versions of the LGIA – one applicable to interconnection requests that are studied serially (Appendix V) and one applicable to interconnection requests studied as part of a queue cluster (Appendix Z).

12 As discussed in Mr. Walling's testimony, the ISO's proposed tariff modifications are also consistent with recommendations that GE has made to ISO New England, Inc. ("ISO-NE") regarding performance requirements for interconnecting wind plants as well as operating practices that should be adopted to facilitate the reliable operation of the system as additional wind sources interconnect. GE's recommendations to ISO-NE are also generally applicable to asynchronous and variable energy generators (not just wind plants) in the California ISO. *See* Walling Testimony at pp. 3-6.

> requirements consistent with the capability of the control equipment and will submit those requirements for Commission approval in a non-conforming LGIA.

A. Revisions to Power Factor Design and Operations Criteria

Article 9.6.1 of the ISO's existing LGIAs requires each interconnection customer to design its large generating facility to provide reactive power by maintaining delivery of electricity within certain power factor ranges, unless different power factor ranges are otherwise specified by the ISO. Specifically, the interconnection customer must:

> [m]aintain a composite power delivery at continuous rated power output at the terminals of the Electric Generating Unit at a power factor within the range of 0.95 leading to 0.90 lagging, unless the CAISO has established different requirements that apply to all generators in the Balancing Authority Area on a comparable basis. Power factor design criteria for wind generators are provided in Appendix H of this LGIA.

Appendix H to the existing LGIAs, in turn, requires each wind generator to operate within a power factor within the range of 0.95 leading to 0.95 lagging (not 0.90 lagging as for non-wind generators), measured at the point of interconnection for the generator, if the interconnection system impact study submitted by the interconnection customer "shows that such a requirement is necessary to ensure safety or reliability."[13]

These tariff provisions must be revised to reflect the fact that, in the coming decade, the ISO will increasingly need to rely on asynchronous variable energy resources to provide reactive power in order to ensure the safety and reliability of the ISO's transmission system. Reactive power is necessary to energize and transmit power in an alternating current transmission system such as the ISO's and, therefore, is fundamental to maintaining voltage stability on the transmission system. There are various sources of reactive power on the transmission system, but the most controllable and, historically, the most robust source of reactive power has been conventional synchronous generators. Over time, however, the displacement of conventional generation by asynchronous variable energy resources will threaten to deprive the transmission system of its present source of reactive power. The ISO must ensure that asynchronous generators are both designed and operated in a manner that sufficiently maintains voltage stability and therefore the safety and reliability of the ISO transmission system.[14] The following modifications will meet this need.

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[13] Appendix V LGIA, Appendix H, Article A(ii); Appendix Z LGIA, Appendix H, Article A(ii).

[14] The purpose of and the ISO's need for reactive power are discussed further at pages 2-6 of Mr. Shah's testimony.

First, Section 9.6.1 of the new LGIAs will specify that Appendix H to those agreements will govern power factor design criteria and operational characteristics for all asynchronous generating facilities.

With respect to power factor design criteria, Appendix H to the new LGIAs will specify that asynchronous generating facilities must be designed with the following characteristics:

- The asynchronous generating facility must have net reactive power sourcing and absorption capability sufficient to achieve or exceed a net reactive power range of approximately 0.95 leading and 0.95 lagging (with the specific required range being a function of the voltage at the point of interconnection, per the graph displayed as Figure 1 in Appendix H), without exceeding the ratings of any equipment in the facility, measured at the Point of Interconnection as defined in individual LGIAs.

  As described in detail in Mr. Walling's testimony, defining the reactive power requirements as a function of voltage at the Point of Interconnection per Figure 1 is intended to limit the requirement that asynchronous generating facilities to providing reactive support to that support that is actually needed from a grid reliability standpoint, thereby avoiding the need for unnecessary support which could be unduly expensive to provide.[15]

- The asynchronous generating facility may meet the power factor range requirement by using power electronics designed to supply the required level of reactive capability (taking into account any limitations due to voltage level and real power output) or fixed and switched capacitors, or a combination of the two.

- The asynchronous generating facility must also provide dynamic voltage support if the interconnection system impact study requires dynamic voltage support for system safety or reliability.

- The asynchronous generating facility must vary its reactive power output between the full sourcing and full absorption capabilities such that any change in the reactive power output does not cause a change in voltage at the point of interconnection greater than 0.02 per unit of the nominal voltage. The 0.02 per unit valid is based on a number of considerations, including common engineering practice, standards for consumer power

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15 Walling Testimony at pp. 21-22.

quality, and consideration of the granularity to which compensation in a facility would need to be divided.[16]

- The maximum voltage change requirement described above will apply when the transmission network is fully intact (no line or transformer outages), or during outage conditions which do not decrease the three-phase short circuit capacity at the point of interconnection to less than 90 percent of the three-phase short-circuit capacity that would be present without the transmission network outage.

Further, in operation, the reactive power capability of each asynchronous generating facility will be subject to the following provisions:

- For plant output power greater than twenty (20) percent of the facility's capacity, the facility will have a net reactive power range at least as great as specified in Figure 1 of Appendix H at the point of interconnection, based on the actual real power output level delivered to the point of interconnection.

- Power output may be curtailed at the direction of the ISO to a value where the net power factor range is met, if the reactive power capability of an asynchronous facility is partially or totally unavailable, and if continued operation causes deviation of the voltage at the point of interconnection outside +/- 0.02 per unit of scheduled voltage level.

- When the output power of the facility is less than 20 percent of the generating facility's maximum generating facility capacity, the net reactive power must be within the range between –6.6 percent and +6.6 percent of the facility's real power rating.

- If the point of interconnection voltage exceeds 1.05 per unit, the asynchronous generating facility must provide reactive power absorption to the extent possible without violating the ratings of the facility's equipment.

- If the point of interconnection voltage is less than 0.95 per unit, the facility must provide reactive power injection to the extent possible without violating the ratings of any equipment.

Except for the provision regarding dynamic voltage support, the ISO proposes to make these provisions applicable to all asynchronous generating facilities that have interconnection requests in a serial queue or queue cluster window and that enter into one of the new LGIAs (*i.e.*, all LGIAs tendered for

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[16] *Id.* at pp. 23-24.

execution after the effective date of this amendment), without the prerequisite of showing a specific need for reactive power in a system impact study. Accordingly, this requirement is not retroactive; it does not impact any existing, operational asynchronous generator or any asynchronous generator interconnection customer that has executed, or been tendered for execution, an LGIA as of the effective date of the amendments.

The ISO recognizes the proposed amendment departs from the Commission's decision in Order No. 661-A, in which the Commission stated that wind generators are required to maintain a power factor of 0.95 leading and 0.95 lagging only if the transmission provider shows, in a system impact study, that such reactive power capability is necessary to ensure the safety or reliability of the transmission system.[17] Nevertheless, the proposed revisions are just and reasonable for a number of reasons.

First, Order No. 661-A was issued in 2005, prior to the establishment of the 20 percent and 33 percent RPS standards for California. The ISO must require all asynchronous generators to follow the revised Appendix H provisions in order to ensure the continued safety and reliability of the transmission system after asynchronous variable energy resources displace conventional generation pursuant to the RPS standards. The fundamental need for all asynchronous resources to provide the power factor capabilities set forth in revised Appendix H is evidenced by findings of the ISO's renewable integration studies. For example, an ISO study from 2007 entitled "Integration of Renewable Resources" concluded that "[a]ll new wind generation units must have the capability to meet the WECC requirements of ± 0.95 power factor. *This reactive capability is essential for adequate voltage control*."[18] A more recent analysis of the Devers area in the service territory of Southern California Edison Company ("SCE") similarly concludes that generation in that remote region requires reactive power support from proposed asynchronous generation to support voltage.[19]

Moreover, in Order No. 661-A, the Commission found that requiring wind generators to install reactive power capability in the absence of a system impact study demonstrating a need to ensure system reliability could raise discrimination issues because such capability was a significant added cost for wind generators but not for conventional generators.[20] The ISO's proposed revisions to Appendix H, however, do not present any discrimination issues. Installing reactive power

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[17] *Interconnection for Wind Energy*, Order No. 661-A, FERC Stats. & Regs. ¶ 31,198, at PP 41-46 (2005) ("Order No. 661-A"). *See also Nevada Power Company*, 130 FERC ¶ 61,147 (2010).

[18] This study is available on the ISO's website at http://www.caiso.com/1ca5/1ca5a7a026270.pdf, and the quoted language above is found on page 4 of the study. *See also* Shah Testimony at p. 6.

[19] This study is provided in Appendix A to Mr. Shah's testimony. *See* also Shah Testimony at p. 6.

[20] Order No. 661-A at PP 41, 45.

capability necessarily adds to the cost of a conventional generator.[21] Similarly, installing reactive power capability to an asynchronous generator will add to its cost, but that cost will be moderated because the ISO proposes to allow each asynchronous generator to choose what equipment it will install to provide the reactive power capability, and various original equipment manufacturers have written the ISO to explain that they currently offer or will soon offer the necessary equipment for sale to wind, solar, and other types of asynchronous generators.[22] The ISO does not expect that the price of installing reactive power capability will significantly add to the cost of an asynchronous generator. As discussed in Mr. Walling's testimony, the compliance cost for meeting the ISO's requirements through this mechanism is likely to be in a range from .25% to 1% of the total plant cost.[23] Therefore, asynchronous generators will not be required to pay for expensive or custom-made equipment to provide reactive power that may reasonably impair the financial viability of otherwise feasible projects. This is anecdotally observed by the continued robust development of wind resources in the balancing authority area of the Bonneville Power Administration (BPA). BPA has adopted reactive power and voltage control requirements that are more stringent in several respects than those proposed by the ISO, *i.e.*, tighter dead band for voltage variations at the point of interconnection.[24] Notwithstanding the imposition of a uniform reactive power requirement on wind facilities, BPA recently estimated that wind capacity within its balancing authority will grow from approximately 2700 MW in 2010 to nearly 8000 MW in 2014.[25]

Most importantly, as explained above, requiring asynchronous generators to have sufficient reactive power capability is essential to preserving system reliability and security. Therefore, it is not unduly discriminatory to require asynchronous generators to have sufficient reactive power capability pursuant to revised Appendix H. To the contrary, such a requirement is eminently fair, because it promotes equitable participation in VAR support, voltage control, and system reliability by all synchronous and asynchronous generators.

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[21] GE Report, Section 2 ("Providing this reactive capability inherently increases the costs of the generator. For example, a synchronous generator with a typical 0.85 power factor rating must be designed to carry armature current that is 15% greater than if the machine were to be designed for unity power factor operation. Thus, reactive capability has never come 'free' for conventional generation, but has always been specified as an expectation.").

[22] GE Report, Sections 2.1 and 2.2; letters to the ISO from original equipment manufacturers provided in Attachment D to the Board Memorandum, available on the ISO's website at http://www.caiso.com/2793/2793abe81a0a6.pdf; Walling Testimony at p. 26 and Appendix C.

[23] Walling Testimony at pp. 27-29.

[24] See Technical Requirements for Interconnection to BPA Transmission Grid, Sec. 7.7 at http://www.transmission.bpa.gov/business/generation_interconnection/documents/STD-N-000001-00-01_071509.pdf.

[25] See http://www.transmission.bpa.gov/PlanProj/Wind/documents/Wind_Forecast_Graph_2015-May2010.pdf.

The revisions to Appendix H are fair and serve system reliability and security in another respect as well: they apply equally to all asynchronous generators other than those subject to one of the exemptions discussed below. Therefore, the ISO will not be in the position of trying to pick out which asynchronous generators are needed to provide reactive power in the near future and which asynchronous generators will be needed to provide reactive power months or years from now. That type of selection process would present a large risk of error, because it is difficult to study ahead of time potential transmission configurations and maximum capacity installation of asynchronous generators under all credible operating scenarios. If the ISO made a mistake in the selection process, it might jeopardize system reliability and security, and it might have to correct the error later by directing an asynchronous generator to retrofit its generating facility to add needed reactive power equipment, at a cost higher than would have been the case if the asynchronous generator had added the reactive power equipment at the outset.[26]

Moreover, the ISO's system impact studies are not the appropriate vehicle to make these long-term planning determinations. They are appropriately focused on the near-term transmission upgrades necessary to safely and reliably interconnect customers to the ISO Controlled Grid. For instance, the system impact studies do not account for forecasted generation retirements, which is one of the main drivers of the need for increased reactive power support from asynchronous resources. Not knowing when certain generators will retire may lead to the ISO's study results being unduly optimistic. Further, long-term studies (10 years and longer) may not be sufficient either, due to the difficulty of foreseeing future events, such as future load forecasts, network upgrades, amounts of new generation, locations and sizes of new generation, and new technologies. Thus, long-term studies have only a limited ability to evaluate all possible contingencies and system conditions.[27] In order to avoid pitfalls such as these, the ISO must, in the interest of maintaining reliability for a broad range of possible future system conditions, ensure that all asynchronous generators that seek to connect to the ISO Controlled Grid be built to contribute to reactive power needs.

Further, making the proposed revisions to Appendix H is far preferable to the main alternative suggested in the stakeholder process: installation by the ISO of dedicated equipment on the transmission system solely to replace lost grid support, with the costs of the equipment being socialized to all grid users. This suggested alternative approach would increase the risk of lower grid performance until a problem actually occurs and would be inefficient. For

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[26] *See* GE Report, Section 1.2 ("With the rapid growth of VER [variable energy resource] penetration in California, it is reasonable for CAISO to have proceeded with development of the proposed requirements on an expedited basis. In the long run, this may save VER plant owners from having to make very expensive plant retrofits in the future.").

[27] Shah Testimony at pp. 7-9.

example, the installation and use of shunt capacitors under peak load conditions and shunt reactors under light load conditions are only partially effective. The reactive power support coming from these devices is "static" in nature, which is satisfactory under normal operating conditions but deteriorates rapidly as voltages start to decline under contingency conditions. These devices do not help the grid arrest a possible voltage collapse under severe contingencies.[28] In addition, variable energy resources can, by installing commercially available equipment, provide most necessary grid support functions at a much lower incremental cost than would be required for the installation of dedicated transmission equipment to perform the same function.[29] In these circumstances, it is fair for all generators – both conventional generators and variable energy resources – to be responsible for their proportional share of grid support.

As explained above, in order to implement these requirements in the fairest and least intrusive manner, these modifications will be limited to the new pro forma LGIAs set forth in Appendices BB and CC, and only those customers that have interconnection requests in a serial queue or queue cluster window and that have been tendered for execution an LGIA after the effective date of this tariff amendment will be required to enter into one of these new LGIAs.[30] However, the ISO does plan to allow an asynchronous solar generating facility with an executed or tendered Appendix V or Appendix Z LGIA as of the effective date of this tariff amendment to elect to comply with the new Appendix H provisions described above, rather than Articles 9.6.1 and 9.6.2 of the executed or tendered Appendix V or Appendix Z LGIA.[31] If the asynchronous generating facility makes that election, it will be required to consult with the ISO and the Participating TO about preparing and submitting any required filings to obtain Commission approval of a non-conforming LGIA.

Several stakeholders requested that the ISO expand its exemptions for reactive power to include all resources with power purchase agreements. The ISO recognizes that many power purchase agreements may be structured in a manner that will not permit an increase in revenue to cover subsequent

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[28] Moreover, Remedial Action Schemes ("RAS"), such as tripping pump loads, may be used to improve sagging voltages when contingencies occur. However, these RAS are typically temporary means to mitigate a particular problem until a permanent and lasting solution is put in place. Requiring variable energy resources to provide reactive power capability mitigates such specific problems and can also help to counter all kinds of adverse voltage situations under all possible contingency conditions.

[29] GE Report, Section 1.1.

[30] As noted above, the ISO is also exempting from the new technical criteria any generating units of an Asynchronous Generating Facility that are, or have been, interconnected to the ISO 's grid at the same location as of the effective date of this amendment.

[31] The distinction is that all resources other than wind under Appendix V and Appendix Z were required to provide reactive power of 0,90 lag and 0.95 lead at the generation terminal, rather than 0.95 lead/lag at the point of interconnection. Given that wind resources were previously subject to the 0.95 lead/lag under Order No. 661-A, if needed, the option is unnecessary for such resources.

regulatory related costs, such as those incurred to comply with the reactive power requirement. However, the ISO elected not to adopt such a broad exemption on several grounds. First, as noted above, the overall cost impact of meeting the reactive power requirement does not appear of sufficient magnitude to materially alter access to project financing or recovery of a reasonable rate of return. Second, there are likely to be certain contracts that would permit such recovery and an individual assessment of contract language imposes an undue administrative burden.

In sum, the ISO's proposed tariff revisions rest on concepts of fairness in providing for system reliability and security, place asynchronous generators on an equal footing with other generators, are far preferable to an alternative approach, and include reasonable exemptions. Therefore, the Commission should find that the proposed tariff revisions are just and reasonable.

In addition to the design and operational requirements described above, the ISO proposes to make clarifying changes Section 8.2.3.3 (Voltage Support) in the main body of the ISO Tariff. There is a discrepancy between Section 8.2.3.3 and Article 9.6.1 of the existing LGIAs regarding the measurement point for calculating the power factor: Section 8.2.3.3 states that the measurement point for all participating generators is the point of interconnection with the ISO Controlled Grid but Article 9.6.1 states that the measurement point for all generators other than wind generators is the generator terminal. The ISO proposes to eliminate this discrepancy by revising Section 8.2.3.3 to: (1) state that all participating generators that are asynchronous generating facilities must maintain the ISO specified voltage schedule at the point of interconnection to the extent possible, except as permitted under Appendix H of the Appendix V and Appendix Z LGIAs, while operating within the power factor range specified in their interconnection agreements; (2) state that all other participating generators must maintain the ISO-specified voltage schedule at the generating unit terminal to the extent possible, while operating within the power factor range specified in the interconnection agreements; and (3) delete the sentence stating that the power factor for both the generating units and loads will be measured at the interconnection point with the ISO Controlled Grid.

B. Revisions to Voltage Regulation and Reactive Power Control Requirements

Article 9.6.2 of the Appendix V and Appendix Z LGIAs currently requires each interconnection customer that has synchronized an electric generating unit with the ISO Controlled Grid to "maintain a voltage schedule by operating the Electric Generating Unit to produce or absorb reactive power within the design limitations of the Electric Generating Unit set forth in Article 9.6.1." As discussed above, over time the displacement of conventional generation by asynchronous variable energy resources will threaten to deprive the transmission system of its present source of reactive power. This loss of reactive power may also reduce the voltage regulation capability otherwise provided by conventional generation.

The ISO proposes to revise Article 9.6.2 and Appendix H of the new LGIAs to ensure that voltage regulation capability is maintained. Specifically, the ISO proposes to revise Article 9.6.2.1 and to add new Article 9.6.2.2 to state (among other things) that, for asynchronous generating facilities, Appendix H sets forth the requirements for the large generating facility to respond to the loss of voltage control capability, and proposes to modify Appendix H to include the following provisions:

- The asynchronous generation facility's reactive power capability will be controlled by an automatic system having both a voltage regulation and a net power factor regulation operating mode, and the default mode of operation will be voltage regulation. This is specified as the default mode because it is generally desirable to maintain a voltage profile in the grid as specified by the transmission operator and is also necessary to adhere to WECC's Minimum Operating Reliability Criteria.[32]

- The voltage regulation function will automatically control the net reactive power of the asynchronous generating facility to regulate the point of interconnection positive sequence component of voltage to within a tolerance of +/- 0.02 per unit of the nominal voltage schedule assigned by the participating transmission owner or the ISO, within the constraints of the reactive power capacity of the asynchronous generation facility, and deviations outside of this voltage band, except as caused by insufficient reactive capacity to maintain the voltage schedule tolerances, will not exceed five minutes duration per incident. As Mr. Walling explains in his testimony, these tariff changes are necessary to provide for secure operation of the transmission system.[33]

- The power factor mode will regulate the net power factor measured at the point of interconnection, and if the asynchronous generating facility uses discrete reactive banks to provide reactive capability, the tolerances of the power factor regulation will be consistent with the reactive banks' sizes meeting the voltage regulation tolerances specified above. As explained in Mr. Walling's testimony, these tariff changes will ensure that the reactive power flow from the facilities is in constant proportion to the real power output and that that the facilities will compensate for their own internal reactive power losses.[34]

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[32] Walling Testimony at pp. 29-30.
[33] *Id.* at pp. 31-32.
[34] *Id.* at pp. 33-34.

- The net reactive power flow into or out of the asynchronous generating facility, in any mode of operation, will not cause the positive sequence component of voltage at the point of interconnection to exceed 1.05 per unit, or fall below 0.95 per unit.

- The ISO, in coordination with the participating transmission owner, may permit the interconnection customer to regulate the voltage at a point on the asynchronous generating facility's side of the point of interconnection, and regulating voltage to a point other than the point of interconnection will not change the asynchronous generating facility's net power factor requirements set forth in Section II.A of this transmittal letter, above.

- The interconnection customer will not disable voltage regulation controls, without the specific permission of the ISO, while the asynchronous generating facility is in operation at a power level greater than 20 percent of the asynchronous generating facility's maximum generating facility capacity.

For reasons similar to those explained above with regard to the proposed revisions to the power factor design criteria, these voltage regulation requirements will serve to maintain the reliability and security of the ISO transmission system even with the introduction of increasing amounts of variable energy resources.

C. Revisions to Frequency and Low Voltage Ride-Through Requirements

The Appendix V and Appendix Z LGIAs contain requirements concerning frequency and low voltage ride-through. Article 9.7.3 of the existing LGIAs defines frequency ride-through as "the ability of a Generating Facility to stay connected to and synchronized with the ISO Controlled Grid during system disturbances within a range of under-frequency and over-frequency conditions, in accordance with Good Utility Practice," and requires an Interconnection Customer to implement under-frequency and over-frequency protection set points for a Large Generating Facility as required by the Applicable Reliability Council (*i.e.*, WECC) to ensure ride-through capability.[35] Also, consistent with

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[35] WECC's frequency ride-through requirements are included in the WECC Underfrequency Load Shedding Relay Application Guide ("WECC Load Shedding Guide"), which is available on WECC's website at http://www.wecc.biz/committees/StandingCommittees/OC/TOS/RWG/Shared%20Documents/UFLS%20Relay%20Application%20Guide.pdf.

the Commission's directives in Order No. 661-A,[36] Appendix H of the existing LGIAs requires wind generators to have low voltage ride-through capability.[37]

The ISO proposes to clarify and enhance the existing ride-through requirements in its tariff to ensure low voltage and frequency ride-through capability by asynchronous generators as they displace conventional generators over the next decade. A known issue arising from transmission system faults near generating stations is "sympathetic tripping" by wind and solar generators, which occurs when such generators trip off-line in response to a grid disturbance that causes a deviation in voltage or frequency. Immediately after a fault occurs, the voltage will typically collapse on the faulted phase or phases. Most transmission system faults will typically be cleared within several cycles. However, if asynchronous generators are not designed with ride-through capability to withstand the temporary low voltage conditions during the fault inception and clearing periods, then such resources will trip and stay offline even after the fault is cleared. The result is that generation will be lost, which is likely to further destabilize the transmission system by increasing the loss of injected supply as further discussed below.

Historically, asynchronous generators have been treated as non-essential to grid resource requirements and have been allowed, or even encouraged, to trip off-line in response to a grid event.[38] As asynchronous generators displace conventional generators at the high voltage transmission level, however, the reliable operation of the grid will require that this practice be abandoned, and that asynchronous generators be able to remain online during voltage disturbance events.

WECC's Reliability Standards state that a balancing authority should be able to withstand the loss of the largest single generator by procuring sufficient contingency reserves.[39] In this regard, one consequence of regularly losing all or a portion of generation due to sympathetic tripping from the outage of transmission lines or other generators is the adverse impact on balancing authority area performance. A fault that trips a nearby generation unit plus a significant amount of wind or solar generation due to sympathetic tripping would

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[36] *See* Order No. 661-A at PP 31-35.

[37] Appendix V LGIA, Appendix H, Article A(i); Appendix Z LGIA, Appendix H, Article A(i). The Appendix V and Appendix Z LGIAs do not currently include a high voltage ride-through requirement, nor does the ISO propose one at present, because of technical hurdles to developing this capability in the near-term. The ISO intends to pursue this issue either through a subsequent ISO process or through the national standards process at NERC. *See* http://www.nerc.com/filez/standards/Generator-Verification-Project-2007-09.html (containing materials related to NERC national standards process).

[38] For instance, IEEE Standard 1547, encourages the disconnection of variable energy resources interconnected at the distribution level during voltage/frequency deviances.

[39] *See* WECC Standard BAL-002-WECC-1 – Contingency Reserves, available on NERC's website at http://www.nerc.com/files/BAL-002-WECC-1_Final.pdf.

result in a more severe system imbalance on the balancing authority area. This could potentially increase the magnitude of the largest single contingency, which has both negative reliability and financial implications.

Similarly, the frequency on the power system is related to the amount of load and generation connected to it. When the load and generation are precisely balanced, the frequency will be 60 Hz. In the event that generation is lost through an unplanned or forced outage (*e.g.*, a generator trips off-line), the frequency will deviate below the nominal of 60 Hz. Immediately following the disturbance, the governors on the remaining generators will adjust in an attempt to stop the frequency decline. It may be necessary for the ISO capacity that is on automatic generation control to make adjustments to bring the system frequency back to 60 Hz. During this transition time, it is essential for the system generators to remain on-line. If additional generators trip during the transition, the system frequency will continue to deteriorate, and frequency restoration will be more difficult. It should be emphasized, however, that the ISO is not requesting that asynchronous generators contribute a governor-type frequency response during under-frequency conditions, but rather to simply continue to generate consistent with their available fuel.

Appendix H to the existing LGIAs already includes low voltage ride-through capability requirements for wind plants.[40] These ISO's proposed modifications are consistent with these existing standards. However, for the reasons articulated above, the ISO believes it is important to clarify that these standards apply to all asynchronous facilities, and to enhance them by providing further detail so as to aid in enforceability and consistency of design. This will, in turn, result in a more level playing field for the market participants,[41] decreasing the need for subjective interpretation of the requirements.

Specifically, the ISO proposes to revise Appendix H of the LGIA as follows:

- Separating the requirements relating to ride-through of single-phase faults with delayed clearing from the requirements applicable to all normally

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[40] There are no existing low voltage ride-through standards for solar photovoltaic generating facilities interconnected to the transmission grid. Walling Testimony at pp. 7-8.

[41] For instance, solar thermal technologies, such as trough and power tower designs, that rely on traditional conventional steam turbines are synchronous generators. Synchronous generators historically exhibit ride-through capabilities through their ability to maintain stability or synchronism during a disturbance. This is accomplished through existing NERC and WECC criteria that as a result of design considerations identified through interconnection studies. The significant issue for synchronous generator fault ride-through is maintaining synchronism with the grid; often referred to as "maintaining stability". The ability to maintain synchronism, and thus ride-through faults, is adequately covered by existing NERC and WECC planning criteria. A key step performed in interconnection studies is the confirmation of generating plant stability for defined fault contingencies.

cleared faults. This renders unambiguous the requirement that an asynchronous generator must ride through the subsequent post-fault voltage recovery for single-phase faults with delayed clearing. This change is designed to eliminate any potential ambiguity that the ride-through requirement could be interpreted as requiring ride-through of post-fault voltage recovery only in the case of normally cleared three-phase faults.[42]

- The existing requirement to ride through normally cleared three-phase faults has been clarified to include all types of normally-cleared faults generally considered inclusive of the more severe three-phased fault (*e.g.*, phase-to-phase, double phase faults), while acknowledging that for some asynchronous generation technologies, ride-through of unbalanced faults, such as two-phase faults, can be more difficult than three-phase faults. This will ensure that generation is not lost as a result of single-contingency faults.[43]

- Establishment of criteria to define which circuit breaker clearing times set the "normal" fault clearing time. There is a range of possible clearing times associated with all the possible faults that could affect an asynchronous generating facility. In order to provide greater up-front clarity as to this range, the ISO is proposing to define the normal clearing time duration for the purpose of application of the ride-through requirements to be the longest normal clearing time (not to exceed nine cycles, or 150 ms) for any three phase fault causing the asynchronous generation facility Point of Interconnection voltage to drop below 0.2 per-unit of nominal. The delayed clearing time duration for the purpose of ride-through requirements is defined to be the longest delayed clearing time for any single-phase fault causing at least one phase voltage at the Point of Interconnection to drop below 0.2 per-unit of nominal.[44]

- Clarifying the meaning of "remaining on line" to specify that it requires the continuous connection between the transmission grid and the generator's facilities, but does not require that the generator continue to inject current into the grid during a fault. This recognizes the critical need for voltage ride-through relates to post-fault support, and that the output of generators during the fault itself is not critical to grid needs. This definition also allows for strategies that could potentially be employed to protect an inverter from the stress of operating during a transmission fault, while still providing grid support from the inverter immediately after the fault clears.[45]

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42 Walling Testimony at pp. 9-10.
43 *Id.* at p. 10.
44 *Id.* at pp. 10-11.
45 *Id.* at pp. 11-12.

- The ISO clarifies that the ride-through requirement is a facility requirement, and does not necessarily require that individual generating units comprising the facility individually have this capability. The ISO also clarifies that auxiliary equipment within the facility can be used to provide or complement the capabilities of the individual generating units. This provides generators with greater flexibility in meeting the ride-through requirements, which will promote more cost-efficient solutions.[46]

- The ISO also clarifies that the ride-through requirements are not applicable to multiple fault events, such as an unsuccessful reclosing attempt. This ensures that the existing requirements will not be interpreted to apply to a very large number of successive faults over a short period of time, which the ISO believes is an unreasonable requirement for generators to meet.[47]

Implementation of the low voltage ride-through provisions set forth above will provide greater protection against the possibility of losing generation, thereby increasing the ability of the grid to withstand disturbances. Those provisions will also provide clear expectations to market participants, thereby decreasing the need for transmission owners, participating transmission owners, and interconnection customers to interpret the requirements.[48] Moreover, the application of those provisions to all asynchronous generators (not just wind generators) is technologically feasible. For example, based on information provided by GE, certain inverters used by the solar photovoltaic industry are substantially similar to inverters used in modern wind turbines that are ride-through compliant,[49] and several equipment manufacturers have confirmed that their inverters for use in photovoltaic solar facilities either currently have or soon will have the capability to meet the ride-through requirements the ISO proposes.[50] The main technical feasibility issue for solar facilities is whether their "balance of plant" systems, such as cooling systems, will not trip-off or can restart following a ride-through event. The ISO has determined, based on input from GE and stakeholders, that these issues are manageable and, in any event, the need for ride-through capability in order to preserve the reliability of the transmission system outweighs the extra cost for variable energy resources to install the necessary equipment. Further, as explained in the GE Report, achieving low voltage ride-through capability may involve relatively little cost for most generators, and to the extent that any generators may have to incur extra costs, they are far less than what the ISO – and ultimately market participants – would

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[46] *Id.* at p. 12.
[47] *Id.*
[48] *Id.* at p. 13.
[49] GE Report, Section 3.2.
[50] *See* Attachment D to Board Memorandum; Walling Testimony at pp 13-16 and Appendix C. Mr. Walling also explains that asynchronous generating facilities can use other equipment to meet the ISO's proposed low voltage ride-through requirements. Walling Testimony at pp. 15-17.

have to pay if the ISO instead had to carry additional contingency reserves to account for the possible tripping of new generation.[51] For these reasons, the costs of complying with revised Appendix H are not a concern for developers, even those with executed power purchase agreements.

Although the ISO believes that these new standards are just and reasonable for the reasons explained above, the ISO recognizes that certain exemptions from these new standards are appropriate. In addition to the general exemptions detailed above, the ISO will exempt from the low-voltage ride-through requirements those interconnection customers that can demonstrate to the ISO a binding commitment, as of May 18, 2010, to purchase inverters for thirty percent or more of the facility's maximum generating capacity that are incapable of complying with the low-voltage ride-through requirement.

Further, it should be noted that some stakeholders requested a phase-in period notwithstanding the presence of commercially available equipment to comply with the ride-through standard. The argument rested, in large part, on the purported unavailability of commercial warranties for the compliant inverters given that there are no standard testing protocols, such as those for distribution inverters under UL 1741. The equipment manufacturers, however, have published representations of the capability of their products. This fact will implicitly provide some legal protection to the developer-buyer. More likely, the original equipment manufacturer will support that representation with some form of express warranty. This warranty may not be standard, but the need to negotiate a mutually acceptable warranty and the potential incremental cost of such a commercial arrangement is outweighed by the reliability benefits of ride-through capability.

With regard to frequency ride-through, the ISO proposes to revise Article 9.6.2.1 and to add new Article 9.6.2.2 to the new LGIAs to state (among other things) that, for asynchronous generating facilities, Appendix H of the new LGIAs sets forth the requirements for the large generating facility regarding the ability to avoid disconnecting automatically or instantaneously from the ISO Controlled Grid or trip any electric generating unit comprising the large generating facility for an under- or over-frequency condition. The ISO also proposes to revise Article 9.7.3 in the new LGIAs to clarify that asynchronous generating facilities are subject to the frequency ride-through capability requirements set forth in Appendix H. In addition, the ISO proposes to add language to new Appendix H stating that an asynchronous generating facility will comply with the off-nominal frequency requirements set forth in the WECC Load Shedding Guide or any successor requirements. These clarifications are consistent with the existing

[51] GE Report, Section 3.3.

language of Article 9.7.3 and therefore simply make explicit the obligation of asynchronous generators to comply with the WECC requirements.[52]

D. Revisions to Generator Power Management Requirements

1. Reasons for the Revisions

As detailed below, the provisions of the ISO Tariff regarding generator power management must be enhanced to allow the ISO to maintain the reliability and security of the transmission system as variable energy resources displace conventional generators in the coming years. Therefore, the ISO proposes tariff revisions regarding three related components of generator power management: (1) active power management, (2) ramp rate limits and control, and (3) frequency response. The ISO proposes to make these tariff revisions effective January 1, 2012, in order to give variable energy resources sufficient time to satisfy the new generator power management requirements and to conduct a stakeholder process in which the ISO and stakeholders will develop the generator power management requirements more fully.

Article 3.2 of the existing LGIAs requires each interconnection customer to comply with all applicable provisions of the ISO Tariff. With regard to generator power management, Section 4.2.1 of the ISO Tariff requires all market participants to comply fully and promptly with dispatch instructions and operating orders issued by the ISO, unless compliance would impair public health or safety or is physically impossible, and Sections 4.6.1.1, 7.1.3, 7.6.1, and 7.7.2.3 of the ISO Tariff require all generating facilities with participating generator agreements to operate such that the ISO can control their output under both normal and emergency conditions. Ramp rate limits and control are not currently addressed in the ISO Tariff, nor does the ISO Tariff require variable energy resources to provide any frequency response.

The need for enhanced tariff provisions to address generator power management of variable energy resources is supported by good utility practice, experience, and recent ISO analysis. From time to time, situations occur on every transmission system where the system cannot absorb available generation. Grid operators must be able to reduce the output of generators in cases where the grid is experiencing over-frequency conditions caused by system-wide over-generation, local transmission congestion caused by contingencies, planned clearances, or unexpected generation output, or to address any other threat to system security that may be alleviated by reducing real power output. The ISO recognizes that variable energy resources use clean, low-cost or no-cost fuel, so curtailing them may not constitute the most economical or environment-friendly solution to solving many system-wide

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52 *See* Walling Testimony at pp. 18-19.

conditions. Nevertheless, circumstances may arise where, due to their location, variable energy resources are the only source of generation capable of efficiently mitigating a problem or contributing to a solution because other dispatchable resources are operating at minimum levels, must maintain their operating capability for subsequent time periods, or are committed to use for other reliability services, such as localized voltage support or frequency response. These types of situations will only become more commonplace as variable energy resources displace conventional generation in California.

Recent analysis indicates that the introduction of new variable energy resources will have a large impact on transmission system performance. The ISO, in coordination with the consulting firm KEMA, Inc., prepared a report for the California Energy Commission in June 2010 that quantified changes in system frequency and area control error and the corresponding impact on system performance resulting from the aggregate increase in system volatility under 20 percent and 33 percent RPS scenarios. Although the report cannot be considered definitive on the operational impacts of a 33 percent RPS penetration level and additional analysis is warranted, the report reasonably concluded that system performance will be harmed, primarily due to variable energy resource ramping in the morning and evening along with traditional morning and evening load ramps.[53] Further, the report estimated that up to 10 times the currently required amount of regulation and balancing capacity may be needed to maintain system performance under the studied scenarios. Consequently, the report recommended that the ISO investigate appropriate protocols and incentives for altering or controlling the ramp rate of wind and solar resources for known ramp events.[54] As discussed further below, the ISO has committed to commencing a stakeholder process to address possible protocols and incentives, but without the foundational generation power management capability, the efficacy of the outcome of the stakeholder process is likely be significantly impaired.

In addition, it is technologically feasible for variable energy resources to satisfy the requirements set forth below regarding generation power management. That capability can be supplied by a range of commercially available equipment offered for sale by various manufacturers for use by wind, solar, and other types of asynchronous generators.[55]

Further, the ISO proposes to provide some flexibility for an asynchronous generating facility that can demonstrate to the ISO the purchase of non-compliant control equipment as of May 18, 2010. In the event that the ISO accepts the asynchronous generating facility's showing, the interconnection customer will be

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[53] "Research Evaluation of Wind Generation, Solar Generation, and Storage Impact on the California Grid," at p. 3. This report is available at http://www.energy.ca.gov/2009publications/CEC-500-2009-084/CEC-500-2009-084.PDF

[54] *Id.* at 3, 5-6.

[55] GE Report, Sections 4.2, 4.3; Attachment D to Board Memorandum;

required to prepare, in consultation with the ISO and the participating transmission owner, any required filings with the Commission to obtain approval of a non-conforming LGIA.

2. Revisions Concerning Active Power Management

The ISO proposes to add the following provisions to Appendix H of the Appendix V and Appendix Z LGIAs with regard to active power management:

- Each asynchronous generating facility must have the capability, as of January 1, 2012, to limit active power output in response to a dispatch instruction or operating order from the ISO. This capability will extend from the minimum operating limit to the maximum operating limit of the asynchronous generating facility in increments of five (5) MW or less. Changes to the power management set point will not cause a change in voltage at the point of interconnection exceeding 0.02 per unit of the nominal voltage.

- For asynchronous generating facilities that are also eligible intermittent resources, the power management establishes only a maximum output limit. There is no requirement for the eligible intermittent resource to maintain a level of power output beyond the capabilities of the available energy source.

- The asynchronous generating facility must provide Supervisory Control and Data Acquisition ("SCADA") capability to transmit data and receive instructions from the participating transmission owner and the ISO to protect system reliability.

- The participating transmission owner, the ISO, and the interconnection customer for the asynchronous generating facility will determine what SCADA information is essential for the proposed plant, taking into account the size of the plant and its characteristics, location, and importance in maintaining generation resource adequacy and transmission system reliability in its area.

- The asynchronous generating facility must be able to receive and respond to automated dispatch system ("ADS") instructions and any other form of communication authorized by the ISO Tariff. The asynchronous generating facility's response time should be capable of conforming to the periods prescribed by the ISO Tariff.

As explained above, the ISO Tariff already requires all market participants – including variable energy resources – to comply fully and promptly with dispatch instructions and operating orders issued by the ISO, unless compliance would impair public health or safety or is physically impossible. The ISO has generally interpreted the physically impossible exception to be restricted to real-time operating circumstances, such as forced outages, start-up times, and, in the case of many variable energy resources, lack of fuel, but not predetermined design limitations. Modern variable energy resources are physically capable of controlling output to varying degrees, as dictated by available fuel (*e.g.*, wind or sun) and the resources' equipment ratings. Further, the proposed 5 MW increment is consistent with the tolerance band for uninstructed deviation penalties under the ISO Tariff.[56] Therefore, the ISO's proposed revisions to Appendix H do not impose a new obligation, but rather clarify existing requirements applicable to variable energy resources. These clarifications will become increasingly important to the safety and reliability of the transmission system and the volume of variable energy resources in California grows.

The ISO's proposed revisions to Appendix H are also consistent with tariff changes implemented or proposed by other transmission system operators. The Commission approved tariff changes filed by the New York Independent System Operator, Inc. to permit it to limit power output from wind generation.[57] Further, the Alberta Electric System Operator ("AESO") has implemented a requirement that wind generating facilities must be adjustable from their minimum operating output to their maximum operating output.[58] The Commission should approve the similar tariff changes that the ISO proposes.

3. Revisions Concerning Ramp Rate Limits and Control

Conventional generators typically have "gradual" ramp rates but variable energy resources may have "steep" ramp rates that can cause reliability issues in accommodating ramps. To address the steep ramp rates of some variable energy resources, the ISO proposes to revise Appendix H of the new LGIAs to require each asynchronous generating facility to have the installed capability to limit power change ramp rates automatically, except for downward ramps resulting from decrease of the available energy resource for eligible intermittent resources. The power ramp control must be capable of limiting rates of power change to a value of 5 percent, 10 percent, or 20 percent of the asynchronous generating facility's maximum generating facility capacity per minute. This is the same ramp rate range proposed by AESO.[59] The asynchronous generating facility may implement this ramping limit by using stepped increments if the individual step size is five (5) MW or less.

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[56] *See* ISO Tariff, Appendix A, definition of Tolerance Band.

[57] *New York Independent System Operator, Inc.*, 127 FERC ¶ 61,130 (2009).

[58] *See* http://www.aeso.ca/files/MOF_Final__Sept26.pdf.

[59] Ramp rate limitation capability has been required of wind generation by a number of grid operators around the world. Walling Testimony at pp. 35-36.

Subject to further consideration in a subsequent stakeholder initiative, the ISO expects that these ramp rate limits may be applied when consistent with the variable energy resource's economic bidding strategy or for specified operating conditions where accommodating the natural ramp rate of variable energy resources could threaten grid reliability. The ISO envisions that the functionality will not be continuously used but instead will be activated by an ISO dispatch instruction or operating order and will be used only when needed to reliably accommodate the upward and downward ramps for variable energy resources. As such, the ISO does not anticipate the need for any special or specific communication procedures or equipment associated with the ramp control features distinct from the general means by which the ISO and generating facilities and their scheduling coordinators interact under existing ISO Tariff authority. Moreover, as explained in Mr. Walling's testimony, even if a generating unit cannot vary its output limit, the ISO requirements allow step-wise ramps up to 5 MW in size. Facilities can, therefore, implement ramping control by turning on and off individual generating units having less than 5 MW capacity.[60] At the present time, the ISO anticipates limiting ramps when a curtailment instruction is engaged or released. In addition, the ability to limit the rate of power change may be necessary during periods of insufficient aggregate ramping capability on the system, primarily during a significant upward ramp of wind or solar resources.[61]

4. Revisions Concerning Frequency Response

The ISO proposes to revise Appendix H of the new versions of the LGIAs to include provisions regarding frequency response, which NERC defines as an automatic and sustained change in the power consumption or output of a device that typically occurs within 30 seconds following a disturbance and is in a

[60] Walling Testimony at p. 37. Mr. Walling also explains that, although pre-engineered plant control packages are available, these should not be necessary to implement the ISO's proposed ramp rate limits because implementing a custom ramp control feature is essentially straightforward as an engineering matter. *Id.* at pp. 37-38.

[61] As a general matter, the ISO does not foresee limiting downward ramps that occur because of the absence of fuel for a variable wind or solar generator. The ISO recognizes that absent an event that causes wind speeds to exceed turbine cutout levels, downward wind ramps in the aggregate tend to be over a reasonably substantial period of time. Further, while the effect of geographic diversity of solar variability requires additional study, it appears that spatial dispersion will also mitigate the impact of cloud cover on the aggregate solar portfolio. Moreover, solar downward ramps due to the sun setting are likely to be more severe absent storage, but these types of down ramps are generally predictable. To the extent ramps due to the sunset need to be managed, whether due to reliability needs or generator economic preferences, these events can be addressed through use of the ramp rate control system coupled with dispatch instructions to reduce output prior to sunset. Any implementation of such a scheme must be supported by further analysis of system impacts and costs as well as consideration of appropriate market mechanisms and triggers.

direction opposing the change in interconnection frequency.[62] Historically, frequency response has been provided by turbine governor response and frequency responsive load. However, due to the implementation of the 20 percent and 33 percent RPS objectives, conventional generators that currently provide frequency response will be displaced by variable energy resources, and therefore variable energy resources will need to become more responsible for providing frequency response.

The WECC Minimum Operating Reliability Criteria ("MORC") require governor response from generators and state that "it is imperative that all entities equitably share the various responsibilities to maintain reliability. . . . To provide an equitable and coordinated system response to load/generation imbalances, governor droop shall be set at 5%." The WECC MORC are applicable reliability criteria under the ISO Tariff.[63] Therefore, the ISO is required to satisfy the WECC MORC both currently and in the future as variable energy resources displace conventional generation.[64]

Consistent with the WECC MORC, the anticipated operation of variable energy resources, and the increase in their percentage of the overall generation portfolio, the ISO proposes to revise Appendix H to the new versions of the LGIA to state that asynchronous generating facilities must have the installed capability to automatically reduce plant power output in response to an over-frequency condition. This frequency response control must, when enabled at the direction of the ISO, continuously monitor the system frequency and automatically reduce the real power output of the asynchronous generating facility with a droop equal to a 100 percent decrease in plant output for a 5 percent rise in frequency (*i.e.*, 5 percent droop) above an intentional dead band of 0.036 Hz.

As stated in proposed Article 9.6.2.2 to the new LGIAs, the ISO would expressly not require asynchronous generating facilities to provide governor response to under-frequency conditions. In order to provide under-frequency response, a variable energy resource would have to increase its real power output, which could only occur if the resource was operating at less than its maximum capacity. The ISO does not believe it is appropriate to preclude variable energy resources from operating at maximum capacity, because that

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[62] "Frequency Response Standard Whitepaper," prepared by the Frequency Task Force of the NERC Resources Subcommittee (Apr. 6, 2004), at 3. This whitepaper is available on NERC's website at http://www.nerc.com/docs/oc/rs/Frequency_Response_White_Paper.pdf.

[63] ISO Tariff, Appendix A, definition of Applicable Reliability Criteria (stating in relevant part that the definition includes "Reliability Standards and *reliability criteria* established by NERC and WECC" (emphasis added)).

[64] *See* ISO Tariff, Section 7.2 ("The CAISO shall exercise Operational Control over the CAISO Controlled Grid in compliance with all Applicable Reliability Criteria and Operating Procedures.").

would require such resources to "spill" their fuel supplies (*e.g.*, wind or sun) so that the resources would not be maximizing their ability to produce energy.[65]

5. Further Stakeholder Process Preceding January 1, 2012 Effective Date

In the stakeholder process that resulted in the filing of the instant tariff amendment, the primary concerns raised by stakeholders regarding the proposed generator power management requirements focused on issues such as under what circumstances the capabilities will be triggered, what operational or market protocols will govern the hierarchy of generation reduction, and what, if any, market rules will apply to compensate for a generation reduction or will incent voluntary reduction of output in response to price signals. The ISO recognizes that issues such as these must be resolved before the generator power management requirements go into effect. Therefore, the ISO plans to resolve them in a stakeholder process that will give stakeholders all the information they need to implement the generator power management requirements. Consistent with this commitment, the ISO requests that its proposed tariff changes regarding generation power management be made effective as of January 1, 2012, in order to accommodate the anticipated timing of the stakeholder process and any transition requirements.

The proposed January 1, 2012 effective date will give variable energy resources that are not exempted from the generator power management requirements ample time to obtain the equipment needed to satisfy those requirements. As explained above, that equipment is commercially available from a variety of manufacturers for both wind and solar photovoltaic technologies.[66] This commercial availability, coupled with the ISO's understanding that equipment procurement generally follows LGIA execution, means that the proposed tariff provisions will not impact the timing of project development. Further, as indicated in the GE Report, experience in the wind industry indicates that adding new control and other grid-related technologies normally takes between 6 and 18 months, and the nature of the equipment needed to meet the ISO's proposed tariff requirements means that the January 1, 2012 effective date is reasonable, prudent, and achievable.[67]

6. Exemption from Power Management Requirements

In addition to the transition period, the ISO will also accommodate those generators who have, as of May 18, 2010, purchased equipment that is not compliant with the new power management criteria. With respect to such projects, the ISO will coordinate with them to develop requirements consistent

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[65] Walling Testimony at p. 35.
[66] *See* Board Memo, Attachments A and D.
[67] GE Report, Section 1.2.

with the capability of the control equipment and will submit those requirements for Commission approval in a non-conforming LGIA. Because this exemption will be reflected in individual LGIAs, the ISO has not included in this filing specific tariff language relating to this exemption. However, the ISO nevertheless requests that the Commission indicate its approval of this proposed approach so that the ISO and developers have a reasonable amount of confidence that incorporating this exemption into future LGIAs will be favorably received.

E. Revisions to Power System Stabilizers Requirements

Article 5.4 of the existing LGIAs currently requires an interconnection customer to procure, install, maintain, and operate power system stabilizers for all generators except wind generators of the induction type. The ISO proposes to revise Article 5.4 in the new versions of the LGIA to specify that the requirements of Article 5.4 will apply to asynchronous generating facilities as set forth in Appendix H, and to revise Appendix H to the new LGIAs to exempt all asynchronous generating facilities (including induction-type wind plants) from the power system stabilizer requirements.

F. Revisions Regarding Interconnection Application Data

The current version of the ISO Tariff does not specify the types of study models that Interconnection Customers must provide to the ISO for studies of their projects. The ISO has determined that provision of standard study models, where possible, will assist in expediting the LGIP study processes and ensure better consistency and higher confidence in the accuracy of the study results. Therefore, the ISO proposes to revise Attachment A to LGIP Appendix 1 of the Appendix U LGIP as well as the Appendix Y LGIP to state that, for each generator, the interconnection customer must provide the WECC-approved standard study models rather than user-defined models, to the extent such models are available. If standard study models are not available, then the interconnection customer can provide user-written or equivalent models.

III. Stakeholder Process

In February 2010, the ISO established the stakeholder process that led to this tariff amendment on an expedited basis. Pursuant to the discussions with stakeholders over the following months, the ISO developed the revised interconnection requirements contained in the instant tariff amendment. At its May 18, 2010 meeting, the ISO Board of Governors authorized the ISO to prepare and file all tariff revisions necessary to implement the revised interconnection requirements.[68]

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[68] A listing of the key dates in the stakeholder process and electronic links to documents on the ISO's website concerning the revised interconnection requirements are provided in Attachment G to the instant filing.

The ISO conducted the stakeholder initiative that led to this tariff amendment on an expedited basis in order to protect system reliability and minimize disruption of project development, as discussed in Section I above. Nevertheless, the ISO has provided ample opportunity for stakeholder input into the revisions proposed herein. The ISO has held four conference calls and meetings with stakeholders to discuss its proposal. The ISO shared draft tariff language with stakeholders and held a conference call to discuss that language. The ISO also solicited written comments and suggested edits to the draft tariff language from stakeholders, which it used to formulate its final proposal.

IV. Effective Dates and Request for Waiver

The ISO respectfully requests waiver of the Commission's regulations to permit the tariff revisions contained in this filing to become effective as of July 3, 2010 (*i.e.*, one day after the filing of this tariff amendment), except for the tariff revisions regarding generator power management, for which the ISO requests waiver of the Commission's regulations to permit an effective date of January 1, 2012.[69] In practice, this will mean that upon Commission approval of this amendment, any interconnection agreements tendered for execution on or after July 3, 2010 will be conformed to those set forth in Appendices BB and CC, depending on whether the interconnection customer is studied serially or as part of a queue cluster. These effective dates will permit modification of the ISO's interconnection requirements on a timely basis, which will benefit system reliability and security and have the other benefits discussed above. This is of particular importance given that the ISO's current interconnection queue contains approximately 20,000 MW in variable resource capacity. Granting the requested effective dates and waiver, therefore, is appropriate.

[69] In particular, the ISO requests waiver, pursuant to Section 35.11 of the Commission's regulations (18 C.F.R. § 35.11), of the 60-day notice requirement set forth in Section 35.3 of the Commission's regulations (18 C.F.R. § 35.3), and to the extent necessary, the ISO respectfully requests that the Commission grant any other waivers of Part 35 of its regulations that may be required in connection with the requested effective dates.

V. Communications

Communications regarding this filing should be addressed to the following individuals, whose names should be put on the official service list established by the Commission with respect to this submittal:

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Senior Counsel
Grant Rosenblum
Senior Counsel
California Independent System
Operator Corporation
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bradley.miliauskas@alston.com

VI. Service

The ISO has served copies of this transmittal letter, and all attachments, on the California Public Utilities Commission, the California Energy Commission, and all parties with effective Scheduling Coordinator Service Agreements under the ISO Tariff. In addition, the ISO is posting this transmittal letter and all attachments on the ISO website.

VII. Attachments

The following attachments, in addition to this transmittal letter, support the instant filing:

Attachment A	Revised ISO Tariff sheets that incorporate the proposed changes described above
Attachment B	The proposed changes to the ISO Tariff shown in black-line format
Attachment C	Comparison between current and revised ISO's pro forma LGIAs
Attachment D	Prepared Testimony of Reigh Walling
Attachment E	Prepared Testimony of Nisar Shah

Attachment F	Materials provided to ISO Board of Governors
Attachment G	Listing of key dates in the stakeholder process and electronic links to documents provided by the ISO and stakeholders in the stakeholder process

VIII. Conclusion

For the foregoing reasons, the Commission should accept the proposed tariff changes contained in the instant filing to become effective as explained herein. Please contact the undersigned if you have any questions regarding this matter.

Respectfully submitted,

/s/ Michael Kunselman
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Counsel for the California Independent System Operator Corporation

Attachment A – Clean Sheets

Tariff Amendment to Modify Interconnection Requirements Applicable to Large Generators

8.2.3.3 Voltage Support

The CAISO shall determine on an hourly basis for each day the quantity and location of Voltage Support required to maintain voltage levels and reactive margins within NERC and WECC reliability standards, including any requirements of the NRC using a power flow study based on the quantity and location of scheduled Demand. The CAISO shall issue daily voltage schedules (Dispatch Instructions) to Participating Generators, Participating TOs and UDCs, which are required to be maintained for CAISO Controlled Grid reliability. All other Generating Units shall comply with the power factor requirements set forth in contractual arrangements in effect on the CAISO Operations Date, or, if no such contractual arrangements exist and the Generating Unit exists within the system of a Participating TO, the power factor requirements applicable under the Participating TO's TO Tariff or other tariff on file with the FERC. All Participating Generators that operate Asynchronous Generating Facilities subject to the Large Generator Interconnection Agreement set forth in Appendix BB or CC shall maintain the CAISO specified voltage schedule for those facilities at the Point of Interconnection to the extent possible, except as permitted under Appendix H of the Large Generator Interconnection Agreement, while operating within the power factor range specified in their interconnection agreements. For all other Generating Units, Participating Generators shall maintain the CAISO specified voltage schedule at the Generating Unit terminals to the extent possible, while operating within the power factor range specified in their interconnection agreements, or, for Regulatory Must-Take Generation, Regulatory Must-Run Generation and Reliability Must-Run Generation, consistent with existing obligations. For Generating Units that do not operate under one of these agreements, the minimum power factor range will be within a band of 0.90 lag (producing VARs) and 0.95 lead (absorbing VARs) power factors. Participating Generators with Generating Units existing at the CAISO Operations Date that are unable to meet this operating power factor requirement may apply to the CAISO for an exemption. Prior to granting such an exemption, the CAISO shall require the Participating TO or UDC to whose system the relevant Generating Units are interconnected to notify it of the existing contractual requirements for Voltage Support established prior to the CAISO Operations Date for such Generating Units. Such requirements may be contained in CPUC Electric Rule 21 or the Interconnection Agreement with the Participating TO or UDC. The CAISO shall not grant any exemption under this Section from such existing contractual requirements. The CAISO shall be entitled to instruct Participating Generators to operate their Generating Units at specified points within their power factor ranges. Participating Generators shall receive no compensation for operating within these specified ranges.

If the CAISO requires additional Voltage Support, it shall procure this either through Reliability Must-Run Contracts or, if no other more economic sources are available**,** by instructing a Generating Unit to move its MVar output outside its mandatory range. Only if the Generating Unit must reduce its MW output in order to comply with such an instruction will it be eligible to recover its opportunity cost in accordance with Section 11.10.1.4.

All Loads directly connected to the CAISO Controlled Grid shall maintain reactive flow at grid interface points within a specified power factor band of 0.97 lag to 0.99 lead. Loads shall not be compensated for the service of maintaining the power factor at required levels within the bandwidth. A UDC interconnecting with the CAISO Controlled Grid at any point other than a Scheduling Point shall be subject to the same power factor requirement.

The CAISO will develop and will be authorized to levy penalties against Participating Generators, UDCs or Loads whose Voltage Support does not comply with the CAISO's requirements. The CAISO will establish voltage control standards with UDCs and the operators of other Balancing Authority Areas and will enter into operational agreements providing for the coordination of actions in the event of a voltage problem occurring.

25.4 Asynchronous Generating Facilities

Asynchronous Generating Facilities that are the subject of Interconnection Requests in a serial study queue and for which a Large Generator Interconnection Agreement has not been executed or tendered for signature as of July 3, 2010 shall be subject to the Large Generator Interconnection Agreement set forth in Appendix BB.   Asynchronous Generating Facilities that are the subject of Interconnection Requests in a Queue Cluster Window and for which a Large Generator Interconnection Agreement has not been executed or tendered for signature as of July 3, 2010 shall be subject to the Large Generator Interconnection Agreement set forth in Appendix CC.

- *Asynchronous Generating Facility*

An induction, doubly-fed, or electronic power generating unit(s) that produces 60 Hz (nominal) alternating current.

Attachment A
To LGIP Appendix 1
Interconnection Request

LARGE GENERATING FACILITY DATA

Provide three copies of this completed form pursuant to Section 7 of LGIP Appendix 1.

1. Provide two original prints and one reproducible copy (no larger than 36” x 24”) of the following:

A. Site drawing to scale, showing generator location and Point of Interconnection with the CAISO Controlled Grid.

B. Single-line diagram showing applicable equipment such as generating units, step-up transformers, auxiliary transformers, switches/disconnects of the proposed interconnection, including the required protection devices and circuit breakers. For wind generator farms, the one line diagram should include the distribution lines connecting the various groups of generating units, the generator capacitor banks, the step up transformers, the distribution lines, and the substation transformers and capacitor banks at the Point of Interconnection with the CAISO Controlled Grid.

2. Generating Facility Information

A) Total Generating Facility rated output (kW): ________________
B) Generating Facility auxiliary Load (kW): ________________
C) Project net capacity (kW): ________________
D) Standby Load when Generating Facility is off-line (kW): ________________
E) Number of Generating Units: ____________________
(Please repeat the following items for each generator)
F) Individual generator rated output (kW for each unit): ____________________________
G) Manufacturer: _______________________________________
H) Year Manufactured: ____________________
I) Nominal Terminal Voltage: ____________________
J) Rated Power Factor (%): ________
K) Type (Induction, Synchronous, D.C. with Inverter): ______________
L) Phase (3 phase or single phase): ________
M) Connection (Delta, Grounded WYE, Ungrounded WYE, impedance grounded): _________
N) Generator Voltage Regulation Range: ______________
O) Generator Power Factor Regulation Range: ______________
P) For combined cycle plants, specify the plant output for an outage of the steam turbine or an outage of a single combustion turbine:

Synchronous Generator – General Information:
(Please repeat the following for each generator)

A. Rated Generator speed (rpm):_____________
B. Rated MVA: ________________
C. Rated Generator Power Factor: _____________
D. Generator Efficiency at Rated Load (%): _____________
E. Moment of Inertia (including prime mover): _____________
F. Inertia Time Constant (on machine base) H: _____________ sec or MJ/MVA
G. SCR (Short-Circuit Ratio - the ratio of the field current required for rated open-circuit voltage to the field current required for rated short-circuit current): _____________
H. Please attach generator reactive capability curves.

I. Rated Hydrogen Cooling Pressure in psig (Steam Units only): ____________

J. Please attach a plot of generator terminal voltage versus field current that shows the air gap line, the open-circuit saturation curve, and the saturation curve at full load and rated power factor.

4. Excitation System Information

(Please repeat the following for each generator)

A. Indicate the Manufacturer ____________________ and Type _____________of excitation system used for the generator. For exciter type, please choose from 1 to 8 below or describe the specific excitation system.

1) Rotating DC commutator exciter with continuously acting regulator. The regulator power source is independent of the generator terminal voltage and current.

2) Rotating DC commentator exciter with continuously acting regulator. The regulator power source is bus fed from the generator terminal voltage.

3) Rotating DC commutator exciter with non-continuously acting regulator (i.e., regulator adjustments are made in discrete increments).

4) Rotating AC Alternator Exciter with non-controlled (diode) rectifiers. The regulator power source is independent of the generator terminal voltage and current (not bus-fed).

5) Rotating AC Alternator Exciter with controlled (thyristor) rectifiers. The regulator power source is fed from the exciter output voltage.

6) Rotating AC Alternator Exciter with controlled (thyristor) rectifiers.

7) Static Exciter with controlled (thyristor) rectifiers. The regulator power source is bus-fed from the generator terminal voltage.

8) Static Exciter with controlled (thyristor) rectifiers. The regulator power source is bus-fed from a combination of generator terminal voltage and current (compound-source controlled rectifiers system.

B. Attach a copy of the block diagram of the excitation system from its instruction manual. The diagram should show the input, output, and all feedback loops of the excitation system.

C. Excitation system response ratio (ASA): ______________

D. Full load rated exciter output voltage: ___________

E. Maximum exciter output voltage (ceiling voltage): ___________

F. Other comments regarding the excitation system?

____

____

____

5. Power System Stabilizer Information.

(Please repeat the following for each generator. All new generators are required to install PSS unless an exemption has been obtained from WECC. Such an exemption can be obtained for units that do not have suitable excitation systems.)

A. Manufacturer: ____

B. Is the PSS digital or analog? __________________

C. Note the input signal source for the PSS?
_____ Bus frequency _____ Shaft speed _____ Bus Voltage
_____________________ Other (specify source)

D. Please attach a copy of a block diagram of the PSS from the PSS Instruction Manual and the correspondence between dial settings and the time constants or PSS gain.

E: Other comments regarding the PSS?
____
____
____

6. Turbine-Governor Information

(Please repeat the following for each generator)

Please complete Part A for steam, gas or combined-cycle turbines, Part B for hydro turbines, and Part C for both.

A. Steam, gas or combined-cycle turbines:

1.) List type of unit (Steam, Gas, or Combined-cycle):__________
2.) If steam or combined-cycle, does the turbine system have a reheat process (i.e., both high and low pressure turbines)? _______
3.) If steam with reheat process, or if combined-cycle, indicate in the space provided, the percent of full load power produced by each turbine:
Low pressure turbine or gas turbine:______%
High pressure turbine or steam turbine:______%

B. Hydro turbines:

1.) Turbine efficiency at rated load: _______%
2.) Length of penstock: ______ft
3.) Average cross-sectional area of the penstock: _______ft2
4.) Typical maximum head (vertical distance from the bottom of the penstock, at the gate, to the water level): ______ft
5.) Is the water supply run-of-the-river or reservoir: ___________
6.) Water flow rate at the typical maximum head: _________ft3/sec
7.) Average energy rate: _________kW-hrs/acre-ft
8.) Estimated yearly energy production: ________kW-hrs

C. Complete this section for each machine, independent of the turbine type.

1.) Turbine manufacturer: _______________
2.) Maximum turbine power output: _______________MW
3.) Minimum turbine power output (while on line): _________MW
4.) Governor information:
a: Droop setting (speed regulation): _____________
b: Is the governor mechanical-hydraulic or electro-hydraulic (Electro-hydraulic governors have an electronic speed sensor and transducer.)? _________________
c: Other comments regarding the turbine governor system?
____
____
____
____

7. Generator and Associated Equipment – Dynamic Models:

A. Synchronous Generators

For each generator, governor, exciter and power system stabilizer, select the appropriate dynamic model from the General Electric PSLF Program Manual and provide the required input data. The manual is available on the GE website at www.gepower.com. Select the following links within the website: 1) Our Businesses, 2) GE Power Systems, 3) Energy Consulting, 4) GE PSLF Software, 5) GE PSLF User's Manual.

There are links within the GE PSLF User's Manual to detailed descriptions of specific models, a definition of each parameter, a list of the output channels, explanatory notes, and a control system block diagram. The block diagrams are also available on the CAISO Website.

If you require assistance in developing the models, we suggest you contact General Electric. Accurate models are important to obtain accurate study results. Costs associated with any changes in facility requirements that are due to differences between model data provided by the generation developer and the actual generator test data, may be the responsibility of the generation developer.

B. Asynchronous Generators

For each generator, the Interconnection Customer must provide WECC approved standard study models (standard models), rather than user-defined models, to the extent standard models are available. If standard models for the generator are not available then the Interconnection Customer may supply user-written or equivalent models.

8. Induction Generator Data:

A. Rated Generator Power Factor at rated load: ____________
B. Moment of Inertia (including prime mover): ____________
C. Do you wish reclose blocking? Yes ___, No ___
Note: Sufficient capacitance may be on the line now, or in the future, and the generator may self-excite unexpectedly.

9. Generator Short Circuit Data

For each generator, provide the following reactances expressed in p.u. on the generator base:

- X"1 – positive sequence subtransient reactance: _____
- X"2 – negative sequence subtransient reactance: _____
- X"0 – zero sequence subtransient reactance: _____

Generator Grounding:

A. _____ Solidly grounded
B. _____ Grounded through an impedance

Impedance value in p.u on generator base. R:_____________p.u.
X:_____________p.u.

C. _____ Ungrounded

10. Step-Up Transformer Data

For each step-up transformer, fill out the data form provided in Table 1.

11. Line Data

There is no need to provide data for new lines that are to be planned by the Participating TO. However, for transmission lines that are to be planned by the generation developer, please provide the following information:

Nominal Voltage: _______________
Line Length (miles): ___________________
Line termination Points: ___________________
Conductor Type: ______ Size: ________
If bundled. Number per phase: ______, Bundle spacing: _____in.
Phase Configuration. Vertical: _______, Horizontal: _______
Phase Spacing (ft): A-B: ______, B-C: _______, C-A: ________
Distance of lowest conductor to Ground: _________ft
Ground Wire Type: ________ Size: _______ Distance to Ground: ______ft
Attach Tower Configuration Diagram
Summer line ratings in amperes (normal and emergency) _________________
Resistance (R): __________ p.u.**
Reactance: (X): __________ p.u**
Line Charging (B/2): __________ p.u**
** On 100-MVA and nominal line voltage (kV) Base

12. Wind Generators

Number of generators to be interconnected pursuant to this Interconnection Request: ____

Elevation: ______ _____ Single Phase _____ Three Phase

Inverter manufacturer, model name, number, and version:
____

List of adjustable setpoints for the protective equipment or software:
____

Field Volts: _________________
Field Amperes: ______________
Motoring Power (kW): _______
Neutral Grounding Resistor (If Applicable): ____________
I_2^2t or K (Heating Time Constant): ____________
Rotor Resistance: ____________
Stator Resistance: ____________
Stator Reactance: ____________
Rotor Reactance: ____________
Magnetizing Reactance: ___________
Short Circuit Reactance: ___________
Exciting Current: ________________
Temperature Rise: ________________
Frame Size: _______________
Design Letter: _____________
Reactive Power Required In Vars (No Load):________
Reactive Power Required In Vars (Full Load):________
Total Rotating Inertia, H: ________ Per Unit on KVA Base

Note: A completed General Electric Company Power Systems Load Flow (PSLF) data sheet must be supplied with the Interconnection Request. If other data sheets are more appropriate to the proposed device then they shall be provided and discussed at Scoping Meeting.

TABLE 1

TRANSFORMER DATA

UNIT______________________________________

NUMBER OF TRANSFORMERS_________ PHASE _______

RATED KVA	H Winding	X Winding	Y Winding
Connection (Delta, Wye, Gnd.)	__________	__________	__________
55 C Rise	__________	__________	__________
65 C Rise	__________	__________	__________
RATED VOLTAGE	__________	__________	__________
BIL	__________	__________	__________
AVAILABLE TAPS (planned or existing)	__________	__________	__________
LOAD TAP CHANGER?	__________	__________	__________
TAP SETTINGS	__________	__________	__________

COOLING TYPE : OA_____ OA/FA_____ OA/FA/FA______ OA/FOA______

IMPEDANCE	H-X	H-Y	X-Y
Percent	__________	__________	__________
MVA Base	__________	__________	__________
Tested Taps	__________	__________	__________

WINDING RESISTANCE	H	X	Y
Ohms	__________	__________	__________

CURRENT TRANSFORMER RATIOS

H_____________ X______________ Y______________ N_____________

PERCENT EXCITING CURRENT 100 % Voltage; _________ 110% Voltage________

Supply copy of nameplate and manufacture's test report when available

CAISO TARIFF APPENDIX Y
LGIP For Requests in a Queue Cluster Window

11.1 Tender

11.1.1 Within thirty (30) Calendar Days after the CAISO provides the final Phase II Interconnection Study report to the Interconnection Customer, the applicable Participating TO(s) and the CAISO shall tender a draft LGIA, together with draft appendices. The draft LGIA shall be in the form of the FERC-approved form of LGIA set forth in CAISO Tariff Appendix Z or Appendix CC, as applicable. The Interconnection Customer shall provide written comments, or notification of no comments, to the draft appendices to the applicable Participating TO(s) and the CAISO within (30) calendar days of receipt.

CAISO TARIFF APPENDIX BB

Standard Large Generator Interconnection Agreement

for Interconnection Requests in a Serial Study Group that are tendered or execute a Large Generator Interconnection Agreement on or after July 3, 2010

TABLE OF CONTENTS

STANDARD LARGE GENERATOR INTERCONNECTION AGREEMENT

[INTERCONNECTION CUSTOMER]

[PARTICIPATING TO]

CALIFORNIA INDEPENDENT SYSTEM OPERATOR CORPORATION

THIS STANDARD LARGE GENERATOR INTERCONNECTION AGREEMENT ("LGIA") is made and entered into this ____ day of _______________ 20___, by and among ________________, a _______________ organized and existing under the laws of the State/Commonwealth of _________ ("Interconnection Customer" with a Large Generating Facility), ________________, a corporation organized and existing under the laws of the State of California ("**Participating TO**"), and **California Independent System Operator Corporation**, a California nonprofit public benefit corporation organized and existing under the laws of the State of California ("CAISO"). Interconnection Customer, Participating TO, and CAISO each may be referred to as a "Party" or collectively as the "Parties."

RECITALS

WHEREAS, CAISO exercises Operational Control over the CAISO Controlled Grid; and

WHEREAS, the Participating TO owns, operates, and maintains the Participating TO's Transmission System; and

WHEREAS, Interconnection Customer intends to own, lease and/or control and operate the Generating Facility identified as a Large Generating Facility in Appendix C to this LGIA; and

WHEREAS, Interconnection Customer, Participating TO, and CAISO have agreed to enter into this LGIA for the purpose of interconnecting the Large Generating Facility with the Participating TO's Transmission System;

NOW, THEREFORE, in consideration of and subject to the mutual covenants contained herein, it is agreed:

When used in this LGIA, terms with initial capitalization that are not defined in Article 1 shall have the meanings specified in the Article in which they are used.

ARTICLE 1. DEFINITIONS

Adverse System Impact shall mean the negative effects due to technical or operational limits on conductors or equipment being exceeded that may compromise the safety and reliability of the electric system.

Affected System shall mean an electric system other than the CAISO Controlled Grid that may be affected by the proposed interconnection, including the Participating TO's electric system that is not part of the CAISO Controlled Grid.

Affiliate shall mean, with respect to a corporation, partnership or other entity, each such other corporation, partnership or other entity that directly or indirectly, through one or more intermediaries, controls, is controlled by, or is under common control with, such corporation, partnership or other entity.

Applicable Laws and Regulations shall mean all duly promulgated applicable federal, state and local laws, regulations, rules, ordinances, codes, decrees, judgments, directives, or judicial or administrative orders, permits and other duly authorized actions of any Governmental Authority.

Applicable Reliability Council shall mean the Western Electricity Coordinating Council or its successor.

Applicable Reliability Standards shall mean the requirements and guidelines of NERC, the Applicable Reliability Council, and the Balancing Authority Area of the Participating TO's Transmission System to which the Generating Facility is directly connected, including requirements adopted pursuant to Section 215 of the Federal Power Act.

Asynchronous Generating Facility shall mean an induction, doubly-fed, or electronic power generating unit(s) that produces 60 Hz (nominal) alternating current.

Balancing Authority shall mean the responsible entity that integrates resource plans ahead of time, maintains load-interchange-generation balance within a Balancing Authority Area, and supports Interconnection frequency in real time.

Balancing Authority Area shall mean the collection of generation, transmission, and loads within the metered boundaries of the Balancing Authority. The Balancing Authority maintains load-resource balance within this area.

Base Case shall mean the base case power flow, short circuit, and stability data bases used for the Interconnection Studies.

Breach shall mean the failure of a Party to perform or observe any material term or condition of this LGIA.

Breaching Party shall mean a Party that is in Breach of this LGIA.

Business Day shall mean Monday through Friday, excluding federal holidays and the day after Thanksgiving Day.

Calendar Day shall mean any day including Saturday, Sunday or a federal holiday.

Commercial Operation shall mean the status of an Electric Generating Unit at a Generating Facility that has commenced generating electricity for sale, excluding electricity generated during Trial Operation.

Commercial Operation Date of an Electric Generating Unit shall mean the date on which the Electric Generating Unit at the Generating Facility commences Commercial Operation as agreed to by the applicable Participating TO and the Interconnection Customer pursuant to Appendix E to this LGIA.

Confidential Information shall mean any confidential, proprietary or trade secret information of a plan, specification, pattern, procedure, design, device, list, concept, policy or compilation relating to the present or planned business of a Party, which is designated as confidential by the Party supplying the information, whether conveyed orally, electronically, in writing, through inspection, or otherwise, subject to Article 22.1.2.

Default shall mean the failure of a Breaching Party to cure its Breach in accordance with Article 17 of this LGIA.

Distribution System shall mean those non-CAISO-controlled transmission and distribution facilities owned by the Participating TO.

Distribution Upgrades shall mean the additions, modifications, and upgrades to the Participating TO's Distribution System. Distribution Upgrades do not include Interconnection Facilities.

Effective Date shall mean the date on which this LGIA becomes effective upon execution by the Parties subject to acceptance by FERC, or if filed unexecuted, upon the date specified by FERC.

Electric Generating Unit shall mean an individual electric generator and its associated plant and apparatus whose electrical output is capable of being separately identified and metered.

Emergency Condition shall mean a condition or situation: (1) that in the judgment of the Party making the claim is imminently likely to endanger life or property; or (2) that, in the case of the CAISO, is imminently likely (as determined in a non-discriminatory manner) to cause a material adverse effect on the security of, or damage to, the CAISO Controlled Grid or the electric systems of others to which the CAISO Controlled Grid is directly connected; (3) that, in the case of the Participating TO, is imminently likely (as determined in a non-discriminatory manner) to cause a material adverse effect on the security of, or damage to, the Participating TO's Transmission System, Participating TO's Interconnection Facilities, Distribution System, or the electric systems of others to which the Participating TO's electric system is directly connected; or (4) that, in the case of the Interconnection Customer, is imminently likely (as determined in a non-discriminatory manner) to cause a material adverse effect on the security of, or damage to, the Generating Facility or Interconnection Customer's Interconnection Facilities. System restoration and black start shall be considered Emergency Conditions; provided, that Interconnection Customer is not obligated by this LGIA to possess black start capability.

Environmental Law shall mean Applicable Laws or Regulations relating to pollution or protection of the environment or natural resources.

Federal Power Act shall mean the Federal Power Act, as amended, 16 U.S.C. §§ 791a *et seq*.

FERC shall mean the Federal Energy Regulatory Commission or its successor.

Force Majeure shall mean any act of God, labor disturbance, act of the public enemy, war, insurrection, riot, fire, storm or flood, explosion, breakage or accident to machinery or equipment, any order, regulation or restriction imposed by governmental, military or lawfully established civilian authorities, or any other cause beyond a Party's control. A Force Majeure event does not include acts of negligence or intentional wrongdoing by the Party claiming Force Majeure.

Generating Facility shall mean the Interconnection Customer's Electric Generating Unit(s) used for the production of electricity identified in the Interconnection Customer's Interconnection Request, but shall not include the Interconnection Customer's Interconnection Facilities.

Generating Facility Capacity shall mean the net capacity of the Generating Facility and the aggregate net capacity of the Generating Facility where it includes multiple energy production devices.

Good Utility Practice shall mean any of the practices, methods and acts engaged in or approved by a significant portion of the electric utility industry during the relevant time period, or any of the practices, methods and acts which, in the exercise of reasonable judgment in light of the facts known at the time the decision was made, could have been expected to accomplish the desired result at a reasonable cost consistent with good business practices, reliability, safety and expedition. Good Utility Practice is not intended to be any one of a number of the optimum practices, methods, or acts to the exclusion of all others, but rather to be acceptable practices, methods, or acts generally accepted in the region.

Governmental Authority shall mean any federal, state, local or other governmental, regulatory or administrative agency, court, commission, department, board, or other governmental subdivision, legislature, rulemaking board, tribunal, or other governmental authority having jurisdiction over the Parties, their respective facilities, or the respective services they provide, and exercising or entitled to exercise any administrative, executive, police, or taxing authority or power; provided, however, that such term does not include the Interconnection Customer, CAISO, Participating TO, or any Affiliate thereof.

Hazardous Substances shall mean any chemicals, materials or substances defined as or included in the definition of "hazardous substances," "hazardous wastes," "hazardous materials," "hazardous constituents," "restricted hazardous materials," "extremely hazardous substances," "toxic substances," "radioactive substances," "contaminants," "pollutants," "toxic pollutants" or words of similar meaning and regulatory effect under any applicable Environmental Law, or any other chemical, material or substance, exposure to which is prohibited, limited or regulated by any applicable Environmental Law.

Initial Synchronization Date shall mean the date upon which an Electric Generating Unit is initially synchronized and upon which Trial Operation begins.

In-Service Date shall mean the date upon which the Interconnection Customer reasonably expects it will be ready to begin use of the Participating TO's Interconnection Facilities to obtain back feed power.

Interconnection Customer's Interconnection Facilities shall mean all facilities and equipment, as identified in Appendix A of this LGIA, that are located between the Generating Facility and the Point of Change of Ownership, including any modification, addition, or upgrades to such facilities and equipment necessary to physically and electrically interconnect the Generating Facility to the Participating TO's Transmission System. Interconnection Customer's Interconnection Facilities are sole use facilities.

Interconnection Facilities shall mean the Participating TO's Interconnection Facilities and the Interconnection Customer's Interconnection Facilities. Collectively, Interconnection Facilities include all facilities and equipment between the Generating Facility and the Point of Interconnection, including any modification, additions or upgrades that are necessary to physically and electrically interconnect the Generating Facility to the Participating TO's Transmission System. Interconnection Facilities are sole use facilities and shall not include Distribution Upgrades, Stand Alone Network Upgrades or Network Upgrades.

Interconnection Facilities Study shall mean the study conducted or caused to be performed by the CAISO, in coordination with the applicable Participating TO(s), or a third party consultant for the Interconnection Customer to determine a list of facilities (including the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades), the cost of those facilities, and the time required to interconnect the Generating Facility with the Participating TO's Transmission System.

Interconnection Facilities Study Agreement shall mean the agreement between the Interconnection Customer and the CAISO for conducting the Interconnection Facilities Study.

Interconnection Feasibility Study shall mean the preliminary evaluation conducted or caused to be performed by the CAISO, in coordination with the applicable Participating TO(s), or a third party consultant for the Interconnection Customer of the system impact and cost of interconnecting the Generating Facility to the Participating TO's Transmission System.

Interconnection Handbook shall mean a handbook, developed by the Participating TO and posted on the Participating TO's web site or otherwise made available by the Participating TO, describing technical and operational requirements for wholesale generators and loads connected to the Participating TO's portion of the CAISO Controlled Grid, as such handbook may be modified or superseded from time to time. Participating TO's standards contained in the Interconnection Handbook shall be deemed consistent with Good Utility Practice and Applicable Reliability Standards. In the event of a conflict between the terms of this LGIA and the terms of the Participating TO's Interconnection Handbook, the terms in this LGIA shall apply.

Interconnection Request shall mean a request, in the form of Appendix 1 to the Standard Large Generator Interconnection Procedures, in accordance with the CAISO Tariff.

Interconnection Service shall mean the service provided by the Participating TO and CAISO associated with interconnecting the Interconnection Customer's Generating Facility to the Participating TO's Transmission System and enabling the CAISO Controlled Grid to receive electric energy and capacity from the Generating Facility at the Point of Interconnection, pursuant to the terms of this LGIA, the Participating TO's Transmission Owner Tariff, and the CAISO Tariff.

Interconnection Study shall mean any of the following studies: the Interconnection Feasibility Study, the Interconnection System Impact Study, and the Interconnection Facilities Study conducted or caused to be performed by the CAISO, in coordination with the applicable Participating TO(s), or a third party consultant for the Interconnection Customer pursuant to the Standard Large Generator Interconnection Procedures.

Interconnection System Impact Study shall mean the engineering study conducted or caused to be performed by the CAISO, in coordination with the applicable Participating TO(s), or a third party consultant for the Interconnection Customer that evaluates the impact of the proposed interconnection on the safety and reliability of the Participating TO's Transmission System and, if applicable, an Affected System. The study shall identify and detail the system impacts that would result if the Generating Facility were interconnected without project modifications or system modifications, focusing on the Adverse System Impacts identified in the Interconnection Feasibility Study, or to study potential impacts, including but not limited to those identified in the Scoping Meeting as described in the Standard Large Generator Interconnection Procedures.

IRS shall mean the Internal Revenue Service.

CAISO Controlled Grid shall mean the system of transmission lines and associated facilities of the parties to the Transmission Control Agreement that have been placed under the CAISO's Operational Control.

CAISO Tariff shall mean the CAISO's tariff, as filed with FERC, and as amended or supplemented from time to time, or any successor tariff.

Large Generating Facility shall mean a Generating Facility having a Generating Facility Capacity of more than 20 MW.

Loss shall mean any and all damages, losses, and claims, including claims and actions relating to injury to or death of any person or damage to property, demand, suits, recoveries, costs and expenses, court costs, attorney fees, and all other obligations by or to third parties.

Material Modification shall mean those modifications that have a material impact on the cost or timing of any Interconnection Request or any other valid interconnection request with a later queue priority date.

Metering Equipment shall mean all metering equipment installed or to be installed for measuring the output of the Generating Facility pursuant to this LGIA at the metering points, including but not limited to instrument transformers, MWh-meters, data acquisition equipment, transducers, remote terminal unit, communications equipment, phone lines, and fiber optics.

NERC shall mean the North American Electric Reliability Council or its successor organization.

Network Upgrades shall be Participating TO's Delivery Network Upgrades and Participating TO's Reliability Network Upgrades.

Operational Control shall mean the rights of the CAISO under the Transmission Control Agreement and the CAISO Tariff to direct the parties to the Transmission Control Agreement how to operate their transmission lines and facilities and other electric plant affecting the reliability of those lines and facilities for the purpose of affording comparable non-discriminatory transmission access and meeting applicable reliability criteria.

Participating TO's Delivery Network Upgrades shall mean the additions, modifications, and upgrades to the Participating TO's Transmission System at or beyond the Point of Interconnection, other than Reliability Network Upgrades, identified in the Interconnection Studies, as identified in Appendix A, to relieve constraints on the CAISO Controlled Grid.

Participating TO's Interconnection Facilities shall mean all facilities and equipment owned, controlled or operated by the Participating TO from the Point of Change of Ownership to the Point of Interconnection as identified in Appendix A to this LGIA, including any modifications, additions or upgrades to such facilities and equipment. Participating TO's Interconnection Facilities are sole use facilities and shall not include Distribution Upgrades, Stand Alone Network Upgrades or Network Upgrades.

Participating TO's Reliability Network Upgrades shall mean the additions, modifications, and upgrades to the Participating TO's Transmission System at or beyond the Point of Interconnection, identified in the Interconnection Studies, as identified in Appendix A, necessary to interconnect the Large Generating Facility safely and reliably to the Participating TO's Transmission System, which would not have been necessary but for the interconnection of the Large Generating Facility, including additions, modifications, and upgrades necessary to remedy short circuit or stability problems resulting from the interconnection of the Large Generating Facility to the Participating TO's Transmission System. Participating TO's Reliability Network Upgrades also include, consistent with Applicable Reliability Council practice, the Participating TO's facilities necessary to mitigate any adverse impact the Large Generating Facility's interconnection may have on a path's Applicable Reliability Council rating.

Participating TO's Transmission System shall mean the facilities owned and operated by the Participating TO and that have been placed under the CAISO's Operational Control, which facilities form part of the CAISO Controlled Grid.

Party or Parties shall mean the Participating TO, CAISO, Interconnection Customer or the applicable combination of the above.

Point of Change of Ownership shall mean the point, as set forth in Appendix A to this LGIA, where the Interconnection Customer's Interconnection Facilities connect to the Participating TO's Interconnection Facilities.

Point of Interconnection shall mean the point, as set forth in Appendix A to this LGIA, where the Interconnection Facilities connect to the Participating TO's Transmission System.

Qualifying Facility shall mean a qualifying cogeneration facility or qualifying small power production facility, as defined in the Code of Federal Regulations, Title 18, Part 292 (18 C.F.R. §292).

QF PGA shall mean a Qualifying Facility Participating Generator Agreement specifying the special provisions for the operating relationship between a Qualifying Facility and the CAISO, a pro forma version of which is set forth in Appendix B.3 of the CAISO Tariff.

Reasonable Efforts shall mean, with respect to an action required to be attempted or taken by a Party under this LGIA, efforts that are timely and consistent with Good Utility Practice and are otherwise substantially equivalent to those a Party would use to protect its own interests.

Scoping Meeting shall mean the meeting among representatives of the Interconnection Customer, the Participating TO(s), other Affected Systems, and the CAISO conducted for the purpose of discussing alternative interconnection options, to exchange information including any transmission data and earlier study evaluations that would be reasonably expected to impact such interconnection options, to analyze such information, and to determine the potential feasible Points of Interconnection.

Stand Alone Network Upgrades shall mean Network Upgrades that the Interconnection Customer may construct without affecting day-to-day operations of the CAISO Controlled Grid or Affected Systems during their construction. The Participating TO, the CAISO, and the Interconnection Customer must agree as to what constitutes Stand Alone Network Upgrades and identify them in Appendix A to this LGIA.

Standard Large Generator Interconnection Procedures (LGIP) shall mean the CAISO protocol that sets forth the interconnection procedures applicable to an Interconnection Request pertaining to a Large Generating Facility that is included in CAISO Tariff Appendix U.

System Protection Facilities shall mean the equipment, including necessary protection signal communications equipment, that protects (1) the Participating TO's Transmission System, Participating TO's Interconnection Facilities, CAISO Controlled Grid, and Affected Systems from faults or other electrical disturbances occurring at the Generating Facility and (2) the Generating Facility from faults or other electrical system disturbances occurring on the CAISO Controlled Grid, Participating TO's Interconnection Facilities, and Affected Systems or on other delivery systems or other generating systems to which the CAISO Controlled Grid is directly connected.

Transmission Control Agreement shall mean CAISO FERC Electric Tariff No. 7.

Trial Operation shall mean the period during which the Interconnection Customer is engaged in on-site test operations and commissioning of an Electric Generating Unit prior to Commercial Operation.

ARTICLE 2. EFFECTIVE DATE, TERM AND TERMINATION

2.1 **Effective Date**. This LGIA shall become effective upon execution by the Parties subject to acceptance by FERC (if applicable), or if filed unexecuted, upon the date specified by FERC. The CAISO and Participating TO shall promptly file this LGIA with FERC upon execution in accordance with Article 3.1, if required.

2.2 **Term of Agreement**. Subject to the provisions of Article 2.3, this LGIA shall remain in effect for a period of ____ years from the Effective Date (Term Specified in Individual Agreements to be ten (10) years or such other longer period as the Interconnection Customer may request) and shall be automatically renewed for each successive one-year period thereafter.

2.3 **Termination Procedures**.

2.3.1 **Written Notice**. This LGIA may be terminated by the Interconnection Customer after giving the CAISO and the Participating TO ninety (90) Calendar Days advance written notice, or by the CAISO and the Participating TO notifying FERC after the Generating Facility permanently ceases Commercial Operation.

2.3.2 **Default**. A Party may terminate this LGIA in accordance with Article 17.

2.3.3 **Suspension of Work**. This LGIA may be deemed terminated in accordance with Article 5.16.

2.3.4 Notwithstanding Articles 2.3.1, 2.3.2, and 2.3.3, no termination shall become effective until the Parties have complied with all Applicable Laws and Regulations applicable to such termination, including the filing with FERC of a notice of termination of this LGIA, which notice has been accepted for filing by FERC.

2.4 **Termination Costs.** If this LGIA terminates pursuant to Article 2.3 above, the Interconnection Customer shall pay all costs incurred or irrevocably committed to be incurred in association with the Interconnection Customer's interconnection (including any cancellation costs relating to orders or contracts for Interconnection Facilities and equipment) and other expenses, including any Network Upgrades and Distribution Upgrades for which the Participating TO or CAISO has incurred expenses or has irrevocably committed to incur expenses and has not been reimbursed by the Interconnection Customer, as of the date of the other Parties' receipt of the notice of termination, subject to the limitations set forth in this Article 2.4. Nothing in this Article 2.4 shall limit the Parties' rights under Article 17.

2.4.1 Notwithstanding the foregoing, in the event of termination by a Party, all Parties shall use commercially Reasonable Efforts to mitigate the costs, damages and charges arising as a consequence of termination. With respect to any portion of the Participating TO's Interconnection Facilities that have not yet been constructed or installed, the Participating TO shall to the extent possible and with the Interconnection Customer's authorization cancel any pending orders of, or return, any materials or equipment for, or contracts for construction of, such facilities; provided that in the event the Interconnection Customer elects not to authorize such cancellation, the Interconnection Customer shall assume all payment obligations with respect to such materials, equipment, and contracts, and the Participating TO shall deliver such material and equipment, and, if necessary, assign such contracts, to the Interconnection Customer as soon as practicable, at the Interconnection Customer's expense. To the extent that the Interconnection Customer has already paid the Participating TO for any or all such costs of materials or equipment not taken by the Interconnection Customer, the Participating TO shall promptly refund such amounts to the Interconnection Customer, less any costs, including penalties, incurred by the Participating TO to cancel any pending orders of or return such materials, equipment, or contracts.

2.4.2 The Participating TO may, at its option, retain any portion of such materials, equipment, or facilities that the Interconnection Customer chooses not to accept delivery of, in which case the Participating TO shall be responsible for all costs associated with procuring such materials, equipment, or facilities.

2.4.3 With respect to any portion of the Interconnection Facilities, and any other facilities already installed or constructed pursuant to the terms of this LGIA, Interconnection Customer shall be responsible for all costs associated with the removal, relocation or other disposition or retirement of such materials, equipment, or facilities.

2.5 **Disconnection**. Upon termination of this LGIA, the Parties will take all appropriate steps to disconnect the Large Generating Facility from the Participating TO's Transmission System. All costs required to effectuate such disconnection shall be borne by the terminating Party, unless such termination resulted from the non-terminating Party's Default of this LGIA or such non-terminating Party otherwise is responsible for these costs under this LGIA.

2.6 **Survival**. This LGIA shall continue in effect after termination to the extent necessary to provide for final billings and payments and for costs incurred hereunder, including billings and payments pursuant to this LGIA; to permit the determination and enforcement of liability and indemnification obligations arising from acts or events that occurred while this LGIA was in effect; and to permit each Party to have access to the lands of the other Parties pursuant to this LGIA or other applicable agreements, to disconnect, remove or salvage its own facilities and equipment.

ARTICLE 3. REGULATORY FILINGS AND CAISO TARIFF COMPLIANCE

3.1 **Filing**. The Participating TO and the CAISO shall file this LGIA (and any amendment hereto) with the appropriate Governmental Authority(ies), if required. The Interconnection Customer may request that any information so provided be subject to the confidentiality provisions of Article 22. If the Interconnection Customer has executed this LGIA, or any amendment thereto, the Interconnection Customer shall reasonably cooperate with the Participating TO and CAISO with respect to such filing and to provide any information reasonably requested by the Participating TO or CAISO needed to comply with applicable regulatory requirements.

3.2 **Agreement Subject to CAISO Tariff**. The Interconnection Customer will comply with all applicable provisions of the CAISO Tariff, including the LGIP.

3.3 **Relationship Between this LGIA and the CAISO Tariff.** With regard to rights and obligations between the Participating TO and the Interconnection Customer, if and to the extent a matter is specifically addressed by a provision of this LGIA (including any appendices, schedules or other attachments to this LGIA), the provisions of this LGIA shall govern. If and to the extent a provision of this LGIA is inconsistent with the CAISO Tariff and dictates rights and obligations between the CAISO and the Participating TO or the CAISO and the Interconnection Customer, the CAISO Tariff shall govern.

3.4 **Relationship Between this LGIA and the QF PGA.** With regard to the rights and obligations of a Qualifying Facility that has entered into a QF PGA with the CAISO and has entered into this LGIA, if and to the extent a matter is specifically addressed by a provision of the QF PGA that is inconsistent with this LGIA, the terms of the QF PGA shall govern.

ARTICLE 4. SCOPE OF SERVICE

4.1 Interconnection Service. Interconnection Service allows the Interconnection Customer to connect the Large Generating Facility to the Participating TO's Transmission System and be eligible to deliver the Large Generating Facility's output using the available capacity of the CAISO Controlled Grid. To the extent the Interconnection Customer wants to receive Interconnection Service, the Participating TO shall construct facilities identified in Appendices A and C that the Participating TO is responsible to construct.

Interconnection Service does not necessarily provide the Interconnection Customer with the capability to physically deliver the output of its Large Generating Facility to any particular load on the CAISO Controlled Grid without incurring congestion costs. In the event of transmission constraints on the CAISO Controlled Grid, the Interconnection Customer's Large Generating Facility shall be subject to the applicable congestion management procedures in the CAISO Tariff in the same manner as all other resources.

4.2 Provision of Service. The Participating TO and the CAISO shall provide Interconnection Service for the Large Generating Facility.

4.3 Performance Standards. Each Party shall perform all of its obligations under this LGIA in accordance with Applicable Laws and Regulations, Applicable Reliability Standards, and Good Utility Practice, and to the extent a Party is required or prevented or limited in taking any action by such regulations and standards, such Party shall not be deemed to be in Breach of this LGIA for its compliance therewith. If such Party is the CAISO or Participating TO, then that Party shall amend the LGIA and submit the amendment to FERC for approval.

4.4 No Transmission Service. The execution of this LGIA does not constitute a request for, nor the provision of, any transmission service under the CAISO Tariff, and does not convey any right to deliver electricity to any specific customer or point of delivery.

4.5 Interconnection Customer Provided Services. The services provided by Interconnection Customer under this LGIA are set forth in Article 9.6 and Article 13.5.1. Interconnection Customer shall be paid for such services in accordance with Article 11.6.

ARTICLE 5. INTERCONNECTION FACILITIES ENGINEERING, PROCUREMENT, AND CONSTRUCTION

Interconnection Facilities, Network Upgrades, and Distribution Upgrades shall be studied, designed, and constructed pursuant to Good Utility Practice. Such studies, design and construction shall be based on the assumed accuracy and completeness of all technical information received by the Participating TO and the CAISO from the Interconnection Customer associated with interconnecting the Large Generating Facility.

5.1 **Options**. Unless otherwise mutually agreed among the Parties, the Interconnection Customer shall select the In-Service Date, Initial Synchronization Date, and Commercial Operation Date; and either Standard Option or Alternate Option set forth below for completion of the Participating TO's Interconnection Facilities and Network Upgrades as set forth in Appendix A, Interconnection Facilities, Network Upgrades, and Distribution Upgrades, and such dates and selected option shall be set forth in Appendix B, Milestones.

5.1.1 **Standard Option**. The Participating TO shall design, procure, and construct the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades, using Reasonable Efforts to complete the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades by the dates set forth in Appendix B, Milestones. The Participating TO shall not be required to undertake any action which is inconsistent with its standard safety practices, its material and equipment specifications, its design criteria and construction procedures, its labor agreements, and Applicable Laws and Regulations. In the event the Participating TO reasonably expects that it will not be able to complete the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades by the specified dates, the Participating TO shall promptly provide written notice to the Interconnection Customer and the CAISO and shall undertake Reasonable Efforts to meet the earliest dates thereafter.

5.1.2 **Alternate Option**. If the dates designated by the Interconnection Customer are acceptable to the Participating TO, the Participating TO shall so notify the Interconnection Customer within thirty (30) Calendar Days, and shall assume responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities by the designated dates.

If the Participating TO subsequently fails to complete the Participating TO's Interconnection Facilities by the In-Service Date, to the extent necessary to provide back feed power; or fails to complete Network Upgrades by the Initial Synchronization Date to the extent necessary to allow for Trial Operation at full power output, unless other arrangements are made by the Parties for such Trial Operation; or fails to complete the Network Upgrades by the Commercial Operation Date, as such dates are reflected in Appendix B, Milestones; the Participating TO shall pay the Interconnection Customer liquidated damages in accordance with Article 5.3, Liquidated Damages, provided, however, the dates designated by the Interconnection Customer shall be extended day for day for each day that the CAISO refuses to grant clearances to install equipment.

5.1.3 **Option to Build**. If the dates designated by the Interconnection Customer are not acceptable to the Participating TO, the Participating TO shall so notify the Interconnection Customer within thirty (30) Calendar Days, and unless the Parties agree otherwise, the Interconnection Customer shall have the option to assume responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades. If the Interconnection Customer elects to exercise its option to assume responsibility for the design, procurement and construction of the Participating TO’s Interconnection Facilities and Stand Alone Network Upgrades, it shall so notify the Participating TO within thirty (30) Calendar Days of receipt of the

Participating TO’s notification that the designated dates are not acceptable to the Participating TO. The Participating TO, CAISO, and Interconnection Customer must agree as to what constitutes Stand Alone Network Upgrades and identify such Stand Alone Network Upgrades in Appendix A to this LGIA. Except for Stand Alone Network Upgrades, the Interconnection Customer shall have no right to construct Network Upgrades under this option.

5.1.4 Negotiated Option. If the Interconnection Customer elects not to exercise its option under Article 5.1.3, Option to Build, the Interconnection Customer shall so notify the Participating TO within thirty (30) Calendar Days of receipt of the Participating TO’s notification that the designated dates are not acceptable to the Participating TO, and the Parties shall in good faith attempt to negotiate terms and conditions (including revision of the specified dates and liquidated damages, the provision of incentives or the procurement and construction of a portion of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades by the Interconnection Customer) pursuant to which the Participating TO is responsible for the design, procurement and construction of the Participating TO's Interconnection Facilities and Network Upgrades. If the Parties are unable to reach agreement on such terms and conditions, the Participating TO shall assume responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities and Network Upgrades pursuant to Article 5.1.1, Standard Option.

5.2 General Conditions Applicable to Option to Build. If the Interconnection Customer assumes responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades,

(1) the Interconnection Customer shall engineer, procure equipment, and construct the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades (or portions thereof) using Good Utility Practice and using standards and specifications provided in advance by the Participating TO;

(2) The Interconnection Customer’s engineering, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades shall comply with all requirements of law to which the Participating TO would be subject in the engineering, procurement or construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades;

(3) the Participating TO shall review, and the Interconnection Customer shall obtain the Participating TO’s approval of, the engineering design, equipment acceptance tests, and the construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades, which approval shall not be unreasonably withheld, and the CAISO may, at its option, review the engineering design, equipment acceptance tests, and the construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades;

(4) prior to commencement of construction, the Interconnection Customer shall provide to the Participating TO, with a copy to the CAISO for informational purposes, a schedule for construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades, and shall promptly respond to requests for information from the Participating TO;

(5) at any time during construction, the Participating TO shall have the right to gain unrestricted access to the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades and to conduct inspections of the same;

(6) at any time during construction, should any phase of the engineering, equipment procurement, or construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades not meet the standards and specifications provided by the Participating TO, the Interconnection Customer shall be obligated to remedy deficiencies in that portion of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades;

(7) the Interconnection Customer shall indemnify the CAISO and Participating TO for claims arising from the Interconnection Customer's construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades under the terms and procedures applicable to Article 18.1 Indemnity;

(8) The Interconnection Customer shall transfer control of the Participating TO's Interconnection Facilities to the Participating TO and shall transfer Operational Control of Stand Alone Network Upgrades to the CAISO;

(9) Unless the Parties otherwise agree, the Interconnection Customer shall transfer ownership of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades to the Participating TO. As soon as reasonably practicable, but within twelve months after completion of the construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades, the Interconnection Customer shall provide an invoice of the final cost of the construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades to the Participating TO, which invoice shall set forth such costs in sufficient detail to enable the Participating TO to reflect the proper costs of such facilities in its transmission rate base and to identify the investment upon which refunds will be provided;

(10) the Participating TO shall accept for operation and maintenance the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades to the extent engineered, procured, and constructed in accordance with this Article 5.2; and

(11) The Interconnection Customer's engineering, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades shall comply with all requirements of the "Option to Build" conditions set forth in Appendix C. Interconnection Customer shall deliver to the Participating TO "as-built" drawings, information, and any other documents that are reasonably required by the Participating TO to assure that the Interconnection Facilities and Stand-Alone Network Upgrades are built to the standards and specifications required by the Participating TO.

5.3 **Liquidated Damages**. The actual damages to the Interconnection Customer, in the event the Participating TO's Interconnection Facilities or Network Upgrades are not completed by the dates designated by the Interconnection Customer and accepted by the Participating TO pursuant to subparagraphs 5.1.2 or 5.1.4, above, may include Interconnection Customer's fixed operation and maintenance costs and lost opportunity costs. Such actual damages are uncertain and impossible to determine at this time. Because of such uncertainty, any liquidated damages paid by the Participating TO to the Interconnection Customer in the event that the Participating TO does not complete any portion of the Participating TO's Interconnection Facilities or Network Upgrades by the applicable dates, shall be an amount equal to ½ of 1 percent per day of the actual cost of the Participating TO's Interconnection Facilities and Network Upgrades, in the aggregate, for which the Participating TO has assumed responsibility to design, procure and construct.

However, in no event shall the total liquidated damages exceed 20 percent of the actual cost of the Participating TO's Interconnection Facilities and Network Upgrades for which the Participating TO has assumed responsibility to design, procure, and construct. The foregoing payments will be made by the Participating TO to the Interconnection Customer as just compensation for the damages caused to the Interconnection Customer, which actual damages are uncertain and impossible to determine at this time, and as reasonable liquidated damages, but not as a penalty or a method to secure performance of this LGIA. Liquidated damages, when the Parties agree to them, are the exclusive remedy for the Participating TO's failure to meet its schedule.

No liquidated damages shall be paid to the Interconnection Customer if: (1) the Interconnection Customer is not ready to commence use of the Participating TO's Interconnection Facilities or Network Upgrades to take the delivery of power for the Electric Generating Unit's Trial Operation or to export power from the Electric Generating Unit on the specified dates, unless the Interconnection Customer would have been able to commence use of the Participating TO's Interconnection Facilities or Network Upgrades to take the delivery of power for Electric Generating Unit's Trial Operation or to export power from the Electric Generating Unit, but for the Participating TO's delay; (2) the Participating TO's failure to meet the specified dates is the result of the action or inaction of the Interconnection Customer or any other interconnection customer who has entered into an interconnection agreement with the CAISO and/or Participating TO, action or inaction by the CAISO, or any cause beyond the Participating TO's reasonable control or reasonable ability to cure; (3) the Interconnection Customer has assumed responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades; or (4) the Parties have otherwise agreed.

In no event shall the CAISO have any responsibility or liability to the Interconnection Customer for liquidated damages pursuant to the provisions of this Article 5.3.

5.4 **Power System Stabilizers**. The Interconnection Customer shall procure, install, maintain and operate Power System Stabilizers in accordance with the guidelines and procedures established by the Applicable Reliability Council and in accordance with the provisions of Section 4.6.5.1 of the CAISO Tariff. The CAISO reserves the right to establish reasonable minimum acceptable settings for any installed Power System Stabilizers, subject to the design and operating limitations of the Large Generating Facility. If the Large Generating Facility's Power System Stabilizers are removed from service or not capable of automatic operation, the Interconnection Customer shall immediately notify the CAISO and the Participating TO and restore the Power System Stabilizers to operation as soon as possible and in accordance with the Reliability Management System Agreement in Appendix G. The CAISO shall have the right to order the reduction in output or disconnection of the Large Generating Facility if the reliability of the CAISO Controlled Grid would be adversely affected as a result of improperly tuned Power System Stabilizers. The requirements of this Article 5.4 shall apply to Asynchronous Generating Facilities in accordance with Appendix H.

5.5 **Equipment Procurement**. If responsibility for construction of the Participating TO's Interconnection Facilities or Network Upgrades is to be borne by the Participating TO, then the Participating TO shall commence design of the Participating TO's Interconnection Facilities or Network Upgrades and procure necessary equipment as soon as practicable after all of the following conditions are satisfied, unless the Parties otherwise agree in writing:

5.5.1 The CAISO, in coordination with the applicable Participating TO(s), has completed the Interconnection Facilities Study pursuant to the Interconnection Facilities Study Agreement;

5.5.2 The Participating TO has received written authorization to proceed with design and procurement from the Interconnection Customer by the date specified in Appendix B, Milestones; and

5.5.3 The Interconnection Customer has provided security to the Participating TO in accordance with Article 11.5 by the dates specified in Appendix B, Milestones.

5.6 Construction Commencement. The Participating TO shall commence construction of the Participating TO's Interconnection Facilities and Network Upgrades for which it is responsible as soon as practicable after the following additional conditions are satisfied:

5.6.1 Approval of the appropriate Governmental Authority has been obtained for any facilities requiring regulatory approval;

5.6.2 Necessary real property rights and rights-of-way have been obtained, to the extent required for the construction of a discrete aspect of the Participating TO's Interconnection Facilities and Network Upgrades;

5.6.3 The Participating TO has received written authorization to proceed with construction from the Interconnection Customer by the date specified in Appendix B, Milestones; and

5.6.4 The Interconnection Customer has provided payment and security to the Participating TO in accordance with Article 11.5 by the dates specified in Appendix B, Milestones.

5.7 Work Progress. The Parties will keep each other advised periodically as to the progress of their respective design, procurement and construction efforts. Any Party may, at any time, request a progress report from another Party. If, at any time, the Interconnection Customer determines that the completion of the Participating TO's Interconnection Facilities will not be required until after the specified In-Service Date, the Interconnection Customer will provide written notice to the Participating TO and CAISO of such later date upon which the completion of the Participating TO's Interconnection Facilities will be required.

5.8 Information Exchange. As soon as reasonably practicable after the Effective Date, the Parties shall exchange information regarding the design and compatibility of the Interconnection Customer's Interconnection Facilities and Participating TO's Interconnection Facilities and compatibility of the Interconnection Facilities with the Participating TO's Transmission System, and shall work diligently and in good faith to make any necessary design changes.

5.9 Limited Operation. If any of the Participating TO's Interconnection Facilities or Network Upgrades are not reasonably expected to be completed prior to the Commercial Operation Date of the Electric Generating Unit, the Participating TO and/or CAISO, as applicable, shall, upon the request and at the expense of the Interconnection Customer, perform operating studies on a timely basis to determine the extent to which the Electric Generating Unit and the Interconnection Customer's Interconnection Facilities may operate prior to the completion of the Participating TO's Interconnection Facilities or Network Upgrades consistent with Applicable Laws and Regulations, Applicable Reliability Standards, Good Utility Practice, and this LGIA. The Participating TO and CAISO shall permit Interconnection Customer to operate the Electric Generating Unit and the Interconnection Customer's Interconnection Facilities in accordance with the results of such studies.

5.10 Interconnection Customer's Interconnection Facilities. The Interconnection Customer shall, at its expense, design, procure, construct, own and install the Interconnection Customer's Interconnection Facilities, as set forth in Appendix A.

5.10.1 Large Generating Facility and Interconnection Customer's Interconnection Facilities Specifications. The Interconnection Customer shall submit initial specifications for the Interconnection Customer's Interconnection Facilities and Large Generating Facility, including System Protection Facilities, to the Participating TO and the CAISO at least one hundred eighty (180) Calendar Days prior to the Initial Synchronization Date; and final specifications for review and comment at least ninety (90) Calendar Days prior to the Initial Synchronization Date. The Participating TO and the CAISO shall review such specifications pursuant to this LGIA and the LGIP to ensure that the Interconnection Customer's Interconnection Facilities and Large Generating Facility are compatible with the technical specifications, operational control, safety requirements, and any other applicable requirements of the Participating TO and the CAISO and comment on such specifications within thirty (30) Calendar Days of the Interconnection Customer's submission. All specifications provided hereunder shall be deemed confidential.

5.10.2 Participating TO's and CAISO's Review. The Participating TO's and the CAISO's review of the Interconnection Customer's final specifications shall not be construed as confirming, endorsing, or providing a warranty as to the design, fitness, safety, durability or reliability of the Large Generating Facility, or the Interconnection Customer's Interconnection Facilities. Interconnection Customer shall make such changes to the Interconnection Customer's Interconnection Facilities as may reasonably be required by the Participating TO or the CAISO, in accordance with Good Utility Practice, to ensure that the Interconnection Customer's Interconnection Facilities are compatible with the technical specifications, Operational Control, and safety requirements of the Participating TO or the CAISO.

5.10.3 Interconnection Customer's Interconnection Facilities Construction. The Interconnection Customer's Interconnection Facilities shall be designed and constructed in accordance with Good Utility Practice. Within one hundred twenty (120) Calendar Days after the Commercial Operation Date, unless the Participating TO and Interconnection Customer agree on another mutually acceptable deadline, the Interconnection Customer shall deliver to the Participating TO and CAISO "as-built" drawings, information and documents for the Interconnection Customer's Interconnection Facilities and the Electric Generating Unit(s), such as: a one-line diagram, a site plan showing the Large Generating Facility and the Interconnection Customer's Interconnection Facilities, plan and elevation drawings showing the layout of the Interconnection Customer's Interconnection Facilities, a relay functional diagram, relaying AC and DC schematic wiring diagrams and relay settings for all facilities associated with the Interconnection Customer's step-up transformers, the facilities connecting the Large Generating Facility to the step-up transformers and the Interconnection Customer's Interconnection Facilities, and the impedances (determined by factory tests) for the associated step-up transformers and the Electric Generating Units. The Interconnection Customer shall provide the Participating TO and the CAISO specifications for the excitation system, automatic voltage regulator, Large Generating Facility control and protection settings, transformer tap settings, and communications, if applicable. Any deviations from the relay settings, machine specifications, and other specifications originally submitted by the Interconnection Customer shall be assessed by the Participating TO and the CAISO pursuant to the appropriate provisions of this LGIA and the LGIP.

5.10.4 Interconnection Customer to Meet Requirements of the Participating TO's Interconnection Handbook. The Interconnection Customer shall comply with the Participating TO's Interconnection Handbook.

5.11 Participating TO's Interconnection Facilities Construction. The Participating TO's Interconnection Facilities shall be designed and constructed in accordance with Good Utility Practice. Upon request, within one hundred twenty (120) Calendar Days after the Commercial Operation Date, unless the Participating TO and Interconnection Customer agree on another mutually acceptable deadline, the Participating TO shall deliver to the Interconnection Customer and the CAISO the following "as-built" drawings, information and documents for the Participating TO's Interconnection Facilities [include appropriate drawings and relay diagrams].

The Participating TO will obtain control for operating and maintenance purposes of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades upon completion of such facilities. Pursuant to Article 5.2, the CAISO will obtain Operational Control of the Stand Alone Network Upgrades prior to the Commercial Operation Date.

5.12 Access Rights. Upon reasonable notice and supervision by a Party, and subject to any required or necessary regulatory approvals, a Party ("Granting Party") shall furnish at no cost to the other Party ("Access Party") any rights of use, licenses, rights of way and easements with respect to lands owned or controlled by the Granting Party, its agents (if allowed under the applicable agency agreement), or any Affiliate, that are necessary to enable the Access Party to obtain ingress and egress to construct, operate, maintain, repair, test (or witness testing), inspect, replace or remove facilities and equipment to: (i) interconnect the Large Generating Facility with the Participating TO's Transmission System; (ii) operate and maintain the Large Generating Facility, the Interconnection Facilities and the Participating TO's Transmission System; and (iii) disconnect or remove the Access Party's facilities and equipment upon termination of this LGIA. In exercising such licenses, rights of way and easements, the Access Party shall not unreasonably disrupt or interfere with normal operation of the Granting Party's business and shall adhere to the safety rules and procedures established in advance, as may be changed from time to time, by the Granting Party and provided to the Access Party.

5.13 Lands of Other Property Owners. If any part of the Participating TO's Interconnection Facilities and/or Network Upgrades are to be installed on property owned by persons other than the Interconnection Customer or Participating TO, the Participating TO shall at the Interconnection Customer's expense use efforts, similar in nature and extent to those that it typically undertakes on its own behalf or on behalf of its Affiliates, including use of its eminent domain authority, and to the extent consistent with state law, to procure from such persons any rights of use, licenses, rights of way and easements that are necessary to construct, operate, maintain, test, inspect, replace or remove the Participating TO's Interconnection Facilities and/or Network Upgrades upon such property.

5.14 Permits. Participating TO and Interconnection Customer shall cooperate with each other in good faith in obtaining all permits, licenses and authorization that are necessary to accomplish the interconnection in compliance with Applicable Laws and Regulations. With respect to this paragraph, the Participating TO shall provide permitting assistance to the Interconnection Customer comparable to that provided to the Participating TO's own, or an Affiliate's generation.

5.15 Early Construction of Base Case Facilities. The Interconnection Customer may request the Participating TO to construct, and the Participating TO shall construct, using Reasonable Efforts to accommodate Interconnection Customer's In-Service Date, all or any portion of any Network Upgrades required for Interconnection Customer to be interconnected to the Participating TO's Transmission System which are included in the Base Case of the Interconnection Studies for the Interconnection Customer, and which also are required to be constructed for another interconnection customer, but where such construction is not scheduled to be completed in time to achieve Interconnection Customer's In-Service Date.

5.16 Suspension. The Interconnection Customer reserves the right, upon written notice to the Participating TO and the CAISO, to suspend at any time all work associated with the construction and installation of the Participating TO's Interconnection Facilities, Network Upgrades, and/or Distribution Upgrades required under this LGIA with the condition that the Participating TO's electrical system and the CAISO Controlled Grid shall be left in a safe and reliable condition in accordance with Good Utility Practice and the Participating TO's safety and reliability criteria and the CAISO's Applicable Reliability Standards. In such event, the Interconnection Customer shall be responsible for all reasonable and necessary costs which the Participating TO (i) has incurred pursuant to this LGIA prior to the suspension and (ii) incurs in suspending such work, including any costs incurred to perform such work as may be necessary to ensure the safety of persons and property and the integrity of the Participating TO's electric system during such suspension and, if applicable, any costs incurred in connection with the cancellation or suspension of material, equipment and labor contracts which the Participating TO cannot reasonably avoid;

provided, however, that prior to canceling or suspending any such material, equipment or labor contract, the Participating TO shall obtain Interconnection Customer's authorization to do so. The Participating TO shall invoice the Interconnection Customer for such costs pursuant to Article 12 and shall use due diligence to minimize its costs. In the event Interconnection Customer suspends work required under this LGIA pursuant to this Article 5.16, and has not requested the Participating TO to recommence the work or has not itself recommenced work required under this LGIA on or before the expiration of three (3) years following commencement of such suspension, this LGIA shall be deemed terminated. The three-year period shall begin on the date the suspension is requested, or the date of the written notice to the Participating TO and the CAISO, if no effective date is specified.

5.17 Taxes.

5.17.1 Interconnection Customer Payments Not Taxable. The Parties intend that all payments or property transfers made by the Interconnection Customer to the Participating TO for the installation of the Participating TO's Interconnection Facilities and the Network Upgrades shall be non-taxable, either as contributions to capital, or as a refundable advance, in accordance with the Internal Revenue Code and any applicable state income tax laws and shall not be taxable as contributions in aid of construction or otherwise under the Internal Revenue Code and any applicable state income tax laws.

5.17.2 Representations And Covenants. In accordance with IRS Notice 2001-82 and IRS Notice 88-129, the Interconnection Customer represents and covenants that (i) ownership of the electricity generated at the Large Generating Facility will pass to another party prior to the transmission of the electricity on the CAISO Controlled Grid, (ii) for income tax purposes, the amount of any payments and the cost of any property transferred to the Participating TO for the Participating TO's Interconnection Facilities will be capitalized by the Interconnection Customer as an intangible asset and recovered using the straight-line method over a useful life of twenty (20) years, and (iii) any portion of the Participating TO's Interconnection Facilities that is a "dual-use intertie," within the meaning of IRS Notice 88-129, is reasonably expected to carry only a de minimis amount of electricity in the direction of the Large Generating Facility. For this purpose, "de minimis amount" means no more than 5 percent of the total power flows in both directions, calculated in accordance with the "5 percent test" set forth in IRS Notice 88-129. This is not intended to be an exclusive list of the relevant conditions that must be met to conform to IRS requirements for non-taxable treatment.

At the Participating TO's request, the Interconnection Customer shall provide the Participating TO with a report from an independent engineer confirming its representation in clause (iii), above. The Participating TO represents and covenants that the cost of the Participating TO's Interconnection Facilities paid for by the Interconnection Customer without the possibility of refund or credit will have no net effect on the base upon which rates are determined.

5.17.3 Indemnification for the Cost Consequence of Current Tax Liability Imposed Upon the Participating TO. Notwithstanding Article 5.17.1, the Interconnection Customer shall protect, indemnify and hold harmless the Participating TO from the cost consequences of any current tax liability imposed against the Participating TO as the result of payments or property transfers made by the Interconnection Customer to the Participating TO under this LGIA for Interconnection Facilities, as well as any interest and penalties, other than interest and penalties attributable to any delay caused by the Participating TO.

The Participating TO shall not include a gross-up for the cost consequences of any current tax liability in the amounts it charges the Interconnection Customer under this LGIA unless (i) the Participating TO has determined, in good faith, that the payments or property transfers made by the Interconnection Customer to the Participating TO should be reported as income subject to taxation or (ii) any Governmental Authority directs the Participating TO to report payments or property as income subject to taxation; provided, however, that the Participating TO may require the Interconnection Customer to provide security for Interconnection Facilities, in a form reasonably acceptable to the Participating TO (such as a parental guarantee or a letter of credit), in an amount equal to the cost consequences of any current tax liability under this Article 5.17. The Interconnection Customer shall reimburse the Participating TO for such costs on a fully grossed-up basis, in accordance with Article 5.17.4, within thirty (30) Calendar Days of receiving written notification from the Participating TO of the amount due, including detail about how the amount was calculated.

The indemnification obligation shall terminate at the earlier of (1) the expiration of the ten year testing period and the applicable statute of limitation, as it may be extended by the Participating TO upon request of the IRS, to keep these years open for audit or adjustment, or (2) the occurrence of a subsequent taxable event and the payment of any related indemnification obligations as contemplated by this Article 5.17.

5.17.4 Tax Gross-Up Amount. The Interconnection Customer's liability for the cost consequences of any current tax liability under this Article 5.17 shall be calculated on a fully grossed-up basis. Except as may otherwise be agreed to by the parties, this means that the Interconnection Customer will pay the Participating TO, in addition to the amount paid for the Interconnection Facilities and Network Upgrades, an amount equal to (1) the current taxes imposed on the Participating TO (“Current Taxes”) on the excess of (a) the gross income realized by the Participating TO as a result of payments or property transfers made by the Interconnection Customer to the Participating TO under this LGIA (without regard to any payments under this Article 5.17) (the “Gross Income Amount”) over (b) the present value of future tax deductions for depreciation that will be available as a result of such payments or property transfers (the “Present Value Depreciation Amount”), plus (2) an additional amount sufficient to permit the Participating TO to receive and retain, after the payment of all Current Taxes, an amount equal to the net amount described in clause (1).

For this purpose, (i) Current Taxes shall be computed based on the Participating TO’s composite federal and state tax rates at the time the payments or property transfers are received and the Participating TO will be treated as being subject to tax at the highest marginal rates in effect at that time (the “Current Tax Rate”), and (ii) the Present Value Depreciation Amount shall be computed by discounting the Participating TO’s anticipated tax depreciation deductions as a result of such payments or property transfers by the Participating TO’s current weighted average cost of capital. Thus, the formula for calculating the Interconnection Customer's liability to the Participating TO pursuant to this Article 5.17.4 can be expressed as follows: (Current Tax Rate x (Gross Income Amount – Present Value of Tax Depreciation))/(1-Current Tax Rate). Interconnection Customer's estimated tax liability in the event taxes are imposed shall be stated in Appendix A, Interconnection Facilities, Network Upgrades and Distribution Upgrades.

5.17.5 Private Letter Ruling or Change or Clarification of Law. At the Interconnection Customer's request and expense, the Participating TO shall file with the IRS a request for a private letter ruling as to whether any property transferred or sums paid, or to be paid, by the Interconnection Customer to the Participating TO under this LGIA are subject to federal income taxation. The Interconnection Customer will prepare the initial draft of the request for a private letter ruling, and will certify under penalties of perjury that all facts represented in such request are true and accurate to the best of the Interconnection Customer's knowledge. The Participating TO and Interconnection Customer shall cooperate in good faith with respect to the submission of such request, provided, however, the Interconnection Customer and the Participating TO explicitly acknowledge (and nothing herein is intended to alter) Participating TO's obligation under law to certify that the facts presented in the ruling request are true, correct and complete.

The Participating TO shall keep the Interconnection Customer fully informed of the status of such request for a private letter ruling and shall execute either a privacy act waiver or a limited power of attorney, in a form acceptable to the IRS, that authorizes the Interconnection Customer to participate in all discussions with the IRS regarding such request for a private letter ruling. The Participating TO shall allow the Interconnection Customer to attend all meetings with IRS officials about the request and shall permit the Interconnection Customer to prepare the initial drafts of any follow-up letters in connection with the request.

5.17.6 Subsequent Taxable Events. If, within 10 years from the date on which the relevant Participating TO's Interconnection Facilities are placed in service, (i) the Interconnection Customer Breaches the covenants contained in Article 5.17.2, (ii) a "disqualification event" occurs within the meaning of IRS Notice 88-129, or (iii) this LGIA terminates and the Participating TO retains ownership of the Interconnection Facilities and Network Upgrades, the Interconnection Customer shall pay a tax gross-up for the cost consequences of any current tax liability imposed on the Participating TO, calculated using the methodology described in Article 5.17.4 and in accordance with IRS Notice 90-60.

5.17.7 Contests. In the event any Governmental Authority determines that the Participating TO's receipt of payments or property constitutes income that is subject to taxation, the Participating TO shall notify the Interconnection Customer, in writing, within thirty (30) Calendar Days of receiving notification of such determination by a Governmental Authority. Upon the timely written request by the Interconnection Customer and at the Interconnection Customer's sole expense, the Participating TO may appeal, protest, seek abatement of, or otherwise oppose such determination. Upon the Interconnection Customer's written request and sole expense, the Participating TO may file a claim for refund with respect to any taxes paid under this Article 5.17, whether or not it has received such a determination. The Participating TO reserve the right to make all decisions with regard to the prosecution of such appeal, protest, abatement or other contest, including the selection of counsel and compromise or settlement of the claim, but the Participating TO shall keep the Interconnection Customer informed, shall consider in good faith suggestions from the Interconnection Customer about the conduct of the contest, and shall reasonably permit the Interconnection Customer or an Interconnection Customer representative to attend contest proceedings.

The Interconnection Customer shall pay to the Participating TO on a periodic basis, as invoiced by the Participating TO, the Participating TO's documented reasonable costs of prosecuting such appeal, protest, abatement or other contest, including any costs associated with obtaining the opinion of independent tax counsel described in this Article 5.17.7. The Participating TO may abandon any contest if the Interconnection Customer fails to provide payment to the Participating TO within thirty (30) Calendar Days of receiving such invoice.

At any time during the contest, the Participating TO may agree to a settlement either with the Interconnection Customer's consent or, if such consent is refused, after obtaining written advice from independent nationally-recognized tax counsel, selected by the Participating TO, but reasonably acceptable to the Interconnection Customer, that the proposed settlement represents a reasonable settlement given the hazards of litigation. The Interconnection Customer's obligation shall be based on the amount of the settlement agreed to by the Interconnection Customer, or if a higher amount, so much of the settlement that is supported by the written advice from nationally-recognized tax counsel selected under the terms of the preceding paragraph. The settlement amount shall be calculated on a fully grossed-up basis to cover any related cost consequences of the current tax liability. The Participating TO may also settle any tax controversy without receiving the Interconnection Customer's consent or any such written advice; however, any such settlement will relieve the Interconnection Customer from any obligation to indemnify the Participating TO for the tax at issue in the contest (unless the failure to obtain written advice is attributable to the Interconnection Customer's unreasonable refusal to the appointment of independent tax counsel).

5.17.8 Refund. In the event that (a) a private letter ruling is issued to the Participating TO which holds that any amount paid or the value of any property transferred by the Interconnection Customer to the Participating TO under the terms of this LGIA is not subject to federal income taxation, (b) any legislative change or administrative announcement, notice, ruling or other determination makes it reasonably clear to the Participating TO in good faith that any amount paid or the value of any property transferred by the Interconnection Customer to the Participating TO under the terms of this LGIA is not taxable to the Participating TO, (c) any abatement, appeal, protest, or other contest results in a determination that any payments or transfers made by the Interconnection Customer to the Participating TO are not subject to federal income tax, or (d) if the Participating TO receives a refund from any taxing authority for any overpayment of tax attributable to any payment or property transfer made by the Interconnection Customer to the Participating TO pursuant to this LGIA, the Participating TO shall promptly refund to the Interconnection Customer the following:

(i) any payment made by Interconnection Customer under this Article 5.17 for taxes that is attributable to the amount determined to be non-taxable, together with interest thereon,

(ii) interest on any amounts paid by the Interconnection Customer to the Participating TO for such taxes which the Participating TO did not submit to the taxing authority, calculated in accordance with the methodology set forth in FERC's regulations at 18 C.F.R. §35.19a(a)(2)(iii) from the date payment was made by the Interconnection Customer to the date the Participating TO refunds such payment to the Interconnection Customer, and

(iii) with respect to any such taxes paid by the Participating TO, any refund or credit the Participating TO receives or to which it may be entitled from any Governmental Authority, interest (or that portion thereof attributable to the payment described in clause (i), above) owed to the Participating TO for such overpayment of taxes (including any reduction in interest otherwise payable by the Participating TO to any Governmental Authority resulting from an offset or credit); provided, however, that the Participating TO will remit such amount promptly to the Interconnection Customer only after and to the extent that the Participating TO has received a tax refund, credit or offset from any Governmental Authority for any applicable overpayment of income tax related to the Participating TO's Interconnection Facilities.

The intent of this provision is to leave the Parties, to the extent practicable, in the event that no taxes are due with respect to any payment for Interconnection Facilities and Network Upgrades hereunder, in the same position they would have been in had no such tax payments been made.

5.17.9 Taxes Other Than Income Taxes. Upon the timely request by the Interconnection Customer, and at the Interconnection Customer's sole expense, the CAISO or Participating TO may appeal, protest, seek abatement of, or otherwise contest any tax (other than federal or state income tax) asserted or assessed against the CAISO or Participating TO for which the Interconnection Customer may be required to reimburse the CAISO or Participating TO under the terms of this LGIA. The Interconnection Customer shall pay to the Participating TO on a periodic basis, as invoiced by the Participating TO, the Participating TO's documented reasonable costs of prosecuting such appeal, protest, abatement, or other contest. The Interconnection Customer, the CAISO, and the Participating TO shall cooperate in good faith with respect to any such contest. Unless the payment of such taxes is a prerequisite to an appeal or abatement or cannot be deferred, no amount shall be payable by the Interconnection Customer to the CAISO or Participating TO for such taxes until they are assessed by a final, non-appealable order by any court or agency of competent jurisdiction. In the event that a tax payment is withheld and ultimately due and payable after appeal, the Interconnection Customer will be responsible for all taxes, interest and penalties, other than penalties attributable to any delay caused by the Participating TO.

5.18 Tax Status. Each Party shall cooperate with the others to maintain the other Parties' tax status. Nothing in this LGIA is intended to adversely affect the CAISO's or any Participating TO's tax exempt status with respect to the issuance of bonds including, but not limited to, Local Furnishing Bonds.

5.19 Modification.

5.19.1 General. The Interconnection Customer or the Participating TO may undertake modifications to its facilities, subject to the provisions of this LGIA and the CAISO Tariff. If a Party plans to undertake a modification that reasonably may be expected to affect the other Parties' facilities, that Party shall provide to the other Parties sufficient information regarding such modification so that the other Parties may evaluate the potential impact of such modification prior to commencement of the work. Such information shall be deemed to be confidential hereunder and shall include information concerning the timing of such modifications and whether such modifications are expected to interrupt the flow of electricity from the Large Generating Facility. The Party desiring to perform such work shall provide the relevant drawings, plans, and specifications to the other Parties at least ninety (90) Calendar Days in advance of the commencement of the work or such shorter period upon which the Parties may agree, which agreement shall not unreasonably be withheld, conditioned or delayed.

In the case of Large Generating Facility modifications that do not require the Interconnection Customer to submit an Interconnection Request, the CAISO or Participating TO shall provide, within thirty (30) Calendar Days (or such other time as the Parties may agree), an estimate of any additional modifications to the CAISO Controlled Grid, Participating TO's Interconnection Facilities, Network Upgrades or Distribution Upgrades necessitated by such Interconnection Customer modification and a good faith estimate of the costs thereof. The Participating TO and the CAISO shall determine if a Large Generating Facility modification is a Material Modification in accordance with the LGIP.

5.19.2 Standards. Any additions, modifications, or replacements made to a Party's facilities shall be designed, constructed and operated in accordance with this LGIA and Good Utility Practice.

5.19.3 Modification Costs. The Interconnection Customer shall not be directly assigned the costs of any additions, modifications, or replacements that the Participating TO makes to the Participating TO's Interconnection Facilities or the Participating TO's Transmission System to facilitate the interconnection of a third party to the Participating TO's Interconnection Facilities or the Participating TO's Transmission System, or to provide transmission service to a third party under the CAISO Tariff. The Interconnection Customer shall be responsible for the costs of any additions, modifications, or replacements to the Interconnection Facilities that may be necessary to maintain or upgrade such Interconnection Facilities consistent with Applicable Laws and Regulations, Applicable Reliability Standards or Good Utility Practice.

ARTICLE 6. TESTING AND INSPECTION

6.1 Pre-Commercial Operation Date Testing and Modifications. Prior to the Commercial Operation Date, the Participating TO shall test the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades and the Interconnection Customer shall test the Large Generating Facility and the Interconnection Customer's Interconnection Facilities to ensure their safe and reliable operation. Similar testing may be required after initial operation. Each Party shall make any modifications to its facilities that are found to be necessary as a result of such testing. The Interconnection Customer shall bear the cost of all such testing and modifications. The Interconnection Customer shall not commence initial parallel operation of an Electric Generating Unit with the Participating TO's Transmission System until the Participating TO provides prior written approval, which approval shall not be unreasonably withheld, for operation of such Electric Generating Unit. The Interconnection Customer shall generate test energy at the Large Generating Facility only if it has arranged for the delivery of such test energy.

6.2 Post-Commercial Operation Date Testing and Modifications. Each Party shall at its own expense perform routine inspection and testing of its facilities and equipment in accordance with Good Utility Practice as may be necessary to ensure the continued interconnection of the Large Generating Facility with the Participating TO's Transmission System in a safe and reliable manner. Each Party shall have the right, upon advance written notice, to require reasonable additional testing of the other Party's facilities, at the requesting Party's expense, as may be in accordance with Good Utility Practice.

6.3 Right to Observe Testing. Each Party shall notify the other Parties at least fourteen (14) days in advance of its performance of tests of its Interconnection Facilities or Generating Facility. The other Parties have the right, at their own expense, to observe such testing.

6.4 Right to Inspect. Each Party shall have the right, but shall have no obligation to: (i) observe another Party's tests and/or inspection of any of its System Protection Facilities and other protective equipment, including Power System Stabilizers; (ii) review the settings of another Party's System Protection Facilities and other protective equipment; and (iii) review another Party's maintenance records relative to the Interconnection Facilities, the System Protection Facilities and other protective equipment. A Party may exercise these rights from time to time as it deems necessary upon reasonable notice to the other Party. The exercise or non-exercise by a Party of any such rights shall not be construed as an endorsement or confirmation of any element or condition of the Interconnection Facilities or the System Protection Facilities or other protective equipment or the operation thereof, or as a warranty as to the fitness, safety, desirability, or reliability of same. Any information that a Party obtains through the exercise of any of its rights under this Article 6.4 shall be deemed to be Confidential Information and treated pursuant to Article 22 of this LGIA.

ARTICLE 7. METERING

7.1 **General.** Each Party shall comply with the Applicable Reliability Council requirements. The Interconnection Customer and CAISO shall comply with the provisions of the CAISO Tariff regarding metering, including Section 10 of the CAISO Tariff. Unless otherwise agreed by the Participating TO and the Interconnection Customer, the Participating TO may install additional Metering Equipment at the Point of Interconnection prior to any operation of any Electric Generating Unit and shall own, operate, test and maintain such Metering Equipment. Power flows to and from the Large Generating Facility shall be measured at or, at the CAISO's or Participating TO's option for its respective Metering Equipment, compensated to, the Point of Interconnection. The CAISO shall provide metering quantities to the Interconnection Customer upon request in accordance with the CAISO Tariff by directly polling the CAISO's meter data acquisition system. The Interconnection Customer shall bear all reasonable documented costs associated with the purchase, installation, operation, testing and maintenance of the Metering Equipment.

7.2 **Check Meters**. The Interconnection Customer, at its option and expense, may install and operate, on its premises and on its side of the Point of Interconnection, one or more check meters to check the CAISO-polled meters or the Participating TO's meters. Such check meters shall be for check purposes only and shall not be used for the measurement of power flows for purposes of this LGIA, except in the case that no other means are available on a temporary basis at the option of the CAISO or the Participating TO. The check meters shall be subject at all reasonable times to inspection and examination by the CAISO or Participating TO or their designees. The installation, operation and maintenance thereof shall be performed entirely by the Interconnection Customer in accordance with Good Utility Practice.

7.3 **Participating TO Retail Metering**. The Participating TO may install retail revenue quality meters and associated equipment, pursuant to the Participating TO's applicable retail tariffs.

ARTICLE 8. COMMUNICATIONS

8.1 Interconnection Customer Obligations. The Interconnection Customer shall maintain satisfactory operating communications with the CAISO in accordance with the provisions of the CAISO Tariff and with the Participating TO’s dispatcher or representative designated by the Participating TO. The Interconnection Customer shall provide standard voice line, dedicated voice line and facsimile communications at its Large Generating Facility control room or central dispatch facility through use of either the public telephone system, or a voice communications system that does not rely on the public telephone system. The Interconnection Customer shall also provide the dedicated data circuit(s) necessary to provide Interconnection Customer data to the CAISO and Participating TO as set forth in Appendix D, Security Arrangements Details. The data circuit(s) shall extend from the Large Generating Facility to the location(s) specified by the CAISO and Participating TO. Any required maintenance of such communications equipment shall be performed by the Interconnection Customer. Operational communications shall be activated and maintained under, but not be limited to, the following events: system paralleling or separation, scheduled and unscheduled shutdowns, equipment clearances, and hourly and daily load data.

8.2 Remote Terminal Unit. Prior to the Initial Synchronization Date of each Electric Generating Unit, a Remote Terminal Unit, or equivalent data collection and transfer equipment acceptable to the Parties, shall be installed by the Interconnection Customer, or by the Participating TO at the Interconnection Customer's expense, to gather accumulated and instantaneous data to be telemetered to the location(s) designated by the CAISO and by the Participating TO through use of a dedicated point-to-point data circuit(s) as indicated in Article 8.1.

Telemetry to the CAISO shall be provided in accordance with the CAISO’s technical standards for direct telemetry. For telemetry to the Participating TO, the communication protocol for the data circuit(s) shall be specified by the Participating TO. Instantaneous bi-directional real power and reactive power flow and any other required information must be telemetered directly to the location(s) specified by the Participating TO.

Each Party will promptly advise the other Parties if it detects or otherwise learns of any metering, telemetry or communications equipment errors or malfunctions that require the attention and/or correction by another Party. The Party owning such equipment shall correct such error or malfunction as soon as reasonably feasible.

8.3 No Annexation. Any and all equipment placed on the premises of a Party shall be and remain the property of the Party providing such equipment regardless of the mode and manner of annexation or attachment to real property, unless otherwise mutually agreed by the Parties.

ARTICLE 9. OPERATIONS

9.1 General. Each Party shall comply with the Applicable Reliability Council requirements, and the Interconnection Customer shall execute the Reliability Management System Agreement of the Applicable Reliability Council attached hereto as Appendix G. Each Party shall provide to the other Party all information that may reasonably be required by the other Party to comply with Applicable Laws and Regulations and Applicable Reliability Standards.

9.2 Balancing Authority Area Notification. At least three months before Initial Synchronization Date, the Interconnection Customer shall notify the CAISO and Participating TO in writing of the Balancing Authority Area in which the Large Generating Facility intends to be located. If the Interconnection Customer intends to locate the Large Generating Facility in a Balancing Authority Area other than the Balancing Authority Area within whose electrically metered boundaries the Large Generating Facility is located, and if permitted to do so by the relevant transmission tariffs, all necessary arrangements, including but not limited to those set forth in Article 7 and Article 8 of this LGIA, and remote Balancing Authority Area generator interchange agreements, if applicable, and the appropriate measures under such agreements, shall be executed and implemented prior to the placement of the Large Generating Facility in the other Balancing Authority Area.

9.3 CAISO and Participating TO Obligations. The CAISO and Participating TO shall cause the Participating TO's Transmission System to be operated and controlled in a safe and reliable manner and in accordance with this LGIA. The Participating TO at the Interconnection Customer's expense shall cause the Participating TO's Interconnection Facilities to be operated, maintained and controlled in a safe and reliable manner and in accordance with this LGIA. The CAISO and Participating TO may provide operating instructions to the Interconnection Customer consistent with this LGIA and Participating TO and CAISO operating protocols and procedures as they may change from time to time. The Participating TO and CAISO will consider changes to their operating protocols and procedures proposed by the Interconnection Customer.

9.4 Interconnection Customer Obligations. The Interconnection Customer shall at its own expense operate, maintain and control the Large Generating Facility and the Interconnection Customer's Interconnection Facilities in a safe and reliable manner and in accordance with this LGIA. The Interconnection Customer shall operate the Large Generating Facility and the Interconnection Customer's Interconnection Facilities in accordance with all applicable requirements of the Balancing Authority Area of which it is part, including such requirements as set forth in Appendix C, Interconnection Details, of this LGIA. Appendix C, Interconnection Details, will be modified to reflect changes to the requirements as they may change from time to time. A Party may request that another Party provide copies of the requirements set forth in Appendix C, Interconnection Details, of this LGIA. The Interconnection Customer shall not commence Commercial Operation of an Electric Generating Unit with the Participating TO's Transmission System until the Participating TO provides prior written approval, which approval shall not be unreasonably withheld, for operation of such Electric Generating Unit.

9.5 Start-Up and Synchronization. Consistent with the Parties' mutually acceptable procedures, the Interconnection Customer is responsible for the proper synchronization of each Electric Generating Unit to the CAISO Controlled Grid.

9.6 Reactive Power.

9.6.1 Power Factor Design Criteria. For all Generating Facilities other than Asynchronous Generating Facilities, the Interconnection Customer shall design the Large Generating Facility to maintain a composite power delivery at continuous rated power output at the terminals of the Electric Generating Unit at a power factor within the range of 0.95 leading to 0.90 lagging, unless the CAISO has established different requirements that apply to all generators in the Balancing Authority Area on a comparable basis. For Asynchronous

Generating Facilities, the Interconnection Customer shall design the Large Generating Facility to maintain power factor criteria in accordance with Appendix H of this LGIA.

9.6.2 Voltage Schedules. Once the Interconnection Customer has synchronized an Electric Generating Unit with the CAISO Controlled Grid, the CAISO or Participating TO shall require the Interconnection Customer to maintain a voltage schedule by operating the Electric Generating Unit to produce or absorb reactive power within the design limitations of the Electric Generating Unit set forth in Article 9.6.1 (Power Factor Design Criteria). CAISO's voltage schedules shall treat all sources of reactive power in the Balancing Authority Area in an equitable and not unduly discriminatory manner. The Participating TO shall exercise Reasonable Efforts to provide the Interconnection Customer with such schedules at least one (1) day in advance, and the CAISO or Participating TO may make changes to such schedules as necessary to maintain the reliability of the CAISO Controlled Grid or the Participating TO's electric system. The Interconnection Customer shall operate the Electric Generating Unit to maintain the specified output voltage or power factor within the design limitations of the Electric Generating Unit set forth in Article 9.6.1 (Power Factor Design Criteria), and as may be required by the CAISO to operate the Electric Generating Unit at a specific voltage schedule within the design limitations set forth in Article 9.6.1. If the Interconnection Customer is unable to maintain the specified voltage or power factor, it shall promptly notify the CAISO and the Participating TO.

9.6.2.1 Governors and Regulators. Whenever an Electric Generating Unit is operated in parallel with the CAISO Controlled Grid and the speed governors (if installed on the Electric Generating Unit pursuant to Good Utility Practice) and voltage regulators are capable of operation, the Interconnection Customer shall operate the Electric Generating Unit with its speed governors and voltage regulators in automatic operation. If the Electric Generating Unit's speed governors and voltage regulators are not capable of such automatic operation, the Interconnection Customer shall immediately notify the CAISO and the Participating TO and ensure that the Electric Generating Unit operates as specified in Article 9.6.2 through manual operation and that such Electric Generating Unit's reactive power production or absorption (measured in MVARs) are within the design capability of the Electric Generating Unit(s) and steady state stability limits. The Interconnection Customer shall restore the speed governors and voltage regulators to automatic operation as soon as possible and in accordance with the Reliability Management System Agreement in Appendix G. If the Large Generating Facility's speed governors and voltage regulators are improperly tuned or malfunctioning, the CAISO shall have the right to order the reduction in output or disconnection of the Large Generating Facility if the reliability of the CAISO Controlled Grid would be adversely affected. The Interconnection Customer shall not cause its Large Generating Facility to disconnect automatically or instantaneously from the CAISO Controlled Grid or trip any Electric Generating Unit comprising the Large Generating Facility for an under or over frequency condition unless the abnormal frequency condition persists for a time period beyond the limits set forth in ANSI/IEEE Standard C37.106, or such other standard as applied to other generators in the Balancing Authority Area on a comparable basis.

9.6.2.2 Loss of Voltage Control and Governor Control for Asynchronous Generating Facilities. For Asynchronous Generating Facilities, Appendix H to this LGIA sets forth the requirements for Large Generating Facilities relating to: (i) the loss of voltage control capability, (ii) governor response to frequency conditions, and (iii) ability not to disconnect automatically or instantaneously from the CAISO Controlled Grid or trip any Electric Generating Unit comprising the Large Generating Facility for an under- or over-frequency condition.

Asynchronous Generating Facilities are not required to provide governor response to under-frequency conditions.

9.6.3 Payment for Reactive Power. CAISO is required to pay the Interconnection Customer for reactive power that Interconnection Customer provides or absorbs from an Electric Generating Unit when the CAISO requests the Interconnection Customer to operate its Electric Generating Unit outside the range specified in Article 9.6.1, provided that if the CAISO pays other generators for reactive power service within the specified range, it must also pay the Interconnection Customer. Payments shall be pursuant to Article 11.6 or such other agreement to which the CAISO and Interconnection Customer have otherwise agreed.

9.7 Outages and Interruptions.

9.7.1 Outages.

9.7.1.1 Outage Authority and Coordination. Each Party may in accordance with Good Utility Practice in coordination with the other Parties remove from service any of its respective Interconnection Facilities or Network Upgrades that may impact another Party's facilities as necessary to perform maintenance or testing or to install or replace equipment. Absent an Emergency Condition, the Party scheduling a removal of such facility(ies) from service will use Reasonable Efforts to schedule such removal on a date and time mutually acceptable to all Parties. In all circumstances any Party planning to remove such facility(ies) from service shall use Reasonable Efforts to minimize the effect on the other Parties of such removal.

9.7.1.2 Outage Schedules. The CAISO shall post scheduled outages of CAISO Controlled Grid facilities in accordance with the provisions of the CAISO Tariff. The Interconnection Customer shall submit its planned maintenance schedules for the Large Generating Facility to the CAISO in accordance with the CAISO Tariff. The Interconnection Customer shall update its planned maintenance schedules in accordance with the CAISO Tariff. The CAISO may request the Interconnection Customer to reschedule its maintenance as necessary to maintain the reliability of the CAISO Controlled Grid in accordance with the CAISO Tariff. Such planned maintenance schedules and updates and changes to such schedules shall be provided by the Interconnection Customer to the Participating TO concurrently with their submittal to the CAISO. The CAISO shall compensate the Interconnection Customer for any additional direct costs that the Interconnection Customer incurs as a result of having to reschedule maintenance in accordance with the CAISO Tariff. The Interconnection Customer will not be eligible to receive compensation, if during the twelve (12) months prior to the date of the scheduled maintenance, the Interconnection Customer had modified its schedule of maintenance activities.

9.7.1.3 Outage Restoration. If an outage on a Party's Interconnection Facilities or Network Upgrades adversely affects another Party's operations or facilities, the Party that owns or controls the facility that is out of service shall use Reasonable Efforts to promptly restore such facility(ies) to a normal operating condition consistent with the nature of the outage. The Party that owns or controls the facility that is out of service shall provide the other Parties, to the extent such information is known, information on the nature of the Emergency Condition, if the outage is caused by an Emergency Condition, an estimated time of restoration, and any corrective actions required. Initial verbal notice shall be followed up as soon as practicable with written notice explaining the nature of the outage, if requested by a Party, which may be provided by e-mail or facsimile.

9.7.2 **Interruption of Service**. If required by Good Utility Practice to do so, the CAISO or the Participating TO may require the Interconnection Customer to interrupt or reduce deliveries of electricity if such delivery of electricity could adversely affect the CAISO's or the Participating TO's ability to perform such activities as are necessary to safely and reliably operate and maintain the Participating TO's electric system or the CAISO Controlled Grid. The following provisions shall apply to any interruption or reduction permitted under this Article 9.7.2:

9.7.2.1 The interruption or reduction shall continue only for so long as reasonably necessary under Good Utility Practice;

9.7.2.2 Any such interruption or reduction shall be made on an equitable, non-discriminatory basis with respect to all generating facilities directly connected to the CAISO Controlled Grid, subject to any conditions specified in this LGIA;

9.7.2.3 When the interruption or reduction must be made under circumstances which do not allow for advance notice, the CAISO or Participating TO, as applicable, shall notify the Interconnection Customer by telephone as soon as practicable of the reasons for the curtailment, interruption, or reduction, and, if known, its expected duration. Telephone notification shall be followed by written notification, if requested by the Interconnection Customer, as soon as practicable;

9.7.2.4 Except during the existence of an Emergency Condition, the CAISO or Participating TO shall notify the Interconnection Customer in advance regarding the timing of such interruption or reduction and further notify the Interconnection Customer of the expected duration. The CAISO or Participating TO shall coordinate with the Interconnection Customer using Good Utility Practice to schedule the interruption or reduction during periods of least impact to the Interconnection Customer, the CAISO, and the Participating TO;

9.7.2.5 The Parties shall cooperate and coordinate with each other to the extent necessary in order to restore the Large Generating Facility, Interconnection Facilities, the Participating TO's Transmission System, and the CAISO Controlled Grid to their normal operating state, consistent with system conditions and Good Utility Practice.

9.7.3 **Under-Frequency and Over Frequency Conditions**. The CAISO Controlled Grid is designed to automatically activate a load-shed program as required by the Applicable Reliability Council in the event of an under-frequency system disturbance. The Interconnection Customer shall implement under-frequency and over-frequency protection set points for the Large Generating Facility as required by the Applicable Reliability Council to ensure "ride through" capability. Large Generating Facility response to frequency deviations of pre-determined magnitudes, both under-frequency and over-frequency deviations, shall be studied and coordinated with the Participating TO and CAISO in accordance with Good Utility Practice. The term "ride through" as used herein shall mean the ability of a Generating Facility to stay connected to and synchronized with the CAISO Controlled Grid during system disturbances within a range of under-frequency and over-frequency conditions, in accordance with Good Utility Practice. Asynchronous Generating Facilities shall be subject to frequency ride through capability requirements in accordance with Appendix H to this LGIA.

9.7.4 System Protection and Other Control Requirements.

9.7.4.1 System Protection Facilities. The Interconnection Customer shall, at its expense, install, operate and maintain System Protection Facilities as a part of the Large Generating Facility or the Interconnection Customer's Interconnection Facilities. The Participating TO shall install at the Interconnection Customer's expense any System Protection Facilities that may be required on the Participating TO's Interconnection Facilities or the Participating TO's Transmission System as a result of the interconnection of the Large Generating Facility and the Interconnection Customer's Interconnection Facilities.

9.7.4.2 The Participating TO's and Interconnection Customer's protection facilities shall be designed and coordinated with other systems in accordance with Applicable Reliability Council criteria and Good Utility Practice.

9.7.4.3 The Participating TO and Interconnection Customer shall each be responsible for protection of its facilities consistent with Good Utility Practice.

9.7.4.4 The Participating TO's and Interconnection Customer's protective relay design shall incorporate the necessary test switches to perform the tests required in Article 6. The required test switches will be placed such that they allow operation of lockout relays while preventing breaker failure schemes from operating and causing unnecessary breaker operations and/or the tripping of the Interconnection Customer's Electric Generating Units.

9.7.4.5 The Participating TO and Interconnection Customer will test, operate and maintain System Protection Facilities in accordance with Good Utility Practice and, if applicable, the requirements of the Participating TO's Interconnection Handbook.

9.7.4.6 Prior to the in-service date, and again prior to the Commercial Operation Date, the Participating TO and Interconnection Customer or their agents shall perform a complete calibration test and functional trip test of the System Protection Facilities. At intervals suggested by Good Utility Practice, the standards and procedures of the Participating TO, including, if applicable, the requirements of the Participating TO's Interconnection Handbook, and following any apparent malfunction of the System Protection Facilities, each Party shall perform both calibration and functional trip tests of its System Protection Facilities. These tests do not require the tripping of any in-service generation unit. These tests do, however, require that all protective relays and lockout contacts be activated.

9.7.5 Requirements for Protection. In compliance with Good Utility Practice and, if applicable, the requirements of the Participating TO's Interconnection Handbook, the Interconnection Customer shall provide, install, own, and maintain relays, circuit breakers and all other devices necessary to remove any fault contribution of the Large Generating Facility to any short circuit occurring on the Participating TO's Transmission System not otherwise isolated by the Participating TO's equipment, such that the removal of the fault contribution shall be coordinated with the protective requirements of the Participating TO's Transmission System. Such protective equipment shall include, without limitation, a disconnecting device with fault current-interrupting capability located between the Large Generating Facility and the Participating TO's Transmission System at a site selected upon mutual agreement (not to be unreasonably withheld, conditioned or delayed) of the Parties. The Interconnection Customer shall be responsible for protection of the Large Generating Facility and the Interconnection Customer's other equipment from such conditions as negative sequence currents, over- or under-frequency, sudden load rejection, over- or under-voltage, and generator loss-of-field. The Interconnection

Customer shall be solely responsible to disconnect the Large Generating Facility and the Interconnection Customer's other equipment if conditions on the CAISO Controlled Grid could adversely affect the Large Generating Facility.

9.7.6 Power Quality. Neither the Participating TO's nor the Interconnection Customer's facilities shall cause excessive voltage flicker nor introduce excessive distortion to the sinusoidal voltage or current waves as defined by ANSI Standard C84.1-1989, in accordance with IEEE Standard 519, any applicable superseding electric industry standard, or any alternative Applicable Reliability Council standard. In the event of a conflict between ANSI Standard C84.1-1989, any applicable superseding electric industry standard, or any alternative Applicable Reliability Council standard, the alternative Applicable Reliability Council standard shall control.

9.8 Switching and Tagging Rules. Each Party shall provide the other Parties a copy of its switching and tagging rules that are applicable to the other Parties' activities. Such switching and tagging rules shall be developed on a non-discriminatory basis. The Parties shall comply with applicable switching and tagging rules, as amended from time to time, in obtaining clearances for work or for switching operations on equipment.

9.9 Use of Interconnection Facilities by Third Parties.

9.9.1 Purpose of Interconnection Facilities. Except as may be required by Applicable Laws and Regulations, or as otherwise agreed to among the Parties, the Interconnection Facilities shall be constructed for the sole purpose of interconnecting the Large Generating Facility to the Participating TO's Transmission System and shall be used for no other purpose.

9.9.2 Third Party Users. If required by Applicable Laws and Regulations or if the Parties mutually agree, such agreement not to be unreasonably withheld, to allow one or more third parties to use the Participating TO's Interconnection Facilities, or any part thereof, the Interconnection Customer will be entitled to compensation for the capital expenses it incurred in connection with the Interconnection Facilities based upon the pro rata use of the Interconnection Facilities by the Participating TO, all third party users, and the Interconnection Customer, in accordance with Applicable Laws and Regulations or upon some other mutually-agreed upon methodology. In addition, cost responsibility for ongoing costs, including operation and maintenance costs associated with the Interconnection Facilities, will be allocated between the Interconnection Customer and any third party users based upon the pro rata use of the Interconnection Facilities by the Participating TO, all third party users, and the Interconnection Customer, in accordance with Applicable Laws and Regulations or upon some other mutually agreed upon methodology. If the issue of such compensation or allocation cannot be resolved through such negotiations, it shall be submitted to FERC for resolution.

9.10 Disturbance Analysis Data Exchange. The Parties will cooperate with one another in the analysis of disturbances to either the Large Generating Facility or the CAISO Controlled Grid by gathering and providing access to any information relating to any disturbance, including information from oscillography, protective relay targets, breaker operations and sequence of events records, and any disturbance information required by Good Utility Practice.

ARTICLE 10. MAINTENANCE

10.1 **Participating TO Obligations.** The Participating TO shall maintain the Participating TO's Transmission System and the Participating TO's Interconnection Facilities in a safe and reliable manner and in accordance with this LGIA.

10.2 **Interconnection Customer Obligations**. The Interconnection Customer shall maintain the Large Generating Facility and the Interconnection Customer's Interconnection Facilities in a safe and reliable manner and in accordance with this LGIA.

10.3 **Coordination**. The Parties shall confer regularly to coordinate the planning, scheduling and performance of preventive and corrective maintenance on the Large Generating Facility and the Interconnection Facilities.

10.4 **Secondary Systems**. The Participating TO and Interconnection Customer shall cooperate with the other Parties in the inspection, maintenance, and testing of control or power circuits that operate below 600 volts, AC or DC, including, but not limited to, any hardware, control or protective devices, cables, conductors, electric raceways, secondary equipment panels, transducers, batteries, chargers, and voltage and current transformers that directly affect the operation of a Party's facilities and equipment which may reasonably be expected to impact the other Parties. Each Party shall provide advance notice to the other Parties before undertaking any work on such circuits, especially on electrical circuits involving circuit breaker trip and close contacts, current transformers, or potential transformers.

10.5 **Operating and Maintenance Expenses**. Subject to the provisions herein addressing the use of facilities by others, and except for operations and maintenance expenses associated with modifications made for providing interconnection or transmission service to a third party and such third party pays for such expenses, the Interconnection Customer shall be responsible for all reasonable expenses including overheads, associated with: (1) owning, operating, maintaining, repairing, and replacing the Interconnection Customer's Interconnection Facilities; and (2) operation, maintenance, repair and replacement of the Participating TO's Interconnection Facilities.

ARTICLE 11. PERFORMANCE OBLIGATION

11.1 Interconnection Customer's Interconnection Facilities. The Interconnection Customer shall design, procure, construct, install, own and/or control the Interconnection Customer's Interconnection Facilities described in Appendix A at its sole expense.

11.2 Participating TO's Interconnection Facilities. The Participating TO shall design, procure, construct, install, own and/or control the Participating TO's Interconnection Facilities described in Appendix A at the sole expense of the Interconnection Customer. Unless the Participating TO elects to fund the capital for the Participating TO's Interconnection Facilities, they shall be solely funded by the Interconnection Customer.

11.3 Network Upgrades and Distribution Upgrades. The Participating TO shall design, procure, construct, install, and own the Network Upgrades and Distribution Upgrades described in Appendix A. The Interconnection Customer shall be responsible for all costs related to Distribution Upgrades. Unless the Participating TO elects to fund the capital for the Distribution Upgrades and Network Upgrades, they shall be solely funded by the Interconnection Customer.

11.4 Transmission Credits. No later than thirty (30) days prior to the Commercial Operation Date, the Interconnection Customer may make a one-time election by written notice to the CAISO and the Participating TO to receive Congestion Revenue Rights as defined in and as available under the CAISO Tariff at the time of the election in accordance with the CAISO Tariff, in lieu of a refund of the cost of Network Upgrades in accordance with Article 11.4.1.

11.4.1 Repayment of Amounts Advanced for Network Upgrades. Upon the Commercial Operation Date, the Interconnection Customer shall be entitled to a repayment, equal to the total amount paid to the Participating TO for the cost of Network Upgrades. Such amount shall include any tax gross-up or other tax-related payments associated with Network Upgrades not refunded to the Interconnection Customer pursuant to Article 5.17.8 or otherwise, and shall be paid to the Interconnection Customer by the Participating TO on a dollar-for-dollar basis either through (1) direct payments made on a levelized basis over the five-year period commencing on the Commercial Operation Date; or (2) any alternative payment schedule that is mutually agreeable to the Interconnection Customer and Participating TO, provided that such amount is paid within five (5) years from the Commercial Operation Date. Notwithstanding the foregoing, if this LGIA terminates within five (5) years from the Commercial Operation Date, the Participating TO's obligation to pay refunds to the Interconnection Customer shall cease as of the date of termination. Any repayment shall include interest calculated in accordance with the methodology set forth in FERC's regulations at 18 C.F.R. §35.19a(a)(2)(iii) from the date of any payment for Network Upgrades through the date on which the Interconnection Customer receives a repayment of such payment. Interest shall continue to accrue on the repayment obligation so long as this LGIA is in effect. The Interconnection Customer may assign such repayment rights to any person.

If the Large Generating Facility fails to achieve commercial operation, but it or another Generating Facility is later constructed and makes use of the Network Upgrades, the Participating TO shall at that time reimburse Interconnection Customer for the amounts advanced for the Network Upgrades. Before any such reimbursement can occur, the Interconnection Customer, or the entity that ultimately constructs the Generating Facility, if different, is responsible for identifying the entity to which reimbursement must be made.

11.4.2 Special Provisions for Affected Systems. The Interconnection Customer shall enter into an agreement with the owner of the Affected System and/or other affected owners of portions of the CAISO Controlled Grid, as applicable, in accordance with the LGIP. Such agreement shall specify the terms governing payments to be made by the

Interconnection Customer to the owner of the Affected System and/or other affected owners of portions of the CAISO Controlled Grid as well as the repayment by the owner of the Affected System and/or other affected owners of portions of the CAISO Controlled Grid. In no event shall the Participating TO be responsible for the repayment for any facilities that are not part of the Participating TO's Transmission System.

11.4.3 Notwithstanding any other provision of this LGIA, nothing herein shall be construed as relinquishing or foreclosing any rights, including but not limited to firm transmission rights, capacity rights, Congestion Revenue Rights, or transmission credits, that the Interconnection Customer shall be entitled to, now or in the future under any other agreement or tariff as a result of, or otherwise associated with, the transmission capacity, if any, created by the Network Upgrades, including the right to obtain cash reimbursements or transmission credits for transmission service that is not associated with the Large Generating Facility.

11.5 **Provision of Security**. At least thirty (30) Calendar Days prior to the commencement of the procurement, installation, or construction of a discrete portion of a Participating TO's Interconnection Facilities, Network Upgrades, or Distribution Upgrades, the Interconnection Customer shall provide the Participating TO, at the Interconnection Customer's option, a guarantee, a surety bond, letter of credit or other form of security that is reasonably acceptable to the Participating TO and is consistent with the Uniform Commercial Code of the jurisdiction identified in Article 14.2.1. Such security for payment shall be in an amount sufficient to cover the costs for constructing, procuring and installing the applicable portion of the Participating TO's Interconnection Facilities, Network Upgrades, or Distribution Upgrades. Such security shall be reduced on a dollar-for-dollar basis for payments made to the Participating TO for these purposes.

In addition:

11.5.1 The guarantee must be made by an entity that meets the creditworthiness requirements of the Participating TO, and contain terms and conditions that guarantee payment of any amount that may be due from the Interconnection Customer, up to an agreed-to maximum amount.

11.5.2 The letter of credit must be issued by a financial institution reasonably acceptable to the Participating TO and must specify a reasonable expiration date.

11.5.3 The surety bond must be issued by an insurer reasonably acceptable to the Participating TO and must specify a reasonable expiration date.

11.6 **Interconnection Customer Compensation**. If the CAISO requests or directs the Interconnection Customer to provide a service pursuant to Articles 9.6.3 (Payment for Reactive Power) or 13.5.1 of this LGIA, the CAISO shall compensate the Interconnection Customer in accordance with the CAISO Tariff.

11.6.1 **Interconnection Customer Compensation for Actions During Emergency Condition**. The CAISO shall compensate the Interconnection Customer in accordance with the CAISO Tariff for its provision of real and reactive power and other Emergency Condition services that the Interconnection Customer provides to support the CAISO Controlled Grid during an Emergency Condition in accordance with Article 11.6.

ARTICLE 12. INVOICE

12.1 **General.** The Participating TO shall submit to the Interconnection Customer, on a monthly basis, invoices of amounts due pursuant to this LGIA for the preceding month. Each invoice shall state the month to which the invoice applies and fully describe the services and equipment provided. The Parties may discharge mutual debts and payment obligations due and owing to each other on the same date through netting, in which case all amounts a Party owes to the other Party under this LGIA, including interest payments or credits, shall be netted so that only the net amount remaining due shall be paid by the owing Party. Notwithstanding the foregoing, any invoices between the CAISO and another Party shall be submitted and paid in accordance with the CAISO Tariff.

12.2 **Final Invoice**. As soon as reasonably practicable, but within twelve months after completion of the construction of the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades, the Participating TO shall provide an invoice of the final cost of the construction of the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades, and shall set forth such costs in sufficient detail to enable the Interconnection Customer to compare the actual costs with the estimates and to ascertain deviations, if any, from the cost estimates. The Participating TO shall refund to the Interconnection Customer any amount by which the actual payment by the Interconnection Customer for estimated costs exceeds the actual costs of construction within thirty (30) Calendar Days of the issuance of such final construction invoice; or, in the event the actual costs of construction exceed the Interconnection Customer's actual payment for estimated costs, then the Interconnection Customer shall pay to the Participating TO any amount by which the actual costs of construction exceed the actual payment by the Interconnection Customer for estimated costs within thirty (30) Calendar Days of the issuance of such final construction invoice.

12.3 **Payment**. Invoices shall be rendered to the Interconnection Customer at the address specified in Appendix F. The Interconnection Customer shall pay, or Participating TO shall refund, the amounts due within thirty (30) Calendar Days of the Interconnection Customer's receipt of the invoice. All payments shall be made in immediately available funds payable to the Interconnection Customer or Participating TO, or by wire transfer to a bank named and account designated by the invoicing Interconnection Customer or Participating TO. Payment of invoices by any Party will not constitute a waiver of any rights or claims any Party may have under this LGIA.

12.4 **Disputes**. In the event of a billing dispute between the Interconnection Customer and the Participating TO, the Participating TO and the CAISO shall continue to provide Interconnection Service under this LGIA as long as the Interconnection Customer: (i) continues to make all payments not in dispute; and (ii) pays to the Participating TO or into an independent escrow account the portion of the invoice in dispute, pending resolution of such dispute. If the Interconnection Customer fails to meet these two requirements for continuation of service, then the Participating TO may provide notice to the Interconnection Customer of a Default pursuant to Article 17. Within thirty (30) Calendar Days after the resolution of the dispute, the Party that owes money to the other Party shall pay the amount due with interest calculated in accordance with the methodology set forth in FERC's Regulations at 18 C.F.R. § 35.19a(a)(2)(iii). Notwithstanding the foregoing, any billing dispute between the CAISO and another Party shall be resolved in accordance with the provisions of Article 27 of this LGIA.

ARTICLE 13. EMERGENCIES

13.1 [Reserved]

13.2 Obligations. Each Party shall comply with the Emergency Condition procedures of the CAISO, NERC, the Applicable Reliability Council, Applicable Laws and Regulations, and any emergency procedures set forth in this LGIA.

13.3 Notice. The Participating TO or the CAISO shall notify the Interconnection Customer promptly when it becomes aware of an Emergency Condition that affects the Participating TO's Interconnection Facilities or Distribution System or the CAISO Controlled Grid, respectively, that may reasonably be expected to affect the Interconnection Customer's operation of the Large Generating Facility or the Interconnection Customer's Interconnection Facilities. The Interconnection Customer shall notify the Participating TO and the CAISO promptly when it becomes aware of an Emergency Condition that affects the Large Generating Facility or the Interconnection Customer's Interconnection Facilities that may reasonably be expected to affect the CAISO Controlled Grid or the Participating TO's Interconnection Facilities. To the extent information is known, the notification shall describe the Emergency Condition, the extent of the damage or deficiency, the expected effect on the operation of the Interconnection Customer's or Participating TO's facilities and operations, its anticipated duration and the corrective action taken and/or to be taken. The initial notice shall be followed as soon as practicable with written notice, if requested by a Party, which may be provided by electronic mail or facsimile, or in the case of the CAISO may be publicly posted on the CAISO's internet web site.

13.4 Immediate Action. Unless, in the Interconnection Customer's reasonable judgment, immediate action is required, the Interconnection Customer shall obtain the consent of the CAISO and the Participating TO, such consent to not be unreasonably withheld, prior to performing any manual switching operations at the Large Generating Facility or the Interconnection Customer's Interconnection Facilities in response to an Emergency Condition declared by the Participating TO or CAISO or in response to any other emergency condition.

13.5 CAISO and Participating TO Authority.

13.5.1 General. The CAISO and Participating TO may take whatever actions or inactions, including issuance of dispatch instructions, with regard to the CAISO Controlled Grid or the Participating TO's Interconnection Facilities or Distribution System they deem necessary during an Emergency Condition in order to (i) preserve public health and safety, (ii) preserve the reliability of the CAISO Controlled Grid or the Participating TO's Interconnection Facilities or Distribution System, and (iii) limit or prevent damage, and (iv) expedite restoration of service.

The Participating TO and the CAISO shall use Reasonable Efforts to minimize the effect of such actions or inactions on the Large Generating Facility or the Interconnection Customer's Interconnection Facilities. The Participating TO or the CAISO may, on the basis of technical considerations, require the Large Generating Facility to mitigate an Emergency Condition by taking actions necessary and limited in scope to remedy the Emergency Condition, including, but not limited to, directing the Interconnection Customer to shut-down, start-up, increase or decrease the real or reactive power output of the Large Generating Facility; implementing a reduction or disconnection pursuant to Article 13.5.2; directing the Interconnection Customer to assist with black start (if available) or restoration efforts; or altering the outage schedules of the Large Generating Facility and the Interconnection Customer's Interconnection Facilities. Interconnection Customer shall comply with all of the CAISO's and Participating TO's operating instructions concerning Large Generating Facility real power and reactive power output within the manufacturer's design limitations of the Large Generating Facility's equipment that is in service and physically available for operation at the time, in compliance with Applicable Laws and Regulations.

13.5.2 Reduction and Disconnection. The Participating TO or the CAISO may reduce Interconnection Service or disconnect the Large Generating Facility or the Interconnection Customer's Interconnection Facilities when such reduction or disconnection is necessary under Good Utility Practice due to Emergency Conditions. These rights are separate and distinct from any right of curtailment of the CAISO pursuant to the CAISO Tariff. When the CAISO or Participating TO can schedule the reduction or disconnection in advance, the CAISO or Participating TO shall notify the Interconnection Customer of the reasons, timing and expected duration of the reduction or disconnection. The CAISO or Participating TO shall coordinate with the Interconnection Customer using Good Utility Practice to schedule the reduction or disconnection during periods of least impact to the Interconnection Customer and the CAISO and Participating TO. Any reduction or disconnection shall continue only for so long as reasonably necessary under Good Utility Practice. The Parties shall cooperate with each other to restore the Large Generating Facility, the Interconnection Facilities, and the CAISO Controlled Grid to their normal operating state as soon as practicable consistent with Good Utility Practice.

13.6 Interconnection Customer Authority. Consistent with Good Utility Practice, this LGIA, and the CAISO Tariff, the Interconnection Customer may take actions or inactions with regard to the Large Generating Facility or the Interconnection Customer's Interconnection Facilities during an Emergency Condition in order to (i) preserve public health and safety, (ii) preserve the reliability of the Large Generating Facility or the Interconnection Customer's Interconnection Facilities, (iii) limit or prevent damage, and (iv) expedite restoration of service. Interconnection Customer shall use Reasonable Efforts to minimize the effect of such actions or inactions on the CAISO Controlled Grid and the Participating TO's Interconnection Facilities. The CAISO and Participating TO shall use Reasonable Efforts to assist Interconnection Customer in such actions.

13.7 Limited Liability. Except as otherwise provided in Article 11.6.1 of this LGIA, no Party shall be liable to any other Party for any action it takes in responding to an Emergency Condition so long as such action is made in good faith and is consistent with Good Utility Practice.

ARTICLE 14. REGULATORY REQUIREMENTS AND GOVERNING LAW

14.1 **Regulatory Requirements**. Each Party's obligations under this LGIA shall be subject to its receipt of any required approval or certificate from one or more Governmental Authorities in the form and substance satisfactory to the applying Party, or the Party making any required filings with, or providing notice to, such Governmental Authorities, and the expiration of any time period associated therewith. Each Party shall in good faith seek and use its Reasonable Efforts to obtain such other approvals. Nothing in this LGIA shall require the Interconnection Customer to take any action that could result in its inability to obtain, or its loss of, status or exemption under the Federal Power Act or the Public Utility Holding Company Act of 1935, as amended, or the Public Utility Regulatory Policies Act of 1978, or the Energy Policy Act of 2005.

14.2 **Governing Law**.

14.2.1 The validity, interpretation and performance of this LGIA and each of its provisions shall be governed by the laws of the state where the Point of Interconnection is located, without regard to its conflicts of law principles.

14.2.2 This LGIA is subject to all Applicable Laws and Regulations.

14.2.3 Each Party expressly reserves the right to seek changes in, appeal, or otherwise contest any laws, orders, rules, or regulations of a Governmental Authority.

ARTICLE 15. NOTICES

15.1 **General**. Unless otherwise provided in this LGIA, any notice, demand or request required or permitted to be given by a Party to another and any instrument required or permitted to be tendered or delivered by a Party in writing to another shall be effective when delivered and may be so given, tendered or delivered, by recognized national courier, or by depositing the same with the United States Postal Service with postage prepaid, for delivery by certified or registered mail, addressed to the Party, or personally delivered to the Party, at the address set out in Appendix F, Addresses for Delivery of Notices and Billings.

A Party must update the information in Appendix F as information changes. A Party may change the notice information in this LGIA by giving five (5) Business Days written notice prior to the effective date of the change. Such changes shall not constitute an amendment to this LGIA.

15.2 **Billings and Payments**. Billings and payments shall be sent to the addresses set out in Appendix F.

15.3 **Alternative Forms of Notice**. Any notice or request required or permitted to be given by a Party to another and not required by this LGIA to be given in writing may be so given by telephone, facsimile or e-mail to the telephone numbers and e-mail addresses set out in Appendix F.

15.4 **Operations and Maintenance Notice**. Each Party shall notify the other Parties in writing of the identity of the person(s) that it designates as the point(s) of contact with respect to the implementation of Articles 9 and 10.

ARTICLE 16. FORCE MAJEURE

16.1 Force Majeure.

16.1.1 Economic hardship is not considered a Force Majeure event.

16.1.2 No Party shall be considered to be in Default with respect to any obligation hereunder, (including obligations under Article 4), other than the obligation to pay money when due, if prevented from fulfilling such obligation by Force Majeure. A Party unable to fulfill any obligation hereunder (other than an obligation to pay money when due) by reason of Force Majeure shall give notice and the full particulars of such Force Majeure to the other Party in writing or by telephone as soon as reasonably possible after the occurrence of the cause relied upon. Telephone notices given pursuant to this Article shall be confirmed in writing as soon as reasonably possible and shall specifically state full particulars of the Force Majeure, the time and date when the Force Majeure occurred and when the Force Majeure is reasonably expected to cease. The Party affected shall exercise due diligence to remove such disability with reasonable dispatch, but shall not be required to accede or agree to any provision not satisfactory to it in order to settle and terminate a strike or other labor disturbance.

ARTICLE 17. DEFAULT

17.1 Default

17.1.1 **General.** No Default shall exist where such failure to discharge an obligation (other than the payment of money) is the result of Force Majeure as defined in this LGIA or the result of an act or omission of the other Party. Upon a Breach, the affected non-Breaching Party(ies) shall give written notice of such Breach to the Breaching Party. Except as provided in Article 17.1.2, the Breaching Party shall have thirty (30) Calendar Days from receipt of the Default notice within which to cure such Breach; provided however, if such Breach is not capable of cure within thirty (30) Calendar Days, the Breaching Party shall commence such cure within thirty (30) Calendar Days after notice and continuously and diligently complete such cure within ninety (90) Calendar Days from receipt of the Default notice; and, if cured within such time, the Breach specified in such notice shall cease to exist.

17.1.2 **Right to Terminate**. If a Breach is not cured as provided in this Article, or if a Breach is not capable of being cured within the period provided for herein, the affected non-Breaching Party(ies) shall have the right to declare a Default and terminate this LGIA by written notice at any time until cure occurs, and be relieved of any further obligation hereunder and, whether or not such Party(ies) terminates this LGIA, to recover from the Breaching Party all amounts due hereunder, plus all other damages and remedies to which it is entitled at law or in equity. The provisions of this Article will survive termination of this LGIA.

ARTICLE 18. INDEMNITY, CONSEQUENTIAL DAMAGES AND INSURANCE

18.1 Indemnity. Each Party shall at all times indemnify, defend, and hold the other Parties harmless from, any and all Losses arising out of or resulting from another Party's action or inactions of its obligations under this LGIA on behalf of the indemnifying Party, except in cases of gross negligence or intentional wrongdoing by the Indemnified Party.

18.1.1 Indemnified Party. If an Indemnified Party is entitled to indemnification under this Article 18 as a result of a claim by a third party, and the Indemnifying Party fails, after notice and reasonable opportunity to proceed under Article 18.1, to assume the defense of such claim, such Indemnified Party may at the expense of the Indemnifying Party contest, settle or consent to the entry of any judgment with respect to, or pay in full, such claim.

18.1.2 Indemnifying Party. If an Indemnifying Party is obligated to indemnify and hold any Indemnified Party harmless under this Article 18, the amount owing to the Indemnified Party shall be the amount of such Indemnified Party's actual Loss, net of any insurance or other recovery.

18.1.3 Indemnity Procedures. Promptly after receipt by an Indemnified Party of any claim or notice of the commencement of any action or administrative or legal proceeding or investigation as to which the indemnity provided for in Article 18.1 may apply, the Indemnified Party shall notify the Indemnifying Party of such fact. Any failure of or delay in such notification shall not affect a Party's indemnification obligation unless such failure or delay is materially prejudicial to the indemnifying Party.

The Indemnifying Party shall have the right to assume the defense thereof with counsel designated by such Indemnifying Party and reasonably satisfactory to the Indemnified Party. If the defendants in any such action include one or more Indemnified Parties and the Indemnifying Party and if the Indemnified Party reasonably concludes that there may be legal defenses available to it and/or other Indemnified Parties which are different from or additional to those available to the Indemnifying Party, the Indemnified Party shall have the right to select separate counsel to assert such legal defenses and to otherwise participate in the defense of such action on its own behalf. In such instances, the Indemnifying Party shall only be required to pay the fees and expenses of one additional attorney to represent an Indemnified Party or Indemnified Parties having such differing or additional legal defenses.

The Indemnified Party shall be entitled, at its expense, to participate in any such action, suit or proceeding, the defense of which has been assumed by the Indemnifying Party. Notwithstanding the foregoing, the Indemnifying Party (i) shall not be entitled to assume and control the defense of any such action, suit or proceedings if and to the extent that, in the opinion of the Indemnified Party and its counsel, such action, suit or proceeding involves the potential imposition of criminal liability on the Indemnified Party, or there exists a conflict or adversity of interest between the Indemnified Party and the Indemnifying Party, in such event the Indemnifying Party shall pay the reasonable expenses of the Indemnified Party, and (ii) shall not settle or consent to the entry of any judgment in any action, suit or proceeding without the consent of the Indemnified Party, which shall not be unreasonably withheld, conditioned or delayed.

18.2 Consequential Damages. Other than the liquidated damages heretofore described in Article 5.3, in no event shall any Party be liable under any provision of this LGIA for any losses, damages, costs or expenses for any special, indirect, incidental, consequential, or punitive damages, including but not limited to loss of profit or revenue, loss of the use of equipment, cost of capital, cost of temporary equipment or services, whether based in whole or in part in contract, in tort, including negligence, strict liability, or any other theory of liability; provided, however, that damages for which a Party may be liable to another Party under another agreement will not be considered to be special, indirect, incidental, or consequential damages hereunder.

18.3 Insurance. Each Party shall, at its own expense, maintain in force throughout the period of this LGIA, and until released by the other Parties, the following minimum insurance coverages, with insurers rated no less than A- (with a minimum size rating of VII) by Bests' Insurance Guide and Key Ratings and authorized to do business in the state where the Point of Interconnection is located, except in the case of the CAISO, the State of California:

18.3.1 Employer's Liability and Workers' Compensation Insurance providing statutory benefits in accordance with the laws and regulations of the state in which the Point of Interconnection is located, except in the case of the CAISO, the State of California.

18.3.2 Commercial General Liability Insurance including premises and operations, personal injury, broad form property damage, broad form blanket contractual liability coverage (including coverage for the contractual indemnification) products and completed operations coverage, coverage for explosion, collapse and underground hazards, independent contractors coverage, coverage for pollution to the extent normally available and punitive damages to the extent normally available and a cross liability endorsement, with minimum limits of One Million Dollars ($1,000,000) per occurrence/One Million Dollars ($1,000,000) aggregate combined single limit for personal injury, bodily injury, including death and property damage.

18.3.3 Business Automobile Liability Insurance for coverage of owned and non-owned and hired vehicles, trailers or semi-trailers designed for travel on public roads, with a minimum, combined single limit of One Million Dollars ($1,000,000) per occurrence for bodily injury, including death, and property damage.

18.3.4 Excess Public Liability Insurance over and above the Employer's Liability Commercial General Liability and Business Automobile Liability Insurance coverage, with a minimum combined single limit of Twenty Million Dollars ($20,000,000) per occurrence/Twenty Million Dollars ($20,000,000) aggregate.

18.3.5 The Commercial General Liability Insurance, Business Automobile Insurance and Excess Public Liability Insurance policies shall name the other Parties, their parents, associated and Affiliate companies and their respective directors, officers, agents, servants and employees ("Other Party Group") as additional insured. All policies shall contain provisions whereby the insurers waive all rights of subrogation in accordance with the provisions of this LGIA against the Other Party Group and provide thirty (30) Calendar Days advance written notice to the Other Party Group prior to anniversary date of cancellation or any material change in coverage or condition.

18.3.6 The Commercial General Liability Insurance, Business Automobile Liability Insurance and Excess Public Liability Insurance policies shall contain provisions that specify that the policies are primary and shall apply to such extent without consideration for other policies separately carried and shall state that each insured is provided coverage as though a separate policy had been issued to each, except the insurer's liability shall not be increased beyond the amount for which the insurer would have been liable had only one insured been covered. Each Party shall be responsible for its respective deductibles or retentions.

18.3.7 The Commercial General Liability Insurance, Business Automobile Liability Insurance and Excess Public Liability Insurance policies, if written on a Claims First Made Basis, shall be maintained in full force and effect for two (2) years after termination of this LGIA, which coverage may be in the form of tail coverage or extended reporting period coverage if agreed by the Parties.

18.3.8 The requirements contained herein as to the types and limits of all insurance to be maintained by the Parties are not intended to and shall not in any manner, limit or qualify the liabilities and obligations assumed by the Parties under this LGIA.

18.3.9 Within ten (10) Calendar Days following execution of this LGIA, and as soon as practicable after the end of each fiscal year or at the renewal of the insurance policy and in any event within ninety (90) Calendar Days thereafter, each Party shall provide certification of all insurance required in this LGIA, executed by each insurer or by an authorized representative of each insurer.

18.3.10 Notwithstanding the foregoing, each Party may self-insure to meet the minimum insurance requirements of Articles 18.3.2 through 18.3.8 to the extent it maintains a self-insurance program; provided that, such Party's senior unsecured debt or issuer rating is BBB-, or better, as rated by Standard & Poor's and that its self-insurance program meets the minimum insurance requirements of Articles 18.3.2 through 18.3.8. For any period of time that a Party's senior unsecured debt rating and issuer rating are both unrated by Standard & Poor's or are both rated at less than BBB- by Standard & Poor's, such Party shall comply with the insurance requirements applicable to it under Articles 18.3.2 through 18.3.9. In the event that a Party is permitted to self-insure pursuant to this Article 18.3.10, it shall notify the other Parties that it meets the requirements to self-insure and that its self-insurance program meets the minimum insurance requirements in a manner consistent with that specified in Article 18.3.9.

18.3.11 The Parties agree to report to each other in writing as soon as practical all accidents or occurrences resulting in injuries to any person, including death, and any property damage arising out of this LGIA.

ARTICLE 19. ASSIGNMENT

19.1 **Assignment**. This LGIA may be assigned by a Party only with the written consent of the other Parties; provided that a Party may assign this LGIA without the consent of the other Parties to any Affiliate of the assigning Party with an equal or greater credit rating and with the legal authority and operational ability to satisfy the obligations of the assigning Party under this LGIA; and provided further that the Interconnection Customer shall have the right to assign this LGIA, without the consent of the CAISO or Participating TO, for collateral security purposes to aid in providing financing for the Large Generating Facility, provided that the Interconnection Customer will promptly notify the CAISO and Participating TO of any such assignment. Any financing arrangement entered into by the Interconnection Customer pursuant to this Article will provide that prior to or upon the exercise of the secured party's, trustee's or mortgagee's assignment rights pursuant to said arrangement, the secured creditor, the trustee or mortgagee will notify the CAISO and Participating TO of the date and particulars of any such exercise of assignment right(s), including providing the CAISO and Participating TO with proof that it meets the requirements of Articles 11.5 and 18.3. Any attempted assignment that violates this Article is void and ineffective. Any assignment under this LGIA shall not relieve a Party of its obligations, nor shall a Party's obligations be enlarged, in whole or in part, by reason thereof. Where required, consent to assignment will not be unreasonably withheld, conditioned or delayed.

ARTICLE 20. SEVERABILITY

20.1 Severability. If any provision in this LGIA is finally determined to be invalid, void or unenforceable by any court or other Governmental Authority having jurisdiction, such determination shall not invalidate, void or make unenforceable any other provision, agreement or covenant of this LGIA; provided that if the Interconnection Customer (or any third party, but only if such third party is not acting at the direction of the Participating TO or CAISO) seeks and obtains such a final determination with respect to any provision of the Alternate Option (Article 5.1.2), or the Negotiated Option (Article 5.1.4), then none of the provisions of Article 5.1.2 or 5.1.4 shall thereafter have any force or effect and the Parties' rights and obligations shall be governed solely by the Standard Option (Article 5.1.1).

ARTICLE 21. COMPARABILITY

21.1 Comparability. The Parties will comply with all applicable comparability and code of conduct laws, rules and regulations, as amended from time to time.

ARTICLE 22. CONFIDENTIALITY

22.1 Confidentiality. Confidential Information shall include, without limitation, all information relating to a Party's technology, research and development, business affairs, and pricing, and any information supplied by any of the Parties to the other Parties prior to the execution of this LGIA.

Information is Confidential Information only if it is clearly designated or marked in writing as confidential on the face of the document, or, if the information is conveyed orally or by inspection, if the Party providing the information orally informs the Parties receiving the information that the information is confidential.

If requested by any Party, the other Parties shall provide in writing, the basis for asserting that the information referred to in this Article 22 warrants confidential treatment, and the requesting Party may disclose such writing to the appropriate Governmental Authority. Each Party shall be responsible for the costs associated with affording confidential treatment to its information.

22.1.1 Term. During the term of this LGIA, and for a period of three (3) years after the expiration or termination of this LGIA, except as otherwise provided in this Article 22, each Party shall hold in confidence and shall not disclose to any person Confidential Information.

22.1.2 Scope. Confidential Information shall not include information that the receiving Party can demonstrate: (1) is generally available to the public other than as a result of a disclosure by the receiving Party; (2) was in the lawful possession of the receiving Party on a non-confidential basis before receiving it from the disclosing Party; (3) was supplied to the receiving Party without restriction by a third party, who, to the knowledge of the receiving Party after due inquiry, was under no obligation to the disclosing Party to keep such information confidential; (4) was independently developed by the receiving Party without reference to Confidential Information of the disclosing Party; (5) is, or becomes, publicly known, through no wrongful act or omission of the receiving Party or Breach of this LGIA; or (6) is required, in accordance with Article 22.1.7 of this LGIA, Order of Disclosure, to be disclosed by any Governmental Authority or is otherwise required to be disclosed by law or subpoena, or is necessary in any legal proceeding establishing rights and obligations under this LGIA. Information designated as Confidential Information will no longer be deemed confidential if the Party that designated the information as confidential notifies the other Parties that it no longer is confidential.

22.1.3 Release of Confidential Information. No Party shall release or disclose Confidential Information to any other person, except to its employees, consultants, Affiliates (limited by the Standards of Conduct requirements set forth in Part 358 of FERC's Regulations, 18 C.F.R. 358), subcontractors, or to parties who may be or considering providing financing to or equity participation with the Interconnection Customer, or to potential purchasers or assignees of the Interconnection Customer, on a need-to-know basis in connection with this LGIA, unless such person has first been advised of the confidentiality provisions of this Article 22 and has agreed to comply with such provisions. Notwithstanding the foregoing, a Party providing Confidential Information to any person shall remain primarily responsible for any release of Confidential Information in contravention of this Article 22.

22.1.4 Rights. Each Party retains all rights, title, and interest in the Confidential Information that each Party discloses to the other Parties. The disclosure by each Party to the other Parties of Confidential Information shall not be deemed a waiver by a Party or any other person or entity of the right to protect the Confidential Information from public disclosure.

22.1.5 No Warranties. The mere fact that a Party has provided Confidential Information does not constitute a warranty or representation as to its accuracy or completeness. In addition, by supplying Confidential Information, no Party obligates itself to provide any particular information or Confidential Information to the other Parties nor to enter into any further agreements or proceed with any other relationship or joint venture.

22.1.6 Standard of Care. Each Party shall use at least the same standard of care to protect Confidential Information it receives as it uses to protect its own Confidential Information from unauthorized disclosure, publication or dissemination. Each Party may use Confidential Information solely to fulfill its obligations to the other Parties under this LGIA or its regulatory requirements.

22.1.7 Order of Disclosure. If a court or a Government Authority or entity with the right, power, and apparent authority to do so requests or requires any Party, by subpoena, oral deposition, interrogatories, requests for production of documents, administrative order, or otherwise, to disclose Confidential Information, that Party shall provide the other Parties with prompt notice of such request(s) or requirement(s) so that the other Parties may seek an appropriate protective order or waive compliance with the terms of this LGIA. Notwithstanding the absence of a protective order or waiver, the Party may disclose such Confidential Information which, in the opinion of its counsel, the Party is legally compelled to disclose. Each Party will use Reasonable Efforts to obtain reliable assurance that confidential treatment will be accorded any Confidential Information so furnished.

22.1.8 Termination of Agreement. Upon termination of this LGIA for any reason, each Party shall, within ten (10) Calendar Days of receipt of a written request from another Party, use Reasonable Efforts to destroy, erase, or delete (with such destruction, erasure, and deletion certified in writing to the other Party) or return to the other Party, without retaining copies thereof, any and all written or electronic Confidential Information received from the other Party.

22.1.9 Remedies. The Parties agree that monetary damages would be inadequate to compensate a Party for another Party's Breach of its obligations under this Article 22. Each Party accordingly agrees that the other Parties shall be entitled to equitable relief, by way of injunction or otherwise, if the first Party Breaches or threatens to Breach its obligations under this Article 22, which equitable relief shall be granted without bond or proof of damages, and the receiving Party shall not plead in defense that there would be an adequate remedy at law. Such remedy shall not be deemed an exclusive remedy for the Breach of this Article 22, but shall be in addition to all other remedies available at law or in equity. The Parties further acknowledge and agree that the covenants contained herein are necessary for the protection of legitimate business interests and are reasonable in scope. No Party, however, shall be liable for indirect, incidental, or consequential or punitive damages of any nature or kind resulting from or arising in connection with this Article 22.

22.1.10 Disclosure to FERC, its Staff, or a State. Notwithstanding anything in this Article 22 to the contrary, and pursuant to 18 C.F.R. section 1b.20, if FERC or its staff, during the course of an investigation or otherwise, requests information from one of the Parties that is otherwise required to be maintained in confidence pursuant to this LGIA, the Party shall provide the requested information to FERC or its staff, within the time provided for in the request for information. In providing the information to FERC or its staff, the Party must, consistent with 18 C.F.R. section 388.112, request that the information be treated as confidential and non-public by FERC and its staff and that the information be withheld from public disclosure. Parties are prohibited from notifying the other Parties to this LGIA prior to the release of the Confidential Information to FERC or its staff. The Party shall notify the other Parties to the LGIA when it is notified by FERC or its staff that a request to release Confidential Information has been received by FERC, at which time any of the Parties may respond before such information would be made public, pursuant to 18 C.F.R. section 388.112. Requests from a state regulatory body conducting a confidential investigation shall be treated in a similar manner if consistent with the applicable state rules and regulations.

22.1.11 Subject to the exception in Article 22.1.10, Confidential Information shall not be disclosed by the other Parties to any person not employed or retained by the other Parties, except to the extent disclosure is (i) required by law; (ii) reasonably deemed by the disclosing Party to be required to be disclosed in connection with a dispute between or among the Parties, or the defense of litigation or dispute; (iii) otherwise permitted by consent of the other Parties, such consent not to be unreasonably withheld; or (iv) necessary to fulfill its obligations under this LGIA or as a transmission service provider or a Balancing Authority including disclosing the Confidential Information to an RTO or ISO or to a regional or national reliability organization. The Party asserting confidentiality shall notify the other Parties in writing of the information it claims is confidential. Prior to any disclosures of another Party's Confidential Information under this subparagraph, or if any third party or Governmental Authority makes any request or demand for any of the information described in this subparagraph, the disclosing Party agrees to promptly notify the other Party in writing and agrees to assert confidentiality and cooperate with the other Party in seeking to protect the Confidential Information from public disclosure by confidentiality agreement, protective order or other reasonable measures.

ARTICLE 23. ENVIRONMENTAL RELEASES

23.1 Each Party shall notify the other Parties, first orally and then in writing, of the release of any Hazardous Substances, any asbestos or lead abatement activities, or any type of remediation activities related to the Large Generating Facility or the Interconnection Facilities, each of which may reasonably be expected to affect the other Parties. The notifying Party shall: (i) provide the notice as soon as practicable, provided such Party makes a good faith effort to provide the notice no later than twenty-four hours after such Party becomes aware of the occurrence; and (ii) promptly furnish to the other Parties copies of any publicly available reports filed with any Governmental Authorities addressing such events.

ARTICLE 24. INFORMATION REQUIREMENTS

24.1 **Information Acquisition**. The Participating TO and the Interconnection Customer shall submit specific information regarding the electrical characteristics of their respective facilities to each other as described below and in accordance with Applicable Reliability Standards.

24.2 **Information Submission by Participating TO**. The initial information submission by the Participating TO shall occur no later than one hundred eighty (180) Calendar Days prior to Trial Operation and shall include the Participating TO's Transmission System information necessary to allow the Interconnection Customer to select equipment and meet any system protection and stability requirements, unless otherwise agreed to by the Participating TO and the Interconnection Customer. On a monthly basis the Participating TO shall provide the Interconnection Customer and the CAISO a status report on the construction and installation of the Participating TO's Interconnection Facilities and Network Upgrades, including, but not limited to, the following information: (1) progress to date; (2) a description of the activities since the last report; (3) a description of the action items for the next period; and (4) the delivery status of equipment ordered.

24.3 **Updated Information Submission by Interconnection Customer**. The updated information submission by the Interconnection Customer, including manufacturer information, shall occur no later than one hundred eighty (180) Calendar Days prior to the Trial Operation. The Interconnection Customer shall submit a completed copy of the Electric Generating Unit data requirements contained in Appendix 1 to the LGIP. It shall also include any additional information provided to the Participating TO and the CAISO for the Interconnection Studies. Information in this submission shall be the most current Electric Generating Unit design or expected performance data. Information submitted for stability models shall be compatible with the Participating TO and CAISO standard models. If there is no compatible model, the Interconnection Customer will work with a consultant mutually agreed to by the Parties to develop and supply a standard model and associated information.

If the Interconnection Customer's data is materially different from what was originally provided to the Participating TO and the CAISO for the Interconnection Studies, then the Participating TO and the CAISO will conduct appropriate studies pursuant to the LGIP to determine the impact on the Participating TO's Transmission System and affected portions of the CAISO Controlled Grid based on the actual data submitted pursuant to this Article 24.3. The Interconnection Customer shall not begin Trial Operation until such studies are completed and all other requirements of this LGIA are satisfied.

24.4 **Information Supplementation**. Prior to the Trial Operation date, the Parties shall supplement their information submissions described above in this Article 24 with any and all "as-built" Electric Generating Unit information or "as-tested" performance information that differs from the initial submissions or, alternatively, written confirmation that no such differences exist. The Interconnection Customer shall conduct tests on the Electric Generating Unit as required by Good Utility Practice such as an open circuit "step voltage" test on the Electric Generating Unit to verify proper operation of the Electric Generating Unit's automatic voltage regulator.

Unless otherwise agreed, the test conditions shall include: (1) Electric Generating Unit at synchronous speed; (2) automatic voltage regulator on and in voltage control mode; and (3) a five percent (5 percent) change in Electric Generating Unit terminal voltage initiated by a change in the voltage regulators reference voltage. The Interconnection Customer shall provide validated test recordings showing the responses of Electric Generating Unit terminal and field voltages. In the event that direct recordings of these voltages is impractical, recordings of other voltages or currents that mirror the response of the Electric Generating Unit's terminal or field voltage are acceptable if information necessary to translate these alternate quantities to actual Electric Generating Unit terminal or field voltages is provided. Electric Generating Unit testing shall be conducted and results provided to the Participating TO and the CAISO for each individual Electric Generating Unit in a station.

Subsequent to the Commercial Operation Date, the Interconnection Customer shall provide the Participating TO and the CAISO any information changes due to equipment replacement, repair, or adjustment. The Participating TO shall provide the Interconnection Customer any information changes due to equipment replacement, repair or adjustment in the directly connected substation or any adjacent Participating TO-owned substation that may affect the Interconnection Customer's Interconnection Facilities equipment ratings, protection or operating requirements. The Parties shall provide such information pursuant to Article 5.19.

ARTICLE 25. INFORMATION ACCESS AND AUDIT RIGHTS

25.1 Information Access. Each Party (the "disclosing Party") shall make available to the other Party information that is in the possession of the disclosing Party and is necessary in order for the other Party to: (i) verify the costs incurred by the disclosing Party for which the other Party is responsible under this LGIA; and (ii) carry out its obligations and responsibilities under this LGIA. The Parties shall not use such information for purposes other than those set forth in this Article 25.1 and to enforce their rights under this LGIA. Nothing in this Article 25 shall obligate the CAISO to make available to a Party any third party information in its possession or control if making such third party information available would violate a CAISO Tariff restriction on the use or disclosure of such third party information.

25.2 Reporting of Non-Force Majeure Events. Each Party (the "notifying Party") shall notify the other Parties when the notifying Party becomes aware of its inability to comply with the provisions of this LGIA for a reason other than a Force Majeure event. The Parties agree to cooperate with each other and provide necessary information regarding such inability to comply, including the date, duration, reason for the inability to comply, and corrective actions taken or planned to be taken with respect to such inability to comply. Notwithstanding the foregoing, notification, cooperation or information provided under this Article shall not entitle the Party receiving such notification to allege a cause for anticipatory breach of this LGIA.

25.3 Audit Rights. Subject to the requirements of confidentiality under Article 22 of this LGIA, the Parties' audit rights shall include audits of a Party's costs pertaining to such Party's performance or satisfaction of obligations owed to the other Party under this LGIA, calculation of invoiced amounts, the CAISO's efforts to allocate responsibility for the provision of reactive support to the CAISO Controlled Grid, the CAISO's efforts to allocate responsibility for interruption or reduction of generation on the CAISO Controlled Grid, and each such Party's actions in an Emergency Condition.

25.3.1 The Interconnection Customer and the Participating TO shall each have the right, during normal business hours, and upon prior reasonable notice to the other Party, to audit at its own expense the other Party's accounts and records pertaining to either such Party's performance or either such Party's satisfaction of obligations owed to the other Party under this LGIA. Subject to Article 25.3.2, any audit authorized by this Article shall be performed at the offices where such accounts and records are maintained and shall be limited to those portions of such accounts and records that relate to each such Party's performance and satisfaction of obligations under this LGIA. Each such Party shall keep such accounts and records for a period equivalent to the audit rights periods described in Article 25.4.

25.3.2 Notwithstanding anything to the contrary in Article 25.3, each Party's rights to audit the CAISO's accounts and records shall be as set forth in Section 22.1 of the CAISO Tariff.

25.4 Audit Rights Periods.

25.4.1 Audit Rights Period for Construction-Related Accounts and Records. Accounts and records related to the design, engineering, procurement, and construction of Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades constructed by the Participating TO shall be subject to audit for a period of twenty-four months following the Participating TO's issuance of a final invoice in accordance with Article 12.2. Accounts and records related to the design, engineering, procurement, and construction of Participating TO's Interconnection Facilities and/or Stand Alone Network Upgrades constructed by the Interconnection Customer shall be subject to audit and verification by the Participating TO and the CAISO for a period of twenty-four months following the Interconnection Customer's issuance of a final invoice in accordance with Article 5.2(8).

25.4.2 Audit Rights Period for All Other Accounts and Records. Accounts and records related to a Party's performance or satisfaction of all obligations under this LGIA other than those described in Article 25.4.1 shall be subject to audit as follows: (i) for an audit relating to cost obligations, the applicable audit rights period shall be twenty-four months after the auditing Party's receipt of an invoice giving rise to such cost obligations; and (ii) for an audit relating to all other obligations, the applicable audit rights period shall be twenty-four months after the event for which the audit is sought; provided that each Party's rights to audit the CAISO's accounts and records shall be as set forth in Section 22.1 of the CAISO Tariff.

25.5 Audit Results. If an audit by the Interconnection Customer or the Participating TO determines that an overpayment or an underpayment has occurred with respect to the other Party, a notice of such overpayment or underpayment shall be given to the other Party together with those records from the audit which supports such determination. The Party that is owed payment shall render an invoice to the other Party and such invoice shall be paid pursuant to Article 12 hereof.

25.5.1 Notwithstanding anything to the contrary in Article 25.5, the Interconnection Customer's and Participating TO's rights to audit the CAISO's accounts and records shall be as set forth in Section 22.1 of the CAISO Tariff, and the CAISO's process for remedying an overpayment or underpayment shall be as set forth in the CAISO Tariff.

ARTICLE 26. SUBCONTRACTORS

26.1 **General**. Nothing in this LGIA shall prevent a Party from utilizing the services of any subcontractor as it deems appropriate to perform its obligations under this LGIA; provided, however, that each Party shall require its subcontractors to comply with all applicable terms and conditions of this LGIA in providing such services and each Party shall remain primarily liable to the other Party for the performance of such subcontractor.

26.2 **Responsibility of Principal**. The creation of any subcontract relationship shall not relieve the hiring Party of any of its obligations under this LGIA. The hiring Party shall be fully responsible to the other Parties for the acts or omissions of any subcontractor the hiring Party hires as if no subcontract had been made; provided, however, that in no event shall the CAISO or Participating TO be liable for the actions or inactions of the Interconnection Customer or its subcontractors with respect to obligations of the Interconnection Customer under Article 5 of this LGIA. Any applicable obligation imposed by this LGIA upon the hiring Party shall be equally binding upon, and shall be construed as having application to, any subcontractor of such Party.

26.3 **No Limitation by Insurance**. The obligations under this Article 26 will not be limited in any way by any limitation of subcontractor’s insurance.

ARTICLE 27. DISPUTES

All disputes arising out of or in connection with this LGIA whereby relief is sought by or from the CAISO shall be settled in accordance with the provisions of Article 13 of the CAISO Tariff, except that references to the CAISO Tariff in such Article 13 of the CAISO Tariff shall be read as references to this LGIA. Disputes arising out of or in connection with this LGIA not subject to provisions of Article 13 of the CAISO Tariff shall be resolved as follows:

27.1 **Submission**. In the event either Party has a dispute, or asserts a claim, that arises out of or in connection with this LGIA or its performance, such Party (the “disputing Party”) shall provide the other Party with written notice of the dispute or claim (“Notice of Dispute”). Such dispute or claim shall be referred to a designated senior representative of each Party for resolution on an informal basis as promptly as practicable after receipt of the Notice of Dispute by the other Party. In the event the designated representatives are unable to resolve the claim or dispute through unassisted or assisted negotiations within thirty (30) Calendar Days of the other Party’s receipt of the Notice of Dispute, such claim or dispute may, upon mutual agreement of the Parties, be submitted to arbitration and resolved in accordance with the arbitration procedures set forth below. In the event the Parties do not agree to submit such claim or dispute to arbitration, each Party may exercise whatever rights and remedies it may have in equity or at law consistent with the terms of this LGIA.

27.2 **External Arbitration Procedures**. Any arbitration initiated under this LGIA shall be conducted before a single neutral arbitrator appointed by the Parties. If the Parties fail to agree upon a single arbitrator within ten (10) Calendar Days of the submission of the dispute to arbitration, each Party shall choose one arbitrator who shall sit on a three-member arbitration panel. The two arbitrators so chosen shall within twenty (20) Calendar Days select a third arbitrator to chair the arbitration panel. In either case, the arbitrators shall be knowledgeable in electric utility matters, including electric transmission and bulk power issues, and shall not have any current or past substantial business or financial relationships with any party to the arbitration (except prior arbitration). The arbitrator(s) shall provide each of the Parties an opportunity to be heard and, except as otherwise provided herein, shall conduct the arbitration in accordance with the Commercial Arbitration Rules of the American Arbitration Association (“Arbitration Rules”) and any applicable FERC regulations; provided, however, in the event of a conflict between the Arbitration Rules and the terms of this Article 27, the terms of this Article 27 shall prevail.

27.3 Arbitration Decisions. Unless otherwise agreed by the Parties, the arbitrator(s) shall render a decision within ninety (90) Calendar Days of appointment and shall notify the Parties in writing of such decision and the reasons therefor. The arbitrator(s) shall be authorized only to interpret and apply the provisions of this LGIA and shall have no power to modify or change any provision of this Agreement in any manner. The decision of the arbitrator(s) shall be final and binding upon the Parties, and judgment on the award may be entered in any court having jurisdiction. The decision of the arbitrator(s) may be appealed solely on the grounds that the conduct of the arbitrator(s), or the decision itself, violated the standards set forth in the Federal Arbitration Act or the Administrative Dispute Resolution Act. The final decision of the arbitrator must also be filed with FERC if it affects jurisdictional rates, terms and conditions of service, Interconnection Facilities, or Network Upgrades.

27.4 Costs. Each Party shall be responsible for its own costs incurred during the arbitration process and for the following costs, if applicable: (1) the cost of the arbitrator chosen by the Party to sit on the three member panel and one half of the cost of the third arbitrator chosen; or (2) one half the cost of the single arbitrator jointly chosen by the Parties.

ARTICLE 28. REPRESENTATIONS, WARRANTIES AND COVENANTS

28.1 General. Each Party makes the following representations, warranties and covenants:

28.1.1 Good Standing. Such Party is duly organized, validly existing and in good standing under the laws of the state in which it is organized, formed, or incorporated, as applicable; that it is qualified to do business in the state or states in which the Large Generating Facility, Interconnection Facilities and Network Upgrades owned by such Party, as applicable, are located; and that it has the corporate power and authority to own its properties, to carry on its business as now being conducted and to enter into this LGIA and carry out the transactions contemplated hereby and perform and carry out all covenants and obligations on its part to be performed under and pursuant to this LGIA.

28.1.2 Authority. Such Party has the right, power and authority to enter into this LGIA, to become a Party hereto and to perform its obligations hereunder. This LGIA is a legal, valid and binding obligation of such Party, enforceable against such Party in accordance with its terms, except as the enforceability thereof may be limited by applicable bankruptcy, insolvency, reorganization or other similar laws affecting creditors' rights generally and by general equitable principles (regardless of whether enforceability is sought in a proceeding in equity or at law).

28.1.3 No Conflict. The execution, delivery and performance of this LGIA does not violate or conflict with the organizational or formation documents, or bylaws or operating agreement, of such Party, or any judgment, license, permit, order, material agreement or instrument applicable to or binding upon such Party or any of its assets.

28.1.4 Consent and Approval. Such Party has sought or obtained, or, in accordance with this LGIA will seek or obtain, each consent, approval, authorization, order, or acceptance by any Governmental Authority in connection with the execution, delivery and performance of this LGIA, and it will provide to any Governmental Authority notice of any actions under this LGIA that are required by Applicable Laws and Regulations.

ARTICLE 29. [RESERVED]

ARTICLE 30. MISCELLANEOUS

30.1 **Binding Effect**. This LGIA and the rights and obligations hereof, shall be binding upon and shall inure to the benefit of the successors and assigns of the Parties hereto.

30.2 **Conflicts**. In the event of a conflict between the body of this LGIA and any attachment, appendices or exhibits hereto, the terms and provisions of the body of this LGIA shall prevail and be deemed the final intent of the Parties.

30.3 **Rules of Interpretation**. This LGIA, unless a clear contrary intention appears, shall be construed and interpreted as follows: (1) the singular number includes the plural number and vice versa; (2) reference to any person includes such person's successors and assigns but, in the case of a Party, only if such successors and assigns are permitted by this LGIA, and reference to a person in a particular capacity excludes such person in any other capacity or individually; (3) reference to any agreement (including this LGIA), document, instrument or tariff means such agreement, document, instrument, or tariff as amended or modified and in effect from time to time in accordance with the terms thereof and, if applicable, the terms hereof; (4) reference to any Applicable Laws and Regulations means such Applicable Laws and Regulations as amended, modified, codified, or reenacted, in whole or in part, and in effect from time to time, including, if applicable, rules and regulations promulgated thereunder; (5) unless expressly stated otherwise, reference to any Article, Section or Appendix means such Article of this LGIA or such Appendix to this LGIA, or such Section to the LGIP or such Appendix to the LGIP, as the case may be; (6) "hereunder", "hereof", "herein", "hereto" and words of similar import shall be deemed references to this LGIA as a whole and not to any particular Article or other provision hereof or thereof; (7) "including" (and with correlative meaning "include") means including without limiting the generality of any description preceding such term; and (8) relative to the determination of any period of time, "from" means "from and including", "to" means "to but excluding" and "through" means "through and including".

30.4 **Entire Agreement**. This LGIA, including all Appendices and Schedules attached hereto, constitutes the entire agreement among the Parties with reference to the subject matter hereof, and supersedes all prior and contemporaneous understandings or agreements, oral or written, between or among the Parties with respect to the subject matter of this LGIA. There are no other agreements, representations, warranties, or covenants which constitute any part of the consideration for, or any condition to, any Party's compliance with its obligations under this LGIA.

30.5 **No Third Party Beneficiaries.** This LGIA is not intended to and does not create rights, remedies, or benefits of any character whatsoever in favor of any persons, corporations, associations, or entities other than the Parties, and the obligations herein assumed are solely for the use and benefit of the Parties, their successors in interest and, where permitted, their assigns.

30.6 **Waiver**. The failure of a Party to this LGIA to insist, on any occasion, upon strict performance of any provision of this LGIA will not be considered a waiver of any obligation, right, or duty of, or imposed upon, such Party.

Any waiver at any time by either Party of its rights with respect to this LGIA shall not be deemed a continuing waiver or a waiver with respect to any other failure to comply with any other obligation, right, duty of this LGIA. Termination or Default of this LGIA for any reason by the Interconnection Customer shall not constitute a waiver of the Interconnection Customer's legal rights to obtain an interconnection from the Participating TO. Any waiver of this LGIA shall, if requested, be provided in writing.

30.7 Headings. The descriptive headings of the various Articles of this LGIA have been inserted for convenience of reference only and are of no significance in the interpretation or construction of this LGIA.

30.8 Multiple Counterparts. This LGIA may be executed in two or more counterparts, each of which is deemed an original but all constitute one and the same instrument.

30.9 Amendment. The Parties may by mutual agreement amend this LGIA by a written instrument duly executed by all of the Parties. Such amendment shall become effective and a part of this LGIA upon satisfaction of all Applicable Laws and Regulations.

30.10 Modification by the Parties. The Parties may by mutual agreement amend the Appendices to this LGIA by a written instrument duly executed by all of the Parties. Such amendment shall become effective and a part of this LGIA upon satisfaction of all Applicable Laws and Regulations.

30.11 Reservation of Rights. The CAISO and Participating TO shall each have the right to make a unilateral filing with FERC to modify this LGIA pursuant to section 205 or any other applicable provision of the Federal Power Act and FERC's rules and regulations thereunder with respect to the following Articles of this LGIA and with respect to any rates, terms and conditions, charges, classifications of service, rule or regulation covered by these Articles:

> Recitals, 1, 2.1, 2.2, 2.3, 2.4, 2.6, 3.1, 3.3, 4.1, 4.2, 4.3, 4.4, 5 preamble, 5.4, 5.7, 5.8, 5.9, 5.12, 5.13, 5.18, 5.19.1, 7.1, 7.2, 8, 9.1, 9.2, 9.3, 9.5, 9.6, 9.7, 9.8, 9.10, 10.3, 11.4, 12.1, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24.3, 24.4, 25.1, 25.2, 25.3 (excluding subparts), 25.4.2, 26, 28, 29, 30, Appendix D, Appendix F, Appendix G, and any other Article not reserved exclusively to the Participating TO or the CAISO below.

The Participating TO shall have the exclusive right to make a unilateral filing with FERC to modify this LGIA pursuant to section 205 or any other applicable provision of the Federal Power Act and FERC's rules and regulations thereunder with respect to the following Articles of this LGIA and with respect to any rates, terms and conditions, charges, classifications of service, rule or regulation covered by these Articles:

> 2.5, 5.1, 5.2, 5.3, 5.5, 5.6, 5.10, 5.11, 5.14, 5.15, 5.16, 5.17, 5.19 (excluding 5.19.1), 6, 7.3, 9.4, 9.9, 10.1, 10.2, 10.4, 10.5, 11.1, 11.2, 11.3, 11.5, 12.2, 12.3, 12.4, 24.1, 24.2, 25.3.1, 25.4.1, 25.5 (excluding 25.5.1), 27 (excluding preamble), Appendix A, Appendix B, Appendix C, and Appendix E.

The CAISO shall have the exclusive right to make a unilateral filing with FERC to modify this LGIA pursuant to section 205 or any other applicable provision of the Federal Power Act and FERC's rules and regulations thereunder with respect to the following Articles of this LGIA and with respect to any rates, terms and conditions, charges, classifications of service, rule or regulation covered by these Articles:

> 3.2, 4.5, 11.6, 25.3.2, 25.5.1, and 27 preamble.

The Interconnection Customer, the CAISO, and the Participating TO shall have the right to make a unilateral filing with FERC to modify this LGIA pursuant to section 206 or any other applicable provision of the Federal Power Act and FERC's rules and regulations thereunder; provided that each Party shall have the right to protest any such filing by another Party and to participate fully in any proceeding before FERC in which such modifications may be considered. Nothing in this LGIA shall limit the rights of the Parties or of FERC under sections 205 or 206 of the Federal Power Act and FERC's rules and regulations thereunder, except to the extent that the Parties otherwise mutually agree as provided herein.

30.12 **No Partnership**. This LGIA shall not be interpreted or construed to create an association, joint venture, agency relationship, or partnership among the Parties or to impose any partnership obligation or partnership liability upon any Party. No Party shall have any right, power or authority to enter into any agreement or undertaking for, or act on behalf of, or to act as or be an agent or representative of, or to otherwise bind, another Party.

30.13 **Joint and Several Obligations**. Except as otherwise provided in this LGIA, the obligations of the CAISO, the Participating TO, and the Interconnection Customer are several, and are neither joint nor joint and several.

IN WITNESS WHEREOF, the Parties have executed this LGIA in multiple originals, each of which shall constitute and be an original effective agreement among the Parties.

[Insert name of Participating TO]

By: ______________________

Title: ______________________

Date:

California Independent System Operator Corporation

By: ______________________

Title: ______________________

Date:

[Insert name of Interconnection Customer]

By: ______________________

Title: ______________________

Date:

Appendices to LGIA

Appendix A   Interconnection Facilities, Network Upgrades and Distribution Upgrades

Appendix B   Milestones

Appendix C   Interconnection Details

Appendix D   Security Arrangements Details

Appendix E   Commercial Operation Date

Appendix F   Addresses for Delivery of Notices and Billings

Appendix G   Reliability Management System Agreement

Appendix H   Interconnection Requirements for a Wind Generating Plant

Appendix A
To LGIA

Interconnection Facilities, Network Upgrades and Distribution Upgrades

1. Interconnection Facilities:

(a) [insert Interconnection Customer's Interconnection Facilities]:

(b) [insert Participating TO’s Interconnection Facilities]:

2. Network Upgrades:

(a) [insert Stand Alone Network Upgrades]:

(b) [insert Other Network Upgrades]:

(i) [insert Participating TO’s Reliability Network Upgrades]

(ii) [insert Participating TO’s Delivery Network Upgrades]

3. Distribution Upgrades:

Appendix B
To LGIA

Milestones

Appendix C
To LGIA

Interconnection Details

Appendix D
To LGIA

Security Arrangements Details

Infrastructure security of CAISO Controlled Grid equipment and operations and control hardware and software is essential to ensure day-to-day CAISO Controlled Grid reliability and operational security. FERC will expect the CAISO, all Participating TOs, market participants, and Interconnection Customers interconnected to the CAISO Controlled Grid to comply with the recommendations offered by the President's Critical Infrastructure Protection Board and, eventually, best practice recommendations from the electric reliability authority. All public utilities will be expected to meet basic standards for system infrastructure and operational security, including physical, operational, and cyber-security practices.

The Interconnection Customer shall meet the requirements for security implemented pursuant to the CAISO Tariff, including the CAISO's standards for information security posted on the CAISO's internet web site at the following internet address: http://www.caiso.com/pubinfo/info-security/index.html.

Appendix E
To LGIA

Commercial Operation Date

This Appendix E is a part of the LGIA.

[Date]

[CAISO Address]

[Participating TO Address]

Re: _____________ Electric Generating Unit

Dear _______________:

On **[Date] [Interconnection Customer]** has completed Trial Operation of Unit No. ___. This letter confirms that [Interconnection Customer] commenced Commercial Operation of Unit No. ___ at the Electric Generating Unit, effective as of **[Date plus one day]**.

Thank you.

[Signature]

[Interconnection Customer Representative]

Appendix F
To LGIA

Addresses for Delivery of Notices and Billings

Notices:.

CAISO:

[To be supplied.]

Participating TO:

[To be supplied.]

Interconnection Customer:

[To be supplied.]

Billings and Payments:

Participating TO:

[To be supplied.]

Interconnection Customer:

[To be supplied.]

CAISO:

[To be supplied.]

Alternative Forms of Delivery of Notices (telephone, facsimile or e-mail):

CAISO:

[To be supplied.]

Participating TO:

[To be supplied.]

Interconnection Customer:

[To be supplied.]

Appendix G
To LGIA

Reliability Management System Agreement

RELIABILITY MANAGEMENT SYSTEM AGREEMENT
by and between
[TRANSMISSION OPERATOR]
and
[GENERATOR]

THIS RELIABILITY MANAGEMENT SYSTEM AGREEMENT (the "Agreement"), is entered into this ____ day of _____________, 2002, by and between ________________________ (the "Transmission Operator") and ________________________ (the "Generator").

WHEREAS, there is a need to maintain the reliability of the interconnected electric systems encompassed by the WSCC in a restructured and competitive electric utility industry;

WHEREAS, with the transition of the electric industry to a more competitive structure, it is desirable to have a uniform set of electric system operating rules within the Western Interconnection, applicable in a fair, comparable and non-discriminatory manner, with which all market participants comply; and

WHEREAS, the members of the WSCC, including the Transmission Operator, have determined that a contractual Reliability Management System provides a reasonable, currently available means of maintaining such reliability.

NOW, THEREFORE, in consideration of the mutual agreements contained herein, and other good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, the Transmission Operator and the Generator agree as follows:

1. PURPOSE OF AGREEMENT

The purpose of this Agreement is to maintain the reliable operation of the Western Interconnection through the Generator's commitment to comply with certain reliability standards.

2. DEFINITIONS

In addition to terms defined in the beginning of this Agreement and in the Recitals hereto, for purposes of this Agreement the following terms shall have the meanings set forth beside them below.

Control Area means an electric system or systems, bounded by interconnection metering and telemetry, capable of controlling generation to maintain its interchange schedule with other Control Areas and contributing to frequency regulation of the Western Interconnection.

FERC means the Federal Energy Regulatory Commission or a successor agency.

Member means any party to the WSCC Agreement.

Party means either the Generator or the Transmission Operator and

Parties means both of the Generator and the Transmission Operator.

Reliability Management System or **RMS** means the contractual reliability management program implemented through the WSCC Reliability Criteria Agreement, the WSCC RMS Agreement, this Agreement, and any similar contractual arrangement.

Western Interconnection means the area comprising those states and provinces, or portions thereof, in Western Canada, Northern Mexico and the Western United States in which Members of the WSCC operate synchronously connected transmission systems.

Working Day means Monday through Friday except for recognized legal holidays in the state in which any notice is received pursuant to Section 8.

WSCC means the Western Systems Coordinating Council or a successor entity.

WSCC Agreement means the Western Systems Coordinating Council Agreement dated March 20, 1967, as such may be amended from time to time.

WSCC Reliability Criteria Agreement means the Western Systems Coordinating Council Reliability Criteria Agreement dated June 18, 1999 among the WSCC and certain of its member transmission operators, as such may be amended from time to time.

WSCC RMS Agreement means an agreement between the WSCC and the Transmission Operator requiring the Transmission Operator to comply with the reliability criteria contained in the WSCC Reliability Criteria Agreement.

WSCC Staff means those employees of the WSCC, including personnel hired by the WSCC on a contract basis, designated as responsible for the administration of the RMS.

3. TERM AND TERMINATION

3.1 Term. This Agreement shall become effective [thirty (30) days after the date of issuance of a final FERC order accepting this Agreement for filing without requiring any changes to this Agreement unacceptable to either Party. Required changes to this Agreement shall be deemed unacceptable to a Party only if that Party provides notice to the other Party within fifteen (15) days of issuance of the applicable FERC order that such order is unacceptable].
[Note: if the interconnection agreement is not FERC jurisdictional, replace bracketed language with: [on the later of: (a) the date of execution; or (b) the effective date of the WSCC RMS Agreement.]]

3.2 Notice of Termination of WSCC RMS Agreement. The Transmission Operator shall give the Generator notice of any notice of termination of the WSCC RMS Agreement by the WSCC or by the Transmission Operator within fifteen (15) days of receipt by the WSCC or the Transmission Operator of such notice of termination.

3.3 Termination by the Generator. The Generator may terminate this Agreement as follows:
(a) following the termination of the WSCC RMS Agreement for any reason by the WSCC or by the Transmission Operator, provided such notice is provided within forty-five (45) days of the termination of the WSCC RMS Agreement;
(b) following the effective date of an amendment to the requirements of the WSCC Reliability Criteria Agreement that adversely affects the Generator, provided notice of such termination is given within forty-five (45) days of the date of issuance of a FERC order accepting such amendment for filing, provided further that the forty-five (45) day period within which notice of termination is required may be extended by the Generator for an additional forty-five (45) days if the Generator gives written notice to the Transmission Operator of such requested extension within the initial forty-five (45) day period; or
(c) for any reason on one year’s written notice to the Transmission Operator and the WSCC.

3.4 Termination by the Transmission Operator. The Transmission Operator may terminate this Agreement on thirty (30) days’ written notice following the termination of the WSCC RMS Agreement for any reason by the WSCC or by the Transmission Operator, provided such notice is provided within thirty (30) days of the termination of the WSCC RMS Agreement.

3.5 Mutual Agreement. This Agreement may be terminated at any time by the mutual agreement of the Transmission Operator and the Generator.

4. COMPLIANCE WITH AND AMENDMENT OF WSCC RELIABILITY CRITERIA

4.1 Compliance with Reliability Criteria. The Generator agrees to comply with the requirements of the WSCC Reliability Criteria Agreement, including the applicable WSCC reliability criteria contained in Section IV of Annex A thereof, and, in the event of failure to comply, agrees to be subject to the sanctions applicable to such failure. Each and all of the provisions of the WSCC Reliability Criteria Agreement are hereby incorporated by reference into this Agreement as though set forth fully herein, and the Generator shall for all purposes be considered a Participant, and shall be entitled to all of the rights and privileges and be subject to all of the obligations of a Participant, under and in connection with the WSCC Reliability Criteria Agreement, including but not limited to the rights, privileges and obligations set forth in Sections 5, 6 and 10 of the WSCC Reliability Criteria Agreement.

4.2 Modifications to WSCC Reliability Criteria Agreement. The Transmission Operator shall notify the Generator within fifteen (15) days of the receipt of notice from the WSCC of the initiation of any WSCC process to modify the WSCC Reliability Criteria Agreement. The WSCC RMS Agreement specifies that such process shall comply with the procedures, rules, and regulations then applicable to the WSCC for modifications to reliability criteria.

4.3 Notice of Modifications to WSCC Reliability Criteria Agreement. If, following the process specified in Section 4.2, any modification to the WSCC Reliability Criteria Agreement is to take effect, the Transmission Operator shall provide notice to the Generator at least forty-five (45) days before such modification is scheduled to take effect.

4.4 Effective Date. Any modification to the WSCC Reliability Criteria Agreement shall take effect on the date specified by FERC in an order accepting such modification for filing.

4.5 Transfer of Control or Sale of Generation Facilities. In any sale or transfer of control of any generation facilities subject to this Agreement, the Generator shall as a condition of such sale or transfer require the acquiring party or transferee with respect to the transferred facilities either to assume the obligations of the Generator with respect to this Agreement or to enter into an agreement with the Control Area Operator in substantially the form of this Agreement.

5. SANCTIONS

5.1 Payment of Monetary Sanctions. The Generator shall be responsible for payment directly to the WSCC of any monetary sanction assessed against the Generator pursuant to this Agreement and the WSCC Reliability Criteria Agreement. Any such payment shall be made pursuant to the procedures specified in the WSCC Reliability Criteria Agreement.

5.2 Publication. The Generator consents to the release by the WSCC of information related to the Generator’s compliance with this Agreement only in accordance with the WSCC Reliability Criteria Agreement.

5.3 Reserved Rights. Nothing in the RMS or the WSCC Reliability Criteria Agreement shall affect the right of the Transmission Operator, subject to any necessary regulatory approval, to take such other measures to maintain reliability, including disconnection, which the Transmission Operator may otherwise be entitled to take.

6. THIRD PARTIES

Except for the rights and obligations between the WSCC and Generator specified in Sections 4 and 5, this Agreement creates contractual rights and obligations solely between the Parties. Nothing in this Agreement shall create, as between the Parties or with respect to the WSCC: (1) any obligation or liability whatsoever (other than as expressly provided in this Agreement), or (2) any duty or standard of care whatsoever. In addition, nothing in this Agreement shall create any duty, liability, or standard of care whatsoever as to any other party. Except for the rights, as a third-party beneficiary with respect to Sections 4 and 5, of the WSCC against Generator, no third party shall have any rights whatsoever with respect to enforcement of any provision of this Agreement. Transmission Operator and Generator expressly intend that the WSCC is a third-party beneficiary to this Agreement, and the WSCC shall have the right to seek to enforce against Generator any provisions of Sections 4 and 5, provided that specific performance shall be the sole remedy available to the WSCC pursuant to this Agreement, and Generator shall not be liable to the WSCC pursuant to this Agreement for damages of any kind whatsoever (other than the payment of sanctions to the WSCC, if so construed), whether direct, compensatory, special, indirect, consequential, or punitive.

7. REGULATORY APPROVALS

This Agreement shall be filed with FERC by the Transmission Operator under Section 205 of the Federal Power Act. In such filing, the Transmission Operator shall request that FERC accept this Agreement for filing without modification to become effective on the day after the date of a FERC order accepting this Agreement for filing. [This section shall be omitted for agreements not subject to FERC jurisdiction.]

8. NOTICES

Any notice, demand or request required or authorized by this Agreement to be given in writing to a Party shall be delivered by hand, courier or overnight delivery service, mailed by certified mail (return receipt requested) postage prepaid, faxed, or delivered by mutually agreed electronic means to such Party at the following address:

_______: ________________________________
____
____
____
Fax: ______________

_______: ________________________________
____
____
____
Fax: ______________

The designation of such person and/or address may be changed at any time by either Party upon receipt by the other of written notice. Such a notice served by mail shall be effective upon receipt. Notice transmitted by facsimile shall be effective upon receipt if received prior to 5:00 p.m. on a Working Day, and if not received prior to 5:00 p.m. on a Working Day, receipt shall be effective on the next Working Day.

9. APPLICABILITY

This Agreement (including all appendices hereto and, by reference, the WSCC Reliability Criteria Agreement) constitutes the entire understanding between the Parties hereto with respect to the subject matter hereof, supersedes any and all previous understandings between the Parties with respect to the subject matter hereof, and binds and inures to the benefit of the Parties and their successors.

10. AMENDMENT

No amendment of all or any part of this Agreement shall be valid unless it is reduced to writing and signed by both Parties hereto. The terms and conditions herein specified shall remain in effect throughout the term and shall not be subject to change through application to the FERC or other governmental body or authority, absent the agreement of the Parties.

11. INTERPRETATION

Interpretation and performance of this Agreement shall be in accordance with, and shall be controlled by, the laws of the State of _______________ but without giving effect to the provisions thereof relating to conflicts of law. Article and section headings are for convenience only and shall not affect the interpretation of this Agreement. References to articles, sections and appendices are, unless the context otherwise requires, references to articles, sections and appendices of this Agreement.

12. PROHIBITION ON ASSIGNMENT

This Agreement may not be assigned by either Party without the consent of the other Party, which consent shall not be unreasonably withheld; provided that the Generator may without the consent of the WSCC assign the obligations of the Generator pursuant to this Agreement to a transferee with respect to any obligations assumed by the transferee by virtue of Section 4.5 of this Agreement.

13. SEVERABILITY

If one or more provisions herein shall be invalid, illegal or unenforceable in any respect, it shall be given effect to the extent permitted by applicable law, and such invalidity, illegality or unenforceability shall not affect the validity of the other provisions of this Agreement.

14. COUNTERPARTS

This Agreement may be executed in counterparts and each shall have the same force and effect as an original.

IN WITNESS WHEREOF, the Transmission Operator and the Generator have each caused this Reliability Management System Agreement to be executed by their respective duly authorized officers as of the date first above written.

____

By: ____

Name:____

Title:____

____

By: ____

Name:____

Title:____

Appendix H
To LGIA

INTERCONNECTION REQUIREMENTS FOR AN ASYNCHRONOUS GENERATING FACILITY

Appendix H sets forth interconnection requirements specific to all Asynchronous Generating Facilities. Existing individual generating units of an Asynchronous Generating Facility that are, or have been, interconnected to the CAISO Controlled Grid at the same location are exempt from the requirements of this Appendix H for the remaining life of the existing generating unit. Generating units that are replaced, however, shall meet the requirements of this Appendix H.

A. Technical Requirements Applicable to Asynchronous Generating Facilities

i. Low Voltage Ride-Through (LVRT) Capability

An Asynchronous Generating Facility shall be able to remain online during voltage disturbances up to the time periods and associated voltage levels set forth in the requirements below.

1. An Asynchronous Generating Facility shall remain online for the voltage disturbance caused by any fault on the transmission grid, or within the Asynchronous Generating Facility between the Point of Interconnection and the high voltage terminals of the Asynchronous Generating Facility's step up transformer, having a duration equal to the lesser of the normal three-phase fault clearing time (4-9 cycles) or one-hundred fifty (150) milliseconds, plus any subsequent post-fault voltage recovery to the final steady-state post-fault voltage. Clearing time shall be based on the maximum normal clearing time associated with any three-phase fault location that reduces the voltage at the Asynchronous Generating Facility's Point of Interconnection to 0.2 per-unit of nominal voltage or less, independent of any fault current contribution from the Asynchronous Generating Facility.

2. An Asynchronous Generating Facility shall remain online for any voltage disturbance caused by a single-phase fault on the transmission grid, or within the Asynchronous Generating Facility between the Point of Interconnection and the high voltage terminals of the Asynchronous Generating Facility's step up transformer, with delayed clearing, plus any subsequent post-fault voltage recovery to the final steady-state post-fault voltage. Clearing time shall be based on the maximum backup clearing time associated with a single point of failure (protection or breaker failure) for any single-phase fault location that reduces any phase-to-ground or phase-to-phase voltage at the Asynchronous Generating Facility's Point of Interconnection to 0.2 per-unit of nominal voltage or less, independent of any fault current contribution from the Asynchronous Generating Facility.

3. Remaining on-line shall be defined as continuous connection between the Point of Interconnection and the Asynchronous Generating Facility's units, without any mechanical isolation. Asynchronous Generating Facilities may cease to inject current into the transmission grid during a fault.

4. The Asynchronous Generating Facility is not required to remain on line during multi-phased faults exceeding the duration described in Section A.i.1 of this Appendix H or single-phase faults exceeding the duration described in Section A.i.2 of this Appendix H.

5. The requirements of this Section A.i of this Appendix H do not apply to faults that occur between the Asynchronous Generating Facility's terminals and the high side of the step-up transformer to the the high-voltage transmission system.

6. Asynchronous Generating Facilities may be tripped after the fault period if this action is intended as part of a special protection system.

7. Asynchronous Generating Facilities may meet the requirements of this Section A.i of this Appendix H through the performance of the generating units or by installing additional equipment within the Asynchronous Generating Facility, or by a combination of generating unit performance and additional equipment.

8. The provisions of this Section A.i of this Appendix H apply only if the voltage at the Point of Interconnection has remained within the range of 0.9 and 1.10 per-unit of nominal voltage for the preceding two seconds, excluding any sub-cycle transient deviations.

The requirements of this Section A.i in this Appendix H shall not apply to any Asynchronous Generating Facility that can demonstrate to the CAISO a binding commitment, as of May 18, 2010, to purchase inverters for thirty (30) percent or more of the Generating Facility's maximum Generating Facility Capacity that are incapable of complying with the requirements of this Section A.i in this Appendix H. The Interconnection Customer must include a statement from the inverter manufacturer confirming the inability to comply with this requirement in addition to any information requested by the CAISO to determine the applicability of this exemption.

ii. Frequency Disturbance Ride-Through Capability

An Asynchronous Generating Facility shall comply with the off nominal frequency requirements set forth in the WECC Under Frequency Load Shedding Relay Application Guide or successor requirements as they may be amended from time to time.

iii. Power Factor Design and Operating Requirements (Reactive Power)

1. Asynchronous Generating Facilities shall meet the following design requirements:

    a. An Asynchronous Generating Facility shall be designed to have sufficient reactive power sourcing capability to achieve a net power factor of 0.95 lagging or less at the Point of Interconnection, at the Generating Facility's maximum Generating Facility Capacity. An Asynchronous Generating Facility shall be designed to have net reactive power sourcing and absorption capability sufficient to achieve or exceed the net reactive power range in Figure 1 as a function of the Point of Interconnection voltage, without exceeding the ratings of any equipment in the Asynchronous Generating Facility. The Point of Interconnection voltage is specified in per-unit of the nominal voltage.

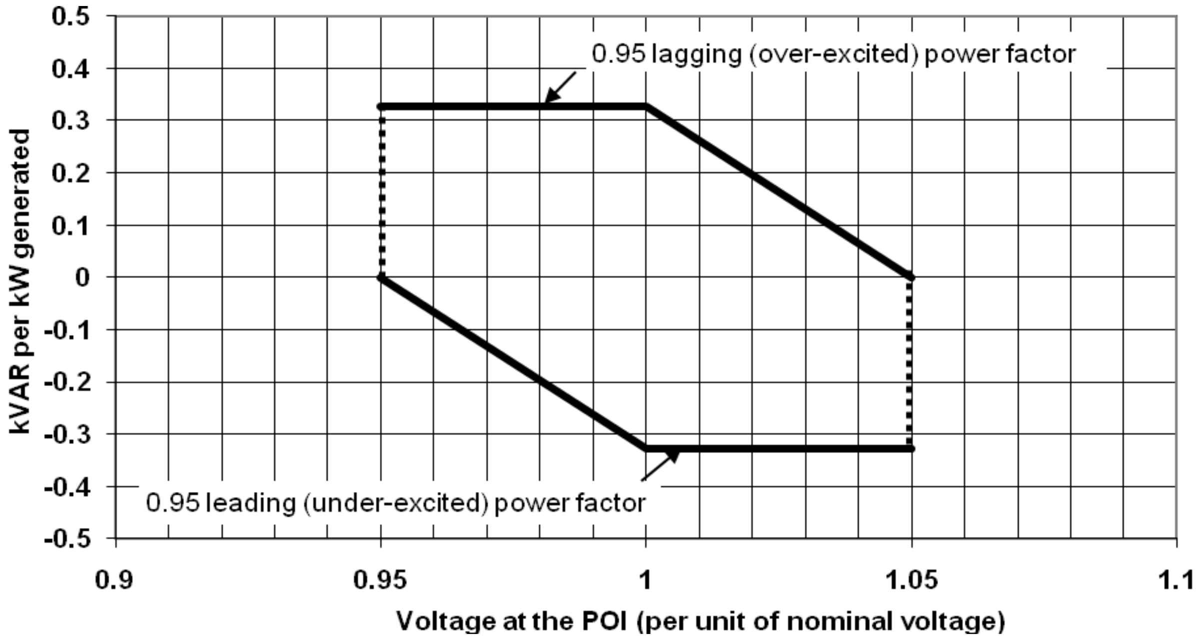

Figure 1

b. Net power factor shall be measured at the Point of Interconnection as defined in this LGIA.

c. Asynchronous Generating Facilities may meet the power factor range requirement by using power electronics designed to supply the required level of reactive capability (taking into account any limitations due to voltage level and real power output) or fixed and switched capacitors, or a combination of the two.

d. Asynchronous Generating Facilities shall also provide dynamic voltage support if the Interconnection Study requires dynamic voltage support for system safety or reliability.

e. Asynchronous Generating Facilities shall vary the reactive power output between the full sourcing and full absorption capabilities such that any step change in the reactive power output does not cause a step change in voltage at the Point of Interconnection greater than 0.02 per unit of the nominal voltage.

f. The maximum voltage change requirement shall apply when the CAISO Controlled Grid is fully intact (no line or transformer outages), or during outage conditions which do not decrease the three-phase short circuit capacity at the Point of Interconnection to less than ninety (90) percent of the three-phase short-circuit capacity that would be present without the transmission network outage.

2. Asynchronous Generating Facilities shall meet the following operational requirements:

   a. When plant output power is greater than twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity, the Asynchronous Generating Facility shall have a net reactive power range at least as great as specified in Figure 1 at the Point of Interconnection, based on the actual real power output level delivered to the Point of Interconnection.

b. Power output may be curtailed at the direction of CAISO to a value where the net power factor range is met, if the reactive power capability of an Asynchronous Generating Facility is partially or totally unavailable, and if continued operation causes deviation of the voltage at the Point of Interconnection outside +/- 0.02 per unit of scheduled voltage level.

c. When the output power of the Asynchronous Generating Facility is less than twenty (20) percent of the Generating Facility's maximum Generating Facility Capacity, the net reactive power shall remain within the range between –6.6% and +6.6% of the Asynchronous Generating Facility's real power rating.

d. If the Point of Interconnection voltage exceeds 1.05 per unit, the Asynchronous Generating Facility shall provide reactive power absorption to the extent possible without violating the ratings of any of the Asynchronous Generating Facility's equipment.

e. If the Point of Interconnection voltage is less than 0.95 per unit, the Asynchronous Generating Facility shall provide reactive power injection to the extent possible without violating the ratings of any of the Asynchronous Generating Facility's equipment.

iv. Voltage Regulation and Reactive Power Control Requirements

1. The Asynchronous Generation Facility's reactive power capability shall be controlled by an automatic system having both voltage regulation and a net power factor regulation operating modes. The default mode of operation will be voltage regulation.

2. The voltage regulation function mode shall automatically control the net reactive power of the Asynchronous Generating Facility to regulate the Point of Interconnection positive sequence component of voltage to within a tolerance of +/- 0.02 per unit of the nominal voltage schedule assigned by the Participating TO or CAISO, within the constraints of the reactive power capacity of the Asynchronous Generation Facility. Deviations outside of this voltage band, except as caused by insufficient reactive capacity to maintain the voltage schedule tolerances, shall not exceed five (5) minutes duration per incident.

3. The power factor mode will regulate the net power factor measured at the Point of Interconnection. If the Asynchronous Generating Facility uses discrete reactive banks to provide reactive capability, the tolerances of the power factor regulation shall be consistent with the reactive banks' sizes meeting the voltage regulation tolerances specified in the preceding paragraph.

4. The net reactive power flow into or out of the Asynchronous Generating Facility, in any mode of operation, shall not cause the positive sequence component of voltage at the Point of Interconnection to exceed 1.05 per unit, or fall below 0.95 per unit.

5. The CAISO, in coordination with the Participating TO, may permit the Interconnection Customer to regulate the voltage at a point on the Asynchronous Generating Facility's side of the Point of Interconnection. Regulating voltage to a point other than the Point of Interconnection shall not change the Asynchronous Generating Facility's net power factor requirements set forth in Section A.iii of this Appendix H.

6. The Interconnection Customer shall not disable voltage regulation controls, without the specific permission of CAISO, while the Asynchronous Generating Facility is in operation at a power level greater than twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity.

v. Plant Power Management

1. As of January 1, 2012, Asynchronous Generating Facilities must have the capability to limit active power output in response to a CAISO Dispatch Instruction or Operating Order as those terms are defined in the CAISO Tariff. This capability shall extend from the Minimum Operating Limit to the Maximum Operating Limit, as those terms are defined in the CAISO Tariff, of the Asynchronous Generating Facility in increments of five (5) MW or less. Changes to the power management set point shall not cause a change in voltage at the Point of Interconnection exceeding 0.02 per unit of the nominal voltage.

2. For Asynchronous Generating Facilities that are also Eligible Intermittent Resources as that term is defined in the CAISO Tariff, these power management requirements establish only a maximum output limit. There is no requirement for the Eligible Intermittent Resource to maintain a level of power output beyond the capabilities of the available energy source.

3. Asynchronous Generating Facilities must have the installed capability to limit power change ramp rates automatically, except for downward ramps resulting from decrease of the available energy resource for Eligible Intermittent Resources. The power ramp control shall be capable of limiting rates of power change to a value of five (5) percent, (10) percent, or twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity per minute. The Asynchronous Generating Facility may implement this ramping limit by using stepped increments if the individual step size is five (5) MW or less.

4. Asynchronous Generating Facilities must have the installed capability to automatically reduce plant power output in response to an over-frequency condition. This frequency response control shall, when enabled at the direction of CAISO, continuously monitor the system frequency and automatically reduce the real power output of the Asynchronous Generating Facility with a droop equal to a one-hundred (100) percent decrease in plant output for a five (5) percent rise in frequency (five (5) percent droop) above an intentional dead band of 0.036 Hz.

vi. Supervisory Control and Data Acquisition (SCADA) and Automated Dispatch System (ADS) Capability

An Asynchronous Generating Facility shall provide SCADA capability to transmit data and receive instructions from the Participating TO and CAISO to protect system reliability. The Participating TO and CAISO and the Asynchronous Generating Facility Interconnection Customer shall determine what SCADA information is essential for the proposed Asynchronous Generating Facility, taking into account the size of the plant and its characteristics, location, and importance in maintaining generation resource adequacy and transmission system reliability.

An Asynchronous Generating Facility must be able to receive and respond to Automated Dispatch System (ADS) instructions and any other form of communication authorized by the CAISO Tariff. The Asynchronous Generating Facility's response time should be capable of conforming to the periods prescribed by the CAISO Tariff.

vii. Power System Stabilizers (PSS)

Power system stabilizers are not required for Asynchronous Generating Facilities.

CAISO TARIFF APPENDIX CC

Large Generator Interconnection Agreement
for Interconnection Requests in a Queue Cluster Window

that are tendered or execute a Large Generator Interconnection Agreement on or after July 3, 2010

LARGE GENERATOR INTERCONNECTION AGREEMENT

[INTERCONNECTION CUSTOMER]

[PARTICIPATING TO]

CALIFORNIA INDEPENDENT SYSTEM OPERATOR CORPORATION

THIS LARGE GENERATOR INTERCONNECTION AGREEMENT ("LGIA") is made and entered into this ____ day of ________________ 20___, by and among _________________, a ________________ organized and existing under the laws of the State/Commonwealth of _________ ("Interconnection Customer" with a Large Generating Facility), _________________, a corporation organized and existing under the laws of the State of California ("**Participating TO**"), and **California Independent System Operator Corporation**, a California nonprofit public benefit corporation organized and existing under the laws of the State of California ("CAISO"). Interconnection Customer, Participating TO, and CAISO each may be referred to as a "Party" or collectively as the "Parties."

RECITALS

WHEREAS, CAISO exercises Operational Control over the CAISO Controlled Grid; and

WHEREAS, the Participating TO owns, operates, and maintains the Participating TO's Transmission System; and

WHEREAS, Interconnection Customer intends to own, lease and/or control and operate the Generating Facility identified as a Large Generating Facility in Appendix C to this LGIA; and

WHEREAS, Interconnection Customer, Participating TO, and CAISO have agreed to enter into this LGIA for the purpose of interconnecting the Large Generating Facility with the Participating TO's Transmission System;

NOW, THEREFORE, in consideration of and subject to the mutual covenants contained herein, it is agreed:

When used in this LGIA, terms with initial capitalization that are not defined in Article 1 shall have the meanings specified in the Article in which they are used.

ARTICLE 1. DEFINITIONS

Adverse System Impact shall mean the negative effects due to technical or operational limits on conductors or equipment being exceeded that may compromise the safety and reliability of the electric system.

Affected System shall mean an electric system other than the CAISO Controlled Grid that may be affected by the proposed interconnection, including the Participating TO's electric system that is not part of the CAISO Controlled Grid.

Affiliate shall mean, with respect to a corporation, partnership or other entity, each such other corporation, partnership or other entity that directly or indirectly, through one or more intermediaries, controls, is controlled by, or is under common control with, such corporation, partnership or other entity.

Applicable Laws and Regulations shall mean all duly promulgated applicable federal, state and local laws, regulations, rules, ordinances, codes, decrees, judgments, directives, or judicial or administrative orders, permits and other duly authorized actions of any Governmental Authority.

Applicable Reliability Council shall mean the Western Electricity Coordinating Council or its successor.

Applicable Reliability Standards shall mean the requirements and guidelines of NERC, the Applicable Reliability Council, and the Balancing Authority Area of the Participating TO's Transmission System to which the Generating Facility is directly connected, including requirements adopted pursuant to Section 215 of the Federal Power Act.

Asynchronous Generating Facility shall mean an induction, doubly-fed, or electronic power generating unit(s) that produces 60 Hz (nominal) alternating current.

Balancing Authority shall mean the responsible entity that integrates resource plans ahead of time, maintains load-interchange-generation balance within a Balancing Authority Area, and supports Interconnection frequency in real time.

Balancing Authority Area shall mean the collection of generation, transmission, and loads within the metered boundaries of the Balancing Authority. The Balancing Authority maintains load-resource balance within this area.

Base Case shall mean the base case power flow, short circuit, and stability data bases used for the Interconnection Studies.

Breach shall mean the failure of a Party to perform or observe any material term or condition of this LGIA.

Breaching Party shall mean a Party that is in Breach of this LGIA.

Business Day shall mean Monday through Friday, excluding federal holidays and the day after Thanksgiving Day.

CAISO Controlled Grid shall mean the system of transmission lines and associated facilities of the parties to the Transmission Control Agreement that have been placed under the CAISO's Operational Control.

CAISO Tariff shall mean the CAISO's tariff, as filed with FERC, and as amended or supplemented from time to time, or any successor tariff.

Calendar Day shall mean any day including Saturday, Sunday or a federal holiday.

Commercial Operation shall mean the status of an Electric Generating Unit or project phase at a Generating Facility that has commenced generating electricity for sale, excluding electricity generated during Trial Operation.

Commercial Operation Date of an Electric Generating Unit or project phase shall mean the date on which the Electric Generating Unit or project phase at the Generating Facility commences Commercial Operation as agreed to by the applicable Participating TO, the CAISO, and the Interconnection Customer pursuant to Appendix E to this LGIA, and in accordance with the implementation plan agreed to by the Participating TO and the CAISO for multiple individual Electric Generating Units or project phases at a Generating Facility where an Interconnection Customer intends to establish separate Commercial Operation Dates for those Electric Generating Units or project phases.

Confidential Information shall mean any confidential, proprietary or trade secret information of a plan, specification, pattern, procedure, design, device, list, concept, policy or compilation relating to the present or planned business of a Party, which is designated as confidential by the Party supplying the information, whether conveyed orally, electronically, in writing, through inspection, or otherwise, subject to Article 22.1.2.

Default shall mean the failure of a Breaching Party to cure its Breach in accordance with Article 17 of this LGIA.

Distribution System shall mean those non-CAISO-controlled transmission and distribution facilities owned by the Participating TO.

Distribution Upgrades shall mean the additions, modifications, and upgrades to the Participating TO's Distribution System. Distribution Upgrades do not include Interconnection Facilities.

Effective Date shall mean the date on which this LGIA becomes effective upon execution by all Parties subject to acceptance by FERC, or if filed unexecuted, upon the date specified by FERC.

Electric Generating Unit shall mean an individual electric generator and its associated plant and apparatus whose electrical output is capable of being separately identified and metered.

Emergency Condition shall mean a condition or situation: (1) that in the judgment of the Party making the claim is imminently likely to endanger life or property; or (2) that, in the case of the CAISO, is imminently likely (as determined in a non-discriminatory manner) to cause a material adverse effect on the security of, or damage to, the CAISO Controlled Grid or the electric systems of others to which the CAISO Controlled Grid is directly connected; (3) that, in the case of the Participating TO, is imminently likely (as determined in a non-discriminatory manner) to cause a material adverse effect on the security of, or damage to, the Participating TO's Transmission System, Participating TO's Interconnection Facilities, Distribution System, or the electric systems of others to which the Participating TO's electric system is directly connected; or (4) that, in the case of the Interconnection Customer, is imminently likely (as determined in a non-discriminatory manner) to cause a material adverse effect on the security of, or damage to, the Generating Facility or Interconnection Customer's Interconnection Facilities. System restoration and black start shall be considered Emergency Conditions; provided, that Interconnection Customer is not obligated by this LGIA to possess black start capability.

Environmental Law shall mean Applicable Laws or Regulations relating to pollution or protection of the environment or natural resources.

Federal Power Act shall mean the Federal Power Act, as amended, 16 U.S.C. §§ 791a et seq.

FERC shall mean the Federal Energy Regulatory Commission or its successor.

Force Majeure shall mean any act of God, labor disturbance, act of the public enemy, war, insurrection, riot, fire, storm or flood, explosion, breakage or accident to machinery or equipment, any order, regulation or restriction imposed by governmental, military or lawfully established civilian authorities, or any other cause beyond a Party's control. A Force Majeure event does not include acts of negligence or intentional wrongdoing by the Party claiming Force Majeure.

Generating Facility shall mean the Interconnection Customer's Electric Generating Unit(s) used for the production of electricity identified in the Interconnection Customer's Interconnection Request, but shall not include the Interconnection Customer's Interconnection Facilities.

Generating Facility Capacity shall mean the net capacity of the Generating Facility and the aggregate net capacity of the Generating Facility where it includes multiple energy production devices.

Good Utility Practice shall mean any of the practices, methods and acts engaged in or approved by a significant portion of the electric utility industry during the relevant time period, or any of the practices, methods and acts which, in the exercise of reasonable judgment in light of the facts known at the time the decision was made, could have been expected to accomplish the desired result at a reasonable cost consistent with good business practices, reliability, safety and expedition. Good Utility Practice is not intended to be any one of a number of the optimum practices, methods, or acts to the exclusion of all others, but rather to be acceptable practices, methods, or acts generally accepted in the region.

Governmental Authority shall mean any federal, state, local or other governmental, regulatory or administrative agency, court, commission, department, board, or other governmental subdivision, legislature, rulemaking board, tribunal, or other governmental authority having jurisdiction over the Parties, their respective facilities, or the respective services they provide, and exercising or entitled to exercise any administrative, executive, police, or taxing authority or power; provided, however, that such term does not include the Interconnection Customer, CAISO, Participating TO, or any Affiliate thereof.

Hazardous Substances shall mean any chemicals, materials or substances defined as or included in the definition of "hazardous substances," "hazardous wastes," "hazardous materials," "hazardous constituents," "restricted hazardous materials," "extremely hazardous substances," "toxic substances," "radioactive substances," "contaminants," "pollutants," "toxic pollutants" or words of similar meaning and regulatory effect under any applicable Environmental Law, or any other chemical, material or substance, exposure to which is prohibited, limited or regulated by any applicable Environmental Law.

Initial Synchronization Date shall mean the date upon which an Electric Generating Unit is initially synchronized and upon which Trial Operation begins.

In-Service Date shall mean the date upon which the Interconnection Customer reasonably expects it will be ready to begin use of the Participating TO's Interconnection Facilities to obtain back feed power.

Interconnection Customer's Interconnection Facilities shall mean all facilities and equipment, as identified in Appendix A of this LGIA, that are located between the Generating Facility and the Point of Change of Ownership, including any modification, addition, or upgrades to such facilities and equipment necessary to physically and electrically interconnect the Generating Facility to the Participating TO's Transmission System. Interconnection Customer's Interconnection Facilities are sole use facilities.

Interconnection Facilities shall mean the Participating TO's Interconnection Facilities and the Interconnection Customer's Interconnection Facilities. Collectively, Interconnection Facilities include all facilities and equipment between the Generating Facility and the Point of Interconnection, including any modification, additions or upgrades that are necessary to physically and electrically interconnect the Generating Facility to the Participating TO's Transmission System. Interconnection Facilities are sole use facilities and shall not include Distribution Upgrades, Stand Alone Network Upgrades or Network Upgrades.

Interconnection Financial Security shall have the meaning assigned to it in Section 1.2 of the LGIP.

Interconnection Handbook shall mean a handbook, developed by the Participating TO and posted on the Participating TO's web site or otherwise made available by the Participating TO, describing technical and operational requirements for wholesale generators and loads connected to the Participating TO's portion of the CAISO Controlled Grid, as such handbook may be modified or superseded from time to time. Participating TO's standards contained in the Interconnection Handbook shall be deemed consistent with Good Utility Practice and Applicable Reliability Standards. In the event of a conflict between the terms of this LGIA and the terms of the Participating TO's Interconnection Handbook, the terms in this LGIA shall apply.

Interconnection Request shall mean a request, in the form of Appendix 1 to the Large Generator Interconnection Procedures, in accordance with the CAISO Tariff.

Interconnection Service shall mean the service provided by the Participating TO and CAISO associated with interconnecting the Interconnection Customer's Generating Facility to the Participating TO's Transmission System and enabling the CAISO Controlled Grid to receive electric energy and capacity from the Generating Facility at the Point of Interconnection, pursuant to the terms of this LGIA, the Participating TO's Transmission Owner Tariff, and the CAISO Tariff.

Interconnection Study shall mean either of the following studies: the Phase I Interconnection Study or the Phase II Interconnection Study conducted or caused to be performed by the CAISO, in coordination with the applicable Participating TO(s), pursuant to the Large Generator Interconnection Procedures.

IRS shall mean the Internal Revenue Service.

Large Generating Facility shall mean a Generating Facility having a Generating Facility Capacity of more than 20 MW.

Large Generator Interconnection Procedures (LGIP) shall mean the CAISO protocol that sets forth the interconnection procedures applicable to an Interconnection Request pertaining to a Large Generating Facility that is included in CAISO Tariff Appendix Y.

Large Generator Interconnection Study Process Agreement shall mean the agreement between the Interconnection Customer and the CAISO for the conduct of the Interconnection Studies.

Loss shall mean any and all damages, losses, and claims, including claims and actions relating to injury to or death of any person or damage to property, demand, suits, recoveries, costs and expenses, court costs, attorney fees, and all other obligations by or to third parties.

Material Modification shall mean those modifications that have a material impact on the cost or timing of any Interconnection Request or any other valid interconnection request with a later queue priority date.

Metering Equipment shall mean all metering equipment installed or to be installed for measuring the output of the Generating Facility pursuant to this LGIA at the metering points, including but not limited to instrument transformers, MWh-meters, data acquisition equipment, transducers, remote terminal unit, communications equipment, phone lines, and fiber optics.

NERC shall mean the North American Electric Reliability Council or its successor organization.

Network Upgrades shall be Participating TO's Delivery Network Upgrades and Participating TO's Reliability Network Upgrades.

Operational Control shall mean the rights of the CAISO under the Transmission Control Agreement and the CAISO Tariff to direct the parties to the Transmission Control Agreement how to operate their transmission lines and facilities and other electric plant affecting the reliability of those lines and facilities for the purpose of affording comparable non-discriminatory transmission access and meeting applicable reliability criteria.

Participating TO's Delivery Network Upgrades shall mean the additions, modifications, and upgrades to the Participating TO's Transmission System at or beyond the Point of Interconnection, other than Reliability Network Upgrades, identified in the Interconnection Studies, as identified in Appendix A, to relieve constraints on the CAISO Controlled Grid.

Participating TO's Interconnection Facilities shall mean all facilities and equipment owned, controlled or operated by the Participating TO from the Point of Change of Ownership to the Point of Interconnection as identified in Appendix A to this LGIA, including any modifications, additions or upgrades to such facilities and equipment. Participating TO's Interconnection Facilities are sole use facilities and shall not include Distribution Upgrades, Stand Alone Network Upgrades or Network Upgrades.

Participating TO's Reliability Network Upgrades shall mean the additions, modifications, and upgrades to the Participating TO's Transmission System at or beyond the Point of Interconnection, identified in the Interconnection Studies, as identified in Appendix A, necessary to interconnect the Large Generating Facility safely and reliably to the Participating TO's Transmission System, which would not have been necessary but for the interconnection of the Large Generating Facility, including additions, modifications, and upgrades necessary to remedy short circuit or stability problems resulting from the interconnection of the Large Generating Facility to the Participating TO's Transmission System. Participating TO's Reliability Network Upgrades also include, consistent with Applicable Reliability Standards and Applicable Reliability Council practice, the Participating TO's facilities necessary to mitigate any adverse impact the Large Generating Facility's interconnection may have on a path's Applicable Reliability Council rating. Participating TO's Reliability Network Upgrades do not include any Participating TO's Delivery Network Upgrades.

Participating TO's Transmission System shall mean the facilities owned and operated by the Participating TO and that have been placed under the CAISO's Operational Control, which facilities form part of the CAISO Controlled Grid.

Party or Parties shall mean the Participating TO, CAISO, Interconnection Customer or the applicable combination of the above.

Phase I Interconnection Study shall mean the engineering study conducted or caused to be performed by the CAISO, in coordination with the applicable Participating TO(s), that evaluates the impact of the proposed interconnection on the safety and reliability of the Participating TO's Transmission System and, if applicable, an Affected System. The study shall identify and detail the system impacts that would result if the Generating Facility(ies) were interconnected without identified project modifications or system modifications, as provided in the On-Peak Deliverability Assessment (as defined in the CAISO Tariff), and other potential impacts, including but not limited to those identified in the Scoping Meeting as described in the Large Generator Interconnection Procedures. The study will also identify the approximate total costs, based on per unit costs, of mitigating these impacts, along with an equitable allocation of those costs to Interconnection Customers for their individual Generating Facilities.

Phase II Interconnection Study shall mean an engineering and operational study conducted or caused to be performed by the CAISO once per calendar year, in coordination with the applicable Participating TO(s), to determine the Point of Interconnection and a list of facilities (including the Participating TO's Interconnection Facilities, Network Upgrades, Distribution Upgrades, and Stand Alone

Network Upgrades), the cost of those facilities, and the time required to interconnect the Generating Facility(ies) with the Participating TO's Transmission System.

Point of Change of Ownership shall mean the point, as set forth in Appendix A to this LGIA, where the Interconnection Customer's Interconnection Facilities connect to the Participating TO's Interconnection Facilities.

Point of Interconnection shall mean the point, as set forth in Appendix A to this LGIA, where the Interconnection Facilities connect to the Participating TO's Transmission System.

QF PGA shall mean a Qualifying Facility Participating Generator Agreement specifying the special provisions for the operating relationship between a Qualifying Facility and the CAISO, a pro forma version of which is set forth in Appendix B.3 of the CAISO Tariff.

Qualifying Facility shall mean a qualifying cogeneration facility or qualifying small power production facility, as defined in the Code of Federal Regulations, Title 18, Part 292 (18 C.F.R. §292).

Reasonable Efforts shall mean, with respect to an action required to be attempted or taken by a Party under this LGIA, efforts that are timely and consistent with Good Utility Practice and are otherwise substantially equivalent to those a Party would use to protect its own interests.

Scoping Meeting shall mean the meeting among representatives of the Interconnection Customer, the Participating TO(s), other Affected Systems, and the CAISO conducted for the purpose of discussing alternative interconnection options, to exchange information including any transmission data and earlier study evaluations that would be reasonably expected to impact such interconnection options, to analyze such information, and to determine the potential feasible Points of Interconnection.

Stand Alone Network Upgrades shall mean Network Upgrades that the Interconnection Customer may construct without affecting day-to-day operations of the CAISO Controlled Grid or Affected Systems during their construction. The Participating TO, the CAISO, and the Interconnection Customer must agree as to what constitutes Stand Alone Network Upgrades and identify them in Appendix A to this LGIA.

System Protection Facilities shall mean the equipment, including necessary protection signal communications equipment, that protects (1) the Participating TO's Transmission System, Participating TO's Interconnection Facilities, CAISO Controlled Grid, and Affected Systems from faults or other electrical disturbances occurring at the Generating Facility and (2) the Generating Facility from faults or other electrical system disturbances occurring on the CAISO Controlled Grid, Participating TO's Interconnection Facilities, and Affected Systems or on other delivery systems or other generating systems to which the CAISO Controlled Grid is directly connected.

Transmission Control Agreement shall mean CAISO FERC Electric Tariff No. 7.

Trial Operation shall mean the period during which the Interconnection Customer is engaged in on-site test operations and commissioning of an Electric Generating Unit prior to Commercial Operation.

ARTICLE 2. EFFECTIVE DATE, TERM AND TERMINATION

2.1 **Effective Date.** This LGIA shall become effective upon execution by all Parties subject to acceptance by FERC (if applicable), or if filed unexecuted, upon the date specified by FERC. The CAISO and Participating TO shall promptly file this LGIA with FERC upon execution in accordance with Article 3.1, if required.

2.2 **Term of Agreement.** Subject to the provisions of Article 2.3, this LGIA shall remain in effect for a period of ____ years from the Effective Date (Term Specified in Individual Agreements to be ten (10) years or such other longer period as the Interconnection Customer may request) and shall be automatically renewed for each successive one-year period thereafter.

2.3 **Termination Procedures.**

2.3.1 **Written Notice.** This LGIA may be terminated by the Interconnection Customer after giving the CAISO and the Participating TO ninety (90) Calendar Days advance written notice, or by the CAISO and the Participating TO notifying FERC after the Generating Facility permanently ceases Commercial Operation.

2.3.2 **Default.** A Party may terminate this LGIA in accordance with Article 17.

2.3.3 **Suspension of Work.** This LGIA may be deemed terminated in accordance with Article 5.16.

2.3.4 Notwithstanding Articles 2.3.1, 2.3.2, and 2.3.3, no termination shall become effective until the Parties have complied with all Applicable Laws and Regulations applicable to such termination, including the filing with FERC of a notice of termination of this LGIA (if applicable), which notice has been accepted for filing by FERC, and the Interconnection Customer has fulfilled its termination cost obligations under Article 2.4.

2.4 **Termination Costs.** Immediately upon the other Parties' receipt of a notice of the termination of this LGIA pursuant to Article 2.3 above, the CAISO and the Participating TO will determine the total cost responsibility of the Interconnection Customer. If, as of the date of the other Parties' receipt of the notice of termination, the Interconnection Customer has not already paid its share of Network Upgrade costs, as set forth in Appendix G to this LGIA, the Participating TO will liquidate the Interconnection Customer's Interconnection Financial Security associated with its cost responsibility for Network Upgrades, in accordance with Section 9.4 of the LGIP.

The Interconnection Customer will also be responsible for all costs incurred or irrevocably committed to be incurred in association with the construction of the Participating TO's Interconnection Facilities (including any cancellation costs relating to orders or contracts for Interconnection Facilities and equipment) and other such expenses, including any Distribution Upgrades for which the Participating TO or CAISO has incurred expenses or has irrevocably committed to incur expenses and has not been reimbursed by the Interconnection Customer, as of the date of the other Parties' receipt of the notice of termination, subject to the limitations set forth in this Article 2.4. Nothing in this Article 2.4 shall limit the Parties' rights under Article 17. If, as of the date of the other Parties' receipt of the notice of termination, the Interconnection Customer has not already reimbursed the Participating TO and the CAISO for costs incurred to construct the Participating TO's Interconnection Facilities, the Participating TO will liquidate the Interconnection Customer's Interconnection Financial Security associated with the construction of the Participating TO's Interconnection Facilities, in accordance with Section 9.4 of the LGIP. If the amount of the Interconnection Financial Security liquidated by the Participating TO under this Article 2.4 is insufficient to compensate the CAISO and the Participating TO for actual costs associated with the construction of the Participating TO's Interconnection Facilities contemplated in this Article, any additional amounts will be the responsibility of the Interconnection Customer, subject to the provisions of Section 9.4 of the LGIP. Any such additional amounts due from the Interconnection Customer beyond the amounts covered by its Interconnection Financial Security will be due to the Participating TO immediately upon termination of this LGIA in accordance with Section 9.4 of the LGIP.

If the amount of the Interconnection Financial Security exceeds the Interconnection Customer's cost responsibility under Section 9.4 of the LGIP, any excess amount will be released to the Interconnection Customer in accordance with Section 9.4 of the LGIP.

2.4.1 Notwithstanding the foregoing, in the event of termination by a Party, all Parties shall use commercially Reasonable Efforts to mitigate the costs, damages and charges arising as a consequence of termination. With respect to any portion of the Participating TO's Interconnection Facilities that have not yet been constructed or installed, the Participating TO shall to the extent possible and with the Interconnection Customer's authorization cancel any pending orders of, or return, any materials or equipment for, or contracts for construction of, such facilities; provided that in the event the Interconnection Customer elects not to authorize such cancellation, the Interconnection Customer shall assume all payment obligations with respect to such materials, equipment, and contracts, and the Participating TO shall deliver such material and equipment, and, if necessary, assign such contracts, to the Interconnection Customer as soon as practicable, at the Interconnection Customer's expense. To the extent that the Interconnection Customer has already paid the Participating TO for any or all such costs of materials or equipment not taken by the Interconnection Customer, the Participating TO shall promptly refund such amounts to the Interconnection Customer, less any costs, including penalties, incurred by the Participating TO to cancel any pending orders of or return such materials, equipment, or contracts.

2.4.2 The Participating TO may, at its option, retain any portion of such materials, equipment, or facilities that the Interconnection Customer chooses not to accept delivery of, in which case the Participating TO shall be responsible for all costs associated with procuring such materials, equipment, or facilities.

2.4.3 With respect to any portion of the Interconnection Facilities, and any other facilities already installed or constructed pursuant to the terms of this LGIA, Interconnection Customer shall be responsible for all costs associated with the removal, relocation or other disposition or retirement of such materials, equipment, or facilities.

2.5 **Disconnection.** Upon termination of this LGIA, the Parties will take all appropriate steps to disconnect the Large Generating Facility from the Participating TO's Transmission System. All costs required to effectuate such disconnection shall be borne by the terminating Party, unless such termination resulted from the non-terminating Party's Default of this LGIA or such non-terminating Party otherwise is responsible for these costs under this LGIA.

2.6 **Survival.** This LGIA shall continue in effect after termination to the extent necessary to provide for final billings and payments and for costs incurred hereunder, including billings and payments pursuant to this LGIA; to permit the determination and enforcement of liability and indemnification obligations arising from acts or events that occurred while this LGIA was in effect; and to permit each Party to have access to the lands of the other Parties pursuant to this LGIA or other applicable agreements, to disconnect, remove or salvage its own facilities and equipment.

ARTICLE 3. REGULATORY FILINGS AND CAISO TARIFF COMPLIANCE

3.1 **Filing.** The Participating TO and the CAISO shall file this LGIA (and any amendment hereto) with the appropriate Governmental Authority(ies), if required. The Interconnection Customer may request that any information so provided be subject to the confidentiality provisions of Article 22. If the Interconnection Customer has executed this LGIA, or any amendment thereto, the Interconnection Customer shall reasonably cooperate with the Participating TO and CAISO with respect to such filing and to provide any information reasonably requested by the Participating TO or CAISO needed to comply with applicable regulatory requirements.

3.2 **Agreement Subject to CAISO Tariff.** The Interconnection Customer will comply with all applicable provisions of the CAISO Tariff, including the LGIP.

3.3 **Relationship Between this LGIA and the CAISO Tariff.** With regard to rights and obligations between the Participating TO and the Interconnection Customer, if and to the extent a matter is specifically addressed by a provision of this LGIA (including any appendices, schedules or other attachments to this LGIA), the provisions of this LGIA shall govern. If and to the extent a provision of this LGIA is inconsistent with the CAISO Tariff and dictates rights and obligations between the CAISO and the Participating TO or the CAISO and the Interconnection Customer, the CAISO Tariff shall govern.

3.4 **Relationship Between this LGIA and the QF PGA.** With regard to the rights and obligations of a Qualifying Facility that has entered into a QF PGA with the CAISO and has entered into this LGIA, if and to the extent a matter is specifically addressed by a provision of the QF PGA that is inconsistent with this LGIA, the terms of the QF PGA shall govern.

ARTICLE 4. SCOPE OF SERVICE

4.1 Interconnection Service. Interconnection Service allows the Interconnection Customer to connect the Large Generating Facility to the Participating TO's Transmission System and be eligible to deliver the Large Generating Facility's output using the available capacity of the CAISO Controlled Grid. To the extent the Interconnection Customer wants to receive Interconnection Service, the Participating TO shall construct facilities identified in Appendices A and C that the Participating TO is responsible to construct.

Interconnection Service does not necessarily provide the Interconnection Customer with the capability to physically deliver the output of its Large Generating Facility to any particular load on the CAISO Controlled Grid without incurring congestion costs. In the event of transmission constraints on the CAISO Controlled Grid, the Interconnection Customer's Large Generating Facility shall be subject to the applicable congestion management procedures in the CAISO Tariff in the same manner as all other resources.

4.2 Provision of Service. The Participating TO and the CAISO shall provide Interconnection Service for the Large Generating Facility.

4.3 Performance Standards. Each Party shall perform all of its obligations under this LGIA in accordance with Applicable Laws and Regulations, Applicable Reliability Standards, and Good Utility Practice, and to the extent a Party is required or prevented or limited in taking any action by such regulations and standards, such Party shall not be deemed to be in Breach of this LGIA for its compliance therewith. If such Party is the CAISO or Participating TO, then that Party shall amend the LGIA and submit the amendment to FERC for approval.

4.4 No Transmission Service. The execution of this LGIA does not constitute a request for, nor the provision of, any transmission service under the CAISO Tariff, and does not convey any right to deliver electricity to any specific customer or point of delivery.

4.5 Interconnection Customer Provided Services. The services provided by Interconnection Customer under this LGIA are set forth in Article 9.6 and Article 13.5.1. Interconnection Customer shall be paid for such services in accordance with Article 11.6.

ARTICLE 5. INTERCONNECTION FACILITIES ENGINEERING, PROCUREMENT, AND CONSTRUCTION

Interconnection Facilities, Network Upgrades, and Distribution Upgrades shall be studied, designed, and constructed pursuant to Good Utility Practice. Such studies, design and construction shall be based on the assumed accuracy and completeness of all technical information received by the Participating TO and the CAISO from the Interconnection Customer associated with interconnecting the Large Generating Facility.

5.1 **Options.** Unless otherwise mutually agreed among the Parties, the Interconnection Customer shall select the In-Service Date, Initial Synchronization Date, and Commercial Operation Date; and either Standard Option or Alternate Option set forth below for completion of the Participating TO's Interconnection Facilities and Network Upgrades as set forth in Appendix A, Interconnection Facilities, Network Upgrades, and Distribution Upgrades, and such dates and selected option shall be set forth in Appendix B, Milestones.

5.1.1 **Standard Option.** The Participating TO shall design, procure, and construct the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades, using Reasonable Efforts to complete the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades by the dates set forth in Appendix B, Milestones. The Participating TO shall not be required to undertake any action which is inconsistent with its standard safety practices, its material and equipment specifications, its design criteria and construction procedures, its labor agreements, and Applicable Laws and Regulations. In the event the Participating TO reasonably expects that it will not be able to complete the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades by the specified dates, the Participating TO shall promptly provide written notice to the Interconnection Customer and the CAISO and shall undertake Reasonable Efforts to meet the earliest dates thereafter.

5.1.2 **Alternate Option.** If the dates designated by the Interconnection Customer are acceptable to the Participating TO, the Participating TO shall so notify the Interconnection Customer within thirty (30) Calendar Days, and shall assume responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities by the designated dates.

If the Participating TO subsequently fails to complete the Participating TO's Interconnection Facilities by the In-Service Date, to the extent necessary to provide back feed power; or fails to complete Network Upgrades by the Initial Synchronization Date to the extent necessary to allow for Trial Operation at full power output, unless other arrangements are made by the Parties for such Trial Operation; or fails to complete the Network Upgrades by the Commercial Operation Date, as such dates are reflected in Appendix B, Milestones; the Participating TO shall pay the Interconnection Customer liquidated damages in accordance with Article 5.3, Liquidated Damages, provided, however, the dates designated by the Interconnection Customer shall be extended day for day for each day that the CAISO refuses to grant clearances to install equipment.

5.1.3 **Option to Build.** If the dates designated by the Interconnection Customer are not acceptable to the Participating TO, the Participating TO shall so notify the Interconnection Customer within thirty (30) Calendar Days, and unless the Parties agree otherwise, the Interconnection Customer shall have the option to assume responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades. If the Interconnection Customer elects to exercise its option to assume responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades, it shall so notify the Participating TO within thirty (30) Calendar Days of receipt of the

Participating TO’s notification that the designated dates are not acceptable to the Participating TO. The Participating TO, CAISO, and Interconnection Customer must agree as to what constitutes Stand Alone Network Upgrades and identify such Stand Alone Network Upgrades in Appendix A to this LGIA. Except for Stand Alone Network Upgrades, the Interconnection Customer shall have no right to construct Network Upgrades under this option.

5.1.4 Negotiated Option. If the Interconnection Customer elects not to exercise its option under Article 5.1.3, Option to Build, the Interconnection Customer shall so notify the Participating TO within thirty (30) Calendar Days of receipt of the Participating TO’s notification that the designated dates are not acceptable to the Participating TO, and the Parties shall in good faith attempt to negotiate terms and conditions (including revision of the specified dates and liquidated damages, the provision of incentives or the procurement and construction of a portion of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades by the Interconnection Customer) pursuant to which the Participating TO is responsible for the design, procurement and construction of the Participating TO's Interconnection Facilities and Network Upgrades. If the Parties are unable to reach agreement on such terms and conditions, the Participating TO shall assume responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities and Network Upgrades pursuant to Article 5.1.1, Standard Option.

5.2 General Conditions Applicable to Option to Build. If the Interconnection Customer assumes responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades,

(1) the Interconnection Customer shall engineer, procure equipment, and construct the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades (or portions thereof) using Good Utility Practice and using standards and specifications provided in advance by the Participating TO;

(2) The Interconnection Customer’s engineering, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades shall comply with all requirements of law to which the Participating TO would be subject in the engineering, procurement or construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades;

(3) the Participating TO shall review, and the Interconnection Customer shall obtain the Participating TO’s approval of, the engineering design, equipment acceptance tests, and the construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades, which approval shall not be unreasonably withheld, and the CAISO may, at its option, review the engineering design, equipment acceptance tests, and the construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades;

(4) prior to commencement of construction, the Interconnection Customer shall provide to the Participating TO, with a copy to the CAISO for informational purposes, a schedule for construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades, and shall promptly respond to requests for information from the Participating TO;

(5) at any time during construction, the Participating TO shall have the right to gain unrestricted access to the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades and to conduct inspections of the same;

(6) at any time during construction, should any phase of the engineering, equipment procurement, or construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades not meet the standards and specifications provided by the Participating TO, the Interconnection Customer shall be obligated to remedy deficiencies in that portion of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades;

(7) the Interconnection Customer shall indemnify the CAISO and Participating TO for claims arising from the Interconnection Customer's construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades under the terms and procedures applicable to Article 18.1 Indemnity;

(8) The Interconnection Customer shall transfer control of the Participating TO's Interconnection Facilities to the Participating TO and shall transfer Operational Control of Stand Alone Network Upgrades to the CAISO;

(9) Unless the Parties otherwise agree, the Interconnection Customer shall transfer ownership of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades to the Participating TO. As soon as reasonably practicable, but within twelve months after completion of the construction of the Participating TO’s Interconnection Facilities and Stand Alone Network Upgrades, the Interconnection Customer shall provide an invoice of the final cost of the construction of the Participating TO’s Interconnection Facilities and Stand Alone Network Upgrades to the Participating TO, which invoice shall set forth such costs in sufficient detail to enable the Participating TO to reflect the proper costs of such facilities in its transmission rate base and to identify the investment upon which refunds will be provided;

(10) the Participating TO shall accept for operation and maintenance the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades to the extent engineered, procured, and constructed in accordance with this Article 5.2; and

(11) The Interconnection Customer’s engineering, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades shall comply with all requirements of the “Option to Build” conditions set forth in Appendix C. Interconnection Customer shall deliver to the Participating TO “as-built” drawings, information, and any other documents that are reasonably required by the Participating TO to assure that the Interconnection Facilities and Stand-Alone Network Upgrades are built to the standards and specifications required by the Participating TO.

5.3 Liquidated Damages. The actual damages to the Interconnection Customer, in the event the Participating TO's Interconnection Facilities or Network Upgrades are not completed by the dates designated by the Interconnection Customer and accepted by the Participating TO pursuant to subparagraphs 5.1.2 or 5.1.4, above, may include Interconnection Customer’s fixed operation and maintenance costs and lost opportunity costs. Such actual damages are uncertain and impossible to determine at this time. Because of such uncertainty, any liquidated damages paid by the Participating TO to the Interconnection Customer in the event that the Participating TO does not complete any portion of the Participating TO's Interconnection Facilities or Network Upgrades by the applicable dates, shall be an amount equal to ½ of 1 percent per day of the actual cost of the Participating TO's Interconnection Facilities and Network Upgrades, in the aggregate, for which the Participating TO has assumed responsibility to design, procure and construct.

However, in no event shall the total liquidated damages exceed 20 percent of the actual cost of the Participating TO’s Interconnection Facilities and Network Upgrades for which the Participating TO has assumed responsibility to design, procure, and construct. The foregoing payments will be made by the Participating TO to the Interconnection Customer as just compensation for the damages caused to the Interconnection Customer, which actual damages are uncertain and impossible to determine at this time, and as reasonable liquidated damages, but not as a penalty or a method to secure performance of this LGIA. Liquidated damages, when the Parties agree to them, are the exclusive remedy for the Participating TO's failure to meet its schedule.

No liquidated damages shall be paid to the Interconnection Customer if: (1) the Interconnection Customer is not ready to commence use of the Participating TO's Interconnection Facilities or Network Upgrades to take the delivery of power for the Electric Generating Unit's Trial Operation or to export power from the Electric Generating Unit on the specified dates, unless the Interconnection Customer would have been able to commence use of the Participating TO's Interconnection Facilities or Network Upgrades to take the delivery of power for Electric Generating Unit's Trial Operation or to export power from the Electric Generating Unit, but for the Participating TO's delay; (2) the Participating TO's failure to meet the specified dates is the result of the action or inaction of the Interconnection Customer or any other interconnection customer who has entered into an interconnection agreement with the CAISO and/or Participating TO, action or inaction by the CAISO, or any cause beyond the Participating TO's reasonable control or reasonable ability to cure; (3) the Interconnection Customer has assumed responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades; or (4) the Parties have otherwise agreed.

In no event shall the CAISO have any responsibility or liability to the Interconnection Customer for liquidated damages pursuant to the provisions of this Article 5.3.

5.4 Power System Stabilizers. The Interconnection Customer shall procure, install, maintain and operate Power System Stabilizers in accordance with Applicable Reliability Standards, the guidelines and procedures established by the Applicable Reliability Council, and the provisions of Section 4.6.5.1 of the CAISO Tariff. The CAISO reserves the right to establish reasonable minimum acceptable settings for any installed Power System Stabilizers, subject to the design and operating limitations of the Large Generating Facility. If the Large Generating Facility's Power System Stabilizers are removed from service or not capable of automatic operation, the Interconnection Customer shall immediately notify the CAISO and the Participating TO and restore the Power System Stabilizers to operation as soon as possible. The CAISO shall have the right to order the reduction in output or disconnection of the Large Generating Facility if the reliability of the CAISO Controlled Grid would be adversely affected as a result of improperly tuned Power System Stabilizers. The requirements of this Article 5.4 shall apply to Asynchronous Generating Facilities in accordance with Appendix H.

5.5 Equipment Procurement. If responsibility for construction of the Participating TO's Interconnection Facilities or Network Upgrades is to be borne by the Participating TO, then the Participating TO shall commence design of the Participating TO's Interconnection Facilities or Network Upgrades and procure necessary equipment as soon as practicable after all of the following conditions are satisfied, unless the Parties otherwise agree in writing:

5.5.1 The CAISO, in coordination with the applicable Participating TO(s), has completed the Phase II Interconnection Study pursuant to the Large Generator Interconnection Facilities Study Process Agreement;

5.5.2 The Participating TO has received written authorization to proceed with design and procurement from the Interconnection Customer by the date specified in Appendix B, Milestones; and

5.5.3 The Interconnection Customer has provided security to the Participating TO in accordance with Article 11.5 by the dates specified in Appendix B, Milestones.

5.6 Construction Commencement. The Participating TO shall commence construction of the Participating TO's Interconnection Facilities and Network Upgrades for which it is responsible as soon as practicable after the following additional conditions are satisfied:

5.6.1 Approval of the appropriate Governmental Authority has been obtained for any facilities requiring regulatory approval;

5.6.2 Necessary real property rights and rights-of-way have been obtained, to the extent required for the construction of a discrete aspect of the Participating TO's Interconnection Facilities and Network Upgrades;

5.6.3 The Participating TO has received written authorization to proceed with construction from the Interconnection Customer by the date specified in Appendix B, Milestones; and

5.6.4 The Interconnection Customer has provided payment and security to the Participating TO in accordance with Article 11.5 by the dates specified in Appendix B, Milestones.

5.7 Work Progress. The Parties will keep each other advised periodically as to the progress of their respective design, procurement and construction efforts. Any Party may, at any time, request a progress report from another Party. If, at any time, the Interconnection Customer determines that the completion of the Participating TO's Interconnection Facilities will not be required until after the specified In-Service Date, the Interconnection Customer will provide written notice to the Participating TO and CAISO of such later date upon which the completion of the Participating TO's Interconnection Facilities will be required.

5.8 Information Exchange. As soon as reasonably practicable after the Effective Date, the Parties shall exchange information regarding the design and compatibility of the Interconnection Customer's Interconnection Facilities and Participating TO's Interconnection Facilities and compatibility of the Interconnection Facilities with the Participating TO's Transmission System, and shall work diligently and in good faith to make any necessary design changes.

5.9 Limited Operation. If any of the Participating TO's Interconnection Facilities or Network Upgrades are not reasonably expected to be completed prior to the Commercial Operation Date of the Electric Generating Unit, the Participating TO and/or CAISO, as applicable, shall, upon the request and at the expense of the Interconnection Customer, perform operating studies on a timely basis to determine the extent to which the Electric Generating Unit and the Interconnection Customer's Interconnection Facilities may operate prior to the completion of the Participating TO's Interconnection Facilities or Network Upgrades consistent with Applicable Laws and Regulations, Applicable Reliability Standards, Good Utility Practice, and this LGIA. The Participating TO and CAISO shall permit Interconnection Customer to operate the Electric Generating Unit and the Interconnection Customer's Interconnection Facilities in accordance with the results of such studies.

5.10 Interconnection Customer's Interconnection Facilities. The Interconnection Customer shall, at its expense, design, procure, construct, own and install the Interconnection Customer's Interconnection Facilities, as set forth in Appendix A.

5.10.1 Large Generating Facility and Interconnection Customer's Interconnection Facilities Specifications. In addition to the Interconnection Customer's responsibility to submit technical data with its Interconnection Request as required by Section 3.5.1 of the LGIP, the Interconnection Customer shall submit all remaining necessary specifications for the Interconnection Customer's Interconnection Facilities and Large Generating Facility, including System Protection Facilities, to the Participating TO and the CAISO at least one hundred eighty (180) Calendar Days prior to the Initial Synchronization Date; and final specifications for review and comment at least ninety (90) Calendar Days prior to the Initial Synchronization Date. The Participating TO and the CAISO shall review such specifications pursuant to this LGIA and the LGIP to ensure that the Interconnection Customer's Interconnection Facilities and Large Generating Facility are compatible with the technical specifications, operational control, safety requirements, and any other applicable requirements of the Participating TO and the CAISO and comment on such specifications within thirty (30) Calendar Days of the Interconnection Customer's submission. All specifications provided hereunder shall be deemed confidential.

5.10.2 Participating TO's and CAISO's Review. The Participating TO's and the CAISO's review of the Interconnection Customer's final specifications shall not be construed as confirming, endorsing, or providing a warranty as to the design, fitness, safety, durability or reliability of the Large Generating Facility, or the Interconnection Customer's Interconnection Facilities. Interconnection Customer shall make such changes to the Interconnection Customer's Interconnection Facilities as may reasonably be required by the Participating TO or the CAISO, in accordance with Good Utility Practice, to ensure that the Interconnection Customer's Interconnection Facilities are compatible with the technical specifications, Operational Control, and safety requirements of the Participating TO or the CAISO.

5.10.3 Interconnection Customer's Interconnection Facilities Construction. The Interconnection Customer's Interconnection Facilities shall be designed and constructed in accordance with Good Utility Practice. Within one hundred twenty (120) Calendar Days after the Commercial Operation Date, unless the Participating TO and Interconnection Customer agree on another mutually acceptable deadline, the Interconnection Customer shall deliver to the Participating TO and CAISO "as-built" drawings, information and documents for the Interconnection Customer's Interconnection Facilities and the Electric Generating Unit(s), such as: a one-line diagram, a site plan showing the Large Generating Facility and the Interconnection Customer's Interconnection Facilities, plan and elevation drawings showing the layout of the Interconnection Customer's Interconnection Facilities, a relay functional diagram, relaying AC and DC schematic wiring diagrams and relay settings for all facilities associated with the Interconnection Customer's step-up transformers, the facilities connecting the Large Generating Facility to the step-up transformers and the Interconnection Customer's Interconnection Facilities, and the impedances (determined by factory tests) for the associated step-up transformers and the Electric Generating Units. The Interconnection Customer shall provide the Participating TO and the CAISO specifications for the excitation system, automatic voltage regulator, Large Generating Facility control and protection settings, transformer tap settings, and communications, if applicable. Any deviations from the relay settings, machine specifications, and other specifications originally submitted by the Interconnection Customer shall be assessed by the Participating TO and the CAISO pursuant to the appropriate provisions of this LGIA and the LGIP.

5.10.4 Interconnection Customer to Meet Requirements of the Participating TO's Interconnection Handbook. The Interconnection Customer shall comply with the Participating TO's Interconnection Handbook.

5.11 Participating TO's Interconnection Facilities Construction. The Participating TO's Interconnection Facilities shall be designed and constructed in accordance with Good Utility Practice. Upon request, within one hundred twenty (120) Calendar Days after the Commercial Operation Date, unless the Participating TO and Interconnection Customer agree on another mutually acceptable deadline, the Participating TO shall deliver to the Interconnection Customer and the CAISO the following "as-built" drawings, information and documents for the Participating TO's Interconnection Facilities [include appropriate drawings and relay diagrams].

The Participating TO will obtain control for operating and maintenance purposes of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades upon completion of such facilities. Pursuant to Article 5.2, the CAISO will obtain Operational Control of the Stand Alone Network Upgrades prior to the Commercial Operation Date.

5.12 **Access Rights.** Upon reasonable notice and supervision by a Party, and subject to any required or necessary regulatory approvals, a Party ("Granting Party") shall furnish at no cost to the other Party ("Access Party") any rights of use, licenses, rights of way and easements with respect to lands owned or controlled by the Granting Party, its agents (if allowed under the applicable agency agreement), or any Affiliate, that are necessary to enable the Access Party to obtain ingress and egress to construct, operate, maintain, repair, test (or witness testing), inspect, replace or remove facilities and equipment to: (i) interconnect the Large Generating Facility with the Participating TO's Transmission System; (ii) operate and maintain the Large Generating Facility, the Interconnection Facilities and the Participating TO's Transmission System; and (iii) disconnect or remove the Access Party's facilities and equipment upon termination of this LGIA. In exercising such licenses, rights of way and easements, the Access Party shall not unreasonably disrupt or interfere with normal operation of the Granting Party's business and shall adhere to the safety rules and procedures established in advance, as may be changed from time to time, by the Granting Party and provided to the Access Party.

5.13 **Lands of Other Property Owners.** If any part of the Participating TO's Interconnection Facilities and/or Network Upgrades are to be installed on property owned by persons other than the Interconnection Customer or Participating TO, the Participating TO shall at the Interconnection Customer's expense use efforts, similar in nature and extent to those that it typically undertakes on its own behalf or on behalf of its Affiliates, including use of its eminent domain authority, and to the extent consistent with state law, to procure from such persons any rights of use, licenses, rights of way and easements that are necessary to construct, operate, maintain, test, inspect, replace or remove the Participating TO's Interconnection Facilities and/or Network Upgrades upon such property.

5.14 **Permits.** Participating TO and Interconnection Customer shall cooperate with each other in good faith in obtaining all permits, licenses and authorization that are necessary to accomplish the interconnection in compliance with Applicable Laws and Regulations. With respect to this paragraph, the Participating TO shall provide permitting assistance to the Interconnection Customer comparable to that provided to the Participating TO's own, or an Affiliate's generation.

5.15 **Early Construction of Base Case Facilities.** The Interconnection Customer may request the Participating TO to construct, and the Participating TO shall construct, using Reasonable Efforts to accommodate Interconnection Customer's In-Service Date, all or any portion of any Network Upgrades required for Interconnection Customer to be interconnected to the Participating TO's Transmission System which are included in the Base Case of the Interconnection Studies for the Interconnection Customer, and which also are required to be constructed for another interconnection customer, but where such construction is not scheduled to be completed in time to achieve Interconnection Customer's In-Service Date.

5.16 **Suspension.** The Interconnection Customer reserves the right, upon written notice to the Participating TO and the CAISO, to suspend at any time all work associated with the construction and installation of the Participating TO's Interconnection Facilities, Network Upgrades, and/or Distribution Upgrades required under this LGIA, other than Network Upgrades identified in the Phase II Interconnection Study as common to multiple Generating Facilities, with the condition that the Participating TO's electrical system and the CAISO Controlled Grid shall be left in a safe and reliable condition in accordance with Good Utility Practice and the Participating TO's safety and reliability criteria and the CAISO's Applicable Reliability Standards. In such event, the Interconnection Customer shall be responsible for all reasonable and necessary costs which the Participating TO (i) has incurred pursuant to this LGIA prior to the suspension and (ii) incurs in suspending such work, including any costs incurred to perform such work as may be necessary to ensure the safety of persons and property and the integrity of the Participating TO's electric system during such suspension and, if applicable, any costs incurred in connection with the cancellation or suspension of material, equipment and labor contracts which the Participating TO cannot reasonably avoid; provided, however, that prior to canceling or suspending any such material, equipment or labor contract, the Participating TO shall obtain Interconnection Customer's authorization to do so.

The Participating TO shall invoice the Interconnection Customer for such costs pursuant to Article 12 and shall use due diligence to minimize its costs. In the event Interconnection Customer suspends work required under this LGIA pursuant to this Article 5.16, and has not requested the Participating TO to recommence the work or has not itself recommenced work required under this LGIA in time to ensure that the new projected Commercial Operation Date for the full Generating Facility Capacity of the Large Generating Facility is no more than three (3) years from the Commercial Operation Date identified in Appendix B hereto, this LGIA shall be deemed terminated and the Interconnection Customer's responsibility for costs will be determined in accordance with Section 2.4 of this LGIA. The suspension period shall begin on the date the suspension is requested, or the date of the written notice to the Participating TO and the CAISO, if no effective date is specified.

5.17 Taxes.

5.17.1 Interconnection Customer Payments Not Taxable. The Parties intend that all payments or property transfers made by the Interconnection Customer to the Participating TO for the installation of the Participating TO's Interconnection Facilities and the Network Upgrades shall be non-taxable, either as contributions to capital, or as a refundable advance, in accordance with the Internal Revenue Code and any applicable state income tax laws and shall not be taxable as contributions in aid of construction or otherwise under the Internal Revenue Code and any applicable state income tax laws.

5.17.2 Representations And Covenants. In accordance with IRS Notice 2001-82 and IRS Notice 88-129, the Interconnection Customer represents and covenants that (i) ownership of the electricity generated at the Large Generating Facility will pass to another party prior to the transmission of the electricity on the CAISO Controlled Grid, (ii) for income tax purposes, the amount of any payments and the cost of any property transferred to the Participating TO for the Participating TO's Interconnection Facilities will be capitalized by the Interconnection Customer as an intangible asset and recovered using the straight-line method over a useful life of twenty (20) years, and (iii) any portion of the Participating TO's Interconnection Facilities that is a "dual-use intertie," within the meaning of IRS Notice 88-129, is reasonably expected to carry only a de minimis amount of electricity in the direction of the Large Generating Facility. For this purpose, "de minimis amount" means no more than 5 percent of the total power flows in both directions, calculated in accordance with the "5 percent test" set forth in IRS Notice 88-129. This is not intended to be an exclusive list of the relevant conditions that must be met to conform to IRS requirements for non-taxable treatment.

At the Participating TO's request, the Interconnection Customer shall provide the Participating TO with a report from an independent engineer confirming its representation in clause (iii), above. The Participating TO represents and covenants that the cost of the Participating TO's Interconnection Facilities paid for by the Interconnection Customer without the possibility of refund or credit will have no net effect on the base upon which rates are determined.

5.17.3 Indemnification for the Cost Consequence of Current Tax Liability Imposed Upon the Participating TO. Notwithstanding Article 5.17.1, the Interconnection Customer shall protect, indemnify and hold harmless the Participating TO from the cost consequences of any current tax liability imposed against the Participating TO as the result of payments or property transfers made by the Interconnection Customer to the Participating TO under this LGIA for Interconnection Facilities, as well as any interest and penalties, other than interest and penalties attributable to any delay caused by the Participating TO.

The Participating TO shall not include a gross-up for the cost consequences of any current tax liability in the amounts it charges the Interconnection Customer under this LGIA unless (i) the Participating TO has determined, in good faith, that the payments or property transfers made by the Interconnection Customer to the Participating TO should be reported as income subject to taxation or (ii) any Governmental Authority directs the Participating TO to report payments or property as income subject to taxation; provided, however, that the Participating TO may require the Interconnection Customer to provide security for Interconnection Facilities, in a form reasonably acceptable to the Participating TO (such as a parental guarantee or a letter of credit), in an amount equal to the cost consequences of any current tax liability under this Article 5.17. The Interconnection Customer shall reimburse the Participating TO for such costs on a fully grossed-up basis, in accordance with Article 5.17.4, within thirty (30) Calendar Days of receiving written notification from the Participating TO of the amount due, including detail about how the amount was calculated.

The indemnification obligation shall terminate at the earlier of (1) the expiration of the ten year testing period and the applicable statute of limitation, as it may be extended by the Participating TO upon request of the IRS, to keep these years open for audit or adjustment, or (2) the occurrence of a subsequent taxable event and the payment of any related indemnification obligations as contemplated by this Article 5.17.

5.17.4 Tax Gross-Up Amount. The Interconnection Customer's liability for the cost consequences of any current tax liability under this Article 5.17 shall be calculated on a fully grossed-up basis. Except as may otherwise be agreed to by the parties, this means that the Interconnection Customer will pay the Participating TO, in addition to the amount paid for the Interconnection Facilities and Network Upgrades, an amount equal to (1) the current taxes imposed on the Participating TO ("Current Taxes") on the excess of (a) the gross income realized by the Participating TO as a result of payments or property transfers made by the Interconnection Customer to the Participating TO under this LGIA (without regard to any payments under this Article 5.17) (the "Gross Income Amount") over (b) the present value of future tax deductions for depreciation that will be available as a result of such payments or property transfers (the "Present Value Depreciation Amount"), plus (2) an additional amount sufficient to permit the Participating TO to receive and retain, after the payment of all Current Taxes, an amount equal to the net amount described in clause (1).

For this purpose, (i) Current Taxes shall be computed based on the Participating TO's composite federal and state tax rates at the time the payments or property transfers are received and the Participating TO will be treated as being subject to tax at the highest marginal rates in effect at that time (the "Current Tax Rate"), and (ii) the Present Value Depreciation Amount shall be computed by discounting the Participating TO's anticipated tax depreciation deductions as a result of such payments or property transfers by the Participating TO's current weighted average cost of capital. Thus, the formula for calculating the Interconnection Customer's liability to the Participating TO pursuant to this Article 5.17.4 can be expressed as follows: (Current Tax Rate x (Gross Income Amount – Present Value of Tax Depreciation))/(1-Current Tax Rate). Interconnection Customer's estimated tax liability in the event taxes are imposed shall be stated in Appendix A, Interconnection Facilities, Network Upgrades and Distribution Upgrades.

5.17.5 Private Letter Ruling or Change or Clarification of Law. At the Interconnection Customer's request and expense, the Participating TO shall file with the IRS a request for a private letter ruling as to whether any property transferred or sums paid, or to be paid, by the Interconnection Customer to the Participating TO under this LGIA are subject to federal income taxation. The Interconnection Customer will prepare the initial draft of the request for a private letter ruling, and will certify under penalties of perjury that all facts represented in such request are true and accurate to the best of the Interconnection Customer's knowledge. The Participating TO and Interconnection Customer shall cooperate in good faith with respect to the submission of such request, provided, however, the Interconnection Customer and the Participating TO explicitly acknowledge (and nothing herein is intended to alter) Participating TO’s obligation under law to certify that the facts presented in the ruling request are true, correct and complete.

The Participating TO shall keep the Interconnection Customer fully informed of the status of such request for a private letter ruling and shall execute either a privacy act waiver or a limited power of attorney, in a form acceptable to the IRS, that authorizes the Interconnection Customer to participate in all discussions with the IRS regarding such request for a private letter ruling. The Participating TO shall allow the Interconnection Customer to attend all meetings with IRS officials about the request and shall permit the Interconnection Customer to prepare the initial drafts of any follow-up letters in connection with the request.

5.17.6 Subsequent Taxable Events. If, within 10 years from the date on which the relevant Participating TO's Interconnection Facilities are placed in service, (i) the Interconnection Customer Breaches the covenants contained in Article 5.17.2, (ii) a "disqualification event" occurs within the meaning of IRS Notice 88-129, or (iii) this LGIA terminates and the Participating TO retains ownership of the Interconnection Facilities and Network Upgrades, the Interconnection Customer shall pay a tax gross-up for the cost consequences of any current tax liability imposed on the Participating TO, calculated using the methodology described in Article 5.17.4 and in accordance with IRS Notice 90-60.

5.17.7 Contests. In the event any Governmental Authority determines that the Participating TO’s receipt of payments or property constitutes income that is subject to taxation, the Participating TO shall notify the Interconnection Customer, in writing, within thirty (30) Calendar Days of receiving notification of such determination by a Governmental Authority. Upon the timely written request by the Interconnection Customer and at the Interconnection Customer's sole expense, the Participating TO may appeal, protest, seek abatement of, or otherwise oppose such determination. Upon the Interconnection Customer's written request and sole expense, the Participating TO may file a claim for refund with respect to any taxes paid under this Article 5.17, whether or not it has received such a determination. The Participating TO reserve the right to make all decisions with regard to the prosecution of such appeal, protest, abatement or other contest, including the selection of counsel and compromise or settlement of the claim, but the Participating TO shall keep the Interconnection Customer informed, shall consider in good faith suggestions from the Interconnection Customer about the conduct of the contest, and shall reasonably permit the Interconnection Customer or an Interconnection Customer representative to attend contest proceedings.

The Interconnection Customer shall pay to the Participating TO on a periodic basis, as invoiced by the Participating TO, the Participating TO’s documented reasonable costs of prosecuting such appeal, protest, abatement or other contest, including any costs associated with obtaining the opinion of independent tax counsel described in this Article 5.17.7. The Participating TO may abandon any contest if the Interconnection Customer fails to provide payment to the Participating TO within thirty (30) Calendar Days of receiving such invoice.

At any time during the contest, the Participating TO may agree to a settlement either with the Interconnection Customer's consent or, if such consent is refused, after obtaining written advice from independent nationally-recognized tax counsel, selected by the Participating TO, but reasonably acceptable to the Interconnection Customer, that the proposed settlement represents a reasonable settlement given the hazards of litigation. The Interconnection Customer's obligation shall be based on the amount of the settlement agreed to by the Interconnection Customer, or if a higher amount, so much of the settlement that is supported by the written advice from nationally-recognized tax counsel selected under the terms of the preceding paragraph. The settlement amount shall be calculated on a fully grossed-up basis to cover any related cost consequences of the current tax liability. The Participating TO may also settle any tax controversy without receiving the Interconnection Customer's consent or any such written advice; however, any such settlement will relieve the Interconnection Customer from any obligation to indemnify the Participating TO for the tax at issue in the contest (unless the failure to obtain written advice is attributable to the Interconnection Customer's unreasonable refusal to the appointment of independent tax counsel).

5.17.8 Refund. In the event that (a) a private letter ruling is issued to the Participating TO which holds that any amount paid or the value of any property transferred by the Interconnection Customer to the Participating TO under the terms of this LGIA is not subject to federal income taxation, (b) any legislative change or administrative announcement, notice, ruling or other determination makes it reasonably clear to the Participating TO in good faith that any amount paid or the value of any property transferred by the Interconnection Customer to the Participating TO under the terms of this LGIA is not taxable to the Participating TO, (c) any abatement, appeal, protest, or other contest results in a determination that any payments or transfers made by the Interconnection Customer to the Participating TO are not subject to federal income tax, or (d) if the Participating TO receives a refund from any taxing authority for any overpayment of tax attributable to any payment or property transfer made by the Interconnection Customer to the Participating TO pursuant to this LGIA, the Participating TO shall promptly refund to the Interconnection Customer the following:

(i) any payment made by Interconnection Customer under this Article 5.17 for taxes that is attributable to the amount determined to be non-taxable, together with interest thereon,

(ii) interest on any amounts paid by the Interconnection Customer to the Participating TO for such taxes which the Participating TO did not submit to the taxing authority, calculated in accordance with the methodology set forth in FERC's regulations at 18 C.F.R. §35.19a(a)(2)(iii) from the date payment was made by the Interconnection Customer to the date the Participating TO refunds such payment to the Interconnection Customer, and

(iii) with respect to any such taxes paid by the Participating TO, any refund or credit the Participating TO receives or to which it may be entitled from any Governmental Authority, interest (or that portion thereof attributable to the payment described in clause (i), above) owed to the Participating TO for such overpayment of taxes (including any reduction in interest otherwise payable by the Participating TO to any Governmental Authority resulting from an offset or credit); provided, however, that the Participating TO will remit such amount promptly to the Interconnection Customer only after and to the extent that the Participating TO has received a tax refund, credit or offset from any Governmental Authority for any applicable overpayment of income tax related to the Participating TO's Interconnection Facilities.

The intent of this provision is to leave the Parties, to the extent practicable, in the event that no taxes are due with respect to any payment for Interconnection Facilities and Network Upgrades hereunder, in the same position they would have been in had no such tax payments been made.

5.17.9 Taxes Other Than Income Taxes. Upon the timely request by the Interconnection Customer, and at the Interconnection Customer's sole expense, the CAISO or Participating TO may appeal, protest, seek abatement of, or otherwise contest any tax (other than federal or state income tax) asserted or assessed against the CAISO or Participating TO for which the Interconnection Customer may be required to reimburse the CAISO or Participating TO under the terms of this LGIA. The Interconnection Customer shall pay to the Participating TO on a periodic basis, as invoiced by the Participating TO, the Participating TO's documented reasonable costs of prosecuting such appeal, protest, abatement, or other contest. The Interconnection Customer, the CAISO, and the Participating TO shall cooperate in good faith with respect to any such contest. Unless the payment of such taxes is a prerequisite to an appeal or abatement or cannot be deferred, no amount shall be payable by the Interconnection Customer to the CAISO or Participating TO for such taxes until they are assessed by a final, non-appealable order by any court or agency of competent jurisdiction. In the event that a tax payment is withheld and ultimately due and payable after appeal, the Interconnection Customer will be responsible for all taxes, interest and penalties, other than penalties attributable to any delay caused by the Participating TO.

5.18 Tax Status. Each Party shall cooperate with the others to maintain the other Parties' tax status. Nothing in this LGIA is intended to adversely affect the CAISO's or any Participating TO's tax exempt status with respect to the issuance of bonds including, but not limited to, Local Furnishing Bonds.

5.19 Modification.

5.19.1 General. The Interconnection Customer or the Participating TO may undertake modifications to its facilities, subject to the provisions of this LGIA and the CAISO Tariff. If a Party plans to undertake a modification that reasonably may be expected to affect the other Parties' facilities, that Party shall provide to the other Parties sufficient information regarding such modification so that the other Parties may evaluate the potential impact of such modification prior to commencement of the work. Such information shall be deemed to be confidential hereunder and shall include information concerning the timing of such modifications and whether such modifications are expected to interrupt the flow of electricity from the Large Generating Facility. The Party desiring to perform such work shall provide the relevant drawings, plans, and specifications to the other Parties at least ninety (90) Calendar Days in advance of the commencement of the work or such shorter period upon which the Parties may agree, which agreement shall not unreasonably be withheld, conditioned or delayed.

In the case of Large Generating Facility modifications that do not require the Interconnection Customer to submit an Interconnection Request, the CAISO or Participating TO shall provide, within thirty (30) Calendar Days (or such other time as the Parties may agree), an estimate of any additional modifications to the CAISO Controlled Grid, Participating TO's Interconnection Facilities, Network Upgrades or Distribution Upgrades necessitated by such Interconnection Customer modification and a good faith estimate of the costs thereof. The Participating TO and the CAISO shall determine if a Large Generating Facility modification is a Material Modification in accordance with the LGIP.

5.19.2 Standards. Any additions, modifications, or replacements made to a Party's facilities shall be designed, constructed and operated in accordance with this LGIA and Good Utility Practice.

5.19.3 Modification Costs. The Interconnection Customer shall not be directly assigned the costs of any additions, modifications, or replacements that the Participating TO makes to the Participating TO's Interconnection Facilities or the Participating TO's Transmission

System to facilitate the interconnection of a third party to the Participating TO's Interconnection Facilities or the Participating TO's Transmission System, or to provide transmission service to a third party under the CAISO Tariff. The Interconnection Customer shall be responsible for the costs of any additions, modifications, or replacements to the Interconnection Facilities that may be necessary to maintain or upgrade such Interconnection Facilities consistent with Applicable Laws and Regulations, Applicable Reliability Standards or Good Utility Practice.

ARTICLE 6. TESTING AND INSPECTION

6.1 Pre-Commercial Operation Date Testing and Modifications. Prior to the Commercial Operation Date, the Participating TO shall test the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades and the Interconnection Customer shall test the Large Generating Facility and the Interconnection Customer's Interconnection Facilities to ensure their safe and reliable operation. Similar testing may be required after initial operation. Each Party shall make any modifications to its facilities that are found to be necessary as a result of such testing. The Interconnection Customer shall bear the cost of all such testing and modifications. The Interconnection Customer shall not commence initial parallel operation of an Electric Generating Unit with the Participating TO's Transmission System until the Participating TO provides prior written approval, which approval shall not be unreasonably withheld, for operation of such Electric Generating Unit. The Interconnection Customer shall generate test energy at the Large Generating Facility only if it has arranged for the delivery of such test energy.

6.2 Post-Commercial Operation Date Testing and Modifications. Each Party shall at its own expense perform routine inspection and testing of its facilities and equipment in accordance with Good Utility Practice as may be necessary to ensure the continued interconnection of the Large Generating Facility with the Participating TO's Transmission System in a safe and reliable manner. Each Party shall have the right, upon advance written notice, to require reasonable additional testing of the other Party's facilities, at the requesting Party's expense, as may be in accordance with Good Utility Practice.

6.3 Right to Observe Testing. Each Party shall notify the other Parties at least fourteen (14) Calendar Days in advance of its performance of tests of its Interconnection Facilities or Generating Facility. The other Parties have the right, at their own expense, to observe such testing.

6.4 Right to Inspect. Each Party shall have the right, but shall have no obligation to: (i) observe another Party's tests and/or inspection of any of its System Protection Facilities and other protective equipment, including Power System Stabilizers; (ii) review the settings of another Party's System Protection Facilities and other protective equipment; and (iii) review another Party's maintenance records relative to the Interconnection Facilities, the System Protection Facilities and other protective equipment. A Party may exercise these rights from time to time as it deems necessary upon reasonable notice to the other Party. The exercise or non-exercise by a Party of any such rights shall not be construed as an endorsement or confirmation of any element or condition of the Interconnection Facilities or the System Protection Facilities or other protective equipment or the operation thereof, or as a warranty as to the fitness, safety, desirability, or reliability of same. Any information that a Party obtains through the exercise of any of its rights under this Article 6.4 shall be deemed to be Confidential Information and treated pursuant to Article 22 of this LGIA.

ARTICLE 7. METERING

7.1 General. Each Party shall comply with any Applicable Reliability Standards and the Applicable Reliability Council requirements. The Interconnection Customer and CAISO shall comply with the provisions of the CAISO Tariff regarding metering, including Section 10 of the CAISO Tariff. Unless otherwise agreed by the Participating TO and the Interconnection Customer, the Participating TO may install additional Metering Equipment at the Point of Interconnection prior to any operation of any Electric Generating Unit and shall own, operate, test and maintain such Metering Equipment. Power flows to and from the Large Generating Facility shall be measured at or, at the CAISO's or Participating TO's option for its respective Metering Equipment, compensated to, the Point of Interconnection. The CAISO shall provide metering quantities to the Interconnection Customer upon request in accordance with the CAISO Tariff by directly polling the CAISO's meter data acquisition system. The Interconnection Customer shall bear all reasonable documented costs associated with the purchase, installation, operation, testing and maintenance of the Metering Equipment.

7.2 Check Meters. The Interconnection Customer, at its option and expense, may install and operate, on its premises and on its side of the Point of Interconnection, one or more check meters to check the CAISO-polled meters or the Participating TO's meters. Such check meters shall be for check purposes only and shall not be used for the measurement of power flows for purposes of this LGIA, except in the case that no other means are available on a temporary basis at the option of the CAISO or the Participating TO. The check meters shall be subject at all reasonable times to inspection and examination by the CAISO or Participating TO or their designees. The installation, operation and maintenance thereof shall be performed entirely by the Interconnection Customer in accordance with Good Utility Practice.

7.3 Participating TO Retail Metering. The Participating TO may install retail revenue quality meters and associated equipment, pursuant to the Participating TO's applicable retail tariffs.

ARTICLE 8. COMMUNICATIONS

8.1 Interconnection Customer Obligations. The Interconnection Customer shall maintain satisfactory operating communications with the CAISO in accordance with the provisions of the CAISO Tariff and with the Participating TO's dispatcher or representative designated by the Participating TO. The Interconnection Customer shall provide standard voice line, dedicated voice line and facsimile communications at its Large Generating Facility control room or central dispatch facility through use of either the public telephone system, or a voice communications system that does not rely on the public telephone system. The Interconnection Customer shall also provide the dedicated data circuit(s) necessary to provide Interconnection Customer data to the CAISO and Participating TO as set forth in Appendix D, Security Arrangements Details. The data circuit(s) shall extend from the Large Generating Facility to the location(s) specified by the CAISO and Participating TO. Any required maintenance of such communications equipment shall be performed by the Interconnection Customer. Operational communications shall be activated and maintained under, but not be limited to, the following events: system paralleling or separation, scheduled and unscheduled shutdowns, equipment clearances, and hourly and daily load data.

8.2 Remote Terminal Unit. Prior to the Initial Synchronization Date of each Electric Generating Unit, a Remote Terminal Unit, or equivalent data collection and transfer equipment acceptable to the Parties, shall be installed by the Interconnection Customer, or by the Participating TO at the Interconnection Customer's expense, to gather accumulated and instantaneous data to be telemetered to the location(s) designated by the CAISO and by the Participating TO through use of a dedicated point-to-point data circuit(s) as indicated in Article 8.1.

Telemetry to the CAISO shall be provided in accordance with the CAISO's technical standards for direct telemetry. For telemetry to the Participating TO, the communication protocol for the data circuit(s) shall be specified by the Participating TO. Instantaneous bi-directional real power and reactive power flow and any other required information must be telemetered directly to the location(s) specified by the Participating TO.

Each Party will promptly advise the other Parties if it detects or otherwise learns of any metering, telemetry or communications equipment errors or malfunctions that require the attention and/or correction by another Party. The Party owning such equipment shall correct such error or malfunction as soon as reasonably feasible.

8.3 No Annexation. Any and all equipment placed on the premises of a Party shall be and remain the property of the Party providing such equipment regardless of the mode and manner of annexation or attachment to real property, unless otherwise mutually agreed by the Parties.

ARTICLE 9. OPERATIONS

9.1 General. Each Party shall comply with Applicable Reliability Standards and the Applicable Reliability Council requirements. Each Party shall provide to the other Party all information that may reasonably be required by the other Party to comply with Applicable Laws and Regulations and Applicable Reliability Standards.

9.2 Balancing Authority Area Notification. At least three months before Initial Synchronization Date, the Interconnection Customer shall notify the CAISO and Participating TO in writing of the Balancing Authority Area in which the Large Generating Facility intends to be located. If the Interconnection Customer intends to locate the Large Generating Facility in a Balancing Authority Area other than the Balancing Authority Area within whose electrically metered boundaries the Large Generating Facility is located, and if permitted to do so by the relevant transmission tariffs, all necessary arrangements, including but not limited to those set forth in Article 7 and Article 8 of this LGIA, and remote Balancing Authority Area generator interchange agreements, if applicable, and the appropriate measures under such agreements, shall be executed and implemented prior to the placement of the Large Generating Facility in the other Balancing Authority Area.

9.3 CAISO and Participating TO Obligations. The CAISO and Participating TO shall cause the Participating TO's Transmission System to be operated and controlled in a safe and reliable manner and in accordance with this LGIA. The Participating TO at the Interconnection Customer's expense shall cause the Participating TO's Interconnection Facilities to be operated, maintained and controlled in a safe and reliable manner and in accordance with this LGIA. The CAISO and Participating TO may provide operating instructions to the Interconnection Customer consistent with this LGIA and Participating TO and CAISO operating protocols and procedures as they may change from time to time. The Participating TO and CAISO will consider changes to their operating protocols and procedures proposed by the Interconnection Customer.

9.4 Interconnection Customer Obligations. The Interconnection Customer shall at its own expense operate, maintain and control the Large Generating Facility and the Interconnection Customer's Interconnection Facilities in a safe and reliable manner and in accordance with this LGIA. The Interconnection Customer shall operate the Large Generating Facility and the Interconnection Customer's Interconnection Facilities in accordance with all applicable requirements of the Balancing Authority Area of which it is part, including such requirements as set forth in Appendix C, Interconnection Details, of this LGIA. Appendix C, Interconnection Details, will be modified to reflect changes to the requirements as they may change from time to time. A Party may request that another Party provide copies of the requirements set forth in Appendix C, Interconnection Details, of this LGIA. The Interconnection Customer shall not commence Commercial Operation of an Electric Generating Unit with the Participating TO's

Transmission System until the Participating TO provides prior written approval, which approval shall not be unreasonably withheld, for operation of such Electric Generating Unit.

9.5 Start-Up and Synchronization. Consistent with the Parties' mutually acceptable procedures, the Interconnection Customer is responsible for the proper synchronization of each Electric Generating Unit to the CAISO Controlled Grid.

9.6 Reactive Power.

9.6.1 Power Factor Design Criteria. For all Generating Facilities other than Asynchronous Generating Facilities, the Interconnection Customer shall design the Large Generating Facility to maintain a composite power delivery at continuous rated power output at the terminals of the Electric Generating Unit at a power factor within the range of 0.95 leading to 0.90 lagging, unless the CAISO has established different requirements that apply to all generators in the Balancing Authority Area on a comparable basis. For Asynchronous Generating Facilities, the Interconnection Customer shall design the Large Generating Facility to maintain power factor criteria in accordance with Appendix H of this LGIA.

9.6.2 Voltage Schedules. Once the Interconnection Customer has synchronized an Electric Generating Unit with the CAISO Controlled Grid, the CAISO or Participating TO shall require the Interconnection Customer to maintain a voltage schedule by operating the Electric Generating Unit to produce or absorb reactive power within the design limitations of the Electric Generating Unit set forth in Article 9.6.1 (Power Factor Design Criteria). CAISO's voltage schedules shall treat all sources of reactive power in the Balancing Authority Area in an equitable and not unduly discriminatory manner. The Participating TO shall exercise Reasonable Efforts to provide the Interconnection Customer with such schedules at least one (1) day in advance, and the CAISO or Participating TO may make changes to such schedules as necessary to maintain the reliability of the CAISO Controlled Grid or the Participating TO's electric system. The Interconnection Customer shall operate the Electric Generating Unit to maintain the specified output voltage or power factor within the design limitations of the Electric Generating Unit set forth in Article 9.6.1 (Power Factor Design Criteria), and as may be required by the CAISO to operate the Electric Generating Unit at a specific voltage schedule within the design limitations set forth in Article 9.6.1. If the Interconnection Customer is unable to maintain the specified voltage or power factor, it shall promptly notify the CAISO and the Participating TO.

9.6.2.1 Governors and Regulators. Whenever an Electric Generating Unit is operated in parallel with the CAISO Controlled Grid and the speed governors (if installed on the Electric Generating Unit pursuant to Good Utility Practice) and voltage regulators are capable of operation, the Interconnection Customer shall operate the Electric Generating Unit with its speed governors and voltage regulators in automatic operation. If the Electric Generating Unit's speed governors and voltage regulators are not capable of such automatic operation, the Interconnection Customer shall immediately notify the CAISO and the Participating TO and ensure that the Electric Generating Unit operates as specified in Article 9.6.2 through manual operation and that such Electric Generating Unit's reactive power production or absorption (measured in MVARs) are within the design capability of the Electric Generating Unit(s) and steady state stability limits. The Interconnection Customer shall restore the speed governors and voltage regulators to automatic operation as soon as possible. If the Large Generating Facility's speed governors and voltage regulators are improperly tuned or malfunctioning, the CAISO shall have the right to order the reduction in output or disconnection of the Large Generating Facility if the reliability of the CAISO Controlled Grid would be adversely affected. The Interconnection Customer shall not cause its Large Generating Facility to disconnect automatically or instantaneously from the CAISO Controlled Grid or trip any Electric Generating Unit comprising the Large Generating Facility for an under or over frequency condition unless the abnormal frequency condition persists for a time period beyond the limits set forth in ANSI/IEEE Standard C37.106, or such other standard as applied to other generators in the Balancing Authority Area on a comparable basis.

9.6.2.2 Loss of Voltage Control and Governor Control for Asynchronous Generating Facilities. For Asynchronous Generating Facilities, Appendix H to this LGIA sets forth the requirements for Large Generating Facilities relating to: (i) loss of voltage control capability, (ii) governor response to frequency conditions, and (iii) ability not to disconnect automatically or instantaneously from the CAISO Controlled Grid or trip any Electric Generating Unit comprising the Large Generating Facility for an under- or over-frequency condition. Asynchronous Generating Facilities are not required to provide governor response to under-frequency conditions.

9.6.3 Payment for Reactive Power. CAISO is required to pay the Interconnection Customer for reactive power that Interconnection Customer provides or absorbs from an Electric Generating Unit when the CAISO requests the Interconnection Customer to operate its Electric Generating Unit outside the range specified in Article 9.6.1, provided that if the CAISO pays other generators for reactive power service within the specified range, it must also pay the Interconnection Customer. Payments shall be pursuant to Article 11.6 or such other agreement to which the CAISO and Interconnection Customer have otherwise agreed.

9.7 Outages and Interruptions.

9.7.1 Outages.

9.7.1.1 Outage Authority and Coordination. Each Party may in accordance with Good Utility Practice in coordination with the other Parties remove from service any of its respective Interconnection Facilities or Network Upgrades that may impact another Party's facilities as necessary to perform maintenance or testing or to install or replace equipment. Absent an Emergency Condition, the Party scheduling a removal of such facility(ies) from service will use Reasonable Efforts to schedule such removal on a date and time mutually acceptable to all Parties. In all circumstances any Party planning to remove such facility(ies) from service shall use Reasonable Efforts to minimize the effect on the other Parties of such removal.

9.7.1.2 Outage Schedules. The CAISO shall post scheduled outages of CAISO Controlled Grid facilities in accordance with the provisions of the CAISO Tariff. The Interconnection Customer shall submit its planned maintenance schedules for the Large Generating Facility to the CAISO in accordance with the CAISO Tariff. The Interconnection Customer shall update its planned maintenance schedules in accordance with the CAISO Tariff. The CAISO may request the Interconnection Customer to reschedule its maintenance as necessary to maintain the reliability of the CAISO Controlled Grid in accordance with the CAISO Tariff. Such planned maintenance schedules and updates and changes to such schedules shall be provided by the Interconnection Customer to the Participating TO concurrently with their submittal to the CAISO. The CAISO shall compensate the Interconnection Customer for any additional direct costs that the Interconnection Customer incurs as a result of having to reschedule maintenance in accordance with the CAISO Tariff. The Interconnection Customer will not be eligible to receive compensation, if during the twelve (12) months prior to the date of the scheduled maintenance, the Interconnection Customer had modified its schedule of maintenance activities.

9.7.1.3 Outage Restoration. If an outage on a Party's Interconnection Facilities or Network Upgrades adversely affects another Party's operations or facilities, the Party that owns or controls the facility that is out of service shall use Reasonable Efforts to promptly restore such facility(ies) to a normal operating condition consistent with the nature of the outage. The Party that owns or controls the facility that is out of service shall provide the other Parties, to the extent such information is known, information on the nature of the Emergency Condition, if the outage is caused by an Emergency Condition, an estimated time of restoration, and any corrective actions required. Initial verbal notice shall be followed up as soon as practicable with written notice explaining the nature of the outage, if requested by a Party, which may be provided by e-mail or facsimile.

9.7.2 Interruption of Service. If required by Good Utility Practice to do so, the CAISO or the Participating TO may require the Interconnection Customer to interrupt or reduce deliveries of electricity if such delivery of electricity could adversely affect the CAISO's or the Participating TO's ability to perform such activities as are necessary to safely and reliably operate and maintain the Participating TO's electric system or the CAISO Controlled Grid. The following provisions shall apply to any interruption or reduction permitted under this Article 9.7.2:

9.7.2.1 The interruption or reduction shall continue only for so long as reasonably necessary under Good Utility Practice;

9.7.2.2 Any such interruption or reduction shall be made on an equitable, non-discriminatory basis with respect to all generating facilities directly connected to the CAISO Controlled Grid, subject to any conditions specified in this LGIA;

9.7.2.3 When the interruption or reduction must be made under circumstances which do not allow for advance notice, the CAISO or Participating TO, as applicable, shall notify the Interconnection Customer by telephone as soon as practicable of the reasons for the curtailment, interruption, or reduction, and, if known, its expected duration. Telephone notification shall be followed by written notification, if requested by the Interconnection Customer, as soon as practicable;

9.7.2.4 Except during the existence of an Emergency Condition, the CAISO or Participating TO shall notify the Interconnection Customer in advance regarding the timing of such interruption or reduction and further notify the Interconnection Customer of the expected duration. The CAISO or Participating TO shall coordinate with the Interconnection Customer using Good Utility Practice to schedule the interruption or reduction during periods of least impact to the Interconnection Customer, the CAISO, and the Participating TO;

9.7.2.5 The Parties shall cooperate and coordinate with each other to the extent necessary in order to restore the Large Generating Facility, Interconnection Facilities, the Participating TO's Transmission System, and the CAISO Controlled Grid to their normal operating state, consistent with system conditions and Good Utility Practice.

9.7.3 Under-Frequency and Over Frequency Conditions. The CAISO Controlled Grid is designed to automatically activate a load-shed program as required by Applicable Reliability Standards and the Applicable Reliability Council in the event of an under-frequency system disturbance. The Interconnection Customer shall implement under-frequency and over-frequency protection set points for the Large Generating Facility as required by Applicable Reliability Standards and the Applicable Reliability Council to ensure "ride through" capability. Large Generating Facility response to frequency deviations of pre-determined magnitudes, both under-frequency and over-frequency deviations, shall be studied and coordinated with the Participating TO and CAISO in accordance with Good Utility Practice. The term "ride through" as used herein shall mean the ability of a Generating Facility to stay connected to and synchronized with the CAISO Controlled Grid during system disturbances within a range of under-frequency and over-frequency conditions, in accordance with Good Utility Practice. . Asynchronous Generating Facilities shall be subject to frequency ride through capability requirements in accordance with Appendix H to this LGIA.

9.7.4 System Protection and Other Control Requirements.

9.7.4.1 System Protection Facilities. The Interconnection Customer shall, at its expense, install, operate and maintain System Protection Facilities as a part of the Large Generating Facility or the Interconnection Customer's Interconnection Facilities. The Participating TO shall install at the Interconnection Customer's expense any System Protection Facilities that may be required on the Participating TO's Interconnection Facilities or the Participating TO's Transmission System as a result of the interconnection of the Large Generating Facility and the Interconnection Customer's Interconnection Facilities.

9.7.4.2 The Participating TO's and Interconnection Customer's protection facilities shall be designed and coordinated with other systems in accordance with Applicable Reliability Standards, Applicable Reliability Council criteria, and Good Utility Practice.

9.7.4.3 The Participating TO and Interconnection Customer shall each be responsible for protection of its facilities consistent with Good Utility Practice.

9.7.4.4 The Participating TO's and Interconnection Customer's protective relay design shall incorporate the necessary test switches to perform the tests required in Article 6. The required test switches will be placed such that they allow operation of lockout relays while preventing breaker failure schemes from operating and causing unnecessary breaker operations and/or the tripping of the Interconnection Customer's Electric Generating Units.

9.7.4.5 The Participating TO and Interconnection Customer will test, operate and maintain System Protection Facilities in accordance with Good Utility Practice and, if applicable, the requirements of the Participating TO's Interconnection Handbook.

9.7.4.6 Prior to the in-service date, and again prior to the Commercial Operation Date, the Participating TO and Interconnection Customer or their agents shall perform a complete calibration test and functional trip test of the System Protection Facilities. At intervals suggested by Good Utility Practice, the standards and procedures of the Participating TO, including, if applicable, the requirements of the Participating TO's Interconnection Handbook, and following any apparent malfunction of the System Protection Facilities, each Party shall perform both calibration and functional trip tests of its System Protection Facilities. These tests do not require the tripping of any in-service generation unit. These tests do, however, require that all protective relays and lockout contacts be activated.

9.7.5 Requirements for Protection. In compliance with Good Utility Practice and, if applicable, the requirements of the Participating TO's Interconnection Handbook, the Interconnection Customer shall provide, install, own, and maintain relays, circuit breakers and all other devices necessary to remove any fault contribution of the Large Generating Facility to any short circuit occurring on the Participating TO's Transmission System not otherwise isolated by the Participating TO's equipment, such that the removal of the fault contribution shall be coordinated with the protective requirements of the Participating TO's Transmission System. Such protective equipment shall include, without limitation, a disconnecting device with fault current-interrupting capability located between the Large Generating Facility and the Participating TO's Transmission System at a site selected upon mutual agreement (not to be unreasonably withheld, conditioned or delayed) of the Parties. The Interconnection Customer shall be responsible for protection of the Large Generating Facility and the Interconnection Customer's other equipment from such conditions as negative sequence currents, over- or under-frequency, sudden load rejection, over- or under-voltage, and generator loss-of-field. The Interconnection Customer shall be solely responsible to disconnect the Large Generating Facility and the Interconnection Customer's other equipment if conditions on the CAISO Controlled Grid could adversely affect the Large Generating Facility.

9.7.6 Power Quality. Neither the Participating TO's nor the Interconnection Customer's facilities shall cause excessive voltage flicker nor introduce excessive distortion to the sinusoidal voltage or current waves as defined by ANSI Standard C84.1-1989, in accordance with IEEE Standard 519, any applicable superseding electric industry standard, or any alternative Applicable Reliability Standard or Applicable Reliability Council standard. In the event of a conflict among ANSI Standard C84.1-1989, any applicable superseding electric industry standard, or any alternative Applicable Reliability Standard or Applicable Reliability Council standard, the alternative Applicable Reliability Standard or Applicable Reliability Council standard shall control.

9.8 Switching and Tagging Rules. Each Party shall provide the other Parties a copy of its switching and tagging rules that are applicable to the other Parties' activities. Such switching and tagging rules shall be developed on a non-discriminatory basis. The Parties shall comply with applicable switching and tagging rules, as amended from time to time, in obtaining clearances for work or for switching operations on equipment.

9.9 Use of Interconnection Facilities by Third Parties.

9.9.1 Purpose of Interconnection Facilities. Except as may be required by Applicable Laws and Regulations, or as otherwise agreed to among the Parties, the Interconnection Facilities shall be constructed for the sole purpose of interconnecting the Large Generating Facility to the Participating TO's Transmission System and shall be used for no other purpose.

9.9.2 Third Party Users. If required by Applicable Laws and Regulations or if the Parties mutually agree, such agreement not to be unreasonably withheld, to allow one or more third parties to use the Participating TO's Interconnection Facilities, or any part thereof, the Interconnection Customer will be entitled to compensation for the capital expenses it incurred in connection with the Interconnection Facilities based upon the pro rata use of the Interconnection Facilities by the Participating TO, all third party users, and the Interconnection Customer, in accordance with Applicable Laws and Regulations or upon some other mutually-agreed upon methodology. In addition, cost responsibility for ongoing costs, including operation and maintenance costs associated with the Interconnection Facilities, will be allocated between the Interconnection Customer and any third party users based upon the pro rata use of the Interconnection Facilities by the Participating TO, all third party users, and the Interconnection Customer, in accordance with Applicable Laws and Regulations or upon some other mutually agreed upon methodology. If the issue of such compensation or allocation cannot be resolved through such negotiations, it shall be submitted to FERC for resolution.

9.10 Disturbance Analysis Data Exchange. The Parties will cooperate with one another in the analysis of disturbances to either the Large Generating Facility or the CAISO Controlled Grid by gathering and providing access to any information relating to any disturbance, including information from oscillography, protective relay targets, breaker operations and sequence of events records, and any disturbance information required by Good Utility Practice.

ARTICLE 10. MAINTENANCE

10.1 Participating TO Obligations. The Participating TO shall maintain the Participating TO's Transmission System and the Participating TO's Interconnection Facilities in a safe and reliable manner and in accordance with this LGIA.

10.2 Interconnection Customer Obligations. The Interconnection Customer shall maintain the Large Generating Facility and the Interconnection Customer's Interconnection Facilities in a safe and reliable manner and in accordance with this LGIA.

10.3 Coordination. The Parties shall confer regularly to coordinate the planning, scheduling and performance of preventive and corrective maintenance on the Large Generating Facility and the Interconnection Facilities.

10.4 Secondary Systems. The Participating TO and Interconnection Customer shall cooperate with the other Parties in the inspection, maintenance, and testing of control or power circuits that operate below 600 volts, AC or DC, including, but not limited to, any hardware, control or protective devices, cables, conductors, electric raceways, secondary equipment panels, transducers, batteries, chargers, and voltage and current transformers that directly affect the operation of a Party's facilities and equipment which may reasonably be expected to impact the other Parties. Each Party shall provide advance notice to the other Parties before undertaking any work on such circuits, especially on electrical circuits involving circuit breaker trip and close contacts, current transformers, or potential transformers.

10.5 Operating and Maintenance Expenses. Subject to the provisions herein addressing the use of facilities by others, and except for operations and maintenance expenses associated with modifications made for providing interconnection or transmission service to a third party and such third party pays for such expenses, the Interconnection Customer shall be responsible for all reasonable expenses including overheads, associated with: (1) owning, operating, maintaining, repairing, and replacing the Interconnection Customer's Interconnection Facilities; and (2) operation, maintenance, repair and replacement of the Participating TO's Interconnection Facilities.

ARTICLE 11. PERFORMANCE OBLIGATION

11.1 Interconnection Customer's Interconnection Facilities. The Interconnection Customer shall design, procure, construct, install, own and/or control the Interconnection Customer's Interconnection Facilities described in Appendix A at its sole expense.

11.2 Participating TO's Interconnection Facilities. The Participating TO shall design, procure, construct, install, own and/or control the Participating TO's Interconnection Facilities described in Appendix A at the sole expense of the Interconnection Customer. Unless the Participating TO elects to fund the capital for the Participating TO's Interconnection Facilities, they shall be solely funded by the Interconnection Customer.

11.3 Network Upgrades and Distribution Upgrades. The Participating TO shall design, procure, construct, install, and own the Network Upgrades and Distribution Upgrades described in Appendix A. The Interconnection Customer shall be responsible for all costs related to Distribution Upgrades. Unless the Participating TO elects to fund the capital for the Distribution

Upgrades and Network Upgrades, they shall be funded by the Interconnection Customer in an amount determined pursuant to the methodology set forth in Section 13 of the LGIP. This specific amount is set forth in Appendix G to this LGIA.

11.4 Transmission Credits. No later than thirty (30) Calendar Days prior to the Commercial Operation Date, the Interconnection Customer may make a one-time election by written notice to the CAISO and the Participating TO to receive Congestion Revenue Rights as defined in and as available under the CAISO Tariff at the time of the election in accordance with the CAISO Tariff, in lieu of a refund of the cost of Network Upgrades in accordance with Article 11.4.1.

11.4.1 Repayment of Amounts Advanced for Network Upgrades. Upon the Commercial Operation Date, the Interconnection Customer shall be entitled to a repayment, equal to the total amount paid to the Participating TO for the costs of Network Upgrades for which it is responsible, as set forth in Appendix G. Such amount shall include any tax gross-up or other tax-related payments associated with Network Upgrades not refunded to the Interconnection Customer pursuant to Article 5.17.8 or otherwise, and shall be paid to the Interconnection Customer by the Participating TO on a dollar-for-dollar basis either through (1) direct payments made on a levelized basis over the five-year period commencing on the Commercial Operation Date; or (2) any alternative payment schedule that is mutually agreeable to the Interconnection Customer and Participating TO, provided that such amount is paid within five (5) years from the Commercial Operation Date. Notwithstanding the foregoing, if this LGIA terminates within five (5) years from the Commercial Operation Date, the Participating TO's obligation to pay refunds to the Interconnection Customer shall cease as of the date of termination. Any repayment shall include interest calculated in accordance with the methodology set forth in FERC's regulations at 18 C.F.R. §35.19a(a)(2)(iii) from the date of any payment for Network Upgrades through the date on which the Interconnection Customer receives a repayment of such payment. Interest shall continue to accrue on the repayment obligation so long as this LGIA is in effect. The Interconnection Customer may assign such repayment rights to any person.

If the Large Generating Facility fails to achieve Commercial Operation, but it or another Generating Facility is later constructed and makes use of the Network Upgrades, the Participating TO shall at that time reimburse Interconnection Customer for the amounts advanced for the Network Upgrades. Before any such reimbursement can occur, the Interconnection Customer, or the entity that ultimately constructs the Generating Facility, if different, is responsible for identifying and demonstrating to the Participating TO the appropriate entity to which reimbursement must be made in order to implement the intent of this reimbursement obligation.

11.4.2 Special Provisions for Affected Systems. The Interconnection Customer shall enter into an agreement with the owner of the Affected System and/or other affected owners of portions of the CAISO Controlled Grid, as applicable, in accordance with the LGIP. Such agreement shall specify the terms governing payments to be made by the Interconnection Customer to the owner of the Affected System and/or other affected owners of portions of the CAISO Controlled Grid as well as the repayment by the owner of the Affected System and/or other affected owners of portions of the CAISO Controlled Grid. In no event shall the Participating TO be responsible for the repayment for any facilities that are not part of the Participating TO's Transmission System. In the event the Participating TO is a joint owner with an Affected System or with any other co-owner of a facility affected by the Large Generating Facility, the Participating TO's obligation to reimburse the Interconnection Customer for payments made to address the impacts of the Large Generating Facility on the system shall not exceed the proportionate amount of the cost of any upgrades attributable to the proportion of the jointly-owned facility owned by the Participating TO.

11.4.3 Notwithstanding any other provision of this LGIA, nothing herein shall be construed as relinquishing or foreclosing any rights, including but not limited to firm transmission rights, capacity rights, Congestion Revenue Rights, or transmission credits, that the Interconnection Customer shall be entitled to, now or in the future under any other agreement or tariff as a result of, or otherwise associated with, the transmission capacity, if any, created by the Network Upgrades, including the right to obtain cash reimbursements, merchant transmission Congestion Revenue Rights in accordance with Section 36.11 of the CAISO Tariff, or transmission credits for transmission service that is not associated with the Large Generating Facility.

11.5 **Provision of Interconnection Financial Security.** The Interconnection Customer is obligated to provide all necessary Interconnection Financial Security required under Section 9 of the LGIP in a manner acceptable under Section 9 of the LGIP. Failure to satisfy the LGIP's requirements for the provision of Interconnection Financial Security shall result in the Interconnection Request being deemed withdrawn and subject to LGIP Section 3.8.

11.6 **Interconnection Customer Compensation.** If the CAISO requests or directs the Interconnection Customer to provide a service pursuant to Articles 9.6.3 (Payment for Reactive Power) or 13.5.1 of this LGIA, the CAISO shall compensate the Interconnection Customer in accordance with the CAISO Tariff.

11.6.1 **Interconnection Customer Compensation for Actions During Emergency Condition.** The CAISO shall compensate the Interconnection Customer in accordance with the CAISO Tariff for its provision of real and reactive power and other Emergency Condition services that the Interconnection Customer provides to support the CAISO Controlled Grid during an Emergency Condition in accordance with Article 11.6.

ARTICLE 12. INVOICE

12.1 **General.** The Participating TO shall submit to the Interconnection Customer, on a monthly basis, invoices of amounts due pursuant to this LGIA for the preceding month. Each invoice shall state the month to which the invoice applies and fully describe the services and equipment provided. The Parties may discharge mutual debts and payment obligations due and owing to each other on the same date through netting, in which case all amounts a Party owes to the other Party under this LGIA, including interest payments or credits, shall be netted so that only the net amount remaining due shall be paid by the owing Party. Notwithstanding the foregoing, any invoices between the CAISO and another Party shall be submitted and paid in accordance with the CAISO Tariff.

12.2 **Final Invoice.** As soon as reasonably practicable, but within twelve months after completion of the construction of the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades, the Participating TO shall provide an invoice of the final cost of the construction of the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades, and shall set forth such costs in sufficient detail to enable the Interconnection Customer to compare the actual costs with the estimates and to ascertain deviations, if any, from the cost estimates. With respect to costs associated with the Participating TO's Interconnection Facilities and Distribution Upgrades, the Participating TO shall refund to the Interconnection Customer any amount by which the actual payment by the Interconnection Customer for estimated costs exceeds the actual costs of construction within thirty (30) Calendar Days of the issuance of such final construction invoice; or, in the event the actual costs of construction exceed the Interconnection Customer's actual payment for estimated costs, then the Interconnection Customer shall pay to the Participating TO any amount by which the actual costs of construction exceed the actual payment by the Interconnection Customer for estimated costs within thirty (30) Calendar Days of the issuance of such final construction invoice. With respect to costs associated with Network Upgrades, the Participating TO shall refund to the Interconnection

Customer any amount by which the actual payment by the Interconnection Customer for estimated costs exceeds the actual costs of construction multiplied by the Interconnection Customer's percentage share of those costs, as set forth in Appendix G to this LGIA within thirty (30) Calendar Days of the issuance of such final construction invoice. In the event the actual costs of construction multiplied by the Interconnection Customer's percentage share of those costs exceed the Interconnection Customer's actual payment for estimated costs, then the Participating TO shall recover such difference through its transmission service rates.

12.3 Payment. Invoices shall be rendered to the Interconnection Customer at the address specified in Appendix F. The Interconnection Customer shall pay, or Participating TO shall refund, the amounts due within thirty (30) Calendar Days of the Interconnection Customer's receipt of the invoice. All payments shall be made in immediately available funds payable to the Interconnection Customer or Participating TO, or by wire transfer to a bank named and account designated by the invoicing Interconnection Customer or Participating TO. Payment of invoices by any Party will not constitute a waiver of any rights or claims any Party may have under this LGIA.

12.4 Disputes. In the event of a billing dispute between the Interconnection Customer and the Participating TO, the Participating TO and the CAISO shall continue to provide Interconnection Service under this LGIA as long as the Interconnection Customer: (i) continues to make all payments not in dispute; and (ii) pays to the Participating TO or into an independent escrow account the portion of the invoice in dispute, pending resolution of such dispute. If the Interconnection Customer fails to meet these two requirements for continuation of service, then the Participating TO may provide notice to the Interconnection Customer of a Default pursuant to Article 17. Within thirty (30) Calendar Days after the resolution of the dispute, the Party that owes money to the other Party shall pay the amount due with interest calculated in accordance with the methodology set forth in FERC's Regulations at 18 C.F.R. § 35.19a(a)(2)(iii). Notwithstanding the foregoing, any billing dispute between the CAISO and another Party shall be resolved in accordance with the provisions of Article 27 of this LGIA.

ARTICLE 13. EMERGENCIES

13.1 [Reserved]

13.2 Obligations. Each Party shall comply with the Emergency Condition procedures of the CAISO, NERC, the Applicable Reliability Council, Applicable Reliability Standards, Applicable Laws and Regulations, and any emergency procedures set forth in this LGIA.

13.3 Notice. The Participating TO or the CAISO shall notify the Interconnection Customer promptly when it becomes aware of an Emergency Condition that affects the Participating TO's Interconnection Facilities or Distribution System or the CAISO Controlled Grid, respectively, that may reasonably be expected to affect the Interconnection Customer's operation of the Large Generating Facility or the Interconnection Customer's Interconnection Facilities. The Interconnection Customer shall notify the Participating TO and the CAISO promptly when it becomes aware of an Emergency Condition that affects the Large Generating Facility or the Interconnection Customer's Interconnection Facilities that may reasonably be expected to affect the CAISO Controlled Grid or the Participating TO's Interconnection Facilities. To the extent information is known, the notification shall describe the Emergency Condition, the extent of the damage or deficiency, the expected effect on the operation of the Interconnection Customer's or Participating TO's facilities and operations, its anticipated duration and the corrective action taken and/or to be taken. The initial notice shall be followed as soon as practicable with written notice, if requested by a Party, which may be provided by electronic mail or facsimile, or in the case of the CAISO may be publicly posted on the CAISO's internet web site.

13.4 Immediate Action. Unless, in the Interconnection Customer's reasonable judgment, immediate action is required, the Interconnection Customer shall obtain the consent of the CAISO and the Participating TO, such consent to not be unreasonably withheld, prior to performing any manual switching operations at the Large Generating Facility or the Interconnection Customer's Interconnection Facilities in response to an Emergency Condition declared by the Participating TO or CAISO or in response to any other emergency condition.

13.5 CAISO and Participating TO Authority.

13.5.1 General. The CAISO and Participating TO may take whatever actions or inactions, including issuance of dispatch instructions, with regard to the CAISO Controlled Grid or the Participating TO's Interconnection Facilities or Distribution System they deem necessary during an Emergency Condition in order to (i) preserve public health and safety, (ii) preserve the reliability of the CAISO Controlled Grid or the Participating TO's Interconnection Facilities or Distribution System, and (iii) limit or prevent damage, and (iv) expedite restoration of service.

The Participating TO and the CAISO shall use Reasonable Efforts to minimize the effect of such actions or inactions on the Large Generating Facility or the Interconnection Customer's Interconnection Facilities. The Participating TO or the CAISO may, on the basis of technical considerations, require the Large Generating Facility to mitigate an Emergency Condition by taking actions necessary and limited in scope to remedy the Emergency Condition, including, but not limited to, directing the Interconnection Customer to shut-down, start-up, increase or decrease the real or reactive power output of the Large Generating Facility; implementing a reduction or disconnection pursuant to Article 13.5.2; directing the Interconnection Customer to assist with black start (if available) or restoration efforts; or altering the outage schedules of the Large Generating Facility and the Interconnection Customer's Interconnection Facilities. Interconnection Customer shall comply with all of the CAISO's and Participating TO's operating instructions concerning Large Generating Facility real power and reactive power output within the manufacturer's design limitations of the Large Generating Facility's equipment that is in service and physically available for operation at the time, in compliance with Applicable Laws and Regulations.

13.5.2 Reduction and Disconnection. The Participating TO or the CAISO may reduce Interconnection Service or disconnect the Large Generating Facility or the Interconnection Customer's Interconnection Facilities when such reduction or disconnection is necessary under Good Utility Practice due to Emergency Conditions. These rights are separate and distinct from any right of curtailment of the CAISO pursuant to the CAISO Tariff. When the CAISO or Participating TO can schedule the reduction or disconnection in advance, the CAISO or Participating TO shall notify the Interconnection Customer of the reasons, timing and expected duration of the reduction or disconnection. The CAISO or Participating TO shall coordinate with the Interconnection Customer using Good Utility Practice to schedule the reduction or disconnection during periods of least impact to the Interconnection Customer and the CAISO and Participating TO. Any reduction or disconnection shall continue only for so long as reasonably necessary under Good Utility Practice. The Parties shall cooperate with each other to restore the Large Generating Facility, the Interconnection Facilities, and the CAISO Controlled Grid to their normal operating state as soon as practicable consistent with Good Utility Practice.

13.6 Interconnection Customer Authority. Consistent with Good Utility Practice, this LGIA, and the CAISO Tariff, the Interconnection Customer may take actions or inactions with regard to the Large Generating Facility or the Interconnection Customer's Interconnection Facilities during an Emergency Condition in order to (i) preserve public health and safety, (ii) preserve the reliability of the Large Generating Facility or the Interconnection Customer's Interconnection Facilities,

(iii) limit or prevent damage, and (iv) expedite restoration of service. Interconnection Customer shall use Reasonable Efforts to minimize the effect of such actions or inactions on the CAISO Controlled Grid and the Participating TO's Interconnection Facilities. The CAISO and Participating TO shall use Reasonable Efforts to assist Interconnection Customer in such actions.

13.7 Limited Liability. Except as otherwise provided in Article 11.6.1 of this LGIA, no Party shall be liable to any other Party for any action it takes in responding to an Emergency Condition so long as such action is made in good faith and is consistent with Good Utility Practice.

ARTICLE 14. REGULATORY REQUIREMENTS AND GOVERNING LAW

14.1 Regulatory Requirements. Each Party's obligations under this LGIA shall be subject to its receipt of any required approval or certificate from one or more Governmental Authorities in the form and substance satisfactory to the applying Party, or the Party making any required filings with, or providing notice to, such Governmental Authorities, and the expiration of any time period associated therewith. Each Party shall in good faith seek and use its Reasonable Efforts to obtain such other approvals. Nothing in this LGIA shall require the Interconnection Customer to take any action that could result in its inability to obtain, or its loss of, status or exemption under the Federal Power Act or the Public Utility Holding Company Act of 1935, as amended, or the Public Utility Regulatory Policies Act of 1978, or the Energy Policy Act of 2005.

14.2 Governing Law.

14.2.1 The validity, interpretation and performance of this LGIA and each of its provisions shall be governed by the laws of the state where the Point of Interconnection is located, without regard to its conflicts of law principles.

14.2.2 This LGIA is subject to all Applicable Laws and Regulations.

14.2.3 Each Party expressly reserves the right to seek changes in, appeal, or otherwise contest any laws, orders, rules, or regulations of a Governmental Authority.

ARTICLE 15. NOTICES

15.1 General. Unless otherwise provided in this LGIA, any notice, demand or request required or permitted to be given by a Party to another and any instrument required or permitted to be tendered or delivered by a Party in writing to another shall be effective when delivered and may be so given, tendered or delivered, by recognized national courier, or by depositing the same with the United States Postal Service with postage prepaid, for delivery by certified or registered mail, addressed to the Party, or personally delivered to the Party, at the address set out in Appendix F, Addresses for Delivery of Notices and Billings.

A Party must update the information in Appendix F as information changes. A Party may change the notice information in this LGIA by giving five (5) Business Days written notice prior to the effective date of the change. Such changes shall not constitute an amendment to this LGIA.

15.2 Billings and Payments. Billings and payments shall be sent to the addresses set out in Appendix F.

15.3 Alternative Forms of Notice. Any notice or request required or permitted to be given by a Party to another and not required by this LGIA to be given in writing may be so given by telephone, facsimile or e-mail to the telephone numbers and e-mail addresses set out in Appendix F.

15.4 Operations and Maintenance Notice. Each Party shall notify the other Parties in writing of the identity of the person(s) that it designates as the point(s) of contact with respect to the implementation of Articles 9 and 10.

ARTICLE 16. FORCE MAJEURE

16.1 Force Majeure.

16.1.1 Economic hardship is not considered a Force Majeure event.

16.1.2 No Party shall be considered to be in Default with respect to any obligation hereunder, (including obligations under Article 4), other than the obligation to pay money when due, if prevented from fulfilling such obligation by Force Majeure. A Party unable to fulfill any obligation hereunder (other than an obligation to pay money when due) by reason of Force Majeure shall give notice and the full particulars of such Force Majeure to the other Party in writing or by telephone as soon as reasonably possible after the occurrence of the cause relied upon. Telephone notices given pursuant to this Article shall be confirmed in writing as soon as reasonably possible and shall specifically state full particulars of the Force Majeure, the time and date when the Force Majeure occurred and when the Force Majeure is reasonably expected to cease. The Party affected shall exercise due diligence to remove such disability with reasonable dispatch, but shall not be required to accede or agree to any provision not satisfactory to it in order to settle and terminate a strike or other labor disturbance.

ARTICLE 17. DEFAULT

17.1 Default.

17.1.1 General. No Default shall exist where such failure to discharge an obligation (other than the payment of money) is the result of Force Majeure as defined in this LGIA or the result of an act or omission of the other Party. Upon a Breach, the affected non-Breaching Party(ies) shall give written notice of such Breach to the Breaching Party. Except as provided in Article 17.1.2, the Breaching Party shall have thirty (30) Calendar Days from receipt of the Default notice within which to cure such Breach; provided however, if such Breach is not capable of cure within thirty (30) Calendar Days, the Breaching Party shall commence such cure within thirty (30) Calendar Days after notice and continuously and diligently complete such cure within ninety (90) Calendar Days from receipt of the Default notice; and, if cured within such time, the Breach specified in such notice shall cease to exist.

17.1.2 Right to Terminate. If a Breach is not cured as provided in this Article, or if a Breach is not capable of being cured within the period provided for herein, the affected non-Breaching Party(ies) shall have the right to declare a Default and terminate this LGIA by written notice at any time until cure occurs, and be relieved of any further obligation hereunder and, whether or not such Party(ies) terminates this LGIA, to recover from the Breaching Party all amounts due hereunder, plus all other damages and remedies to which it is entitled at law or in equity. The provisions of this Article will survive termination of this LGIA.

ARTICLE 18. INDEMNITY, CONSEQUENTIAL DAMAGES AND INSURANCE

18.1 Indemnity. Each Party shall at all times indemnify, defend, and hold the other Parties harmless from, any and all Losses arising out of or resulting from another Party's action or inactions of its obligations under this LGIA on behalf of the indemnifying Party, except in cases of gross negligence or intentional wrongdoing by the Indemnified Party.

18.1.1 Indemnified Party. If an Indemnified Party is entitled to indemnification under this Article 18 as a result of a claim by a third party, and the Indemnifying Party fails, after notice and reasonable opportunity to proceed under Article 18.1, to assume the defense of such claim, such Indemnified Party may at the expense of the Indemnifying Party contest, settle or consent to the entry of any judgment with respect to, or pay in full, such claim.

18.1.2 Indemnifying Party. If an Indemnifying Party is obligated to indemnify and hold any Indemnified Party harmless under this Article 18, the amount owing to the Indemnified Party shall be the amount of such Indemnified Party's actual Loss, net of any insurance or other recovery.

18.1.3 Indemnity Procedures. Promptly after receipt by an Indemnified Party of any claim or notice of the commencement of any action or administrative or legal proceeding or investigation as to which the indemnity provided for in Article 18.1 may apply, the Indemnified Party shall notify the Indemnifying Party of such fact. Any failure of or delay in such notification shall not affect a Party's indemnification obligation unless such failure or delay is materially prejudicial to the indemnifying Party.

The Indemnifying Party shall have the right to assume the defense thereof with counsel designated by such Indemnifying Party and reasonably satisfactory to the Indemnified Party. If the defendants in any such action include one or more Indemnified Parties and the Indemnifying Party and if the Indemnified Party reasonably concludes that there may be legal defenses available to it and/or other Indemnified Parties which are different from or additional to those available to the Indemnifying Party, the Indemnified Party shall have the right to select separate counsel to assert such legal defenses and to otherwise participate in the defense of such action on its own behalf. In such instances, the Indemnifying Party shall only be required to pay the fees and expenses of one additional attorney to represent an Indemnified Party or Indemnified Parties having such differing or additional legal defenses.

The Indemnified Party shall be entitled, at its expense, to participate in any such action, suit or proceeding, the defense of which has been assumed by the Indemnifying Party. Notwithstanding the foregoing, the Indemnifying Party (i) shall not be entitled to assume and control the defense of any such action, suit or proceedings if and to the extent that, in the opinion of the Indemnified Party and its counsel, such action, suit or proceeding involves the potential imposition of criminal liability on the Indemnified Party, or there exists a conflict or adversity of interest between the Indemnified Party and the Indemnifying Party, in such event the Indemnifying Party shall pay the reasonable expenses of the Indemnified Party, and (ii) shall not settle or consent to the entry of any judgment in any action, suit or proceeding without the consent of the Indemnified Party, which shall not be unreasonably withheld, conditioned or delayed.

18.2 Consequential Damages. Other than the liquidated damages heretofore described in Article 5.3, in no event shall any Party be liable under any provision of this LGIA for any losses, damages, costs or expenses for any special, indirect, incidental, consequential, or punitive damages, including but not limited to loss of profit or revenue, loss of the use of equipment, cost of capital, cost of temporary equipment or services, whether based in whole or in part in contract, in tort, including negligence, strict liability, or any other theory of liability; provided, however, that damages for which a Party may be liable to another Party under another agreement will not be considered to be special, indirect, incidental, or consequential damages hereunder.

18.3 **Insurance.** Each Party shall, at its own expense, maintain in force throughout the period of this LGIA, and until released by the other Parties, the following minimum insurance coverages, with insurers rated no less than A- (with a minimum size rating of VII) by Bests' Insurance Guide and Key Ratings and authorized to do business in the state where the Point of Interconnection is located, except in the case of the CAISO, the State of California:

18.3.1 Employer's Liability and Workers' Compensation Insurance providing statutory benefits in accordance with the laws and regulations of the state in which the Point of Interconnection is located, except in the case of the CAISO, the State of California.

18.3.2 Commercial General Liability Insurance including premises and operations, personal injury, broad form property damage, broad form blanket contractual liability coverage (including coverage for the contractual indemnification) products and completed operations coverage, coverage for explosion, collapse and underground hazards, independent contractors coverage, coverage for pollution to the extent normally available and punitive damages to the extent normally available and a cross liability endorsement, with minimum limits of One Million Dollars ($1,000,000) per occurrence/One Million Dollars ($1,000,000) aggregate combined single limit for personal injury, bodily injury, including death and property damage.

18.3.3 Business Automobile Liability Insurance for coverage of owned and non-owned and hired vehicles, trailers or semi-trailers designed for travel on public roads, with a minimum, combined single limit of One Million Dollars ($1,000,000) per occurrence for bodily injury, including death, and property damage.

18.3.4 Excess Public Liability Insurance over and above the Employer's Liability Commercial General Liability and Business Automobile Liability Insurance coverage, with a minimum combined single limit of Twenty Million Dollars ($20,000,000) per occurrence/Twenty Million Dollars ($20,000,000) aggregate.

18.3.5 The Commercial General Liability Insurance, Business Automobile Insurance and Excess Public Liability Insurance policies shall name the other Parties, their parents, associated and Affiliate companies and their respective directors, officers, agents, servants and employees ("Other Party Group") as additional insured. All policies shall contain provisions whereby the insurers waive all rights of subrogation in accordance with the provisions of this LGIA against the Other Party Group and provide thirty (30) Calendar Days advance written notice to the Other Party Group prior to anniversary date of cancellation or any material change in coverage or condition.

18.3.6 The Commercial General Liability Insurance, Business Automobile Liability Insurance and Excess Public Liability Insurance policies shall contain provisions that specify that the policies are primary and shall apply to such extent without consideration for other policies separately carried and shall state that each insured is provided coverage as though a separate policy had been issued to each, except the insurer's liability shall not be increased beyond the amount for which the insurer would have been liable had only one insured been covered. Each Party shall be responsible for its respective deductibles or retentions.

18.3.7 The Commercial General Liability Insurance, Business Automobile Liability Insurance and Excess Public Liability Insurance policies, if written on a Claims First Made Basis, shall be maintained in full force and effect for two (2) years after termination of this LGIA, which coverage may be in the form of tail coverage or extended reporting period coverage if agreed by the Parties.

18.3.8 The requirements contained herein as to the types and limits of all insurance to be maintained by the Parties are not intended to and shall not in any manner, limit or qualify the liabilities and obligations assumed by the Parties under this LGIA.

18.3.9 Within ten (10) Calendar Days following execution of this LGIA, and as soon as practicable after the end of each fiscal year or at the renewal of the insurance policy and in any event within ninety (90) Calendar Days thereafter, each Party shall provide certification of all insurance required in this LGIA, executed by each insurer or by an authorized representative of each insurer.

18.3.10 Notwithstanding the foregoing, each Party may self-insure to meet the minimum insurance requirements of Articles 18.3.2 through 18.3.8 to the extent it maintains a self-insurance program; provided that, such Party's senior unsecured debt or issuer rating is BBB-, or better, as rated by Standard & Poor's and that its self-insurance program meets the minimum insurance requirements of Articles 18.3.2 through 18.3.8. For any period of time that a Party's senior unsecured debt rating and issuer rating are both unrated by Standard & Poor's or are both rated at less than BBB- by Standard & Poor's, such Party shall comply with the insurance requirements applicable to it under Articles 18.3.2 through 18.3.9. In the event that a Party is permitted to self-insure pursuant to this Article 18.3.10, it shall notify the other Parties that it meets the requirements to self-insure and that its self-insurance program meets the minimum insurance requirements in a manner consistent with that specified in Article 18.3.9.

18.3.11 The Parties agree to report to each other in writing as soon as practical all accidents or occurrences resulting in injuries to any person, including death, and any property damage arising out of this LGIA.

ARTICLE 19. ASSIGNMENT

19.1 **Assignment.** This LGIA may be assigned by a Party only with the written consent of the other Parties; provided that a Party may assign this LGIA without the consent of the other Parties to any Affiliate of the assigning Party with an equal or greater credit rating and with the legal authority and operational ability to satisfy the obligations of the assigning Party under this LGIA; and provided further that the Interconnection Customer shall have the right to assign this LGIA, without the consent of the CAISO or Participating TO, for collateral security purposes to aid in providing financing for the Large Generating Facility, provided that the Interconnection Customer will promptly notify the CAISO and Participating TO of any such assignment. Any financing arrangement entered into by the Interconnection Customer pursuant to this Article will provide that prior to or upon the exercise of the secured party's, trustee's or mortgagee's assignment rights pursuant to said arrangement, the secured creditor, the trustee or mortgagee will notify the CAISO and Participating TO of the date and particulars of any such exercise of assignment right(s), including providing the CAISO and Participating TO with proof that it meets the requirements of Articles 11.5 and 18.3. Any attempted assignment that violates this Article is void and ineffective. Any assignment under this LGIA shall not relieve a Party of its obligations, nor shall a Party's obligations be enlarged, in whole or in part, by reason thereof. Where required, consent to assignment will not be unreasonably withheld, conditioned or delayed.

ARTICLE 20. SEVERABILITY

20.1 **Severability.** If any provision in this LGIA is finally determined to be invalid, void or unenforceable by any court or other Governmental Authority having jurisdiction, such determination shall not invalidate, void or make unenforceable any other provision, agreement or covenant of this LGIA; provided that if the Interconnection Customer (or any third party, but only if such third party is not acting at the direction of the Participating TO or CAISO) seeks and obtains such a final determination with respect to any provision of the Alternate Option (Article 5.1.2), or the Negotiated Option (Article 5.1.4), then none of the provisions of Article 5.1.2 or 5.1.4 shall thereafter have any force or effect and the Parties' rights and obligations shall be governed solely by the Standard Option (Article 5.1.1).

ARTICLE 21. COMPARABILITY

21.1 Comparability. The Parties will comply with all applicable comparability and code of conduct laws, rules and regulations, as amended from time to time.

ARTICLE 22. CONFIDENTIALITY

22.1 Confidentiality. Confidential Information shall include, without limitation, all information relating to a Party's technology, research and development, business affairs, and pricing, and any information supplied by any of the Parties to the other Parties prior to the execution of this LGIA.

Information is Confidential Information only if it is clearly designated or marked in writing as confidential on the face of the document, or, if the information is conveyed orally or by inspection, if the Party providing the information orally informs the Parties receiving the information that the information is confidential.

If requested by any Party, the other Parties shall provide in writing, the basis for asserting that the information referred to in this Article 22 warrants confidential treatment, and the requesting Party may disclose such writing to the appropriate Governmental Authority. Each Party shall be responsible for the costs associated with affording confidential treatment to its information.

22.1.1 Term. During the term of this LGIA, and for a period of three (3) years after the expiration or termination of this LGIA, except as otherwise provided in this Article 22, each Party shall hold in confidence and shall not disclose to any person Confidential Information.

22.1.2 Scope. Confidential Information shall not include information that the receiving Party can demonstrate: (1) is generally available to the public other than as a result of a disclosure by the receiving Party; (2) was in the lawful possession of the receiving Party on a non-confidential basis before receiving it from the disclosing Party; (3) was supplied to the receiving Party without restriction by a third party, who, to the knowledge of the receiving Party after due inquiry, was under no obligation to the disclosing Party to keep such information confidential; (4) was independently developed by the receiving Party without reference to Confidential Information of the disclosing Party; (5) is, or becomes, publicly known, through no wrongful act or omission of the receiving Party or Breach of this LGIA; or (6) is required, in accordance with Article 22.1.7 of this LGIA, Order of Disclosure, to be disclosed by any Governmental Authority or is otherwise required to be disclosed by law or subpoena, or is necessary in any legal proceeding establishing rights and obligations under this LGIA. Information designated as Confidential Information will no longer be deemed confidential if the Party that designated the information as confidential notifies the other Parties that it no longer is confidential.

22.1.3 Release of Confidential Information. No Party shall release or disclose Confidential Information to any other person, except to its employees, consultants, Affiliates (limited by the Standards of Conduct requirements set forth in Part 358 of FERC's Regulations, 18 C.F.R. 358), subcontractors, or to parties who may be or considering providing financing to or equity participation with the Interconnection Customer, or to potential purchasers or assignees of the Interconnection Customer, on a need-to-know basis in connection with this LGIA, unless such person has first been advised of the confidentiality provisions of this Article 22 and has agreed to comply with such provisions. Notwithstanding the foregoing, a Party providing Confidential Information to any person shall remain primarily responsible for any release of Confidential Information in contravention of this Article 22.

22.1.4 Rights. Each Party retains all rights, title, and interest in the Confidential Information that each Party discloses to the other Parties. The disclosure by each Party to the other Parties of Confidential Information shall not be deemed a waiver by a Party or any other person or entity of the right to protect the Confidential Information from public disclosure.

22.1.5 No Warranties. The mere fact that a Party has provided Confidential Information does not constitute a warranty or representation as to its accuracy or completeness. In addition, by supplying Confidential Information, no Party obligates itself to provide any particular information or Confidential Information to the other Parties nor to enter into any further agreements or proceed with any other relationship or joint venture.

22.1.6 Standard of Care. Each Party shall use at least the same standard of care to protect Confidential Information it receives as it uses to protect its own Confidential Information from unauthorized disclosure, publication or dissemination. Each Party may use Confidential Information solely to fulfill its obligations to the other Parties under this LGIA or its regulatory requirements.

22.1.7 Order of Disclosure. If a court or a Government Authority or entity with the right, power, and apparent authority to do so requests or requires any Party, by subpoena, oral deposition, interrogatories, requests for production of documents, administrative order, or otherwise, to disclose Confidential Information, that Party shall provide the other Parties with prompt notice of such request(s) or requirement(s) so that the other Parties may seek an appropriate protective order or waive compliance with the terms of this LGIA. Notwithstanding the absence of a protective order or waiver, the Party may disclose such Confidential Information which, in the opinion of its counsel, the Party is legally compelled to disclose. Each Party will use Reasonable Efforts to obtain reliable assurance that confidential treatment will be accorded any Confidential Information so furnished.

22.1.8 Termination of Agreement. Upon termination of this LGIA for any reason, each Party shall, within ten (10) Calendar Days of receipt of a written request from another Party, use Reasonable Efforts to destroy, erase, or delete (with such destruction, erasure, and deletion certified in writing to the other Party) or return to the other Party, without retaining copies thereof, any and all written or electronic Confidential Information received from the other Party.

22.1.9 Remedies. The Parties agree that monetary damages would be inadequate to compensate a Party for another Party's Breach of its obligations under this Article 22. Each Party accordingly agrees that the other Parties shall be entitled to equitable relief, by way of injunction or otherwise, if the first Party Breaches or threatens to Breach its obligations under this Article 22, which equitable relief shall be granted without bond or proof of damages, and the receiving Party shall not plead in defense that there would be an adequate remedy at law. Such remedy shall not be deemed an exclusive remedy for the Breach of this Article 22, but shall be in addition to all other remedies available at law or in equity. The Parties further acknowledge and agree that the covenants contained herein are necessary for the protection of legitimate business interests and are reasonable in scope. No Party, however, shall be liable for indirect, incidental, or consequential or punitive damages of any nature or kind resulting from or arising in connection with this Article 22.

22.1.10 Disclosure to FERC, its Staff, or a State. Notwithstanding anything in this Article 22 to the contrary, and pursuant to 18 C.F.R. section 1b.20, if FERC or its staff, during the course of an investigation or otherwise, requests information from one of the Parties that is otherwise required to be maintained in confidence pursuant to this LGIA, the Party shall provide the requested information to FERC or its staff, within the time provided for in the request for information. In providing the information to FERC or its staff, the Party must, consistent with 18 C.F.R. section 388.112, request that the information be treated as confidential and non-public by FERC and its staff and that the information be withheld from public disclosure. Parties are prohibited from notifying the other Parties to this LGIA prior to the release of the Confidential Information to FERC or its staff. The Party shall notify the other Parties to the LGIA when it is notified by FERC or its staff that a request to release Confidential Information has been received by FERC, at which time any of the Parties may respond before such information would be made public, pursuant to 18 C.F.R. section 388.112. Requests from a state regulatory body conducting a confidential investigation shall be treated in a similar manner if consistent with the applicable state rules and regulations.

22.1.11 Subject to the exception in Article 22.1.10, Confidential Information shall not be disclosed by the other Parties to any person not employed or retained by the other Parties, except to the extent disclosure is (i) required by law; (ii) reasonably deemed by the disclosing Party to be required to be disclosed in connection with a dispute between or among the Parties, or the defense of litigation or dispute; (iii) otherwise permitted by consent of the other Parties, such consent not to be unreasonably withheld; or (iv) necessary to fulfill its obligations under this LGIA or as a transmission service provider or a Balancing Authority including disclosing the Confidential Information to an RTO or ISO or to a regional or national reliability organization. The Party asserting confidentiality shall notify the other Parties in writing of the information it claims is confidential. Prior to any disclosures of another Party's Confidential Information under this subparagraph, or if any third party or Governmental Authority makes any request or demand for any of the information described in this subparagraph, the disclosing Party agrees to promptly notify the other Party in writing and agrees to assert confidentiality and cooperate with the other Party in seeking to protect the Confidential Information from public disclosure by confidentiality agreement, protective order or other reasonable measures.

ARTICLE 23. ENVIRONMENTAL RELEASES

23.1 Each Party shall notify the other Parties, first orally and then in writing, of the release of any Hazardous Substances, any asbestos or lead abatement activities, or any type of remediation activities related to the Large Generating Facility or the Interconnection Facilities, each of which may reasonably be expected to affect the other Parties. The notifying Party shall: (i) provide the notice as soon as practicable, provided such Party makes a good faith effort to provide the notice no later than twenty-four hours after such Party becomes aware of the occurrence; and (ii) promptly furnish to the other Parties copies of any publicly available reports filed with any Governmental Authorities addressing such events.

ARTICLE 24. INFORMATION REQUIREMENTS

24.1 **Information Acquisition.** The Participating TO and the Interconnection Customer shall submit specific information regarding the electrical characteristics of their respective facilities to each other as described below and in accordance with Applicable Reliability Standards.

24.2 **Information Submission by Participating TO.** The initial information submission by the Participating TO shall occur no later than one hundred eighty (180) Calendar Days prior to Trial Operation and shall include the Participating TO's Transmission System information necessary to allow the Interconnection Customer to select equipment and meet any system protection and stability requirements, unless otherwise agreed to by the Participating TO and the Interconnection Customer. On a monthly basis the Participating TO shall provide the Interconnection Customer and the CAISO a status report on the construction and installation of the Participating TO's Interconnection Facilities and Network Upgrades, including, but not limited to, the following information: (1) progress to date; (2) a description of the activities since the last report; (3) a description of the action items for the next period; and (4) the delivery status of equipment ordered.

24.3 Updated Information Submission by Interconnection Customer. The updated information submission by the Interconnection Customer, including manufacturer information, shall occur no later than one hundred eighty (180) Calendar Days prior to the Trial Operation. The Interconnection Customer shall submit a completed copy of the Electric Generating Unit data requirements contained in Appendix 1 to the LGIP. It shall also include any additional information provided to the Participating TO and the CAISO for the Interconnection Studies. Information in this submission shall be the most current Electric Generating Unit design or expected performance data. Information submitted for stability models shall be compatible with the Participating TO and CAISO standard models. If there is no compatible model, the Interconnection Customer will work with a consultant mutually agreed to by the Parties to develop and supply a standard model and associated information.

If the Interconnection Customer's data is materially different from what was originally provided to the Participating TO and the CAISO for the Interconnection Studies, then the Participating TO and the CAISO will conduct appropriate studies pursuant to the LGIP to determine the impact on the Participating TO's Transmission System and affected portions of the CAISO Controlled Grid based on the actual data submitted pursuant to this Article 24.3. The Interconnection Customer shall not begin Trial Operation until such studies are completed and all other requirements of this LGIA are satisfied.

24.4 Information Supplementation. Prior to the Trial Operation date, the Parties shall supplement their information submissions described above in this Article 24 with any and all "as-built" Electric Generating Unit information or "as-tested" performance information that differs from the initial submissions or, alternatively, written confirmation that no such differences exist. The Interconnection Customer shall conduct tests on the Electric Generating Unit as required by Good Utility Practice such as an open circuit "step voltage" test on the Electric Generating Unit to verify proper operation of the Electric Generating Unit's automatic voltage regulator.

Unless otherwise agreed, the test conditions shall include: (1) Electric Generating Unit at synchronous speed; (2) automatic voltage regulator on and in voltage control mode; and (3) a five percent (5 percent) change in Electric Generating Unit terminal voltage initiated by a change in the voltage regulators reference voltage. The Interconnection Customer shall provide validated test recordings showing the responses of Electric Generating Unit terminal and field voltages. In the event that direct recordings of these voltages is impractical, recordings of other voltages or currents that mirror the response of the Electric Generating Unit's terminal or field voltage are acceptable if information necessary to translate these alternate quantities to actual Electric Generating Unit terminal or field voltages is provided. Electric Generating Unit testing shall be conducted and results provided to the Participating TO and the CAISO for each individual Electric Generating Unit in a station.

Subsequent to the Commercial Operation Date, the Interconnection Customer shall provide the Participating TO and the CAISO any information changes due to equipment replacement, repair, or adjustment. The Participating TO shall provide the Interconnection Customer any information changes due to equipment replacement, repair or adjustment in the directly connected substation or any adjacent Participating TO-owned substation that may affect the Interconnection Customer's Interconnection Facilities equipment ratings, protection or operating requirements. The Parties shall provide such information pursuant to Article 5.19.

ARTICLE 25. INFORMATION ACCESS AND AUDIT RIGHTS

25.1 Information Access. Each Party (the "disclosing Party") shall make available to the other Party information that is in the possession of the disclosing Party and is necessary in order for the other Party to: (i) verify the costs incurred by the disclosing Party for which the other Party is responsible under this LGIA; and (ii) carry out its obligations and responsibilities under this LGIA. The Parties shall not use such information for purposes other than those set forth in this Article 25.1 and to enforce their rights under this LGIA. Nothing in this Article 25 shall obligate the CAISO to make available to a Party any third party information in its possession or control if making such third party information available would violate a CAISO Tariff restriction on the use or disclosure of such third party information.

25.2 Reporting of Non-Force Majeure Events. Each Party (the "notifying Party") shall notify the other Parties when the notifying Party becomes aware of its inability to comply with the provisions of this LGIA for a reason other than a Force Majeure event. The Parties agree to cooperate with each other and provide necessary information regarding such inability to comply, including the date, duration, reason for the inability to comply, and corrective actions taken or planned to be taken with respect to such inability to comply. Notwithstanding the foregoing, notification, cooperation or information provided under this Article shall not entitle the Party receiving such notification to allege a cause for anticipatory breach of this LGIA.

25.3 Audit Rights. Subject to the requirements of confidentiality under Article 22 of this LGIA, the Parties' audit rights shall include audits of a Party's costs pertaining to such Party's performance or satisfaction of obligations owed to the other Party under this LGIA, calculation of invoiced amounts, the CAISO's efforts to allocate responsibility for the provision of reactive support to the CAISO Controlled Grid, the CAISO's efforts to allocate responsibility for interruption or reduction of generation on the CAISO Controlled Grid, and each such Party's actions in an Emergency Condition.

25.3.1 The Interconnection Customer and the Participating TO shall each have the right, during normal business hours, and upon prior reasonable notice to the other Party, to audit at its own expense the other Party's accounts and records pertaining to either such Party's performance or either such Party's satisfaction of obligations owed to the other Party under this LGIA. Subject to Article 25.3.2, any audit authorized by this Article shall be performed at the offices where such accounts and records are maintained and shall be limited to those portions of such accounts and records that relate to each such Party's performance and satisfaction of obligations under this LGIA. Each such Party shall keep such accounts and records for a period equivalent to the audit rights periods described in Article 25.4.

25.3.2 Notwithstanding anything to the contrary in Article 25.3, each Party's rights to audit the CAISO's accounts and records shall be as set forth in Section 22.1 of the CAISO Tariff.

25.4 Audit Rights Periods.

25.4.1 Audit Rights Period for Construction-Related Accounts and Records. Accounts and records related to the design, engineering, procurement, and construction of Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades constructed by the Participating TO shall be subject to audit for a period of twenty-four months following the Participating TO's issuance of a final invoice in accordance with Article 12.2. Accounts and records related to the design, engineering, procurement, and construction of Participating TO's Interconnection Facilities and/or Stand Alone Network Upgrades constructed by the Interconnection Customer shall be subject to audit and verification by the Participating TO and the CAISO for a period of twenty-four months following the Interconnection Customer's issuance of a final invoice in accordance with Article 5.2(8).

25.4.2 **Audit Rights Period for All Other Accounts and Records.** Accounts and records related to a Party's performance or satisfaction of all obligations under this LGIA other than those described in Article 25.4.1 shall be subject to audit as follows: (i) for an audit relating to cost obligations, the applicable audit rights period shall be twenty-four months after the auditing Party's receipt of an invoice giving rise to such cost obligations; and (ii) for an audit relating to all other obligations, the applicable audit rights period shall be twenty-four months after the event for which the audit is sought; provided that each Party's rights to audit the CAISO's accounts and records shall be as set forth in Section 22.1 of the CAISO Tariff.

25.5 **Audit Results.** If an audit by the Interconnection Customer or the Participating TO determines that an overpayment or an underpayment has occurred with respect to the other Party, a notice of such overpayment or underpayment shall be given to the other Party together with those records from the audit which supports such determination. The Party that is owed payment shall render an invoice to the other Party and such invoice shall be paid pursuant to Article 12 hereof.

25.5.1 Notwithstanding anything to the contrary in Article 25.5, the Interconnection Customer's and Participating TO's rights to audit the CAISO's accounts and records shall be as set forth in Section 22.1 of the CAISO Tariff, and the CAISO's process for remedying an overpayment or underpayment shall be as set forth in the CAISO Tariff.

ARTICLE 26. SUBCONTRACTORS

26.1 **General.** Nothing in this LGIA shall prevent a Party from utilizing the services of any subcontractor as it deems appropriate to perform its obligations under this LGIA; provided, however, that each Party shall require its subcontractors to comply with all applicable terms and conditions of this LGIA in providing such services and each Party shall remain primarily liable to the other Party for the performance of such subcontractor.

26.2 **Responsibility of Principal.** The creation of any subcontract relationship shall not relieve the hiring Party of any of its obligations under this LGIA. The hiring Party shall be fully responsible to the other Parties for the acts or omissions of any subcontractor the hiring Party hires as if no subcontract had been made; provided, however, that in no event shall the CAISO or Participating TO be liable for the actions or inactions of the Interconnection Customer or its subcontractors with respect to obligations of the Interconnection Customer under Article 5 of this LGIA. Any applicable obligation imposed by this LGIA upon the hiring Party shall be equally binding upon, and shall be construed as having application to, any subcontractor of such Party.

26.3 **No Limitation by Insurance.** The obligations under this Article 26 will not be limited in any way by any limitation of subcontractor's insurance.

ARTICLE 27. DISPUTES

All disputes arising out of or in connection with this LGIA whereby relief is sought by or from the CAISO shall be settled in accordance with the provisions of Article 13 of the CAISO Tariff, except that references to the CAISO Tariff in such Article 13 of the CAISO Tariff shall be read as references to this LGIA. Disputes arising out of or in connection with this LGIA not subject to provisions of Article 13 of the CAISO Tariff shall be resolved as follows:

27.1 **Submission.** In the event either Party has a dispute, or asserts a claim, that arises out of or in connection with this LGIA or its performance, such Party (the "disputing Party") shall provide the other Party with written notice of the dispute or claim ("Notice of Dispute"). Such dispute or claim shall be referred to a designated senior representative of each Party for resolution on an informal basis as promptly as practicable after receipt of the Notice of Dispute by the other Party. In the event the designated representatives are unable to resolve the claim or dispute through unassisted or assisted negotiations within thirty (30) Calendar Days of the other Party's receipt of the Notice of Dispute, such claim or dispute may, upon mutual agreement of the Parties, be submitted to arbitration and resolved in accordance with the arbitration procedures set forth below. In the event the Parties do not agree to submit such claim or dispute to arbitration, each Party may exercise whatever rights and remedies it may have in equity or at law consistent with the terms of this LGIA.

27.2 External Arbitration Procedures. Any arbitration initiated under this LGIA shall be conducted before a single neutral arbitrator appointed by the Parties. If the Parties fail to agree upon a single arbitrator within ten (10) Calendar Days of the submission of the dispute to arbitration, each Party shall choose one arbitrator who shall sit on a three-member arbitration panel. The two arbitrators so chosen shall within twenty (20) Calendar Days select a third arbitrator to chair the arbitration panel. In either case, the arbitrators shall be knowledgeable in electric utility matters, including electric transmission and bulk power issues, and shall not have any current or past substantial business or financial relationships with any party to the arbitration (except prior arbitration). The arbitrator(s) shall provide each of the Parties an opportunity to be heard and, except as otherwise provided herein, shall conduct the arbitration in accordance with the Commercial Arbitration Rules of the American Arbitration Association ("Arbitration Rules") and any applicable FERC regulations; provided, however, in the event of a conflict between the Arbitration Rules and the terms of this Article 27, the terms of this Article 27 shall prevail.

27.3 Arbitration Decisions. Unless otherwise agreed by the Parties, the arbitrator(s) shall render a decision within ninety (90) Calendar Days of appointment and shall notify the Parties in writing of such decision and the reasons therefor. The arbitrator(s) shall be authorized only to interpret and apply the provisions of this LGIA and shall have no power to modify or change any provision of this Agreement in any manner. The decision of the arbitrator(s) shall be final and binding upon the Parties, and judgment on the award may be entered in any court having jurisdiction. The decision of the arbitrator(s) may be appealed solely on the grounds that the conduct of the arbitrator(s), or the decision itself, violated the standards set forth in the Federal Arbitration Act or the Administrative Dispute Resolution Act. The final decision of the arbitrator(s) must also be filed with FERC if it affects jurisdictional rates, terms and conditions of service, Interconnection Facilities, or Network Upgrades.

27.4 Costs. Each Party shall be responsible for its own costs incurred during the arbitration process and for the following costs, if applicable: (1) the cost of the arbitrator chosen by the Party to sit on the three member panel and one half of the cost of the third arbitrator chosen; or (2) one half the cost of the single arbitrator jointly chosen by the Parties.

ARTICLE 28. REPRESENTATIONS, WARRANTIES AND COVENANTS

28.1 General. Each Party makes the following representations, warranties and covenants:

28.1.1 Good Standing. Such Party is duly organized, validly existing and in good standing under the laws of the state in which it is organized, formed, or incorporated, as applicable; that it is qualified to do business in the state or states in which the Large Generating Facility, Interconnection Facilities and Network Upgrades owned by such Party, as applicable, are located; and that it has the corporate power and authority to own its properties, to carry on its business as now being conducted and to enter into this LGIA and carry out the transactions contemplated hereby and perform and carry out all covenants and obligations on its part to be performed under and pursuant to this LGIA.

28.1.2 Authority. Such Party has the right, power and authority to enter into this LGIA, to become a Party hereto and to perform its obligations hereunder. This LGIA is a legal, valid and binding obligation of such Party, enforceable against such Party in accordance with its terms, except as the enforceability thereof may be limited by applicable bankruptcy, insolvency, reorganization or other similar laws affecting creditors' rights generally and by general equitable principles (regardless of whether enforceability is sought in a proceeding in equity or at law).

28.1.3 **No Conflict.** The execution, delivery and performance of this LGIA does not violate or conflict with the organizational or formation documents, or bylaws or operating agreement, of such Party, or any judgment, license, permit, order, material agreement or instrument applicable to or binding upon such Party or any of its assets.

28.1.4 **Consent and Approval.** Such Party has sought or obtained, or, in accordance with this LGIA will seek or obtain, each consent, approval, authorization, order, or acceptance by any Governmental Authority in connection with the execution, delivery and performance of this LGIA, and it will provide to any Governmental Authority notice of any actions under this LGIA that are required by Applicable Laws and Regulations.

ARTICLE 29. [RESERVED]

ARTICLE 30. MISCELLANEOUS

30.1 **Binding Effect.** This LGIA and the rights and obligations hereof, shall be binding upon and shall inure to the benefit of the successors and assigns of the Parties hereto.

30.2 **Conflicts.** In the event of a conflict between the body of this LGIA and any attachment, appendices or exhibits hereto, the terms and provisions of the body of this LGIA shall prevail and be deemed the final intent of the Parties.

30.3 **Rules of Interpretation.** This LGIA, unless a clear contrary intention appears, shall be construed and interpreted as follows: (1) the singular number includes the plural number and vice versa; (2) reference to any person includes such person's successors and assigns but, in the case of a Party, only if such successors and assigns are permitted by this LGIA, and reference to a person in a particular capacity excludes such person in any other capacity or individually; (3) reference to any agreement (including this LGIA), document, instrument or tariff means such agreement, document, instrument, or tariff as amended or modified and in effect from time to time in accordance with the terms thereof and, if applicable, the terms hereof; (4) reference to any Applicable Laws and Regulations means such Applicable Laws and Regulations as amended, modified, codified, or reenacted, in whole or in part, and in effect from time to time, including, if applicable, rules and regulations promulgated thereunder; (5) unless expressly stated otherwise, reference to any Article, Section or Appendix means such Article of this LGIA or such Appendix to this LGIA, or such Section to the LGIP or such Appendix to the LGIP, as the case may be; (6) "hereunder", "hereof", "herein", "hereto" and words of similar import shall be deemed references to this LGIA as a whole and not to any particular Article or other provision hereof or thereof; (7) "including" (and with correlative meaning "include") means including without limiting the generality of any description preceding such term; and (8) relative to the determination of any period of time, "from" means "from and including", "to" means "to but excluding" and "through" means "through and including".

30.4 **Entire Agreement.** This LGIA, including all Appendices and Schedules attached hereto, constitutes the entire agreement among the Parties with reference to the subject matter hereof, and supersedes all prior and contemporaneous understandings or agreements, oral or written, between or among the Parties with respect to the subject matter of this LGIA. There are no other agreements, representations, warranties, or covenants which constitute any part of the consideration for, or any condition to, any Party's compliance with its obligations under this LGIA.

30.5 No Third Party Beneficiaries. This LGIA is not intended to and does not create rights, remedies, or benefits of any character whatsoever in favor of any persons, corporations, associations, or entities other than the Parties, and the obligations herein assumed are solely for the use and benefit of the Parties, their successors in interest and, where permitted, their assigns.

30.6 Waiver. The failure of a Party to this LGIA to insist, on any occasion, upon strict performance of any provision of this LGIA will not be considered a waiver of any obligation, right, or duty of, or imposed upon, such Party.

Any waiver at any time by either Party of its rights with respect to this LGIA shall not be deemed a continuing waiver or a waiver with respect to any other failure to comply with any other obligation, right, duty of this LGIA. Termination or Default of this LGIA for any reason by the Interconnection Customer shall not constitute a waiver of the Interconnection Customer's legal rights to obtain an interconnection from the Participating TO. Any waiver of this LGIA shall, if requested, be provided in writing.

30.7 Headings. The descriptive headings of the various Articles of this LGIA have been inserted for convenience of reference only and are of no significance in the interpretation or construction of this LGIA.

30.8 Multiple Counterparts. This LGIA may be executed in two or more counterparts, each of which is deemed an original but all constitute one and the same instrument.

30.9 Amendment. The Parties may by mutual agreement amend this LGIA by a written instrument duly executed by all of the Parties. Such amendment shall become effective and a part of this LGIA upon satisfaction of all Applicable Laws and Regulations.

30.10 Modification by the Parties. The Parties may by mutual agreement amend the Appendices to this LGIA by a written instrument duly executed by all of the Parties. Such amendment shall become effective and a part of this LGIA upon satisfaction of all Applicable Laws and Regulations.

30.11 Reservation of Rights. The CAISO and Participating TO shall each have the right to make a unilateral filing with FERC to modify this LGIA pursuant to section 205 or any other applicable provision of the Federal Power Act and FERC's rules and regulations thereunder with respect to the following Articles and Appendices of this LGIA and with respect to any rates, terms and conditions, charges, classifications of service, rule or regulation covered by these Articles and Appendices:

> Recitals, 1, 2.1, 2.2, 2.3, 2.4, 2.6, 3.1, 3.3, 4.1, 4.2, 4.3, 4.4, 5 preamble, 5.4, 5.7, 5.8, 5.9, 5.12, 5.13, 5.18, 5.19.1, 7.1, 7.2, 8, 9.1, 9.2, 9.3, 9.5, 9.6, 9.7, 9.8, 9.10, 10.3, 11.4, 12.1, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24.3, 24.4, 25.1, 25.2, 25.3 (excluding subparts), 25.4.2, 26, 28, 29, 30, Appendix D, Appendix F, Appendix G, and any other Article not reserved exclusively to the Participating TO or the CAISO below.

The Participating TO shall have the exclusive right to make a unilateral filing with FERC to modify this LGIA pursuant to section 205 or any other applicable provision of the Federal Power Act and FERC's rules and regulations thereunder with respect to the following Articles and Appendices of this LGIA and with respect to any rates, terms and conditions, charges, classifications of service, rule or regulation covered by these Articles and Appendices:

> 2.5, 5.1, 5.2, 5.3, 5.5, 5.6, 5.10, 5.11, 5.14, 5.15, 5.16, 5.17, 5.19 (excluding 5.19.1), 6, 7.3, 9.4, 9.9, 10.1, 10.2, 10.4, 10.5, 11.1, 11.2, 11.3, 11.5, 12.2, 12.3, 12.4, 24.1, 24.2,

25.3.1, 25.4.1, 25.5 (excluding 25.5.1), 27 (excluding preamble), Appendix A, Appendix B, Appendix C, and Appendix E.

The CAISO shall have the exclusive right to make a unilateral filing with FERC to modify this LGIA pursuant to section 205 or any other applicable provision of the Federal Power Act and FERC's rules and regulations thereunder with respect to the following Articles of this LGIA and with respect to any rates, terms and conditions, charges, classifications of service, rule or regulation covered by these Articles:

3.2, 4.5, 11.6, 25.3.2, 25.5.1, and 27 preamble.

The Interconnection Customer, the CAISO, and the Participating TO shall have the right to make a unilateral filing with FERC to modify this LGIA pursuant to section 206 or any other applicable provision of the Federal Power Act and FERC's rules and regulations thereunder; provided that each Party shall have the right to protest any such filing by another Party and to participate fully in any proceeding before FERC in which such modifications may be considered. Nothing in this LGIA shall limit the rights of the Parties or of FERC under sections 205 or 206 of the Federal Power Act and FERC's rules and regulations thereunder, except to the extent that the Parties otherwise mutually agree as provided herein.

30.12 No Partnership. This LGIA shall not be interpreted or construed to create an association, joint venture, agency relationship, or partnership among the Parties or to impose any partnership obligation or partnership liability upon any Party. No Party shall have any right, power or authority to enter into any agreement or undertaking for, or act on behalf of, or to act as or be an agent or representative of, or to otherwise bind, another Party.

30.13 Joint and Several Obligations. Except as otherwise provided in this LGIA, the obligations of the CAISO, the Participating TO, and the Interconnection Customer are several, and are neither joint nor joint and several.

IN WITNESS WHEREOF, the Parties have executed this LGIA in multiple originals, each of which shall constitute and be an original effective agreement among the Parties.

[Insert name of Interconnection Customer]

By: ______________________

Title: ______________________

Date:

[Insert name of Participating TO]

By: ______________________

Title:

Date:

California Independent System Operator Corporation

By:

Title:

Date:

Appendices to LGIA

Appendix A	Interconnection Facilities, Network Upgrades and Distribution Upgrades
Appendix B	Milestones
Appendix C	Interconnection Details
Appendix D	Security Arrangements Details
Appendix E	Commercial Operation Date
Appendix F	Addresses for Delivery of Notices and Billings
Appendix G	Interconnection Customer’s Proportional Share of Costs of Network Upgrades for Applicable Project Group
Appendix H	Interconnection Requirements for a Wind Generating Plant

Appendix A
To LGIA

Interconnection Facilities, Network Upgrades and Distribution Upgrades

1. Interconnection Facilities:

(a) [insert Interconnection Customer's Interconnection Facilities]:

(b) [insert Participating TO's Interconnection Facilities]:

2. Network Upgrades:

(a) [insert Stand Alone Network Upgrades]:

(b) [insert Other Network Upgrades]:

(i) [insert Participating TO's Reliability Network Upgrades]

(ii) [insert Participating TO's Delivery Network Upgrades]

3. Distribution Upgrades:

Appendix B
To LGIA

Milestones

Appendix C
To LGIA

Interconnection Details

Appendix D
To LGIA

Security Arrangements Details

Infrastructure security of CAISO Controlled Grid equipment and operations and control hardware and software is essential to ensure day-to-day CAISO Controlled Grid reliability and operational security. FERC will expect the CAISO, all Participating TOs, market participants, and Interconnection Customers interconnected to the CAISO Controlled Grid to comply with the recommendations offered by the President's Critical Infrastructure Protection Board and, eventually, best practice recommendations from the electric reliability authority. All public utilities will be expected to meet basic standards for system infrastructure and operational security, including physical, operational, and cyber-security practices.

The Interconnection Customer shall meet the requirements for security implemented pursuant to the CAISO Tariff, including the CAISO's standards for information security posted on the CAISO's internet web site at the following internet address: http://www.caiso.com/pubinfo/info-security/index.html.

Appendix E
To LGIA

Commercial Operation Date

[This Appendix E sets forth a form of letter to be provided by the Interconnection Customer to the CAISO and Participating TO to provide formal notice of the Commercial Operation of an Electric Generating Unit.]

[Date]

[CAISO Address]

[Participating TO Address]

Re: _____________ Electric Generating Unit

Dear _______________:

On **[Date] [Interconnection Customer]** has completed Trial Operation of Unit No. ___. This letter confirms that [Interconnection Customer] commenced Commercial Operation of Unit No. ___ at the Electric Generating Unit, effective as of **[Date plus one day]** and that [Interconnection Customer] provided the CAISO's operations personnel advance notice of its intended Commercial Operation Date no less than five Business Days prior to that date.

Thank you.

[Signature]

[Interconnection Customer Representative]

Appendix F
To LGIA

Addresses for Delivery of Notices and Billings

Notices:

Participating TO:

[To be supplied.]

Interconnection Customer:

[To be supplied.]

CAISO:

[To be supplied.]

Billings and Payments:

Participating TO:

[To be supplied.]

Interconnection Customer:

[To be supplied.]

CAISO:

[To be supplied.]

Alternative Forms of Delivery of Notices (telephone, facsimile or e-mail):

Participating TO:

[To be supplied.]

Interconnection Customer:

[To be supplied.]

CAISO:

[To be supplied.]

Appendix G
To LGIA

Interconnection Customer's Proportional Share of Costs of Network Upgrades for Applicable Project Group

Appendix H
To LGIA

INTERCONNECTION REQUIREMENTS FOR AN ASYNCHRONOUS GENERATING FACILITY

Appendix H sets forth interconnection requirements specific to all Asynchronous Generating Facilities. Existing individual generating units of an Asynchronous Generating Facility that are, or have been, interconnected to the CAISO Controlled Grid at the same location are exempt from the requirements of this Appendix H for the remaining life of the existing generating unit. Generating units that are replaced, however, shall meet the requirements of this Appendix H.

A. Technical Requirements Applicable to Asynchronous Generating Facilities

i. Low Voltage Ride-Through (LVRT) Capability

An Asynchronous Generating Facility shall be able to remain online during voltage disturbances up to the time periods and associated voltage levels set forth in the requirements below.

A. An Asynchronous Generating Facility shall remain online for the voltage disturbance caused by any fault on the transmission grid, or within the Asynchronous Generating Facility between the Point of Interconnection and the high voltage terminals of the Asynchronous Generating Facility's step up transformer, having a duration equal to the lesser of the normal three-phase fault clearing time (4-9 cycles) or one-hundred fifty (150) milliseconds, plus any subsequent post-fault voltage recovery to the final steady-state post-fault voltage. Clearing time shall be based on the maximum normal clearing time associated with any three-phase fault location that reduces the voltage at the Asynchronous Generating Facility's Point of Interconnection to 0.2 per-unit of nominal voltage or less, independent of any fault current contribution from the Asynchronous Generating Facility.

B. An Asynchronous Generating Facility shall remain online for any voltage disturbance caused by a single-phase fault on the transmission grid, or within the Asynchronous Generating Facility between the Point of Interconnection and the high voltage terminals of the Asynchronous Generating Facility's step up transformer, with delayed clearing, plus any subsequent post-fault voltage recovery to the final steady-state post-fault voltage. Clearing time shall be based on the maximum backup clearing time associated with a single point of failure (protection or breaker failure) for any single-phase fault location that reduces any phase-to-ground or phase-to-phase voltage at the Asynchronous Generating Facility's Point of Interconnection to 0.2 per-unit of nominal voltage or less, independent of any fault current contribution from the Asynchronous Generating Facility.

C. Remaining on-line shall be defined as continuous connection between the Point of Interconnection and the Asynchronous Generating Facility's units, without any mechanical isolation. Asynchronous Generating Facilities may cease to inject current into the transmission grid during a fault.

D. The Asynchronous Generating Facility is not required to remain on line during multi-phased faults exceeding the duration described in Section A.i.1 of this Appendix H or single-phase faults exceeding the duration described in Section A.i.2 of this Appendix H.

E. The requirements of this Section A.i. of this Appendix H do not apply to faults that occur between the Asynchronous Generating Facility's terminals and the high side of the step-up transformer to the high-voltage transmission system.

F. Asynchronous Generating Facilities may be tripped after the fault period if this action is intended as part of a special protection system.

G. Asynchronous Generating Facilities may meet the requirements of this Section A.i of this Appendix H through the performance of the generating units or by installing additional equipment within the Asynchronous Generating Facility, or by a combination of generating unit performance and additional equipment.

H. The provisions of this Section A.i of this Appendix H apply only if the voltage at the Point of Interconnection has remained within the range of 0.9 and 1.10 per-unit of nominal voltage for the preceding two seconds, excluding any sub-cycle transient deviations.

The requirements of this Section A.i in this Appendix H shall not apply to any Asynchronous Generating Facility that can demonstrate to the CAISO a binding commitment, as of May 18, 2010, to purchase inverters for thirty (30) percent or more of the Generating Facility's maximum Generating Facility Capacity that are incapable of complying with the requirements of this Section A.i in this Appendix H. The Interconnection Customer must include a statement from the inverter manufacturer confirming the inability to comply with this requirement in addition to any information requested by the CAISO to determine the applicability of this exemption.

ii. Frequency Disturbance Ride-Through Capability

An Asynchronous Generating Facility shall comply with the off nominal frequency requirements set forth in the WECC Under Frequency Load Shedding Relay Application Guide or successor requirements as they may be amended from time to time.

iii. Power Factor Design and Operating Requirements (Reactive Power)

1) Asynchronous Generating Facilities shall meet the following design requirements:

An Asynchronous Generating Facility shall be designed to have sufficient reactive power sourcing capability to achieve a net power factor of 0.95 lagging or less at the Point of Interconnection, at the Generating Facility's maximum Generating Facility Capacity An Asynchronous Generating Facility shall be designed to have net reactive power sourcing and absorption capability sufficient to achieve or exceed the net reactive power range in Figure 1 as a function of the Point of Interconnection voltage, without exceeding the ratings of any equipment in the Asynchronous Generating Facility. The Point of Interconnection voltage is specified in per-unit of the nominal voltage.

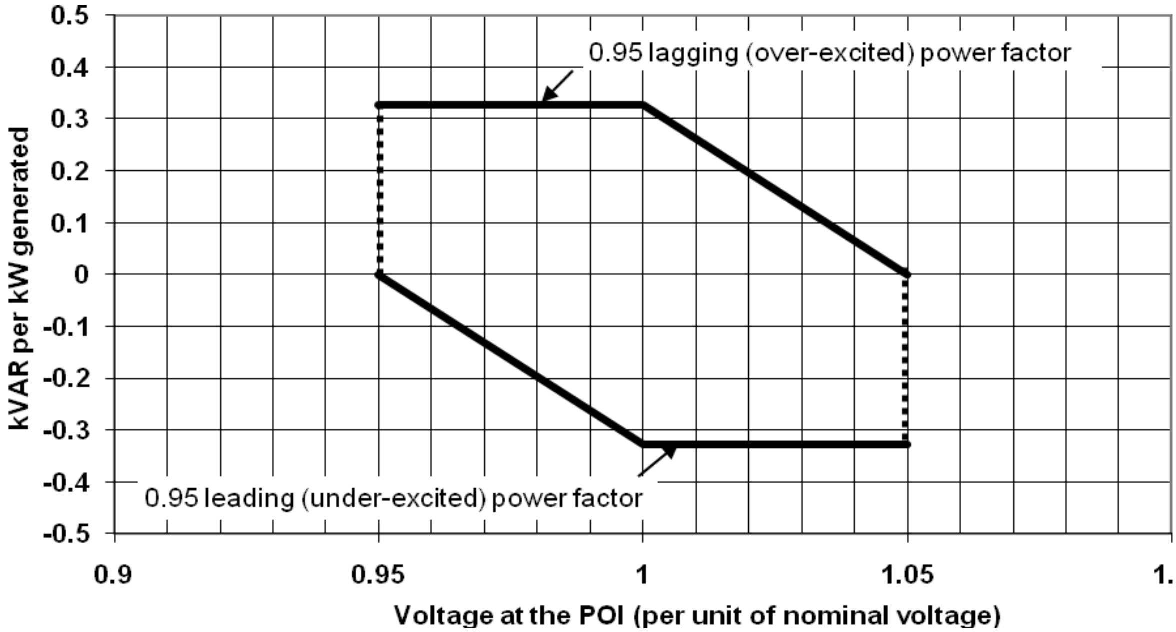

Figure 1

Net power factor shall be measured at the Point of Interconnection as defined in this LGIA.

Asynchronous Generating Facilities may meet the power factor range requirement by using power electronics designed to supply the required level of reactive capability (taking into account any limitations due to voltage level and real power output) or fixed and switched capacitors, or a combination of the two.

Asynchronous Generating Facilities shall also provide dynamic voltage support if the Interconnection Study requires dynamic voltage support for system safety or reliability.

Asynchronous Generating Facilities shall vary the reactive power output between the full sourcing and full absorption capabilities such that any step change in the reactive power output does not cause a step change in voltage at the Point of Interconnection greater than 0.02 per unit of the nominal voltage.

The maximum voltage change requirement shall apply when the CAISO Controlled Grid is fully intact (no line or transformer outages), or during outage conditions which do not decrease the three-phase short circuit capacity at the Point of Interconnection to less than ninety (90) percent of the three-phase short-circuit capacity that would be present without the transmission network outage.

2) Asynchronous Generating Facilities shall meet the following operational requirements:

When plant output power is greater than twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity, the Asynchronous Generating Facility shall have a net reactive power range at least as great as specified in Figure 1 at the Point of Interconnection, based on the actual real power output level delivered to the Point of Interconnection.

Power output may be curtailed at the direction of CAISO to a value where the net power factor range is met, if the reactive power capability of an Asynchronous Generating Facility is partially or totally unavailable, and if continued operation causes deviation of the voltage at the Point of Interconnection outside +/- 0.02 per unit of scheduled voltage level.

When the output power of the Asynchronous Generating Facility is less than twenty (20) percent of the Generating Facility's maximum Generating Facility Capacity, the net reactive power shall remain within the range between –6.6% and +6.6% of the Asynchronous Generating Facility's real power rating.

If the Point of Interconnection voltage exceeds 1.05 per unit, the Asynchronous Generating Facility shall provide reactive power absorption to the extent possible without violating the ratings of any of the Asynchronous Generating Facility's equipment.

If the Point of Interconnection voltage is less than 0.95 per unit, the Asynchronous Generating Facility shall provide reactive power injection to the extent possible without violating the ratings of any of the Asynchronous Generating Facility's equipment.

iv. Voltage Regulation and Reactive Power Control Requirements

The Asynchronous Generation Facility's reactive power capability shall be controlled by an automatic system having both voltage regulation and a net power factor regulation operating modes. The default mode of operation will be voltage regulation.

The voltage regulation function mode shall automatically control the net reactive power of the Asynchronous Generating Facility to regulate the Point of Interconnection positive sequence component of voltage to within a tolerance of +/- 0.02 per unit of the nominal voltage schedule assigned by the Participating TO or CAISO, within the constraints of the reactive power capacity of the Asynchronous Generation Facility. Deviations outside of this voltage band, except as caused by insufficient reactive capacity to maintain the voltage schedule tolerances, shall not exceed five (5) minutes duration per incident.

The power factor mode will regulate the net power factor measured at the Point of Interconnection. If the Asynchronous Generating Facility uses discrete reactive banks to provide reactive capability, the tolerances of the power factor regulation shall be consistent with the reactive banks' sizes meeting the voltage regulation tolerances specified in the preceding paragraph.

The net reactive power flow into or out of the Asynchronous Generating Facility, in any mode of operation, shall not cause the positive sequence component of voltage at the Point of Interconnection to exceed 1.05 per unit, or fall below 0.95 per unit.

The CAISO, in coordination with the Participating TO, may permit the Interconnection Customer to regulate the voltage at a point on the Asynchronous Generating Facility's side of the Point of Interconnection. Regulating voltage to a point other than the Point of Interconnection shall not change the Asynchronous Generating Facility's net power factor requirements set forth in Section A.iii of this Appendix H.

The Interconnection Customer shall not disable voltage regulation controls, without the specific permission of CAISO, while the Asynchronous Generating Facility is in operation at a power level greater than twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity.

v. Plant Power Management

As of January 1, 2012, Asynchronous Generating Facilities must have the capability to limit active power output in response to a CAISO Dispatch Instruction or Operating Order as those terms are defined in the CAISO Tariff. This capability shall extend from the Minimum Operating Limit to the Maximum Operating Limit, as those terms are defined in the CAISO Tariff, of the Asynchronous Generating Facility in increments of five (5) MW or less. Changes to the power management set point shall not cause a change in voltage at the Point of Interconnection exceeding 0.02 per unit of the nominal voltage.

For Asynchronous Generating Facilities that are also Eligible Intermittent Resources as that term is defined in the CAISO Tariff, these power management requirements establish only a maximum output limit. There is no requirement for the Eligible Intermittent Resource to maintain a level of power output beyond the capabilities of the available energy source.

Asynchronous Generating Facilities must have the installed capability to limit power change ramp rates automatically, except for downward ramps resulting from decrease of the available energy resource for Eligible Intermittent Resources. The power ramp control shall be capable of limiting rates of power change to a value of five (5) percent, (10) percent, or twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity per minute. The Asynchronous Generating Facility may implement this ramping limit by using stepped increments if the individual step size is five (5) MW or less.

Asynchronous Generating Facilities must have the installed capability to automatically reduce plant power output in response to an over-frequency condition. This frequency response control shall, when enabled at the direction of CAISO, continuously monitor the system frequency and automatically reduce the real power output of the Asynchronous Generating Facility with a droop equal to a one-hundred (100) percent decrease in plant output for a five (5) percent rise in frequency (five (5) percent droop) above an intentional dead band of 0.036 Hz.

vi. Supervisory Control and Data Acquisition (SCADA) and Automated Dispatch System (ADS) Capability

An Asynchronous Generating Facility shall provide SCADA capability to transmit data and receive instructions from the Participating TO and CAISO to protect system reliability. The Participating TO and CAISO and the Asynchronous Generating Facility Interconnection Customer shall determine what SCADA information is essential for the proposed Asynchronous Generating Facility, taking into account the size of the plant and its characteristics, location, and importance in maintaining generation resource adequacy and transmission system reliability.

An Asynchronous Generating Facility must be able to receive and respond to Automated Dispatch System (ADS) instructions and any other form of communication authorized by the CAISO Tariff. The Asynchronous Generating Facility's response time should be capable of conforming to the periods prescribed by the CAISO Tariff.

vii. Power System Stabilizers (PSS)

Power system stabilizers are not required for Asynchronous Generating Facilities.

Attachment B - Blacklines

Tariff Amendment to Modify Interconnection Requirements Applicable to Large Generators

* * *

8.2.3.3 Voltage Support

The CAISO shall determine on an hourly basis for each day the quantity and location of Voltage Support required to maintain voltage levels and reactive margins within NERC and WECC reliability standards, including any requirements of the NRC using a power flow study based on the quantity and location of scheduled Demand. The CAISO shall issue daily voltage schedules (Dispatch Instructions) to Participating Generators, Participating TOs and UDCs, which are required to be maintained for CAISO Controlled Grid reliability. All other Generating Units shall comply with the power factor requirements set forth in contractual arrangements in effect on the CAISO Operations Date, or, if no such contractual arrangements exist and the Generating Unit exists within the system of a Participating TO, the power factor requirements applicable under the Participating TO's TO Tariff or other tariff on file with the FERC. All Participating Generators that operate Asynchronous Generating Facilities subject to the Large Generator Interconnection Agreement set forth in Appendix BB or CC shall maintain the CAISO specified voltage schedule for those facilities at the Point of Interconnection~~transmission interconnection points~~ to the extent possible, except as permitted under Appendix H of the Large Generator Interconnection Agreement, while operating within the power factor range specified in their interconnection agreements. For all other Generating Units, Participating Generators shall maintain the CAISO specified voltage schedule at the Generating Unit terminals to the extent possible, while operating within the power factor range specified in their interconnection agreements, or, for Regulatory Must-Take Generation, Regulatory Must-Run Generation and Reliability Must-Run Generation, consistent with existing obligations. For Generating Units that do not operate under one of these agreements, the minimum power factor range will be within a band of 0.90 lag (producing VARs) and 0.95 lead (absorbing VARs) power factors. Participating Generators with Generating Units existing at the CAISO Operations Date that are unable to meet this operating power factor requirement may apply to the CAISO for an exemption. Prior to granting such an exemption, the CAISO shall require the Participating TO or UDC to whose system the relevant Generating Units are interconnected to notify it of the existing contractual requirements for Voltage Support established prior to the CAISO Operations Date for such Generating Units. Such requirements may be contained in CPUC Electric Rule 21 or the Interconnection Agreement with the Participating TO or UDC. The CAISO shall not grant any exemption under this Section from such existing contractual requirements. The CAISO shall be entitled to instruct Participating Generators to operate their Generating Units at specified points within their power factor ranges. Participating Generators shall receive no compensation for operating within these specified ranges.

If the CAISO requires additional Voltage Support, it shall procure this either through Reliability Must-Run Contracts or, if no other more economic sources are available**,** by instructing a Generating Unit to move its MVar output outside its mandatory range. Only if the Generating Unit must reduce its MW output in order to comply with such an instruction will it be eligible to recover its opportunity cost in accordance with Section 11.10.1.4.

All Loads directly connected to the CAISO Controlled Grid shall maintain reactive flow at grid interface points within a specified power factor band of 0.97 lag to 0.99 lead. Loads shall not be compensated for the service of maintaining the power factor at required levels within the bandwidth. A UDC interconnecting with the CAISO Controlled Grid at any point other than a Scheduling Point shall be subject to the same power factor requirement.

~~The power factor for both the Generating Units and Loads shall be measured at the interconnection point with the CAISO Controlled Grid.~~ The CAISO will develop and will be authorized to levy penalties against Participating Generators, UDCs or Loads whose Voltage Support does not comply with the CAISO's requirements. The CAISO will establish voltage control standards with UDCs and the operators of other Balancing Authority Areas and will enter into operational agreements providing for the coordination of actions in the event of a voltage problem occurring.

*** * ***

25.4 Asynchronous Generating Facilities

Asynchronous Generating Facilities that are the subject of Interconnection Requests in a serial study queue and for which a Large Generator Interconnection Agreement has not been executed or tendered for signature as of July 3, 2010 shall be subject to the Large Generator Interconnection Agreement set forth in Appendix BB. Asynchronous Generating Facilities that are the subject of Interconnection

Requests in a Queue Cluster Window and for which a Large Generator Interconnection Agreement has not been executed or tendered for signature as of July 3, 2010 shall be subject to the Large Generator Interconnection Agreement set forth in Appendix CC.

* * *

Appendix A

Definitions

* * *

- Asynchronous Generating Facility

An induction, doubly-fed, or electronic power generating unit(s) that produces 60 Hz (nominal) alternating current.

* * *

Appendix U

Standard Large Generator Interconnection Procedures (LGIP)

* * *

Attachment A
To LGIP Appendix 1
Interconnection Request

LARGE GENERATING FACILITY DATA

* * *

7. ~~Synchronous~~ Generator and Associated Equipment – Dynamic Models:

A. Synchronous Generators

For each generator, governor, exciter and power system stabilizer, select the appropriate dynamic model from the General Electric PSLF Program Manual and provide the required input data. The manual is available on the GE website at www.gepower.com. Select the following links within the website: 1) Our Businesses, 2) GE Power Systems, 3) Energy Consulting, 4) GE PSLF Software, 5) GE PSLF User's Manual.

There are links within the GE PSLF User's Manual to detailed descriptions of specific models, a definition of each parameter, a list of the output channels, explanatory notes, and a control system block diagram. The block diagrams are also available on the CAISO Website.

If you require assistance in developing the models, we suggest you contact General Electric. Accurate models are important to obtain accurate study results. Costs associated with any changes in facility requirements that are due to differences between model data provided by the generation developer and the actual generator test data, may be the responsibility of the generation developer.

B. Asynchronous Generators

For each generator, the Interconnection Customer must provide WECC approved standard study models (standard models), rather than user-defined models, to the extent standard models are available. If standard models for the generator are not available then the Interconnection Customer may supply user-written or equivalent models.

Appendix Y
LGIP For Requests In A Queue Cluster Window

11.1 Tender

11.1.1 Within thirty (30) Calendar Days after the CAISO provides the final Phase II Interconnection Study report to the Interconnection Customer, the applicable Participating TO(s) and the CAISO shall tender a draft LGIA, together with draft appendices. The draft LGIA shall be in the form of the FERC-approved form of LGIA set forth in CAISO Tariff Appendix Z or Appendix CC, as applicable. The Interconnection Customer shall provide written comments, or notification of no comments, to the draft appendices to the applicable Participating TO(s) and the CAISO within (30) calendar days of receipt.

* * *

CAISO TARIFF APPENDIX BB

Standard Large Generator Interconnection Agreement

for Interconnection Requests in a Serial Study Group that are tendered or execute a Large Generator Interconnection Agreement on or after July 3, 2010

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Appendices

STANDARD LARGE GENERATOR INTERCONNECTION AGREEMENT

[INTERCONNECTION CUSTOMER]

[PARTICIPATING TO]

CALIFORNIA INDEPENDENT SYSTEM OPERATOR CORPORATION

THIS STANDARD LARGE GENERATOR INTERCONNECTION AGREEMENT ("LGIA") is made and entered into this _____ day of ________________ 20___, by and among _________________, a ________________ organized and existing under the laws of the State/Commonwealth of __________ ("Interconnection Customer" with a Large Generating Facility), _________________, a corporation organized and existing under the laws of the State of California ("**Participating TO**"), and **California Independent System Operator Corporation**, a California nonprofit public benefit corporation organized and existing under the laws of the State of California ("CAISO"). Interconnection Customer, Participating TO, and CAISO each may be referred to as a "Party" or collectively as the "Parties."

RECITALS

WHEREAS, CAISO exercises Operational Control over the CAISO Controlled Grid; and

WHEREAS, the Participating TO owns, operates, and maintains the Participating TO's Transmission System; and

WHEREAS, Interconnection Customer intends to own, lease and/or control and operate the Generating Facility identified as a Large Generating Facility in Appendix C to this LGIA; and

WHEREAS, Interconnection Customer, Participating TO, and CAISO have agreed to enter into this LGIA for the purpose of interconnecting the Large Generating Facility with the Participating TO's Transmission System;

NOW, THEREFORE, in consideration of and subject to the mutual covenants contained herein, it is agreed:

When used in this LGIA, terms with initial capitalization that are not defined in Article 1 shall have the meanings specified in the Article in which they are used.

ARTICLE 1. DEFINITIONS

Adverse System Impact shall mean the negative effects due to technical or operational limits on conductors or equipment being exceeded that may compromise the safety and reliability of the electric system.

Affected System shall mean an electric system other than the CAISO Controlled Grid that may be affected by the proposed interconnection, including the Participating TO's electric system that is not part of the CAISO Controlled Grid.

Affiliate shall mean, with respect to a corporation, partnership or other entity, each such other corporation, partnership or other entity that directly or indirectly, through one or more intermediaries, controls, is controlled by, or is under common control with, such corporation, partnership or other entity.

Applicable Laws and Regulations shall mean all duly promulgated applicable federal, state and local laws, regulations, rules, ordinances, codes, decrees, judgments, directives, or judicial or administrative orders, permits and other duly authorized actions of any Governmental Authority.

Applicable Reliability Council shall mean the Western Electricity Coordinating Council or its successor.

Applicable Reliability Standards shall mean the requirements and guidelines of NERC, the Applicable Reliability Council, and the Balancing Authority Area of the Participating TO's Transmission System to which the Generating Facility is directly connected, including requirements adopted pursuant to Section 215 of the Federal Power Act.

Asynchronous Generating Facility shall mean an induction, doubly-fed, or electronic power generating unit(s) that produces 60 Hz (nominal) alternating current.

Balancing Authority shall mean the responsible entity that integrates resource plans ahead of time, maintains load-interchange-generation balance within a Balancing Authority Area, and supports Interconnection frequency in real time.

Balancing Authority Area shall mean the collection of generation, transmission, and loads within the metered boundaries of the Balancing Authority. The Balancing Authority maintains load-resource balance within this area.

Base Case shall mean the base case power flow, short circuit, and stability data bases used for the Interconnection Studies.

Breach shall mean the failure of a Party to perform or observe any material term or condition of this LGIA.

Breaching Party shall mean a Party that is in Breach of this LGIA.

Business Day shall mean Monday through Friday, excluding federal holidays and the day after Thanksgiving Day.

Calendar Day shall mean any day including Saturday, Sunday or a federal holiday.

Commercial Operation shall mean the status of an Electric Generating Unit at a Generating Facility that has commenced generating electricity for sale, excluding electricity generated during Trial Operation.

Commercial Operation Date of an Electric Generating Unit shall mean the date on which the Electric Generating Unit at the Generating Facility commences Commercial Operation as agreed to by the applicable Participating TO and the Interconnection Customer pursuant to Appendix E to this LGIA.

Confidential Information shall mean any confidential, proprietary or trade secret information of a plan, specification, pattern, procedure, design, device, list, concept, policy or compilation relating to the present or planned business of a Party, which is designated as confidential by the Party supplying the information, whether conveyed orally, electronically, in writing, through inspection, or otherwise, subject to Article 22.1.2.

Default shall mean the failure of a Breaching Party to cure its Breach in accordance with Article 17 of this LGIA.

Distribution System shall mean those non-CAISO-controlled transmission and distribution facilities owned by the Participating TO.

Distribution Upgrades shall mean the additions, modifications, and upgrades to the Participating TO's Distribution System. Distribution Upgrades do not include Interconnection Facilities.

Effective Date shall mean the date on which this LGIA becomes effective upon execution by the Parties subject to acceptance by FERC, or if filed unexecuted, upon the date specified by FERC.

Electric Generating Unit shall mean an individual electric generator and its associated plant and apparatus whose electrical output is capable of being separately identified and metered.

Emergency Condition shall mean a condition or situation: (1) that in the judgment of the Party making the claim is imminently likely to endanger life or property; or (2) that, in the case of the CAISO, is imminently likely (as determined in a non-discriminatory manner) to cause a material adverse effect on the security of, or damage to, the CAISO Controlled Grid or the electric systems of others to which the CAISO Controlled Grid is directly connected; (3) that, in the case of the Participating TO, is imminently likely (as determined in a non-discriminatory manner) to cause a material adverse effect on the security of, or damage to, the Participating TO's Transmission System, Participating TO's Interconnection Facilities, Distribution System, or the electric systems of others to which the Participating TO's electric system is directly connected; or (4) that, in the case of the Interconnection Customer, is imminently likely (as determined in a non-discriminatory manner) to cause a material adverse effect on the security of, or damage to, the Generating Facility or Interconnection Customer's Interconnection Facilities. System restoration and black start shall be considered Emergency Conditions; provided, that Interconnection Customer is not obligated by this LGIA to possess black start capability.

Environmental Law shall mean Applicable Laws or Regulations relating to pollution or protection of the environment or natural resources.

Federal Power Act shall mean the Federal Power Act, as amended, 16 U.S.C. §§ 791a *et seq*.

FERC shall mean the Federal Energy Regulatory Commission or its successor.

Force Majeure shall mean any act of God, labor disturbance, act of the public enemy, war, insurrection, riot, fire, storm or flood, explosion, breakage or accident to machinery or equipment, any order, regulation or restriction imposed by governmental, military or lawfully established civilian authorities, or any other cause beyond a Party's control. A Force Majeure event does not include acts of negligence or intentional wrongdoing by the Party claiming Force Majeure.

Generating Facility shall mean the Interconnection Customer's Electric Generating Unit(s) used for the production of electricity identified in the Interconnection Customer's Interconnection Request, but shall not include the Interconnection Customer's Interconnection Facilities.

Generating Facility Capacity shall mean the net capacity of the Generating Facility and the aggregate net capacity of the Generating Facility where it includes multiple energy production devices.

Good Utility Practice shall mean any of the practices, methods and acts engaged in or approved by a significant portion of the electric utility industry during the relevant time period, or any of the practices, methods and acts which, in the exercise of reasonable judgment in light of the facts known at the time the decision was made, could have been expected to accomplish the desired result at a reasonable cost consistent with good business practices, reliability, safety and expedition. Good Utility Practice is not intended to be any one of a number of the optimum practices, methods, or acts to the exclusion of all others, but rather to be acceptable practices, methods, or acts generally accepted in the region.

Governmental Authority shall mean any federal, state, local or other governmental, regulatory or administrative agency, court, commission, department, board, or other governmental subdivision, legislature, rulemaking board, tribunal, or other governmental authority having jurisdiction over the Parties, their respective facilities, or the respective services they provide, and exercising or entitled to exercise any administrative, executive, police, or taxing authority or power; provided, however, that such term does not include the Interconnection Customer, CAISO, Participating TO, or any Affiliate thereof.

Hazardous Substances shall mean any chemicals, materials or substances defined as or included in the definition of "hazardous substances," "hazardous wastes," "hazardous materials," "hazardous constituents," "restricted hazardous materials," "extremely hazardous substances," "toxic substances," "radioactive substances," "contaminants," "pollutants," "toxic pollutants" or words of similar meaning and regulatory effect under any applicable Environmental Law, or any other chemical, material or substance, exposure to which is prohibited, limited or regulated by any applicable Environmental Law.

Initial Synchronization Date shall mean the date upon which an Electric Generating Unit is initially synchronized and upon which Trial Operation begins.

In-Service Date shall mean the date upon which the Interconnection Customer reasonably expects it will be ready to begin use of the Participating TO's Interconnection Facilities to obtain back feed power.

Interconnection Customer's Interconnection Facilities shall mean all facilities and equipment, as identified in Appendix A of this LGIA, that are located between the Generating Facility and the Point of Change of Ownership, including any modification, addition, or upgrades to such facilities and equipment necessary to physically and electrically interconnect the Generating Facility to the Participating TO's Transmission System. Interconnection Customer's Interconnection Facilities are sole use facilities.

Interconnection Facilities shall mean the Participating TO's Interconnection Facilities and the Interconnection Customer's Interconnection Facilities. Collectively, Interconnection Facilities include all facilities and equipment between the Generating Facility and the Point of Interconnection, including any modification, additions or upgrades that are necessary to physically and electrically interconnect the Generating Facility to the Participating TO's Transmission System. Interconnection Facilities are sole use facilities and shall not include Distribution Upgrades, Stand Alone Network Upgrades or Network Upgrades.

Interconnection Facilities Study shall mean the study conducted or caused to be performed by the CAISO, in coordination with the applicable Participating TO(s), or a third party consultant for the Interconnection Customer to determine a list of facilities (including the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades), the cost of those facilities, and the time required to interconnect the Generating Facility with the Participating TO's Transmission System.

Interconnection Facilities Study Agreement shall mean the agreement between the Interconnection Customer and the CAISO for conducting the Interconnection Facilities Study.

Interconnection Feasibility Study shall mean the preliminary evaluation conducted or caused to be performed by the CAISO, in coordination with the applicable Participating TO(s), or a third party consultant for the Interconnection Customer of the system impact and cost of interconnecting the Generating Facility to the Participating TO's Transmission System.

Interconnection Handbook shall mean a handbook, developed by the Participating TO and posted on the Participating TO's web site or otherwise made available by the Participating TO, describing technical and operational requirements for wholesale generators and loads connected to the Participating TO's portion of the CAISO Controlled Grid, as such handbook may be modified or superseded from time to time. Participating TO's standards contained in the Interconnection Handbook shall be deemed consistent with Good Utility Practice and Applicable Reliability Standards. In the event of a conflict between the terms of this LGIA and the terms of the Participating TO's Interconnection Handbook, the terms in this LGIA shall apply.

Interconnection Request shall mean a request, in the form of Appendix 1 to the Standard Large Generator Interconnection Procedures, in accordance with the CAISO Tariff.

Interconnection Service shall mean the service provided by the Participating TO and CAISO associated with interconnecting the Interconnection Customer's Generating Facility to the Participating TO's Transmission System and enabling the CAISO Controlled Grid to receive electric energy and capacity from the Generating Facility at the Point of Interconnection, pursuant to the terms of this LGIA, the Participating TO's Transmission Owner Tariff, and the CAISO Tariff.

Interconnection Study shall mean any of the following studies: the Interconnection Feasibility Study, the Interconnection System Impact Study, and the Interconnection Facilities Study conducted or caused to be performed by the CAISO, in coordination with the applicable Participating TO(s), or a third party consultant for the Interconnection Customer pursuant to the Standard Large Generator Interconnection Procedures.

Interconnection System Impact Study shall mean the engineering study conducted or caused to be performed by the CAISO, in coordination with the applicable Participating TO(s), or a third party consultant for the Interconnection Customer that evaluates the impact of the proposed interconnection on the safety and reliability of the Participating TO's Transmission System and, if applicable, an Affected System. The study shall identify and detail the system impacts that would result if the Generating Facility were interconnected without project modifications or system modifications, focusing on the Adverse System Impacts identified in the Interconnection Feasibility Study, or to study potential impacts, including but not limited to those identified in the Scoping Meeting as described in the Standard Large Generator Interconnection Procedures.

IRS shall mean the Internal Revenue Service.

CAISO Controlled Grid shall mean the system of transmission lines and associated facilities of the parties to the Transmission Control Agreement that have been placed under the CAISO's Operational Control.

CAISO Tariff shall mean the CAISO's tariff, as filed with FERC, and as amended or supplemented from time to time, or any successor tariff.

Large Generating Facility shall mean a Generating Facility having a Generating Facility Capacity of more than 20 MW.

Loss shall mean any and all damages, losses, and claims, including claims and actions relating to injury to or death of any person or damage to property, demand, suits, recoveries, costs and expenses, court costs, attorney fees, and all other obligations by or to third parties.

Material Modification shall mean those modifications that have a material impact on the cost or timing of any Interconnection Request or any other valid interconnection request with a later queue priority date.

Metering Equipment shall mean all metering equipment installed or to be installed for measuring the output of the Generating Facility pursuant to this LGIA at the metering points, including but not limited to instrument transformers, MWh-meters, data acquisition equipment, transducers, remote terminal unit, communications equipment, phone lines, and fiber optics.

NERC shall mean the North American Electric Reliability Council or its successor organization.

Network Upgrades shall be Participating TO's Delivery Network Upgrades and Participating TO's Reliability Network Upgrades.

Operational Control shall mean the rights of the CAISO under the Transmission Control Agreement and the CAISO Tariff to direct the parties to the Transmission Control Agreement how to operate their transmission lines and facilities and other electric plant affecting the reliability of those lines and facilities for the purpose of affording comparable non-discriminatory transmission access and meeting applicable reliability criteria.

Participating TO's Delivery Network Upgrades shall mean the additions, modifications, and upgrades to the Participating TO's Transmission System at or beyond the Point of Interconnection, other than Reliability Network Upgrades, identified in the Interconnection Studies, as identified in Appendix A, to relieve constraints on the CAISO Controlled Grid.

Participating TO's Interconnection Facilities shall mean all facilities and equipment owned, controlled or operated by the Participating TO from the Point of Change of Ownership to the Point of Interconnection as identified in Appendix A to this LGIA, including any modifications, additions or upgrades to such facilities and equipment. Participating TO's Interconnection Facilities are sole use facilities and shall not include Distribution Upgrades, Stand Alone Network Upgrades or Network Upgrades.

Participating TO's Reliability Network Upgrades shall mean the additions, modifications, and upgrades to the Participating TO's Transmission System at or beyond the Point of Interconnection, identified in the Interconnection Studies, as identified in Appendix A, necessary to interconnect the Large Generating Facility safely and reliably to the Participating TO's Transmission System, which would not have been necessary but for the interconnection of the Large Generating Facility, including additions, modifications, and upgrades necessary to remedy short circuit or stability problems resulting from the interconnection of the Large Generating Facility to the Participating TO's Transmission System. Participating TO's Reliability Network Upgrades also include, consistent with Applicable Reliability Council practice, the Participating TO's facilities necessary to mitigate any adverse impact the Large Generating Facility's interconnection may have on a path's Applicable Reliability Council rating.

Participating TO's Transmission System shall mean the facilities owned and operated by the Participating TO and that have been placed under the CAISO's Operational Control, which facilities form part of the CAISO Controlled Grid.

Party or Parties shall mean the Participating TO, CAISO, Interconnection Customer or the applicable combination of the above.

Point of Change of Ownership shall mean the point, as set forth in Appendix A to this LGIA, where the Interconnection Customer's Interconnection Facilities connect to the Participating TO's Interconnection Facilities.

Point of Interconnection shall mean the point, as set forth in Appendix A to this LGIA, where the Interconnection Facilities connect to the Participating TO's Transmission System.

Qualifying Facility shall mean a qualifying cogeneration facility or qualifying small power production facility, as defined in the Code of Federal Regulations, Title 18, Part 292 (18 C.F.R. §292).

QF PGA shall mean a Qualifying Facility Participating Generator Agreement specifying the special provisions for the operating relationship between a Qualifying Facility and the CAISO, a pro forma version of which is set forth in Appendix B.3 of the CAISO Tariff.

Reasonable Efforts shall mean, with respect to an action required to be attempted or taken by a Party under this LGIA, efforts that are timely and consistent with Good Utility Practice and are otherwise substantially equivalent to those a Party would use to protect its own interests.

Scoping Meeting shall mean the meeting among representatives of the Interconnection Customer, the Participating TO(s), other Affected Systems, and the CAISO conducted for the purpose of discussing alternative interconnection options, to exchange information including any transmission data and earlier study evaluations that would be reasonably expected to impact such interconnection options, to analyze such information, and to determine the potential feasible Points of Interconnection.

Stand Alone Network Upgrades shall mean Network Upgrades that the Interconnection Customer may construct without affecting day-to-day operations of the CAISO Controlled Grid or Affected Systems during their construction. The Participating TO, the CAISO, and the Interconnection Customer must agree as to what constitutes Stand Alone Network Upgrades and identify them in Appendix A to this LGIA.

Standard Large Generator Interconnection Procedures (LGIP) shall mean the CAISO protocol that sets forth the interconnection procedures applicable to an Interconnection Request pertaining to a Large Generating Facility that is included in CAISO Tariff Appendix U.

System Protection Facilities shall mean the equipment, including necessary protection signal communications equipment, that protects (1) the Participating TO's Transmission System, Participating TO's Interconnection Facilities, CAISO Controlled Grid, and Affected Systems from faults or other electrical disturbances occurring at the Generating Facility and (2) the Generating Facility from faults or other electrical system disturbances occurring on the CAISO Controlled Grid, Participating TO's Interconnection Facilities, and Affected Systems or on other delivery systems or other generating systems to which the CAISO Controlled Grid is directly connected.

Transmission Control Agreement shall mean CAISO FERC Electric Tariff No. 7.

Trial Operation shall mean the period during which the Interconnection Customer is engaged in on-site test operations and commissioning of an Electric Generating Unit prior to Commercial Operation.

ARTICLE 2. EFFECTIVE DATE, TERM AND TERMINATION

2.1 Effective Date. This LGIA shall become effective upon execution by the Parties subject to acceptance by FERC (if applicable), or if filed unexecuted, upon the date specified by FERC. The CAISO and Participating TO shall promptly file this LGIA with FERC upon execution in accordance with Article 3.1, if required.

2.2 Term of Agreement. Subject to the provisions of Article 2.3, this LGIA shall remain in effect for a period of _____ years from the Effective Date (Term Specified in Individual Agreements to be ten (10) years or such other longer period as the Interconnection Customer may request) and shall be automatically renewed for each successive one-year period thereafter.

2.3 Termination Procedures.

2.3.1 Written Notice. This LGIA may be terminated by the Interconnection Customer after giving the CAISO and the Participating TO ninety (90) Calendar Days advance written notice, or by the CAISO and the Participating TO notifying FERC after the Generating Facility permanently ceases Commercial Operation.

2.3.2 Default. A Party may terminate this LGIA in accordance with Article 17.

2.3.3 Suspension of Work. This LGIA may be deemed terminated in accordance with Article 5.16.

2.3.4 Notwithstanding Articles 2.3.1, 2.3.2, and 2.3.3, no termination shall become effective until the Parties have complied with all Applicable Laws and Regulations applicable to such termination, including the filing with FERC of a notice of termination of this LGIA, which notice has been accepted for filing by FERC.

2.4 Termination Costs. If this LGIA terminates pursuant to Article 2.3 above, the Interconnection Customer shall pay all costs incurred or irrevocably committed to be incurred in association with the Interconnection Customer's interconnection (including any cancellation costs relating to orders or contracts for Interconnection Facilities and equipment) and other expenses, including any Network Upgrades and Distribution Upgrades for which the Participating TO or CAISO has incurred expenses or has irrevocably committed to incur expenses and has not been reimbursed by the Interconnection Customer, as of the date of the other Parties' receipt of the notice of termination, subject to the limitations set forth in this Article 2.4. Nothing in this Article 2.4 shall limit the Parties' rights under Article 17.

2.4.1 Notwithstanding the foregoing, in the event of termination by a Party, all Parties shall use commercially Reasonable Efforts to mitigate the costs, damages and charges arising as a consequence of termination. With respect to any portion of the Participating TO's Interconnection Facilities that have not yet been constructed or installed, the Participating TO shall to the extent possible and with the Interconnection Customer's authorization cancel any pending orders of, or return, any materials or equipment for, or contracts for construction of, such facilities; provided that in the event the Interconnection Customer elects not to authorize such cancellation, the Interconnection Customer shall assume all payment obligations with respect to such materials, equipment, and contracts, and the Participating TO shall deliver such material and equipment, and, if necessary, assign such contracts, to the Interconnection Customer as soon as practicable, at the Interconnection Customer's expense. To the extent that the Interconnection Customer has already paid the Participating TO for any or all such costs of materials or equipment not taken by the Interconnection Customer, the Participating TO shall promptly refund such amounts to the Interconnection Customer, less any costs, including penalties, incurred by the Participating TO to cancel any pending orders of or return such materials, equipment, or contracts.

2.4.2 The Participating TO may, at its option, retain any portion of such materials, equipment, or facilities that the Interconnection Customer chooses not to accept delivery of, in which case the Participating TO shall be responsible for all costs associated with procuring such materials, equipment, or facilities.

2.4.3 With respect to any portion of the Interconnection Facilities, and any other facilities already installed or constructed pursuant to the terms of this LGIA, Interconnection Customer shall be responsible for all costs associated with the removal, relocation or other disposition or retirement of such materials, equipment, or facilities.

2.5 **Disconnection**. Upon termination of this LGIA, the Parties will take all appropriate steps to disconnect the Large Generating Facility from the Participating TO's Transmission System. All costs required to effectuate such disconnection shall be borne by the terminating Party, unless such termination resulted from the non-terminating Party's Default of this LGIA or such non-terminating Party otherwise is responsible for these costs under this LGIA.

2.6 **Survival**. This LGIA shall continue in effect after termination to the extent necessary to provide for final billings and payments and for costs incurred hereunder, including billings and payments pursuant to this LGIA; to permit the determination and enforcement of liability and indemnification obligations arising from acts or events that occurred while this LGIA was in effect; and to permit each Party to have access to the lands of the other Parties pursuant to this LGIA or other applicable agreements, to disconnect, remove or salvage its own facilities and equipment.

ARTICLE 3. REGULATORY FILINGS AND CAISO TARIFF COMPLIANCE

3.1 **Filing**. The Participating TO and the CAISO shall file this LGIA (and any amendment hereto) with the appropriate Governmental Authority(ies), if required. The Interconnection Customer may request that any information so provided be subject to the confidentiality provisions of Article 22. If the Interconnection Customer has executed this LGIA, or any amendment thereto, the Interconnection Customer shall reasonably cooperate with the Participating TO and CAISO with respect to such filing and to provide any information reasonably requested by the Participating TO or CAISO needed to comply with applicable regulatory requirements.

3.2 Agreement Subject to CAISO Tariff. The Interconnection Customer will comply with all applicable provisions of the CAISO Tariff, including the LGIP.

3.3 Relationship Between this LGIA and the CAISO Tariff. With regard to rights and obligations between the Participating TO and the Interconnection Customer, if and to the extent a matter is specifically addressed by a provision of this LGIA (including any appendices, schedules or other attachments to this LGIA), the provisions of this LGIA shall govern. If and to the extent a provision of this LGIA is inconsistent with the CAISO Tariff and dictates rights and obligations between the CAISO and the Participating TO or the CAISO and the Interconnection Customer, the CAISO Tariff shall govern.

3.4 Relationship Between this LGIA and the QF PGA. With regard to the rights and obligations of a Qualifying Facility that has entered into a QF PGA with the CAISO and has entered into this LGIA, if and to the extent a matter is specifically addressed by a provision of the QF PGA that is inconsistent with this LGIA, the terms of the QF PGA shall govern.

ARTICLE 4. SCOPE OF SERVICE

4.1 Interconnection Service. Interconnection Service allows the Interconnection Customer to connect the Large Generating Facility to the Participating TO's Transmission System and be eligible to deliver the Large Generating Facility's output using the available capacity of the CAISO Controlled Grid. To the extent the Interconnection Customer wants to receive Interconnection Service, the Participating TO shall construct facilities identified in Appendices A and C that the Participating TO is responsible to construct.

Interconnection Service does not necessarily provide the Interconnection Customer with the capability to physically deliver the output of its Large Generating Facility to any particular load on the CAISO Controlled Grid without incurring congestion costs. In the event of transmission constraints on the CAISO Controlled Grid, the Interconnection Customer's Large Generating Facility shall be subject to the applicable congestion management procedures in the CAISO Tariff in the same manner as all other resources.

4.2 Provision of Service. The Participating TO and the CAISO shall provide Interconnection Service for the Large Generating Facility.

4.3 Performance Standards. Each Party shall perform all of its obligations under this LGIA in accordance with Applicable Laws and Regulations, Applicable Reliability Standards, and Good Utility Practice, and to the extent a Party is required or prevented or limited in taking any action by such regulations and standards, such Party shall not be deemed to be in Breach of this LGIA for its compliance therewith. If such Party is the CAISO or Participating TO, then that Party shall amend the LGIA and submit the amendment to FERC for approval.

4.4 No Transmission Service. The execution of this LGIA does not constitute a request for, nor the provision of, any transmission service under the CAISO Tariff, and does not convey any right to deliver electricity to any specific customer or point of delivery.

4.5 Interconnection Customer Provided Services. The services provided by Interconnection Customer under this LGIA are set forth in Article 9.6 and Article 13.5.1. Interconnection Customer shall be paid for such services in accordance with Article 11.6.

ARTICLE 5. INTERCONNECTION FACILITIES ENGINEERING, PROCUREMENT, AND CONSTRUCTION

Interconnection Facilities, Network Upgrades, and Distribution Upgrades shall be studied, designed, and constructed pursuant to Good Utility Practice. Such studies, design and construction shall be based on the assumed accuracy and completeness of all technical information received by the Participating TO and the CAISO from the Interconnection Customer associated with interconnecting the Large Generating Facility.

5.1 Options. Unless otherwise mutually agreed among the Parties, the Interconnection Customer shall select the In-Service Date, Initial Synchronization Date, and Commercial Operation Date; and either Standard Option or Alternate Option set forth below for completion of the Participating TO's Interconnection Facilities and Network Upgrades as set forth in Appendix A, Interconnection Facilities, Network Upgrades, and Distribution Upgrades, and such dates and selected option shall be set forth in Appendix B, Milestones.

5.1.1 Standard Option. The Participating TO shall design, procure, and construct the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades, using Reasonable Efforts to complete the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades by the dates set forth in Appendix B, Milestones. The Participating TO shall not be required to undertake any action which is inconsistent with its standard safety practices, its material and equipment specifications, its design criteria and construction procedures, its labor agreements, and Applicable Laws and Regulations. In the event the Participating TO reasonably expects that it will not be able to complete the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades by the specified dates, the Participating TO shall promptly provide written notice to the Interconnection Customer and the CAISO and shall undertake Reasonable Efforts to meet the earliest dates thereafter.

5.1.2 Alternate Option. If the dates designated by the Interconnection Customer are acceptable to the Participating TO, the Participating TO shall so notify the Interconnection Customer within thirty (30) Calendar Days, and shall assume responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities by the designated dates.

If the Participating TO subsequently fails to complete the Participating TO's Interconnection Facilities by the In-Service Date, to the extent necessary to provide back feed power; or fails to complete Network Upgrades by the Initial Synchronization Date to the extent necessary to allow for Trial Operation at full power output, unless other arrangements are made by the Parties for such Trial Operation; or fails to complete the Network Upgrades by the Commercial Operation Date, as such dates are reflected in Appendix B, Milestones; the Participating TO shall pay the Interconnection Customer liquidated damages in accordance with Article 5.3, Liquidated Damages, provided, however, the dates designated by the Interconnection Customer shall be extended day for day for each day that the CAISO refuses to grant clearances to install equipment.

5.1.3 Option to Build. If the dates designated by the Interconnection Customer are not acceptable to the Participating TO, the Participating TO shall so notify the Interconnection Customer within thirty (30) Calendar Days, and unless the Parties agree otherwise, the Interconnection Customer shall have the option to assume responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades. If the Interconnection Customer elects to exercise its option to assume responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades, it shall so notify the Participating TO within thirty (30) Calendar Days of receipt of the Participating TO's notification that the designated dates are not acceptable to the

Participating TO. The Participating TO, CAISO, and Interconnection Customer must agree as to what constitutes Stand Alone Network Upgrades and identify such Stand Alone Network Upgrades in Appendix A to this LGIA. Except for Stand Alone Network Upgrades, the Interconnection Customer shall have no right to construct Network Upgrades under this option.

5.1.4 Negotiated Option. If the Interconnection Customer elects not to exercise its option under Article 5.1.3, Option to Build, the Interconnection Customer shall so notify the Participating TO within thirty (30) Calendar Days of receipt of the Participating TO's notification that the designated dates are not acceptable to the Participating TO, and the Parties shall in good faith attempt to negotiate terms and conditions (including revision of the specified dates and liquidated damages, the provision of incentives or the procurement and construction of a portion of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades by the Interconnection Customer) pursuant to which the Participating TO is responsible for the design, procurement and construction of the Participating TO's Interconnection Facilities and Network Upgrades. If the Parties are unable to reach agreement on such terms and conditions, the Participating TO shall assume responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities and Network Upgrades pursuant to Article 5.1.1, Standard Option.

5.2 General Conditions Applicable to Option to Build. If the Interconnection Customer assumes responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades,

(1) the Interconnection Customer shall engineer, procure equipment, and construct the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades (or portions thereof) using Good Utility Practice and using standards and specifications provided in advance by the Participating TO;

(2) The Interconnection Customer's engineering, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades shall comply with all requirements of law to which the Participating TO would be subject in the engineering, procurement or construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades;

(3) the Participating TO shall review, and the Interconnection Customer shall obtain the Participating TO's approval of, the engineering design, equipment acceptance tests, and the construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades, which approval shall not be unreasonably withheld, and the CAISO may, at its option, review the engineering design, equipment acceptance tests, and the construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades;

(4) prior to commencement of construction, the Interconnection Customer shall provide to the Participating TO, with a copy to the CAISO for informational purposes, a schedule for construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades, and shall promptly respond to requests for information from the Participating TO;

(5) at any time during construction, the Participating TO shall have the right to gain unrestricted access to the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades and to conduct inspections of the same;

(6) at any time during construction, should any phase of the engineering, equipment procurement, or construction of the Participating TO's Interconnection Facilities and

Stand Alone Network Upgrades not meet the standards and specifications provided by the Participating TO, the Interconnection Customer shall be obligated to remedy deficiencies in that portion of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades;

(7) the Interconnection Customer shall indemnify the CAISO and Participating TO for claims arising from the Interconnection Customer's construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades under the terms and procedures applicable to Article 18.1 Indemnity;

(8) The Interconnection Customer shall transfer control of the Participating TO's Interconnection Facilities to the Participating TO and shall transfer Operational Control of Stand Alone Network Upgrades to the CAISO;

(9) Unless the Parties otherwise agree, the Interconnection Customer shall transfer ownership of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades to the Participating TO. As soon as reasonably practicable, but within twelve months after completion of the construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades, the Interconnection Customer shall provide an invoice of the final cost of the construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades to the Participating TO, which invoice shall set forth such costs in sufficient detail to enable the Participating TO to reflect the proper costs of such facilities in its transmission rate base and to identify the investment upon which refunds will be provided;

(10) the Participating TO shall accept for operation and maintenance the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades to the extent engineered, procured, and constructed in accordance with this Article 5.2; and

(11) The Interconnection Customer's engineering, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades shall comply with all requirements of the "Option to Build" conditions set forth in Appendix C. Interconnection Customer shall deliver to the Participating TO "as-built" drawings, information, and any other documents that are reasonably required by the Participating TO to assure that the Interconnection Facilities and Stand-Alone Network Upgrades are built to the standards and specifications required by the Participating TO.

5.3 Liquidated Damages. The actual damages to the Interconnection Customer, in the event the Participating TO's Interconnection Facilities or Network Upgrades are not completed by the dates designated by the Interconnection Customer and accepted by the Participating TO pursuant to subparagraphs 5.1.2 or 5.1.4, above, may include Interconnection Customer's fixed operation and maintenance costs and lost opportunity costs. Such actual damages are uncertain and impossible to determine at this time. Because of such uncertainty, any liquidated damages paid by the Participating TO to the Interconnection Customer in the event that the Participating TO does not complete any portion of the Participating TO's Interconnection Facilities or Network Upgrades by the applicable dates, shall be an amount equal to ½ of 1 percent per day of the actual cost of the Participating TO's Interconnection Facilities and Network Upgrades, in the aggregate, for which the Participating TO has assumed responsibility to design, procure and construct.

However, in no event shall the total liquidated damages exceed 20 percent of the actual cost of the Participating TO's Interconnection Facilities and Network Upgrades for which the Participating TO has assumed responsibility to design, procure, and construct. The foregoing payments will be made by the Participating TO to the Interconnection Customer as just compensation for the damages caused to the Interconnection Customer, which actual damages are uncertain and impossible to determine at this time, and as reasonable liquidated damages, but not as a penalty or a method to secure performance of this LGIA. Liquidated damages, when the Parties agree to them, are the exclusive remedy for the Participating TO's failure to meet its schedule.

No liquidated damages shall be paid to the Interconnection Customer if: (1) the Interconnection Customer is not ready to commence use of the Participating TO's Interconnection Facilities or Network Upgrades to take the delivery of power for the Electric Generating Unit's Trial Operation or to export power from the Electric Generating Unit on the specified dates, unless the Interconnection Customer would have been able to commence use of the Participating TO's Interconnection Facilities or Network Upgrades to take the delivery of power for Electric Generating Unit's Trial Operation or to export power from the Electric Generating Unit, but for the Participating TO's delay; (2) the Participating TO's failure to meet the specified dates is the result of the action or inaction of the Interconnection Customer or any other interconnection customer who has entered into an interconnection agreement with the CAISO and/or Participating TO, action or inaction by the CAISO, or any cause beyond the Participating TO's reasonable control or reasonable ability to cure; (3) the Interconnection Customer has assumed responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades; or (4) the Parties have otherwise agreed.

In no event shall the CAISO have any responsibility or liability to the Interconnection Customer for liquidated damages pursuant to the provisions of this Article 5.3.

5.4 Power System Stabilizers. The Interconnection Customer shall procure, install, maintain and operate Power System Stabilizers in accordance with the guidelines and procedures established by the Applicable Reliability Council and in accordance with the provisions of Section 4.6.5.1 of the CAISO Tariff. The CAISO reserves the right to establish reasonable minimum acceptable settings for any installed Power System Stabilizers, subject to the design and operating limitations of the Large Generating Facility. If the Large Generating Facility's Power System Stabilizers are removed from service or not capable of automatic operation, the Interconnection Customer shall immediately notify the CAISO and the Participating TO and restore the Power System Stabilizers to operation as soon as possible and in accordance with the Reliability Management System Agreement in Appendix G. The CAISO shall have the right to order the reduction in output or disconnection of the Large Generating Facility if the reliability of the CAISO Controlled Grid would be adversely affected as a result of improperly tuned Power System Stabilizers. The requirements of this Article 5.4 shall apply to Asynchronous Generating Facilities in accordance with Appendix H.

5.5 Equipment Procurement. If responsibility for construction of the Participating TO's Interconnection Facilities or Network Upgrades is to be borne by the Participating TO, then the Participating TO shall commence design of the Participating TO's Interconnection Facilities or Network Upgrades and procure necessary equipment as soon as practicable after all of the following conditions are satisfied, unless the Parties otherwise agree in writing:

5.5.1 The CAISO, in coordination with the applicable Participating TO(s), has completed the Interconnection Facilities Study pursuant to the Interconnection Facilities Study Agreement;

5.5.2 The Participating TO has received written authorization to proceed with design and procurement from the Interconnection Customer by the date specified in Appendix B, Milestones; and

5.5.3 The Interconnection Customer has provided security to the Participating TO in accordance with Article 11.5 by the dates specified in Appendix B, Milestones.

5.6 Construction Commencement. The Participating TO shall commence construction of the Participating TO's Interconnection Facilities and Network Upgrades for which it is responsible as soon as practicable after the following additional conditions are satisfied:

5.6.1 Approval of the appropriate Governmental Authority has been obtained for any facilities requiring regulatory approval;

5.6.2 Necessary real property rights and rights-of-way have been obtained, to the extent required for the construction of a discrete aspect of the Participating TO's Interconnection Facilities and Network Upgrades;

5.6.3 The Participating TO has received written authorization to proceed with construction from the Interconnection Customer by the date specified in Appendix B, Milestones; and

5.6.4 The Interconnection Customer has provided payment and security to the Participating TO in accordance with Article 11.5 by the dates specified in Appendix B, Milestones.

5.7 Work Progress. The Parties will keep each other advised periodically as to the progress of their respective design, procurement and construction efforts. Any Party may, at any time, request a progress report from another Party. If, at any time, the Interconnection Customer determines that the completion of the Participating TO's Interconnection Facilities will not be required until after the specified In-Service Date, the Interconnection Customer will provide written notice to the Participating TO and CAISO of such later date upon which the completion of the Participating TO's Interconnection Facilities will be required.

5.8 Information Exchange. As soon as reasonably practicable after the Effective Date, the Parties shall exchange information regarding the design and compatibility of the Interconnection Customer's Interconnection Facilities and Participating TO's Interconnection Facilities and compatibility of the Interconnection Facilities with the Participating TO's Transmission System, and shall work diligently and in good faith to make any necessary design changes.

5.9 Limited Operation. If any of the Participating TO's Interconnection Facilities or Network Upgrades are not reasonably expected to be completed prior to the Commercial Operation Date of the Electric Generating Unit, the Participating TO and/or CAISO, as applicable, shall, upon the request and at the expense of the Interconnection Customer, perform operating studies on a timely basis to determine the extent to which the Electric Generating Unit and the Interconnection Customer's Interconnection Facilities may operate prior to the completion of the Participating TO's Interconnection Facilities or Network Upgrades consistent with Applicable Laws and Regulations, Applicable Reliability Standards, Good Utility Practice, and this LGIA. The Participating TO and CAISO shall permit Interconnection Customer to operate the Electric Generating Unit and the Interconnection Customer's Interconnection Facilities in accordance with the results of such studies.

5.10 Interconnection Customer's Interconnection Facilities. The Interconnection Customer shall, at its expense, design, procure, construct, own and install the Interconnection Customer's Interconnection Facilities, as set forth in Appendix A.

5.10.1 Large Generating Facility and Interconnection Customer's Interconnection Facilities Specifications. The Interconnection Customer shall submit initial specifications for the Interconnection Customer's Interconnection Facilities and Large Generating Facility, including System Protection Facilities, to the Participating TO and the CAISO at least one hundred eighty (180) Calendar Days prior to the Initial Synchronization Date; and final specifications for review and comment at least ninety (90) Calendar Days prior to the Initial Synchronization Date. The Participating TO and the CAISO shall review such specifications pursuant to this LGIA and the LGIP to ensure that the Interconnection Customer's Interconnection Facilities and Large Generating Facility are compatible with the technical specifications, operational control, safety requirements, and any other applicable requirements of the Participating TO and the CAISO and comment on such specifications within thirty (30) Calendar Days of the Interconnection

Customer's submission. All specifications provided hereunder shall be deemed confidential.

5.10.2 Participating TO's and CAISO's Review. The Participating TO's and the CAISO's review of the Interconnection Customer's final specifications shall not be construed as confirming, endorsing, or providing a warranty as to the design, fitness, safety, durability or reliability of the Large Generating Facility, or the Interconnection Customer's Interconnection Facilities. Interconnection Customer shall make such changes to the Interconnection Customer's Interconnection Facilities as may reasonably be required by the Participating TO or the CAISO, in accordance with Good Utility Practice, to ensure that the Interconnection Customer's Interconnection Facilities are compatible with the technical specifications, Operational Control, and safety requirements of the Participating TO or the CAISO.

5.10.3 Interconnection Customer's Interconnection Facilities Construction. The Interconnection Customer's Interconnection Facilities shall be designed and constructed in accordance with Good Utility Practice. Within one hundred twenty (120) Calendar Days after the Commercial Operation Date, unless the Participating TO and Interconnection Customer agree on another mutually acceptable deadline, the Interconnection Customer shall deliver to the Participating TO and CAISO "as-built" drawings, information and documents for the Interconnection Customer's Interconnection Facilities and the Electric Generating Unit(s), such as: a one-line diagram, a site plan showing the Large Generating Facility and the Interconnection Customer's Interconnection Facilities, plan and elevation drawings showing the layout of the Interconnection Customer's Interconnection Facilities, a relay functional diagram, relaying AC and DC schematic wiring diagrams and relay settings for all facilities associated with the Interconnection Customer's step-up transformers, the facilities connecting the Large Generating Facility to the step-up transformers and the Interconnection Customer's Interconnection Facilities, and the impedances (determined by factory tests) for the associated step-up transformers and the Electric Generating Units. The Interconnection Customer shall provide the Participating TO and the CAISO specifications for the excitation system, automatic voltage regulator, Large Generating Facility control and protection settings, transformer tap settings, and communications, if applicable. Any deviations from the relay settings, machine specifications, and other specifications originally submitted by the Interconnection Customer shall be assessed by the Participating TO and the CAISO pursuant to the appropriate provisions of this LGIA and the LGIP.

5.10.4 Interconnection Customer to Meet Requirements of the Participating TO's Interconnection Handbook. The Interconnection Customer shall comply with the Participating TO's Interconnection Handbook.

5.11 Participating TO's Interconnection Facilities Construction. The Participating TO's Interconnection Facilities shall be designed and constructed in accordance with Good Utility Practice. Upon request, within one hundred twenty (120) Calendar Days after the Commercial Operation Date, unless the Participating TO and Interconnection Customer agree on another mutually acceptable deadline, the Participating TO shall deliver to the Interconnection Customer and the CAISO the following "as-built" drawings, information and documents for the Participating TO's Interconnection Facilities [include appropriate drawings and relay diagrams].

The Participating TO will obtain control for operating and maintenance purposes of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades upon completion of such facilities. Pursuant to Article 5.2, the CAISO will obtain Operational Control of the Stand Alone Network Upgrades prior to the Commercial Operation Date.

5.12 Access Rights. Upon reasonable notice and supervision by a Party, and subject to any required or necessary regulatory approvals, a Party ("Granting Party") shall furnish at no cost to the other Party ("Access Party") any rights of use, licenses, rights of way and easements with respect to lands owned or controlled by the Granting Party, its agents (if allowed under the applicable agency agreement), or any Affiliate, that are necessary to enable the Access Party to obtain ingress and egress to construct, operate, maintain, repair, test (or witness testing), inspect, replace or remove facilities and equipment to: (i) interconnect the Large Generating Facility with the Participating TO's Transmission System; (ii) operate and maintain the Large Generating Facility, the Interconnection Facilities and the Participating TO's Transmission System; and (iii) disconnect or remove the Access Party's facilities and equipment upon termination of this LGIA. In exercising such licenses, rights of way and easements, the Access Party shall not unreasonably disrupt or interfere with normal operation of the Granting Party's business and shall adhere to the safety rules and procedures established in advance, as may be changed from time to time, by the Granting Party and provided to the Access Party.

5.13 Lands of Other Property Owners. If any part of the Participating TO's Interconnection Facilities and/or Network Upgrades are to be installed on property owned by persons other than the Interconnection Customer or Participating TO, the Participating TO shall at the Interconnection Customer's expense use efforts, similar in nature and extent to those that it typically undertakes on its own behalf or on behalf of its Affiliates, including use of its eminent domain authority, and to the extent consistent with state law, to procure from such persons any rights of use, licenses, rights of way and easements that are necessary to construct, operate, maintain, test, inspect, replace or remove the Participating TO's Interconnection Facilities and/or Network Upgrades upon such property.

5.14 Permits. Participating TO and Interconnection Customer shall cooperate with each other in good faith in obtaining all permits, licenses and authorization that are necessary to accomplish the interconnection in compliance with Applicable Laws and Regulations. With respect to this paragraph, the Participating TO shall provide permitting assistance to the Interconnection Customer comparable to that provided to the Participating TO's own, or an Affiliate's generation.

5.15 Early Construction of Base Case Facilities. The Interconnection Customer may request the Participating TO to construct, and the Participating TO shall construct, using Reasonable Efforts to accommodate Interconnection Customer's In-Service Date, all or any portion of any Network Upgrades required for Interconnection Customer to be interconnected to the Participating TO's Transmission System which are included in the Base Case of the Interconnection Studies for the Interconnection Customer, and which also are required to be constructed for another interconnection customer, but where such construction is not scheduled to be completed in time to achieve Interconnection Customer's In-Service Date.

5.16 Suspension. The Interconnection Customer reserves the right, upon written notice to the Participating TO and the CAISO, to suspend at any time all work associated with the construction and installation of the Participating TO's Interconnection Facilities, Network Upgrades, and/or Distribution Upgrades required under this LGIA with the condition that the Participating TO's electrical system and the CAISO Controlled Grid shall be left in a safe and reliable condition in accordance with Good Utility Practice and the Participating TO's safety and reliability criteria and the CAISO's Applicable Reliability Standards. In such event, the Interconnection Customer shall be responsible for all reasonable and necessary costs which the Participating TO (i) has incurred pursuant to this LGIA prior to the suspension and (ii) incurs in suspending such work, including any costs incurred to perform such work as may be necessary to ensure the safety of persons and property and the integrity of the Participating TO's electric system during such suspension and, if applicable, any costs incurred in connection with the cancellation or suspension of material, equipment and labor contracts which the Participating TO cannot reasonably avoid; provided, however, that prior to canceling or suspending any such material, equipment or labor contract, the Participating TO shall obtain Interconnection Customer's authorization to do so.

The Participating TO shall invoice the Interconnection Customer for such costs pursuant to Article 12 and shall use due diligence to minimize its costs. In the event Interconnection Customer suspends work required under this LGIA pursuant to this Article 5.16, and has not requested the Participating TO to recommence the work or has not itself recommenced work required under this LGIA on or before the expiration of three (3) years following commencement of such suspension, this LGIA shall be deemed terminated. The three-year period shall begin on the date the suspension is requested, or the date of the written notice to the Participating TO and the CAISO, if no effective date is specified.

5.17 Taxes.

5.17.1 Interconnection Customer Payments Not Taxable. The Parties intend that all payments or property transfers made by the Interconnection Customer to the Participating TO for the installation of the Participating TO's Interconnection Facilities and the Network Upgrades shall be non-taxable, either as contributions to capital, or as a refundable advance, in accordance with the Internal Revenue Code and any applicable state income tax laws and shall not be taxable as contributions in aid of construction or otherwise under the Internal Revenue Code and any applicable state income tax laws.

5.17.2 Representations And Covenants. In accordance with IRS Notice 2001-82 and IRS Notice 88-129, the Interconnection Customer represents and covenants that (i) ownership of the electricity generated at the Large Generating Facility will pass to another party prior to the transmission of the electricity on the CAISO Controlled Grid, (ii) for income tax purposes, the amount of any payments and the cost of any property transferred to the Participating TO for the Participating TO's Interconnection Facilities will be capitalized by the Interconnection Customer as an intangible asset and recovered using the straight-line method over a useful life of twenty (20) years, and (iii) any portion of the Participating TO's Interconnection Facilities that is a “dual-use intertie,” within the meaning of IRS Notice 88-129, is reasonably expected to carry only a de minimis amount of electricity in the direction of the Large Generating Facility. For this purpose, “de minimis amount” means no more than 5 percent of the total power flows in both directions, calculated in accordance with the “5 percent test” set forth in IRS Notice 88-129. This is not intended to be an exclusive list of the relevant conditions that must be met to conform to IRS requirements for non-taxable treatment.

At the Participating TO’s request, the Interconnection Customer shall provide the Participating TO with a report from an independent engineer confirming its representation in clause (iii), above. The Participating TO represents and covenants that the cost of the Participating TO's Interconnection Facilities paid for by the Interconnection Customer without the possibility of refund or credit will have no net effect on the base upon which rates are determined.

5.17.3 Indemnification for the Cost Consequence of Current Tax Liability Imposed Upon the Participating TO. Notwithstanding Article 5.17.1, the Interconnection Customer shall protect, indemnify and hold harmless the Participating TO from the cost consequences of any current tax liability imposed against the Participating TO as the result of payments or property transfers made by the Interconnection Customer to the Participating TO under this LGIA for Interconnection Facilities, as well as any interest and penalties, other than interest and penalties attributable to any delay caused by the Participating TO.

The Participating TO shall not include a gross-up for the cost consequences of any current tax liability in the amounts it charges the Interconnection Customer under this LGIA unless (i) the Participating TO has determined, in good faith, that the payments or property transfers made by the Interconnection Customer to the Participating TO should be reported as income subject to taxation or (ii) any Governmental Authority directs the Participating TO to report payments or property as income subject to taxation; provided, however, that the Participating TO may require the Interconnection Customer to provide security for Interconnection Facilities, in a form reasonably acceptable to the Participating TO (such as a parental guarantee or a letter of credit), in an amount equal to the cost consequences of any current tax liability under this Article 5.17. The Interconnection Customer shall reimburse the Participating TO for such costs on a fully grossed-up basis, in accordance with Article 5.17.4, within thirty (30) Calendar Days of receiving written notification from the Participating TO of the amount due, including detail about how the amount was calculated.

The indemnification obligation shall terminate at the earlier of (1) the expiration of the ten year testing period and the applicable statute of limitation, as it may be extended by the Participating TO upon request of the IRS, to keep these years open for audit or adjustment, or (2) the occurrence of a subsequent taxable event and the payment of any related indemnification obligations as contemplated by this Article 5.17.

5.17.4 Tax Gross-Up Amount. The Interconnection Customer's liability for the cost consequences of any current tax liability under this Article 5.17 shall be calculated on a fully grossed-up basis. Except as may otherwise be agreed to by the parties, this means that the Interconnection Customer will pay the Participating TO, in addition to the amount paid for the Interconnection Facilities and Network Upgrades, an amount equal to (1) the current taxes imposed on the Participating TO ("Current Taxes") on the excess of (a) the gross income realized by the Participating TO as a result of payments or property transfers made by the Interconnection Customer to the Participating TO under this LGIA (without regard to any payments under this Article 5.17) (the "Gross Income Amount") over (b) the present value of future tax deductions for depreciation that will be available as a result of such payments or property transfers (the "Present Value Depreciation Amount"), plus (2) an additional amount sufficient to permit the Participating TO to receive and retain, after the payment of all Current Taxes, an amount equal to the net amount described in clause (1).

For this purpose, (i) Current Taxes shall be computed based on the Participating TO's composite federal and state tax rates at the time the payments or property transfers are received and the Participating TO will be treated as being subject to tax at the highest marginal rates in effect at that time (the "Current Tax Rate"), and (ii) the Present Value Depreciation Amount shall be computed by discounting the Participating TO's anticipated tax depreciation deductions as a result of such payments or property transfers by the Participating TO's current weighted average cost of capital. Thus, the formula for calculating the Interconnection Customer's liability to the Participating TO pursuant to this Article 5.17.4 can be expressed as follows: (Current Tax Rate x (Gross Income Amount – Present Value of Tax Depreciation))/(1-Current Tax Rate). Interconnection Customer's estimated tax liability in the event taxes are imposed shall be stated in Appendix A, Interconnection Facilities, Network Upgrades and Distribution Upgrades.

5.17.5 Private Letter Ruling or Change or Clarification of Law. At the Interconnection Customer's request and expense, the Participating TO shall file with the IRS a request for a private letter ruling as to whether any property transferred or sums paid, or to be paid, by the Interconnection Customer to the Participating TO under this LGIA are subject to federal income taxation. The Interconnection Customer will prepare the initial draft of the request for a private letter ruling, and will certify under penalties of perjury that all facts represented in such request are true and accurate to the best of the Interconnection Customer's knowledge. The Participating TO and Interconnection Customer shall cooperate in good faith with respect to the submission of such request, provided, however, the Interconnection Customer and the Participating TO explicitly acknowledge (and nothing herein is intended to alter) Participating TO's obligation under law to certify that the facts presented in the ruling request are true, correct and complete.

The Participating TO shall keep the Interconnection Customer fully informed of the status of such request for a private letter ruling and shall execute either a privacy act waiver or a limited power of attorney, in a form acceptable to the IRS, that authorizes the Interconnection Customer to participate in all discussions with the IRS regarding such request for a private letter ruling. The Participating TO shall allow the Interconnection Customer to attend all meetings with IRS officials about the request and shall permit the Interconnection Customer to prepare the initial drafts of any follow-up letters in connection with the request.

5.17.6 Subsequent Taxable Events. If, within 10 years from the date on which the relevant Participating TO's Interconnection Facilities are placed in service, (i) the Interconnection Customer Breaches the covenants contained in Article 5.17.2, (ii) a "disqualification event" occurs within the meaning of IRS Notice 88-129, or (iii) this LGIA terminates and the Participating TO retains ownership of the Interconnection Facilities and Network Upgrades, the Interconnection Customer shall pay a tax gross-up for the cost consequences of any current tax liability imposed on the Participating TO, calculated using the methodology described in Article 5.17.4 and in accordance with IRS Notice 90-60.

5.17.7 Contests. In the event any Governmental Authority determines that the Participating TO's receipt of payments or property constitutes income that is subject to taxation, the Participating TO shall notify the Interconnection Customer, in writing, within thirty (30) Calendar Days of receiving notification of such determination by a Governmental Authority. Upon the timely written request by the Interconnection Customer and at the Interconnection Customer's sole expense, the Participating TO may appeal, protest, seek abatement of, or otherwise oppose such determination. Upon the Interconnection Customer's written request and sole expense, the Participating TO may file a claim for refund with respect to any taxes paid under this Article 5.17, whether or not it has received such a determination. The Participating TO reserve the right to make all decisions with regard to the prosecution of such appeal, protest, abatement or other contest, including the selection of counsel and compromise or settlement of the claim, but the Participating TO shall keep the Interconnection Customer informed, shall consider in good faith suggestions from the Interconnection Customer about the conduct of the contest, and shall reasonably permit the Interconnection Customer or an Interconnection Customer representative to attend contest proceedings.

The Interconnection Customer shall pay to the Participating TO on a periodic basis, as invoiced by the Participating TO, the Participating TO's documented reasonable costs of prosecuting such appeal, protest, abatement or other contest, including any costs associated with obtaining the opinion of independent tax counsel described in this Article 5.17.7. The Participating TO may abandon any contest if the Interconnection Customer fails to provide payment to the Participating TO within thirty (30) Calendar Days of receiving such invoice.

At any time during the contest, the Participating TO may agree to a settlement either with the Interconnection Customer's consent or, if such consent is refused, after obtaining written advice from independent nationally-recognized tax counsel, selected by the Participating TO, but reasonably acceptable to the Interconnection Customer, that the proposed settlement represents a reasonable settlement given the hazards of litigation. The Interconnection Customer's obligation shall be based on the amount of the settlement agreed to by the Interconnection Customer, or if a higher amount, so much of the settlement that is supported by the written advice from nationally-recognized tax counsel selected under the terms of the preceding paragraph. The settlement amount shall be calculated on a fully grossed-up basis to cover any related cost consequences of the current tax liability. The Participating TO may also settle any tax controversy without receiving the Interconnection Customer's consent or any such written advice; however, any such settlement will relieve the Interconnection Customer from any obligation to indemnify the Participating TO for the tax at issue in the contest (unless the failure to obtain written advice is attributable to the Interconnection Customer's unreasonable refusal to the appointment of independent tax counsel).

5.17.8 Refund. In the event that (a) a private letter ruling is issued to the Participating TO which holds that any amount paid or the value of any property transferred by the Interconnection Customer to the Participating TO under the terms of this LGIA is not subject to federal income taxation, (b) any legislative change or administrative announcement, notice, ruling or other determination makes it reasonably clear to the Participating TO in good faith that any amount paid or the value of any property transferred by the Interconnection Customer to the Participating TO under the terms of this LGIA is not taxable to the Participating TO, (c) any abatement, appeal, protest, or other contest results in a determination that any payments or transfers made by the Interconnection Customer to the Participating TO are not subject to federal income tax, or (d) if the Participating TO receives a refund from any taxing authority for any overpayment of tax attributable to any payment or property transfer made by the Interconnection Customer to the Participating TO pursuant to this LGIA, the Participating TO shall promptly refund to the Interconnection Customer the following:

(i) any payment made by Interconnection Customer under this Article 5.17 for taxes that is attributable to the amount determined to be non-taxable, together with interest thereon,

(ii) interest on any amounts paid by the Interconnection Customer to the Participating TO for such taxes which the Participating TO did not submit to the taxing authority, calculated in accordance with the methodology set forth in FERC's regulations at 18 C.F.R. §35.19a(a)(2)(iii) from the date payment was made by the Interconnection Customer to the date the Participating TO refunds such payment to the Interconnection Customer, and

(iii) with respect to any such taxes paid by the Participating TO, any refund or credit the Participating TO receives or to which it may be entitled from any Governmental Authority, interest (or that portion thereof attributable to the payment described in clause (i), above) owed to the Participating TO for such overpayment of taxes (including any reduction in interest otherwise payable by the Participating TO to any Governmental Authority resulting from an offset or credit); provided, however, that the Participating TO will remit such amount promptly to the Interconnection Customer only after and to the extent that the Participating TO has received a tax refund, credit or offset from any Governmental Authority for any applicable overpayment of income tax related to the Participating TO's Interconnection Facilities.

The intent of this provision is to leave the Parties, to the extent practicable, in the event that no taxes are due with respect to any payment for Interconnection Facilities and Network Upgrades hereunder, in the same position they would have been in had no such tax payments been made.

5.17.9 Taxes Other Than Income Taxes. Upon the timely request by the Interconnection Customer, and at the Interconnection Customer's sole expense, the CAISO or Participating TO may appeal, protest, seek abatement of, or otherwise contest any tax (other than federal or state income tax) asserted or assessed against the CAISO or Participating TO for which the Interconnection Customer may be required to reimburse the CAISO or Participating TO under the terms of this LGIA. The Interconnection Customer shall pay to the Participating TO on a periodic basis, as invoiced by the Participating TO, the Participating TO's documented reasonable costs of prosecuting such appeal, protest, abatement, or other contest. The Interconnection Customer, the CAISO, and the Participating TO shall cooperate in good faith with respect to any such contest. Unless the payment of such taxes is a prerequisite to an appeal or abatement or cannot be deferred, no amount shall be payable by the Interconnection Customer to the CAISO or Participating TO for such taxes until they are assessed by a final, non-appealable order by any court or agency of competent jurisdiction. In the event that a tax payment is withheld and ultimately due and payable after appeal, the Interconnection Customer will be responsible for all taxes, interest and penalties, other than penalties attributable to any delay caused by the Participating TO.

5.18 Tax Status. Each Party shall cooperate with the others to maintain the other Parties' tax status. Nothing in this LGIA is intended to adversely affect the CAISO's or any Participating TO's tax exempt status with respect to the issuance of bonds including, but not limited to, Local Furnishing Bonds.

5.19 Modification.

5.19.1 General. The Interconnection Customer or the Participating TO may undertake modifications to its facilities, subject to the provisions of this LGIA and the CAISO Tariff. If a Party plans to undertake a modification that reasonably may be expected to affect the other Parties' facilities, that Party shall provide to the other Parties sufficient information regarding such modification so that the other Parties may evaluate the potential impact of such modification prior to commencement of the work. Such information shall be deemed to be confidential hereunder and shall include information concerning the timing of such modifications and whether such modifications are expected to interrupt the flow of electricity from the Large Generating Facility. The Party desiring to perform such work shall provide the relevant drawings, plans, and specifications to the other Parties at least ninety (90) Calendar Days in advance of the commencement of the work or such shorter period upon which the Parties may agree, which agreement shall not unreasonably be withheld, conditioned or delayed.

In the case of Large Generating Facility modifications that do not require the Interconnection Customer to submit an Interconnection Request, the CAISO or Participating TO shall provide, within thirty (30) Calendar Days (or such other time as the Parties may agree), an estimate of any additional modifications to the CAISO Controlled Grid, Participating TO's Interconnection Facilities, Network Upgrades or Distribution Upgrades necessitated by such Interconnection Customer modification and a good faith estimate of the costs thereof. The Participating TO and the CAISO shall determine if a Large Generating Facility modification is a Material Modification in accordance with the LGIP.

5.19.2 Standards. Any additions, modifications, or replacements made to a Party's facilities shall be designed, constructed and operated in accordance with this LGIA and Good Utility Practice.

5.19.3 Modification Costs. The Interconnection Customer shall not be directly assigned the costs of any additions, modifications, or replacements that the Participating TO makes to the Participating TO's Interconnection Facilities or the Participating TO's Transmission System to facilitate the interconnection of a third party to the Participating TO's Interconnection Facilities or the Participating TO's Transmission System, or to provide transmission service to a third party under the CAISO Tariff. The Interconnection Customer shall be responsible for the costs of any additions, modifications, or replacements to the Interconnection Facilities that may be necessary to maintain or upgrade such Interconnection Facilities consistent with Applicable Laws and Regulations, Applicable Reliability Standards or Good Utility Practice.

ARTICLE 6. TESTING AND INSPECTION

6.1 Pre-Commercial Operation Date Testing and Modifications. Prior to the Commercial Operation Date, the Participating TO shall test the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades and the Interconnection Customer shall test the Large Generating Facility and the Interconnection Customer's Interconnection Facilities to ensure their safe and reliable operation. Similar testing may be required after initial operation. Each Party shall make any modifications to its facilities that are found to be necessary as a result of such testing. The Interconnection Customer shall bear the cost of all such testing and modifications. The Interconnection Customer shall not commence initial parallel operation of an Electric Generating Unit with the Participating TO's Transmission System until the Participating TO provides prior written approval, which approval shall not be unreasonably withheld, for operation of such Electric Generating Unit. The Interconnection Customer shall generate test energy at the Large Generating Facility only if it has arranged for the delivery of such test energy.

6.2 Post-Commercial Operation Date Testing and Modifications. Each Party shall at its own expense perform routine inspection and testing of its facilities and equipment in accordance with Good Utility Practice as may be necessary to ensure the continued interconnection of the Large Generating Facility with the Participating TO's Transmission System in a safe and reliable manner. Each Party shall have the right, upon advance written notice, to require reasonable additional testing of the other Party's facilities, at the requesting Party's expense, as may be in accordance with Good Utility Practice.

6.3 Right to Observe Testing. Each Party shall notify the other Parties at least fourteen (14) days in advance of its performance of tests of its Interconnection Facilities or Generating Facility. The other Parties have the right, at their own expense, to observe such testing.

6.4 Right to Inspect. Each Party shall have the right, but shall have no obligation to: (i) observe another Party's tests and/or inspection of any of its System Protection Facilities and other protective equipment, including Power System Stabilizers; (ii) review the settings of another Party's System Protection Facilities and other protective equipment; and (iii) review another Party's maintenance records relative to the Interconnection Facilities, the System Protection Facilities and other protective equipment. A Party may exercise these rights from time to time as it deems necessary upon reasonable notice to the other Party. The exercise or non-exercise by a Party of any such rights shall not be construed as an endorsement or confirmation of any element or condition of the Interconnection Facilities or the System Protection Facilities or other protective equipment or the operation thereof, or as a warranty as to the fitness, safety, desirability, or reliability of same. Any information that a Party obtains through the exercise of any of its rights under this Article 6.4 shall be deemed to be Confidential Information and treated pursuant to Article 22 of this LGIA.

ARTICLE 7. METERING

7.1 General. Each Party shall comply with the Applicable Reliability Council requirements. The Interconnection Customer and CAISO shall comply with the provisions of the CAISO Tariff regarding metering, including Section 10 of the CAISO Tariff. Unless otherwise agreed by the Participating TO and the Interconnection Customer, the Participating TO may install additional Metering Equipment at the Point of Interconnection prior to any operation of any Electric Generating Unit and shall own, operate, test and maintain such Metering Equipment. Power flows to and from the Large Generating Facility shall be measured at or, at the CAISO's or Participating TO's option for its respective Metering Equipment, compensated to, the Point of Interconnection. The CAISO shall provide metering quantities to the Interconnection Customer upon request in accordance with the CAISO Tariff by directly polling the CAISO's meter data acquisition system. The Interconnection Customer shall bear all reasonable documented costs associated with the purchase, installation, operation, testing and maintenance of the Metering Equipment.

7.2 Check Meters. The Interconnection Customer, at its option and expense, may install and operate, on its premises and on its side of the Point of Interconnection, one or more check meters to check the CAISO-polled meters or the Participating TO's meters. Such check meters shall be for check purposes only and shall not be used for the measurement of power flows for purposes of this LGIA, except in the case that no other means are available on a temporary basis at the option of the CAISO or the Participating TO. The check meters shall be subject at all reasonable times to inspection and examination by the CAISO or Participating TO or their designees. The installation, operation and maintenance thereof shall be performed entirely by the Interconnection Customer in accordance with Good Utility Practice.

7.3 Participating TO Retail Metering. The Participating TO may install retail revenue quality meters and associated equipment, pursuant to the Participating TO's applicable retail tariffs.

ARTICLE 8. COMMUNICATIONS

8.1 Interconnection Customer Obligations. The Interconnection Customer shall maintain satisfactory operating communications with the CAISO in accordance with the provisions of the CAISO Tariff and with the Participating TO's dispatcher or representative designated by the Participating TO. The Interconnection Customer shall provide standard voice line, dedicated voice line and facsimile communications at its Large Generating Facility control room or central dispatch facility through use of either the public telephone system, or a voice communications system that does not rely on the public telephone system. The Interconnection Customer shall also provide the dedicated data circuit(s) necessary to provide Interconnection Customer data to the CAISO and Participating TO as set forth in Appendix D, Security Arrangements Details. The data circuit(s) shall extend from the Large Generating Facility to the location(s) specified by the CAISO and Participating TO. Any required maintenance of such communications equipment shall be performed by the Interconnection Customer. Operational communications shall be activated and maintained under, but not be limited to, the following events: system paralleling or separation, scheduled and unscheduled shutdowns, equipment clearances, and hourly and daily load data.

8.2 Remote Terminal Unit. Prior to the Initial Synchronization Date of each Electric Generating Unit, a Remote Terminal Unit, or equivalent data collection and transfer equipment acceptable to the Parties, shall be installed by the Interconnection Customer, or by the Participating TO at the Interconnection Customer's expense, to gather accumulated and instantaneous data to be telemetered to the location(s) designated by the CAISO and by the Participating TO through use of a dedicated point-to-point data circuit(s) as indicated in Article 8.1.

Telemetry to the CAISO shall be provided in accordance with the CAISO's technical standards for direct telemetry. For telemetry to the Participating TO, the communication protocol for the data circuit(s) shall be specified by the Participating TO. Instantaneous bi-directional real power and reactive power flow and any other required information must be telemetered directly to the location(s) specified by the Participating TO.

Each Party will promptly advise the other Parties if it detects or otherwise learns of any metering, telemetry or communications equipment errors or malfunctions that require the attention and/or correction by another Party. The Party owning such equipment shall correct such error or malfunction as soon as reasonably feasible.

8.3 No Annexation. Any and all equipment placed on the premises of a Party shall be and remain the property of the Party providing such equipment regardless of the mode and manner of annexation or attachment to real property, unless otherwise mutually agreed by the Parties.

ARTICLE 9. OPERATIONS

9.1 General. Each Party shall comply with the Applicable Reliability Council requirements, and the Interconnection Customer shall execute the Reliability Management System Agreement of the Applicable Reliability Council attached hereto as Appendix G. Each Party shall provide to the other Party all information that may reasonably be required by the other Party to comply with Applicable Laws and Regulations and Applicable Reliability Standards.

9.2 Balancing Authority Area Notification. At least three months before Initial Synchronization Date, the Interconnection Customer shall notify the CAISO and Participating TO in writing of the Balancing Authority Area in which the Large Generating Facility intends to be located. If the Interconnection Customer intends to locate the Large Generating Facility in a Balancing Authority Area other than the Balancing Authority Area within whose electrically metered boundaries the Large Generating Facility is located, and if permitted to do so by the relevant transmission tariffs, all necessary arrangements, including but not limited to those set forth in Article 7 and Article 8 of this LGIA, and remote Balancing Authority Area generator interchange agreements, if applicable, and the appropriate measures under such agreements, shall be executed and implemented prior to the placement of the Large Generating Facility in the other Balancing Authority Area.

9.3 CAISO and Participating TO Obligations. The CAISO and Participating TO shall cause the Participating TO's Transmission System to be operated and controlled in a safe and reliable manner and in accordance with this LGIA. The Participating TO at the Interconnection Customer's expense shall cause the Participating TO's Interconnection Facilities to be operated, maintained and controlled in a safe and reliable manner and in accordance with this LGIA. The CAISO and Participating TO may provide operating instructions to the Interconnection Customer consistent with this LGIA and Participating TO and CAISO operating protocols and procedures as they may change from time to time. The Participating TO and CAISO will consider changes to their operating protocols and procedures proposed by the Interconnection Customer.

9.4 Interconnection Customer Obligations. The Interconnection Customer shall at its own expense operate, maintain and control the Large Generating Facility and the Interconnection Customer's Interconnection Facilities in a safe and reliable manner and in accordance with this LGIA. The Interconnection Customer shall operate the Large Generating Facility and the Interconnection Customer's Interconnection Facilities in accordance with all applicable requirements of the Balancing Authority Area of which it is part, including such requirements as set forth in Appendix C, Interconnection Details, of this LGIA. Appendix C, Interconnection Details, will be modified to reflect changes to the requirements as they may change from time to time. A Party may request that another Party provide copies of the requirements set forth in Appendix C, Interconnection Details, of this LGIA. The Interconnection Customer shall not commence Commercial Operation of an Electric Generating Unit with the Participating TO's Transmission System until the Participating TO provides prior written approval, which approval shall not be unreasonably withheld, for operation of such Electric Generating Unit.

9.5 Start-Up and Synchronization. Consistent with the Parties' mutually acceptable procedures, the Interconnection Customer is responsible for the proper synchronization of each Electric Generating Unit to the CAISO Controlled Grid.

9.6 Reactive Power.

9.6.1 Power Factor Design Criteria. For all Generating Facilities other than Asynchronous Generating Facilities, the Interconnection Customer shall design the Large Generating Facility to maintain a composite power delivery at continuous rated power output at the terminals of the Electric Generating Unit at a power factor within the range of 0.95 leading to 0.90 lagging, unless the CAISO has established different requirements that apply to all generators in the Balancing Authority Area on a comparable basis. For Asynchronous Generating Facilities, the Interconnection Customer shall design the Large Generating Facility to maintain power factor criteria in accordance with Appendix H of this LGIA.

9.6.2 Voltage Schedules. Once the Interconnection Customer has synchronized an Electric Generating Unit with the CAISO Controlled Grid, the CAISO or Participating TO shall require the Interconnection Customer to maintain a voltage schedule by operating the Electric Generating Unit to produce or absorb reactive power within the design limitations of the Electric Generating Unit set forth in Article 9.6.1 (Power Factor Design Criteria). CAISO's voltage schedules shall treat all sources of reactive power in the Balancing Authority Area in an equitable and not unduly discriminatory manner. The Participating TO shall exercise Reasonable Efforts to provide the Interconnection Customer with such schedules at least one (1) day in advance, and the CAISO or Participating TO may make changes to such schedules as necessary to maintain the reliability of the CAISO Controlled Grid or the Participating TO's electric system. The Interconnection Customer shall operate the Electric Generating Unit to maintain the specified output voltage or power factor within the design limitations of the Electric Generating Unit set forth in Article 9.6.1 (Power Factor Design Criteria), and as may be required by the CAISO to operate the Electric Generating Unit at a specific voltage schedule within the design limitations set forth in Article 9.6.1. If the Interconnection Customer is unable to maintain the specified voltage or power factor, it shall promptly notify the CAISO and the Participating TO.

9.6.2.1 Governors and Regulators. Whenever an Electric Generating Unit is operated in parallel with the CAISO Controlled Grid and the speed governors (if installed on the Electric Generating Unit pursuant to Good Utility Practice) and voltage regulators are capable of operation, the Interconnection Customer shall operate the Electric Generating Unit with its speed governors and voltage regulators in automatic operation. If the Electric Generating Unit's speed governors and voltage regulators are not capable of such automatic operation, the Interconnection Customer shall immediately notify the CAISO and the Participating TO and ensure that the Electric Generating Unit operates as specified in Article 9.6.2 through manual operation and that such Electric Generating Unit's reactive power production or absorption (measured in MVARs) are within the design capability of the Electric Generating Unit(s) and steady state stability limits. The Interconnection Customer shall restore the speed governors and voltage regulators to automatic operation as soon as possible and in accordance with the Reliability Management System Agreement in Appendix G. If the Large Generating Facility's speed governors and voltage regulators are improperly tuned or malfunctioning, the CAISO shall have the right to order the reduction in output or disconnection of the Large Generating Facility if the reliability of the CAISO Controlled Grid would be adversely affected. The Interconnection Customer shall not cause its Large Generating Facility to disconnect automatically or instantaneously from the CAISO Controlled Grid or trip any Electric Generating Unit comprising the Large Generating Facility for an under or over frequency condition unless the abnormal frequency condition persists for a time period beyond the limits set forth in ANSI/IEEE Standard C37.106, or such other standard as applied to other generators in the Balancing Authority Area on a comparable basis.

9.6.2.2 Loss of Voltage Control and Governor Control for Asynchronous Generating Facilities. For Asynchronous Generating Facilities, Appendix H to this LGIA sets forth the requirements for Large Generating Facilities relating to: (i) the loss of voltage control capability, (ii) governor response to frequency conditions, and (iii) ability not to disconnect automatically or instantaneously from the CAISO Controlled Grid or trip any Electric Generating Unit comprising the Large Generating Facility for an under- or over-frequency condition. Asynchronous Generating Facilities are not required to provide governor response to under-frequency conditions.

9.6.3 Payment for Reactive Power. CAISO is required to pay the Interconnection Customer for reactive power that Interconnection Customer provides or absorbs from an Electric Generating Unit when the CAISO requests the Interconnection Customer to operate its Electric Generating Unit outside the range specified in Article 9.6.1, provided that if the CAISO pays other generators for reactive power service within the specified range, it must also pay the Interconnection Customer. Payments shall be pursuant to Article 11.6 or such other agreement to which the CAISO and Interconnection Customer have otherwise agreed.

9.7 Outages and Interruptions.

9.7.1 Outages.

9.7.1.1 Outage Authority and Coordination. Each Party may in accordance with Good Utility Practice in coordination with the other Parties remove from service any of its respective Interconnection Facilities or Network Upgrades that may impact another Party's facilities as necessary to perform maintenance or testing or to install or replace equipment. Absent an Emergency Condition, the Party scheduling a removal of such facility(ies) from service will use Reasonable Efforts to schedule such removal on a date and time mutually acceptable to all Parties. In all circumstances any Party planning to remove such facility(ies) from service shall use Reasonable Efforts to minimize the effect on the other Parties of such removal.

9.7.1.2 Outage Schedules. The CAISO shall post scheduled outages of CAISO Controlled Grid facilities in accordance with the provisions of the CAISO Tariff. The Interconnection Customer shall submit its planned maintenance schedules for the Large Generating Facility to the CAISO in accordance with the CAISO Tariff. The Interconnection Customer shall update its planned maintenance schedules in accordance with the CAISO Tariff. The CAISO may request the Interconnection Customer to reschedule its maintenance as necessary to maintain the reliability of the CAISO Controlled Grid in accordance with the CAISO Tariff. Such planned maintenance schedules and updates and changes to such schedules shall be provided by the Interconnection Customer to the Participating TO concurrently with their submittal to the CAISO. The CAISO shall compensate the Interconnection Customer for any additional direct costs that the Interconnection Customer incurs as a result of having to reschedule maintenance in accordance with the CAISO Tariff. The Interconnection Customer will not be eligible to receive compensation, if during the twelve (12) months prior to the date of the scheduled maintenance, the Interconnection Customer had modified its schedule of maintenance activities.

9.7.1.3 Outage Restoration. If an outage on a Party's Interconnection Facilities or Network Upgrades adversely affects another Party's operations or facilities, the Party that owns or controls the facility that is out of service shall use Reasonable Efforts to promptly restore such facility(ies) to a normal operating condition consistent with the nature of the outage. The Party that owns or controls the facility that is out of service shall provide the other Parties, to the extent such information is known, information on the nature of the Emergency Condition, if the outage is caused by an Emergency Condition, an estimated time of restoration, and any corrective actions required. Initial verbal notice shall be followed up as soon as practicable with written notice explaining the nature of the outage, if requested by a Party, which may be provided by e-mail or facsimile.

9.7.2 Interruption of Service. If required by Good Utility Practice to do so, the CAISO or the Participating TO may require the Interconnection Customer to interrupt or reduce deliveries of electricity if such delivery of electricity could adversely affect the CAISO's or the Participating TO's ability to perform such activities as are necessary to safely and reliably operate and maintain the Participating TO's electric system or the CAISO Controlled Grid. The following provisions shall apply to any interruption or reduction permitted under this Article 9.7.2:

9.7.2.1 The interruption or reduction shall continue only for so long as reasonably necessary under Good Utility Practice;

9.7.2.2 Any such interruption or reduction shall be made on an equitable, non-discriminatory basis with respect to all generating facilities directly connected to the CAISO Controlled Grid, subject to any conditions specified in this LGIA;

9.7.2.3 When the interruption or reduction must be made under circumstances which do not allow for advance notice, the CAISO or Participating TO, as applicable, shall notify the Interconnection Customer by telephone as soon as practicable of the reasons for the curtailment, interruption, or reduction, and, if known, its expected duration. Telephone notification shall be followed by written notification, if requested by the Interconnection Customer, as soon as practicable;

9.7.2.4 Except during the existence of an Emergency Condition, the CAISO or Participating TO shall notify the Interconnection Customer in advance regarding the timing of such interruption or reduction and further notify the Interconnection Customer of the expected duration. The CAISO or Participating TO shall coordinate with the Interconnection Customer using Good Utility Practice to schedule the interruption or reduction during periods of least impact to the Interconnection Customer, the CAISO, and the Participating TO;

9.7.2.5 The Parties shall cooperate and coordinate with each other to the extent necessary in order to restore the Large Generating Facility, Interconnection Facilities, the Participating TO's Transmission System, and the CAISO Controlled Grid to their normal operating state, consistent with system conditions and Good Utility Practice.

9.7.3 Under-Frequency and Over Frequency Conditions. The CAISO Controlled Grid is designed to automatically activate a load-shed program as required by the Applicable Reliability Council in the event of an under-frequency system disturbance. The Interconnection Customer shall implement under-frequency and over-frequency protection set points for the Large Generating Facility as required by the Applicable Reliability Council to ensure "ride through" capability. Large Generating Facility response to frequency deviations of pre-determined magnitudes, both under-frequency and over-frequency deviations, shall be studied and coordinated with the Participating TO and CAISO in accordance with Good Utility Practice. The term "ride through" as used herein shall mean the ability of a Generating Facility to stay connected to and synchronized with the CAISO Controlled Grid during system disturbances within a range of under-frequency and over-frequency conditions, in accordance with Good Utility Practice. Asynchronous Generating Facilities shall be subject to frequency ride through capability requirements in accordance with Appendix H to this LGIA.

9.7.4 System Protection and Other Control Requirements.

9.7.4.1 System Protection Facilities. The Interconnection Customer shall, at its expense, install, operate and maintain System Protection Facilities as a part of the Large Generating Facility or the Interconnection Customer's Interconnection

Facilities. The Participating TO shall install at the Interconnection Customer's expense any System Protection Facilities that may be required on the Participating TO's Interconnection Facilities or the Participating TO's Transmission System as a result of the interconnection of the Large Generating Facility and the Interconnection Customer's Interconnection Facilities.

9.7.4.2 The Participating TO's and Interconnection Customer's protection facilities shall be designed and coordinated with other systems in accordance with Applicable Reliability Council criteria and Good Utility Practice.

9.7.4.3 The Participating TO and Interconnection Customer shall each be responsible for protection of its facilities consistent with Good Utility Practice.

9.7.4.4 The Participating TO's and Interconnection Customer's protective relay design shall incorporate the necessary test switches to perform the tests required in Article 6. The required test switches will be placed such that they allow operation of lockout relays while preventing breaker failure schemes from operating and causing unnecessary breaker operations and/or the tripping of the Interconnection Customer's Electric Generating Units.

9.7.4.5 The Participating TO and Interconnection Customer will test, operate and maintain System Protection Facilities in accordance with Good Utility Practice and, if applicable, the requirements of the Participating TO's Interconnection Handbook.

9.7.4.6 Prior to the in-service date, and again prior to the Commercial Operation Date, the Participating TO and Interconnection Customer or their agents shall perform a complete calibration test and functional trip test of the System Protection Facilities. At intervals suggested by Good Utility Practice, the standards and procedures of the Participating TO, including, if applicable, the requirements of the Participating TO's Interconnection Handbook, and following any apparent malfunction of the System Protection Facilities, each Party shall perform both calibration and functional trip tests of its System Protection Facilities. These tests do not require the tripping of any in-service generation unit. These tests do, however, require that all protective relays and lockout contacts be activated.

9.7.5 **Requirements for Protection**. In compliance with Good Utility Practice and, if applicable, the requirements of the Participating TO's Interconnection Handbook, the Interconnection Customer shall provide, install, own, and maintain relays, circuit breakers and all other devices necessary to remove any fault contribution of the Large Generating Facility to any short circuit occurring on the Participating TO's Transmission System not otherwise isolated by the Participating TO's equipment, such that the removal of the fault contribution shall be coordinated with the protective requirements of the Participating TO's Transmission System. Such protective equipment shall include, without limitation, a disconnecting device with fault current-interrupting capability located between the Large Generating Facility and the Participating TO's Transmission System at a site selected upon mutual agreement (not to be unreasonably withheld, conditioned or delayed) of the Parties. The Interconnection Customer shall be responsible for protection of the Large Generating Facility and the Interconnection Customer's other equipment from such conditions as negative sequence currents, over- or under-frequency, sudden load rejection, over- or under-voltage, and generator loss-of-field. The Interconnection Customer shall be solely responsible to disconnect the Large Generating Facility and the Interconnection Customer's other equipment if conditions on the CAISO Controlled Grid could adversely affect the Large Generating Facility.

9.7.6 Power Quality. Neither the Participating TO's nor the Interconnection Customer's facilities shall cause excessive voltage flicker nor introduce excessive distortion to the sinusoidal voltage or current waves as defined by ANSI Standard C84.1-1989, in accordance with IEEE Standard 519, any applicable superseding electric industry standard, or any alternative Applicable Reliability Council standard. In the event of a conflict between ANSI Standard C84.1-1989, any applicable superseding electric industry standard, or any alternative Applicable Reliability Council standard, the alternative Applicable Reliability Council standard shall control.

9.8 Switching and Tagging Rules. Each Party shall provide the other Parties a copy of its switching and tagging rules that are applicable to the other Parties' activities. Such switching and tagging rules shall be developed on a non-discriminatory basis. The Parties shall comply with applicable switching and tagging rules, as amended from time to time, in obtaining clearances for work or for switching operations on equipment.

9.9 Use of Interconnection Facilities by Third Parties.

9.9.1 Purpose of Interconnection Facilities. Except as may be required by Applicable Laws and Regulations, or as otherwise agreed to among the Parties, the Interconnection Facilities shall be constructed for the sole purpose of interconnecting the Large Generating Facility to the Participating TO's Transmission System and shall be used for no other purpose.

9.9.2 Third Party Users. If required by Applicable Laws and Regulations or if the Parties mutually agree, such agreement not to be unreasonably withheld, to allow one or more third parties to use the Participating TO's Interconnection Facilities, or any part thereof, the Interconnection Customer will be entitled to compensation for the capital expenses it incurred in connection with the Interconnection Facilities based upon the pro rata use of the Interconnection Facilities by the Participating TO, all third party users, and the Interconnection Customer, in accordance with Applicable Laws and Regulations or upon some other mutually-agreed upon methodology. In addition, cost responsibility for ongoing costs, including operation and maintenance costs associated with the Interconnection Facilities, will be allocated between the Interconnection Customer and any third party users based upon the pro rata use of the Interconnection Facilities by the Participating TO, all third party users, and the Interconnection Customer, in accordance with Applicable Laws and Regulations or upon some other mutually agreed upon methodology. If the issue of such compensation or allocation cannot be resolved through such negotiations, it shall be submitted to FERC for resolution.

9.10 Disturbance Analysis Data Exchange. The Parties will cooperate with one another in the analysis of disturbances to either the Large Generating Facility or the CAISO Controlled Grid by gathering and providing access to any information relating to any disturbance, including information from oscillography, protective relay targets, breaker operations and sequence of events records, and any disturbance information required by Good Utility Practice.

ARTICLE 10. MAINTENANCE

10.1 Participating TO Obligations. The Participating TO shall maintain the Participating TO's Transmission System and the Participating TO's Interconnection Facilities in a safe and reliable manner and in accordance with this LGIA.

10.2 Interconnection Customer Obligations. The Interconnection Customer shall maintain the Large Generating Facility and the Interconnection Customer's Interconnection Facilities in a safe and reliable manner and in accordance with this LGIA.

10.3 Coordination. The Parties shall confer regularly to coordinate the planning, scheduling and performance of preventive and corrective maintenance on the Large Generating Facility and the Interconnection Facilities.

10.4 Secondary Systems. The Participating TO and Interconnection Customer shall cooperate with the other Parties in the inspection, maintenance, and testing of control or power circuits that operate below 600 volts, AC or DC, including, but not limited to, any hardware, control or protective devices, cables, conductors, electric raceways, secondary equipment panels, transducers, batteries, chargers, and voltage and current transformers that directly affect the operation of a Party's facilities and equipment which may reasonably be expected to impact the other Parties. Each Party shall provide advance notice to the other Parties before undertaking any work on such circuits, especially on electrical circuits involving circuit breaker trip and close contacts, current transformers, or potential transformers.

10.5 Operating and Maintenance Expenses. Subject to the provisions herein addressing the use of facilities by others, and except for operations and maintenance expenses associated with modifications made for providing interconnection or transmission service to a third party and such third party pays for such expenses, the Interconnection Customer shall be responsible for all reasonable expenses including overheads, associated with: (1) owning, operating, maintaining, repairing, and replacing the Interconnection Customer's Interconnection Facilities; and (2) operation, maintenance, repair and replacement of the Participating TO's Interconnection Facilities.

ARTICLE 11. PERFORMANCE OBLIGATION

11.1 Interconnection Customer's Interconnection Facilities. The Interconnection Customer shall design, procure, construct, install, own and/or control the Interconnection Customer's Interconnection Facilities described in Appendix A at its sole expense.

11.2 Participating TO's Interconnection Facilities. The Participating TO shall design, procure, construct, install, own and/or control the Participating TO's Interconnection Facilities described in Appendix A at the sole expense of the Interconnection Customer. Unless the Participating TO elects to fund the capital for the Participating TO's Interconnection Facilities, they shall be solely funded by the Interconnection Customer.

11.3 Network Upgrades and Distribution Upgrades. The Participating TO shall design, procure, construct, install, and own the Network Upgrades and Distribution Upgrades described in Appendix A. The Interconnection Customer shall be responsible for all costs related to Distribution Upgrades. Unless the Participating TO elects to fund the capital for the Distribution Upgrades and Network Upgrades, they shall be solely funded by the Interconnection Customer.

11.4 Transmission Credits. No later than thirty (30) days prior to the Commercial Operation Date, the Interconnection Customer may make a one-time election by written notice to the CAISO and the Participating TO to receive Congestion Revenue Rights as defined in and as available under the CAISO Tariff at the time of the election in accordance with the CAISO Tariff, in lieu of a refund of the cost of Network Upgrades in accordance with Article 11.4.1.

11.4.1 Repayment of Amounts Advanced for Network Upgrades. Upon the Commercial Operation Date, the Interconnection Customer shall be entitled to a repayment, equal to the total amount paid to the Participating TO for the cost of Network Upgrades. Such amount shall include any tax gross-up or other tax-related payments associated with Network Upgrades not refunded to the Interconnection Customer pursuant to Article 5.17.8 or otherwise, and shall be paid to the Interconnection Customer by the Participating TO on a dollar-for-dollar basis either through (1) direct payments made on a levelized basis over the five-year period commencing on the Commercial Operation Date; or (2) any alternative payment schedule that is mutually agreeable to the Interconnection

Customer and Participating TO, provided that such amount is paid within five (5) years from the Commercial Operation Date. Notwithstanding the foregoing, if this LGIA terminates within five (5) years from the Commercial Operation Date, the Participating TO's obligation to pay refunds to the Interconnection Customer shall cease as of the date of termination. Any repayment shall include interest calculated in accordance with the methodology set forth in FERC's regulations at 18 C.F.R. §35.19a(a)(2)(iii) from the date of any payment for Network Upgrades through the date on which the Interconnection Customer receives a repayment of such payment. Interest shall continue to accrue on the repayment obligation so long as this LGIA is in effect. The Interconnection Customer may assign such repayment rights to any person.

If the Large Generating Facility fails to achieve commercial operation, but it or another Generating Facility is later constructed and makes use of the Network Upgrades, the Participating TO shall at that time reimburse Interconnection Customer for the amounts advanced for the Network Upgrades. Before any such reimbursement can occur, the Interconnection Customer, or the entity that ultimately constructs the Generating Facility, if different, is responsible for identifying the entity to which reimbursement must be made.

11.4.2 Special Provisions for Affected Systems. The Interconnection Customer shall enter into an agreement with the owner of the Affected System and/or other affected owners of portions of the CAISO Controlled Grid, as applicable, in accordance with the LGIP. Such agreement shall specify the terms governing payments to be made by the Interconnection Customer to the owner of the Affected System and/or other affected owners of portions of the CAISO Controlled Grid as well as the repayment by the owner of the Affected System and/or other affected owners of portions of the CAISO Controlled Grid. In no event shall the Participating TO be responsible for the repayment for any facilities that are not part of the Participating TO's Transmission System.

11.4.3 Notwithstanding any other provision of this LGIA, nothing herein shall be construed as relinquishing or foreclosing any rights, including but not limited to firm transmission rights, capacity rights, Congestion Revenue Rights, or transmission credits, that the Interconnection Customer shall be entitled to, now or in the future under any other agreement or tariff as a result of, or otherwise associated with, the transmission capacity, if any, created by the Network Upgrades, including the right to obtain cash reimbursements or transmission credits for transmission service that is not associated with the Large Generating Facility.

11.5 Provision of Security. At least thirty (30) Calendar Days prior to the commencement of the procurement, installation, or construction of a discrete portion of a Participating TO's Interconnection Facilities, Network Upgrades, or Distribution Upgrades, the Interconnection Customer shall provide the Participating TO, at the Interconnection Customer's option, a guarantee, a surety bond, letter of credit or other form of security that is reasonably acceptable to the Participating TO and is consistent with the Uniform Commercial Code of the jurisdiction identified in Article 14.2.1. Such security for payment shall be in an amount sufficient to cover the costs for constructing, procuring and installing the applicable portion of the Participating TO's Interconnection Facilities, Network Upgrades, or Distribution Upgrades. Such security shall be reduced on a dollar-for-dollar basis for payments made to the Participating TO for these purposes.

In addition:

11.5.1 The guarantee must be made by an entity that meets the creditworthiness requirements of the Participating TO, and contain terms and conditions that guarantee payment of any amount that may be due from the Interconnection Customer, up to an agreed-to maximum amount.

11.5.2 The letter of credit must be issued by a financial institution reasonably acceptable to the Participating TO and must specify a reasonable expiration date.

11.5.3 The surety bond must be issued by an insurer reasonably acceptable to the Participating TO and must specify a reasonable expiration date.

11.6 Interconnection Customer Compensation. If the CAISO requests or directs the Interconnection Customer to provide a service pursuant to Articles 9.6.3 (Payment for Reactive Power) or 13.5.1 of this LGIA, the CAISO shall compensate the Interconnection Customer in accordance with the CAISO Tariff.

11.6.1 Interconnection Customer Compensation for Actions During Emergency Condition. The CAISO shall compensate the Interconnection Customer in accordance with the CAISO Tariff for its provision of real and reactive power and other Emergency Condition services that the Interconnection Customer provides to support the CAISO Controlled Grid during an Emergency Condition in accordance with Article 11.6.

ARTICLE 12. INVOICE

12.1 General. The Participating TO shall submit to the Interconnection Customer, on a monthly basis, invoices of amounts due pursuant to this LGIA for the preceding month. Each invoice shall state the month to which the invoice applies and fully describe the services and equipment provided. The Parties may discharge mutual debts and payment obligations due and owing to each other on the same date through netting, in which case all amounts a Party owes to the other Party under this LGIA, including interest payments or credits, shall be netted so that only the net amount remaining due shall be paid by the owing Party. Notwithstanding the foregoing, any invoices between the CAISO and another Party shall be submitted and paid in accordance with the CAISO Tariff.

12.2 Final Invoice. As soon as reasonably practicable, but within twelve months after completion of the construction of the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades, the Participating TO shall provide an invoice of the final cost of the construction of the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades, and shall set forth such costs in sufficient detail to enable the Interconnection Customer to compare the actual costs with the estimates and to ascertain deviations, if any, from the cost estimates. The Participating TO shall refund to the Interconnection Customer any amount by which the actual payment by the Interconnection Customer for estimated costs exceeds the actual costs of construction within thirty (30) Calendar Days of the issuance of such final construction invoice; or, in the event the actual costs of construction exceed the Interconnection Customer's actual payment for estimated costs, then the Interconnection Customer shall pay to the Participating TO any amount by which the actual costs of construction exceed the actual payment by the Interconnection Customer for estimated costs within thirty (30) Calendar Days of the issuance of such final construction invoice.

12.3 Payment. Invoices shall be rendered to the Interconnection Customer at the address specified in Appendix F. The Interconnection Customer shall pay, or Participating TO shall refund, the amounts due within thirty (30) Calendar Days of the Interconnection Customer's receipt of the invoice. All payments shall be made in immediately available funds payable to the Interconnection Customer or Participating TO, or by wire transfer to a bank named and account designated by the invoicing Interconnection Customer or Participating TO. Payment of invoices by any Party will not constitute a waiver of any rights or claims any Party may have under this LGIA.

12.4 Disputes. In the event of a billing dispute between the Interconnection Customer and the Participating TO, the Participating TO and the CAISO shall continue to provide Interconnection Service under this LGIA as long as the Interconnection Customer: (i) continues to make all payments not in dispute; and (ii) pays to the Participating TO or into an independent escrow account the portion of the invoice in dispute, pending resolution of such dispute. If the Interconnection Customer fails to meet these two requirements for continuation of service, then the Participating TO may provide notice to the Interconnection Customer of a Default pursuant to Article 17. Within thirty (30) Calendar Days after the resolution of the dispute, the Party that owes money to the other Party shall pay the amount due with interest calculated in accordance with the methodology set forth in FERC's Regulations at 18 C.F.R. § 35.19a(a)(2)(iii). Notwithstanding the foregoing, any billing dispute between the CAISO and another Party shall be resolved in accordance with the provisions of Article 27 of this LGIA.

ARTICLE 13. EMERGENCIES

13.1 [Reserved]

13.2 Obligations. Each Party shall comply with the Emergency Condition procedures of the CAISO, NERC, the Applicable Reliability Council, Applicable Laws and Regulations, and any emergency procedures set forth in this LGIA.

13.3 Notice. The Participating TO or the CAISO shall notify the Interconnection Customer promptly when it becomes aware of an Emergency Condition that affects the Participating TO's Interconnection Facilities or Distribution System or the CAISO Controlled Grid, respectively, that may reasonably be expected to affect the Interconnection Customer's operation of the Large Generating Facility or the Interconnection Customer's Interconnection Facilities. The Interconnection Customer shall notify the Participating TO and the CAISO promptly when it becomes aware of an Emergency Condition that affects the Large Generating Facility or the Interconnection Customer's Interconnection Facilities that may reasonably be expected to affect the CAISO Controlled Grid or the Participating TO's Interconnection Facilities. To the extent information is known, the notification shall describe the Emergency Condition, the extent of the damage or deficiency, the expected effect on the operation of the Interconnection Customer's or Participating TO's facilities and operations, its anticipated duration and the corrective action taken and/or to be taken. The initial notice shall be followed as soon as practicable with written notice, if requested by a Party, which may be provided by electronic mail or facsimile, or in the case of the CAISO may be publicly posted on the CAISO's internet web site.

13.4 Immediate Action. Unless, in the Interconnection Customer's reasonable judgment, immediate action is required, the Interconnection Customer shall obtain the consent of the CAISO and the Participating TO, such consent to not be unreasonably withheld, prior to performing any manual switching operations at the Large Generating Facility or the Interconnection Customer's Interconnection Facilities in response to an Emergency Condition declared by the Participating TO or CAISO or in response to any other emergency condition.

13.5 CAISO and Participating TO Authority.

13.5.1 General. The CAISO and Participating TO may take whatever actions or inactions, including issuance of dispatch instructions, with regard to the CAISO Controlled Grid or the Participating TO's Interconnection Facilities or Distribution System they deem necessary during an Emergency Condition in order to (i) preserve public health and safety, (ii) preserve the reliability of the CAISO Controlled Grid or the Participating TO's Interconnection Facilities or Distribution System, and (iii) limit or prevent damage, and (iv) expedite restoration of service.

The Participating TO and the CAISO shall use Reasonable Efforts to minimize the effect of such actions or inactions on the Large Generating Facility or the Interconnection Customer's Interconnection Facilities. The Participating TO or the CAISO may, on the basis of technical considerations, require the Large Generating Facility to mitigate an Emergency Condition by taking actions necessary and limited in scope to remedy the

Emergency Condition, including, but not limited to, directing the Interconnection Customer to shut-down, start-up, increase or decrease the real or reactive power output of the Large Generating Facility; implementing a reduction or disconnection pursuant to Article 13.5.2; directing the Interconnection Customer to assist with black start (if available) or restoration efforts; or altering the outage schedules of the Large Generating Facility and the Interconnection Customer's Interconnection Facilities. Interconnection Customer shall comply with all of the CAISO's and Participating TO's operating instructions concerning Large Generating Facility real power and reactive power output within the manufacturer's design limitations of the Large Generating Facility's equipment that is in service and physically available for operation at the time, in compliance with Applicable Laws and Regulations.

13.5.2 Reduction and Disconnection. The Participating TO or the CAISO may reduce Interconnection Service or disconnect the Large Generating Facility or the Interconnection Customer's Interconnection Facilities when such reduction or disconnection is necessary under Good Utility Practice due to Emergency Conditions. These rights are separate and distinct from any right of curtailment of the CAISO pursuant to the CAISO Tariff. When the CAISO or Participating TO can schedule the reduction or disconnection in advance, the CAISO or Participating TO shall notify the Interconnection Customer of the reasons, timing and expected duration of the reduction or disconnection. The CAISO or Participating TO shall coordinate with the Interconnection Customer using Good Utility Practice to schedule the reduction or disconnection during periods of least impact to the Interconnection Customer and the CAISO and Participating TO. Any reduction or disconnection shall continue only for so long as reasonably necessary under Good Utility Practice. The Parties shall cooperate with each other to restore the Large Generating Facility, the Interconnection Facilities, and the CAISO Controlled Grid to their normal operating state as soon as practicable consistent with Good Utility Practice.

13.6 Interconnection Customer Authority. Consistent with Good Utility Practice, this LGIA, and the CAISO Tariff, the Interconnection Customer may take actions or inactions with regard to the Large Generating Facility or the Interconnection Customer's Interconnection Facilities during an Emergency Condition in order to (i) preserve public health and safety, (ii) preserve the reliability of the Large Generating Facility or the Interconnection Customer's Interconnection Facilities, (iii) limit or prevent damage, and (iv) expedite restoration of service. Interconnection Customer shall use Reasonable Efforts to minimize the effect of such actions or inactions on the CAISO Controlled Grid and the Participating TO's Interconnection Facilities. The CAISO and Participating TO shall use Reasonable Efforts to assist Interconnection Customer in such actions.

13.7 Limited Liability. Except as otherwise provided in Article 11.6.1 of this LGIA, no Party shall be liable to any other Party for any action it takes in responding to an Emergency Condition so long as such action is made in good faith and is consistent with Good Utility Practice.

ARTICLE 14. REGULATORY REQUIREMENTS AND GOVERNING LAW

14.1 Regulatory Requirements. Each Party's obligations under this LGIA shall be subject to its receipt of any required approval or certificate from one or more Governmental Authorities in the form and substance satisfactory to the applying Party, or the Party making any required filings with, or providing notice to, such Governmental Authorities, and the expiration of any time period associated therewith. Each Party shall in good faith seek and use its Reasonable Efforts to obtain such other approvals. Nothing in this LGIA shall require the Interconnection Customer to take any action that could result in its inability to obtain, or its loss of, status or exemption under the Federal Power Act or the Public Utility Holding Company Act of 1935, as amended, or the Public Utility Regulatory Policies Act of 1978, or the Energy Policy Act of 2005.

14.2 Governing Law.

14.2.1 The validity, interpretation and performance of this LGIA and each of its provisions shall be governed by the laws of the state where the Point of Interconnection is located, without regard to its conflicts of law principles.

14.2.2 This LGIA is subject to all Applicable Laws and Regulations.

14.2.3 Each Party expressly reserves the right to seek changes in, appeal, or otherwise contest any laws, orders, rules, or regulations of a Governmental Authority.

ARTICLE 15. NOTICES

15.1 General. Unless otherwise provided in this LGIA, any notice, demand or request required or permitted to be given by a Party to another and any instrument required or permitted to be tendered or delivered by a Party in writing to another shall be effective when delivered and may be so given, tendered or delivered, by recognized national courier, or by depositing the same with the United States Postal Service with postage prepaid, for delivery by certified or registered mail, addressed to the Party, or personally delivered to the Party, at the address set out in Appendix F, Addresses for Delivery of Notices and Billings.

A Party must update the information in Appendix F as information changes. A Party may change the notice information in this LGIA by giving five (5) Business Days written notice prior to the effective date of the change. Such changes shall not constitute an amendment to this LGIA.

15.2 Billings and Payments. Billings and payments shall be sent to the addresses set out in Appendix F.

15.3 Alternative Forms of Notice. Any notice or request required or permitted to be given by a Party to another and not required by this LGIA to be given in writing may be so given by telephone, facsimile or e-mail to the telephone numbers and e-mail addresses set out in Appendix F.

15.4 Operations and Maintenance Notice. Each Party shall notify the other Parties in writing of the identity of the person(s) that it designates as the point(s) of contact with respect to the implementation of Articles 9 and 10.

ARTICLE 16. FORCE MAJEURE

16.1 Force Majeure.

16.1.1 Economic hardship is not considered a Force Majeure event.

16.1.2 No Party shall be considered to be in Default with respect to any obligation hereunder, (including obligations under Article 4), other than the obligation to pay money when due, if prevented from fulfilling such obligation by Force Majeure. A Party unable to fulfill any obligation hereunder (other than an obligation to pay money when due) by reason of Force Majeure shall give notice and the full particulars of such Force Majeure to the other Party in writing or by telephone as soon as reasonably possible after the occurrence of the cause relied upon. Telephone notices given pursuant to this Article shall be confirmed in writing as soon as reasonably possible and shall specifically state full particulars of the Force Majeure, the time and date when the Force Majeure occurred and when the Force Majeure is reasonably expected to cease. The Party affected shall exercise due diligence to remove such disability with reasonable dispatch, but shall not be required to accede or agree to any provision not satisfactory to it in order to settle and terminate a strike or other labor disturbance.

ARTICLE 17. DEFAULT

17.1 Default

17.1.1 General. No Default shall exist where such failure to discharge an obligation (other than the payment of money) is the result of Force Majeure as defined in this LGIA or the result of an act or omission of the other Party. Upon a Breach, the affected non-Breaching Party(ies) shall give written notice of such Breach to the Breaching Party. Except as provided in Article 17.1.2, the Breaching Party shall have thirty (30) Calendar Days from receipt of the Default notice within which to cure such Breach; provided however, if such Breach is not capable of cure within thirty (30) Calendar Days, the Breaching Party shall commence such cure within thirty (30) Calendar Days after notice and continuously and diligently complete such cure within ninety (90) Calendar Days from receipt of the Default notice; and, if cured within such time, the Breach specified in such notice shall cease to exist.

17.1.2 Right to Terminate. If a Breach is not cured as provided in this Article, or if a Breach is not capable of being cured within the period provided for herein, the affected non-Breaching Party(ies) shall have the right to declare a Default and terminate this LGIA by written notice at any time until cure occurs, and be relieved of any further obligation hereunder and, whether or not such Party(ies) terminates this LGIA, to recover from the Breaching Party all amounts due hereunder, plus all other damages and remedies to which it is entitled at law or in equity. The provisions of this Article will survive termination of this LGIA.

ARTICLE 18. INDEMNITY, CONSEQUENTIAL DAMAGES AND INSURANCE

18.1 Indemnity. Each Party shall at all times indemnify, defend, and hold the other Parties harmless from, any and all Losses arising out of or resulting from another Party's action or inactions of its obligations under this LGIA on behalf of the indemnifying Party, except in cases of gross negligence or intentional wrongdoing by the Indemnified Party.

18.1.1 Indemnified Party. If an Indemnified Party is entitled to indemnification under this Article 18 as a result of a claim by a third party, and the Indemnifying Party fails, after notice and reasonable opportunity to proceed under Article 18.1, to assume the defense of such claim, such Indemnified Party may at the expense of the Indemnifying Party contest, settle or consent to the entry of any judgment with respect to, or pay in full, such claim.

18.1.2 Indemnifying Party. If an Indemnifying Party is obligated to indemnify and hold any Indemnified Party harmless under this Article 18, the amount owing to the Indemnified Party shall be the amount of such Indemnified Party's actual Loss, net of any insurance or other recovery.

18.1.3 Indemnity Procedures. Promptly after receipt by an Indemnified Party of any claim or notice of the commencement of any action or administrative or legal proceeding or investigation as to which the indemnity provided for in Article 18.1 may apply, the Indemnified Party shall notify the Indemnifying Party of such fact. Any failure of or delay in such notification shall not affect a Party's indemnification obligation unless such failure or delay is materially prejudicial to the indemnifying Party.

The Indemnifying Party shall have the right to assume the defense thereof with counsel designated by such Indemnifying Party and reasonably satisfactory to the Indemnified Party. If the defendants in any such action include one or more Indemnified Parties and the Indemnifying Party and if the Indemnified Party reasonably concludes that there may be legal defenses available to it and/or other Indemnified Parties which are different from or additional to those available to the Indemnifying Party, the Indemnified Party shall have the right to select separate counsel to assert such legal defenses and to otherwise participate in the defense of such action on its own behalf. In such instances, the Indemnifying Party shall only be required to pay the fees and expenses of one additional attorney to represent an Indemnified Party or Indemnified Parties having such differing or additional legal defenses.

The Indemnified Party shall be entitled, at its expense, to participate in any such action, suit or proceeding, the defense of which has been assumed by the Indemnifying Party. Notwithstanding the foregoing, the Indemnifying Party (i) shall not be entitled to assume and control the defense of any such action, suit or proceedings if and to the extent that, in the opinion of the Indemnified Party and its counsel, such action, suit or proceeding involves the potential imposition of criminal liability on the Indemnified Party, or there exists a conflict or adversity of interest between the Indemnified Party and the Indemnifying Party, in such event the Indemnifying Party shall pay the reasonable expenses of the Indemnified Party, and (ii) shall not settle or consent to the entry of any judgment in any action, suit or proceeding without the consent of the Indemnified Party, which shall not be unreasonably withheld, conditioned or delayed.

18.2 Consequential Damages. Other than the liquidated damages heretofore described in Article 5.3, in no event shall any Party be liable under any provision of this LGIA for any losses, damages, costs or expenses for any special, indirect, incidental, consequential, or punitive damages, including but not limited to loss of profit or revenue, loss of the use of equipment, cost of capital, cost of temporary equipment or services, whether based in whole or in part in contract, in tort, including negligence, strict liability, or any other theory of liability; provided, however, that damages for which a Party may be liable to another Party under another agreement will not be considered to be special, indirect, incidental, or consequential damages hereunder.

18.3 Insurance. Each Party shall, at its own expense, maintain in force throughout the period of this LGIA, and until released by the other Parties, the following minimum insurance coverages, with insurers rated no less than A- (with a minimum size rating of VII) by Bests' Insurance Guide and Key Ratings and authorized to do business in the state where the Point of Interconnection is located, except in the case of the CAISO, the State of California:

18.3.1 Employer's Liability and Workers' Compensation Insurance providing statutory benefits in accordance with the laws and regulations of the state in which the Point of Interconnection is located, except in the case of the CAISO, the State of California.

18.3.2 Commercial General Liability Insurance including premises and operations, personal injury, broad form property damage, broad form blanket contractual liability coverage (including coverage for the contractual indemnification) products and completed operations coverage, coverage for explosion, collapse and underground hazards, independent contractors coverage, coverage for pollution to the extent normally available and punitive damages to the extent normally available and a cross liability endorsement, with minimum limits of One Million Dollars ($1,000,000) per occurrence/One Million Dollars ($1,000,000) aggregate combined single limit for personal injury, bodily injury, including death and property damage.

18.3.3 Business Automobile Liability Insurance for coverage of owned and non-owned and hired vehicles, trailers or semi-trailers designed for travel on public roads, with a minimum, combined single limit of One Million Dollars ($1,000,000) per occurrence for bodily injury, including death, and property damage.

18.3.4 Excess Public Liability Insurance over and above the Employer's Liability Commercial General Liability and Business Automobile Liability Insurance coverage, with a minimum combined single limit of Twenty Million Dollars ($20,000,000) per occurrence/Twenty Million Dollars ($20,000,000) aggregate.

18.3.5 The Commercial General Liability Insurance, Business Automobile Insurance and Excess Public Liability Insurance policies shall name the other Parties, their parents, associated and Affiliate companies and their respective directors, officers, agents, servants and employees ("Other Party Group") as additional insured. All policies shall contain provisions whereby the insurers waive all rights of subrogation in accordance with the provisions of this LGIA against the Other Party Group and provide thirty (30) Calendar Days advance written notice to the Other Party Group prior to anniversary date of cancellation or any material change in coverage or condition.

18.3.6 The Commercial General Liability Insurance, Business Automobile Liability Insurance and Excess Public Liability Insurance policies shall contain provisions that specify that the policies are primary and shall apply to such extent without consideration for other policies separately carried and shall state that each insured is provided coverage as though a separate policy had been issued to each, except the insurer's liability shall not be increased beyond the amount for which the insurer would have been liable had only one insured been covered. Each Party shall be responsible for its respective deductibles or retentions.

18.3.7 The Commercial General Liability Insurance, Business Automobile Liability Insurance and Excess Public Liability Insurance policies, if written on a Claims First Made Basis, shall be maintained in full force and effect for two (2) years after termination of this LGIA, which coverage may be in the form of tail coverage or extended reporting period coverage if agreed by the Parties.

18.3.8 The requirements contained herein as to the types and limits of all insurance to be maintained by the Parties are not intended to and shall not in any manner, limit or qualify the liabilities and obligations assumed by the Parties under this LGIA.

18.3.9 Within ten (10) Calendar Days following execution of this LGIA, and as soon as practicable after the end of each fiscal year or at the renewal of the insurance policy and in any event within ninety (90) Calendar Days thereafter, each Party shall provide certification of all insurance required in this LGIA, executed by each insurer or by an authorized representative of each insurer.

18.3.10 Notwithstanding the foregoing, each Party may self-insure to meet the minimum insurance requirements of Articles 18.3.2 through 18.3.8 to the extent it maintains a self-insurance program; provided that, such Party's senior unsecured debt or issuer rating is BBB-, or better, as rated by Standard & Poor's and that its self-insurance program meets the minimum insurance requirements of Articles 18.3.2 through 18.3.8. For any period of time that a Party's senior unsecured debt rating and issuer rating are both unrated by Standard & Poor's or are both rated at less than BBB- by Standard & Poor's, such Party shall comply with the insurance requirements applicable to it under Articles 18.3.2 through 18.3.9. In the event that a Party is permitted to self-insure pursuant to this Article 18.3.10, it shall notify the other Parties that it meets the requirements to self-insure and that its self-insurance program meets the minimum insurance requirements in a manner consistent with that specified in Article 18.3.9.

18.3.11 The Parties agree to report to each other in writing as soon as practical all accidents or occurrences resulting in injuries to any person, including death, and any property damage arising out of this LGIA.

ARTICLE 19. ASSIGNMENT

19.1 **Assignment**. This LGIA may be assigned by a Party only with the written consent of the other Parties; provided that a Party may assign this LGIA without the consent of the other Parties to any Affiliate of the assigning Party with an equal or greater credit rating and with the legal authority and operational ability to satisfy the obligations of the assigning Party under this LGIA; and provided further that the Interconnection Customer shall have the right to assign this LGIA, without the consent of the CAISO or Participating TO, for collateral security purposes to aid in providing financing for the Large Generating Facility, provided that the Interconnection Customer will promptly notify the CAISO and Participating TO of any such assignment. Any financing arrangement entered into by the Interconnection Customer pursuant to this Article will provide that prior to or upon the exercise of the secured party's, trustee's or mortgagee's assignment rights pursuant to said arrangement, the secured creditor, the trustee or mortgagee will notify the CAISO and Participating TO of the date and particulars of any such exercise of assignment right(s), including providing the CAISO and Participating TO with proof that it meets the requirements of Articles 11.5 and 18.3. Any attempted assignment that violates this Article is void and ineffective. Any assignment under this LGIA shall not relieve a Party of its obligations, nor shall a Party's obligations be enlarged, in whole or in part, by reason thereof. Where required, consent to assignment will not be unreasonably withheld, conditioned or delayed.

ARTICLE 20. SEVERABILITY

20.1 **Severability**. If any provision in this LGIA is finally determined to be invalid, void or unenforceable by any court or other Governmental Authority having jurisdiction, such determination shall not invalidate, void or make unenforceable any other provision, agreement or covenant of this LGIA; provided that if the Interconnection Customer (or any third party, but only if such third party is not acting at the direction of the Participating TO or CAISO) seeks and obtains such a final determination with respect to any provision of the Alternate Option (Article 5.1.2), or the Negotiated Option (Article 5.1.4), then none of the provisions of Article 5.1.2 or 5.1.4 shall thereafter have any force or effect and the Parties' rights and obligations shall be governed solely by the Standard Option (Article 5.1.1).

ARTICLE 21. COMPARABILITY

21.1 Comparability. The Parties will comply with all applicable comparability and code of conduct laws, rules and regulations, as amended from time to time.

ARTICLE 22. CONFIDENTIALITY

22.1 Confidentiality. Confidential Information shall include, without limitation, all information relating to a Party's technology, research and development, business affairs, and pricing, and any information supplied by any of the Parties to the other Parties prior to the execution of this LGIA.

Information is Confidential Information only if it is clearly designated or marked in writing as confidential on the face of the document, or, if the information is conveyed orally or by inspection, if the Party providing the information orally informs the Parties receiving the information that the information is confidential.

If requested by any Party, the other Parties shall provide in writing, the basis for asserting that the information referred to in this Article 22 warrants confidential treatment, and the requesting Party may disclose such writing to the appropriate Governmental Authority. Each Party shall be responsible for the costs associated with affording confidential treatment to its information.

22.1.1 Term. During the term of this LGIA, and for a period of three (3) years after the expiration or termination of this LGIA, except as otherwise provided in this Article 22, each Party shall hold in confidence and shall not disclose to any person Confidential Information.

22.1.2 Scope. Confidential Information shall not include information that the receiving Party can demonstrate: (1) is generally available to the public other than as a result of a disclosure by the receiving Party; (2) was in the lawful possession of the receiving Party on a non-confidential basis before receiving it from the disclosing Party; (3) was supplied to the receiving Party without restriction by a third party, who, to the knowledge of the receiving Party after due inquiry, was under no obligation to the disclosing Party to keep such information confidential; (4) was independently developed by the receiving Party without reference to Confidential Information of the disclosing Party; (5) is, or becomes, publicly known, through no wrongful act or omission of the receiving Party or Breach of this LGIA; or (6) is required, in accordance with Article 22.1.7 of this LGIA, Order of Disclosure, to be disclosed by any Governmental Authority or is otherwise required to be disclosed by law or subpoena, or is necessary in any legal proceeding establishing rights and obligations under this LGIA. Information designated as Confidential Information will no longer be deemed confidential if the Party that designated the information as confidential notifies the other Parties that it no longer is confidential.

22.1.3 Release of Confidential Information. No Party shall release or disclose Confidential Information to any other person, except to its employees, consultants, Affiliates (limited by the Standards of Conduct requirements set forth in Part 358 of FERC's Regulations, 18 C.F.R. 358), subcontractors, or to parties who may be or considering providing financing to or equity participation with the Interconnection Customer, or to potential purchasers or assignees of the Interconnection Customer, on a need-to-know basis in connection with this LGIA, unless such person has first been advised of the confidentiality provisions of this Article 22 and has agreed to comply with such provisions. Notwithstanding the foregoing, a Party providing Confidential Information to any person shall remain primarily responsible for any release of Confidential Information in contravention of this Article 22.

22.1.4 Rights. Each Party retains all rights, title, and interest in the Confidential Information that each Party discloses to the other Parties. The disclosure by each Party to the other

Parties of Confidential Information shall not be deemed a waiver by a Party or any other person or entity of the right to protect the Confidential Information from public disclosure.

22.1.5 No Warranties. The mere fact that a Party has provided Confidential Information does not constitute a warranty or representation as to its accuracy or completeness. In addition, by supplying Confidential Information, no Party obligates itself to provide any particular information or Confidential Information to the other Parties nor to enter into any further agreements or proceed with any other relationship or joint venture.

22.1.6 Standard of Care. Each Party shall use at least the same standard of care to protect Confidential Information it receives as it uses to protect its own Confidential Information from unauthorized disclosure, publication or dissemination. Each Party may use Confidential Information solely to fulfill its obligations to the other Parties under this LGIA or its regulatory requirements.

22.1.7 Order of Disclosure. If a court or a Government Authority or entity with the right, power, and apparent authority to do so requests or requires any Party, by subpoena, oral deposition, interrogatories, requests for production of documents, administrative order, or otherwise, to disclose Confidential Information, that Party shall provide the other Parties with prompt notice of such request(s) or requirement(s) so that the other Parties may seek an appropriate protective order or waive compliance with the terms of this LGIA. Notwithstanding the absence of a protective order or waiver, the Party may disclose such Confidential Information which, in the opinion of its counsel, the Party is legally compelled to disclose. Each Party will use Reasonable Efforts to obtain reliable assurance that confidential treatment will be accorded any Confidential Information so furnished.

22.1.8 Termination of Agreement. Upon termination of this LGIA for any reason, each Party shall, within ten (10) Calendar Days of receipt of a written request from another Party, use Reasonable Efforts to destroy, erase, or delete (with such destruction, erasure, and deletion certified in writing to the other Party) or return to the other Party, without retaining copies thereof, any and all written or electronic Confidential Information received from the other Party.

22.1.9 Remedies. The Parties agree that monetary damages would be inadequate to compensate a Party for another Party's Breach of its obligations under this Article 22. Each Party accordingly agrees that the other Parties shall be entitled to equitable relief, by way of injunction or otherwise, if the first Party Breaches or threatens to Breach its obligations under this Article 22, which equitable relief shall be granted without bond or proof of damages, and the receiving Party shall not plead in defense that there would be an adequate remedy at law. Such remedy shall not be deemed an exclusive remedy for the Breach of this Article 22, but shall be in addition to all other remedies available at law or in equity. The Parties further acknowledge and agree that the covenants contained herein are necessary for the protection of legitimate business interests and are reasonable in scope. No Party, however, shall be liable for indirect, incidental, or consequential or punitive damages of any nature or kind resulting from or arising in connection with this Article 22.

22.1.10 Disclosure to FERC, its Staff, or a State. Notwithstanding anything in this Article 22 to the contrary, and pursuant to 18 C.F.R. section 1b.20, if FERC or its staff, during the course of an investigation or otherwise, requests information from one of the Parties that is otherwise required to be maintained in confidence pursuant to this LGIA, the Party shall provide the requested information to FERC or its staff, within the time provided for in the request for information. In providing the information to FERC or its staff, the Party must, consistent with 18 C.F.R. section 388.112, request that the information be treated as confidential and non-public by FERC and its staff and that the information be withheld from public disclosure. Parties are prohibited from notifying the other Parties to this LGIA prior to the release of the Confidential Information to FERC or its staff. The Party shall notify the other Parties to the LGIA when it is notified by FERC or its staff that a request to release Confidential Information has been received by FERC, at which time any of the Parties may respond before such information would be made public, pursuant to 18 C.F.R. section 388.112. Requests from a state regulatory body conducting a confidential investigation shall be treated in a similar manner if consistent with the applicable state rules and regulations.

22.1.11 Subject to the exception in Article 22.1.10, Confidential Information shall not be disclosed by the other Parties to any person not employed or retained by the other Parties, except to the extent disclosure is (i) required by law; (ii) reasonably deemed by the disclosing Party to be required to be disclosed in connection with a dispute between or among the Parties, or the defense of litigation or dispute; (iii) otherwise permitted by consent of the other Parties, such consent not to be unreasonably withheld; or (iv) necessary to fulfill its obligations under this LGIA or as a transmission service provider or a Balancing Authority including disclosing the Confidential Information to an RTO or ISO or to a regional or national reliability organization. The Party asserting confidentiality shall notify the other Parties in writing of the information it claims is confidential. Prior to any disclosures of another Party's Confidential Information under this subparagraph, or if any third party or Governmental Authority makes any request or demand for any of the information described in this subparagraph, the disclosing Party agrees to promptly notify the other Party in writing and agrees to assert confidentiality and cooperate with the other Party in seeking to protect the Confidential Information from public disclosure by confidentiality agreement, protective order or other reasonable measures.

ARTICLE 23. ENVIRONMENTAL RELEASES

23.1 Each Party shall notify the other Parties, first orally and then in writing, of the release of any Hazardous Substances, any asbestos or lead abatement activities, or any type of remediation activities related to the Large Generating Facility or the Interconnection Facilities, each of which may reasonably be expected to affect the other Parties. The notifying Party shall: (i) provide the notice as soon as practicable, provided such Party makes a good faith effort to provide the notice no later than twenty-four hours after such Party becomes aware of the occurrence; and (ii) promptly furnish to the other Parties copies of any publicly available reports filed with any Governmental Authorities addressing such events.

ARTICLE 24. INFORMATION REQUIREMENTS

24.1 **Information Acquisition**. The Participating TO and the Interconnection Customer shall submit specific information regarding the electrical characteristics of their respective facilities to each other as described below and in accordance with Applicable Reliability Standards.

24.2 **Information Submission by Participating TO**. The initial information submission by the Participating TO shall occur no later than one hundred eighty (180) Calendar Days prior to Trial Operation and shall include the Participating TO's Transmission System information necessary to allow the Interconnection Customer to select equipment and meet any system protection and stability requirements, unless otherwise agreed to by the Participating TO and the Interconnection Customer. On a monthly basis the Participating TO shall provide the Interconnection Customer and the CAISO a status report on the construction and installation of the Participating TO's Interconnection Facilities and Network Upgrades, including, but not limited to, the following information: (1) progress to date; (2) a description of the activities since the last report; (3) a description of the action items for the next period; and (4) the delivery status of equipment ordered.

24.3 **Updated Information Submission by Interconnection Customer**. The updated information submission by the Interconnection Customer, including manufacturer information, shall occur no later than one hundred eighty (180) Calendar Days prior to the Trial Operation. The Interconnection Customer shall submit a completed copy of the Electric Generating Unit data requirements contained in Appendix 1 to the LGIP. It shall also include any additional information provided to the Participating TO and the CAISO for the Interconnection Studies. Information in this submission shall be the most current Electric Generating Unit design or expected performance data. Information submitted for stability models shall be compatible with the Participating TO and CAISO standard models. If there is no compatible model, the Interconnection Customer will work with a consultant mutually agreed to by the Parties to develop and supply a standard model and associated information.

If the Interconnection Customer's data is materially different from what was originally provided to the Participating TO and the CAISO for the Interconnection Studies, then the Participating TO and the CAISO will conduct appropriate studies pursuant to the LGIP to determine the impact on the Participating TO's Transmission System and affected portions of the CAISO Controlled Grid based on the actual data submitted pursuant to this Article 24.3. The Interconnection Customer shall not begin Trial Operation until such studies are completed and all other requirements of this LGIA are satisfied.

24.4 Information Supplementation. Prior to the Trial Operation date, the Parties shall supplement their information submissions described above in this Article 24 with any and all "as-built" Electric Generating Unit information or "as-tested" performance information that differs from the initial submissions or, alternatively, written confirmation that no such differences exist. The Interconnection Customer shall conduct tests on the Electric Generating Unit as required by Good Utility Practice such as an open circuit "step voltage" test on the Electric Generating Unit to verify proper operation of the Electric Generating Unit's automatic voltage regulator.

Unless otherwise agreed, the test conditions shall include: (1) Electric Generating Unit at synchronous speed; (2) automatic voltage regulator on and in voltage control mode; and (3) a five percent (5 percent) change in Electric Generating Unit terminal voltage initiated by a change in the voltage regulators reference voltage. The Interconnection Customer shall provide validated test recordings showing the responses of Electric Generating Unit terminal and field voltages. In the event that direct recordings of these voltages is impractical, recordings of other voltages or currents that mirror the response of the Electric Generating Unit's terminal or field voltage are acceptable if information necessary to translate these alternate quantities to actual Electric Generating Unit terminal or field voltages is provided. Electric Generating Unit testing shall be conducted and results provided to the Participating TO and the CAISO for each individual Electric Generating Unit in a station.

Subsequent to the Commercial Operation Date, the Interconnection Customer shall provide the Participating TO and the CAISO any information changes due to equipment replacement, repair, or adjustment. The Participating TO shall provide the Interconnection Customer any information changes due to equipment replacement, repair or adjustment in the directly connected substation or any adjacent Participating TO-owned substation that may affect the Interconnection Customer's Interconnection Facilities equipment ratings, protection or operating requirements. The Parties shall provide such information pursuant to Article 5.19.

ARTICLE 25. INFORMATION ACCESS AND AUDIT RIGHTS

25.1 Information Access. Each Party (the "disclosing Party") shall make available to the other Party information that is in the possession of the disclosing Party and is necessary in order for the other Party to: (i) verify the costs incurred by the disclosing Party for which the other Party is responsible under this LGIA; and (ii) carry out its obligations and responsibilities under this LGIA. The Parties shall not use such information for purposes other than those set forth in this Article 25.1 and to enforce their rights under this LGIA. Nothing in this Article 25 shall obligate the CAISO to make available to a Party any third party information in its possession or control if making such third party information available would violate a CAISO Tariff restriction on the use or disclosure of such third party information.

25.2 Reporting of Non-Force Majeure Events. Each Party (the "notifying Party") shall notify the other Parties when the notifying Party becomes aware of its inability to comply with the provisions of this LGIA for a reason other than a Force Majeure event. The Parties agree to cooperate with each other and provide necessary information regarding such inability to comply, including the date, duration, reason for the inability to comply, and corrective actions taken or planned to be taken with respect to such inability to comply. Notwithstanding the foregoing, notification, cooperation or information provided under this Article shall not entitle the Party receiving such notification to allege a cause for anticipatory breach of this LGIA.

25.3 Audit Rights. Subject to the requirements of confidentiality under Article 22 of this LGIA, the Parties' audit rights shall include audits of a Party's costs pertaining to such Party's performance or satisfaction of obligations owed to the other Party under this LGIA, calculation of invoiced amounts, the CAISO's efforts to allocate responsibility for the provision of reactive support to the CAISO Controlled Grid, the CAISO's efforts to allocate responsibility for interruption or reduction of generation on the CAISO Controlled Grid, and each such Party's actions in an Emergency Condition.

25.3.1 The Interconnection Customer and the Participating TO shall each have the right, during normal business hours, and upon prior reasonable notice to the other Party, to audit at its own expense the other Party's accounts and records pertaining to either such Party's performance or either such Party's satisfaction of obligations owed to the other Party under this LGIA. Subject to Article 25.3.2, any audit authorized by this Article shall be performed at the offices where such accounts and records are maintained and shall be limited to those portions of such accounts and records that relate to each such Party's performance and satisfaction of obligations under this LGIA. Each such Party shall keep such accounts and records for a period equivalent to the audit rights periods described in Article 25.4.

25.3.2 Notwithstanding anything to the contrary in Article 25.3, each Party's rights to audit the CAISO's accounts and records shall be as set forth in Section 22.1 of the CAISO Tariff.

25.4 Audit Rights Periods.

25.4.1 Audit Rights Period for Construction-Related Accounts and Records. Accounts and records related to the design, engineering, procurement, and construction of Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades constructed by the Participating TO shall be subject to audit for a period of twenty-four months following the Participating TO's issuance of a final invoice in accordance with Article 12.2. Accounts and records related to the design, engineering, procurement, and construction of Participating TO's Interconnection Facilities and/or Stand Alone Network Upgrades constructed by the Interconnection Customer shall be subject to audit and verification by the Participating TO and the CAISO for a period of twenty-four months following the Interconnection Customer's issuance of a final invoice in accordance with Article 5.2(8).

25.4.2 Audit Rights Period for All Other Accounts and Records. Accounts and records related to a Party's performance or satisfaction of all obligations under this LGIA other than those described in Article 25.4.1 shall be subject to audit as follows: (i) for an audit relating to cost obligations, the applicable audit rights period shall be twenty-four months after the auditing Party's receipt of an invoice giving rise to such cost obligations; and (ii) for an audit relating to all other obligations, the applicable audit rights period shall be twenty-four months after the event for which the audit is sought; provided that each Party's rights to audit the CAISO's accounts and records shall be as set forth in Section 22.1 of the CAISO Tariff.

25.5 Audit Results. If an audit by the Interconnection Customer or the Participating TO determines that an overpayment or an underpayment has occurred with respect to the other Party, a notice of such overpayment or underpayment shall be given to the other Party together with those records from the audit which supports such determination. The Party that is owed payment shall render an invoice to the other Party and such invoice shall be paid pursuant to Article 12 hereof.

25.5.1 Notwithstanding anything to the contrary in Article 25.5, the Interconnection Customer's and Participating TO's rights to audit the CAISO's accounts and records shall be as set forth in Section 22.1 of the CAISO Tariff, and the CAISO's process for remedying an overpayment or underpayment shall be as set forth in the CAISO Tariff.

ARTICLE 26. SUBCONTRACTORS

26.1 General. Nothing in this LGIA shall prevent a Party from utilizing the services of any subcontractor as it deems appropriate to perform its obligations under this LGIA; provided, however, that each Party shall require its subcontractors to comply with all applicable terms and conditions of this LGIA in providing such services and each Party shall remain primarily liable to the other Party for the performance of such subcontractor.

26.2 Responsibility of Principal. The creation of any subcontract relationship shall not relieve the hiring Party of any of its obligations under this LGIA. The hiring Party shall be fully responsible to the other Parties for the acts or omissions of any subcontractor the hiring Party hires as if no subcontract had been made; provided, however, that in no event shall the CAISO or Participating TO be liable for the actions or inactions of the Interconnection Customer or its subcontractors with respect to obligations of the Interconnection Customer under Article 5 of this LGIA. Any applicable obligation imposed by this LGIA upon the hiring Party shall be equally binding upon, and shall be construed as having application to, any subcontractor of such Party.

26.3 No Limitation by Insurance. The obligations under this Article 26 will not be limited in any way by any limitation of subcontractor's insurance.

ARTICLE 27. DISPUTES

All disputes arising out of or in connection with this LGIA whereby relief is sought by or from the CAISO shall be settled in accordance with the provisions of Article 13 of the CAISO Tariff, except that references to the CAISO Tariff in such Article 13 of the CAISO Tariff shall be read as references to this LGIA. Disputes arising out of or in connection with this LGIA not subject to provisions of Article 13 of the CAISO Tariff shall be resolved as follows:

27.1 Submission. In the event either Party has a dispute, or asserts a claim, that arises out of or in connection with this LGIA or its performance, such Party (the "disputing Party") shall provide the other Party with written notice of the dispute or claim ("Notice of Dispute"). Such dispute or claim shall be referred to a designated senior representative of each Party for resolution on an informal basis as promptly as practicable after receipt of the Notice of Dispute by the other Party. In the event the designated representatives are unable to resolve the claim or dispute through unassisted or assisted negotiations within thirty (30) Calendar Days of the other Party's receipt of the Notice of Dispute, such claim or dispute may, upon mutual agreement of the Parties, be submitted to arbitration and resolved in accordance with the arbitration procedures set forth below. In the event the Parties do not agree to submit such claim or dispute to arbitration, each Party may exercise whatever rights and remedies it may have in equity or at law consistent with the terms of this LGIA.

27.2 External Arbitration Procedures. Any arbitration initiated under this LGIA shall be conducted before a single neutral arbitrator appointed by the Parties. If the Parties fail to agree upon a single arbitrator within ten (10) Calendar Days of the submission of the dispute to arbitration, each Party shall choose one arbitrator who shall sit on a three-member arbitration panel. The two arbitrators so chosen shall within twenty (20) Calendar Days select a third arbitrator to chair the arbitration panel. In either case, the arbitrators shall be knowledgeable in electric utility matters, including electric transmission and bulk power issues, and shall not have any current or past substantial business or financial relationships with any party to the arbitration (except prior arbitration). The arbitrator(s) shall provide each of the Parties an opportunity to be heard and, except as otherwise provided herein, shall conduct the arbitration in accordance with the Commercial Arbitration Rules of the American Arbitration Association ("Arbitration Rules") and any applicable FERC regulations; provided, however, in the event of a conflict between the Arbitration Rules and the terms of this Article 27, the terms of this Article 27 shall prevail.

27.3 Arbitration Decisions. Unless otherwise agreed by the Parties, the arbitrator(s) shall render a decision within ninety (90) Calendar Days of appointment and shall notify the Parties in writing of such decision and the reasons therefor. The arbitrator(s) shall be authorized only to interpret and apply the provisions of this LGIA and shall have no power to modify or change any provision of this Agreement in any manner. The decision of the arbitrator(s) shall be final and binding upon the Parties, and judgment on the award may be entered in any court having jurisdiction. The decision of the arbitrator(s) may be appealed solely on the grounds that the conduct of the arbitrator(s), or the decision itself, violated the standards set forth in the Federal Arbitration Act or the Administrative Dispute Resolution Act. The final decision of the arbitrator must also be filed with FERC if it affects jurisdictional rates, terms and conditions of service, Interconnection Facilities, or Network Upgrades.

27.4 Costs. Each Party shall be responsible for its own costs incurred during the arbitration process and for the following costs, if applicable: (1) the cost of the arbitrator chosen by the Party to sit on the three member panel and one half of the cost of the third arbitrator chosen; or (2) one half the cost of the single arbitrator jointly chosen by the Parties.

ARTICLE 28. REPRESENTATIONS, WARRANTIES AND COVENANTS

28.1 General. Each Party makes the following representations, warranties and covenants:

28.1.1 Good Standing. Such Party is duly organized, validly existing and in good standing under the laws of the state in which it is organized, formed, or incorporated, as applicable; that it is qualified to do business in the state or states in which the Large Generating Facility, Interconnection Facilities and Network Upgrades owned by such Party, as applicable, are located; and that it has the corporate power and authority to own its properties, to carry on its business as now being conducted and to enter into this LGIA and carry out the transactions contemplated hereby and perform and carry out all covenants and obligations on its part to be performed under and pursuant to this LGIA.

28.1.2 Authority. Such Party has the right, power and authority to enter into this LGIA, to become a Party hereto and to perform its obligations hereunder. This LGIA is a legal, valid and binding obligation of such Party, enforceable against such Party in accordance with its terms, except as the enforceability thereof may be limited by applicable bankruptcy, insolvency, reorganization or other similar laws affecting creditors' rights generally and by general equitable principles (regardless of whether enforceability is sought in a proceeding in equity or at law).

28.1.3 No Conflict. The execution, delivery and performance of this LGIA does not violate or conflict with the organizational or formation documents, or bylaws or operating agreement, of such Party, or any judgment, license, permit, order, material agreement or instrument applicable to or binding upon such Party or any of its assets.

28.1.4 Consent and Approval. Such Party has sought or obtained, or, in accordance with this LGIA will seek or obtain, each consent, approval, authorization, order, or acceptance by any Governmental Authority in connection with the execution, delivery and performance of this LGIA, and it will provide to any Governmental Authority notice of any actions under this LGIA that are required by Applicable Laws and Regulations.

ARTICLE 29. [RESERVED]

ARTICLE 30. MISCELLANEOUS

30.1 Binding Effect. This LGIA and the rights and obligations hereof, shall be binding upon and shall inure to the benefit of the successors and assigns of the Parties hereto.

30.2 Conflicts. In the event of a conflict between the body of this LGIA and any attachment, appendices or exhibits hereto, the terms and provisions of the body of this LGIA shall prevail and be deemed the final intent of the Parties.

30.3 Rules of Interpretation. This LGIA, unless a clear contrary intention appears, shall be construed and interpreted as follows: (1) the singular number includes the plural number and vice versa; (2) reference to any person includes such person's successors and assigns but, in the case of a Party, only if such successors and assigns are permitted by this LGIA, and reference to a person in a particular capacity excludes such person in any other capacity or individually; (3) reference to any agreement (including this LGIA), document, instrument or tariff means such agreement, document, instrument, or tariff as amended or modified and in effect from time to time in accordance with the terms thereof and, if applicable, the terms hereof; (4) reference to any Applicable Laws and Regulations means such Applicable Laws and Regulations as amended, modified, codified, or reenacted, in whole or in part, and in effect from time to time, including, if applicable, rules and regulations promulgated thereunder; (5) unless expressly stated otherwise, reference to any Article, Section or Appendix means such Article of this LGIA or such Appendix to this LGIA, or such Section to the LGIP or such Appendix to the LGIP, as the case may be; (6)

"hereunder", "hereof", "herein", "hereto" and words of similar import shall be deemed references to this LGIA as a whole and not to any particular Article or other provision hereof or thereof; (7) "including" (and with correlative meaning "include") means including without limiting the generality of any description preceding such term; and (8) relative to the determination of any period of time, "from" means "from and including", "to" means "to but excluding" and "through" means "through and including".

30.4 Entire Agreement. This LGIA, including all Appendices and Schedules attached hereto, constitutes the entire agreement among the Parties with reference to the subject matter hereof, and supersedes all prior and contemporaneous understandings or agreements, oral or written, between or among the Parties with respect to the subject matter of this LGIA. There are no other agreements, representations, warranties, or covenants which constitute any part of the consideration for, or any condition to, any Party's compliance with its obligations under this LGIA.

30.5 No Third Party Beneficiaries. This LGIA is not intended to and does not create rights, remedies, or benefits of any character whatsoever in favor of any persons, corporations, associations, or entities other than the Parties, and the obligations herein assumed are solely for the use and benefit of the Parties, their successors in interest and, where permitted, their assigns.

30.6 Waiver. The failure of a Party to this LGIA to insist, on any occasion, upon strict performance of any provision of this LGIA will not be considered a waiver of any obligation, right, or duty of, or imposed upon, such Party.

Any waiver at any time by either Party of its rights with respect to this LGIA shall not be deemed a continuing waiver or a waiver with respect to any other failure to comply with any other obligation, right, duty of this LGIA. Termination or Default of this LGIA for any reason by the Interconnection Customer shall not constitute a waiver of the Interconnection Customer's legal rights to obtain an interconnection from the Participating TO. Any waiver of this LGIA shall, if requested, be provided in writing.

30.7 Headings. The descriptive headings of the various Articles of this LGIA have been inserted for convenience of reference only and are of no significance in the interpretation or construction of this LGIA.

30.8 Multiple Counterparts. This LGIA may be executed in two or more counterparts, each of which is deemed an original but all constitute one and the same instrument.

30.9 Amendment. The Parties may by mutual agreement amend this LGIA by a written instrument duly executed by all of the Parties. Such amendment shall become effective and a part of this LGIA upon satisfaction of all Applicable Laws and Regulations.

30.10 Modification by the Parties. The Parties may by mutual agreement amend the Appendices to this LGIA by a written instrument duly executed by all of the Parties. Such amendment shall become effective and a part of this LGIA upon satisfaction of all Applicable Laws and Regulations.

30.11 Reservation of Rights. The CAISO and Participating TO shall each have the right to make a unilateral filing with FERC to modify this LGIA pursuant to section 205 or any other applicable provision of the Federal Power Act and FERC's rules and regulations thereunder with respect to the following Articles of this LGIA and with respect to any rates, terms and conditions, charges, classifications of service, rule or regulation covered by these Articles:

Recitals, 1, 2.1, 2.2, 2.3, 2.4, 2.6, 3.1, 3.3, 4.1, 4.2, 4.3, 4.4, 5 preamble, 5.4, 5.7, 5.8, 5.9, 5.12, 5.13, 5.18, 5.19.1, 7.1, 7.2, 8, 9.1, 9.2, 9.3, 9.5, 9.6, 9.7, 9.8, 9.10, 10.3, 11.4, 12.1, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24.3, 24.4, 25.1, 25.2, 25.3 (excluding subparts), 25.4.2, 26, 28, 29, 30, Appendix D, Appendix F, Appendix G, and any other Article not reserved exclusively to the Participating TO or the CAISO below.

The Participating TO shall have the exclusive right to make a unilateral filing with FERC to modify this LGIA pursuant to section 205 or any other applicable provision of the Federal Power Act and FERC's rules and regulations thereunder with respect to the following Articles of this LGIA and with respect to any rates, terms and conditions, charges, classifications of service, rule or regulation covered by these Articles:

2.5, 5.1, 5.2, 5.3, 5.5, 5.6, 5.10, 5.11, 5.14, 5.15, 5.16, 5.17, 5.19 (excluding 5.19.1), 6, 7.3, 9.4, 9.9, 10.1, 10.2, 10.4, 10.5, 11.1, 11.2, 11.3, 11.5, 12.2, 12.3, 12.4, 24.1, 24.2, 25.3.1, 25.4.1, 25.5 (excluding 25.5.1), 27 (excluding preamble), Appendix A, Appendix B, Appendix C, and Appendix E.

The CAISO shall have the exclusive right to make a unilateral filing with FERC to modify this LGIA pursuant to section 205 or any other applicable provision of the Federal Power Act and FERC's rules and regulations thereunder with respect to the following Articles of this LGIA and with respect to any rates, terms and conditions, charges, classifications of service, rule or regulation covered by these Articles:

3.2, 4.5, 11.6, 25.3.2, 25.5.1, and 27 preamble.

The Interconnection Customer, the CAISO, and the Participating TO shall have the right to make a unilateral filing with FERC to modify this LGIA pursuant to section 206 or any other applicable provision of the Federal Power Act and FERC's rules and regulations thereunder; provided that each Party shall have the right to protest any such filing by another Party and to participate fully in any proceeding before FERC in which such modifications may be considered. Nothing in this LGIA shall limit the rights of the Parties or of FERC under sections 205 or 206 of the Federal Power Act and FERC's rules and regulations thereunder, except to the extent that the Parties otherwise mutually agree as provided herein.

30.12 No Partnership. This LGIA shall not be interpreted or construed to create an association, joint venture, agency relationship, or partnership among the Parties or to impose any partnership obligation or partnership liability upon any Party. No Party shall have any right, power or authority to enter into any agreement or undertaking for, or act on behalf of, or to act as or be an agent or representative of, or to otherwise bind, another Party.

30.13 Joint and Several Obligations. Except as otherwise provided in this LGIA, the obligations of the CAISO, the Participating TO, and the Interconnection Customer are several, and are neither joint nor joint and several.

IN WITNESS WHEREOF, the Parties have executed this LGIA in multiple originals, each of which shall constitute and be an original effective agreement among the Parties.

[Insert name of Participating TO]

By: ______________________________

Title: ______________________________

Date: __

California Independent System Operator Corporation

By: ________________________________

Title: ______________________________

Date: __

[Insert name of Interconnection Customer]

By: ________________________________

Title: ______________________________

Date: __

____

Appendices to LGIA

Appendix A Interconnection Facilities, Network Upgrades and Distribution Upgrades

Appendix B Milestones

Appendix C Interconnection Details

Appendix D Security Arrangements Details

Appendix E Commercial Operation Date

Appendix F Addresses for Delivery of Notices and Billings

Appendix G Reliability Management System Agreement

Appendix H Interconnection Requirements for a Wind Generating Plant

Appendix A
To LGIA

Interconnection Facilities, Network Upgrades and Distribution Upgrades

1. Interconnection Facilities:

(a) [insert Interconnection Customer's Interconnection Facilities]:

(b) [insert Participating TO's Interconnection Facilities]:

2. Network Upgrades:

(a) [insert Stand Alone Network Upgrades]:

(b) [insert Other Network Upgrades]:

(i) [insert Participating TO's Reliability Network Upgrades]

(ii) [insert Participating TO's Delivery Network Upgrades]

3. Distribution Upgrades:

Appendix B
To LGIA

Milestones

Appendix C
To LGIA

Interconnection Details

Appendix D
To LGIA

Security Arrangements Details

Infrastructure security of CAISO Controlled Grid equipment and operations and control hardware and software is essential to ensure day-to-day CAISO Controlled Grid reliability and operational security. FERC will expect the CAISO, all Participating TOs, market participants, and Interconnection Customers interconnected to the CAISO Controlled Grid to comply with the recommendations offered by the President's Critical Infrastructure Protection Board and, eventually, best practice recommendations from the electric reliability authority. All public utilities will be expected to meet basic standards for system infrastructure and operational security, including physical, operational, and cyber-security practices.

The Interconnection Customer shall meet the requirements for security implemented pursuant to the CAISO Tariff, including the CAISO's standards for information security posted on the CAISO's internet web site at the following internet address: http://www.caiso.com/pubinfo/info-security/index.html.

Appendix E
To LGIA

Commercial Operation Date

This Appendix E is a part of the LGIA.

[Date]

[CAISO Address]

[Participating TO Address]

Re: _______________ Electric Generating Unit

Dear _________________:

On **[Date] [Interconnection Customer]** has completed Trial Operation of Unit No. ____. This letter confirms that [Interconnection Customer] commenced Commercial Operation of Unit No. ___ at the Electric Generating Unit, effective as of **[Date plus one day]**.

Thank you.

[Signature]

[Interconnection Customer Representative]

Appendix F
To LGIA

Addresses for Delivery of Notices and Billings

Notices:.

CAISO:

[To be supplied.]

Participating TO:

[To be supplied.]

Interconnection Customer:

[To be supplied.]

Billings and Payments:

Participating TO:

[To be supplied.]

Interconnection Customer:

[To be supplied.]

CAISO:

[To be supplied.]

Alternative Forms of Delivery of Notices (telephone, facsimile or e-mail):

CAISO:

[To be supplied.]

Participating TO:

[To be supplied.]

Interconnection Customer:

[To be supplied.]

Appendix G
To LGIA

Reliability Management System Agreement

RELIABILITY MANAGEMENT SYSTEM AGREEMENT
by and between
[TRANSMISSION OPERATOR]
and
[GENERATOR]

THIS RELIABILITY MANAGEMENT SYSTEM AGREEMENT (the "Agreement"), is entered into this ____ day of _____________, 2002, by and between _______________________ (the "Transmission Operator") and _______________________ (the "Generator").

WHEREAS, there is a need to maintain the reliability of the interconnected electric systems encompassed by the WSCC in a restructured and competitive electric utility industry;

WHEREAS, with the transition of the electric industry to a more competitive structure, it is desirable to have a uniform set of electric system operating rules within the Western Interconnection, applicable in a fair, comparable and non-discriminatory manner, with which all market participants comply; and

WHEREAS, the members of the WSCC, including the Transmission Operator, have determined that a contractual Reliability Management System provides a reasonable, currently available means of maintaining such reliability.

NOW, THEREFORE, in consideration of the mutual agreements contained herein, and other good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, the Transmission Operator and the Generator agree as follows:

1. PURPOSE OF AGREEMENT

The purpose of this Agreement is to maintain the reliable operation of the Western Interconnection through the Generator's commitment to comply with certain reliability standards.

2. DEFINITIONS

In addition to terms defined in the beginning of this Agreement and in the Recitals hereto, for purposes of this Agreement the following terms shall have the meanings set forth beside them below.

Control Area means an electric system or systems, bounded by interconnection metering and telemetry, capable of controlling generation to maintain its interchange schedule with other Control Areas and contributing to frequency regulation of the Western Interconnection.

FERC means the Federal Energy Regulatory Commission or a successor agency.

Member means any party to the WSCC Agreement.

Party means either the Generator or the Transmission Operator and

Parties means both of the Generator and the Transmission Operator.

Reliability Management System or **RMS** means the contractual reliability management program implemented through the WSCC Reliability Criteria Agreement, the WSCC RMS Agreement, this Agreement, and any similar contractual arrangement.

Western Interconnection means the area comprising those states and provinces, or portions thereof, in Western Canada, Northern Mexico and the Western United States in which Members of the WSCC operate synchronously connected transmission systems.

Working Day means Monday through Friday except for recognized legal holidays in the state in which any notice is received pursuant to Section 8.

WSCC means the Western Systems Coordinating Council or a successor entity.

WSCC Agreement means the Western Systems Coordinating Council Agreement dated March 20, 1967, as such may be amended from time to time.

WSCC Reliability Criteria Agreement means the Western Systems Coordinating Council Reliability Criteria Agreement dated June 18, 1999 among the WSCC and certain of its member transmission operators, as such may be amended from time to time.

WSCC RMS Agreement means an agreement between the WSCC and the Transmission Operator requiring the Transmission Operator to comply with the reliability criteria contained in the WSCC Reliability Criteria Agreement.

WSCC Staff means those employees of the WSCC, including personnel hired by the WSCC on a contract basis, designated as responsible for the administration of the RMS.

3. TERM AND TERMINATION

3.1 Term. This Agreement shall become effective [thirty (30) days after the date of issuance of a final FERC order accepting this Agreement for filing without requiring any changes to this Agreement unacceptable to either Party. Required changes to this Agreement shall be deemed unacceptable to a Party only if that Party provides notice to the other Party within fifteen (15) days of issuance of the applicable FERC order that such order is unacceptable].
[Note: if the interconnection agreement is not FERC jurisdictional, replace bracketed language with: [on the later of: (a) the date of execution; or (b) the effective date of the WSCC RMS Agreement.]]

3.2 Notice of Termination of WSCC RMS Agreement. The Transmission Operator shall give the Generator notice of any notice of termination of the WSCC RMS Agreement by the WSCC or by the Transmission Operator within fifteen (15) days of receipt by the WSCC or the Transmission Operator of such notice of termination.

3.3 Termination by the Generator. The Generator may terminate this Agreement as follows:
(a) following the termination of the WSCC RMS Agreement for any reason by the WSCC or by the Transmission Operator, provided such notice is provided within forty-five (45) days of the termination of the WSCC RMS Agreement;
(b) following the effective date of an amendment to the requirements of the WSCC Reliability Criteria Agreement that adversely affects the Generator, provided notice of such termination is given within forty-five (45) days of the date of issuance of a FERC order accepting such amendment for filing, provided further that the forty-five (45) day period within which notice of termination is required may be extended by the Generator for an additional forty-five (45) days if the Generator gives written notice to the Transmission Operator of such requested extension within the initial forty-five (45) day period; or
(c) for any reason on one year's written notice to the Transmission Operator and the WSCC.

3.4 Termination by the Transmission Operator. The Transmission Operator may terminate this Agreement on thirty (30) days' written notice following the termination of the WSCC RMS Agreement for any reason by the WSCC or by the Transmission Operator, provided such notice is provided within thirty (30) days of the termination of the WSCC RMS Agreement.

3.5 Mutual Agreement. This Agreement may be terminated at any time by the mutual agreement of the Transmission Operator and the Generator.

4. COMPLIANCE WITH AND AMENDMENT OF WSCC RELIABILITY CRITERIA

4.1 Compliance with Reliability Criteria. The Generator agrees to comply with the requirements of the WSCC Reliability Criteria Agreement, including the applicable WSCC reliability criteria contained in Section IV of Annex A thereof, and, in the event of failure to comply, agrees to be subject to the sanctions applicable to such failure. Each and all of the provisions of the WSCC Reliability Criteria Agreement are hereby incorporated by reference into this Agreement as though set forth fully herein, and the Generator shall for all purposes be considered a Participant, and shall be entitled to all of the rights and privileges and be subject to all of the obligations of a Participant, under and in connection with the WSCC Reliability Criteria Agreement, including but not limited to the rights, privileges and obligations set forth in Sections 5, 6 and 10 of the WSCC Reliability Criteria Agreement.

4.2 Modifications to WSCC Reliability Criteria Agreement. The Transmission Operator shall notify the Generator within fifteen (15) days of the receipt of notice from the WSCC of the initiation of any WSCC process to modify the WSCC Reliability Criteria Agreement. The WSCC RMS Agreement specifies that such process shall comply with the procedures, rules, and regulations then applicable to the WSCC for modifications to reliability criteria.

4.3 Notice of Modifications to WSCC Reliability Criteria Agreement. If, following the process specified in Section 4.2, any modification to the WSCC Reliability Criteria Agreement is to take effect, the Transmission Operator shall provide notice to the Generator at least forty-five (45) days before such modification is scheduled to take effect.

4.4 Effective Date. Any modification to the WSCC Reliability Criteria Agreement shall take effect on the date specified by FERC in an order accepting such modification for filing.

4.5 Transfer of Control or Sale of Generation Facilities. In any sale or transfer of control of any generation facilities subject to this Agreement, the Generator shall as a condition of such sale or transfer require the acquiring party or transferee with respect to the transferred facilities either to assume the obligations of the Generator with respect to this Agreement or to enter into an agreement with the Control Area Operator in substantially the form of this Agreement.

5. SANCTIONS

5.1 Payment of Monetary Sanctions. The Generator shall be responsible for payment directly to the WSCC of any monetary sanction assessed against the Generator pursuant to this Agreement and the WSCC Reliability Criteria Agreement. Any such payment shall be made pursuant to the procedures specified in the WSCC Reliability Criteria Agreement.

5.2 Publication. The Generator consents to the release by the WSCC of information related to the Generator's compliance with this Agreement only in accordance with the WSCC Reliability Criteria Agreement.

5.3 Reserved Rights. Nothing in the RMS or the WSCC Reliability Criteria Agreement shall affect the right of the Transmission Operator, subject to any necessary regulatory approval, to take such other measures to maintain reliability, including disconnection, which the Transmission Operator may otherwise be entitled to take.

6. THIRD PARTIES

Except for the rights and obligations between the WSCC and Generator specified in Sections 4 and 5, this Agreement creates contractual rights and obligations solely between the Parties. Nothing in this Agreement shall create, as between the Parties or with respect to the WSCC: (1) any obligation or liability whatsoever (other than as expressly provided in this Agreement), or (2) any duty or standard of care whatsoever. In addition, nothing in this Agreement shall create any duty, liability, or standard of care whatsoever as to any other party. Except for the rights, as a third-party beneficiary with respect to Sections 4 and 5, of the WSCC against Generator, no third party shall have any rights whatsoever with respect to enforcement of any provision of this Agreement. Transmission Operator and Generator expressly intend that the WSCC is a third-party beneficiary to this Agreement, and the WSCC shall have the right to seek to enforce against Generator any provisions of Sections 4 and 5, provided that specific performance shall be the sole remedy available to the WSCC pursuant to this Agreement, and Generator shall not be liable to the WSCC pursuant to this Agreement for damages of any kind whatsoever (other than the payment of sanctions to the WSCC, if so construed), whether direct, compensatory, special, indirect, consequential, or punitive.

7. REGULATORY APPROVALS

This Agreement shall be filed with FERC by the Transmission Operator under Section 205 of the Federal Power Act. In such filing, the Transmission Operator shall request that FERC accept this Agreement for filing without modification to become effective on the day after the date of a FERC order accepting this Agreement for filing. [This section shall be omitted for agreements not subject to FERC jurisdiction.]

8. NOTICES

Any notice, demand or request required or authorized by this Agreement to be given in writing to a Party shall be delivered by hand, courier or overnight delivery service, mailed by certified mail (return receipt requested) postage prepaid, faxed, or delivered by mutually agreed electronic means to such Party at the following address:

________: ______________________________
____
____
____
Fax: ______________

________: ______________________________
____
____
____
Fax: ______________

The designation of such person and/or address may be changed at any time by either Party upon receipt by the other of written notice. Such a notice served by mail shall be effective upon receipt. Notice transmitted by facsimile shall be effective upon receipt if received prior to 5:00 p.m. on a Working Day, and if not received prior to 5:00 p.m. on a Working Day, receipt shall be effective on the next Working Day.

9. APPLICABILITY

This Agreement (including all appendices hereto and, by reference, the WSCC Reliability Criteria Agreement) constitutes the entire understanding between the Parties hereto with respect to the subject matter hereof, supersedes any and all previous understandings between the Parties with respect to the subject matter hereof, and binds and inures to the benefit of the Parties and their successors.

10. AMENDMENT

No amendment of all or any part of this Agreement shall be valid unless it is reduced to writing and signed by both Parties hereto. The terms and conditions herein specified shall remain in effect throughout the term and shall not be subject to change through application to the FERC or other governmental body or authority, absent the agreement of the Parties.

11. INTERPRETATION

Interpretation and performance of this Agreement shall be in accordance with, and shall be controlled by, the laws of the State of _______________ but without giving effect to the provisions thereof relating to conflicts of law. Article and section headings are for convenience only and shall not affect the interpretation of this Agreement. References to articles, sections and appendices are, unless the context otherwise requires, references to articles, sections and appendices of this Agreement.

12. PROHIBITION ON ASSIGNMENT

This Agreement may not be assigned by either Party without the consent of the other Party, which consent shall not be unreasonably withheld; provided that the Generator may without the consent of the WSCC assign the obligations of the Generator pursuant to this Agreement to a transferee with respect to any obligations assumed by the transferee by virtue of Section 4.5 of this Agreement.

13. SEVERABILITY

If one or more provisions herein shall be invalid, illegal or unenforceable in any respect, it shall be given effect to the extent permitted by applicable law, and such invalidity, illegality or unenforceability shall not affect the validity of the other provisions of this Agreement.

14. COUNTERPARTS

This Agreement may be executed in counterparts and each shall have the same force and effect as an original.

IN WITNESS WHEREOF, the Transmission Operator and the Generator have each caused this Reliability Management System Agreement to be executed by their respective duly authorized officers as of the date first above written.

____

By: ____

Name: ____

Title: ____

____

By: ____

Name: ____

Title: ____

Appendix H
To LGIA

INTERCONNECTION REQUIREMENTS FOR AN ASYNCHRONOUS GENERATING FACILITY

Appendix H sets forth interconnection requirements specific to all Asynchronous Generating Facilities. Existing individual generating units of an Asynchronous Generating Facility that are, or have been, interconnected to the CAISO Controlled Grid at the same location are exempt from the requirements of this Appendix H for the remaining life of the existing generating unit. Generating units that are replaced, however, shall meet the requirements of this Appendix H.

A. Technical Requirements Applicable to Asynchronous Generating Facilities

i. Low Voltage Ride-Through (LVRT) Capability

An Asynchronous Generating Facility shall be able to remain online during voltage disturbances up to the time periods and associated voltage levels set forth in the requirements below.

1. An Asynchronous Generating Facility shall remain online for the voltage disturbance caused by any fault on the transmission grid, or within the Asynchronous Generating Facility between the Point of Interconnection and the high voltage terminals of the Asynchronous Generating Facility's step up transformer, having a duration equal to the lesser of the normal three-phase fault clearing time (4-9 cycles) or one-hundred fifty (150) milliseconds, plus any subsequent post-fault voltage recovery to the final steady-state post-fault voltage. Clearing time shall be based on the maximum normal clearing time associated with any three-phase fault location that reduces the voltage at the Asynchronous Generating Facility's Point of Interconnection to 0.2 per-unit of nominal voltage or less, independent of any fault current contribution from the Asynchronous Generating Facility.

2. An Asynchronous Generating Facility shall remain online for any voltage disturbance caused by a single-phase fault on the transmission grid, or within the Asynchronous Generating Facility between the Point of Interconnection and the high voltage terminals of the Asynchronous Generating Facility's step up transformer, with delayed clearing, plus any subsequent post-fault voltage recovery to the final steady-state post-fault voltage. Clearing time shall be based on the maximum backup clearing time associated with a single point of failure (protection or breaker failure) for any single-phase fault location that reduces any phase-to-ground or phase-to-phase voltage at the Asynchronous Generating Facility's Point of Interconnection to 0.2 per-unit of nominal voltage or less, independent of any fault current contribution from the Asynchronous Generating Facility.

3. Remaining on-line shall be defined as continuous connection between the Point of Interconnection and the Asynchronous Generating Facility's units, without any mechanical isolation. Asynchronous Generating Facilities may cease to inject current into the transmission grid during a fault.

4. The Asynchronous Generating Facility is not required to remain on line during multi-phased faults exceeding the duration described in Section A.i.1 of this Appendix H or single-phase faults exceeding the duration described in Section A.i.2 of this Appendix H.

5. The requirements of this Section A.i of this Appendix H do not apply to faults that occur between the Asynchronous Generating Facility's terminals and the high side of the step-up transformer to the the high-voltage transmission system.

6. Asynchronous Generating Facilities may be tripped after the fault period if this action is intended as part of a special protection system.

7. Asynchronous Generating Facilities may meet the requirements of this Section A.i of this Appendix H through the performance of the generating units or by installing additional equipment within the Asynchronous Generating Facility, or by a combination of generating unit performance and additional equipment.

8. The provisions of this Section A.i of this Appendix H apply only if the voltage at the Point of Interconnection has remained within the range of 0.9 and 1.10 per-unit of nominal voltage for the preceding two seconds, excluding any sub-cycle transient deviations.

The requirements of this Section A.i in this Appendix H shall not apply to any Asynchronous Generating Facility that can demonstrate to the CAISO a binding commitment, as of May 18, 2010, to purchase inverters for thirty (30) percent or more of the Generating Facility's maximum Generating Facility Capacity that are incapable of complying with the requirements of this Section A.i in this Appendix H. The Interconnection Customer must include a statement from the inverter manufacturer confirming the inability to comply with this requirement in addition to any information requested by the CAISO to determine the applicability of this exemption.

ii. Frequency Disturbance Ride-Through Capability

An Asynchronous Generating Facility shall comply with the off nominal frequency requirements set forth in the WECC Under Frequency Load Shedding Relay Application Guide or successor requirements as they may be amended from time to time.

iii. Power Factor Design and Operating Requirements (Reactive Power)

1. Asynchronous Generating Facilities shall meet the following design requirements:

   a. An Asynchronous Generating Facility shall be designed to have sufficient reactive power sourcing capability to achieve a net power factor of 0.95 lagging or less at the Point of Interconnection, at the Generating Facility's maximum Generating Facility Capacity. An Asynchronous Generating Facility shall be designed to have net reactive power sourcing and absorption capability sufficient to achieve or exceed the net reactive power range in Figure 1 as a function of the Point of Interconnection voltage, without exceeding the ratings of any equipment in the Asynchronous Generating Facility. The Point of Interconnection voltage is specified in per-unit of the nominal voltage.

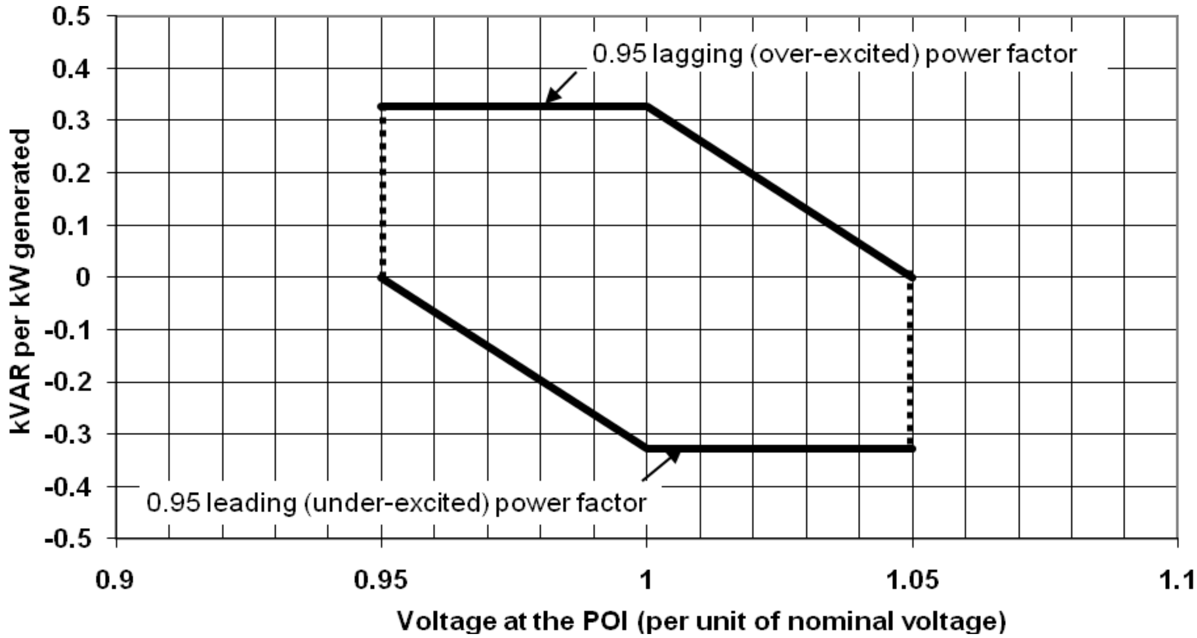

Figure 1

b. Net power factor shall be measured at the Point of Interconnection as defined in this LGIA.

c. Asynchronous Generating Facilities may meet the power factor range requirement by using power electronics designed to supply the required level of reactive capability (taking into account any limitations due to voltage level and real power output) or fixed and switched capacitors, or a combination of the two.

d. Asynchronous Generating Facilities shall also provide dynamic voltage support if the Interconnection Study requires dynamic voltage support for system safety or reliability.

e. Asynchronous Generating Facilities shall vary the reactive power output between the full sourcing and full absorption capabilities such that any step change in the reactive power output does not cause a step change in voltage at the Point of Interconnection greater than 0.02 per unit of the nominal voltage.

f. The maximum voltage change requirement shall apply when the CAISO Controlled Grid is fully intact (no line or transformer outages), or during outage conditions which do not decrease the three-phase short circuit capacity at the Point of Interconnection to less than ninety (90) percent of the three-phase short-circuit capacity that would be present without the transmission network outage.

2. Asynchronous Generating Facilities shall meet the following operational requirements:

a. When plant output power is greater than twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity, the Asynchronous Generating Facility shall have a net reactive power range at least as great as specified in Figure 1 at the Point of Interconnection, based on the actual real power output level delivered to the Point of Interconnection.

b. Power output may be curtailed at the direction of CAISO to a value where the net power factor range is met, if the reactive power capability of an Asynchronous Generating Facility is partially or totally unavailable, and if continued operation causes deviation of the voltage at the Point of Interconnection outside +/- 0.02 per unit of scheduled voltage level.

c. When the output power of the Asynchronous Generating Facility is less than twenty (20) percent of the Generating Facility's maximum Generating Facility Capacity, the net reactive power shall remain within the range between –6.6% and +6.6% of the Asynchronous Generating Facility's real power rating.

d. If the Point of Interconnection voltage exceeds 1.05 per unit, the Asynchronous Generating Facility shall provide reactive power absorption to the extent possible without violating the ratings of any of the Asynchronous Generating Facility's equipment.

e. If the Point of Interconnection voltage is less than 0.95 per unit, the Asynchronous Generating Facility shall provide reactive power injection to the extent possible without violating the ratings of any of the Asynchronous Generating Facility's equipment.

iv. Voltage Regulation and Reactive Power Control Requirements

1. The Asynchronous Generation Facility's reactive power capability shall be controlled by an automatic system having both voltage regulation and a net power factor regulation operating modes. The default mode of operation will be voltage regulation.

2. The voltage regulation function mode shall automatically control the net reactive power of the Asynchronous Generating Facility to regulate the Point of Interconnection positive sequence component of voltage to within a tolerance of +/- 0.02 per unit of the nominal voltage schedule assigned by the Participating TO or CAISO, within the constraints of the reactive power capacity of the Asynchronous Generation Facility. Deviations outside of this voltage band, except as caused by insufficient reactive capacity to maintain the voltage schedule tolerances, shall not exceed five (5) minutes duration per incident.

3. The power factor mode will regulate the net power factor measured at the Point of Interconnection. If the Asynchronous Generating Facility uses discrete reactive banks to provide reactive capability, the tolerances of the power factor regulation shall be consistent with the reactive banks' sizes meeting the voltage regulation tolerances specified in the preceding paragraph.

4. The net reactive power flow into or out of the Asynchronous Generating Facility, in any mode of operation, shall not cause the positive sequence component of voltage at the Point of Interconnection to exceed 1.05 per unit, or fall below 0.95 per unit.

5. The CAISO, in coordination with the Participating TO, may permit the Interconnection Customer to regulate the voltage at a point on the Asynchronous Generating Facility's side of the Point of Interconnection. Regulating voltage to a point other than the Point of Interconnection shall not change the Asynchronous Generating Facility's net power factor requirements set forth in Section A.iii of this Appendix H.

6. The Interconnection Customer shall not disable voltage regulation controls, without the specific permission of CAISO, while the Asynchronous Generating Facility is in operation at a power level greater than twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity.

v. Plant Power Management

1. As of January 1, 2012, Asynchronous Generating Facilities must have the capability to limit active power output in response to a CAISO Dispatch Instruction or Operating Order as those terms are defined in the CAISO Tariff. This capability shall extend from the Minimum Operating Limit to the Maximum Operating Limit, as those terms are defined in the CAISO Tariff, of the Asynchronous Generating Facility in increments of five (5) MW or less. Changes to the power management set point shall not cause a change in voltage at the Point of Interconnection exceeding 0.02 per unit of the nominal voltage.

2. For Asynchronous Generating Facilities that are also Eligible Intermittent Resources as that term is defined in the CAISO Tariff, these power management requirements establish only a maximum output limit. There is no requirement for the Eligible Intermittent Resource to maintain a level of power output beyond the capabilities of the available energy source.

3. Asynchronous Generating Facilities must have the installed capability to limit power change ramp rates automatically, except for downward ramps resulting from decrease of the available energy resource for Eligible Intermittent Resources. The power ramp control shall be capable of limiting rates of power change to a value of five (5) percent, (10) percent, or twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity per minute. The Asynchronous Generating Facility may implement this ramping limit by using stepped increments if the individual step size is five (5) MW or less.

4. Asynchronous Generating Facilities must have the installed capability to automatically reduce plant power output in response to an over-frequency condition. This frequency response control shall, when enabled at the direction of CAISO, continuously monitor the system frequency and automatically reduce the real power output of the Asynchronous Generating Facility with a droop equal to a one-hundred (100) percent decrease in plant output for a five (5) percent rise in frequency (five (5) percent droop) above an intentional dead band of 0.036 Hz.

vi. Supervisory Control and Data Acquisition (SCADA) and Automated Dispatch System (ADS) Capability

An Asynchronous Generating Facility shall provide SCADA capability to transmit data and receive instructions from the Participating TO and CAISO to protect system reliability. The Participating TO and CAISO and the Asynchronous Generating Facility Interconnection Customer shall determine what SCADA information is essential for the proposed Asynchronous Generating Facility, taking into account the size of the plant and its characteristics, location, and importance in maintaining generation resource adequacy and transmission system reliability.

An Asynchronous Generating Facility must be able to receive and respond to Automated Dispatch System (ADS) instructions and any other form of communication authorized by the CAISO Tariff. The Asynchronous Generating Facility's response time should be capable of conforming to the periods prescribed by the CAISO Tariff.

vii. Power System Stabilizers (PSS)

Power system stabilizers are not required for Asynchronous Generating Facilities.

CAISO TARIFF APPENDIX CC

Large Generator Interconnection Agreement
for Interconnection Requests in a Queue Cluster Window

that are tendered or execute a Large Generator Interconnection Agreement on or after July 3, 2010

LARGE GENERATOR INTERCONNECTION AGREEMENT

[INTERCONNECTION CUSTOMER]

[PARTICIPATING TO]

CALIFORNIA INDEPENDENT SYSTEM OPERATOR CORPORATION

THIS LARGE GENERATOR INTERCONNECTION AGREEMENT ("LGIA") is made and entered into this ____ day of ________________ 20___, by and among ________________, a ______________ organized and existing under the laws of the State/Commonwealth of _________ ("Interconnection Customer" with a Large Generating Facility), ________________, a corporation organized and existing under the laws of the State of California ("**Participating TO**"), and **California Independent System Operator Corporation**, a California nonprofit public benefit corporation organized and existing under the laws of the State of California ("CAISO"). Interconnection Customer, Participating TO, and CAISO each may be referred to as a "Party" or collectively as the "Parties."

RECITALS

WHEREAS, CAISO exercises Operational Control over the CAISO Controlled Grid; and

WHEREAS, the Participating TO owns, operates, and maintains the Participating TO's Transmission System; and

WHEREAS, Interconnection Customer intends to own, lease and/or control and operate the Generating Facility identified as a Large Generating Facility in Appendix C to this LGIA; and

WHEREAS, Interconnection Customer, Participating TO, and CAISO have agreed to enter into this LGIA for the purpose of interconnecting the Large Generating Facility with the Participating TO's Transmission System;

NOW, THEREFORE, in consideration of and subject to the mutual covenants contained herein, it is agreed:

When used in this LGIA, terms with initial capitalization that are not defined in Article 1 shall have the meanings specified in the Article in which they are used.

ARTICLE 1. DEFINITIONS

Adverse System Impact shall mean the negative effects due to technical or operational limits on conductors or equipment being exceeded that may compromise the safety and reliability of the electric system.

Affected System shall mean an electric system other than the CAISO Controlled Grid that may be affected by the proposed interconnection, including the Participating TO's electric system that is not part of the CAISO Controlled Grid.

Affiliate shall mean, with respect to a corporation, partnership or other entity, each such other corporation, partnership or other entity that directly or indirectly, through one or more intermediaries, controls, is controlled by, or is under common control with, such corporation, partnership or other entity.

Applicable Laws and Regulations shall mean all duly promulgated applicable federal, state and local laws, regulations, rules, ordinances, codes, decrees, judgments, directives, or judicial or administrative orders, permits and other duly authorized actions of any Governmental Authority.

Applicable Reliability Council shall mean the Western Electricity Coordinating Council or its successor.

Applicable Reliability Standards shall mean the requirements and guidelines of NERC, the Applicable Reliability Council, and the Balancing Authority Area of the Participating TO's Transmission System to which the Generating Facility is directly connected, including requirements adopted pursuant to Section 215 of the Federal Power Act.

Asynchronous Generating Facility shall mean an induction, doubly-fed, or electronic power generating unit(s) that produces 60 Hz (nominal) alternating current.

Balancing Authority shall mean the responsible entity that integrates resource plans ahead of time, maintains load-interchange-generation balance within a Balancing Authority Area, and supports Interconnection frequency in real time.

Balancing Authority Area shall mean the collection of generation, transmission, and loads within the metered boundaries of the Balancing Authority. The Balancing Authority maintains load-resource balance within this area.

Base Case shall mean the base case power flow, short circuit, and stability data bases used for the Interconnection Studies.

Breach shall mean the failure of a Party to perform or observe any material term or condition of this LGIA.

Breaching Party shall mean a Party that is in Breach of this LGIA.

Business Day shall mean Monday through Friday, excluding federal holidays and the day after Thanksgiving Day.

CAISO Controlled Grid shall mean the system of transmission lines and associated facilities of the parties to the Transmission Control Agreement that have been placed under the CAISO's Operational Control.

CAISO Tariff shall mean the CAISO's tariff, as filed with FERC, and as amended or supplemented from time to time, or any successor tariff.

Calendar Day shall mean any day including Saturday, Sunday or a federal holiday.

Commercial Operation shall mean the status of an Electric Generating Unit or project phase at a Generating Facility that has commenced generating electricity for sale, excluding electricity generated during Trial Operation.

Commercial Operation Date of an Electric Generating Unit or project phase shall mean the date on which the Electric Generating Unit or project phase at the Generating Facility commences Commercial Operation as agreed to by the applicable Participating TO, the CAISO, and the Interconnection Customer pursuant to Appendix E to this LGIA, and in accordance with the implementation plan agreed to by the Participating TO and the CAISO for multiple individual Electric Generating Units or project phases at a Generating Facility where an Interconnection Customer intends to establish separate Commercial Operation Dates for those Electric Generating Units or project phases.

Confidential Information shall mean any confidential, proprietary or trade secret information of a plan, specification, pattern, procedure, design, device, list, concept, policy or compilation relating to the present or planned business of a Party, which is designated as confidential by the Party supplying the information, whether conveyed orally, electronically, in writing, through inspection, or otherwise, subject to Article 22.1.2.

Default shall mean the failure of a Breaching Party to cure its Breach in accordance with Article 17 of this LGIA.

Distribution System shall mean those non-CAISO-controlled transmission and distribution facilities owned by the Participating TO.

Distribution Upgrades shall mean the additions, modifications, and upgrades to the Participating TO's Distribution System. Distribution Upgrades do not include Interconnection Facilities.

Effective Date shall mean the date on which this LGIA becomes effective upon execution by all Parties subject to acceptance by FERC, or if filed unexecuted, upon the date specified by FERC.

Electric Generating Unit shall mean an individual electric generator and its associated plant and apparatus whose electrical output is capable of being separately identified and metered.

Emergency Condition shall mean a condition or situation: (1) that in the judgment of the Party making the claim is imminently likely to endanger life or property; or (2) that, in the case of the CAISO, is imminently likely (as determined in a non-discriminatory manner) to cause a material adverse effect on the security of, or damage to, the CAISO Controlled Grid or the electric systems of others to which the CAISO Controlled Grid is directly connected; (3) that, in the case of the Participating TO, is imminently likely (as determined in a non-discriminatory manner) to cause a material adverse effect on the security of, or damage to, the Participating TO's Transmission System, Participating TO's Interconnection Facilities, Distribution System, or the electric systems of others to which the Participating TO's electric system is directly connected; or (4) that, in the case of the Interconnection Customer, is imminently likely (as determined in a non-discriminatory manner) to cause a material adverse effect on the security of, or damage to, the Generating Facility or Interconnection Customer's Interconnection Facilities. System restoration and black start shall be considered Emergency Conditions; provided, that Interconnection Customer is not obligated by this LGIA to possess black start capability.

Environmental Law shall mean Applicable Laws or Regulations relating to pollution or protection of the environment or natural resources.

Federal Power Act shall mean the Federal Power Act, as amended, 16 U.S.C. §§ 791a et seq.

FERC shall mean the Federal Energy Regulatory Commission or its successor.

Force Majeure shall mean any act of God, labor disturbance, act of the public enemy, war, insurrection, riot, fire, storm or flood, explosion, breakage or accident to machinery or equipment, any order, regulation or restriction imposed by governmental, military or lawfully established civilian authorities, or any other cause beyond a Party's control. A Force Majeure event does not include acts of negligence or intentional wrongdoing by the Party claiming Force Majeure.

Generating Facility shall mean the Interconnection Customer's Electric Generating Unit(s) used for the production of electricity identified in the Interconnection Customer's Interconnection Request, but shall not include the Interconnection Customer's Interconnection Facilities.

Generating Facility Capacity shall mean the net capacity of the Generating Facility and the aggregate net capacity of the Generating Facility where it includes multiple energy production devices.

Good Utility Practice shall mean any of the practices, methods and acts engaged in or approved by a significant portion of the electric utility industry during the relevant time period, or any of the practices, methods and acts which, in the exercise of reasonable judgment in light of the facts known at the time the decision was made, could have been expected to accomplish the desired result at a reasonable cost consistent with good business practices, reliability, safety and expedition. Good Utility Practice is not intended to be any one of a number of the optimum practices, methods, or acts to the exclusion of all others, but rather to be acceptable practices, methods, or acts generally accepted in the region.

Governmental Authority shall mean any federal, state, local or other governmental, regulatory or administrative agency, court, commission, department, board, or other governmental subdivision, legislature, rulemaking board, tribunal, or other governmental authority having jurisdiction over the Parties, their respective facilities, or the respective services they provide, and exercising or entitled to exercise any administrative, executive, police, or taxing authority or power; provided, however, that such term does not include the Interconnection Customer, CAISO, Participating TO, or any Affiliate thereof.

Hazardous Substances shall mean any chemicals, materials or substances defined as or included in the definition of "hazardous substances," "hazardous wastes," "hazardous materials," "hazardous constituents," "restricted hazardous materials," "extremely hazardous substances," "toxic substances," "radioactive substances," "contaminants," "pollutants," "toxic pollutants" or words of similar meaning and regulatory effect under any applicable Environmental Law, or any other chemical, material or substance, exposure to which is prohibited, limited or regulated by any applicable Environmental Law.

Initial Synchronization Date shall mean the date upon which an Electric Generating Unit is initially synchronized and upon which Trial Operation begins.

In-Service Date shall mean the date upon which the Interconnection Customer reasonably expects it will be ready to begin use of the Participating TO's Interconnection Facilities to obtain back feed power.

Interconnection Customer's Interconnection Facilities shall mean all facilities and equipment, as identified in Appendix A of this LGIA, that are located between the Generating Facility and the Point of Change of Ownership, including any modification, addition, or upgrades to such facilities and equipment necessary to physically and electrically interconnect the Generating Facility to the Participating TO's Transmission System. Interconnection Customer's Interconnection Facilities are sole use facilities.

Interconnection Facilities shall mean the Participating TO's Interconnection Facilities and the Interconnection Customer's Interconnection Facilities. Collectively, Interconnection Facilities include all facilities and equipment between the Generating Facility and the Point of Interconnection, including any modification, additions or upgrades that are necessary to physically and electrically interconnect the Generating Facility to the Participating TO's Transmission System. Interconnection Facilities are sole use facilities and shall not include Distribution Upgrades, Stand Alone Network Upgrades or Network Upgrades.

Interconnection Financial Security shall have the meaning assigned to it in Section 1.2 of the LGIP.

Interconnection Handbook shall mean a handbook, developed by the Participating TO and posted on the Participating TO's web site or otherwise made available by the Participating TO, describing technical and operational requirements for wholesale generators and loads connected to the Participating TO's portion of the CAISO Controlled Grid, as such handbook may be modified or superseded from time to time. Participating TO's standards contained in the Interconnection Handbook shall be deemed consistent with Good Utility Practice and Applicable Reliability Standards. In the event of a conflict between the terms of this LGIA and the terms of the Participating TO's Interconnection Handbook, the terms in this LGIA shall apply.

Interconnection Request shall mean a request, in the form of Appendix 1 to the Large Generator Interconnection Procedures, in accordance with the CAISO Tariff.

Interconnection Service shall mean the service provided by the Participating TO and CAISO associated with interconnecting the Interconnection Customer's Generating Facility to the Participating TO's Transmission System and enabling the CAISO Controlled Grid to receive electric energy and capacity from the Generating Facility at the Point of Interconnection, pursuant to the terms of this LGIA, the Participating TO's Transmission Owner Tariff, and the CAISO Tariff.

Interconnection Study shall mean either of the following studies: the Phase I Interconnection Study or the Phase II Interconnection Study conducted or caused to be performed by the CAISO, in coordination with the applicable Participating TO(s), pursuant to the Large Generator Interconnection Procedures.

IRS shall mean the Internal Revenue Service.

Large Generating Facility shall mean a Generating Facility having a Generating Facility Capacity of more than 20 MW.

Large Generator Interconnection Procedures (LGIP) shall mean the CAISO protocol that sets forth the interconnection procedures applicable to an Interconnection Request pertaining to a Large Generating Facility that is included in CAISO Tariff Appendix Y.

Large Generator Interconnection Study Process Agreement shall mean the agreement between the Interconnection Customer and the CAISO for the conduct of the Interconnection Studies.

Loss shall mean any and all damages, losses, and claims, including claims and actions relating to injury to or death of any person or damage to property, demand, suits, recoveries, costs and expenses, court costs, attorney fees, and all other obligations by or to third parties.

Material Modification shall mean those modifications that have a material impact on the cost or timing of any Interconnection Request or any other valid interconnection request with a later queue priority date.

Metering Equipment shall mean all metering equipment installed or to be installed for measuring the output of the Generating Facility pursuant to this LGIA at the metering points, including but not limited to instrument transformers, MWh-meters, data acquisition equipment, transducers, remote terminal unit, communications equipment, phone lines, and fiber optics.

NERC shall mean the North American Electric Reliability Council or its successor organization.

Network Upgrades shall be Participating TO's Delivery Network Upgrades and Participating TO's Reliability Network Upgrades.

Operational Control shall mean the rights of the CAISO under the Transmission Control Agreement and the CAISO Tariff to direct the parties to the Transmission Control Agreement how to operate their transmission lines and facilities and other electric plant affecting the reliability of those lines and facilities for the purpose of affording comparable non-discriminatory transmission access and meeting applicable reliability criteria.

Participating TO's Delivery Network Upgrades shall mean the additions, modifications, and upgrades to the Participating TO's Transmission System at or beyond the Point of Interconnection, other than Reliability Network Upgrades, identified in the Interconnection Studies, as identified in Appendix A, to relieve constraints on the CAISO Controlled Grid.

Participating TO's Interconnection Facilities shall mean all facilities and equipment owned, controlled or operated by the Participating TO from the Point of Change of Ownership to the Point of Interconnection as identified in Appendix A to this LGIA, including any modifications, additions or upgrades to such facilities and equipment. Participating TO's Interconnection Facilities are sole use facilities and shall not include Distribution Upgrades, Stand Alone Network Upgrades or Network Upgrades.

Participating TO's Reliability Network Upgrades shall mean the additions, modifications, and upgrades to the Participating TO's Transmission System at or beyond the Point of Interconnection, identified in the Interconnection Studies, as identified in Appendix A, necessary to interconnect the Large Generating Facility safely and reliably to the Participating TO's Transmission System, which would not have been necessary but for the interconnection of the Large Generating Facility, including additions, modifications, and upgrades necessary to remedy short circuit or stability problems resulting from the interconnection of the Large Generating Facility to the Participating TO's Transmission System. Participating TO's Reliability Network Upgrades also include, consistent with Applicable Reliability Standards and Applicable Reliability Council practice, the Participating TO's facilities necessary to mitigate any adverse impact the Large Generating Facility's interconnection may have on a path's Applicable Reliability Council rating. Participating TO's Reliability Network Upgrades do not include any Participating TO's Delivery Network Upgrades.

Participating TO's Transmission System shall mean the facilities owned and operated by the Participating TO and that have been placed under the CAISO's Operational Control, which facilities form part of the CAISO Controlled Grid.

Party or Parties shall mean the Participating TO, CAISO, Interconnection Customer or the applicable combination of the above.

Phase I Interconnection Study shall mean the engineering study conducted or caused to be performed by the CAISO, in coordination with the applicable Participating TO(s), that evaluates the impact of the proposed interconnection on the safety and reliability of the Participating TO's Transmission System and, if applicable, an Affected System. The study shall identify and detail the system impacts that would result if the Generating Facility(ies) were interconnected without identified project modifications or system modifications, as provided in the On-Peak Deliverability Assessment (as defined in the CAISO Tariff), and other potential impacts, including but not limited to those identified in the Scoping Meeting as described in the Large Generator Interconnection Procedures. The study will also identify the approximate total costs, based on per unit costs, of mitigating these impacts, along with an equitable allocation of those costs to Interconnection Customers for their individual Generating Facilities.

Phase II Interconnection Study shall mean an engineering and operational study conducted or caused to be performed by the CAISO once per calendar year, in coordination with the applicable Participating TO(s), to determine the Point of Interconnection and a list of facilities (including the Participating TO's Interconnection Facilities, Network Upgrades, Distribution Upgrades, and Stand Alone Network Upgrades), the cost of those facilities, and the time required to interconnect the Generating Facility(ies) with the Participating TO's Transmission System.

Point of Change of Ownership shall mean the point, as set forth in Appendix A to this LGIA, where the Interconnection Customer's Interconnection Facilities connect to the Participating TO's Interconnection Facilities.

Point of Interconnection shall mean the point, as set forth in Appendix A to this LGIA, where the Interconnection Facilities connect to the Participating TO's Transmission System.

QF PGA shall mean a Qualifying Facility Participating Generator Agreement specifying the special provisions for the operating relationship between a Qualifying Facility and the CAISO, a pro forma version of which is set forth in Appendix B.3 of the CAISO Tariff.

Qualifying Facility shall mean a qualifying cogeneration facility or qualifying small power production facility, as defined in the Code of Federal Regulations, Title 18, Part 292 (18 C.F.R. §292).

Reasonable Efforts shall mean, with respect to an action required to be attempted or taken by a Party under this LGIA, efforts that are timely and consistent with Good Utility Practice and are otherwise substantially equivalent to those a Party would use to protect its own interests.

Scoping Meeting shall mean the meeting among representatives of the Interconnection Customer, the Participating TO(s), other Affected Systems, and the CAISO conducted for the purpose of discussing alternative interconnection options, to exchange information including any transmission data and earlier study evaluations that would be reasonably expected to impact such interconnection options, to analyze such information, and to determine the potential feasible Points of Interconnection.

Stand Alone Network Upgrades shall mean Network Upgrades that the Interconnection Customer may construct without affecting day-to-day operations of the CAISO Controlled Grid or Affected Systems during their construction. The Participating TO, the CAISO, and the Interconnection Customer must agree as to what constitutes Stand Alone Network Upgrades and identify them in Appendix A to this LGIA.

System Protection Facilities shall mean the equipment, including necessary protection signal communications equipment, that protects (1) the Participating TO's Transmission System, Participating TO's Interconnection Facilities, CAISO Controlled Grid, and Affected Systems from faults or other electrical disturbances occurring at the Generating Facility and (2) the Generating Facility from faults or other electrical system disturbances occurring on the CAISO Controlled Grid, Participating TO's Interconnection Facilities, and Affected Systems or on other delivery systems or other generating systems to which the CAISO Controlled Grid is directly connected.

Transmission Control Agreement shall mean CAISO FERC Electric Tariff No. 7.

Trial Operation shall mean the period during which the Interconnection Customer is engaged in on-site test operations and commissioning of an Electric Generating Unit prior to Commercial Operation.

ARTICLE 2. EFFECTIVE DATE, TERM AND TERMINATION

2.1 Effective Date. This LGIA shall become effective upon execution by all Parties subject to acceptance by FERC (if applicable), or if filed unexecuted, upon the date specified by FERC. The CAISO and Participating TO shall promptly file this LGIA with FERC upon execution in accordance with Article 3.1, if required.

2.2 Term of Agreement. Subject to the provisions of Article 2.3, this LGIA shall remain in effect for a period of _____ years from the Effective Date (Term Specified in Individual Agreements to be ten (10) years or such other longer period as the Interconnection Customer may request) and shall be automatically renewed for each successive one-year period thereafter.

2.3 Termination Procedures.

2.3.1 Written Notice. This LGIA may be terminated by the Interconnection Customer after giving the CAISO and the Participating TO ninety (90) Calendar Days advance written notice, or by the CAISO and the Participating TO notifying FERC after the Generating Facility permanently ceases Commercial Operation.

2.3.2 Default. A Party may terminate this LGIA in accordance with Article 17.

2.3.3 Suspension of Work. This LGIA may be deemed terminated in accordance with Article 5.16.

2.3.4 Notwithstanding Articles 2.3.1, 2.3.2, and 2.3.3, no termination shall become effective until the Parties have complied with all Applicable Laws and Regulations applicable to such termination, including the filing with FERC of a notice of termination of this LGIA (if applicable), which notice has been accepted for filing by FERC, and the Interconnection Customer has fulfilled its termination cost obligations under Article 2.4.

2.4 Termination Costs. Immediately upon the other Parties' receipt of a notice of the termination of this LGIA pursuant to Article 2.3 above, the CAISO and the Participating TO will determine the total cost responsibility of the Interconnection Customer. If, as of the date of the other Parties' receipt of the notice of termination, the Interconnection Customer has not already paid its share of Network Upgrade costs, as set forth in Appendix G to this LGIA, the Participating TO will liquidate the Interconnection Customer's Interconnection Financial Security associated with its cost responsibility for Network Upgrades, in accordance with Section 9.4 of the LGIP.

The Interconnection Customer will also be responsible for all costs incurred or irrevocably committed to be incurred in association with the construction of the Participating TO's Interconnection Facilities (including any cancellation costs relating to orders or contracts for Interconnection Facilities and equipment) and other such expenses, including any Distribution Upgrades for which the Participating TO or CAISO has incurred expenses or has irrevocably committed to incur expenses and has not been reimbursed by the Interconnection Customer, as of the date of the other Parties' receipt of the notice of termination, subject to the limitations set forth in this Article 2.4. Nothing in this Article 2.4 shall limit the Parties' rights under Article 17. If, as of the date of the other Parties' receipt of the notice of termination, the Interconnection Customer has not already reimbursed the Participating TO and the CAISO for costs incurred to construct the Participating TO's Interconnection Facilities, the Participating TO will liquidate the Interconnection Customer's Interconnection Financial Security associated with the construction of the Participating TO's Interconnection Facilities, in accordance with Section 9.4 of the LGIP. If the amount of the Interconnection Financial Security liquidated by the Participating TO under this Article 2.4 is insufficient to compensate the CAISO and the Participating TO for actual costs associated with the construction of the Participating TO's Interconnection Facilities contemplated in this Article, any additional amounts will be the responsibility of the Interconnection Customer, subject to the provisions of Section 9.4 of the LGIP. Any such additional amounts due from the Interconnection Customer beyond the amounts covered by its Interconnection Financial Security will be due to the Participating TO immediately upon termination of this LGIA in accordance with Section 9.4 of the LGIP.

If the amount of the Interconnection Financial Security exceeds the Interconnection Customer's cost responsibility under Section 9.4 of the LGIP, any excess amount will be released to the Interconnection Customer in accordance with Section 9.4 of the LGIP.

2.4.1 Notwithstanding the foregoing, in the event of termination by a Party, all Parties shall use commercially Reasonable Efforts to mitigate the costs, damages and charges arising as a consequence of termination. With respect to any portion of the Participating TO's Interconnection Facilities that have not yet been constructed or installed, the Participating

TO shall to the extent possible and with the Interconnection Customer's authorization cancel any pending orders of, or return, any materials or equipment for, or contracts for construction of, such facilities; provided that in the event the Interconnection Customer elects not to authorize such cancellation, the Interconnection Customer shall assume all payment obligations with respect to such materials, equipment, and contracts, and the Participating TO shall deliver such material and equipment, and, if necessary, assign such contracts, to the Interconnection Customer as soon as practicable, at the Interconnection Customer's expense. To the extent that the Interconnection Customer has already paid the Participating TO for any or all such costs of materials or equipment not taken by the Interconnection Customer, the Participating TO shall promptly refund such amounts to the Interconnection Customer, less any costs, including penalties, incurred by the Participating TO to cancel any pending orders of or return such materials, equipment, or contracts.

2.4.2 The Participating TO may, at its option, retain any portion of such materials, equipment, or facilities that the Interconnection Customer chooses not to accept delivery of, in which case the Participating TO shall be responsible for all costs associated with procuring such materials, equipment, or facilities.

2.4.3 With respect to any portion of the Interconnection Facilities, and any other facilities already installed or constructed pursuant to the terms of this LGIA, Interconnection Customer shall be responsible for all costs associated with the removal, relocation or other disposition or retirement of such materials, equipment, or facilities.

2.5 Disconnection. Upon termination of this LGIA, the Parties will take all appropriate steps to disconnect the Large Generating Facility from the Participating TO's Transmission System. All costs required to effectuate such disconnection shall be borne by the terminating Party, unless such termination resulted from the non-terminating Party's Default of this LGIA or such non-terminating Party otherwise is responsible for these costs under this LGIA.

2.6 Survival. This LGIA shall continue in effect after termination to the extent necessary to provide for final billings and payments and for costs incurred hereunder, including billings and payments pursuant to this LGIA; to permit the determination and enforcement of liability and indemnification obligations arising from acts or events that occurred while this LGIA was in effect; and to permit each Party to have access to the lands of the other Parties pursuant to this LGIA or other applicable agreements, to disconnect, remove or salvage its own facilities and equipment.

ARTICLE 3. REGULATORY FILINGS AND CAISO TARIFF COMPLIANCE

3.1 Filing. The Participating TO and the CAISO shall file this LGIA (and any amendment hereto) with the appropriate Governmental Authority(ies), if required. The Interconnection Customer may request that any information so provided be subject to the confidentiality provisions of Article 22. If the Interconnection Customer has executed this LGIA, or any amendment thereto, the Interconnection Customer shall reasonably cooperate with the Participating TO and CAISO with respect to such filing and to provide any information reasonably requested by the Participating TO or CAISO needed to comply with applicable regulatory requirements.

3.2 Agreement Subject to CAISO Tariff. The Interconnection Customer will comply with all applicable provisions of the CAISO Tariff, including the LGIP.

3.3 Relationship Between this LGIA and the CAISO Tariff. With regard to rights and obligations between the Participating TO and the Interconnection Customer, if and to the extent a matter is specifically addressed by a provision of this LGIA (including any appendices, schedules or other attachments to this LGIA), the provisions of this LGIA shall govern. If and to the extent a provision of this LGIA is inconsistent with the CAISO Tariff and dictates rights and obligations between the CAISO and the Participating TO or the CAISO and the Interconnection Customer, the CAISO Tariff shall govern.

3.4 Relationship Between this LGIA and the QF PGA. With regard to the rights and obligations of a Qualifying Facility that has entered into a QF PGA with the CAISO and has entered into this LGIA, if and to the extent a matter is specifically addressed by a provision of the QF PGA that is inconsistent with this LGIA, the terms of the QF PGA shall govern.

ARTICLE 4. SCOPE OF SERVICE

4.1 Interconnection Service. Interconnection Service allows the Interconnection Customer to connect the Large Generating Facility to the Participating TO's Transmission System and be eligible to deliver the Large Generating Facility's output using the available capacity of the CAISO Controlled Grid. To the extent the Interconnection Customer wants to receive Interconnection Service, the Participating TO shall construct facilities identified in Appendices A and C that the Participating TO is responsible to construct.

Interconnection Service does not necessarily provide the Interconnection Customer with the capability to physically deliver the output of its Large Generating Facility to any particular load on the CAISO Controlled Grid without incurring congestion costs. In the event of transmission constraints on the CAISO Controlled Grid, the Interconnection Customer's Large Generating Facility shall be subject to the applicable congestion management procedures in the CAISO Tariff in the same manner as all other resources.

4.2 Provision of Service. The Participating TO and the CAISO shall provide Interconnection Service for the Large Generating Facility.

4.3 Performance Standards. Each Party shall perform all of its obligations under this LGIA in accordance with Applicable Laws and Regulations, Applicable Reliability Standards, and Good Utility Practice, and to the extent a Party is required or prevented or limited in taking any action by such regulations and standards, such Party shall not be deemed to be in Breach of this LGIA for its compliance therewith. If such Party is the CAISO or Participating TO, then that Party shall amend the LGIA and submit the amendment to FERC for approval.

4.4 No Transmission Service. The execution of this LGIA does not constitute a request for, nor the provision of, any transmission service under the CAISO Tariff, and does not convey any right to deliver electricity to any specific customer or point of delivery.

4.5 Interconnection Customer Provided Services. The services provided by Interconnection Customer under this LGIA are set forth in Article 9.6 and Article 13.5.1. Interconnection Customer shall be paid for such services in accordance with Article 11.6.

ARTICLE 5. INTERCONNECTION FACILITIES ENGINEERING, PROCUREMENT, AND CONSTRUCTION

Interconnection Facilities, Network Upgrades, and Distribution Upgrades shall be studied, designed, and constructed pursuant to Good Utility Practice. Such studies, design and construction shall be based on the assumed accuracy and completeness of all technical information received by the Participating TO and the CAISO from the Interconnection Customer associated with interconnecting the Large Generating Facility.

5.1 Options. Unless otherwise mutually agreed among the Parties, the Interconnection Customer shall select the In-Service Date, Initial Synchronization Date, and Commercial Operation Date; and either Standard Option or Alternate Option set forth below for completion of the Participating TO's Interconnection Facilities and Network Upgrades as set forth in Appendix A, Interconnection

Facilities, Network Upgrades, and Distribution Upgrades, and such dates and selected option shall be set forth in Appendix B, Milestones.

5.1.1 Standard Option. The Participating TO shall design, procure, and construct the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades, using Reasonable Efforts to complete the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades by the dates set forth in Appendix B, Milestones. The Participating TO shall not be required to undertake any action which is inconsistent with its standard safety practices, its material and equipment specifications, its design criteria and construction procedures, its labor agreements, and Applicable Laws and Regulations. In the event the Participating TO reasonably expects that it will not be able to complete the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades by the specified dates, the Participating TO shall promptly provide written notice to the Interconnection Customer and the CAISO and shall undertake Reasonable Efforts to meet the earliest dates thereafter.

5.1.2 Alternate Option. If the dates designated by the Interconnection Customer are acceptable to the Participating TO, the Participating TO shall so notify the Interconnection Customer within thirty (30) Calendar Days, and shall assume responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities by the designated dates.

If the Participating TO subsequently fails to complete the Participating TO's Interconnection Facilities by the In-Service Date, to the extent necessary to provide back feed power; or fails to complete Network Upgrades by the Initial Synchronization Date to the extent necessary to allow for Trial Operation at full power output, unless other arrangements are made by the Parties for such Trial Operation; or fails to complete the Network Upgrades by the Commercial Operation Date, as such dates are reflected in Appendix B, Milestones; the Participating TO shall pay the Interconnection Customer liquidated damages in accordance with Article 5.3, Liquidated Damages, provided, however, the dates designated by the Interconnection Customer shall be extended day for day for each day that the CAISO refuses to grant clearances to install equipment.

5.1.3 Option to Build. If the dates designated by the Interconnection Customer are not acceptable to the Participating TO, the Participating TO shall so notify the Interconnection Customer within thirty (30) Calendar Days, and unless the Parties agree otherwise, the Interconnection Customer shall have the option to assume responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades. If the Interconnection Customer elects to exercise its option to assume responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades, it shall so notify the Participating TO within thirty (30) Calendar Days of receipt of the Participating TO's notification that the designated dates are not acceptable to the Participating TO. The Participating TO, CAISO, and Interconnection Customer must agree as to what constitutes Stand Alone Network Upgrades and identify such Stand Alone Network Upgrades in Appendix A to this LGIA. Except for Stand Alone Network Upgrades, the Interconnection Customer shall have no right to construct Network Upgrades under this option.

5.1.4 Negotiated Option. If the Interconnection Customer elects not to exercise its option under Article 5.1.3, Option to Build, the Interconnection Customer shall so notify the Participating TO within thirty (30) Calendar Days of receipt of the Participating TO's notification that the designated dates are not acceptable to the Participating TO, and the Parties shall in good faith attempt to negotiate terms and conditions (including revision of the specified dates and liquidated damages, the provision of incentives or the procurement and construction of a portion of the Participating TO's Interconnection

Facilities and Stand Alone Network Upgrades by the Interconnection Customer) pursuant to which the Participating TO is responsible for the design, procurement and construction of the Participating TO's Interconnection Facilities and Network Upgrades. If the Parties are unable to reach agreement on such terms and conditions, the Participating TO shall assume responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities and Network Upgrades pursuant to Article 5.1.1, Standard Option.

5.2 General Conditions Applicable to Option to Build. If the Interconnection Customer assumes responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades,

(1) the Interconnection Customer shall engineer, procure equipment, and construct the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades (or portions thereof) using Good Utility Practice and using standards and specifications provided in advance by the Participating TO;

(2) The Interconnection Customer’s engineering, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades shall comply with all requirements of law to which the Participating TO would be subject in the engineering, procurement or construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades;

(3) the Participating TO shall review, and the Interconnection Customer shall obtain the Participating TO’s approval of, the engineering design, equipment acceptance tests, and the construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades, which approval shall not be unreasonably withheld, and the CAISO may, at its option, review the engineering design, equipment acceptance tests, and the construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades;

(4) prior to commencement of construction, the Interconnection Customer shall provide to the Participating TO, with a copy to the CAISO for informational purposes, a schedule for construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades, and shall promptly respond to requests for information from the Participating TO;

(5) at any time during construction, the Participating TO shall have the right to gain unrestricted access to the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades and to conduct inspections of the same;

(6) at any time during construction, should any phase of the engineering, equipment procurement, or construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades not meet the standards and specifications provided by the Participating TO, the Interconnection Customer shall be obligated to remedy deficiencies in that portion of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades;

(7) the Interconnection Customer shall indemnify the CAISO and Participating TO for claims arising from the Interconnection Customer's construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades under the terms and procedures applicable to Article 18.1 Indemnity;

(8) The Interconnection Customer shall transfer control of the Participating TO's Interconnection Facilities to the Participating TO and shall transfer Operational Control of Stand Alone Network Upgrades to the CAISO;

(9) Unless the Parties otherwise agree, the Interconnection Customer shall transfer ownership of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades to the Participating TO. As soon as reasonably practicable, but within twelve months after completion of the construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades, the Interconnection Customer shall provide an invoice of the final cost of the construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades to the Participating TO, which invoice shall set forth such costs in sufficient detail to enable the Participating TO to reflect the proper costs of such facilities in its transmission rate base and to identify the investment upon which refunds will be provided;

(10) the Participating TO shall accept for operation and maintenance the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades to the extent engineered, procured, and constructed in accordance with this Article 5.2; and

(11) The Interconnection Customer's engineering, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades shall comply with all requirements of the "Option to Build" conditions set forth in Appendix C. Interconnection Customer shall deliver to the Participating TO "as-built" drawings, information, and any other documents that are reasonably required by the Participating TO to assure that the Interconnection Facilities and Stand-Alone Network Upgrades are built to the standards and specifications required by the Participating TO.

5.3 Liquidated Damages. The actual damages to the Interconnection Customer, in the event the Participating TO's Interconnection Facilities or Network Upgrades are not completed by the dates designated by the Interconnection Customer and accepted by the Participating TO pursuant to subparagraphs 5.1.2 or 5.1.4, above, may include Interconnection Customer's fixed operation and maintenance costs and lost opportunity costs. Such actual damages are uncertain and impossible to determine at this time. Because of such uncertainty, any liquidated damages paid by the Participating TO to the Interconnection Customer in the event that the Participating TO does not complete any portion of the Participating TO's Interconnection Facilities or Network Upgrades by the applicable dates, shall be an amount equal to ½ of 1 percent per day of the actual cost of the Participating TO's Interconnection Facilities and Network Upgrades, in the aggregate, for which the Participating TO has assumed responsibility to design, procure and construct.

However, in no event shall the total liquidated damages exceed 20 percent of the actual cost of the Participating TO's Interconnection Facilities and Network Upgrades for which the Participating TO has assumed responsibility to design, procure, and construct. The foregoing payments will be made by the Participating TO to the Interconnection Customer as just compensation for the damages caused to the Interconnection Customer, which actual damages are uncertain and impossible to determine at this time, and as reasonable liquidated damages, but not as a penalty or a method to secure performance of this LGIA. Liquidated damages, when the Parties agree to them, are the exclusive remedy for the Participating TO's failure to meet its schedule.

No liquidated damages shall be paid to the Interconnection Customer if: (1) the Interconnection Customer is not ready to commence use of the Participating TO's Interconnection Facilities or Network Upgrades to take the delivery of power for the Electric Generating Unit's Trial Operation or to export power from the Electric Generating Unit on the specified dates, unless the Interconnection Customer would have been able to commence use of the Participating TO's Interconnection Facilities or Network Upgrades to take the delivery of power for Electric Generating Unit's Trial Operation or to export power from the Electric Generating Unit, but for the Participating TO's delay; (2) the Participating TO's failure to meet the specified dates is the result of the action or inaction of the Interconnection Customer or any other interconnection customer who has entered into an interconnection agreement with the CAISO and/or Participating TO, action or inaction by the CAISO, or any cause beyond the Participating TO's reasonable control or reasonable ability to cure; (3) the Interconnection Customer has assumed responsibility for the design, procurement and construction of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades; or (4) the Parties have otherwise agreed.

In no event shall the CAISO have any responsibility or liability to the Interconnection Customer for liquidated damages pursuant to the provisions of this Article 5.3.

5.4 Power System Stabilizers. The Interconnection Customer shall procure, install, maintain and operate Power System Stabilizers in accordance with Applicable Reliability Standards, the guidelines and procedures established by the Applicable Reliability Council, and the provisions of Section 4.6.5.1 of the CAISO Tariff. The CAISO reserves the right to establish reasonable minimum acceptable settings for any installed Power System Stabilizers, subject to the design and operating limitations of the Large Generating Facility. If the Large Generating Facility's Power System Stabilizers are removed from service or not capable of automatic operation, the Interconnection Customer shall immediately notify the CAISO and the Participating TO and restore the Power System Stabilizers to operation as soon as possible. The CAISO shall have the right to order the reduction in output or disconnection of the Large Generating Facility if the reliability of the CAISO Controlled Grid would be adversely affected as a result of improperly tuned Power System Stabilizers. The requirements of this Article 5.4 shall apply to Asynchronous Generating Facilities in accordance with Appendix H.

5.5 Equipment Procurement. If responsibility for construction of the Participating TO's Interconnection Facilities or Network Upgrades is to be borne by the Participating TO, then the Participating TO shall commence design of the Participating TO's Interconnection Facilities or Network Upgrades and procure necessary equipment as soon as practicable after all of the following conditions are satisfied, unless the Parties otherwise agree in writing:

5.5.1 The CAISO, in coordination with the applicable Participating TO(s), has completed the Phase II Interconnection Study pursuant to the Large Generator Interconnection Facilities Study Process Agreement;

5.5.2 The Participating TO has received written authorization to proceed with design and procurement from the Interconnection Customer by the date specified in Appendix B, Milestones; and

5.5.3 The Interconnection Customer has provided security to the Participating TO in accordance with Article 11.5 by the dates specified in Appendix B, Milestones.

5.6 Construction Commencement. The Participating TO shall commence construction of the Participating TO's Interconnection Facilities and Network Upgrades for which it is responsible as soon as practicable after the following additional conditions are satisfied:

5.6.1 Approval of the appropriate Governmental Authority has been obtained for any facilities requiring regulatory approval;

5.6.2 Necessary real property rights and rights-of-way have been obtained, to the extent required for the construction of a discrete aspect of the Participating TO's Interconnection Facilities and Network Upgrades;

5.6.3 The Participating TO has received written authorization to proceed with construction from the Interconnection Customer by the date specified in Appendix B, Milestones; and

5.6.4 The Interconnection Customer has provided payment and security to the Participating TO in accordance with Article 11.5 by the dates specified in Appendix B, Milestones.

5.7 Work Progress. The Parties will keep each other advised periodically as to the progress of their respective design, procurement and construction efforts. Any Party may, at any time, request a progress report from another Party. If, at any time, the Interconnection Customer determines that the completion of the Participating TO's Interconnection Facilities will not be required until after the specified In-Service Date, the Interconnection Customer will provide written notice to the Participating TO and CAISO of such later date upon which the completion of the Participating TO's Interconnection Facilities will be required.

5.8 Information Exchange. As soon as reasonably practicable after the Effective Date, the Parties shall exchange information regarding the design and compatibility of the Interconnection Customer's Interconnection Facilities and Participating TO's Interconnection Facilities and compatibility of the Interconnection Facilities with the Participating TO's Transmission System, and shall work diligently and in good faith to make any necessary design changes.

5.9 Limited Operation. If any of the Participating TO's Interconnection Facilities or Network Upgrades are not reasonably expected to be completed prior to the Commercial Operation Date of the Electric Generating Unit, the Participating TO and/or CAISO, as applicable, shall, upon the request and at the expense of the Interconnection Customer, perform operating studies on a timely basis to determine the extent to which the Electric Generating Unit and the Interconnection Customer's Interconnection Facilities may operate prior to the completion of the Participating TO's Interconnection Facilities or Network Upgrades consistent with Applicable Laws and Regulations, Applicable Reliability Standards, Good Utility Practice, and this LGIA. The Participating TO and CAISO shall permit Interconnection Customer to operate the Electric Generating Unit and the Interconnection Customer's Interconnection Facilities in accordance with the results of such studies.

5.10 Interconnection Customer's Interconnection Facilities. The Interconnection Customer shall, at its expense, design, procure, construct, own and install the Interconnection Customer's Interconnection Facilities, as set forth in Appendix A.

5.10.1 Large Generating Facility and Interconnection Customer's Interconnection Facilities Specifications. In addition to the Interconnection Customer's responsibility to submit technical data with its Interconnection Request as required by Section 3.5.1 of the LGIP, the Interconnection Customer shall submit all remaining necessary specifications for the Interconnection Customer's Interconnection Facilities and Large Generating Facility, including System Protection Facilities, to the Participating TO and the CAISO at least one hundred eighty (180) Calendar Days prior to the Initial Synchronization Date; and final specifications for review and comment at least ninety (90) Calendar Days prior to the Initial Synchronization Date. The Participating TO and the CAISO shall review such specifications pursuant to this LGIA and the LGIP to ensure that the Interconnection Customer's Interconnection Facilities and Large Generating Facility are compatible with the technical specifications, operational control, safety requirements, and any other applicable requirements of the Participating TO and the CAISO and comment on such specifications within thirty (30) Calendar Days of the Interconnection Customer's submission. All specifications provided hereunder shall be deemed confidential.

5.10.2 Participating TO's and CAISO's Review. The Participating TO's and the CAISO's review of the Interconnection Customer's final specifications shall not be construed as confirming, endorsing, or providing a warranty as to the design, fitness, safety, durability or reliability of the Large Generating Facility, or the Interconnection Customer's Interconnection Facilities. Interconnection Customer shall make such changes to the Interconnection Customer's Interconnection Facilities as may reasonably be required by the Participating TO or the CAISO, in accordance with Good Utility Practice, to ensure that the Interconnection Customer's Interconnection Facilities are compatible with the technical specifications, Operational Control, and safety requirements of the Participating TO or the CAISO.

5.10.3 Interconnection Customer's Interconnection Facilities Construction. The Interconnection Customer's Interconnection Facilities shall be designed and constructed in accordance with Good Utility Practice. Within one hundred twenty (120) Calendar Days after the Commercial Operation Date, unless the Participating TO and Interconnection Customer agree on another mutually acceptable deadline, the Interconnection Customer shall deliver to the Participating TO and CAISO "as-built" drawings, information and documents for the Interconnection Customer's Interconnection Facilities and the Electric Generating Unit(s), such as: a one-line diagram, a site plan showing the Large Generating Facility and the Interconnection Customer's Interconnection Facilities, plan and elevation drawings showing the layout of the Interconnection Customer's Interconnection Facilities, a relay functional diagram, relaying AC and DC schematic wiring diagrams and relay settings for all facilities associated with the Interconnection Customer's step-up transformers, the facilities connecting the Large Generating Facility to the step-up transformers and the Interconnection Customer's Interconnection Facilities, and the impedances (determined by factory tests) for the associated step-up transformers and the Electric Generating Units. The Interconnection Customer shall provide the Participating TO and the CAISO specifications for the excitation system, automatic voltage regulator, Large Generating Facility control and protection settings, transformer tap settings, and communications, if applicable. Any deviations from the relay settings, machine specifications, and other specifications originally submitted by the Interconnection Customer shall be assessed by the Participating TO and the CAISO pursuant to the appropriate provisions of this LGIA and the LGIP.

5.10.4 Interconnection Customer to Meet Requirements of the Participating TO's Interconnection Handbook. The Interconnection Customer shall comply with the Participating TO's Interconnection Handbook.

5.11 Participating TO's Interconnection Facilities Construction. The Participating TO's Interconnection Facilities shall be designed and constructed in accordance with Good Utility Practice. Upon request, within one hundred twenty (120) Calendar Days after the Commercial Operation Date, unless the Participating TO and Interconnection Customer agree on another mutually acceptable deadline, the Participating TO shall deliver to the Interconnection Customer and the CAISO the following "as-built" drawings, information and documents for the Participating TO's Interconnection Facilities [include appropriate drawings and relay diagrams].

The Participating TO will obtain control for operating and maintenance purposes of the Participating TO's Interconnection Facilities and Stand Alone Network Upgrades upon completion of such facilities. Pursuant to Article 5.2, the CAISO will obtain Operational Control of the Stand Alone Network Upgrades prior to the Commercial Operation Date.

5.12 Access Rights. Upon reasonable notice and supervision by a Party, and subject to any required or necessary regulatory approvals, a Party ("Granting Party") shall furnish at no cost to the other Party ("Access Party") any rights of use, licenses, rights of way and easements with respect to lands owned or controlled by the Granting Party, its agents (if allowed under the applicable agency agreement), or any Affiliate, that are necessary to enable the Access Party to obtain ingress and egress to construct, operate, maintain, repair, test (or witness testing), inspect, replace or remove facilities and equipment to: (i) interconnect the Large Generating Facility with the Participating TO's Transmission System; (ii) operate and maintain the Large Generating Facility, the Interconnection Facilities and the Participating TO's Transmission System; and (iii) disconnect or remove the Access Party's facilities and equipment upon termination of this LGIA. In exercising such licenses, rights of way and easements, the Access Party shall not unreasonably disrupt or interfere with normal operation of the Granting Party's business and shall adhere to the safety rules and procedures established in advance, as may be changed from time to time, by the Granting Party and provided to the Access Party.

5.13 Lands of Other Property Owners. If any part of the Participating TO's Interconnection Facilities and/or Network Upgrades are to be installed on property owned by persons other than the Interconnection Customer or Participating TO, the Participating TO shall at the Interconnection Customer's expense use efforts, similar in nature and extent to those that it typically undertakes on its own behalf or on behalf of its Affiliates, including use of its eminent domain authority, and to the extent consistent with state law, to procure from such persons any rights of use, licenses, rights of way and easements that are necessary to construct, operate, maintain, test, inspect, replace or remove the Participating TO's Interconnection Facilities and/or Network Upgrades upon such property.

5.14 Permits. Participating TO and Interconnection Customer shall cooperate with each other in good faith in obtaining all permits, licenses and authorization that are necessary to accomplish the interconnection in compliance with Applicable Laws and Regulations. With respect to this paragraph, the Participating TO shall provide permitting assistance to the Interconnection Customer comparable to that provided to the Participating TO's own, or an Affiliate's generation.

5.15 Early Construction of Base Case Facilities. The Interconnection Customer may request the Participating TO to construct, and the Participating TO shall construct, using Reasonable Efforts to accommodate Interconnection Customer's In-Service Date, all or any portion of any Network Upgrades required for Interconnection Customer to be interconnected to the Participating TO's Transmission System which are included in the Base Case of the Interconnection Studies for the Interconnection Customer, and which also are required to be constructed for another interconnection customer, but where such construction is not scheduled to be completed in time to achieve Interconnection Customer's In-Service Date.

5.16 Suspension. The Interconnection Customer reserves the right, upon written notice to the Participating TO and the CAISO, to suspend at any time all work associated with the construction and installation of the Participating TO's Interconnection Facilities, Network Upgrades, and/or Distribution Upgrades required under this LGIA, other than Network Upgrades identified in the Phase II Interconnection Study as common to multiple Generating Facilities, with the condition that the Participating TO's electrical system and the CAISO Controlled Grid shall be left in a safe and reliable condition in accordance with Good Utility Practice and the Participating TO's safety and reliability criteria and the CAISO's Applicable Reliability Standards. In such event, the Interconnection Customer shall be responsible for all reasonable and necessary costs which the Participating TO (i) has incurred pursuant to this LGIA prior to the suspension and (ii) incurs in suspending such work, including any costs incurred to perform such work as may be necessary to ensure the safety of persons and property and the integrity of the Participating TO's electric system during such suspension and, if applicable, any costs incurred in connection with the cancellation or suspension of material, equipment and labor contracts which the Participating TO cannot reasonably avoid; provided, however, that prior to canceling or suspending any such material, equipment or labor contract, the Participating TO shall obtain Interconnection Customer's authorization to do so.

The Participating TO shall invoice the Interconnection Customer for such costs pursuant to Article 12 and shall use due diligence to minimize its costs. In the event Interconnection Customer suspends work required under this LGIA pursuant to this Article 5.16, and has not requested the Participating TO to recommence the work or has not itself recommenced work required under this LGIA in time to ensure that the new projected Commercial Operation Date for the full Generating Facility Capacity of the Large Generating Facility is no more than three (3) years from the Commercial Operation Date identified in Appendix B hereto, this LGIA shall be deemed terminated and the Interconnection Customer's responsibility for costs will be determined in accordance with Section 2.4 of this LGIA. The suspension period shall begin on the date the suspension is requested, or the date of the written notice to the Participating TO and the CAISO, if no effective date is specified.

5.17 Taxes.

5.17.1 Interconnection Customer Payments Not Taxable. The Parties intend that all payments or property transfers made by the Interconnection Customer to the Participating TO for the installation of the Participating TO's Interconnection Facilities and the Network Upgrades shall be non-taxable, either as contributions to capital, or as a refundable advance, in accordance with the Internal Revenue Code and any applicable state income tax laws and shall not be taxable as contributions in aid of construction or otherwise under the Internal Revenue Code and any applicable state income tax laws.

5.17.2 Representations And Covenants. In accordance with IRS Notice 2001-82 and IRS Notice 88-129, the Interconnection Customer represents and covenants that (i) ownership of the electricity generated at the Large Generating Facility will pass to another party prior to the transmission of the electricity on the CAISO Controlled Grid, (ii) for income tax purposes, the amount of any payments and the cost of any property transferred to the Participating TO for the Participating TO's Interconnection Facilities will be capitalized by the Interconnection Customer as an intangible asset and recovered using the straight-line method over a useful life of twenty (20) years, and (iii) any portion of the Participating TO's Interconnection Facilities that is a "dual-use intertie," within the meaning of IRS Notice 88-129, is reasonably expected to carry only a de minimis amount of electricity in the direction of the Large Generating Facility. For this purpose, "de minimis amount" means no more than 5 percent of the total power flows in both directions, calculated in accordance with the "5 percent test" set forth in IRS Notice 88-129. This is not intended to be an exclusive list of the relevant conditions that must be met to conform to IRS requirements for non-taxable treatment.

At the Participating TO's request, the Interconnection Customer shall provide the Participating TO with a report from an independent engineer confirming its representation in clause (iii), above. The Participating TO represents and covenants that the cost of the Participating TO's Interconnection Facilities paid for by the Interconnection Customer without the possibility of refund or credit will have no net effect on the base upon which rates are determined.

5.17.3 Indemnification for the Cost Consequence of Current Tax Liability Imposed Upon the Participating TO. Notwithstanding Article 5.17.1, the Interconnection Customer shall protect, indemnify and hold harmless the Participating TO from the cost consequences of any current tax liability imposed against the Participating TO as the result of payments or property transfers made by the Interconnection Customer to the Participating TO under this LGIA for Interconnection Facilities, as well as any interest and penalties, other than interest and penalties attributable to any delay caused by the Participating TO.

The Participating TO shall not include a gross-up for the cost consequences of any current tax liability in the amounts it charges the Interconnection Customer under this LGIA unless (i) the Participating TO has determined, in good faith, that the payments or property transfers made by the Interconnection Customer to the Participating TO should be reported as income subject to taxation or (ii) any Governmental Authority directs the Participating TO to report payments or property as income subject to taxation; provided, however, that the Participating TO may require the Interconnection Customer to provide security for Interconnection Facilities, in a form reasonably acceptable to the Participating TO (such as a parental guarantee or a letter of credit), in an amount equal to the cost consequences of any current tax liability under this Article 5.17. The Interconnection Customer shall reimburse the Participating TO for such costs on a fully grossed-up basis, in accordance with Article 5.17.4, within thirty (30) Calendar Days of receiving written notification from the Participating TO of the amount due, including detail about how the amount was calculated.

The indemnification obligation shall terminate at the earlier of (1) the expiration of the ten year testing period and the applicable statute of limitation, as it may be extended by the Participating TO upon request of the IRS, to keep these years open for audit or adjustment, or (2) the occurrence of a subsequent taxable event and the payment of any related indemnification obligations as contemplated by this Article 5.17.

5.17.4 Tax Gross-Up Amount. The Interconnection Customer's liability for the cost consequences of any current tax liability under this Article 5.17 shall be calculated on a fully grossed-up basis. Except as may otherwise be agreed to by the parties, this means that the Interconnection Customer will pay the Participating TO, in addition to the amount paid for the Interconnection Facilities and Network Upgrades, an amount equal to (1) the current taxes imposed on the Participating TO ("Current Taxes") on the excess of (a) the gross income realized by the Participating TO as a result of payments or property transfers made by the Interconnection Customer to the Participating TO under this LGIA (without regard to any payments under this Article 5.17) (the "Gross Income Amount") over (b) the present value of future tax deductions for depreciation that will be available as a result of such payments or property transfers (the "Present Value Depreciation Amount"), plus (2) an additional amount sufficient to permit the Participating TO to receive and retain, after the payment of all Current Taxes, an amount equal to the net amount described in clause (1).

For this purpose, (i) Current Taxes shall be computed based on the Participating TO's composite federal and state tax rates at the time the payments or property transfers are received and the Participating TO will be treated as being subject to tax at the highest marginal rates in effect at that time (the "Current Tax Rate"), and (ii) the Present Value Depreciation Amount shall be computed by discounting the Participating TO's anticipated tax depreciation deductions as a result of such payments or property transfers by the Participating TO's current weighted average cost of capital. Thus, the formula for calculating the Interconnection Customer's liability to the Participating TO pursuant to this Article 5.17.4 can be expressed as follows: (Current Tax Rate x (Gross Income Amount – Present Value of Tax Depreciation))/(1-Current Tax Rate). Interconnection Customer's estimated tax liability in the event taxes are imposed shall be stated in Appendix A, Interconnection Facilities, Network Upgrades and Distribution Upgrades.

5.17.5 Private Letter Ruling or Change or Clarification of Law. At the Interconnection Customer's request and expense, the Participating TO shall file with the IRS a request for a private letter ruling as to whether any property transferred or sums paid, or to be paid, by the Interconnection Customer to the Participating TO under this LGIA are subject to federal income taxation. The Interconnection Customer will prepare the initial draft of the request for a private letter ruling, and will certify under penalties of perjury that all facts represented in such request are true and accurate to the best of the Interconnection Customer's knowledge. The Participating TO and Interconnection Customer shall cooperate in good faith with respect to the submission of such request, provided, however, the Interconnection Customer and the Participating TO explicitly acknowledge (and nothing herein is intended to alter) Participating TO's obligation under law to certify that the facts presented in the ruling request are true, correct and complete.

The Participating TO shall keep the Interconnection Customer fully informed of the status of such request for a private letter ruling and shall execute either a privacy act waiver or a limited power of attorney, in a form acceptable to the IRS, that authorizes the Interconnection Customer to participate in all discussions with the IRS regarding such request for a private letter ruling. The Participating TO shall allow the Interconnection Customer to attend all meetings with IRS officials about the request and shall permit the Interconnection Customer to prepare the initial drafts of any follow-up letters in connection with the request.

5.17.6 Subsequent Taxable Events. If, within 10 years from the date on which the relevant Participating TO's Interconnection Facilities are placed in service, (i) the Interconnection Customer Breaches the covenants contained in Article 5.17.2, (ii) a "disqualification event" occurs within the meaning of IRS Notice 88-129, or (iii) this LGIA terminates and the Participating TO retains ownership of the Interconnection Facilities and Network Upgrades, the Interconnection Customer shall pay a tax gross-up for the cost consequences of any current tax liability imposed on the Participating TO, calculated using the methodology described in Article 5.17.4 and in accordance with IRS Notice 90-60.

5.17.7 Contests. In the event any Governmental Authority determines that the Participating TO's receipt of payments or property constitutes income that is subject to taxation, the Participating TO shall notify the Interconnection Customer, in writing, within thirty (30) Calendar Days of receiving notification of such determination by a Governmental Authority. Upon the timely written request by the Interconnection Customer and at the Interconnection Customer's sole expense, the Participating TO may appeal, protest, seek abatement of, or otherwise oppose such determination. Upon the Interconnection Customer's written request and sole expense, the Participating TO may file a claim for refund with respect to any taxes paid under this Article 5.17, whether or not it has received such a determination. The Participating TO reserve the right to make all decisions with regard to the prosecution of such appeal, protest, abatement or other contest, including the selection of counsel and compromise or settlement of the claim, but the Participating TO shall keep the Interconnection Customer informed, shall consider in good faith suggestions from the Interconnection Customer about the conduct of the contest, and shall reasonably permit the Interconnection Customer or an Interconnection Customer representative to attend contest proceedings.

The Interconnection Customer shall pay to the Participating TO on a periodic basis, as invoiced by the Participating TO, the Participating TO's documented reasonable costs of prosecuting such appeal, protest, abatement or other contest, including any costs associated with obtaining the opinion of independent tax counsel described in this Article 5.17.7. The Participating TO may abandon any contest if the Interconnection Customer fails to provide payment to the Participating TO within thirty (30) Calendar Days of receiving such invoice.

At any time during the contest, the Participating TO may agree to a settlement either with the Interconnection Customer's consent or, if such consent is refused, after obtaining written advice from independent nationally-recognized tax counsel, selected by the Participating TO, but reasonably acceptable to the Interconnection Customer, that the proposed settlement represents a reasonable settlement given the hazards of litigation. The Interconnection Customer's obligation shall be based on the amount of the settlement agreed to by the Interconnection Customer, or if a higher amount, so much of the settlement that is supported by the written advice from nationally-recognized tax counsel selected under the terms of the preceding paragraph. The settlement amount shall be calculated on a fully grossed-up basis to cover any related cost consequences of the current tax liability. The Participating TO may also settle any tax controversy without receiving the Interconnection Customer's consent or any such written advice; however, any such settlement will relieve the Interconnection Customer from any obligation to indemnify the Participating TO for the tax at issue in the contest (unless the failure to obtain written advice is attributable to the Interconnection Customer's unreasonable refusal to the appointment of independent tax counsel).

5.17.8 Refund. In the event that (a) a private letter ruling is issued to the Participating TO which holds that any amount paid or the value of any property transferred by the Interconnection Customer to the Participating TO under the terms of this LGIA is not subject to federal income taxation, (b) any legislative change or administrative announcement, notice, ruling or other determination makes it reasonably clear to the Participating TO in good faith that any amount paid or the value of any property transferred by the Interconnection Customer to the Participating TO under the terms of this LGIA is not taxable to the Participating TO, (c) any abatement, appeal, protest, or other contest results in a determination that any payments or transfers made by the Interconnection Customer to the Participating TO are not subject to federal income tax, or (d) if the Participating TO receives a refund from any taxing authority for any overpayment of tax attributable to any payment or property transfer made by the Interconnection Customer to the Participating TO pursuant to this LGIA, the Participating TO shall promptly refund to the Interconnection Customer the following:

(i) any payment made by Interconnection Customer under this Article 5.17 for taxes that is attributable to the amount determined to be non-taxable, together with interest thereon,

(ii) interest on any amounts paid by the Interconnection Customer to the Participating TO for such taxes which the Participating TO did not submit to the taxing authority, calculated in accordance with the methodology set forth in FERC's regulations at 18 C.F.R. §35.19a(a)(2)(iii) from the date payment was made by the Interconnection Customer to the date the Participating TO refunds such payment to the Interconnection Customer, and

(iii) with respect to any such taxes paid by the Participating TO, any refund or credit the Participating TO receives or to which it may be entitled from any Governmental Authority, interest (or that portion thereof attributable to the payment described in clause (i), above) owed to the Participating TO for such overpayment of taxes (including any reduction in interest otherwise payable by the Participating TO to any Governmental Authority resulting from an offset or credit); provided, however, that the Participating TO will remit such amount promptly to the Interconnection Customer only after and to the extent that the Participating TO has received a tax refund, credit or offset from any Governmental Authority for any applicable overpayment of income tax related to the Participating TO's Interconnection Facilities.

The intent of this provision is to leave the Parties, to the extent practicable, in the event that no taxes are due with respect to any payment for Interconnection Facilities and Network Upgrades hereunder, in the same position they would have been in had no such tax payments been made.

5.17.9 Taxes Other Than Income Taxes. Upon the timely request by the Interconnection Customer, and at the Interconnection Customer's sole expense, the CAISO or Participating TO may appeal, protest, seek abatement of, or otherwise contest any tax (other than federal or state income tax) asserted or assessed against the CAISO or Participating TO for which the Interconnection Customer may be required to reimburse the CAISO or Participating TO under the terms of this LGIA. The Interconnection Customer shall pay to the Participating TO on a periodic basis, as invoiced by the Participating TO, the Participating TO's documented reasonable costs of prosecuting such appeal, protest, abatement, or other contest. The Interconnection Customer, the CAISO, and the Participating TO shall cooperate in good faith with respect to any such contest. Unless the payment of such taxes is a prerequisite to an appeal or abatement or cannot be deferred, no amount shall be payable by the Interconnection Customer to the CAISO or Participating TO for such taxes until they are assessed by a final, non-appealable order by any court or agency of competent jurisdiction. In the event that a tax payment is withheld and ultimately due and payable after appeal, the Interconnection Customer will be responsible for all taxes, interest and penalties, other than penalties attributable to any delay caused by the Participating TO.

5.18 Tax Status. Each Party shall cooperate with the others to maintain the other Parties' tax status. Nothing in this LGIA is intended to adversely affect the CAISO's or any Participating TO's tax exempt status with respect to the issuance of bonds including, but not limited to, Local Furnishing Bonds.

5.19 Modification.

5.19.1 General. The Interconnection Customer or the Participating TO may undertake modifications to its facilities, subject to the provisions of this LGIA and the CAISO Tariff. If a Party plans to undertake a modification that reasonably may be expected to affect the other Parties' facilities, that Party shall provide to the other Parties sufficient information regarding such modification so that the other Parties may evaluate the potential impact of such modification prior to commencement of the work. Such information shall be deemed to be confidential hereunder and shall include information concerning the timing of such modifications and whether such modifications are expected to interrupt the flow of electricity from the Large Generating Facility. The Party desiring to perform such work shall provide the relevant drawings, plans, and specifications to the other Parties at least ninety (90) Calendar Days in advance of the commencement of the work or such shorter period upon which the Parties may agree, which agreement shall not unreasonably be withheld, conditioned or delayed.

In the case of Large Generating Facility modifications that do not require the Interconnection Customer to submit an Interconnection Request, the CAISO or Participating TO shall provide, within thirty (30) Calendar Days (or such other time as the Parties may agree), an estimate of any additional modifications to the CAISO Controlled Grid, Participating TO's Interconnection Facilities, Network Upgrades or Distribution Upgrades necessitated by such Interconnection Customer modification and a good faith estimate of the costs thereof. The Participating TO and the CAISO shall determine if a Large Generating Facility modification is a Material Modification in accordance with the LGIP.

5.19.2 Standards. Any additions, modifications, or replacements made to a Party's facilities shall be designed, constructed and operated in accordance with this LGIA and Good Utility Practice.

5.19.3 Modification Costs. The Interconnection Customer shall not be directly assigned the costs of any additions, modifications, or replacements that the Participating TO makes to the Participating TO's Interconnection Facilities or the Participating TO's Transmission System to facilitate the interconnection of a third party to the Participating TO's Interconnection Facilities or the Participating TO's Transmission System, or to provide transmission service to a third party under the CAISO Tariff. The Interconnection Customer shall be responsible for the costs of any additions, modifications, or replacements to the Interconnection Facilities that may be necessary to maintain or upgrade such Interconnection Facilities consistent with Applicable Laws and Regulations, Applicable Reliability Standards or Good Utility Practice.

ARTICLE 6. TESTING AND INSPECTION

6.1 Pre-Commercial Operation Date Testing and Modifications. Prior to the Commercial Operation Date, the Participating TO shall test the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades and the Interconnection Customer shall test the Large Generating Facility and the Interconnection Customer's Interconnection Facilities to ensure their safe and reliable operation. Similar testing may be required after initial operation. Each Party shall make any modifications to its facilities that are found to be necessary as a result of such testing. The Interconnection Customer shall bear the cost of all such testing and modifications. The Interconnection Customer shall not commence initial parallel operation of an Electric Generating Unit with the Participating TO's Transmission System until the Participating TO provides prior written approval, which approval shall not be unreasonably withheld, for operation of such Electric Generating Unit. The Interconnection Customer shall generate test energy at the Large Generating Facility only if it has arranged for the delivery of such test energy.

6.2 Post-Commercial Operation Date Testing and Modifications. Each Party shall at its own expense perform routine inspection and testing of its facilities and equipment in accordance with Good Utility Practice as may be necessary to ensure the continued interconnection of the Large Generating Facility with the Participating TO's Transmission System in a safe and reliable manner. Each Party shall have the right, upon advance written notice, to require reasonable additional testing of the other Party's facilities, at the requesting Party's expense, as may be in accordance with Good Utility Practice.

6.3 Right to Observe Testing. Each Party shall notify the other Parties at least fourteen (14) Calendar Days in advance of its performance of tests of its Interconnection Facilities or Generating Facility. The other Parties have the right, at their own expense, to observe such testing.

6.4 Right to Inspect. Each Party shall have the right, but shall have no obligation to: (i) observe another Party's tests and/or inspection of any of its System Protection Facilities and other protective equipment, including Power System Stabilizers; (ii) review the settings of another Party's System Protection Facilities and other protective equipment; and (iii) review another Party's maintenance records relative to the Interconnection Facilities, the System Protection Facilities and other protective equipment. A Party may exercise these rights from time to time as it deems necessary upon reasonable notice to the other Party. The exercise or non-exercise by a Party of any such rights shall not be construed as an endorsement or confirmation of any element or condition of the Interconnection Facilities or the System Protection Facilities or other protective equipment or the operation thereof, or as a warranty as to the fitness, safety, desirability, or reliability of same. Any information that a Party obtains through the exercise of any of its rights under this Article 6.4 shall be deemed to be Confidential Information and treated pursuant to Article 22 of this LGIA.

ARTICLE 7. METERING

7.1 General. Each Party shall comply with any Applicable Reliability Standards and the Applicable Reliability Council requirements. The Interconnection Customer and CAISO shall comply with the provisions of the CAISO Tariff regarding metering, including Section 10 of the CAISO Tariff. Unless otherwise agreed by the Participating TO and the Interconnection Customer, the Participating TO may install additional Metering Equipment at the Point of Interconnection prior to any operation of any Electric Generating Unit and shall own, operate, test and maintain such Metering Equipment. Power flows to and from the Large Generating Facility shall be measured at or, at the CAISO's or Participating TO's option for its respective Metering Equipment, compensated to, the Point of Interconnection. The CAISO shall provide metering quantities to the Interconnection Customer upon request in accordance with the CAISO Tariff by directly polling the CAISO's meter data acquisition system. The Interconnection Customer shall bear all reasonable documented costs associated with the purchase, installation, operation, testing and maintenance of the Metering Equipment.

7.2 Check Meters. The Interconnection Customer, at its option and expense, may install and operate, on its premises and on its side of the Point of Interconnection, one or more check meters to check the CAISO-polled meters or the Participating TO's meters. Such check meters shall be for check purposes only and shall not be used for the measurement of power flows for purposes of this LGIA, except in the case that no other means are available on a temporary basis at the option of the CAISO or the Participating TO. The check meters shall be subject at all reasonable times to inspection and examination by the CAISO or Participating TO or their designees. The installation, operation and maintenance thereof shall be performed entirely by the Interconnection Customer in accordance with Good Utility Practice.

7.3 Participating TO Retail Metering. The Participating TO may install retail revenue quality meters and associated equipment, pursuant to the Participating TO's applicable retail tariffs.

ARTICLE 8. COMMUNICATIONS

8.1 Interconnection Customer Obligations. The Interconnection Customer shall maintain satisfactory operating communications with the CAISO in accordance with the provisions of the CAISO Tariff and with the Participating TO's dispatcher or representative designated by the Participating TO. The Interconnection Customer shall provide standard voice line, dedicated voice line and facsimile communications at its Large Generating Facility control room or central dispatch facility through use of either the public telephone system, or a voice communications system that does not rely on the public telephone system. The Interconnection Customer shall also provide the dedicated data circuit(s) necessary to provide Interconnection Customer data to the CAISO and Participating TO as set forth in Appendix D, Security Arrangements Details. The data circuit(s) shall extend from the Large Generating Facility to the location(s) specified by the CAISO and Participating TO. Any required maintenance of such communications equipment shall be performed by the Interconnection Customer. Operational communications shall be activated and maintained under, but not be limited to, the following events: system paralleling or separation, scheduled and unscheduled shutdowns, equipment clearances, and hourly and daily load data.

8.2 Remote Terminal Unit. Prior to the Initial Synchronization Date of each Electric Generating Unit, a Remote Terminal Unit, or equivalent data collection and transfer equipment acceptable to the Parties, shall be installed by the Interconnection Customer, or by the Participating TO at the Interconnection Customer's expense, to gather accumulated and instantaneous data to be telemetered to the location(s) designated by the CAISO and by the Participating TO through use of a dedicated point-to-point data circuit(s) as indicated in Article 8.1.

Telemetry to the CAISO shall be provided in accordance with the CAISO's technical standards for direct telemetry. For telemetry to the Participating TO, the communication protocol for the data circuit(s) shall be specified by the Participating TO. Instantaneous bi-directional real power and reactive power flow and any other required information must be telemetered directly to the location(s) specified by the Participating TO.

Each Party will promptly advise the other Parties if it detects or otherwise learns of any metering, telemetry or communications equipment errors or malfunctions that require the attention and/or correction by another Party. The Party owning such equipment shall correct such error or malfunction as soon as reasonably feasible.

8.3 No Annexation. Any and all equipment placed on the premises of a Party shall be and remain the property of the Party providing such equipment regardless of the mode and manner of annexation or attachment to real property, unless otherwise mutually agreed by the Parties.

ARTICLE 9. OPERATIONS

9.1 General. Each Party shall comply with Applicable Reliability Standards and the Applicable Reliability Council requirements. Each Party shall provide to the other Party all information that may reasonably be required by the other Party to comply with Applicable Laws and Regulations and Applicable Reliability Standards.

9.2 Balancing Authority Area Notification. At least three months before Initial Synchronization Date, the Interconnection Customer shall notify the CAISO and Participating TO in writing of the Balancing Authority Area in which the Large Generating Facility intends to be located. If the

Interconnection Customer intends to locate the Large Generating Facility in a Balancing Authority Area other than the Balancing Authority Area within whose electrically metered boundaries the Large Generating Facility is located, and if permitted to do so by the relevant transmission tariffs, all necessary arrangements, including but not limited to those set forth in Article 7 and Article 8 of this LGIA, and remote Balancing Authority Area generator interchange agreements, if applicable, and the appropriate measures under such agreements, shall be executed and implemented prior to the placement of the Large Generating Facility in the other Balancing Authority Area.

9.3 CAISO and Participating TO Obligations. The CAISO and Participating TO shall cause the Participating TO's Transmission System to be operated and controlled in a safe and reliable manner and in accordance with this LGIA. The Participating TO at the Interconnection Customer's expense shall cause the Participating TO's Interconnection Facilities to be operated, maintained and controlled in a safe and reliable manner and in accordance with this LGIA. The CAISO and Participating TO may provide operating instructions to the Interconnection Customer consistent with this LGIA and Participating TO and CAISO operating protocols and procedures as they may change from time to time. The Participating TO and CAISO will consider changes to their operating protocols and procedures proposed by the Interconnection Customer.

9.4 Interconnection Customer Obligations. The Interconnection Customer shall at its own expense operate, maintain and control the Large Generating Facility and the Interconnection Customer's Interconnection Facilities in a safe and reliable manner and in accordance with this LGIA. The Interconnection Customer shall operate the Large Generating Facility and the Interconnection Customer's Interconnection Facilities in accordance with all applicable requirements of the Balancing Authority Area of which it is part, including such requirements as set forth in Appendix C, Interconnection Details, of this LGIA. Appendix C, Interconnection Details, will be modified to reflect changes to the requirements as they may change from time to time. A Party may request that another Party provide copies of the requirements set forth in Appendix C, Interconnection Details, of this LGIA. The Interconnection Customer shall not commence Commercial Operation of an Electric Generating Unit with the Participating TO's Transmission System until the Participating TO provides prior written approval, which approval shall not be unreasonably withheld, for operation of such Electric Generating Unit.

9.5 Start-Up and Synchronization. Consistent with the Parties' mutually acceptable procedures, the Interconnection Customer is responsible for the proper synchronization of each Electric Generating Unit to the CAISO Controlled Grid.

9.6 Reactive Power.

9.6.1 Power Factor Design Criteria. For all Generating Facilities other than Asynchronous Generating Facilities, the Interconnection Customer shall design the Large Generating Facility to maintain a composite power delivery at continuous rated power output at the terminals of the Electric Generating Unit at a power factor within the range of 0.95 leading to 0.90 lagging, unless the CAISO has established different requirements that apply to all generators in the Balancing Authority Area on a comparable basis. For Asynchronous Generating Facilities, the Interconnection Customer shall design the Large Generating Facility to maintain power factor criteria in accordance with Appendix H of this LGIA.

9.6.2 Voltage Schedules. Once the Interconnection Customer has synchronized an Electric Generating Unit with the CAISO Controlled Grid, the CAISO or Participating TO shall require the Interconnection Customer to maintain a voltage schedule by operating the Electric Generating Unit to produce or absorb reactive power within the design limitations of the Electric Generating Unit set forth in Article 9.6.1 (Power Factor Design Criteria). CAISO's voltage schedules shall treat all sources of reactive power in the Balancing Authority Area in an equitable and not unduly discriminatory manner. The Participating TO shall exercise Reasonable Efforts to provide the Interconnection Customer with such schedules at least one (1) day in advance, and the CAISO or Participating TO may make changes to such schedules as necessary to maintain the reliability of the CAISO Controlled Grid or the Participating TO's electric system. The Interconnection Customer shall operate the Electric Generating Unit to maintain the specified output voltage or power factor within the design limitations of the Electric Generating Unit set forth in Article 9.6.1 (Power Factor Design Criteria), and as may be required by the CAISO to operate the Electric Generating Unit at a specific voltage schedule within the design limitations set forth in Article 9.6.1. If the Interconnection Customer is unable to maintain the specified voltage or power factor, it shall promptly notify the CAISO and the Participating TO.

9.6.2.1 Governors and Regulators. Whenever an Electric Generating Unit is operated in parallel with the CAISO Controlled Grid and the speed governors (if installed on the Electric Generating Unit pursuant to Good Utility Practice) and voltage regulators are capable of operation, the Interconnection Customer shall operate the Electric Generating Unit with its speed governors and voltage regulators in automatic operation. If the Electric Generating Unit's speed governors and voltage regulators are not capable of such automatic operation, the Interconnection Customer shall immediately notify the CAISO and the Participating TO and ensure that the Electric Generating Unit operates as specified in Article 9.6.2 through manual operation and that such Electric Generating Unit's reactive power production or absorption (measured in MVARs) are within the design capability of the Electric Generating Unit(s) and steady state stability limits. The Interconnection Customer shall restore the speed governors and voltage regulators to automatic operation as soon as possible. If the Large Generating Facility's speed governors and voltage regulators are improperly tuned or malfunctioning, the CAISO shall have the right to order the reduction in output or disconnection of the Large Generating Facility if the reliability of the CAISO Controlled Grid would be adversely affected. The Interconnection Customer shall not cause its Large Generating Facility to disconnect automatically or instantaneously from the CAISO Controlled Grid or trip any Electric Generating Unit comprising the Large Generating Facility for an under or over frequency condition unless the abnormal frequency condition persists for a time period beyond the limits set forth in ANSI/IEEE Standard C37.106, or such other standard as applied to other generators in the Balancing Authority Area on a comparable basis.

9.6.2.2 Loss of Voltage Control and Governor Control for Asynchronous Generating Facilities. For Asynchronous Generating Facilities, Appendix H to this LGIA sets forth the requirements for Large Generating Facilities relating to: (i) loss of voltage control capability, (ii) governor response to frequency conditions, and (iii) ability not to disconnect automatically or instantaneously from the CAISO Controlled Grid or trip any Electric Generating Unit comprising the Large Generating Facility for an under- or over-frequency condition. Asynchronous Generating Facilities are not required to provide governor response to under-frequency conditions.

9.6.3 Payment for Reactive Power. CAISO is required to pay the Interconnection Customer for reactive power that Interconnection Customer provides or absorbs from an Electric Generating Unit when the CAISO requests the Interconnection Customer to operate its Electric Generating Unit outside the range specified in Article 9.6.1, provided that if the CAISO pays other generators for reactive power service within the specified range, it must also pay the Interconnection Customer. Payments shall be pursuant to Article 11.6 or such other agreement to which the CAISO and Interconnection Customer have otherwise agreed.

9.7 Outages and Interruptions.

9.7.1 Outages.

9.7.1.1 Outage Authority and Coordination. Each Party may in accordance with Good Utility Practice in coordination with the other Parties remove from service any of its respective Interconnection Facilities or Network Upgrades that may impact another Party's facilities as necessary to perform maintenance or testing or to install or replace equipment. Absent an Emergency Condition, the Party scheduling a removal of such facility(ies) from service will use Reasonable Efforts to schedule such removal on a date and time mutually acceptable to all Parties. In all circumstances any Party planning to remove such facility(ies) from service shall use Reasonable Efforts to minimize the effect on the other Parties of such removal.

9.7.1.2 Outage Schedules. The CAISO shall post scheduled outages of CAISO Controlled Grid facilities in accordance with the provisions of the CAISO Tariff. The Interconnection Customer shall submit its planned maintenance schedules for the Large Generating Facility to the CAISO in accordance with the CAISO Tariff. The Interconnection Customer shall update its planned maintenance schedules in accordance with the CAISO Tariff. The CAISO may request the Interconnection Customer to reschedule its maintenance as necessary to maintain the reliability of the CAISO Controlled Grid in accordance with the CAISO Tariff. Such planned maintenance schedules and updates and changes to such schedules shall be provided by the Interconnection Customer to the Participating TO concurrently with their submittal to the CAISO. The CAISO shall compensate the Interconnection Customer for any additional direct costs that the Interconnection Customer incurs as a result of having to reschedule maintenance in accordance with the CAISO Tariff. The Interconnection Customer will not be eligible to receive compensation, if during the twelve (12) months prior to the date of the scheduled maintenance, the Interconnection Customer had modified its schedule of maintenance activities.

9.7.1.3 Outage Restoration. If an outage on a Party's Interconnection Facilities or Network Upgrades adversely affects another Party's operations or facilities, the Party that owns or controls the facility that is out of service shall use Reasonable Efforts to promptly restore such facility(ies) to a normal operating condition consistent with the nature of the outage. The Party that owns or controls the facility that is out of service shall provide the other Parties, to the extent such information is known, information on the nature of the Emergency Condition, if the outage is caused by an Emergency Condition, an estimated time of restoration, and any corrective actions required. Initial verbal notice shall be followed up as soon as practicable with written notice explaining the nature of the outage, if requested by a Party, which may be provided by e-mail or facsimile.

9.7.2 Interruption of Service. If required by Good Utility Practice to do so, the CAISO or the Participating TO may require the Interconnection Customer to interrupt or reduce deliveries of electricity if such delivery of electricity could adversely affect the CAISO's or the Participating TO's ability to perform such activities as are necessary to safely and reliably operate and maintain the Participating TO's electric system or the CAISO Controlled Grid. The following provisions shall apply to any interruption or reduction permitted under this Article 9.7.2:

9.7.2.1 The interruption or reduction shall continue only for so long as reasonably necessary under Good Utility Practice;

9.7.2.2 Any such interruption or reduction shall be made on an equitable, non-discriminatory basis with respect to all generating facilities directly connected to the CAISO Controlled Grid, subject to any conditions specified in this LGIA;

9.7.2.3 When the interruption or reduction must be made under circumstances which do not allow for advance notice, the CAISO or Participating TO, as applicable, shall notify the Interconnection Customer by telephone as soon as practicable of the reasons for the curtailment, interruption, or reduction, and, if known, its expected duration. Telephone notification shall be followed by written notification, if requested by the Interconnection Customer, as soon as practicable;

9.7.2.4 Except during the existence of an Emergency Condition, the CAISO or Participating TO shall notify the Interconnection Customer in advance regarding the timing of such interruption or reduction and further notify the Interconnection Customer of the expected duration. The CAISO or Participating TO shall coordinate with the Interconnection Customer using Good Utility Practice to schedule the interruption or reduction during periods of least impact to the Interconnection Customer, the CAISO, and the Participating TO;

9.7.2.5 The Parties shall cooperate and coordinate with each other to the extent necessary in order to restore the Large Generating Facility, Interconnection Facilities, the Participating TO's Transmission System, and the CAISO Controlled Grid to their normal operating state, consistent with system conditions and Good Utility Practice.

9.7.3 Under-Frequency and Over Frequency Conditions. The CAISO Controlled Grid is designed to automatically activate a load-shed program as required by Applicable Reliability Standards and the Applicable Reliability Council in the event of an under-frequency system disturbance. The Interconnection Customer shall implement under-frequency and over-frequency protection set points for the Large Generating Facility as required by Applicable Reliability Standards and the Applicable Reliability Council to ensure "ride through" capability. Large Generating Facility response to frequency deviations of pre-determined magnitudes, both under-frequency and over-frequency deviations, shall be studied and coordinated with the Participating TO and CAISO in accordance with Good Utility Practice. The term "ride through" as used herein shall mean the ability of a Generating Facility to stay connected to and synchronized with the CAISO Controlled Grid during system disturbances within a range of under-frequency and over-frequency conditions, in accordance with Good Utility Practice. . Asynchronous Generating Facilities shall be subject to frequency ride through capability requirements in accordance with Appendix H to this LGIA.

9.7.4 System Protection and Other Control Requirements.

9.7.4.1 System Protection Facilities. The Interconnection Customer shall, at its expense, install, operate and maintain System Protection Facilities as a part of the Large Generating Facility or the Interconnection Customer's Interconnection Facilities. The Participating TO shall install at the Interconnection Customer's expense any System Protection Facilities that may be required on the Participating TO's Interconnection Facilities or the Participating TO's Transmission System as a result of the interconnection of the Large Generating Facility and the Interconnection Customer's Interconnection Facilities.

9.7.4.2 The Participating TO's and Interconnection Customer's protection facilities shall be designed and coordinated with other systems in accordance with Applicable Reliability Standards, Applicable Reliability Council criteria, and Good Utility Practice.

9.7.4.3 The Participating TO and Interconnection Customer shall each be responsible for protection of its facilities consistent with Good Utility Practice.

9.7.4.4 The Participating TO's and Interconnection Customer's protective relay design shall incorporate the necessary test switches to perform the tests required in Article 6. The required test switches will be placed such that they allow operation of lockout relays while preventing breaker failure schemes from operating and causing unnecessary breaker operations and/or the tripping of the Interconnection Customer's Electric Generating Units.

9.7.4.5 The Participating TO and Interconnection Customer will test, operate and maintain System Protection Facilities in accordance with Good Utility Practice and, if applicable, the requirements of the Participating TO's Interconnection Handbook.

9.7.4.6 Prior to the in-service date, and again prior to the Commercial Operation Date, the Participating TO and Interconnection Customer or their agents shall perform a complete calibration test and functional trip test of the System Protection Facilities. At intervals suggested by Good Utility Practice, the standards and procedures of the Participating TO, including, if applicable, the requirements of the Participating TO's Interconnection Handbook, and following any apparent malfunction of the System Protection Facilities, each Party shall perform both calibration and functional trip tests of its System Protection Facilities. These tests do not require the tripping of any in-service generation unit. These tests do, however, require that all protective relays and lockout contacts be activated.

9.7.5 **Requirements for Protection.** In compliance with Good Utility Practice and, if applicable, the requirements of the Participating TO's Interconnection Handbook, the Interconnection Customer shall provide, install, own, and maintain relays, circuit breakers and all other devices necessary to remove any fault contribution of the Large Generating Facility to any short circuit occurring on the Participating TO's Transmission System not otherwise isolated by the Participating TO's equipment, such that the removal of the fault contribution shall be coordinated with the protective requirements of the Participating TO's Transmission System. Such protective equipment shall include, without limitation, a disconnecting device with fault current-interrupting capability located between the Large Generating Facility and the Participating TO's Transmission System at a site selected upon mutual agreement (not to be unreasonably withheld, conditioned or delayed) of the Parties. The Interconnection Customer shall be responsible for protection of the Large Generating Facility and the Interconnection Customer's other equipment from such conditions as negative sequence currents, over- or under-frequency, sudden load rejection, over- or under-voltage, and generator loss-of-field. The Interconnection Customer shall be solely responsible to disconnect the Large Generating Facility and the Interconnection Customer's other equipment if conditions on the CAISO Controlled Grid could adversely affect the Large Generating Facility.

9.7.6 **Power Quality.** Neither the Participating TO's nor the Interconnection Customer's facilities shall cause excessive voltage flicker nor introduce excessive distortion to the sinusoidal voltage or current waves as defined by ANSI Standard C84.1-1989, in accordance with IEEE Standard 519, any applicable superseding electric industry standard, or any alternative Applicable Reliability Standard or Applicable Reliability Council standard. In the event of a conflict among ANSI Standard C84.1-1989, any applicable superseding electric industry standard, or any alternative Applicable Reliability Standard or Applicable Reliability Council standard, the alternative Applicable Reliability Standard or Applicable Reliability Council standard shall control.

9.8 Switching and Tagging Rules. Each Party shall provide the other Parties a copy of its switching and tagging rules that are applicable to the other Parties' activities. Such switching and tagging rules shall be developed on a non-discriminatory basis. The Parties shall comply with applicable switching and tagging rules, as amended from time to time, in obtaining clearances for work or for switching operations on equipment.

9.9 Use of Interconnection Facilities by Third Parties.

9.9.1 Purpose of Interconnection Facilities. Except as may be required by Applicable Laws and Regulations, or as otherwise agreed to among the Parties, the Interconnection Facilities shall be constructed for the sole purpose of interconnecting the Large Generating Facility to the Participating TO's Transmission System and shall be used for no other purpose.

9.9.2 Third Party Users. If required by Applicable Laws and Regulations or if the Parties mutually agree, such agreement not to be unreasonably withheld, to allow one or more third parties to use the Participating TO's Interconnection Facilities, or any part thereof, the Interconnection Customer will be entitled to compensation for the capital expenses it incurred in connection with the Interconnection Facilities based upon the pro rata use of the Interconnection Facilities by the Participating TO, all third party users, and the Interconnection Customer, in accordance with Applicable Laws and Regulations or upon some other mutually-agreed upon methodology. In addition, cost responsibility for ongoing costs, including operation and maintenance costs associated with the Interconnection Facilities, will be allocated between the Interconnection Customer and any third party users based upon the pro rata use of the Interconnection Facilities by the Participating TO, all third party users, and the Interconnection Customer, in accordance with Applicable Laws and Regulations or upon some other mutually agreed upon methodology. If the issue of such compensation or allocation cannot be resolved through such negotiations, it shall be submitted to FERC for resolution.

9.10 Disturbance Analysis Data Exchange. The Parties will cooperate with one another in the analysis of disturbances to either the Large Generating Facility or the CAISO Controlled Grid by gathering and providing access to any information relating to any disturbance, including information from oscillography, protective relay targets, breaker operations and sequence of events records, and any disturbance information required by Good Utility Practice.

ARTICLE 10. MAINTENANCE

10.1 Participating TO Obligations. The Participating TO shall maintain the Participating TO's Transmission System and the Participating TO's Interconnection Facilities in a safe and reliable manner and in accordance with this LGIA.

10.2 Interconnection Customer Obligations. The Interconnection Customer shall maintain the Large Generating Facility and the Interconnection Customer's Interconnection Facilities in a safe and reliable manner and in accordance with this LGIA.

10.3 Coordination. The Parties shall confer regularly to coordinate the planning, scheduling and performance of preventive and corrective maintenance on the Large Generating Facility and the Interconnection Facilities.

10.4 Secondary Systems. The Participating TO and Interconnection Customer shall cooperate with the other Parties in the inspection, maintenance, and testing of control or power circuits that operate below 600 volts, AC or DC, including, but not limited to, any hardware, control or protective devices, cables, conductors, electric raceways, secondary equipment panels, transducers, batteries, chargers, and voltage and current transformers that directly affect the operation of a Party's facilities and equipment which may reasonably be expected to impact the other Parties. Each Party shall provide advance notice to the other Parties before undertaking any work on such circuits, especially on electrical circuits involving circuit breaker trip and close contacts, current transformers, or potential transformers.

10.5 Operating and Maintenance Expenses. Subject to the provisions herein addressing the use of facilities by others, and except for operations and maintenance expenses associated with modifications made for providing interconnection or transmission service to a third party and such third party pays for such expenses, the Interconnection Customer shall be responsible for all reasonable expenses including overheads, associated with: (1) owning, operating, maintaining, repairing, and replacing the Interconnection Customer's Interconnection Facilities; and (2) operation, maintenance, repair and replacement of the Participating TO's Interconnection Facilities.

ARTICLE 11. PERFORMANCE OBLIGATION

11.1 Interconnection Customer's Interconnection Facilities. The Interconnection Customer shall design, procure, construct, install, own and/or control the Interconnection Customer's Interconnection Facilities described in Appendix A at its sole expense.

11.2 Participating TO's Interconnection Facilities. The Participating TO shall design, procure, construct, install, own and/or control the Participating TO's Interconnection Facilities described in Appendix A at the sole expense of the Interconnection Customer. Unless the Participating TO elects to fund the capital for the Participating TO's Interconnection Facilities, they shall be solely funded by the Interconnection Customer.

11.3 Network Upgrades and Distribution Upgrades. The Participating TO shall design, procure, construct, install, and own the Network Upgrades and Distribution Upgrades described in Appendix A. The Interconnection Customer shall be responsible for all costs related to Distribution Upgrades. Unless the Participating TO elects to fund the capital for the Distribution Upgrades and Network Upgrades, they shall be funded by the Interconnection Customer in an amount determined pursuant to the methodology set forth in Section 13 of the LGIP. This specific amount is set forth in Appendix G to this LGIA.

11.4 Transmission Credits. No later than thirty (30) Calendar Days prior to the Commercial Operation Date, the Interconnection Customer may make a one-time election by written notice to the CAISO and the Participating TO to receive Congestion Revenue Rights as defined in and as available under the CAISO Tariff at the time of the election in accordance with the CAISO Tariff, in lieu of a refund of the cost of Network Upgrades in accordance with Article 11.4.1.

11.4.1 Repayment of Amounts Advanced for Network Upgrades. Upon the Commercial Operation Date, the Interconnection Customer shall be entitled to a repayment, equal to the total amount paid to the Participating TO for the costs of Network Upgrades for which it is responsible, as set forth in Appendix G. Such amount shall include any tax gross-up or other tax-related payments associated with Network Upgrades not refunded to the Interconnection Customer pursuant to Article 5.17.8 or otherwise, and shall be paid to the Interconnection Customer by the Participating TO on a dollar-for-dollar basis either through (1) direct payments made on a levelized basis over the five-year period commencing on the Commercial Operation Date; or (2) any alternative payment schedule that is mutually agreeable to the Interconnection Customer and Participating TO, provided that such amount is paid within five (5) years from the Commercial Operation Date. Notwithstanding the foregoing, if this LGIA terminates within five (5) years from the Commercial Operation Date, the Participating TO's obligation to pay refunds to the Interconnection Customer shall cease as of the date of termination. Any repayment shall include interest calculated in accordance with the methodology set forth in FERC's regulations at 18 C.F.R. §35.19a(a)(2)(iii) from the date of any payment for Network Upgrades through the date on which the Interconnection Customer receives a repayment of such payment. Interest shall continue to accrue on the repayment obligation so long as this LGIA is in effect. The Interconnection Customer may assign such repayment rights to any person.

If the Large Generating Facility fails to achieve Commercial Operation, but it or another Generating Facility is later constructed and makes use of the Network Upgrades, the Participating TO shall at that time reimburse Interconnection Customer for the amounts advanced for the Network Upgrades. Before any such reimbursement can occur, the Interconnection Customer, or the entity that ultimately constructs the Generating Facility, if different, is responsible for identifying and demonstrating to the Participating TO the appropriate entity to which reimbursement must be made in order to implement the intent of this reimbursement obligation.

11.4.2 Special Provisions for Affected Systems. The Interconnection Customer shall enter into an agreement with the owner of the Affected System and/or other affected owners of portions of the CAISO Controlled Grid, as applicable, in accordance with the LGIP. Such agreement shall specify the terms governing payments to be made by the Interconnection Customer to the owner of the Affected System and/or other affected owners of portions of the CAISO Controlled Grid as well as the repayment by the owner of the Affected System and/or other affected owners of portions of the CAISO Controlled Grid. In no event shall the Participating TO be responsible for the repayment for any facilities that are not part of the Participating TO's Transmission System. In the event the Participating TO is a joint owner with an Affected System or with any other co-owner of a facility affected by the Large Generating Facility, the Participating TO's obligation to reimburse the Interconnection Customer for payments made to address the impacts of the Large Generating Facility on the system shall not exceed the proportionate amount of the cost of any upgrades attributable to the proportion of the jointly-owned facility owned by the Participating TO.

11.4.3 Notwithstanding any other provision of this LGIA, nothing herein shall be construed as relinquishing or foreclosing any rights, including but not limited to firm transmission rights, capacity rights, Congestion Revenue Rights, or transmission credits, that the Interconnection Customer shall be entitled to, now or in the future under any other agreement or tariff as a result of, or otherwise associated with, the transmission capacity, if any, created by the Network Upgrades, including the right to obtain cash reimbursements, merchant transmission Congestion Revenue Rights in accordance with Section 36.11 of the CAISO Tariff, or transmission credits for transmission service that is not associated with the Large Generating Facility.

11.5 Provision of Interconnection Financial Security. The Interconnection Customer is obligated to provide all necessary Interconnection Financial Security required under Section 9 of the LGIP in a manner acceptable under Section 9 of the LGIP. Failure to satisfy the LGIP's requirements for the provision of Interconnection Financial Security shall result in the Interconnection Request being deemed withdrawn and subject to LGIP Section 3.8.

11.6 Interconnection Customer Compensation. If the CAISO requests or directs the Interconnection Customer to provide a service pursuant to Articles 9.6.3 (Payment for Reactive Power) or 13.5.1 of this LGIA, the CAISO shall compensate the Interconnection Customer in accordance with the CAISO Tariff.

11.6.1 Interconnection Customer Compensation for Actions During Emergency Condition. The CAISO shall compensate the Interconnection Customer in accordance with the CAISO Tariff for its provision of real and reactive power and other Emergency Condition services that the Interconnection Customer provides to support the CAISO Controlled Grid during an Emergency Condition in accordance with Article 11.6.

ARTICLE 12. INVOICE

12.1 General. The Participating TO shall submit to the Interconnection Customer, on a monthly basis, invoices of amounts due pursuant to this LGIA for the preceding month. Each invoice shall state the month to which the invoice applies and fully describe the services and equipment provided. The Parties may discharge mutual debts and payment obligations due and owing to each other on the same date through netting, in which case all amounts a Party owes to the other Party under this LGIA, including interest payments or credits, shall be netted so that only the net amount remaining due shall be paid by the owing Party. Notwithstanding the foregoing, any invoices between the CAISO and another Party shall be submitted and paid in accordance with the CAISO Tariff.

12.2 Final Invoice. As soon as reasonably practicable, but within twelve months after completion of the construction of the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades, the Participating TO shall provide an invoice of the final cost of the construction of the Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades, and shall set forth such costs in sufficient detail to enable the Interconnection Customer to compare the actual costs with the estimates and to ascertain deviations, if any, from the cost estimates. With respect to costs associated with the Participating TO's Interconnection Facilities and Distribution Upgrades, the Participating TO shall refund to the Interconnection Customer any amount by which the actual payment by the Interconnection Customer for estimated costs exceeds the actual costs of construction within thirty (30) Calendar Days of the issuance of such final construction invoice; or, in the event the actual costs of construction exceed the Interconnection Customer's actual payment for estimated costs, then the Interconnection Customer shall pay to the Participating TO any amount by which the actual costs of construction exceed the actual payment by the Interconnection Customer for estimated costs within thirty (30) Calendar Days of the issuance of such final construction invoice. With respect to costs associated with Network Upgrades, the Participating TO shall refund to the Interconnection Customer any amount by which the actual payment by the Interconnection Customer for estimated costs exceeds the actual costs of construction multiplied by the Interconnection Customer's percentage share of those costs, as set forth in Appendix G to this LGIA within thirty (30) Calendar Days of the issuance of such final construction invoice. In the event the actual costs of construction multiplied by the Interconnection Customer's percentage share of those costs exceed the Interconnection Customer's actual payment for estimated costs, then the Participating TO shall recover such difference through its transmission service rates.

12.3 Payment. Invoices shall be rendered to the Interconnection Customer at the address specified in Appendix F. The Interconnection Customer shall pay, or Participating TO shall refund, the amounts due within thirty (30) Calendar Days of the Interconnection Customer's receipt of the invoice. All payments shall be made in immediately available funds payable to the Interconnection Customer or Participating TO, or by wire transfer to a bank named and account designated by the invoicing Interconnection Customer or Participating TO. Payment of invoices by any Party will not constitute a waiver of any rights or claims any Party may have under this LGIA.

12.4 Disputes. In the event of a billing dispute between the Interconnection Customer and the Participating TO, the Participating TO and the CAISO shall continue to provide Interconnection Service under this LGIA as long as the Interconnection Customer: (i) continues to make all payments not in dispute; and (ii) pays to the Participating TO or into an independent escrow account the portion of the invoice in dispute, pending resolution of such dispute. If the Interconnection Customer fails to meet these two requirements for continuation of service, then the Participating TO may provide notice to the Interconnection Customer of a Default pursuant to Article 17. Within thirty (30) Calendar Days after the resolution of the dispute, the Party that owes money to the other Party shall pay the amount due with interest calculated in accordance with the methodology set forth in FERC's Regulations at 18 C.F.R. § 35.19a(a)(2)(iii). Notwithstanding the foregoing, any billing dispute between the CAISO and another Party shall be resolved in accordance with the provisions of Article 27 of this LGIA.

ARTICLE 13. EMERGENCIES

13.1 [Reserved]

13.2 Obligations. Each Party shall comply with the Emergency Condition procedures of the CAISO, NERC, the Applicable Reliability Council, Applicable Reliability Standards, Applicable Laws and Regulations, and any emergency procedures set forth in this LGIA.

13.3 Notice. The Participating TO or the CAISO shall notify the Interconnection Customer promptly when it becomes aware of an Emergency Condition that affects the Participating TO's Interconnection Facilities or Distribution System or the CAISO Controlled Grid, respectively, that may reasonably be expected to affect the Interconnection Customer's operation of the Large Generating Facility or the Interconnection Customer's Interconnection Facilities. The Interconnection Customer shall notify the Participating TO and the CAISO promptly when it becomes aware of an Emergency Condition that affects the Large Generating Facility or the Interconnection Customer's Interconnection Facilities that may reasonably be expected to affect the CAISO Controlled Grid or the Participating TO's Interconnection Facilities. To the extent information is known, the notification shall describe the Emergency Condition, the extent of the damage or deficiency, the expected effect on the operation of the Interconnection Customer's or Participating TO's facilities and operations, its anticipated duration and the corrective action taken and/or to be taken. The initial notice shall be followed as soon as practicable with written notice, if requested by a Party, which may be provided by electronic mail or facsimile, or in the case of the CAISO may be publicly posted on the CAISO's internet web site.

13.4 Immediate Action. Unless, in the Interconnection Customer's reasonable judgment, immediate action is required, the Interconnection Customer shall obtain the consent of the CAISO and the Participating TO, such consent to not be unreasonably withheld, prior to performing any manual switching operations at the Large Generating Facility or the Interconnection Customer's Interconnection Facilities in response to an Emergency Condition declared by the Participating TO or CAISO or in response to any other emergency condition.

13.5 CAISO and Participating TO Authority.

13.5.1 General. The CAISO and Participating TO may take whatever actions or inactions, including issuance of dispatch instructions, with regard to the CAISO Controlled Grid or the Participating TO's Interconnection Facilities or Distribution System they deem necessary during an Emergency Condition in order to (i) preserve public health and safety, (ii) preserve the reliability of the CAISO Controlled Grid or the Participating TO's Interconnection Facilities or Distribution System, and (iii) limit or prevent damage, and (iv) expedite restoration of service.

The Participating TO and the CAISO shall use Reasonable Efforts to minimize the effect of such actions or inactions on the Large Generating Facility or the Interconnection Customer's Interconnection Facilities. The Participating TO or the CAISO may, on the basis of technical considerations, require the Large Generating Facility to mitigate an Emergency Condition by taking actions necessary and limited in scope to remedy the Emergency Condition, including, but not limited to, directing the Interconnection Customer to shut-down, start-up, increase or decrease the real or reactive power output of the Large Generating Facility; implementing a reduction or disconnection pursuant to Article 13.5.2; directing the Interconnection Customer to assist with black start (if available) or restoration efforts; or altering the outage schedules of the Large Generating Facility and the Interconnection Customer's Interconnection Facilities. Interconnection Customer shall comply with all of the CAISO's and Participating TO's operating instructions concerning Large Generating Facility real power and reactive power output within the manufacturer's design limitations of the Large Generating Facility's equipment that is in service and physically available for operation at the time, in compliance with Applicable Laws and Regulations.

13.5.2 Reduction and Disconnection. The Participating TO or the CAISO may reduce Interconnection Service or disconnect the Large Generating Facility or the Interconnection Customer's Interconnection Facilities when such reduction or disconnection is necessary under Good Utility Practice due to Emergency Conditions. These rights are separate and distinct from any right of curtailment of the CAISO pursuant to the CAISO Tariff. When the CAISO or Participating TO can schedule the reduction or disconnection in advance, the CAISO or Participating TO shall notify the Interconnection Customer of the reasons, timing and expected duration of the reduction or disconnection. The CAISO or Participating TO shall coordinate with the Interconnection Customer using Good Utility Practice to schedule the reduction or disconnection during periods of least impact to the Interconnection Customer and the CAISO and Participating TO. Any reduction or disconnection shall continue only for so long as reasonably necessary under Good Utility Practice. The Parties shall cooperate with each other to restore the Large Generating Facility, the Interconnection Facilities, and the CAISO Controlled Grid to their normal operating state as soon as practicable consistent with Good Utility Practice.

13.6 Interconnection Customer Authority. Consistent with Good Utility Practice, this LGIA, and the CAISO Tariff, the Interconnection Customer may take actions or inactions with regard to the Large Generating Facility or the Interconnection Customer's Interconnection Facilities during an Emergency Condition in order to (i) preserve public health and safety, (ii) preserve the reliability of the Large Generating Facility or the Interconnection Customer's Interconnection Facilities, (iii) limit or prevent damage, and (iv) expedite restoration of service. Interconnection Customer shall use Reasonable Efforts to minimize the effect of such actions or inactions on the CAISO Controlled Grid and the Participating TO's Interconnection Facilities. The CAISO and Participating TO shall use Reasonable Efforts to assist Interconnection Customer in such actions.

13.7 Limited Liability. Except as otherwise provided in Article 11.6.1 of this LGIA, no Party shall be liable to any other Party for any action it takes in responding to an Emergency Condition so long as such action is made in good faith and is consistent with Good Utility Practice.

ARTICLE 14. REGULATORY REQUIREMENTS AND GOVERNING LAW

14.1 Regulatory Requirements. Each Party's obligations under this LGIA shall be subject to its receipt of any required approval or certificate from one or more Governmental Authorities in the form and substance satisfactory to the applying Party, or the Party making any required filings with, or providing notice to, such Governmental Authorities, and the expiration of any time period associated therewith. Each Party shall in good faith seek and use its Reasonable Efforts to obtain such other approvals. Nothing in this LGIA shall require the Interconnection Customer to take any action that could result in its inability to obtain, or its loss of, status or exemption under the Federal Power Act or the Public Utility Holding Company Act of 1935, as amended, or the Public Utility Regulatory Policies Act of 1978, or the Energy Policy Act of 2005.

14.2 Governing Law.

14.2.1 The validity, interpretation and performance of this LGIA and each of its provisions shall be governed by the laws of the state where the Point of Interconnection is located, without regard to its conflicts of law principles.

14.2.2 This LGIA is subject to all Applicable Laws and Regulations.

14.2.3 Each Party expressly reserves the right to seek changes in, appeal, or otherwise contest any laws, orders, rules, or regulations of a Governmental Authority.

ARTICLE 15. NOTICES

15.1 General. Unless otherwise provided in this LGIA, any notice, demand or request required or permitted to be given by a Party to another and any instrument required or permitted to be tendered or delivered by a Party in writing to another shall be effective when delivered and may be so given, tendered or delivered, by recognized national courier, or by depositing the same with the United States Postal Service with postage prepaid, for delivery by certified or registered mail, addressed to the Party, or personally delivered to the Party, at the address set out in Appendix F, Addresses for Delivery of Notices and Billings.

A Party must update the information in Appendix F as information changes. A Party may change the notice information in this LGIA by giving five (5) Business Days written notice prior to the effective date of the change. Such changes shall not constitute an amendment to this LGIA.

15.2 Billings and Payments. Billings and payments shall be sent to the addresses set out in Appendix F.

15.3 Alternative Forms of Notice. Any notice or request required or permitted to be given by a Party to another and not required by this LGIA to be given in writing may be so given by telephone, facsimile or e-mail to the telephone numbers and e-mail addresses set out in Appendix F.

15.4 Operations and Maintenance Notice. Each Party shall notify the other Parties in writing of the identity of the person(s) that it designates as the point(s) of contact with respect to the implementation of Articles 9 and 10.

ARTICLE 16. FORCE MAJEURE

16.1 Force Majeure.

16.1.1 Economic hardship is not considered a Force Majeure event.

16.1.2 No Party shall be considered to be in Default with respect to any obligation hereunder, (including obligations under Article 4), other than the obligation to pay money when due, if prevented from fulfilling such obligation by Force Majeure. A Party unable to fulfill any obligation hereunder (other than an obligation to pay money when due) by reason of Force Majeure shall give notice and the full particulars of such Force Majeure to the other Party in writing or by telephone as soon as reasonably possible after the occurrence of the cause relied upon. Telephone notices given pursuant to this Article shall be confirmed in writing as soon as reasonably possible and shall specifically state full particulars of the Force Majeure, the time and date when the Force Majeure occurred and when the Force Majeure is reasonably expected to cease. The Party affected shall exercise due diligence to remove such disability with reasonable dispatch, but shall not be required to accede or agree to any provision not satisfactory to it in order to settle and terminate a strike or other labor disturbance.

ARTICLE 17. DEFAULT

17.1 Default.

17.1.1 General. No Default shall exist where such failure to discharge an obligation (other than the payment of money) is the result of Force Majeure as defined in this LGIA or the result of an act or omission of the other Party. Upon a Breach, the affected non-Breaching Party(ies) shall give written notice of such Breach to the Breaching Party. Except as provided in Article 17.1.2, the Breaching Party shall have thirty (30) Calendar Days from receipt of the Default notice within which to cure such Breach; provided however, if such Breach is not capable of cure within thirty (30) Calendar Days, the Breaching Party shall commence such cure within thirty (30) Calendar Days after notice and continuously and diligently complete such cure within ninety (90) Calendar Days from receipt of the Default notice; and, if cured within such time, the Breach specified in such notice shall cease to exist.

17.1.2 Right to Terminate. If a Breach is not cured as provided in this Article, or if a Breach is not capable of being cured within the period provided for herein, the affected non-Breaching Party(ies) shall have the right to declare a Default and terminate this LGIA by written notice at any time until cure occurs, and be relieved of any further obligation hereunder and, whether or not such Party(ies) terminates this LGIA, to recover from the Breaching Party all amounts due hereunder, plus all other damages and remedies to which it is entitled at law or in equity. The provisions of this Article will survive termination of this LGIA.

ARTICLE 18. INDEMNITY, CONSEQUENTIAL DAMAGES AND INSURANCE

18.1 Indemnity. Each Party shall at all times indemnify, defend, and hold the other Parties harmless from, any and all Losses arising out of or resulting from another Party's action or inactions of its obligations under this LGIA on behalf of the indemnifying Party, except in cases of gross negligence or intentional wrongdoing by the Indemnified Party.

18.1.1 Indemnified Party. If an Indemnified Party is entitled to indemnification under this Article 18 as a result of a claim by a third party, and the Indemnifying Party fails, after notice and reasonable opportunity to proceed under Article 18.1, to assume the defense of such claim, such Indemnified Party may at the expense of the Indemnifying Party contest, settle or consent to the entry of any judgment with respect to, or pay in full, such claim.

18.1.2 Indemnifying Party. If an Indemnifying Party is obligated to indemnify and hold any Indemnified Party harmless under this Article 18, the amount owing to the Indemnified Party shall be the amount of such Indemnified Party's actual Loss, net of any insurance or other recovery.

18.1.3 Indemnity Procedures. Promptly after receipt by an Indemnified Party of any claim or notice of the commencement of any action or administrative or legal proceeding or investigation as to which the indemnity provided for in Article 18.1 may apply, the Indemnified Party shall notify the Indemnifying Party of such fact. Any failure of or delay in such notification shall not affect a Party's indemnification obligation unless such failure or delay is materially prejudicial to the indemnifying Party.

The Indemnifying Party shall have the right to assume the defense thereof with counsel designated by such Indemnifying Party and reasonably satisfactory to the Indemnified Party. If the defendants in any such action include one or more Indemnified Parties and the Indemnifying Party and if the Indemnified Party reasonably concludes that there may be legal defenses available to it and/or other Indemnified Parties which are different from or additional to those available to the Indemnifying Party, the Indemnified Party shall have the right to select separate counsel to assert such legal defenses and to otherwise participate in the defense of such action on its own behalf. In such instances, the Indemnifying Party shall only be required to pay the fees and expenses of one additional attorney to represent an Indemnified Party or Indemnified Parties having such differing or additional legal defenses.

The Indemnified Party shall be entitled, at its expense, to participate in any such action, suit or proceeding, the defense of which has been assumed by the Indemnifying Party.

Notwithstanding the foregoing, the Indemnifying Party (i) shall not be entitled to assume and control the defense of any such action, suit or proceedings if and to the extent that, in the opinion of the Indemnified Party and its counsel, such action, suit or proceeding involves the potential imposition of criminal liability on the Indemnified Party, or there exists a conflict or adversity of interest between the Indemnified Party and the Indemnifying Party, in such event the Indemnifying Party shall pay the reasonable expenses of the Indemnified Party, and (ii) shall not settle or consent to the entry of any judgment in any action, suit or proceeding without the consent of the Indemnified Party, which shall not be unreasonably withheld, conditioned or delayed.

18.2 Consequential Damages. Other than the liquidated damages heretofore described in Article 5.3, in no event shall any Party be liable under any provision of this LGIA for any losses, damages, costs or expenses for any special, indirect, incidental, consequential, or punitive damages, including but not limited to loss of profit or revenue, loss of the use of equipment, cost of capital, cost of temporary equipment or services, whether based in whole or in part in contract, in tort, including negligence, strict liability, or any other theory of liability; provided, however, that damages for which a Party may be liable to another Party under another agreement will not be considered to be special, indirect, incidental, or consequential damages hereunder.

18.3 Insurance. Each Party shall, at its own expense, maintain in force throughout the period of this LGIA, and until released by the other Parties, the following minimum insurance coverages, with insurers rated no less than A- (with a minimum size rating of VII) by Bests' Insurance Guide and Key Ratings and authorized to do business in the state where the Point of Interconnection is located, except in the case of the CAISO, the State of California:

18.3.1 Employer's Liability and Workers' Compensation Insurance providing statutory benefits in accordance with the laws and regulations of the state in which the Point of Interconnection is located, except in the case of the CAISO, the State of California.

18.3.2 Commercial General Liability Insurance including premises and operations, personal injury, broad form property damage, broad form blanket contractual liability coverage (including coverage for the contractual indemnification) products and completed operations coverage, coverage for explosion, collapse and underground hazards, independent contractors coverage, coverage for pollution to the extent normally available and punitive damages to the extent normally available and a cross liability endorsement, with minimum limits of One Million Dollars ($1,000,000) per occurrence/One Million Dollars ($1,000,000) aggregate combined single limit for personal injury, bodily injury, including death and property damage.

18.3.3 Business Automobile Liability Insurance for coverage of owned and non-owned and hired vehicles, trailers or semi-trailers designed for travel on public roads, with a minimum, combined single limit of One Million Dollars ($1,000,000) per occurrence for bodily injury, including death, and property damage.

18.3.4 Excess Public Liability Insurance over and above the Employer's Liability Commercial General Liability and Business Automobile Liability Insurance coverage, with a minimum combined single limit of Twenty Million Dollars ($20,000,000) per occurrence/Twenty Million Dollars ($20,000,000) aggregate.

18.3.5 The Commercial General Liability Insurance, Business Automobile Insurance and Excess Public Liability Insurance policies shall name the other Parties, their parents, associated and Affiliate companies and their respective directors, officers, agents, servants and employees ("Other Party Group") as additional insured. All policies shall contain provisions whereby the insurers waive all rights of subrogation in accordance with the provisions of this LGIA against the Other Party Group and provide thirty (30)

Calendar Days advance written notice to the Other Party Group prior to anniversary date of cancellation or any material change in coverage or condition.

18.3.6 The Commercial General Liability Insurance, Business Automobile Liability Insurance and Excess Public Liability Insurance policies shall contain provisions that specify that the policies are primary and shall apply to such extent without consideration for other policies separately carried and shall state that each insured is provided coverage as though a separate policy had been issued to each, except the insurer's liability shall not be increased beyond the amount for which the insurer would have been liable had only one insured been covered. Each Party shall be responsible for its respective deductibles or retentions.

18.3.7 The Commercial General Liability Insurance, Business Automobile Liability Insurance and Excess Public Liability Insurance policies, if written on a Claims First Made Basis, shall be maintained in full force and effect for two (2) years after termination of this LGIA, which coverage may be in the form of tail coverage or extended reporting period coverage if agreed by the Parties.

18.3.8 The requirements contained herein as to the types and limits of all insurance to be maintained by the Parties are not intended to and shall not in any manner, limit or qualify the liabilities and obligations assumed by the Parties under this LGIA.

18.3.9 Within ten (10) Calendar Days following execution of this LGIA, and as soon as practicable after the end of each fiscal year or at the renewal of the insurance policy and in any event within ninety (90) Calendar Days thereafter, each Party shall provide certification of all insurance required in this LGIA, executed by each insurer or by an authorized representative of each insurer.

18.3.10 Notwithstanding the foregoing, each Party may self-insure to meet the minimum insurance requirements of Articles 18.3.2 through 18.3.8 to the extent it maintains a self-insurance program; provided that, such Party's senior unsecured debt or issuer rating is BBB-, or better, as rated by Standard & Poor's and that its self-insurance program meets the minimum insurance requirements of Articles 18.3.2 through 18.3.8. For any period of time that a Party's senior unsecured debt rating and issuer rating are both unrated by Standard & Poor's or are both rated at less than BBB- by Standard & Poor's, such Party shall comply with the insurance requirements applicable to it under Articles 18.3.2 through 18.3.9. In the event that a Party is permitted to self-insure pursuant to this Article 18.3.10, it shall notify the other Parties that it meets the requirements to self-insure and that its self-insurance program meets the minimum insurance requirements in a manner consistent with that specified in Article 18.3.9.

18.3.11 The Parties agree to report to each other in writing as soon as practical all accidents or occurrences resulting in injuries to any person, including death, and any property damage arising out of this LGIA.

ARTICLE 19. ASSIGNMENT

19.1 Assignment. This LGIA may be assigned by a Party only with the written consent of the other Parties; provided that a Party may assign this LGIA without the consent of the other Parties to any Affiliate of the assigning Party with an equal or greater credit rating and with the legal authority and operational ability to satisfy the obligations of the assigning Party under this LGIA; and provided further that the Interconnection Customer shall have the right to assign this LGIA, without the consent of the CAISO or Participating TO, for collateral security purposes to aid in providing financing for the Large Generating Facility, provided that the Interconnection Customer will promptly notify the CAISO and Participating TO of any such assignment. Any financing arrangement entered into by the Interconnection Customer pursuant to this Article will provide that prior to or upon the exercise of the secured party's, trustee's or mortgagee's assignment rights pursuant to said arrangement, the secured creditor, the trustee or mortgagee will notify the CAISO and Participating TO of the date and particulars of any such exercise of assignment right(s), including providing the CAISO and Participating TO with proof that it meets the requirements of Articles 11.5 and 18.3. Any attempted assignment that violates this Article is void and ineffective. Any assignment under this LGIA shall not relieve a Party of its obligations, nor shall a Party's obligations be enlarged, in whole or in part, by reason thereof. Where required, consent to assignment will not be unreasonably withheld, conditioned or delayed.

ARTICLE 20. SEVERABILITY

20.1 Severability. If any provision in this LGIA is finally determined to be invalid, void or unenforceable by any court or other Governmental Authority having jurisdiction, such determination shall not invalidate, void or make unenforceable any other provision, agreement or covenant of this LGIA; provided that if the Interconnection Customer (or any third party, but only if such third party is not acting at the direction of the Participating TO or CAISO) seeks and obtains such a final determination with respect to any provision of the Alternate Option (Article 5.1.2), or the Negotiated Option (Article 5.1.4), then none of the provisions of Article 5.1.2 or 5.1.4 shall thereafter have any force or effect and the Parties' rights and obligations shall be governed solely by the Standard Option (Article 5.1.1).

ARTICLE 21. COMPARABILITY

21.1 Comparability. The Parties will comply with all applicable comparability and code of conduct laws, rules and regulations, as amended from time to time.

ARTICLE 22. CONFIDENTIALITY

22.1 Confidentiality. Confidential Information shall include, without limitation, all information relating to a Party's technology, research and development, business affairs, and pricing, and any information supplied by any of the Parties to the other Parties prior to the execution of this LGIA.

Information is Confidential Information only if it is clearly designated or marked in writing as confidential on the face of the document, or, if the information is conveyed orally or by inspection, if the Party providing the information orally informs the Parties receiving the information that the information is confidential.

If requested by any Party, the other Parties shall provide in writing, the basis for asserting that the information referred to in this Article 22 warrants confidential treatment, and the requesting Party may disclose such writing to the appropriate Governmental Authority. Each Party shall be responsible for the costs associated with affording confidential treatment to its information.

22.1.1 Term. During the term of this LGIA, and for a period of three (3) years after the expiration or termination of this LGIA, except as otherwise provided in this Article 22, each Party shall hold in confidence and shall not disclose to any person Confidential Information.

22.1.2 Scope. Confidential Information shall not include information that the receiving Party can demonstrate: (1) is generally available to the public other than as a result of a disclosure by the receiving Party; (2) was in the lawful possession of the receiving Party on a non-confidential basis before receiving it from the disclosing Party; (3) was supplied to the receiving Party without restriction by a third party, who, to the knowledge of the receiving Party after due inquiry, was under no obligation to the disclosing Party to keep such information confidential; (4) was independently developed by the receiving Party without reference to Confidential Information of the disclosing Party; (5) is, or becomes, publicly known, through no wrongful act or omission of the receiving Party or Breach of this LGIA; or (6) is required, in accordance with Article 22.1.7 of this LGIA, Order of

Disclosure, to be disclosed by any Governmental Authority or is otherwise required to be disclosed by law or subpoena, or is necessary in any legal proceeding establishing rights and obligations under this LGIA. Information designated as Confidential Information will no longer be deemed confidential if the Party that designated the information as confidential notifies the other Parties that it no longer is confidential.

22.1.3 Release of Confidential Information. No Party shall release or disclose Confidential Information to any other person, except to its employees, consultants, Affiliates (limited by the Standards of Conduct requirements set forth in Part 358 of FERC's Regulations, 18 C.F.R. 358), subcontractors, or to parties who may be or considering providing financing to or equity participation with the Interconnection Customer, or to potential purchasers or assignees of the Interconnection Customer, on a need-to-know basis in connection with this LGIA, unless such person has first been advised of the confidentiality provisions of this Article 22 and has agreed to comply with such provisions. Notwithstanding the foregoing, a Party providing Confidential Information to any person shall remain primarily responsible for any release of Confidential Information in contravention of this Article 22.

22.1.4 Rights. Each Party retains all rights, title, and interest in the Confidential Information that each Party discloses to the other Parties. The disclosure by each Party to the other Parties of Confidential Information shall not be deemed a waiver by a Party or any other person or entity of the right to protect the Confidential Information from public disclosure.

22.1.5 No Warranties. The mere fact that a Party has provided Confidential Information does not constitute a warranty or representation as to its accuracy or completeness. In addition, by supplying Confidential Information, no Party obligates itself to provide any particular information or Confidential Information to the other Parties nor to enter into any further agreements or proceed with any other relationship or joint venture.

22.1.6 Standard of Care. Each Party shall use at least the same standard of care to protect Confidential Information it receives as it uses to protect its own Confidential Information from unauthorized disclosure, publication or dissemination. Each Party may use Confidential Information solely to fulfill its obligations to the other Parties under this LGIA or its regulatory requirements.

22.1.7 Order of Disclosure. If a court or a Government Authority or entity with the right, power, and apparent authority to do so requests or requires any Party, by subpoena, oral deposition, interrogatories, requests for production of documents, administrative order, or otherwise, to disclose Confidential Information, that Party shall provide the other Parties with prompt notice of such request(s) or requirement(s) so that the other Parties may seek an appropriate protective order or waive compliance with the terms of this LGIA. Notwithstanding the absence of a protective order or waiver, the Party may disclose such Confidential Information which, in the opinion of its counsel, the Party is legally compelled to disclose. Each Party will use Reasonable Efforts to obtain reliable assurance that confidential treatment will be accorded any Confidential Information so furnished.

22.1.8 Termination of Agreement. Upon termination of this LGIA for any reason, each Party shall, within ten (10) Calendar Days of receipt of a written request from another Party, use Reasonable Efforts to destroy, erase, or delete (with such destruction, erasure, and deletion certified in writing to the other Party) or return to the other Party, without retaining copies thereof, any and all written or electronic Confidential Information received from the other Party.

22.1.9 Remedies. The Parties agree that monetary damages would be inadequate to compensate a Party for another Party's Breach of its obligations under this Article 22. Each Party accordingly agrees that the other Parties shall be entitled to equitable relief, by way of injunction or otherwise, if the first Party Breaches or threatens to Breach its obligations under this Article 22, which equitable relief shall be granted without bond or proof of damages, and the receiving Party shall not plead in defense that there would be an adequate remedy at law. Such remedy shall not be deemed an exclusive remedy for the Breach of this Article 22, but shall be in addition to all other remedies available at law or in equity. The Parties further acknowledge and agree that the covenants contained herein are necessary for the protection of legitimate business interests and are reasonable in scope. No Party, however, shall be liable for indirect, incidental, or consequential or punitive damages of any nature or kind resulting from or arising in connection with this Article 22.

22.1.10 Disclosure to FERC, its Staff, or a State. Notwithstanding anything in this Article 22 to the contrary, and pursuant to 18 C.F.R. section 1b.20, if FERC or its staff, during the course of an investigation or otherwise, requests information from one of the Parties that is otherwise required to be maintained in confidence pursuant to this LGIA, the Party shall provide the requested information to FERC or its staff, within the time provided for in the request for information. In providing the information to FERC or its staff, the Party must, consistent with 18 C.F.R. section 388.112, request that the information be treated as confidential and non-public by FERC and its staff and that the information be withheld from public disclosure. Parties are prohibited from notifying the other Parties to this LGIA prior to the release of the Confidential Information to FERC or its staff. The Party shall notify the other Parties to the LGIA when it is notified by FERC or its staff that a request to release Confidential Information has been received by FERC, at which time any of the Parties may respond before such information would be made public, pursuant to 18 C.F.R. section 388.112. Requests from a state regulatory body conducting a confidential investigation shall be treated in a similar manner if consistent with the applicable state rules and regulations.

22.1.11 Subject to the exception in Article 22.1.10, Confidential Information shall not be disclosed by the other Parties to any person not employed or retained by the other Parties, except to the extent disclosure is (i) required by law; (ii) reasonably deemed by the disclosing Party to be required to be disclosed in connection with a dispute between or among the Parties, or the defense of litigation or dispute; (iii) otherwise permitted by consent of the other Parties, such consent not to be unreasonably withheld; or (iv) necessary to fulfill its obligations under this LGIA or as a transmission service provider or a Balancing Authority including disclosing the Confidential Information to an RTO or ISO or to a regional or national reliability organization. The Party asserting confidentiality shall notify the other Parties in writing of the information it claims is confidential. Prior to any disclosures of another Party’s Confidential Information under this subparagraph, or if any third party or Governmental Authority makes any request or demand for any of the information described in this subparagraph, the disclosing Party agrees to promptly notify the other Party in writing and agrees to assert confidentiality and cooperate with the other Party in seeking to protect the Confidential Information from public disclosure by confidentiality agreement, protective order or other reasonable measures.

ARTICLE 23. ENVIRONMENTAL RELEASES

23.1 Each Party shall notify the other Parties, first orally and then in writing, of the release of any Hazardous Substances, any asbestos or lead abatement activities, or any type of remediation activities related to the Large Generating Facility or the Interconnection Facilities, each of which may reasonably be expected to affect the other Parties. The notifying Party shall: (i) provide the notice as soon as practicable, provided such Party makes a good faith effort to provide the notice no later than twenty-four hours after such Party becomes aware of the occurrence; and (ii) promptly furnish to the other Parties copies of any publicly available reports filed with any Governmental Authorities addressing such events.

ARTICLE 24. INFORMATION REQUIREMENTS

24.1 Information Acquisition. The Participating TO and the Interconnection Customer shall submit specific information regarding the electrical characteristics of their respective facilities to each other as described below and in accordance with Applicable Reliability Standards.

24.2 Information Submission by Participating TO. The initial information submission by the Participating TO shall occur no later than one hundred eighty (180) Calendar Days prior to Trial Operation and shall include the Participating TO's Transmission System information necessary to allow the Interconnection Customer to select equipment and meet any system protection and stability requirements, unless otherwise agreed to by the Participating TO and the Interconnection Customer. On a monthly basis the Participating TO shall provide the Interconnection Customer and the CAISO a status report on the construction and installation of the Participating TO's Interconnection Facilities and Network Upgrades, including, but not limited to, the following information: (1) progress to date; (2) a description of the activities since the last report; (3) a description of the action items for the next period; and (4) the delivery status of equipment ordered.

24.3 Updated Information Submission by Interconnection Customer. The updated information submission by the Interconnection Customer, including manufacturer information, shall occur no later than one hundred eighty (180) Calendar Days prior to the Trial Operation. The Interconnection Customer shall submit a completed copy of the Electric Generating Unit data requirements contained in Appendix 1 to the LGIP. It shall also include any additional information provided to the Participating TO and the CAISO for the Interconnection Studies. Information in this submission shall be the most current Electric Generating Unit design or expected performance data. Information submitted for stability models shall be compatible with the Participating TO and CAISO standard models. If there is no compatible model, the Interconnection Customer will work with a consultant mutually agreed to by the Parties to develop and supply a standard model and associated information.

If the Interconnection Customer's data is materially different from what was originally provided to the Participating TO and the CAISO for the Interconnection Studies, then the Participating TO and the CAISO will conduct appropriate studies pursuant to the LGIP to determine the impact on the Participating TO's Transmission System and affected portions of the CAISO Controlled Grid based on the actual data submitted pursuant to this Article 24.3. The Interconnection Customer shall not begin Trial Operation until such studies are completed and all other requirements of this LGIA are satisfied.

24.4 Information Supplementation. Prior to the Trial Operation date, the Parties shall supplement their information submissions described above in this Article 24 with any and all "as-built" Electric Generating Unit information or "as-tested" performance information that differs from the initial submissions or, alternatively, written confirmation that no such differences exist. The Interconnection Customer shall conduct tests on the Electric Generating Unit as required by Good Utility Practice such as an open circuit "step voltage" test on the Electric Generating Unit to verify proper operation of the Electric Generating Unit's automatic voltage regulator.

Unless otherwise agreed, the test conditions shall include: (1) Electric Generating Unit at synchronous speed; (2) automatic voltage regulator on and in voltage control mode; and (3) a five percent (5 percent) change in Electric Generating Unit terminal voltage initiated by a change in the voltage regulators reference voltage. The Interconnection Customer shall provide validated test recordings showing the responses of Electric Generating Unit terminal and field voltages. In the event that direct recordings of these voltages is impractical, recordings of other voltages or currents that mirror the response of the Electric Generating Unit's terminal or field voltage are acceptable if information necessary to translate these alternate quantities to actual Electric Generating Unit terminal or field voltages is provided. Electric Generating Unit testing shall be conducted and results provided to the Participating TO and the CAISO for each individual Electric Generating Unit in a station.

Subsequent to the Commercial Operation Date, the Interconnection Customer shall provide the Participating TO and the CAISO any information changes due to equipment replacement, repair, or adjustment. The Participating TO shall provide the Interconnection Customer any information changes due to equipment replacement, repair or adjustment in the directly connected substation or any adjacent Participating TO-owned substation that may affect the Interconnection Customer's Interconnection Facilities equipment ratings, protection or operating requirements. The Parties shall provide such information pursuant to Article 5.19.

ARTICLE 25. INFORMATION ACCESS AND AUDIT RIGHTS

25.1 Information Access. Each Party (the "disclosing Party") shall make available to the other Party information that is in the possession of the disclosing Party and is necessary in order for the other Party to: (i) verify the costs incurred by the disclosing Party for which the other Party is responsible under this LGIA; and (ii) carry out its obligations and responsibilities under this LGIA. The Parties shall not use such information for purposes other than those set forth in this Article 25.1 and to enforce their rights under this LGIA. Nothing in this Article 25 shall obligate the CAISO to make available to a Party any third party information in its possession or control if making such third party information available would violate a CAISO Tariff restriction on the use or disclosure of such third party information.

25.2 Reporting of Non-Force Majeure Events. Each Party (the "notifying Party") shall notify the other Parties when the notifying Party becomes aware of its inability to comply with the provisions of this LGIA for a reason other than a Force Majeure event. The Parties agree to cooperate with each other and provide necessary information regarding such inability to comply, including the date, duration, reason for the inability to comply, and corrective actions taken or planned to be taken with respect to such inability to comply. Notwithstanding the foregoing, notification, cooperation or information provided under this Article shall not entitle the Party receiving such notification to allege a cause for anticipatory breach of this LGIA.

25.3 Audit Rights. Subject to the requirements of confidentiality under Article 22 of this LGIA, the Parties' audit rights shall include audits of a Party's costs pertaining to such Party's performance or satisfaction of obligations owed to the other Party under this LGIA, calculation of invoiced amounts, the CAISO's efforts to allocate responsibility for the provision of reactive support to the CAISO Controlled Grid, the CAISO's efforts to allocate responsibility for interruption or reduction of generation on the CAISO Controlled Grid, and each such Party's actions in an Emergency Condition.

25.3.1 The Interconnection Customer and the Participating TO shall each have the right, during normal business hours, and upon prior reasonable notice to the other Party, to audit at its own expense the other Party's accounts and records pertaining to either such Party's performance or either such Party's satisfaction of obligations owed to the other Party under this LGIA. Subject to Article 25.3.2, any audit authorized by this Article shall be performed at the offices where such accounts and records are maintained and shall be limited to those portions of such accounts and records that relate to each such Party's performance and satisfaction of obligations under this LGIA. Each such Party shall keep such accounts and records for a period equivalent to the audit rights periods described in Article 25.4.

25.3.2 Notwithstanding anything to the contrary in Article 25.3, each Party's rights to audit the CAISO's accounts and records shall be as set forth in Section 22.1 of the CAISO Tariff.

25.4 Audit Rights Periods.

25.4.1 Audit Rights Period for Construction-Related Accounts and Records. Accounts and records related to the design, engineering, procurement, and construction of Participating TO's Interconnection Facilities, Network Upgrades, and Distribution Upgrades constructed by the Participating TO shall be subject to audit for a period of twenty-four months following the Participating TO's issuance of a final invoice in accordance with Article 12.2. Accounts and records related to the design, engineering, procurement, and construction of Participating TO's Interconnection Facilities and/or Stand Alone Network Upgrades constructed by the Interconnection Customer shall be subject to audit and verification by the Participating TO and the CAISO for a period of twenty-four months following the Interconnection Customer's issuance of a final invoice in accordance with Article 5.2(8).

25.4.2 Audit Rights Period for All Other Accounts and Records. Accounts and records related to a Party's performance or satisfaction of all obligations under this LGIA other than those described in Article 25.4.1 shall be subject to audit as follows: (i) for an audit relating to cost obligations, the applicable audit rights period shall be twenty-four months after the auditing Party's receipt of an invoice giving rise to such cost obligations; and (ii) for an audit relating to all other obligations, the applicable audit rights period shall be twenty-four months after the event for which the audit is sought; provided that each Party's rights to audit the CAISO's accounts and records shall be as set forth in Section 22.1 of the CAISO Tariff.

25.5 Audit Results. If an audit by the Interconnection Customer or the Participating TO determines that an overpayment or an underpayment has occurred with respect to the other Party, a notice of such overpayment or underpayment shall be given to the other Party together with those records from the audit which supports such determination. The Party that is owed payment shall render an invoice to the other Party and such invoice shall be paid pursuant to Article 12 hereof.

25.5.1 Notwithstanding anything to the contrary in Article 25.5, the Interconnection Customer's and Participating TO's rights to audit the CAISO's accounts and records shall be as set forth in Section 22.1 of the CAISO Tariff, and the CAISO's process for remedying an overpayment or underpayment shall be as set forth in the CAISO Tariff.

ARTICLE 26. SUBCONTRACTORS

26.1 General. Nothing in this LGIA shall prevent a Party from utilizing the services of any subcontractor as it deems appropriate to perform its obligations under this LGIA; provided, however, that each Party shall require its subcontractors to comply with all applicable terms and conditions of this LGIA in providing such services and each Party shall remain primarily liable to the other Party for the performance of such subcontractor.

26.2 Responsibility of Principal. The creation of any subcontract relationship shall not relieve the hiring Party of any of its obligations under this LGIA. The hiring Party shall be fully responsible to the other Parties for the acts or omissions of any subcontractor the hiring Party hires as if no subcontract had been made; provided, however, that in no event shall the CAISO or Participating TO be liable for the actions or inactions of the Interconnection Customer or its subcontractors with respect to obligations of the Interconnection Customer under Article 5 of this LGIA. Any applicable obligation imposed by this LGIA upon the hiring Party shall be equally binding upon, and shall be construed as having application to, any subcontractor of such Party.

26.3 No Limitation by Insurance. The obligations under this Article 26 will not be limited in any way by any limitation of subcontractor's insurance.

ARTICLE 27. DISPUTES

All disputes arising out of or in connection with this LGIA whereby relief is sought by or from the CAISO shall be settled in accordance with the provisions of Article 13 of the CAISO Tariff, except that references to the CAISO Tariff in such Article 13 of the CAISO Tariff shall be read as references to this LGIA. Disputes arising out of or in connection with this LGIA not subject to provisions of Article 13 of the CAISO Tariff shall be resolved as follows:

27.1 Submission. In the event either Party has a dispute, or asserts a claim, that arises out of or in connection with this LGIA or its performance, such Party (the "disputing Party") shall provide the other Party with written notice of the dispute or claim ("Notice of Dispute"). Such dispute or claim shall be referred to a designated senior representative of each Party for resolution on an informal basis as promptly as practicable after receipt of the Notice of Dispute by the other Party. In the event the designated representatives are unable to resolve the claim or dispute through unassisted or assisted negotiations within thirty (30) Calendar Days of the other Party's receipt of the Notice of Dispute, such claim or dispute may, upon mutual agreement of the Parties, be submitted to arbitration and resolved in accordance with the arbitration procedures set forth below. In the event the Parties do not agree to submit such claim or dispute to arbitration, each Party may exercise whatever rights and remedies it may have in equity or at law consistent with the terms of this LGIA.

27.2 External Arbitration Procedures. Any arbitration initiated under this LGIA shall be conducted before a single neutral arbitrator appointed by the Parties. If the Parties fail to agree upon a single arbitrator within ten (10) Calendar Days of the submission of the dispute to arbitration, each Party shall choose one arbitrator who shall sit on a three-member arbitration panel. The two arbitrators so chosen shall within twenty (20) Calendar Days select a third arbitrator to chair the arbitration panel. In either case, the arbitrators shall be knowledgeable in electric utility matters, including electric transmission and bulk power issues, and shall not have any current or past substantial business or financial relationships with any party to the arbitration (except prior arbitration). The arbitrator(s) shall provide each of the Parties an opportunity to be heard and, except as otherwise provided herein, shall conduct the arbitration in accordance with the Commercial Arbitration Rules of the American Arbitration Association ("Arbitration Rules") and any applicable FERC regulations; provided, however, in the event of a conflict between the Arbitration Rules and the terms of this Article 27, the terms of this Article 27 shall prevail.

27.3 Arbitration Decisions. Unless otherwise agreed by the Parties, the arbitrator(s) shall render a decision within ninety (90) Calendar Days of appointment and shall notify the Parties in writing of such decision and the reasons therefor. The arbitrator(s) shall be authorized only to interpret and apply the provisions of this LGIA and shall have no power to modify or change any provision of this Agreement in any manner. The decision of the arbitrator(s) shall be final and binding upon the Parties, and judgment on the award may be entered in any court having jurisdiction. The decision of the arbitrator(s) may be appealed solely on the grounds that the conduct of the arbitrator(s), or the decision itself, violated the standards set forth in the Federal Arbitration Act or the Administrative Dispute Resolution Act. The final decision of the arbitrator(s) must also be filed with FERC if it affects jurisdictional rates, terms and conditions of service, Interconnection Facilities, or Network Upgrades.

27.4 Costs. Each Party shall be responsible for its own costs incurred during the arbitration process and for the following costs, if applicable: (1) the cost of the arbitrator chosen by the Party to sit on the three member panel and one half of the cost of the third arbitrator chosen; or (2) one half the cost of the single arbitrator jointly chosen by the Parties.

ARTICLE 28. REPRESENTATIONS, WARRANTIES AND COVENANTS

28.1 General. Each Party makes the following representations, warranties and covenants:

28.1.1 Good Standing. Such Party is duly organized, validly existing and in good standing under the laws of the state in which it is organized, formed, or incorporated, as applicable; that it is qualified to do business in the state or states in which the Large Generating Facility, Interconnection Facilities and Network Upgrades owned by such Party, as applicable, are located; and that it has the corporate power and authority to own its properties, to carry on its business as now being conducted and to enter into this LGIA and carry out the transactions contemplated hereby and perform and carry out all covenants and obligations on its part to be performed under and pursuant to this LGIA.

28.1.2 Authority. Such Party has the right, power and authority to enter into this LGIA, to become a Party hereto and to perform its obligations hereunder. This LGIA is a legal, valid and binding obligation of such Party, enforceable against such Party in accordance with its terms, except as the enforceability thereof may be limited by applicable bankruptcy, insolvency, reorganization or other similar laws affecting creditors' rights generally and by general equitable principles (regardless of whether enforceability is sought in a proceeding in equity or at law).

28.1.3 No Conflict. The execution, delivery and performance of this LGIA does not violate or conflict with the organizational or formation documents, or bylaws or operating agreement, of such Party, or any judgment, license, permit, order, material agreement or instrument applicable to or binding upon such Party or any of its assets.

28.1.4 Consent and Approval. Such Party has sought or obtained, or, in accordance with this LGIA will seek or obtain, each consent, approval, authorization, order, or acceptance by any Governmental Authority in connection with the execution, delivery and performance of this LGIA, and it will provide to any Governmental Authority notice of any actions under this LGIA that are required by Applicable Laws and Regulations.

ARTICLE 29. [RESERVED]

ARTICLE 30. MISCELLANEOUS

30.1 Binding Effect. This LGIA and the rights and obligations hereof, shall be binding upon and shall inure to the benefit of the successors and assigns of the Parties hereto.

30.2 Conflicts. In the event of a conflict between the body of this LGIA and any attachment, appendices or exhibits hereto, the terms and provisions of the body of this LGIA shall prevail and be deemed the final intent of the Parties.

30.3 Rules of Interpretation. This LGIA, unless a clear contrary intention appears, shall be construed and interpreted as follows: (1) the singular number includes the plural number and vice versa; (2) reference to any person includes such person's successors and assigns but, in the case of a Party, only if such successors and assigns are permitted by this LGIA, and reference to a person in a particular capacity excludes such person in any other capacity or individually; (3) reference to any agreement (including this LGIA), document, instrument or tariff means such agreement, document, instrument, or tariff as amended or modified and in effect from time to time in accordance with the terms thereof and, if applicable, the terms hereof; (4) reference to any Applicable Laws and Regulations means such Applicable Laws and Regulations as amended, modified, codified, or reenacted, in whole or in part, and in effect from time to time, including, if applicable, rules and regulations promulgated thereunder; (5) unless expressly stated otherwise, reference to any Article, Section or Appendix means such Article of this LGIA or such Appendix to this LGIA, or such Section to the LGIP or such Appendix to the LGIP, as the case may be; (6) "hereunder", "hereof", "herein", "hereto" and words of similar import shall be deemed references to this LGIA as a whole and not to any particular Article or other provision hereof or thereof; (7)

"including" (and with correlative meaning "include") means including without limiting the generality of any description preceding such term; and (8) relative to the determination of any period of time, "from" means "from and including", "to" means "to but excluding" and "through" means "through and including".

30.4 Entire Agreement. This LGIA, including all Appendices and Schedules attached hereto, constitutes the entire agreement among the Parties with reference to the subject matter hereof, and supersedes all prior and contemporaneous understandings or agreements, oral or written, between or among the Parties with respect to the subject matter of this LGIA. There are no other agreements, representations, warranties, or covenants which constitute any part of the consideration for, or any condition to, any Party's compliance with its obligations under this LGIA.

30.5 No Third Party Beneficiaries. This LGIA is not intended to and does not create rights, remedies, or benefits of any character whatsoever in favor of any persons, corporations, associations, or entities other than the Parties, and the obligations herein assumed are solely for the use and benefit of the Parties, their successors in interest and, where permitted, their assigns.

30.6 Waiver. The failure of a Party to this LGIA to insist, on any occasion, upon strict performance of any provision of this LGIA will not be considered a waiver of any obligation, right, or duty of, or imposed upon, such Party.

Any waiver at any time by either Party of its rights with respect to this LGIA shall not be deemed a continuing waiver or a waiver with respect to any other failure to comply with any other obligation, right, duty of this LGIA. Termination or Default of this LGIA for any reason by the Interconnection Customer shall not constitute a waiver of the Interconnection Customer's legal rights to obtain an interconnection from the Participating TO. Any waiver of this LGIA shall, if requested, be provided in writing.

30.7 Headings. The descriptive headings of the various Articles of this LGIA have been inserted for convenience of reference only and are of no significance in the interpretation or construction of this LGIA.

30.8 Multiple Counterparts. This LGIA may be executed in two or more counterparts, each of which is deemed an original but all constitute one and the same instrument.

30.9 Amendment. The Parties may by mutual agreement amend this LGIA by a written instrument duly executed by all of the Parties. Such amendment shall become effective and a part of this LGIA upon satisfaction of all Applicable Laws and Regulations.

30.10 Modification by the Parties. The Parties may by mutual agreement amend the Appendices to this LGIA by a written instrument duly executed by all of the Parties. Such amendment shall become effective and a part of this LGIA upon satisfaction of all Applicable Laws and Regulations.

30.11 Reservation of Rights. The CAISO and Participating TO shall each have the right to make a unilateral filing with FERC to modify this LGIA pursuant to section 205 or any other applicable provision of the Federal Power Act and FERC's rules and regulations thereunder with respect to the following Articles and Appendices of this LGIA and with respect to any rates, terms and conditions, charges, classifications of service, rule or regulation covered by these Articles and Appendices:

> Recitals, 1, 2.1, 2.2, 2.3, 2.4, 2.6, 3.1, 3.3, 4.1, 4.2, 4.3, 4.4, 5 preamble, 5.4, 5.7, 5.8, 5.9, 5.12, 5.13, 5.18, 5.19.1, 7.1, 7.2, 8, 9.1, 9.2, 9.3, 9.5, 9.6, 9.7, 9.8, 9.10, 10.3, 11.4, 12.1, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24.3, 24.4, 25.1, 25.2, 25.3 (excluding subparts), 25.4.2, 26, 28, 29, 30, Appendix D, Appendix F, Appendix G, and any other Article not reserved exclusively to the Participating TO or the CAISO below.

The Participating TO shall have the exclusive right to make a unilateral filing with FERC to modify this LGIA pursuant to section 205 or any other applicable provision of the Federal Power Act and FERC's rules and regulations thereunder with respect to the following Articles and Appendices of this LGIA and with respect to any rates, terms and conditions, charges, classifications of service, rule or regulation covered by these Articles and Appendices:

2.5, 5.1, 5.2, 5.3, 5.5, 5.6, 5.10, 5.11, 5.14, 5.15, 5.16, 5.17, 5.19 (excluding 5.19.1), 6, 7.3, 9.4, 9.9, 10.1, 10.2, 10.4, 10.5, 11.1, 11.2, 11.3, 11.5, 12.2, 12.3, 12.4, 24.1, 24.2, 25.3.1, 25.4.1, 25.5 (excluding 25.5.1), 27 (excluding preamble), Appendix A, Appendix B, Appendix C, and Appendix E.

The CAISO shall have the exclusive right to make a unilateral filing with FERC to modify this LGIA pursuant to section 205 or any other applicable provision of the Federal Power Act and FERC's rules and regulations thereunder with respect to the following Articles of this LGIA and with respect to any rates, terms and conditions, charges, classifications of service, rule or regulation covered by these Articles:

3.2, 4.5, 11.6, 25.3.2, 25.5.1, and 27 preamble.

The Interconnection Customer, the CAISO, and the Participating TO shall have the right to make a unilateral filing with FERC to modify this LGIA pursuant to section 206 or any other applicable provision of the Federal Power Act and FERC's rules and regulations thereunder; provided that each Party shall have the right to protest any such filing by another Party and to participate fully in any proceeding before FERC in which such modifications may be considered. Nothing in this LGIA shall limit the rights of the Parties or of FERC under sections 205 or 206 of the Federal Power Act and FERC's rules and regulations thereunder, except to the extent that the Parties otherwise mutually agree as provided herein.

30.12 No Partnership. This LGIA shall not be interpreted or construed to create an association, joint venture, agency relationship, or partnership among the Parties or to impose any partnership obligation or partnership liability upon any Party. No Party shall have any right, power or authority to enter into any agreement or undertaking for, or act on behalf of, or to act as or be an agent or representative of, or to otherwise bind, another Party.

30.13 Joint and Several Obligations. Except as otherwise provided in this LGIA, the obligations of the CAISO, the Participating TO, and the Interconnection Customer are several, and are neither joint nor joint and several.

IN WITNESS WHEREOF, the Parties have executed this LGIA in multiple originals, each of which shall constitute and be an original effective agreement among the Parties.

[Insert name of Interconnection Customer]

By: ______________________________

Title: ______________________________

Date: __

[Insert name of Participating TO]

By: ________________________________

Title: ___

Date: ___

California Independent System Operator Corporation

By: ____

Title: ___

Date: ___

Appendices to LGIA

Appendix A Interconnection Facilities, Network Upgrades and Distribution Upgrades

Appendix B Milestones

Appendix C Interconnection Details

Appendix D Security Arrangements Details

Appendix E Commercial Operation Date

Appendix F Addresses for Delivery of Notices and Billings

Appendix G Interconnection Customer's Proportional Share of Costs of Network Upgrades for Applicable Project Group

Appendix H Interconnection Requirements for a Wind Generating Plant

Appendix A
To LGIA

Interconnection Facilities, Network Upgrades and Distribution Upgrades

1. Interconnection Facilities:

(a) [insert Interconnection Customer's Interconnection Facilities]:

(b) [insert Participating TO’s Interconnection Facilities]:

2. Network Upgrades:

(a) [insert Stand Alone Network Upgrades]:

(b) [insert Other Network Upgrades]:

(i) [insert Participating TO’s Reliability Network Upgrades]

(ii) [insert Participating TO’s Delivery Network Upgrades]

3. Distribution Upgrades:

Appendix B
To LGIA

Milestones

Appendix C
To LGIA

Interconnection Details

Appendix D
To LGIA

Security Arrangements Details

Infrastructure security of CAISO Controlled Grid equipment and operations and control hardware and software is essential to ensure day-to-day CAISO Controlled Grid reliability and operational security. FERC will expect the CAISO, all Participating TOs, market participants, and Interconnection Customers interconnected to the CAISO Controlled Grid to comply with the recommendations offered by the President's Critical Infrastructure Protection Board and, eventually, best practice recommendations from the electric reliability authority. All public utilities will be expected to meet basic standards for system infrastructure and operational security, including physical, operational, and cyber-security practices.

The Interconnection Customer shall meet the requirements for security implemented pursuant to the CAISO Tariff, including the CAISO's standards for information security posted on the CAISO's internet web site at the following internet address: http://www.caiso.com/pubinfo/info-security/index.html.

Appendix E
To LGIA

Commercial Operation Date

[This Appendix E sets forth a form of letter to be provided by the Interconnection Customer to the CAISO and Participating TO to provide formal notice of the Commercial Operation of an Electric Generating Unit.]

[Date]

[CAISO Address]

[Participating TO Address]

Re: _______________ Electric Generating Unit

Dear ________________:

On **[Date] [Interconnection Customer]** has completed Trial Operation of Unit No. ___. This letter confirms that [Interconnection Customer] commenced Commercial Operation of Unit No. ___ at the Electric Generating Unit, effective as of **[Date plus one day]** and that [Interconnection Customer] provided the CAISO's operations personnel advance notice of its intended Commercial Operation Date no less than five Business Days prior to that date.

Thank you.

[Signature]

[Interconnection Customer Representative]

Appendix F
To LGIA

Addresses for Delivery of Notices and Billings

Notices:

Participating TO:

[To be supplied.]

Interconnection Customer:

[To be supplied.]

CAISO:

[To be supplied.]

Billings and Payments:

Participating TO:

[To be supplied.]

Interconnection Customer:

[To be supplied.]

CAISO:

[To be supplied.]

Alternative Forms of Delivery of Notices (telephone, facsimile or e-mail):

Participating TO:

[To be supplied.]

Interconnection Customer:

[To be supplied.]

CAISO:

[To be supplied.]

Appendix G
To LGIA

Interconnection Customer's Proportional Share of Costs of Network Upgrades for Applicable Project Group

Appendix H
To LGIA

INTERCONNECTION REQUIREMENTS FOR AN ASYNCHRONOUS GENERATING FACILITY

Appendix H sets forth interconnection requirements specific to all Asynchronous Generating Facilities. Existing individual generating units of an Asynchronous Generating Facility that are, or have been, interconnected to the CAISO Controlled Grid at the same location are exempt from the requirements of this Appendix H for the remaining life of the existing generating unit. Generating units that are replaced, however, shall meet the requirements of this Appendix H.

A. Technical Requirements Applicable to Asynchronous Generating Facilities

i. Low Voltage Ride-Through (LVRT) Capability

An Asynchronous Generating Facility shall be able to remain online during voltage disturbances up to the time periods and associated voltage levels set forth in the requirements below.

1. An Asynchronous Generating Facility shall remain online for the voltage disturbance caused by any fault on the transmission grid, or within the Asynchronous Generating Facility between the Point of Interconnection and the high voltage terminals of the Asynchronous Generating Facility's step up transformer, having a duration equal to the lesser of the normal three-phase fault clearing time (4-9 cycles) or one-hundred fifty (150) milliseconds, plus any subsequent post-fault voltage recovery to the final steady-state post-fault voltage. Clearing time shall be based on the maximum normal clearing time associated with any three-phase fault location that reduces the voltage at the Asynchronous Generating Facility's Point of Interconnection to 0.2 per-unit of nominal voltage or less, independent of any fault current contribution from the Asynchronous Generating Facility.

2. An Asynchronous Generating Facility shall remain online for any voltage disturbance caused by a single-phase fault on the transmission grid, or within the Asynchronous Generating Facility between the Point of Interconnection and the high voltage terminals of the Asynchronous Generating Facility's step up transformer, with delayed clearing, plus any subsequent post-fault voltage recovery to the final steady-state post-fault voltage. Clearing time shall be based on the maximum backup clearing time associated with a single point of failure (protection or breaker failure) for any single-phase fault location that reduces any phase-to-ground or phase-to-phase voltage at the Asynchronous Generating Facility's Point of Interconnection to 0.2 per-unit of nominal voltage or less, independent of any fault current contribution from the Asynchronous Generating Facility.

3. Remaining on-line shall be defined as continuous connection between the Point of Interconnection and the Asynchronous Generating Facility's units, without any mechanical isolation. Asynchronous Generating Facilities may cease to inject current into the transmission grid during a fault.

4. The Asynchronous Generating Facility is not required to remain on line during multi-phased faults exceeding the duration described in Section A.i.1 of this Appendix H or single-phase faults exceeding the duration described in Section A.i.2 of this Appendix H.

5. The requirements of this Section A.i. of this Appendix H do not apply to faults that occur between the Asynchronous Generating Facility's terminals and the high side of the step-up transformer to the high-voltage transmission system.

6. Asynchronous Generating Facilities may be tripped after the fault period if this action is intended as part of a special protection system.

7. Asynchronous Generating Facilities may meet the requirements of this Section A.i of this Appendix H through the performance of the generating units or by installing additional equipment within the Asynchronous Generating Facility, or by a combination of generating unit performance and additional equipment.

8. The provisions of this Section A.i of this Appendix H apply only if the voltage at the Point of Interconnection has remained within the range of 0.9 and 1.10 per-unit of nominal voltage for the preceding two seconds, excluding any sub-cycle transient deviations.

The requirements of this Section A.i in this Appendix H shall not apply to any Asynchronous Generating Facility that can demonstrate to the CAISO a binding commitment, as of May 18, 2010, to purchase inverters for thirty (30) percent or more of the Generating Facility's maximum Generating Facility Capacity that are incapable of complying with the requirements of this Section A.i in this Appendix H. The Interconnection Customer must include a statement from the inverter manufacturer confirming the inability to comply with this requirement in addition to any information requested by the CAISO to determine the applicability of this exemption.

ii. Frequency Disturbance Ride-Through Capability

An Asynchronous Generating Facility shall comply with the off nominal frequency requirements set forth in the WECC Under Frequency Load Shedding Relay Application Guide or successor requirements as they may be amended from time to time.

iii. Power Factor Design and Operating Requirements (Reactive Power)

1. Asynchronous Generating Facilities shall meet the following design requirements:

    a. An Asynchronous Generating Facility shall be designed to have sufficient reactive power sourcing capability to achieve a net power factor of 0.95 lagging or less at the Point of Interconnection, at the Generating Facility's maximum Generating Facility Capacity An Asynchronous Generating Facility shall be designed to have net reactive power sourcing and absorption capability sufficient to achieve or exceed the net reactive power range in Figure 1 as a function of the Point of Interconnection voltage, without exceeding the ratings of any equipment in the Asynchronous Generating Facility. The Point of Interconnection voltage is specified in per-unit of the nominal voltage.

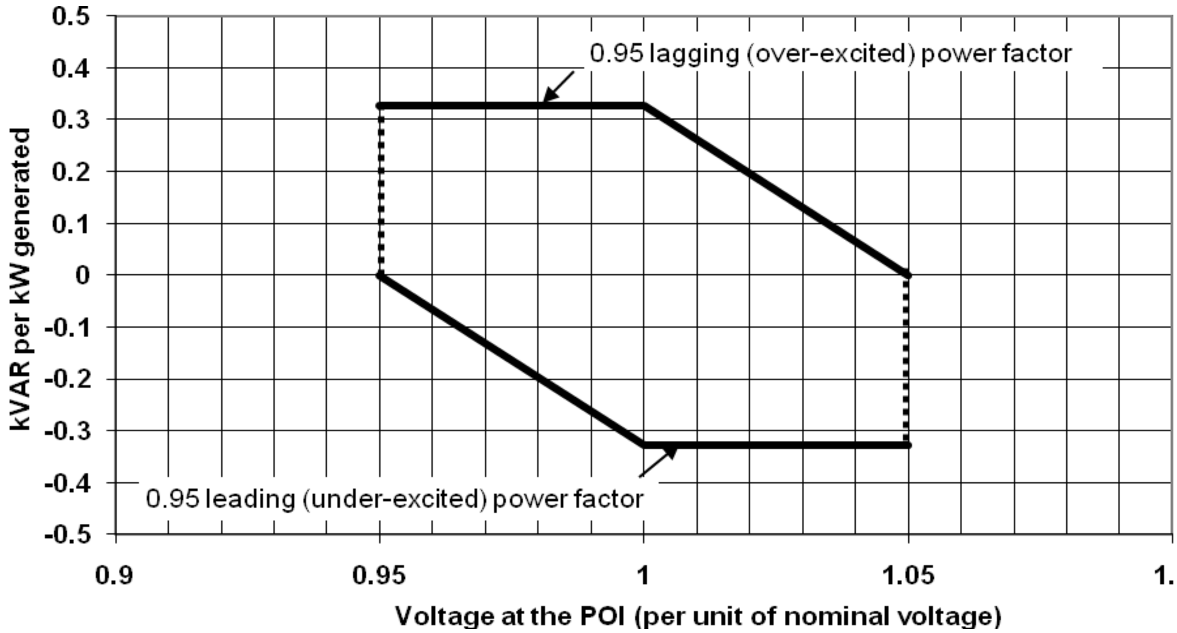

Figure 1

b. Net power factor shall be measured at the Point of Interconnection as defined in this LGIA.

c. Asynchronous Generating Facilities may meet the power factor range requirement by using power electronics designed to supply the required level of reactive capability (taking into account any limitations due to voltage level and real power output) or fixed and switched capacitors, or a combination of the two.

d. Asynchronous Generating Facilities shall also provide dynamic voltage support if the Interconnection Study requires dynamic voltage support for system safety or reliability.

e. Asynchronous Generating Facilities shall vary the reactive power output between the full sourcing and full absorption capabilities such that any step change in the reactive power output does not cause a step change in voltage at the Point of Interconnection greater than 0.02 per unit of the nominal voltage.

f. The maximum voltage change requirement shall apply when the CAISO Controlled Grid is fully intact (no line or transformer outages), or during outage conditions which do not decrease the three-phase short circuit capacity at the Point of Interconnection to less than ninety (90) percent of the three-phase short-circuit capacity that would be present without the transmission network outage.

2. Asynchronous Generating Facilities shall meet the following operational requirements:

a. When plant output power is greater than twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity, the Asynchronous Generating Facility shall have a net reactive power range at least as great as specified in Figure 1 at the Point of Interconnection, based on the actual real power output level delivered to the Point of Interconnection.

b. Power output may be curtailed at the direction of CAISO to a value where the net power factor range is met, if the reactive power capability of an Asynchronous Generating Facility is partially or totally unavailable, and if continued operation causes deviation of the voltage at the Point of Interconnection outside +/- 0.02 per unit of scheduled voltage level.

c. When the output power of the Asynchronous Generating Facility is less than twenty (20) percent of the Generating Facility's maximum Generating Facility Capacity, the net reactive power shall remain within the range between –6.6% and +6.6% of the Asynchronous Generating Facility's real power rating.

d. If the Point of Interconnection voltage exceeds 1.05 per unit, the Asynchronous Generating Facility shall provide reactive power absorption to the extent possible without violating the ratings of any of the Asynchronous Generating Facility's equipment.

e. If the Point of Interconnection voltage is less than 0.95 per unit, the Asynchronous Generating Facility shall provide reactive power injection to the extent possible without violating the ratings of any of the Asynchronous Generating Facility's equipment.

iv. Voltage Regulation and Reactive Power Control Requirements

1. The Asynchronous Generation Facility's reactive power capability shall be controlled by an automatic system having both voltage regulation and a net power factor regulation operating modes. The default mode of operation will be voltage regulation.

2. The voltage regulation function mode shall automatically control the net reactive power of the Asynchronous Generating Facility to regulate the Point of Interconnection positive sequence component of voltage to within a tolerance of +/- 0.02 per unit of the nominal voltage schedule assigned by the Participating TO or CAISO, within the constraints of the reactive power capacity of the Asynchronous Generation Facility. Deviations outside of this voltage band, except as caused by insufficient reactive capacity to maintain the voltage schedule tolerances, shall not exceed five (5) minutes duration per incident.

3. The power factor mode will regulate the net power factor measured at the Point of Interconnection. If the Asynchronous Generating Facility uses discrete reactive banks to provide reactive capability, the tolerances of the power factor regulation shall be consistent with the reactive banks' sizes meeting the voltage regulation tolerances specified in the preceding paragraph.

4. The net reactive power flow into or out of the Asynchronous Generating Facility, in any mode of operation, shall not cause the positive sequence component of voltage at the Point of Interconnection to exceed 1.05 per unit, or fall below 0.95 per unit.

5. The CAISO, in coordination with the Participating TO, may permit the Interconnection Customer to regulate the voltage at a point on the Asynchronous Generating Facility's side of the Point of Interconnection. Regulating voltage to a point other than the Point of Interconnection shall not change the Asynchronous Generating Facility's net power factor requirements set forth in Section A.iii of this Appendix H.

6. The Interconnection Customer shall not disable voltage regulation controls, without the specific permission of CAISO, while the Asynchronous Generating Facility is in operation at a power level greater than twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity.

v. Plant Power Management

1. As of January 1, 2012, Asynchronous Generating Facilities must have the capability to limit active power output in response to a CAISO Dispatch Instruction or Operating Order as those terms are defined in the CAISO Tariff. This capability shall extend from the Minimum Operating Limit to the Maximum Operating Limit, as those terms are defined in the CAISO Tariff, of the Asynchronous Generating Facility in increments of five (5) MW or less. Changes to the power management set point shall not cause a change in voltage at the Point of Interconnection exceeding 0.02 per unit of the nominal voltage.

2. For Asynchronous Generating Facilities that are also Eligible Intermittent Resources as that term is defined in the CAISO Tariff, these power management requirements establish only a maximum output limit. There is no requirement for the Eligible Intermittent Resource to maintain a level of power output beyond the capabilities of the available energy source.

3. Asynchronous Generating Facilities must have the installed capability to limit power change ramp rates automatically, except for downward ramps resulting from decrease of the available energy resource for Eligible Intermittent Resources. The power ramp control shall be capable of limiting rates of power change to a value of five (5) percent, (10) percent, or twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity per minute. The Asynchronous Generating Facility may implement this ramping limit by using stepped increments if the individual step size is five (5) MW or less.

4. Asynchronous Generating Facilities must have the installed capability to automatically reduce plant power output in response to an over-frequency condition. This frequency response control shall, when enabled at the direction of CAISO, continuously monitor the system frequency and automatically reduce the real power output of the Asynchronous Generating Facility with a droop equal to a one-hundred (100) percent decrease in plant output for a five (5) percent rise in frequency (five (5) percent droop) above an intentional dead band of 0.036 Hz.

vi. Supervisory Control and Data Acquisition (SCADA) and Automated Dispatch System (ADS) Capability

An Asynchronous Generating Facility shall provide SCADA capability to transmit data and receive instructions from the Participating TO and CAISO to protect system reliability. The Participating TO and CAISO and the Asynchronous Generating Facility Interconnection Customer shall determine what SCADA information is essential for the proposed Asynchronous Generating Facility, taking into account the size of the plant and its characteristics, location, and importance in maintaining generation resource adequacy and transmission system reliability.

An Asynchronous Generating Facility must be able to receive and respond to Automated Dispatch System (ADS) instructions and any other form of communication authorized by the CAISO Tariff. The Asynchronous Generating Facility's response time should be capable of conforming to the periods prescribed by the CAISO Tariff.

vii. Power System Stabilizers (PSS)

Power system stabilizers are not required for Asynchronous Generating Facilities.

Attachment C

CAISO TARIFF APPENDIX ~~V~~ BB

Standard Large Generator Interconnection Agreement

for Interconnection Requests in a Serial Study Group that are tendered or execute a Large Generator Interconnection Agreement on or after July 2, 2010

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ARTICLE 1. DEFINITIONS

Asynchronous Generating Facility shall mean an induction, doubly-fed, or electronic power generating unit(s) that produces 60 Hz (nominal) alternating current.

* * *

ARTICLE 5. INTERCONNECTION FACILITIES ENGINEERING, PROCUREMENT, AND CONSTRUCTION

* * *

5.4 Power System Stabilizers. The Interconnection Customer shall procure, install, maintain and operate Power System Stabilizers in accordance with the guidelines and procedures established by the Applicable Reliability Council and in accordance with the provisions of Section 4.6.5.1 of the CAISO Tariff. The CAISO reserves the right to establish reasonable minimum acceptable settings for any installed Power System Stabilizers, subject to the design and operating limitations of the Large Generating Facility. If the Large Generating Facility's Power System Stabilizers are removed from service or not capable of automatic operation, the Interconnection Customer shall immediately notify the CAISO and the Participating TO and restore the Power System Stabilizers to operation as soon as possible and in accordance with the Reliability Management System Agreement in Appendix G. The CAISO shall have the right to order the reduction in output or disconnection of the Large Generating Facility if the reliability of the CAISO Controlled Grid would be adversely affected as a result of improperly tuned Power System Stabilizers. The requirements of this Article 5.4 shall ~~not~~ apply to Asynchronous Generating Facilities in accordance with Appendix H~~wind generators of the induction type~~.

ARTICLE 9. OPERATIONS

9.6 Reactive Power.

9.6.1 Power Factor Design Criteria. For all Generating Facilities other than Asynchronous Generating Facilities, ~~T~~the Interconnection Customer shall design the Large Generating Facility to maintain a composite power delivery at continuous rated power output at the terminals of the Electric Generating Unit at a power factor within the range of 0.95 leading to 0.90 lagging, unless the CAISO has established different requirements that apply to all generators in the Balancing Authority Area on a comparable basis. For Asynchronous Generating Facilities, the Interconnection Customer shall design the Large Generating Facility to maintain power factor criteria in accordance with~~Power factor design criteria for wind generators are provided in~~ Appendix H of this LGIA.

* * *

9.6.2.2 Loss of Voltage Control and Governor Control for Asynchronous Generating Facilities. For Asynchronous Generating Facilities, Appendix H to this LGIA sets forth the requirements for Large Generating Facilities relating to: (i) the loss of voltage control capability, (ii) governor response to frequency conditions, and (iii) ability not to disconnect automatically or instantaneously from the CAISO Controlled Grid or trip any Electric Generating Unit comprising the Large Generating Facility for an under- or over-frequency condition. Asynchronous Generating Facilities are not required to provide governor response to under-frequency conditions.

* * *

9.7 Outages and Interruptions.

* * *

9.7.3 Under-Frequency and Over Frequency Conditions. The CAISO Controlled Grid is designed to automatically activate a load-shed program as required by the Applicable Reliability Council in the event of an under-frequency system disturbance. The Interconnection Customer shall implement under-frequency and over-frequency protection set points for the Large Generating Facility as required by the Applicable Reliability Council to ensure “ride through” capability. Large Generating Facility response to frequency deviations of pre-determined magnitudes, both under-frequency and over-frequency deviations, shall be studied and coordinated with the Participating TO and CAISO in accordance with Good Utility Practice. The term "ride through" as used herein shall mean the ability of a Generating Facility to stay connected to and synchronized with the CAISO Controlled Grid during system disturbances within a range of under-frequency and over-frequency conditions, in accordance with Good Utility Practice. Asynchronous Generating Facilities shall be subject to frequency ride through capability requirements in accordance with Appendix H to this LGIA.

* * *

Appendix H
To LGIA

INTERCONNECTION REQUIREMENTS FOR AN ASYNCHRONOUS GENERATING FACILITY ~~WIND GENERATING PLANT~~

Appendix H sets forth interconnection requirements ~~and provisions~~ specific to all Asychronous Generating Facilities ~~a wind generating plant. All other requirements of this LGIA continue to apply to wind generating plant interconnections~~. Existing individual generating units of an Asynchronous Generating Facility that are, or have been, interconnected to the CAISO Controlled Grid at the same location are exempt from the requirements of this Appendix H for the remaining life of the existing generating unit. Generating units that are replaced, however, shall meet the requirements of this Appendix H.

A. Technical ~~Standards~~ Requirements Applicable to Asynchronous Generating Facilities~~a Wind Generating Plant~~

i. Low Voltage Ride-Through (LVRT) Capability

An Asynchronous Generating Facility shall be able to remain online during voltage disturbances up to the time periods and associated voltage levels set forth in the requirements below. ~~A wind generating plant shall be able to remain online during voltage disturbances up to the time periods and associated voltage levels set forth in the standard below. The LVRT standard provides for a transition period standard and a post-transition period standard.~~

1. An Asynchronous Generating Facility shall remain online for the voltage disturbance caused by any fault on the transmission grid, or within the Asynchronous Generating Facility between the Point of Interconnection and the high voltage terminals of the Asynchronous Generating Facility's step up transformer, having a duration equal to the lesser of the normal three-phase fault clearing time (4-9 cycles) or one-hundred fifty (150) milliseconds, plus any subsequent post-fault voltage recovery to the final steady-state post-fault voltage. Clearing time shall be based on the maximum normal clearing time associated with any three-phase fault location that reduces the voltage at the Asynchronous Generating Facility's Point of Interconnection to 0.2 per-unit of nominal voltage or less, independent of any fault current contribution from the Asynchronous Generating Facility.

2. An Asynchronous Generating Facility shall remain online for any voltage disturbance caused by a single-phase fault on the transmission grid, or within the Asynchronous Generating Facility between the Point of Interconnection and the high voltage terminals of the Asynchronous Generating Facility's step up transformer, with delayed clearing, plus any subsequent post-fault voltage recovery to the final steady-state post-fault voltage. Clearing time shall be based on the maximum backup clearing time associated with a single point of failure (protection or breaker failure) for any single-phase fault location that reduces any phase-to-ground or phase-to-phase voltage at the Asynchronous Generating Facility's Point of Interconnection to 0.2 per-unit of nominal voltage or less, independent of any fault current contribution from the Asynchronous Generating Facility.

3. Remaining on-line shall be defined as continuous connection between the Point of Interconnection and the Asynchronous Generating Facility's units, without any mechanical isolation. Asynchronous Generating Facilities may cease to inject current into the transmission grid during a fault.

4. The Asynchronous Generating Facility is not required to remain on line during multi-phased faults exceeding the duration described in Section A.i.1 of this Appendix H or single-phase faults exceeding the duration described in Section A.i.2 of this Appendix H.

5. The requirements of this Section A.i.of this Appendix H do not apply to faults that occur between the Asynchronous Generator Facility's terminals and the high side of the step-up transformer to the high-voltage transmission system.

6. Asynchronous Generating Facilities may be tripped after the fault period if this action is intended as part of a special protection system.

7. Asynchronous Generating Facilities may meet the requirements of this Section A.i of this Appendix H through the performance of the generating units or by installing additional equipment within the Asynchronous Generating Facility, or by a combination of generating unit performance and additional equipment.

8. The provisions of this Section A.i of this Appendix H apply only if the voltage at the Point of Interconnection has remained within the range of 0.9 and 1.10 per-unit of nominal voltage for the preceding two seconds, excluding any sub-cycle transient deviations.

The requirements of this Section A.i in this Appendix H shall not apply to any Asynchronous Generating Facility that can demonstrate to the CAISO a binding commitment, as of May 18, 2010, to purchase inverters for thirty (30) percent or more of the Generating Facility's maximum Generating Facility Capacity that are incapable of complying with the requirements of this Section A.i in this Appendix H. The Interconnection Customer must include a statement from the inverter manufacturer confirming the inability to comply with this requirement in addition to any information requested by the CAISO to determine the applicability of this exemption.

~~**Transition Period LVRT Standard**~~

~~The transition period standard applies to wind generating plants subject to FERC Order 661 that have either: (i) interconnection agreements signed and filed with FERC, filed with FERC in unexecuted form, or filed with FERC as non-conforming agreements between January 1, 2006 and December 31, 2006, with a scheduled In-Service Date no later than December 31, 2007, or (ii) wind generating turbines subject to a wind turbine procurement contract executed prior to December 31, 2005, for delivery through 2007.~~

1. ~~Wind generating plants are required to remain in-service during three-phase faults with normal clearing (which is a time period of approximately 4 – 9 cycles) and single line to ground faults with delayed clearing, and subsequent post-fault voltage recovery to prefault voltage unless clearing the fault effectively disconnects the generator from the system. The clearing time requirement for a three-phase fault will be specific to the wind generating plant substation location, as determined by and documented by the Participating TO. The maximum clearing time the wind generating plant shall be required to withstand for a three-phase fault shall be 9 cycles at a voltage as low as 0.15 p.u., as measured at the high side of the wind generating plant step-up transformer (i.e. the transformer that steps the voltage up to the transmission interconnection voltage or "GSU"), after which, if the fault remains following the location-specific normal clearing time for three-phase faults, the wind generating plant may disconnect from the transmission system.~~

2. ~~This requirement does not apply to faults that would occur between the wind generator terminals and the high side of the GSU or to faults that would result in a voltage lower than 0.15 per unit on the high side of the GSU serving the facility.~~

3. ~~Wind generating plants may be tripped after the fault period if this action is intended as part of a special protection system.~~

4. ~~Wind generating plants may meet the LVRT requirements of this standard by the performance of the~~

generators or by installing additional equipment (e.g., Static VAr Compensator, etc.) within the wind generating plant or by a combination of generator performance and additional equipment.

5. Existing individual generator units that are, or have been, interconnected to the network at the same location at the effective date of the Appendix H LVRT Standard are exempt from meeting the Appendix H LVRT Standard for the remaining life of the existing generation equipment. Existing individual generator units that are replaced are required to meet the Appendix H LVRT Standard.

Post-transition Period LVRT Standard

All wind generating plants subject to FERC Order No. 661 and not covered by the transition period described above must meet the following requirements:

1. Wind generating plants are required to remain in-service during three-phase faults with normal clearing (which is a time period of approximately 4 – 9 cycles) and single line to ground faults with delayed clearing, and subsequent post-fault voltage recovery to prefault voltage unless clearing the fault effectively disconnects the generator from the system. The clearing time requirement for a three-phase fault will be specific to the wind generating plant substation location, as determined by and documented by the Participating TO. The maximum clearing time the wind generating plant shall be required to withstand for a three-phase fault shall be 9 cycles after which, if the fault remains following the location-specific normal clearing time for three-phase faults, the wind generating plant may disconnect from the CAISO Controlled Grid. A wind generating plant shall remain interconnected during such a fault on the CAISO Controlled Grid for a voltage level as low as zero volts, as measured at the high voltage side of the wind GSU.

2. This requirement does not apply to faults that would occur between the wind generator terminals and the high side of the GSU.

3. Wind generating plants may be tripped after the fault period if this action is intended as part of a special protection system.

4. Wind generating plants may meet the LVRT requirements of this standard by the performance of the generators or by installing additional equipment (e.g., Static VAr Compensator) within the wind generating plant or by a combination of generator performance and additional equipment.

5. Existing individual generator units that are, or have been, interconnected to the CAISO Controlled Grid at the same location at the effective date of the Appendix H LVRT Standard are exempt from meeting the Appendix H LVRT Standard for the remaining life of the existing generation equipment. Existing individual generator units that are replaced are required to meet the Appendix H LVRT Standard.

ii. Frequency Disturbance Ride-Through CapabilityPower Factor Design Criteria (Reactive Power)

An Asynchronous Generating Facility shall comply with the off nominal frequency requirements set forth in the WECC Under Frequency Load Shedding Relay Application Guide or successor requirements as they may be amended from time to time.

iii. Power Factor Design and Operating Requirements (Reactive Power)

1. Asynchronous Generating Facilities shall meet the following design requirements:

   a. An Asynchronous Generating Facility shall be designed to have sufficient reactive power sourcing capability to achieve a net power factor of 0.95 lagging or less at the Point of Interconnection, at the Generating Facility's maximum Generating Facility Capacity. An Asynchronous Generating Facility shall be designed to have net reactive power sourcing and absorption capability sufficient to achieve or exceed the net reactive power range in Figure 1 as a function of the Point of Interconnection voltage, without exceeding the ratings of any equipment in the Asynchronous Generating Facility. The Point of Interconnection voltage is specified in per-unit of the nominal voltage.

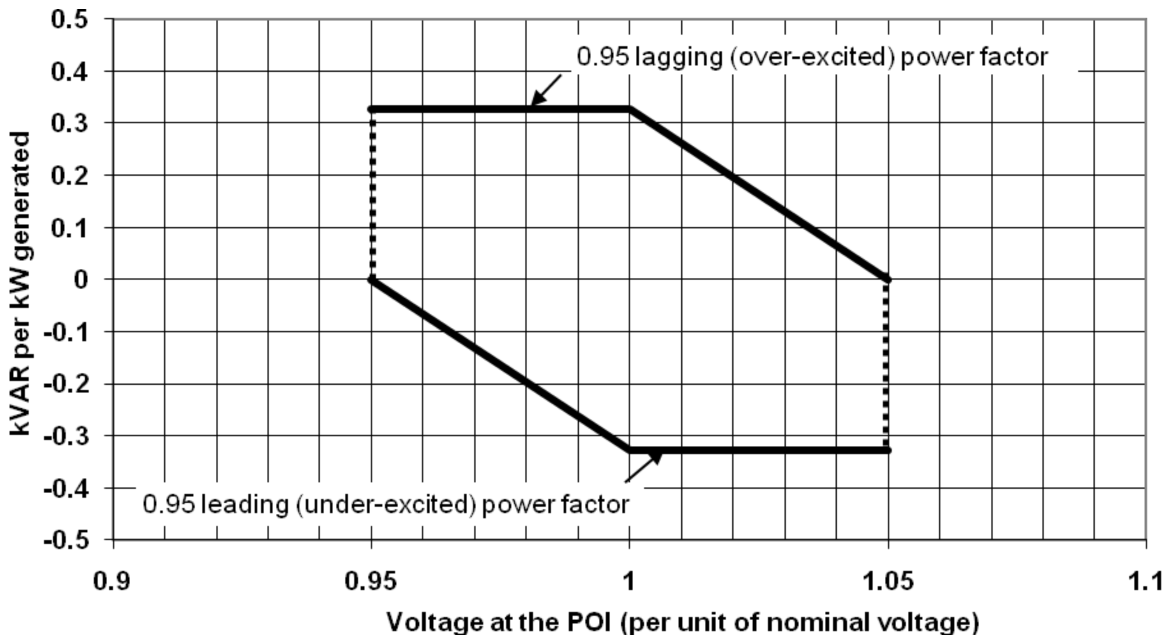

Figure 1

b. Net power factor shall be measured at the Point of Interconnection as defined in this LGIA.

c. Asynchronous Generating Facilities may meet the power factor range requirement by using power electronics designed to supply the required level of reactive capability (taking into account any limitations due to voltage level and real power output) or fixed and switched capacitors, or a combination of the two.

d. Asynchronous Generating Facilities shall also provide dynamic voltage support if the Interconnection Study requires dynamic voltage support for system safety or reliability.

e. Asynchronous Generating Facilities shall vary the reactive power output between the full sourcing and full absorption capabilities such that any step change in the reactive power output does not cause a step change in voltage at the Point of Interconnection greater than 0.02 per unit of the nominal voltage.

f. The maximum voltage change requirement shall apply when the CAISO Controlled Grid is fully intact (no line or transformer outages), or during outage conditions which do not decrease the three-phase short circuit capacity at the Point of Interconnection to less than ninety (90) percent of the three-phase short-circuit capacity that would be present without the transmission network outage.

2. Asynchronous Generating Facilities shall meet the following operational requirements:

a. When plant output power is greater than twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity, the Asynchronous Generating Facility shall have a net reactive power range at least as great as specified in Figure 1 at the Point of Interconnection, based on the actual real power output level delivered to the Point of Interconnection.

b. Power output may be curtailed at the direction of CAISO to a value where the net power factor range is met, if the reactive power capability of an Asynchronous Generating Facility is partially or totally unavailable, and if continued operation causes deviation of the voltage at the Point of Interconnection outside +/- 0.02 per unit of scheduled voltage level.

c. When the output power of the Asynchronous Generating Facility is less than twenty (20) percent of the Generating Facility's maximum Generating Facility Capacity, the net reactive power shall remain within the range between –6.6% and +6.6% of the Asynchronous Generating Facility's real power rating.

d. If the Point of Interconnection voltage exceeds 1.05 per unit, the Asynchronous Generating Facility shall provide reactive power absorption to the extent possible without violating the ratings of any of the Asynchronous Generating Facility's equipment.

e. If the Point of Interconnection voltage is less than 0.95 per unit, the Asynchronous Generating Facility shall provide reactive power injection to the extent possible without violating the ratings of any of the Asynchronous Generating Facility's equipment.

iv. Voltage Regulation and Reactive Power Control Requirements

1. The Asynchronous Generation Facility's reactive power capability shall be controlled by an automatic system having both voltage regulation and a net power factor regulation operating modes. The default mode of operation will be voltage regulation.

2. The voltage regulation function mode shall automatically control the net reactive power of the Asynchronous Generating Facility to regulate the Point of Interconnection positive sequence component of voltage to within a tolerance of +/- 0.02 per unit of the nominal voltage schedule assigned by the Participating TO or CAISO, within the constraints of the reactive power capacity of the Asynchronous Generation Facility. Deviations outside of this voltage band, except as caused by insufficient reactive capacity to maintain the voltage schedule tolerances, shall not exceed five (5) minutes duration per incident.

3. The power factor mode will regulate the net power factor measured at the Point of Interconnection. If the Asynchronous Generating Facility uses discrete reactive banks to provide reactive capability, the tolerances of the power factor regulation shall be consistent with the reactive banks' sizes meeting the voltage regulation tolerances specified in the preceding paragraph.

4. The net reactive power flow into or out of the Asynchronous Generating Facility, in any mode of operation, shall not cause the positive sequence component of voltage at the Point of Interconnection to exceed 1.05 per unit, or fall below 0.95 per unit.

5. The CAISO, in coordination with the Participating TO, may permit the Interconnection Customer to regulate the voltage at a point on the Asynchronous Generating Facility's side of the Point of Interconnection. Regulating voltage to a point other than the Point of Interconnection shall not change the Asynchronous Generating Facility's net power factor requirements set forth in Section A.iii of this Appendix H.

6. The Interconnection Customer shall not disable voltage regulation controls, without the specific permission of CAISO, while the Asynchronous Generating Facility is in operation at a power level

greater than twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity.

v. Plant Power Management

1. As of January 1, 2012, Asynchronous Generating Facilities must have the capability to limit active power output in response to a CAISO Dispatch Instruction or Operating Order as those terms are defined in the CAISO Tariff. This capability shall extend from the Minimum Operating Limit to the Maximum Operating Limit of the Asynchronous Generating Facility in increments of five (5) MW or less. Changes to the power management set point shall not cause a change in voltage at the Point of Interconnection exceeding 0.02 per unit of the nominal voltage.

2. For Asynchronous Generating Facilities that are also Eligible Intermittent Resources as that term is defined in the CAISO Tariff, these power management requirements establish only a maximum output limit. There is no requirement for the Eligible Intermittent Resource to maintain a level of power output beyond the capabilities of the available energy source.

3. Asynchronous Generating Facilities must have the installed capability to limit power change ramp rates automatically, except for downward ramps resulting from decrease of the available energy resource for Eligible Intermittent Resources. The power ramp control shall be capable of limiting rates of power change to a value of five (5) percent, (10) percent, or twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity per minute. The Asynchronous Generating Facility may implement this ramping limit by using stepped increments if the individual step size is five (5) MW or less.

4. Asynchronous Generating Facilities must have the installed capability to automatically reduce plant power output in response to an over-frequency condition. This frequency response control shall, when enabled at the direction of CAISO, continuously monitor the system frequency and automatically reduce the real power output of the Asynchronous Generating Facility with a droop equal to a one-hundred (100) percent decrease in plant output for a five (5) percent rise in frequency (five (5) percent droop) above an intentional dead band of 0.036 Hz.

vi. Supervisory Control and Data Acquisition (SCADA) and Automated Dispatch System (ADS) Capability

An Asynchronous Generating Facility shall provide SCADA capability to transmit data and receive instructions from the Participating TO and CAISO to protect system reliability. The Participating TO and CAISO and the Asynchronous Generating Facility Interconnection Customer shall determine what SCADA information is essential for the proposed Asynchronous Generating Facility, taking into account the size of the plant and its characteristics, location, and importance in maintaining generation resource adequacy and transmission system reliability.

An Asynchronous Generating Facility must be able to receive and respond to Automated Dispatch System (ADS) instructions and any other form of communication authorized by the CAISO Tariff. The Asynchronous Generating Facility's response time should be capable of conforming to the periods prescribed by the CAISO Tariff.

vii. Power System Stabilizers (PSS)

Power system stabilizers are not required for Asynchronous Generating Facilities.

~~A wind generating plant shall operate within a power factor within the range of 0.95 leading to 0.95 lagging, measured at the Point of Interconnection as defined in this LGIA in order to maintain a specified voltage schedule, if the Interconnection System Impact Study shows that such a requirement is necessary to ensure safety or reliability. The power factor range standard can be met by using, for example, power electronics designed to supply this level of reactive capability (taking into account any~~

limitations due to voltage level, real power output, etc.) or fixed and switched capacitors, or a combination of the two, if agreed to by the Participating TO and CAISO. The Interconnection Customer shall not disable power factor equipment while the wind plant is in operation. Wind plants shall also be able to provide sufficient dynamic voltage support in lieu of the power system stabilizer and automatic voltage regulation at the generator excitation system if the Interconnection System Impact Study shows this to be required for system safety or reliability.

iii. Supervisory Control and Data Acquisition (SCADA) Capability

The wind plant shall provide SCADA capability to transmit data and receive instructions from the Participating TO and CAISO to protect system reliability. The Participating TO and CAISO and the wind plant Interconnection Customer shall determine what SCADA information is essential for the proposed wind plant, taking into account the size of the plant and its characteristics, location, and importance in maintaining generation resource adequacy and transmission system reliability in its area.

CAISO TARIFF APPENDIX ~~Z~~CC

Large Generator Interconnection Agreement

for Interconnection Requests in a Queue Cluster Window

that are tendered or execute a Large Generator Interconnection Agreement on or after July 2, 2010

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ARTICLE 1. DEFINITIONS

Asynchronous Generating Facility shall mean an induction, doubly-fed, or electronic power generating unit(s) that produces 60 Hz (nominal) alternating current.

* * *

ARTICLE 5. INTERCONNECTION FACILITIES ENGINEERING, PROCUREMENT, AND CONSTRUCTION

5.4 **Power System Stabilizers.** The Interconnection Customer shall procure, install, maintain and operate Power System Stabilizers in accordance with Applicable Reliability Standards, the guidelines and procedures established by the Applicable Reliability Council, and the provisions of Section 4.6.5.1 of the CAISO Tariff. The CAISO reserves the right to establish reasonable minimum acceptable settings for any installed Power System Stabilizers, subject to the design and operating limitations of the Large Generating Facility. If the Large Generating Facility's Power System Stabilizers are removed from service or not capable of automatic operation, the Interconnection Customer shall immediately notify the CAISO and the Participating TO and restore the Power System Stabilizers to operation as soon as possible. The CAISO shall have the right to order the reduction in output or disconnection of the Large Generating Facility if the reliability of the CAISO Controlled Grid would be adversely affected as a result of improperly tuned Power System Stabilizers. The requirements of this Article 5.4 shall ~~not~~ apply to Asynchronous Generating Facilities in accordance with Appendix H ~~wind generators of the induction type~~.

ARTICLE 9. OPERATIONS

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9.6 Reactive Power.

9.6.1 Power Factor Design Criteria. For all Generating Facilities other than Asynchronous Generating Facilities, tThe Interconnection Customer shall design the Large Generating Facility to maintain a composite power delivery at continuous rated power output at the terminals of the Electric Generating Unit at a power factor within the range of 0.95 leading to 0.90 lagging, unless the CAISO has established different requirements that apply to all generators in the Balancing Authority Area on a comparable basis. For Asynchronous Generating Facilities, the Interconnection Customer shall design the Large Generating Facility to maintain power factor criteria in accordance withPower factor design criteria for wind generators are provided in Appendix H of this LGIA.

* * *

9.6.2.2 Loss of Voltage Control and Governor Control for Asynchronous Generating Facilities. For Asynchronous Generating Facilities, Appendix H to this LGIA sets forth the requirements for Large Generating Facilities relating to: (i) loss of voltage control capability, (ii) governor response to frequency conditions, and (iii) ability not to disconnect automatically or instantaneously from the CAISO Controlled Grid or trip any Electric Generating Unit comprising the Large Generating Facility for an under- or over-frequency condition. Asynchronous Generating Facilities are not required to provide governor response to under-frequency conditions.

* * *

9.7 Outages and Interruptions.

*** * ***

9.7.3 Under-Frequency and Over Frequency Conditions. The CAISO Controlled Grid is designed to automatically activate a load-shed program as required by Applicable Reliability Standards and the Applicable Reliability Council in the event of an under-frequency system disturbance. The Interconnection Customer shall implement under-frequency and over-frequency protection set points for the Large Generating Facility as required by Applicable Reliability Standards and the Applicable Reliability Council to ensure "ride through" capability. Large Generating Facility response to frequency deviations of pre-determined magnitudes, both under-frequency and over-frequency deviations, shall be studied and coordinated with the Participating TO and CAISO in accordance with Good Utility Practice. The term "ride through" as used herein shall mean the ability of a Generating Facility to stay connected to and synchronized with the CAISO Controlled Grid during system disturbances within a range of under-frequency and over-frequency conditions, in accordance with Good Utility Practice. Asynchronous Generating Facilities shall be subject to frequency ride through capability requirements in accordance with Appendix H to this LGIA.

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Appendix H
To LGIA

INTERCONNECTION REQUIREMENTS FOR AN ASYNCHRONOUS GENERATING FACILITY WIND GENERATING PLANT

Appendix H sets forth interconnection requirements and provisions specific to all Asychronous Generating Facilitiesa wind generating plant. All other requirements of this LGIA continue to apply to wind generating plant interconnections. Existing individual generating units of an Asynchronous Generating Facility that are, or have been, interconnected to the CAISO Controlled Grid at the same location are exempt from the requirements of this Appendix H for the remaining life of the existing generating unit. Generating units that are replaced, however, shall meet the requirements of this Appendix H.

A. Technical Standards Requirements Applicable to Asynchronous Generating Facilitiesa Wind Generating Plant

i. Low Voltage Ride-Through (LVRT) Capability

An Asynchronous Generating Facility shall be able to remain online during voltage disturbances up to the time periods and associated voltage levels set forth in the requirements below.A wind generating plant shall be able to remain online during voltage disturbances up to the time periods and associated voltage levels set forth in the standard below.

1. An Asynchronous Generating Facility shall remain online for the voltage disturbance caused by any fault on the transmission grid, or within the Asynchronous Generating Facility between the Point of Interconnection and the high voltage terminals of the Asynchronous Generating Facility's step up transformer, having a duration equal to the lesser of the normal three-phase fault clearing time (4-9 cycles) or one-hundred fifty (150) milliseconds, plus any subsequent post-fault voltage recovery to the final steady-state post-fault voltage. Clearing time shall be based on the maximum normal clearing time associated with any three-phase fault location that reduces the voltage at the Asynchronous Generating Facility's Point of Interconnection to 0.2 per-unit of nominal voltage or less, independent of any fault current contribution from the Asynchronous Generating Facility.

2. An Asynchronous Generating Facility shall remain online for any voltage disturbance caused by a single-phase fault on the transmission grid, or within the Asynchronous Generating Facility between the Point of Interconnection and the high voltage terminals of the Asynchronous Generating Facility's step up transformer, with delayed clearing, plus any subsequent post-fault voltage recovery to the final steady-state post-fault voltage. Clearing time shall be based on the maximum backup clearing time associated with a single point of failure (protection or breaker failure) for any single-phase fault location that reduces any phase-to-ground or phase-to-phase voltage at the Asynchronous Generating Facility's Point of Interconnection to 0.2 per-unit of nominal voltage or less, independent of any fault current contribution from the Asynchronous Generating Facility.

3. Remaining on-line shall be defined as continuous connection between the Point of Interconnection and the Asynchronous Generating Facility's units, without any mechanical isolation. Asynchronous Generating Facilities may cease to inject current into the transmission grid during a fault.

4. The Asynchronous Generating Facility is not required to remain on line during multi-phased faults exceeding the duration described in Section A.i1 of this Appendix H or single-phase faults exceeding the duration described in Section A.i.2 of this Appendix H.

5. The requirements of this Section A.i of this Appendix H do not apply to faults that occur between the Asynchronous Generator Facility's terminals and the high side of the step-up transformer to the high-voltage transmission system.

6. Asynchronous Generating Facilities may be tripped after the fault period if this action is intended as part of a special protection system.

7. Asynchronous Generating Facilities may meet the requirements of this Section A.i of this Appendix H through the performance of the generating units or by installing additional equipment within the Asynchronous Generating Facility, or by a combination of generating unit performance and additional equipment.

8. The provisions of this Section A.i of this Appendix H apply only if the voltage at the Point of Interconnection has remained within the range of 0.9 and 1.10 per-unit of nominal voltage for the preceding two seconds, excluding any sub-cycle transient deviations.

The requirements of this Section A.i in this Appendix H shall not apply to any Asynchronous Generating Facility that can demonstrate to the CAISO a binding commitment, as of May 18, 2010, to purchase inverters for thirty (30) percent or more of the Generating Facility's maximum Generating Facility Capacity that are incapable of complying with the requirements of this Section A.i in this Appendix H. The Interconnection Customer must include a statement from the inverter manufacturer confirming the inability to comply with this requirement in addition to any information requested by the CAISO to determine the applicability of this exemption.

~~All wind generating plants subject to FERC Order No. 661 must meet the following requirements:~~

1. ~~Wind generating plants are required to remain in-service during three-phase faults with normal clearing (which is a time period of approximately 4 – 9 cycles) and single line to ground faults with delayed clearing, and subsequent post-fault voltage recovery to prefault voltage unless clearing the fault effectively disconnects the generator from the system. The clearing time requirement for a three-phase fault will be specific to the wind generating plant substation location, as determined by and documented by the Participating TO. The maximum clearing time the wind generating plant shall be required to withstand for a three-phase fault shall be 9 cycles after which, if the fault remains following the location-specific normal clearing time for three-phase faults, the wind generating plant may disconnect from the CAISO Controlled Grid. A wind generating plant shall remain interconnected during such a fault on the CAISO Controlled Grid for a voltage level as low as zero volts, as measured at the high voltage side of the wind GSU.~~

2. ~~This requirement does not apply to faults that would occur between the wind generator terminals and the high side of the GSU.~~

3. ~~Wind generating plants may be tripped after the fault period if this action is intended as part of a special protection system.~~

4. ~~Wind generating plants may meet the LVRT requirements of this standard by the performance of the generators or by installing additional equipment (e.g., Static VAr Compensator) within the wind generating plant or by a combination of generator performance and additional equipment.~~

5. ~~Existing individual generator units that are, or have been, interconnected to the CAISO Controlled Grid at the same location at the effective date of the Appendix H LVRT Standard are exempt from meeting the Appendix H LVRT Standard for the remaining life of the existing generation equipment. Existing individual generator units that are replaced are required to meet the Appendix H LVRT Standard.~~

ii. Frequency Disturbance Ride-Through CapabilityPower Factor Design Criteria (Reactive Power)

An Asynchronous Generating Facility shall comply with the off nominal frequency requirements set forth in the WECC Under Frequency Load Shedding Relay Application Guide or successor requirements as they may be amended from time to time.

A wind generating plant shall operate within a power factor within the range of 0.95 leading to 0.95 lagging, measured at the Point of Interconnection as defined in this LGIA in order to maintain a specified voltage schedule, if the Phase II Interconnection Study shows that such a requirement is necessary to ensure safety or reliability. The power factor range standard can be met by using, for example, power electronics designed to supply this level of reactive capability (taking into account any limitations due to voltage level, real power output, etc.) or fixed and switched capacitors, or a combination of the two, if agreed to by the Participating TO and CAISO. The Interconnection Customer shall not disable power factor equipment while the wind plant is in operation. Wind plants shall also be able to provide sufficient dynamic voltage support in lieu of the power system stabilizer and automatic voltage regulation at the generator excitation system if the Phase II Interconnection Study shows this to be required for system safety or reliability.

iii. Supervisory Control and Data Acquisition (SCADA) Capability Power Factor Design and Operating Requirements (Reactive Power)

1. Asynchronous Generating Facilities shall meet the following design requirements:

   a. An Asynchronous Generating Facility shall be designed to have sufficient reactive power sourcing capability to achieve a net power factor of 0.95 lagging or less at the Point of Interconnection, at the Generating Facility's maximum Generating Facility Capacity An Asynchronous Generating Facility shall be designed to have net reactive power sourcing and absorption capability sufficient to achieve or exceed the net reactive power range in Figure 1 as a function of the Point of Interconnection voltage, without exceeding the ratings of any equipment in the Asynchronous Generating Facility. The Point of Interconnection voltage is specified in per-unit of the nominal voltage.

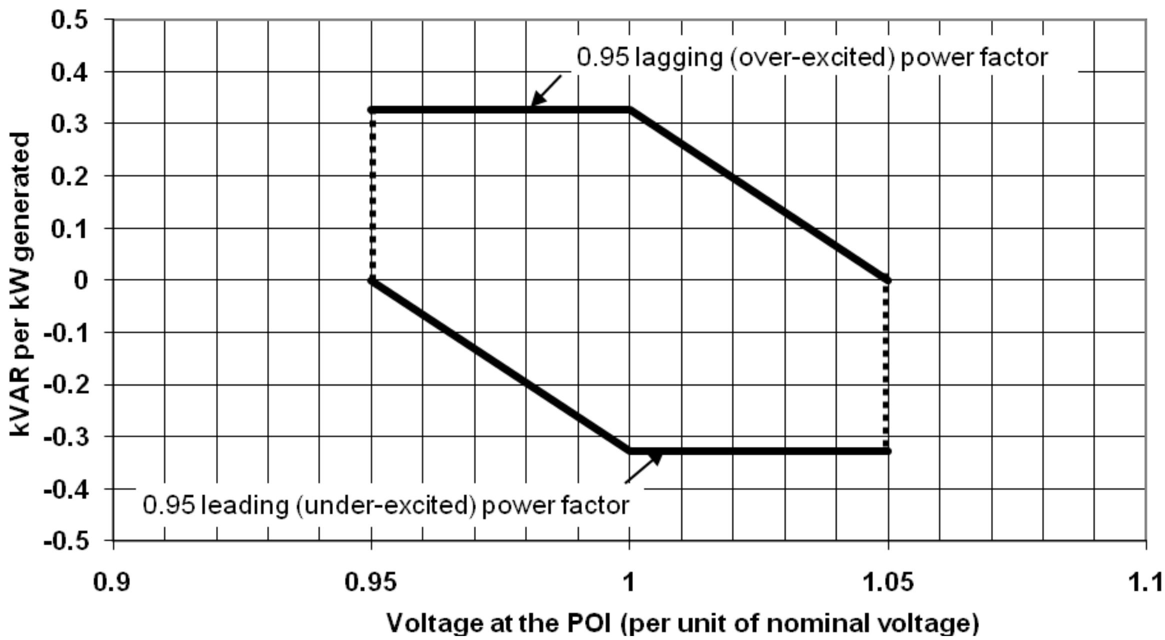

Figure 1

b. Net power factor shall be measured at the Point of Interconnection as defined in this LGIA.

c. Asynchronous Generating Facilities may meet the power factor range requirement by using power electronics designed to supply the required level of reactive capability (taking into account any limitations due to voltage level and real power output) or fixed and switched capacitors, or a combination of the two.

d. Asynchronous Generating Facilities shall also provide dynamic voltage support if the Interconnection Study requires dynamic voltage support for system safety or reliability.

e. Asynchronous Generating Facilities shall vary the reactive power output between the full sourcing and full absorption capabilities such that any step change in the reactive power output does not cause a step change in voltage at the Point of Interconnection greater than 0.02 per unit of the nominal voltage.

f. The maximum voltage change requirement shall apply when the CAISO Controlled Grid is fully intact (no line or transformer outages), or during outage conditions which do not decrease the three-phase short circuit capacity at the Point of Interconnection to less than ninety (90) percent of the three-phase short-circuit capacity that would be present without the transmission network outage.

2. Asynchronous Generating Facilities shall meet the following operational requirements:

a. When plant output power is greater than twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity, the Asynchronous Generating Facility shall have a net reactive power range at least as great as specified in Figure 1 at the Point of Interconnection, based on the actual real power output level delivered to the Point of Interconnection.

b. Power output may be curtailed at the direction of CAISO to a value where the net power factor range is met, if the reactive power capability of an Asynchronous Generating Facility is partially or totally unavailable, and if continued operation causes deviation of the voltage at the Point of Interconnection outside +/- 0.02 per unit of scheduled voltage level.

c. When the output power of the Asynchronous Generating Facility is less than twenty (20) percent of the Generating Facility's maximum Generating Facility Capacity, the net reactive power shall remain within the range between –6.6% and +6.6% of the Asynchronous Generating Facility's real power rating.

d. If the Point of Interconnection voltage exceeds 1.05 per unit, the Asynchronous Generating Facility shall provide reactive power absorption to the extent possible without violating the ratings of any of the Asynchronous Generating Facility's equipment.

e. If the Point of Interconnection voltage is less than 0.95 per unit, the Asynchronous Generating Facility shall provide reactive power injection to the extent possible without violating the ratings of any of the Asynchronous Generating Facility's equipment.

iv. Voltage Regulation and Reactive Power Control Requirements

1. The Asynchronous Generation Facility's reactive power capability shall be controlled by an automatic system having both voltage regulation and a net power factor regulation operating modes. The default mode of operation will be voltage regulation.

2. The voltage regulation function mode shall automatically control the net reactive power of the Asynchronous Generating Facility to regulate the Point of Interconnection positive sequence component of voltage to within a tolerance of +/- 0.02 per unit of the nominal voltage schedule assigned by the Participating TO or CAISO, within the constraints of the reactive power capacity of the Asynchronous Generation Facility. Deviations outside of this voltage band, except as caused by insufficient reactive capacity to maintain the voltage schedule tolerances, shall not exceed five (5) minutes duration per incident.

3. The power factor mode will regulate the net power factor measured at the Point of Interconnection. If the Asynchronous Generating Facility uses discrete reactive banks to provide reactive capability, the tolerances of the power factor regulation shall be consistent with the reactive banks' sizes meeting the voltage regulation tolerances specified in the preceding paragraph.

4. The net reactive power flow into or out of the Asynchronous Generating Facility, in any mode of operation, shall not cause the positive sequence component of voltage at the Point of Interconnection to exceed 1.05 per unit, or fall below 0.95 per unit.

5. The CAISO, in coordination with the Participating TO, may permit the Interconnection Customer to regulate the voltage at a point on the Asynchronous Generating Facility's side of the Point of Interconnection. Regulating voltage to a point other than the Point of Interconnection shall not change the Asynchronous Generating Facility's net power factor requirements set forth in Section A.iii of this Appendix H.

6. The Interconnection Customer shall not disable voltage regulation controls, without the specific permission of CAISO, while the Asynchronous Generating Facility is in operation at a power level greater than twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity.

v. Plant Power Management

1. As of January 1, 2012, Asynchronous Generating Facilities must have the capability to limit active power output in response to a CAISO Dispatch Instruction or Operating Order as those terms are defined in the CAISO Tariff. This capability shall extend from the Minimum Operating Limit to the Maximum Operating Limit of the Asynchronous Generating Facility in increments of five (5) MW or less. Changes to the power management set point shall not cause a change in voltage at the Point of Interconnection exceeding 0.02 per unit of the nominal voltage.

2. For Asynchronous Generating Facilities that are also Eligible Intermittent Resources as that term is defined in the CAISO Tariff, these power management requirements establish only a maximum output limit. There is no requirement for the Eligible Intermittent Resource to maintain a level of power output beyond the capabilities of the available energy source.

3. Asynchronous Generating Facilities must have the installed capability to limit power change ramp rates automatically, except for downward ramps resulting from decrease of the available energy resource for Eligible Intermittent Resources. The power ramp control shall be capable of limiting rates of power change to a value of five (5) percent, (10) percent, or twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity per minute. The Asynchronous Generating Facility may implement this ramping limit by using stepped increments if the individual step size is five (5) MW or less.

4. Asynchronous Generating Facilities must have the installed capability to automatically reduce plant power output in response to an over-frequency condition. This frequency response control shall, when enabled at the direction of CAISO, continuously monitor the system frequency and automatically reduce the real power output of the Asynchronous Generating Facility with a droop

equal to a one-hundred (100) percent decrease in plant output for a five (5) percent rise in frequency (five (5) percent droop) above an intentional dead band of 0.036 Hz.

vi. Supervisory Control and Data Acquisition (SCADA) and Automated Dispatch System (ADS) Capability

An Asynchronous Generating Facility shall provide SCADA capability to transmit data and receive instructions from the Participating TO and CAISO to protect system reliability. The Participating TO and CAISO and the Asynchronous Generating Facility Interconnection Customer shall determine what SCADA information is essential for the proposed Asynchronous Generating Facility, taking into account the size of the plant and its characteristics, location, and importance in maintaining generation resource adequacy and transmission system reliability.

An Asynchronous Generating Facility must be able to receive and respond to Automated Dispatch System (ADS) instructions and any other form of communication authorized by the CAISO Tariff. The Asynchronous Generating Facility's response time should be capable of conforming to the periods prescribed by the CAISO Tariff.

vii. Power System Stabilizers (PSS)

Power system stabilizers are not required for Asynchronous Generating Facilities.
The wind plant shall provide SCADA capability to transmit data and receive instructions from the Participating TO and CAISO to protect system reliability. The Participating TO and CAISO and the wind plant Interconnection Customer shall determine what SCADA information is essential for the proposed wind plant, taking into account the size of the plant and its characteristics, location, and importance in maintaining generation resource adequacy and transmission system reliability in its area.

CAISO TARIFF APPENDIX ~~V~~ BB

Standard Large Generator Interconnection Agreement

for Interconnection Requests in a Serial Study Group that are tendered or execute a Large Generator Interconnection Agreement on or after July 2, 2010

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ARTICLE 1. DEFINITIONS

Asynchronous Generating Facility shall mean an induction, doubly-fed, or electronic power generating unit(s) that produces 60 Hz (nominal) alternating current.

* * *

ARTICLE 5. INTERCONNECTION FACILITIES ENGINEERING, PROCUREMENT, AND CONSTRUCTION

* * *

5.4 Power System Stabilizers. The Interconnection Customer shall procure, install, maintain and operate Power System Stabilizers in accordance with the guidelines and procedures established by the Applicable Reliability Council and in accordance with the provisions of Section 4.6.5.1 of the CAISO Tariff. The CAISO reserves the right to establish reasonable minimum acceptable settings for any installed Power System Stabilizers, subject to the design and operating limitations of the Large Generating Facility. If the Large Generating Facility's Power System Stabilizers are removed from service or not capable of automatic operation, the Interconnection Customer shall immediately notify the CAISO and the Participating TO and restore the Power System Stabilizers to operation as soon as possible and in accordance with the Reliability Management System Agreement in Appendix G. The CAISO shall have the right to order the reduction in output or disconnection of the Large Generating Facility if the reliability of the CAISO Controlled Grid would be adversely affected as a result of improperly tuned Power System Stabilizers. The requirements of this Article 5.4 shall ~~not~~ apply to Asynchronous Generating Facilities in accordance with Appendix H~~wind generators of the induction type~~.

ARTICLE 9. OPERATIONS

9.6 Reactive Power.

9.6.1 Power Factor Design Criteria. For all Generating Facilities other than Asynchronous Generating Facilities, ~~T~~the Interconnection Customer shall design the Large Generating Facility to maintain a composite power delivery at continuous rated power output at the terminals of the Electric Generating Unit at a power factor within the range of 0.95 leading to 0.90 lagging, unless the CAISO has established different requirements that apply to all generators in the Balancing Authority Area on a comparable basis. For Asynchronous Generating Facilities, the Interconnection Customer shall design the Large Generating Facility to maintain power factor criteria in accordance with~~Power factor design criteria for wind generators are provided in~~ Appendix H of this LGIA.

* * *

9.6.2.2 Loss of Voltage Control and Governor Control for Asynchronous Generating Facilities. For Asynchronous Generating Facilities, Appendix H to this LGIA sets forth the requirements for Large Generating Facilities relating to: (i) the loss of voltage control capability, (ii) governor response to frequency conditions, and (iii) ability not to disconnect automatically or instantaneously from the CAISO Controlled Grid or trip any Electric Generating Unit comprising the Large Generating Facility for an under- or over-frequency condition. Asynchronous Generating Facilities are not required to provide governor response to under-frequency conditions.

* * *

9.7 Outages and Interruptions.

* * *

9.7.3 Under-Frequency and Over Frequency Conditions. The CAISO Controlled Grid is designed to automatically activate a load-shed program as required by the Applicable Reliability Council in the event of an under-frequency system disturbance. The Interconnection Customer shall implement under-frequency and over-frequency protection set points for the Large Generating Facility as required by the Applicable Reliability Council to ensure “ride through” capability. Large Generating Facility response to frequency deviations of pre-determined magnitudes, both under-frequency and over-frequency deviations, shall be studied and coordinated with the Participating TO and CAISO in accordance with Good Utility Practice. The term "ride through" as used herein shall mean the ability of a Generating Facility to stay connected to and synchronized with the CAISO Controlled Grid during system disturbances within a range of under-frequency and over-frequency conditions, in accordance with Good Utility Practice. Asynchronous Generating Facilities shall be subject to frequency ride through capability requirements in accordance with Appendix H to this LGIA.

* * *

Appendix H
To LGIA

INTERCONNECTION REQUIREMENTS FOR AN ASYNCHRONOUS GENERATING FACILITY WIND GENERATING PLANT

Appendix H sets forth interconnection requirements and provisions specific to all Asychronous Generating Facilities a wind generating plant. All other requirements of this LGIA continue to apply to wind generating plant interconnections. Existing individual generating units of an Asynchronous Generating Facility that are, or have been, interconnected to the CAISO Controlled Grid at the same location are exempt from the requirements of this Appendix H for the remaining life of the existing generating unit. Generating units that are replaced, however, shall meet the requirements of this Appendix H.

A. Technical Standards Requirements Applicable to Asynchronous Generating Facilitiesa Wind Generating Plant

i. Low Voltage Ride-Through (LVRT) Capability

An Asynchronous Generating Facility shall be able to remain online during voltage disturbances up to the time periods and associated voltage levels set forth in the requirements below. A wind generating plant shall be able to remain online during voltage disturbances up to the time periods and associated voltage levels set forth in the standard below. The LVRT standard provides for a transition period standard and a post-transition period standard.

1. An Asynchronous Generating Facility shall remain online for the voltage disturbance caused by any fault on the transmission grid, or within the Asynchronous Generating Facility between the Point of Interconnection and the high voltage terminals of the Asynchronous Generating Facility's step up transformer, having a duration equal to the lesser of the normal three-phase fault clearing time (4-9 cycles) or one-hundred fifty (150) milliseconds, plus any subsequent post-fault voltage recovery to the final steady-state post-fault voltage. Clearing time shall be based on the maximum normal clearing time associated with any three-phase fault location that reduces the voltage at the Asynchronous Generating Facility's Point of Interconnection to 0.2 per-unit of nominal voltage or less, independent of any fault current contribution from the Asynchronous Generating Facility.

2. An Asynchronous Generating Facility shall remain online for any voltage disturbance caused by a single-phase fault on the transmission grid, or within the Asynchronous Generating Facility between the Point of Interconnection and the high voltage terminals of the Asynchronous Generating Facility's step up transformer, with delayed clearing, plus any subsequent post-fault voltage recovery to the final steady-state post-fault voltage. Clearing time shall be based on the maximum backup clearing time associated with a single point of failure (protection or breaker failure) for any single-phase fault location that reduces any phase-to-ground or phase-to-phase voltage at the Asynchronous Generating Facility's Point of Interconnection to 0.2 per-unit of nominal voltage or less, independent of any fault current contribution from the Asynchronous Generating Facility.

3. Remaining on-line shall be defined as continuous connection between the Point of Interconnection and the Asynchronous Generating Facility's units, without any mechanical isolation. Asynchronous Generating Facilities may cease to inject current into the transmission grid during a fault.

4. The Asynchronous Generating Facility is not required to remain on line during multi-phased faults exceeding the duration described in Section A.i.1 of this Appendix H or single-phase faults exceeding the duration described in Section A.i.2 of this Appendix H.

5. The requirements of this Section A.i.of this Appendix H do not apply to faults that occur between the Asynchronous Generator Facility's terminals and the high side of the step-up transformer to the high-voltage transmission system.

6. Asynchronous Generating Facilities may be tripped after the fault period if this action is intended as part of a special protection system.

7. Asynchronous Generating Facilities may meet the requirements of this Section A.i of this Appendix H through the performance of the generating units or by installing additional equipment within the Asynchronous Generating Facility, or by a combination of generating unit performance and additional equipment.

8. The provisions of this Section A.i of this Appendix H apply only if the voltage at the Point of Interconnection has remained within the range of 0.9 and 1.10 per-unit of nominal voltage for the preceding two seconds, excluding any sub-cycle transient deviations.

The requirements of this Section A.i in this Appendix H shall not apply to any Asynchronous Generating Facility that can demonstrate to the CAISO a binding commitment, as of May 18, 2010, to purchase inverters for thirty (30) percent or more of the Generating Facility's maximum Generating Facility Capacity that are incapable of complying with the requirements of this Section A.i in this Appendix H. The Interconnection Customer must include a statement from the inverter manufacturer confirming the inability to comply with this requirement in addition to any information requested by the CAISO to determine the applicability of this exemption.

Transition Period LVRT Standard

The transition period standard applies to wind generating plants subject to FERC Order 661 that have either: (i) interconnection agreements signed and filed with FERC, filed with FERC in unexecuted form, or filed with FERC as non-conforming agreements between January 1, 2006 and December 31, 2006, with a scheduled In-Service Date no later than December 31, 2007, or (ii) wind generating turbines subject to a wind turbine procurement contract executed prior to December 31, 2005, for delivery through 2007.

1. Wind generating plants are required to remain in-service during three-phase faults with normal clearing (which is a time period of approximately 4 – 9 cycles) and single line to ground faults with delayed clearing, and subsequent post-fault voltage recovery to prefault voltage unless clearing the fault effectively disconnects the generator from the system. The clearing time requirement for a three-phase fault will be specific to the wind generating plant substation location, as determined by and documented by the Participating TO. The maximum clearing time the wind generating plant shall be required to withstand for a three-phase fault shall be 9 cycles at a voltage as low as 0.15 p.u., as measured at the high side of the wind generating plant step-up transformer (i.e. the transformer that steps the voltage up to the transmission interconnection voltage or "GSU"), after which, if the fault remains following the location-specific normal clearing time for three-phase faults, the wind generating plant may disconnect from the transmission system.

2. This requirement does not apply to faults that would occur between the wind generator terminals and the high side of the GSU or to faults that would result in a voltage lower than 0.15 per unit on the high side of the GSU serving the facility.

3. Wind generating plants may be tripped after the fault period if this action is intended as part of a special protection system.

4. Wind generating plants may meet the LVRT requirements of this standard by the performance of the

generators or by installing additional equipment (e.g., Static VAr Compensator, etc.) within the wind generating plant or by a combination of generator performance and additional equipment.

5. Existing individual generator units that are, or have been, interconnected to the network at the same location at the effective date of the Appendix H LVRT Standard are exempt from meeting the Appendix H LVRT Standard for the remaining life of the existing generation equipment. Existing individual generator units that are replaced are required to meet the Appendix H LVRT Standard.

Post-transition Period LVRT Standard

All wind generating plants subject to FERC Order No. 661 and not covered by the transition period described above must meet the following requirements:

1. Wind generating plants are required to remain in-service during three-phase faults with normal clearing (which is a time period of approximately 4 – 9 cycles) and single line to ground faults with delayed clearing, and subsequent post-fault voltage recovery to prefault voltage unless clearing the fault effectively disconnects the generator from the system. The clearing time requirement for a three-phase fault will be specific to the wind generating plant substation location, as determined by and documented by the Participating TO. The maximum clearing time the wind generating plant shall be required to withstand for a three-phase fault shall be 9 cycles after which, if the fault remains following the location-specific normal clearing time for three-phase faults, the wind generating plant may disconnect from the CAISO Controlled Grid. A wind generating plant shall remain interconnected during such a fault on the CAISO Controlled Grid for a voltage level as low as zero volts, as measured at the high voltage side of the wind GSU.

2. This requirement does not apply to faults that would occur between the wind generator terminals and the high side of the GSU.

3. Wind generating plants may be tripped after the fault period if this action is intended as part of a special protection system.

4. Wind generating plants may meet the LVRT requirements of this standard by the performance of the generators or by installing additional equipment (e.g., Static VAr Compensator) within the wind generating plant or by a combination of generator performance and additional equipment.

5. Existing individual generator units that are, or have been, interconnected to the CAISO Controlled Grid at the same location at the effective date of the Appendix H LVRT Standard are exempt from meeting the Appendix H LVRT Standard for the remaining life of the existing generation equipment. Existing individual generator units that are replaced are required to meet the Appendix H LVRT Standard.

ii. Frequency Disturbance Ride-Through CapabilityPower Factor Design Criteria (Reactive Power)

An Asynchronous Generating Facility shall comply with the off nominal frequency requirements set forth in the WECC Under Frequency Load Shedding Relay Application Guide or successor requirements as they may be amended from time to time.

iii. Power Factor Design and Operating Requirements (Reactive Power)

1. Asynchronous Generating Facilities shall meet the following design requirements:

   a. An Asynchronous Generating Facility shall be designed to have sufficient reactive power sourcing capability to achieve a net power factor of 0.95 lagging or less at the Point of Interconnection, at the Generating Facility's maximum Generating Facility Capacity. An Asynchronous Generating Facility shall be designed to have net reactive power sourcing and absorption capability sufficient to achieve or exceed the net reactive power range in Figure 1 as a function of the Point of Interconnection voltage, without exceeding the ratings of any equipment in the Asynchronous Generating Facility. The Point of Interconnection voltage is specified in per-unit of the nominal voltage.

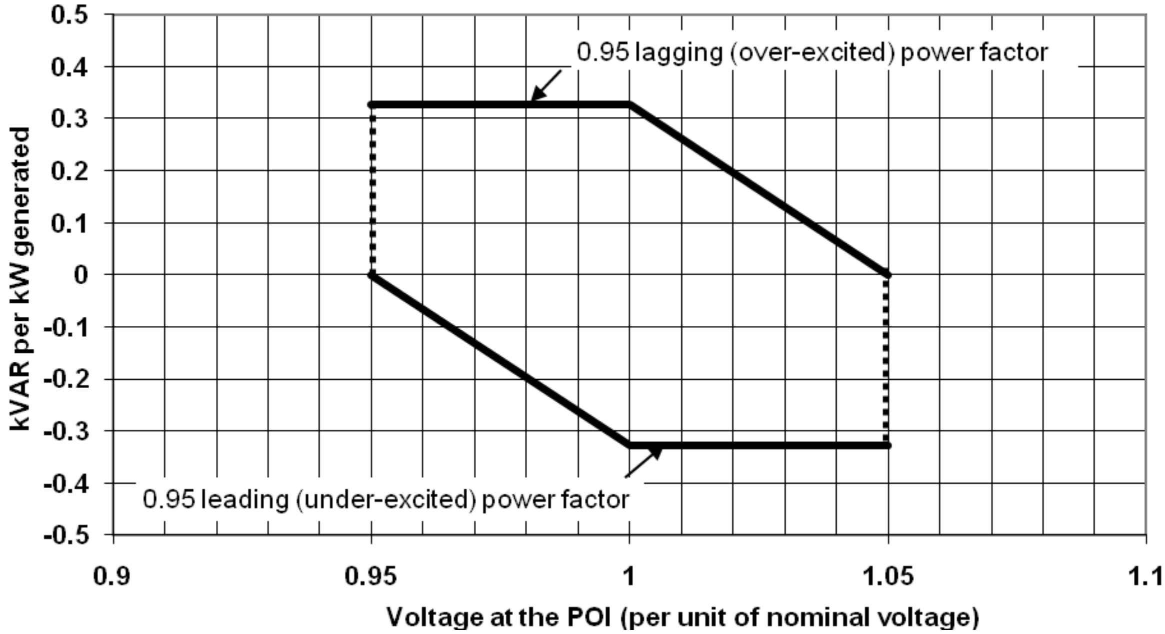

Figure 1

b. Net power factor shall be measured at the Point of Interconnection as defined in this LGIA.

c. Asynchronous Generating Facilities may meet the power factor range requirement by using power electronics designed to supply the required level of reactive capability (taking into account any limitations due to voltage level and real power output) or fixed and switched capacitors, or a combination of the two.

d. Asynchronous Generating Facilities shall also provide dynamic voltage support if the Interconnection Study requires dynamic voltage support for system safety or reliability.

e. Asynchronous Generating Facilities shall vary the reactive power output between the full sourcing and full absorption capabilities such that any step change in the reactive power output does not cause a step change in voltage at the Point of Interconnection greater than 0.02 per unit of the nominal voltage.

f. The maximum voltage change requirement shall apply when the CAISO Controlled Grid is fully intact (no line or transformer outages), or during outage conditions which do not decrease the three-phase short circuit capacity at the Point of Interconnection to less than ninety (90) percent of the three-phase short-circuit capacity that would be present without the transmission network outage.

2. Asynchronous Generating Facilities shall meet the following operational requirements:

a. When plant output power is greater than twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity, the Asynchronous Generating Facility shall have a net reactive power range at least as great as specified in Figure 1 at the Point of Interconnection, based on the actual real power output level delivered to the Point of Interconnection.

b. Power output may be curtailed at the direction of CAISO to a value where the net power factor range is met, if the reactive power capability of an Asynchronous Generating Facility is partially or totally unavailable, and if continued operation causes deviation of the voltage at the Point of Interconnection outside +/- 0.02 per unit of scheduled voltage level.

c. When the output power of the Asynchronous Generating Facility is less than twenty (20) percent of the Generating Facility's maximum Generating Facility Capacity, the net reactive power shall remain within the range between –6.6% and +6.6% of the Asynchronous Generating Facility's real power rating.

d. If the Point of Interconnection voltage exceeds 1.05 per unit, the Asynchronous Generating Facility shall provide reactive power absorption to the extent possible without violating the ratings of any of the Asynchronous Generating Facility's equipment.

e. If the Point of Interconnection voltage is less than 0.95 per unit, the Asynchronous Generating Facility shall provide reactive power injection to the extent possible without violating the ratings of any of the Asynchronous Generating Facility's equipment.

iv. Voltage Regulation and Reactive Power Control Requirements

1. The Asynchronous Generation Facility's reactive power capability shall be controlled by an automatic system having both voltage regulation and a net power factor regulation operating modes. The default mode of operation will be voltage regulation.

2. The voltage regulation function mode shall automatically control the net reactive power of the Asynchronous Generating Facility to regulate the Point of Interconnection positive sequence component of voltage to within a tolerance of +/- 0.02 per unit of the nominal voltage schedule assigned by the Participating TO or CAISO, within the constraints of the reactive power capacity of the Asynchronous Generation Facility. Deviations outside of this voltage band, except as caused by insufficient reactive capacity to maintain the voltage schedule tolerances, shall not exceed five (5) minutes duration per incident.

3. The power factor mode will regulate the net power factor measured at the Point of Interconnection. If the Asynchronous Generating Facility uses discrete reactive banks to provide reactive capability, the tolerances of the power factor regulation shall be consistent with the reactive banks' sizes meeting the voltage regulation tolerances specified in the preceding paragraph.

4. The net reactive power flow into or out of the Asynchronous Generating Facility, in any mode of operation, shall not cause the positive sequence component of voltage at the Point of Interconnection to exceed 1.05 per unit, or fall below 0.95 per unit.

5. The CAISO, in coordination with the Participating TO, may permit the Interconnection Customer to regulate the voltage at a point on the Asynchronous Generating Facility's side of the Point of Interconnection. Regulating voltage to a point other than the Point of Interconnection shall not change the Asynchronous Generating Facility's net power factor requirements set forth in Section A.iii of this Appendix H.

6. The Interconnection Customer shall not disable voltage regulation controls, without the specific permission of CAISO, while the Asynchronous Generating Facility is in operation at a power level

greater than twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity.

v. Plant Power Management

1. As of January 1, 2012, Asynchronous Generating Facilities must have the capability to limit active power output in response to a CAISO Dispatch Instruction or Operating Order as those terms are defined in the CAISO Tariff. This capability shall extend from the Minimum Operating Limit to the Maximum Operating Limit of the Asynchronous Generating Facility in increments of five (5) MW or less. Changes to the power management set point shall not cause a change in voltage at the Point of Interconnection exceeding 0.02 per unit of the nominal voltage.

2. For Asynchronous Generating Facilities that are also Eligible Intermittent Resources as that term is defined in the CAISO Tariff, these power management requirements establish only a maximum output limit. There is no requirement for the Eligible Intermittent Resource to maintain a level of power output beyond the capabilities of the available energy source.

3. Asynchronous Generating Facilities must have the installed capability to limit power change ramp rates automatically, except for downward ramps resulting from decrease of the available energy resource for Eligible Intermittent Resources. The power ramp control shall be capable of limiting rates of power change to a value of five (5) percent, (10) percent, or twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity per minute. The Asynchronous Generating Facility may implement this ramping limit by using stepped increments if the individual step size is five (5) MW or less.

4. Asynchronous Generating Facilities must have the installed capability to automatically reduce plant power output in response to an over-frequency condition. This frequency response control shall, when enabled at the direction of CAISO, continuously monitor the system frequency and automatically reduce the real power output of the Asynchronous Generating Facility with a droop equal to a one-hundred (100) percent decrease in plant output for a five (5) percent rise in frequency (five (5) percent droop) above an intentional dead band of 0.036 Hz.

vi. Supervisory Control and Data Acquisition (SCADA) and Automated Dispatch System (ADS) Capability

An Asynchronous Generating Facility shall provide SCADA capability to transmit data and receive instructions from the Participating TO and CAISO to protect system reliability. The Participating TO and CAISO and the Asynchronous Generating Facility Interconnection Customer shall determine what SCADA information is essential for the proposed Asynchronous Generating Facility, taking into account the size of the plant and its characteristics, location, and importance in maintaining generation resource adequacy and transmission system reliability.

An Asynchronous Generating Facility must be able to receive and respond to Automated Dispatch System (ADS) instructions and any other form of communication authorized by the CAISO Tariff. The Asynchronous Generating Facility's response time should be capable of conforming to the periods prescribed by the CAISO Tariff.

vii. Power System Stabilizers (PSS)

Power system stabilizers are not required for Asynchronous Generating Facilities.

~~A wind generating plant shall operate within a power factor within the range of 0.95 leading to 0.95 lagging, measured at the Point of Interconnection as defined in this LGIA in order to maintain a specified voltage schedule, if the Interconnection System Impact Study shows that such a requirement is necessary to ensure safety or reliability. The power factor range standard can be met by using, for example, power electronics designed to supply this level of reactive capability (taking into account any~~

limitations due to voltage level, real power output, etc.) or fixed and switched capacitors, or a combination of the two, if agreed to by the Participating TO and CAISO. The Interconnection Customer shall not disable power factor equipment while the wind plant is in operation. Wind plants shall also be able to provide sufficient dynamic voltage support in lieu of the power system stabilizer and automatic voltage regulation at the generator excitation system if the Interconnection System Impact Study shows this to be required for system safety or reliability.

iii. Supervisory Control and Data Acquisition (SCADA) Capability

The wind plant shall provide SCADA capability to transmit data and receive instructions from the Participating TO and CAISO to protect system reliability. The Participating TO and CAISO and the wind plant Interconnection Customer shall determine what SCADA information is essential for the proposed wind plant, taking into account the size of the plant and its characteristics, location, and importance in maintaining generation resource adequacy and transmission system reliability in its area.

CAISO TARIFF APPENDIX ~~Z~~CC

Large Generator Interconnection Agreement

for Interconnection Requests in a Queue Cluster Window

that are tendered or execute a Large Generator Interconnection Agreement on or after July 2, 2010

*** * ***

ARTICLE 1. DEFINITIONS

Asynchronous Generating Facility shall mean an induction, doubly-fed, or electronic power generating unit(s) that produces 60 Hz (nominal) alternating current.

* * *

ARTICLE 5. INTERCONNECTION FACILITIES ENGINEERING, PROCUREMENT, AND CONSTRUCTION

5.4 Power System Stabilizers. The Interconnection Customer shall procure, install, maintain and operate Power System Stabilizers in accordance with Applicable Reliability Standards, the guidelines and procedures established by the Applicable Reliability Council, and the provisions of Section 4.6.5.1 of the CAISO Tariff. The CAISO reserves the right to establish reasonable minimum acceptable settings for any installed Power System Stabilizers, subject to the design and operating limitations of the Large Generating Facility. If the Large Generating Facility's Power System Stabilizers are removed from service or not capable of automatic operation, the Interconnection Customer shall immediately notify the CAISO and the Participating TO and restore the Power System Stabilizers to operation as soon as possible. The CAISO shall have the right to order the reduction in output or disconnection of the Large Generating Facility if the reliability of the CAISO Controlled Grid would be adversely affected as a result of improperly tuned Power System Stabilizers. The requirements of this Article 5.4 shall ~~not~~ apply to Asynchronous Generating Facilities in accordance with Appendix H ~~wind generators of the induction type~~.

ARTICLE 9. OPERATIONS

* * *

9.6 Reactive Power.

9.6.1 Power Factor Design Criteria. For all Generating Facilities other than Asynchronous Generating Facilities, tThe Interconnection Customer shall design the Large Generating Facility to maintain a composite power delivery at continuous rated power output at the terminals of the Electric Generating Unit at a power factor within the range of 0.95 leading to 0.90 lagging, unless the CAISO has established different requirements that apply to all generators in the Balancing Authority Area on a comparable basis. For Asynchronous Generating Facilities, the Interconnection Customer shall design the Large Generating Facility to maintain power factor criteria in accordance withPower factor design criteria for wind generators are provided in Appendix H of this LGIA.

* * *

9.6.2.2 Loss of Voltage Control and Governor Control for Asynchronous Generating Facilities. For Asynchronous Generating Facilities, Appendix H to this LGIA sets forth the requirements for Large Generating Facilities relating to: (i) loss of voltage control capability, (ii) governor response to frequency conditions, and (iii) ability not to disconnect automatically or instantaneously from the CAISO Controlled Grid or trip any Electric Generating Unit comprising the Large Generating Facility for an under- or over-frequency condition. Asynchronous Generating Facilities are not required to provide governor response to under-frequency conditions.

* * *

9.7 Outages and Interruptions.

*** * ***

9.7.3 Under-Frequency and Over Frequency Conditions. The CAISO Controlled Grid is designed to automatically activate a load-shed program as required by Applicable Reliability Standards and the Applicable Reliability Council in the event of an under-frequency system disturbance. The Interconnection Customer shall implement under-frequency and over-frequency protection set points for the Large Generating Facility as required by Applicable Reliability Standards and the Applicable Reliability Council to ensure "ride through" capability. Large Generating Facility response to frequency deviations of pre-determined magnitudes, both under-frequency and over-frequency deviations, shall be studied and coordinated with the Participating TO and CAISO in accordance with Good Utility Practice. The term "ride through" as used herein shall mean the ability of a Generating Facility to stay connected to and synchronized with the CAISO Controlled Grid during system disturbances within a range of under-frequency and over-frequency conditions, in accordance with Good Utility Practice. Asynchronous Generating Facilities shall be subject to frequency ride through capability requirements in accordance with Appendix H to this LGIA.

* * *

* * *

Appendix H
To LGIA

INTERCONNECTION REQUIREMENTS FOR AN ASYNCHRONOUS GENERATING FACILITY WIND GENERATING PLANT

Appendix H sets forth interconnection requirements and provisions specific to all Asychronous Generating Facilitiesa wind generating plant. All other requirements of this LGIA continue to apply to wind generating plant interconnections. Existing individual generating units of an Asynchronous Generating Facility that are, or have been, interconnected to the CAISO Controlled Grid at the same location are exempt from the requirements of this Appendix H for the remaining life of the existing generating unit. Generating units that are replaced, however, shall meet the requirements of this Appendix H.

A. Technical Standards Requirements Applicable to Asynchronous Generating Facilitiesa Wind Generating Plant

i. Low Voltage Ride-Through (LVRT) Capability

An Asynchronous Generating Facility shall be able to remain online during voltage disturbances up to the time periods and associated voltage levels set forth in the requirements below.A wind generating plant shall be able to remain online during voltage disturbances up to the time periods and associated voltage levels set forth in the standard below.

1. An Asynchronous Generating Facility shall remain online for the voltage disturbance caused by any fault on the transmission grid, or within the Asynchronous Generating Facility between the Point of Interconnection and the high voltage terminals of the Asynchronous Generating Facility's step up transformer, having a duration equal to the lesser of the normal three-phase fault clearing time (4-9 cycles) or one-hundred fifty (150) milliseconds, plus any subsequent post-fault voltage recovery to the final steady-state post-fault voltage. Clearing time shall be based on the maximum normal clearing time associated with any three-phase fault location that reduces the voltage at the Asynchronous Generating Facility's Point of Interconnection to 0.2 per-unit of nominal voltage or less, independent of any fault current contribution from the Asynchronous Generating Facility.

2. An Asynchronous Generating Facility shall remain online for any voltage disturbance caused by a single-phase fault on the transmission grid, or within the Asynchronous Generating Facility between the Point of Interconnection and the high voltage terminals of the Asynchronous Generating Facility's step up transformer, with delayed clearing, plus any subsequent post-fault voltage recovery to the final steady-state post-fault voltage. Clearing time shall be based on the maximum backup clearing time associated with a single point of failure (protection or breaker failure) for any single-phase fault location that reduces any phase-to-ground or phase-to-phase voltage at the Asynchronous Generating Facility's Point of Interconnection to 0.2 per-unit of nominal voltage or less, independent of any fault current contribution from the Asynchronous Generating Facility.

3. Remaining on-line shall be defined as continuous connection between the Point of Interconnection and the Asynchronous Generating Facility's units, without any mechanical isolation. Asynchronous Generating Facilities may cease to inject current into the transmission grid during a fault.

4. The Asynchronous Generating Facility is not required to remain on line during multi-phased faults exceeding the duration described in Section A.i1 of this Appendix H or single-phase faults exceeding the duration described in Section A.i.2 of this Appendix H.

5. The requirements of this Section A.i of this Appendix H do not apply to faults that occur between the Asynchronous Generator Facility's terminals and the high side of the step-up transformer to the high-voltage transmission system.

6. Asynchronous Generating Facilities may be tripped after the fault period if this action is intended as part of a special protection system.

7. Asynchronous Generating Facilities may meet the requirements of this Section A.i of this Appendix H through the performance of the generating units or by installing additional equipment within the Asynchronous Generating Facility, or by a combination of generating unit performance and additional equipment.

8. The provisions of this Section A.i of this Appendix H apply only if the voltage at the Point of Interconnection has remained within the range of 0.9 and 1.10 per-unit of nominal voltage for the preceding two seconds, excluding any sub-cycle transient deviations.

The requirements of this Section A.i in this Appendix H shall not apply to any Asynchronous Generating Facility that can demonstrate to the CAISO a binding commitment, as of May 18, 2010, to purchase inverters for thirty (30) percent or more of the Generating Facility's maximum Generating Facility Capacity that are incapable of complying with the requirements of this Section A.i in this Appendix H. The Interconnection Customer must include a statement from the inverter manufacturer confirming the inability to comply with this requirement in addition to any information requested by the CAISO to determine the applicability of this exemption.

~~All wind generating plants subject to FERC Order No. 661 must meet the following requirements:~~

~~1. Wind generating plants are required to remain in-service during three-phase faults with normal clearing (which is a time period of approximately 4 – 9 cycles) and single line to ground faults with delayed clearing, and subsequent post-fault voltage recovery to prefault voltage unless clearing the fault effectively disconnects the generator from the system. The clearing time requirement for a three-phase fault will be specific to the wind generating plant substation location, as determined by and documented by the Participating TO. The maximum clearing time the wind generating plant shall be required to withstand for a three-phase fault shall be 9 cycles after which, if the fault remains following the location-specific normal clearing time for three-phase faults, the wind generating plant may disconnect from the CAISO Controlled Grid. A wind generating plant shall remain interconnected during such a fault on the CAISO Controlled Grid for a voltage level as low as zero volts, as measured at the high voltage side of the wind GSU.~~

~~2. This requirement does not apply to faults that would occur between the wind generator terminals and the high side of the GSU.~~

~~3. Wind generating plants may be tripped after the fault period if this action is intended as part of a special protection system.~~

~~4. Wind generating plants may meet the LVRT requirements of this standard by the performance of the generators or by installing additional equipment (e.g., Static VAr Compensator) within the wind generating plant or by a combination of generator performance and additional equipment.~~

~~5. Existing individual generator units that are, or have been, interconnected to the CAISO Controlled Grid at the same location at the effective date of the Appendix H LVRT Standard are exempt from meeting the Appendix H LVRT Standard for the remaining life of the existing generation equipment. Existing individual generator units that are replaced are required to meet the Appendix H LVRT Standard.~~

ii. Frequency Disturbance Ride-Through CapabilityPower Factor Design Criteria (Reactive Power)

An Asynchronous Generating Facility shall comply with the off nominal frequency requirements set forth in the WECC Under Frequency Load Shedding Relay Application Guide or successor requirements as they may be amended from time to time.

A wind generating plant shall operate within a power factor within the range of 0.95 leading to 0.95 lagging, measured at the Point of Interconnection as defined in this LGIA in order to maintain a specified voltage schedule, if the Phase II Interconnection Study shows that such a requirement is necessary to ensure safety or reliability. The power factor range standard can be met by using, for example, power electronics designed to supply this level of reactive capability (taking into account any limitations due to voltage level, real power output, etc.) or fixed and switched capacitors, or a combination of the two, if agreed to by the Participating TO and CAISO. The Interconnection Customer shall not disable power factor equipment while the wind plant is in operation. Wind plants shall also be able to provide sufficient dynamic voltage support in lieu of the power system stabilizer and automatic voltage regulation at the generator excitation system if the Phase II Interconnection Study shows this to be required for system safety or reliability.

iii. Supervisory Control and Data Acquisition (SCADA) Capability Power Factor Design and Operating Requirements (Reactive Power)

1. Asynchronous Generating Facilities shall meet the following design requirements:

   a. An Asynchronous Generating Facility shall be designed to have sufficient reactive power sourcing capability to achieve a net power factor of 0.95 lagging or less at the Point of Interconnection, at the Generating Facility's maximum Generating Facility Capacity An Asynchronous Generating Facility shall be designed to have net reactive power sourcing and absorption capability sufficient to achieve or exceed the net reactive power range in Figure 1 as a function of the Point of Interconnection voltage, without exceeding the ratings of any equipment in the Asynchronous Generating Facility. The Point of Interconnection voltage is specified in per-unit of the nominal voltage.

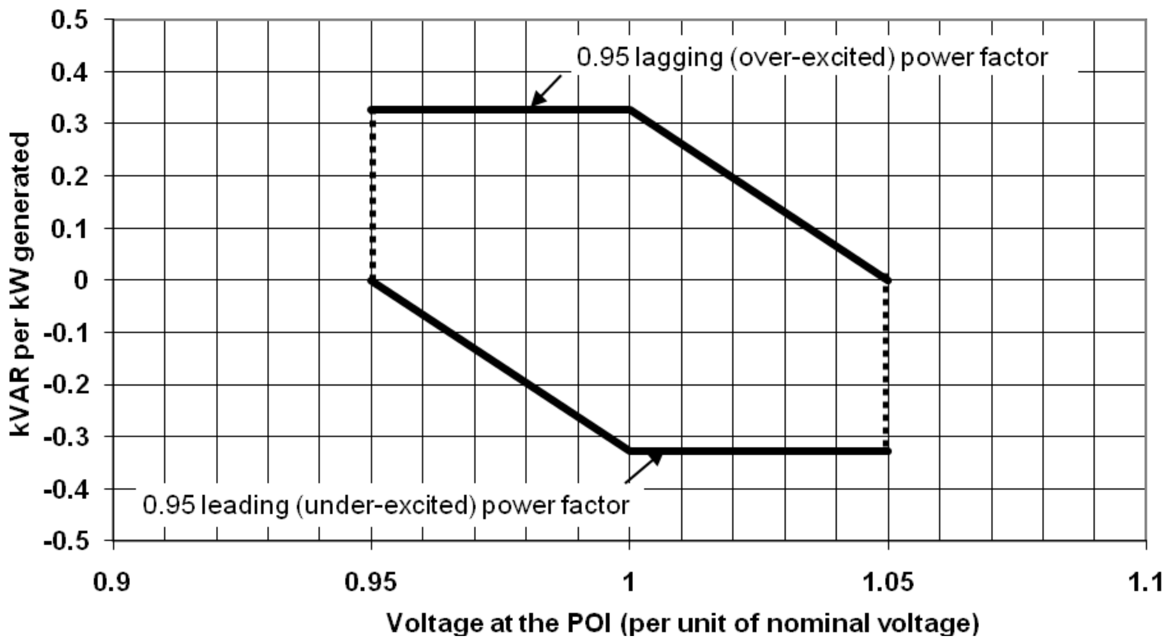

Figure 1

b. Net power factor shall be measured at the Point of Interconnection as defined in this LGIA.

c. Asynchronous Generating Facilities may meet the power factor range requirement by using power electronics designed to supply the required level of reactive capability (taking into account any limitations due to voltage level and real power output) or fixed and switched capacitors, or a combination of the two.

d. Asynchronous Generating Facilities shall also provide dynamic voltage support if the Interconnection Study requires dynamic voltage support for system safety or reliability.

e. Asynchronous Generating Facilities shall vary the reactive power output between the full sourcing and full absorption capabilities such that any step change in the reactive power output does not cause a step change in voltage at the Point of Interconnection greater than 0.02 per unit of the nominal voltage.

f. The maximum voltage change requirement shall apply when the CAISO Controlled Grid is fully intact (no line or transformer outages), or during outage conditions which do not decrease the three-phase short circuit capacity at the Point of Interconnection to less than ninety (90) percent of the three-phase short-circuit capacity that would be present without the transmission network outage.

2. Asynchronous Generating Facilities shall meet the following operational requirements:

a. When plant output power is greater than twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity, the Asynchronous Generating Facility shall have a net reactive power range at least as great as specified in Figure 1 at the Point of Interconnection, based on the actual real power output level delivered to the Point of Interconnection.

b. Power output may be curtailed at the direction of CAISO to a value where the net power factor range is met, if the reactive power capability of an Asynchronous Generating Facility is partially or totally unavailable, and if continued operation causes deviation of the voltage at the Point of Interconnection outside +/- 0.02 per unit of scheduled voltage level.

c. When the output power of the Asynchronous Generating Facility is less than twenty (20) percent of the Generating Facility's maximum Generating Facility Capacity, the net reactive power shall remain within the range between –6.6% and +6.6% of the Asynchronous Generating Facility's real power rating.

d. If the Point of Interconnection voltage exceeds 1.05 per unit, the Asynchronous Generating Facility shall provide reactive power absorption to the extent possible without violating the ratings of any of the Asynchronous Generating Facility's equipment.

e. If the Point of Interconnection voltage is less than 0.95 per unit, the Asynchronous Generating Facility shall provide reactive power injection to the extent possible without violating the ratings of any of the Asynchronous Generating Facility's equipment.

iv. Voltage Regulation and Reactive Power Control Requirements

1. The Asynchronous Generation Facility's reactive power capability shall be controlled by an automatic system having both voltage regulation and a net power factor regulation operating modes. The default mode of operation will be voltage regulation.

2. The voltage regulation function mode shall automatically control the net reactive power of the Asynchronous Generating Facility to regulate the Point of Interconnection positive sequence component of voltage to within a tolerance of +/- 0.02 per unit of the nominal voltage schedule assigned by the Participating TO or CAISO, within the constraints of the reactive power capacity of the Asynchronous Generation Facility. Deviations outside of this voltage band, except as caused by insufficient reactive capacity to maintain the voltage schedule tolerances, shall not exceed five (5) minutes duration per incident.

3. The power factor mode will regulate the net power factor measured at the Point of Interconnection. If the Asynchronous Generating Facility uses discrete reactive banks to provide reactive capability, the tolerances of the power factor regulation shall be consistent with the reactive banks' sizes meeting the voltage regulation tolerances specified in the preceding paragraph.

4. The net reactive power flow into or out of the Asynchronous Generating Facility, in any mode of operation, shall not cause the positive sequence component of voltage at the Point of Interconnection to exceed 1.05 per unit, or fall below 0.95 per unit.

5. The CAISO, in coordination with the Participating TO, may permit the Interconnection Customer to regulate the voltage at a point on the Asynchronous Generating Facility's side of the Point of Interconnection. Regulating voltage to a point other than the Point of Interconnection shall not change the Asynchronous Generating Facility's net power factor requirements set forth in Section A.iii of this Appendix H.

6. The Interconnection Customer shall not disable voltage regulation controls, without the specific permission of CAISO, while the Asynchronous Generating Facility is in operation at a power level greater than twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity.

v. Plant Power Management

1. As of January 1, 2012, Asynchronous Generating Facilities must have the capability to limit active power output in response to a CAISO Dispatch Instruction or Operating Order as those terms are defined in the CAISO Tariff. This capability shall extend from the Minimum Operating Limit to the Maximum Operating Limit of the Asynchronous Generating Facility in increments of five (5) MW or less. Changes to the power management set point shall not cause a change in voltage at the Point of Interconnection exceeding 0.02 per unit of the nominal voltage.

2. For Asynchronous Generating Facilities that are also Eligible Intermittent Resources as that term is defined in the CAISO Tariff, these power management requirements establish only a maximum output limit. There is no requirement for the Eligible Intermittent Resource to maintain a level of power output beyond the capabilities of the available energy source.

3. Asynchronous Generating Facilities must have the installed capability to limit power change ramp rates automatically, except for downward ramps resulting from decrease of the available energy resource for Eligible Intermittent Resources. The power ramp control shall be capable of limiting rates of power change to a value of five (5) percent, (10) percent, or twenty (20) percent of the Asynchronous Generating Facility's maximum Generating Facility Capacity per minute. The Asynchronous Generating Facility may implement this ramping limit by using stepped increments if the individual step size is five (5) MW or less.

4. Asynchronous Generating Facilities must have the installed capability to automatically reduce plant power output in response to an over-frequency condition. This frequency response control shall, when enabled at the direction of CAISO, continuously monitor the system frequency and automatically reduce the real power output of the Asynchronous Generating Facility with a droop

equal to a one-hundred (100) percent decrease in plant output for a five (5) percent rise in frequency (five (5) percent droop) above an intentional dead band of 0.036 Hz.

vi. Supervisory Control and Data Acquisition (SCADA) and Automated Dispatch System (ADS) Capability

An Asynchronous Generating Facility shall provide SCADA capability to transmit data and receive instructions from the Participating TO and CAISO to protect system reliability. The Participating TO and CAISO and the Asynchronous Generating Facility Interconnection Customer shall determine what SCADA information is essential for the proposed Asynchronous Generating Facility, taking into account the size of the plant and its characteristics, location, and importance in maintaining generation resource adequacy and transmission system reliability.

An Asynchronous Generating Facility must be able to receive and respond to Automated Dispatch System (ADS) instructions and any other form of communication authorized by the CAISO Tariff. The Asynchronous Generating Facility's response time should be capable of conforming to the periods prescribed by the CAISO Tariff.

vii. Power System Stabilizers (PSS)

Power system stabilizers are not required for Asynchronous Generating Facilities.
~~The wind plant shall provide SCADA capability to transmit data and receive instructions from the Participating TO and CAISO to protect system reliability. The Participating TO and CAISO and the wind plant Interconnection Customer shall determine what SCADA information is essential for the proposed wind plant, taking into account the size of the plant and its characteristics, location, and importance in maintaining generation resource adequacy and transmission system reliability in its area.~~

Attachment D

Prepared Testimony of Reigh Walling and Appendices A-C to Testimony

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

California Independent System Operator Corporation	))))	**Docket No. ER10-**______

Prepared Testimony of Reigh Walling

I. Introduction and Overview

Q. What is your name?

A. Reigh Walling.

Q. By whom are you employed?

A. I am employed by the Energy Applications and Systems Engineering Department of General Electric International, Inc.

Q. Could you please describe your professional background?

A. I have worked as a consultant to the electric power industry for the 29 years that I have been employed by GE. Much of my recent consulting practice has been in the area of renewable generation systems, particularly renewable generation integration and interconnection. I have published in excess of sixty technical papers and articles, with a number of these papers related to renewable generation integration. I have been elected a Fellow of the Institution of Electrical and Electronic Engineers (IEEE). A list of my publications is attached hereto as Appendix A.

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to describe the interconnection requirements proposed by the ISO for asynchronous generating facilities as well as the commercial availability and cost of equipment that will allow asynchronous generating facilities to design their facilities to meet these requirements.

Q. Please describe asynchronous generating facilities.

A. The ISO has proposed to define asynchronous generating facilities as an induction, doubly-fed or electronic power generating unit(s) that produces 60 Hz (nominal) alternating current. This definition captures the current scope of commercial asynchronous generators. The listed facilities include wind and solar photovoltaic (PV) resources and may also include certain solar thermal resources, such as generators using Stirling engine systems.

Q. Are you familiar with issues facing transmission operators in facilitating the interconnection and operation of asynchronous generating facilities?

A. Yes, this is the primary focus of my consulting practice. I was the director in charge of a GE study concerning the impact of wind generation on the ancillary services requirements of the ERCOT system. GE has performed many of the major wind integration studies in the US, and we are currently performing a major wind integration study for the Independent System Operator of New England.

As part of the wind integration work conducted on behalf of ISO-NE, GE, in conjunction with EnerNex Corporation and AWS Truepower, produced a document titled "Technical Requirements for Wind Generation Interconnection and Integration".[1] A copy of this document is attached as Appendix B. This document describes the performance characteristics of current wind turbine and wind plant technology, the present state of wind forecasting technology, and the impacts on system operations of significant wind generation penetration. In addition to this background information, the document provides detailed recommendations to ISO-NE regarding performance requirements for wind plants interconnecting to that system as well as operating practices that should be adopted to facilitate the reliable operation of the system as additional wind resources interconnect.

However, the ISO-NE document should not be viewed as narrowly applying to wind resources only or ISO-NE's specific system needs. Many

[1] A copy of this document is published on the website of the Integration of Variable Generation Task Force of the North American Reliability Corporation. http://www.nerc.com/docs/pc/ivgtf/Final_16_Nov_09_Interconnection_req_newis_report.pdf

of the recommendations in the ISO-NE document, and the underlying analysis supporting the recommendations, rest not only on the specific characteristics of wind resources, but rather on the more fundamental characteristics of asynchronous and variable energy generators. As such, the document prepared for ISO-NE served as a foundation for GE's consulting work with the ISO and provides relevant, but certainly not the exclusive, technical support for the currently proposed interconnection requirements applicable to all asynchronous generators, including solar technologies. For example, the recommendations developed by GE and EnerNex for ISO-NE include, among others:

- Power factor range of ±0.95 lead/lag at the point of interconnection on the basis that "[t]oday's wind plant technology is fully capable of meeting this power factor range requirement, and reactive power support with closed loop voltage control is essential to the operation and reliability of a power grid."
- Adoption of a more "prescriptive" interpretation of Order No. 661a that requires wind plants provide voltage regulation at the specified point of interconnection by delivering the reactive power required to meet a specified voltage (under control of a voltage regulator) anywhere within the required power factor range.
- Recognition that under low active power conditions, it can be difficult for wind plants to meet tight requirements for voltage and

reactive power control and therefore requirements for voltage regulation should be relaxed at low power output levels.

- Adoption of both low voltage and frequency ride-through.
- Adoption of the capability to limit the rate of power increase or decrease, except due to a decline in wind speed, along with the recognition that this functionality should not be required under all operating conditions, but may be called upon for curtailment commands, shut-down sequences, response to market conditions and other control actions.

As discussed further below, these recommendations for ISO-NE are consistent with those advanced by the ISO in this proceeding. In both cases, these recommendations strike a balance between system needs, availability of appropriate technology, and economic burden on asynchronous generator owners and developers.

Q. Are similar general system considerations addressed for ISO-NE also relevant to the ISO's efforts to integrate asynchronous generating facilities?

A. Yes. The ISO is projecting that a large amount of variable generation in the form of wind and solar PV will interconnect to the transmission system it operates during the next several years. The need to develop performance requirements for asynchronous generating facilities anticipated to interconnect to the ISO is more acute than ISO-NE given the larger volume of resources seeking to interconnect to the ISO transmission grid as compared to the ISO-NE system.

Q. Please identify the proposed interconnection requirements to which your prepared testimony applies.

A. My testimony discusses the following proposed interconnection requirements: low voltage ride through capability, frequency disturbance ride-through capability, power factor design and operation, voltage regulation and reactive power control, and power plant management.

II. Low Voltage Ride Through Capability

Q. What is the purpose of the ISO's proposed low voltage ride through capability requirements for asynchronous generating facilities?

A. The purpose of the ISO's proposed requirements is to expand the pool of resources that can sustain the operation of the electric system when contingencies occur. If asynchronous generating facilities do not have low voltage ride through capability, they are likely to trip during disturbances, especially disturbances on adjacent substations and disturbances that cause major voltage depression. The loss of these real power resources during a contingency may trigger cascading events.

Q. Are there existing low voltage ride through standards for solar PV generating facilities?

A. No, not for facilities interconnected to the transmission grid. The solar PV industry has strong roots in the distributed generation application of their equipment, where individual facilities are small and connected to distribution systems. Almost all distribution feeders in North America are of radial configuration. Faults on these feeders are cleared by tripping the feeders, and there is a risk that any distributed generation connected to a tripped feeder could cause the uncontrolled energization of the feeder ("islanding"), and exposure of utility customers to abnormal voltage and frequency, as well as potential exposure of utility workers and the general public to continued energization of a feeder that should not be energized.

The scope of the IEEE 1547 is specifically limited to facilities having an aggregate capacity of 10 MVA or less, and which are interconnected at primary or secondary distribution voltages. Thus, this standard does not apply to transmission-interconnected asynchronous generating facilities, with an aggregate capacity of 20 MVA or greater, which is the scope of facilities subject to the proposed ISO requirements. IEEE Standard 1547 was adopted, in part, to minimize this risk of distribution feeder islanding" by requiring that a distributed generator trip in response to a system disturbance.. However, this disturbance "non-ride-through" requirement is in direct conflict with the performance that should be provided by large transmission-connected facilities that are covered by the ISO's proposed tariff amendment. Without explicit low-voltage ride-through requirements, many transmission connected solar resources will tend to use inverters designed originally for the distributed generation market, where the provisions of IEEE Standard 1547 apply. The wind industry has matured from what was once considered to be an insignificant resource that should immediately trip at the first signs of system disturbance to a resource that is considered critical to grid support and therefore must not trip during ordinary contingencies. Likewise, the solar PV industry must mature if it is to participate as a transmission-connected resource.

Q. What low voltage ride through requirements is the ISO proposing to apply to asynchronous generating facilities?

A. The ISO is proposing to extend the low voltage ride through requirements established by FERC for wind generators to all asynchronous generating facilities. These proposed requirements track the specific low voltage ride through provisions adopted by FERC with some modifications.

Q. Notwithstanding that FERC previously elected to limit the low voltage ride through requirements to wind generators, is there a justification for the ISO to limit the proposed requirement to asynchronous generating facilities and not apply it to all generator types?

A. A significant issue for synchronous generator fault ride through is maintaining synchronism with the grid; often referred to as "maintaining stability". The ability to maintain synchronism, and thus ride-through faults, is adequately covered by existing NERC and WECC planning criteria. A key step performed in interconnection studies is to confirm generating plant stability for defined fault contingencies. As such, low voltage ride through capacities already exist for conventional generators. The ISO's proposed requirements merely extend the general requirements already applicable to wind generators to other asynchronous generating facilities.

Q. Can you please describe the specific modifications the ISO is proposing to the low voltage ride through requirements that FERC adopted for wind generators?

A. The modifications are intended to maintain the original intent and function of the FERC Order No. 661a standard, while providing additional clarity to aid in enforceability and consistency of system design. The specific changes are as follows:

1. The ISO has separated the ride-through requirements for single-phase faults with delayed clearing from the requirements applicable to all normally cleared faults. This language makes unambiguous the requirement that the asynchronous generating facility must ride through the subsequent post-fault voltage recovery for single-phase

faults with delayed clearing. The wording of the language from FERC's Order No. 661a could be interpreted as requiring ride-through of post-fault voltage recovery only in the case of normally-cleared three-phase faults. It is important from a grid reliability standpoint that asynchronous generators have the ability to ride-through both single- and multi-phase faults.

2. The ISO is requiring asynchronous generating facilities to ride through all normally-cleared faults. The requirement to ride through normally cleared three-phase faults has been clarified in the ISO's proposed language to include all types of normally-cleared faults generally considered inclusive of the more severe three-phased fault (*e.g.*, phase-to-phase and double phase faults). However, is the ISO's proposal also acknowledges that for some asynchronous generating technologies, ride through of unbalanced faults, such as two-phase faults, can be more difficult than three-phase faults. This change is intended to ensure generation is not lost as a consequence of single-contingency faults.

3. The ISO's proposed language establishes criteria to define which circuit breaker clearing times set the "normal" fault clearing time. Faults in a range of locations in the transmission system, potentially including a number of different lines and transformers, may result in

a large voltage decrease at an asynchronous generation facility's Point of interconnection. Under normal circumstances, each fault location will be detected by a specific protection system and will be cleared by a given set of circuit breakers. Thus, there is a range of possible clearing times associated with all the possible faults that could affect an asynchronous generating facility. The ISO's proposed language defines the *normal* clearing time duration as the longest normal clearing time (not to exceed nine cycles, or 150 milliseconds) for any three phase fault causing the asynchronous generation facility point of interconnection voltage to drop below 0.2 per-unit of nominal voltage. The *delayed* clearing time duration for the purpose of ride-through requirements is defined to be the longest delayed clearing time for any single-phase fault causing at least one phase voltage at the point of interconnection to drop below 0.2 per-unit of nominal voltage. This language clarifies the requirements of FERC Order 661a, which do not specify the means to determine the applicable normal and delayed clearing times.

4. The ISO proposed language provides a definition for "remaining on line" that is useful when applied to inverters with the capability to be blocked from power conversion without opening any circuit breaker, and which also can instantly resume operation through control of the power electronics without any switchgear closing time. The

material requirement for voltage ride-through performance is post-fault support,. This requirement is permissive of strategies that could potentially be employed to protect an inverter from the stress of operating into a transmission fault, while still providing grid support from the inverter immediately after the fault clears.

5. The ISO's proposed language clarifies that the ride-through requirement is a facility requirement, and does not necessarily require that individual generating units that comprise the facility have this capability. Auxiliary equipment within the facility can be used to provide or complement the capabilities of individual generating units. This provides generators with greater flexibility in meeting the ride-through requirements, thereby promoting more cost-efficient solutions.

6. The ISO clarifies that its proposed ride-through requirements do not require asynchronous generators to ride-through multiple fault events, such as an unsuccessful reclosing attempt. FERC's Order 661a does not address this issue. The ISO's proposed language prevents a utility form interpreting the FERC's 661a requirements to apply to a very large number of successive faults over a short period of time, which could be considered to be an unreasonable requirement for equipment to endure.

Q. Why is the ISO proposing these changes?

A. The ISO needs to apply objective low voltage ride through requirements to a wide range of asynchronous generation technologies. The explicit performance requirements proposed by the ISO should provide clear expectations to market participants, decreasing the need for transmission owners, participating transmission owners and interconnection customers to interpret the requirements.

Q. Can asynchronous generating facilities practically design their systems to meet these proposed requirements?

A. Yes, asynchronous generating facilities can meet the ISO's proposed low voltage ride through requirements through the purchase of inverters or generators for individual generating units, or with the use of supplemental equipment that compensates for voltage levels through which a facility must continue to operate.

Q. What is an inverter?

A. An inverter is a device that converts direct current to alternating current.

Q. Are inverters also commercially available for solar PV generation facilities that will allow these asynchronous generating facilities to continue to operate during low voltage conditions indentified in the ISO's proposed requirements?

A. Yes. Inverters intended for solar PV application are readily available that can meet the low voltage ride through capability requirements proposed by the ISO.

Q. Have you conducted a survey of manufacturers of solar PV inverters to confirm whether equipment is commercially available to satisfy the ISO's proposed requirements?

A. Yes, inverters that allow for low voltage ride through characteristics are available from at least the following manufactures, based on their publicly disclosed websites:

- ABB
- GE Energy
- SATCON
- Siemens AG
- SMA
- Sun Power
- Xantrex, a subsidiary of Group Schneider

Most of these manufacturers claim that their equipment provides the low-voltage ride-through capability required to meet certain European grid codes. The low-voltage ride-through requirements of these grid codes are generally at least as demanding as those set forth in FERC Order No. 661a and as reflected in the proposed ISO requirements. Appendix C to my testimony contains a summary of different inverters and their capabilities that are available.

Q. What are the cost impacts, if any, for asynchronous generating facilities that need to procure inverters capable of meeting the ISO's proposed low voltage ride through requirements?

A. Although low-voltage ride-through has been particularly challenging for the wind generation industry due to the mechanical impacts on the wind turbines, and the induction generation technology used in some wind turbines, achieving this performance in a solar PV inverter is significantly less challenging. This performance in a solar PV inverter can be achieved by appropriate control design, with little to no change needed in the power components. Thus, the incremental cost for low-voltage ride-through functionality to the project developer is not driven so much by material costs, but by the market value of the intellectual property made by the inverter equipment manufacturer. With multiple vendors offering this capability, the competitive market should inherently drive the incremental costs down to a rather low level, if not de minimis, in proportion to total project costs.

Q. What other equipment, if any, can asynchronous generating facilities use to meet the proposed low voltage ride through requirements?

A. Asynchronous generating facilities may install equipment such as static synchronous compensators or static VAR compensators, to modify the voltages through which a facility must operate. The wind industry has widely relied on such equipment to allow low-voltage ride through capability in cases where a generator was not capable of riding through a specified voltage level at the point of interconnection.

Q. Can you describe the estimated costs of using this type of equipment?

A. The costs for such equipment are generally on the order of $100 - $200 per injected continuous kVAR. Some technologies permit short-term kVAR injection to be several times the continuous rating. The amount of injected kVAR to ride through low voltage conditions, however, depends on a number of factors, including system conditions, the specifics of the plant design and the terminal voltage constraints for the asynchronous generating facility. The cost will increase to the extent additional kVARs are necessary to boost voltage at the generating unit terminals.

Q. Are there other balance of plant changes that must also be made to ensure the facility is able to ride-through a voltage dip?

A. Yes. Certain balance of plant equipment can boost voltage within a plant, thus allowing generator units to ride through a point of interconnection voltage drop that is less than the minimum terminal voltage ride-through capability of individual generating units. This equipment includes, for example, static synchronous compensators (STATCOM) and static var compensators (SVC).

III. Frequency Disturbance Ride Through Capability

Q. What is the purpose of the ISO's proposed frequency disturbance ride through capability requirements for asynchronous generating facilities?

A. The frequency on the power system is related to the amount of load and generation that are connected. When the load and generation are precisely balanced, the frequency will be 60 Hz. In the event that generation is lost through an unplanned or forced outage (e.g., a generating unit trips off line), the frequency will deviate below the nominal of 60 Hz. Immediately following a frequency disturbance, the governors on the remaining generation units will adjust to attempt to arrest the frequency decline. During this transition time, it is essential for the system generators to remain on line. If additional generators trip during the transition, the system frequency will continue to deteriorate, and frequency restoration will be more difficult.

Similar to voltage ride through capabilities, the purpose of the ISO's proposed requirements is to expand the pool of resources that can sustain the operation of the electric system when contingencies occur. If asynchronous generating facilities do not have frequency disturbance ride through capability, they are likely to trip during frequency disturbances, especially disturbances on adjacent substations and disturbances that cause major frequency deviations. The loss of these real power resources during a contingency may trigger cascading events.

Unlike voltage, however, the frequency at the terminals of generating units that are part of an asynchronous generating facility must remain the same as the frequency at the point of interconnection. There is no effective means of meeting frequency ride-through requirements other than to ensure generating units maintain the same frequency range as specified at the point of interconnection.

Q. Is the ISO's proposed frequency disturbance ride through requirement a new interconnection requirement?

A. No. The ISO's existing Large Generator Interconnection Agreement requires the interconnection customer to design high and low frequency ride through, as required by Western Electric Coordinating Council (WECC).[2] The ISO is proposing only to clarify that these requirements also apply to asynchronous generating facilities. These frequency-ride through requirements are set forth in the WECC Off-Nominal Frequency Plan. The ride-through requirements are also discussed in the WECC Under-frequency Load Shedding Relay Application Guide, which is available at the following website:

[2] ISO Tariff , Appendices V and Z at Article 9.7.3.

http://www.wecc.biz/committees/StandingCommittees/OC/TOS/RWG/Shared%20Documents/UFLS%20Relay%20Application%20Guide.pdf

Q. Can you summarize the frequency disturbance ride through requirements?

A. Yes, the following chart specifies both the under frequency and over frequency requirements that apply to all generators in the western interconnection.

WECC Generator Off-Nominal Frequency Performance Requirement

Under-frequency Limit	Over-frequency Limit	WECC Minimum Time
> 59.4 Hz	60 Hz to < 60.6 Hz	N/A (continuous operation)
≤ 59.4 Hz	≥60.6 Hz	3 minutes
≤ 58.4 Hz	≥61.6 Hz	30 seconds
≤ 57.8 Hz	-	7.5 seconds
≤ 57.3 Hz	-	45 cycles
≤ 57 Hz	>61.7 Hz	Instantaneous trip

Q, How are the frequency ride-through requirements met?

A. An existing inverter design should meet these frequency ride-through requirements. Alternatively, minor design modifications should enable an existing non-compliant inverter to achieve compliance. An inverter must be able to operate at the frequency of the grid. Accommodating a small range of variability in grid frequency in the conversion process itself is easily achievable. It is generally just a software issue. There also are magnetic power devices in a typical inverter. Magnetic devices are limited by a volts-per-Hertz capability. A decrease in frequency could potentially require an increase in the rating of these devices, if the device is selected to operate at fundamental frequency with absolutely no design margin. An increase in frequency can slightly increase losses in the power electronics and in any magnetic devices**.**

IV. Power Factor Design and Operating Requirements

Q. What is the purpose of the ISO's proposed power factor design and operating requirements for asynchronous generating facilities?

A. The ISO has proposed a power factor requirement for asynchronous generating facilities seeking to interconnect to the ISO. The purpose of requiring this reactive capability is to maintain adequate voltage control on the system.

Q. What do you mean by the term power factor?

A. The term power factor refers to the ratio of the real power to the total "apparent power". Apparent power includes both the real power and the reactive power, and it is a measure of the loading of transformers and lines. Only real power can perform useful work, and only real power derives revenue in the present market. Reactive power, however, is necessary to support the transmission system voltage; it is effectively a facilitator of the transmission of real power..

Q. Please describe the ISO's proposed requirements?

A. The ISO has specified a power factor range of 0.95 leading (under-excited) to 0.95 lagging (overexcited) at the point of interconnection for asynchronous generating facilities. The ISO's proposal requires an asynchronous generating facility to have a net reactive power range in Figure 1 below as a function of the voltage at the facility's point of interconnection.

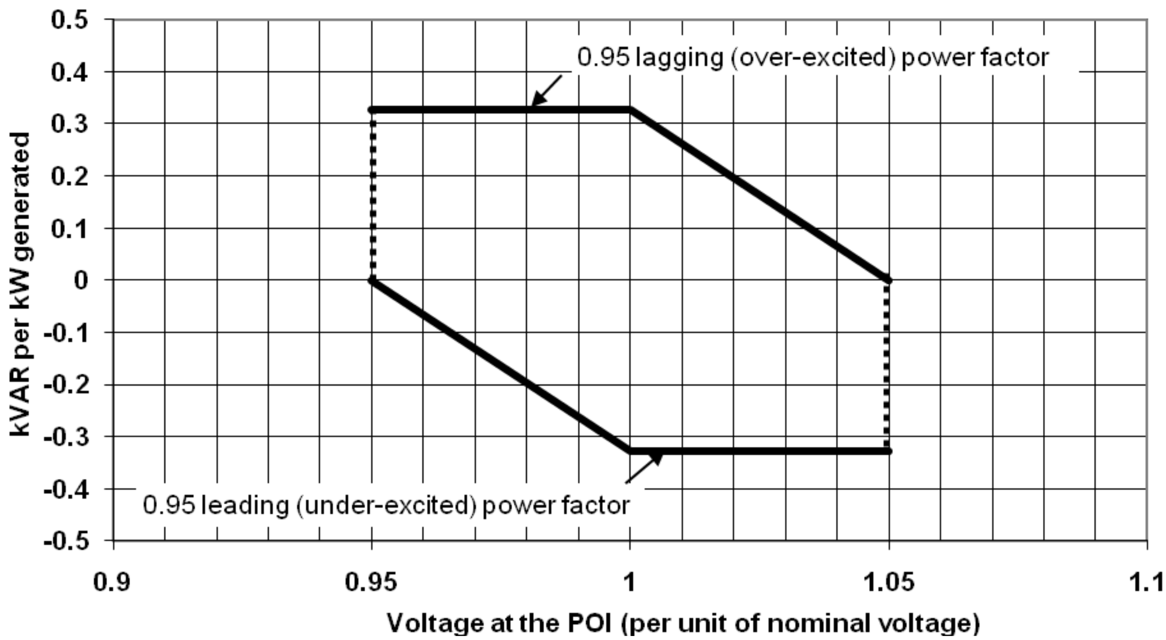

Figure 1

Figure 1 specifies that an asynchronous generating facility need only provide a sufficient power factor (KVAR per KW generated) as voltage levels at the point of interconnection increase or decrease. The ISO is not proposing that asynchronous generating facilities be required to provide full reactive capability during high and low voltage conditions. Instead, the ISO's proposed power factor requirement is proportional to the voltage level at the point of interconnection.

A large amount of reactive power export (overexcited power factor) when the transmission system voltage is high tends to result in terminal voltages at generating units located at the remote ends of wind and solar farm collector systems that are even higher on a per-unit basis. Often, the voltages of such units will exceed the generating unit terminal voltage limits. To avoid this, it would be necessary to specify on-load tap changers on the facility substation transformers, at a large incremental capital and maintenance expense. At the same time, it is rarely ever the case that the transmission system would need such reactive power supply from the asynchronous generating facility during high voltage conditions.

There is also no need for a facility to have maximum reactive power absorption (underexcited power factor) during low transmission voltage conditions. Therefore, the ISO has adopted the requirements shown in Figure 1 to exclude any unneeded and expensive "corner" requirements on the part of asynchronous generators. A similar reactive power capability requirement applies to wind generation facilities in the United Kingdom.

Q. What other power factor design requirements is the ISO proposing?

A. The ISO's proposed language would require the design of asynchronous generating facilities to vary their reactive power output without creating a significant abrupt change in voltage at the Point of Interconnection. The ISO has limited any such voltage change to 0.02 per unit of the nominal voltage. The ISO requirements have been written such that use of discrete capacitor and reactor banks can be used to achieve the reactive power capability of the asynchronous generating facility, unless specific studies indicate that dynamic reactive capability is required for transmission system reliability. Without any bounds imposed by the ISO, the entire reactive power output could be in one switchable compensation bank. Switching a large bank could result in an abrupt change in voltage that could be objectionable to power users, and could also impose undesirable stress on power generating equipment. The rationale for this requirement is thus to impose a bound on the size of reactive compensation banks, not measured in terms of reactive power rating, but rather on the basis of the grid impact that bank switching could cause. The chosen value of 0.02 per unit of nominal voltage is based on a number of considerations, including common engineering practice, standards for consumer power quality, and consideration of the granularity to which compensation in a facility would need to be divided.

The ISO has also proposed several operational requirements related to reactive power capabilities of asynchronous generating facilities. These proposed requirements establish the required reactive support expected from asynchronous generating facilities, including the net reactive power range based on the real power output delivered at the point of interconnection, the need for the ISO curtail power output if reactive power capability is unavailable, as well as the conditions during which an asynchronous generating facility must absorb reactive power and conditions when it must provide reactive power. The ISO's proposed requirements are intended to provide objective parameters to allow for the design of asynchronous generating facilities.

Q. Are these requirements technically feasible for asynchronous generating facilities?

A. Yes. Asynchronous generating facilities can meet this requirement by three different means:

- Provide reactive power control via the aggregate capability of the generating units that comprise the asynchronous generating facility;

- Rely solely on switched or variable reactive compensation devices within the facility, with the generating units limited to unity power factor, or other fixed power factor, operation; or

- A hybrid of the first two options.

To apply the first option, the generating units must have a lagging power factor less than 0.95 at high load levels in order to compensate for reactive power losses in the collection system. At low power, the generating units may need a leading power factor less than 0.95 to compensate for the collector feeder cable capacitive charging current. An asynchronous generating facility must typically increase the rating of the generating unit power conversion equipment in order to provide this reactive capability. The approximate increase is the reciprocal of the minimum power factor, minus one. An important consideration is that this increase applies only to the rating of the power conversion equipment (*e.g.*, the generator or inverter) and not the prime mover (wind turbine or PV panels) of the generating units.

Q. Can you confirm whether equipment is commercially available to satisfy the ISO's proposed reactive power requirements?

A. The equipment is readily available. As noted above, the reactive power sources used to comply with this design requirement include: (1) the inverters associated with the asynchronous generation, (2) switched capacitors and reactors (inductors) or static devices (such as a STATCOM), or (3) a combination of these sources. Appendix C to my testimony provides a survey of inverter manufacturers that represent they can provide reactive power. Capacitors and reactors have been used extensively for many years to provide reactive power support to the power system. Capacitors are readily available and the application to the power grid is well understood by power system engineers. As such, applying these requirements are not expected to result in material engineering changes by the developer, delays in permitting, or the need to delay or reassess any existing ISO interconnection studies. The issue for developers of asynchronous generating facilities is merely one of cost.

Q. Can you describe the range of costs that asynchronous generating units will incur in order to meet the ISO's proposed power factor requirements?

A. The costs related to the increase power conversion, needed to meet the ISO requirements are generally modest regardless of which option a developer chooses in order to meet the power factor requirements. In a typical plant design, the minimum power factor for a generating unit needed to compensate for the facilities reactive losses is on the order of 0.90. The mega volt-ampere rating needs to be increased approximately 11%, with a resulting cost increase of this amount or less. Power conversion costs typically range between $100/kVA to $200/kVA. The resulting costs, calculated by applying the 11% increase to the power conversion cost range, are on the order of $11 - $22 per kW of plant rating. The Phase 2A Working Subgroup of the California Renewable Energy Transmission Initiative (RETI) recently posted a draft Project

Characteristics and Cost Calculator spreadsheet that informs that group's transmission planning efforts. The listed capital costs for fixed and tracking photovoltaic projects are assumed to be $3800 kW and $4500 kW, respectively. Wind project capital costs also have a range, but the lowest value is assumed to be $2160 kW. See RETI materials on the California Energy Commission website at http://www.energy.ca.gov/reti/steering/workgroups/phase2A_update/. Based on the RETI draft estimates of capital costs, the compliance cost for meeting the ISO requirement through this mechanism for solar PV is likely to be in a range from 0.25% to 0.58% of the total plant cost depending on the underlying solar technology, including the primary energy equipment (prime mover, but exclusive of transmission related costs). For wind generators using the lowest RETI project capital cost estimate, compliance will be approximately 1% or less of total plant cost. Thus, the cost of compliance is relatively small in relation to the total capital cost of wind and solar PV projects.

Except where dynamic reactive compensation range is identified as a necessity by a specific interconnection study, simple switched shunt reactive compensation banks can be used to implement the second option. The proposed ISO requirements specifically allow for the use of low-cost switched compensation as a means of providing net reactive power range, relieving the need for generating unit equipment with reactive capability.

Where dynamic reactive compensation is required, this capability can be provided by static synchronous compensators (STATCOM) or static var compensators (SVC) connected to the facility. These compensators are available from a number of different vendors, and are widely used in wind plant applications. The installed costs for shunt capacitive compensation is on the order of $10-$15/kVAR, including the necessary switchgear and substation infrastructure. The installed costs for shunt inductive compensation may also fall in the range of $15 - $20/kVAR. Because bi-directional reactive capability is required, both shunt capacitive and inductive compensation banks would be needed. The cost of implementing reactive power range compliance solely with switched compensation banks is on the order of $8 - $12 per kW of plant rating. This option tends to be less expensive than uprating power conversion equipment, but it does not have the same degree of controllability. Again, using the RETI capital cost assumptions, the cost of compliance under this option is approximately 0.32% or less of the total plant cost for solar PV or wind facilities.

A hybrid of switched compensation and dynamic compensation provided by generating units provides the capability to provide a continuously variable reactive power supply while extending the range of the generating units. Continuous variability can be accomplished if the reactive outputs of the generating units are coordinated with the shunt reactive bank switching such that the step change at bank switching is compensated by an opposing shift in the output of the generating range. In this way, asynchronous generating facilities can design the most cost-effective means of meeting the ISO's proposed requirements.

V. Voltage Regulation and Reactive Power Control Requirements

Q. What is the purpose of the ISO's proposed voltage regulation and reactive power control requirements for asynchronous generating facilities?

A. The purpose of the ISO proposed requirements is to ensure that asynchronous generating facilities have an automatic system to regulate voltage levels and reactive power at the point of interconnection.

Q. Can you summarize the ISO's proposed requirements for the design of these automatic systems.

A. The ISO's proposed design for these automatic systems requires asynchronous generating facilities to regulate voltage levels and the net power factor level within tolerance bands at the point of interconnection depending on the facility's operating mode.

Q. What operating modes must an asynchronous generating facility meet under the ISO's proposed requirements?

A. Under the ISO's requirements, an asynchronous generator must have a voltage regulation operating mode and a net power factor regulation operating mode. The ISO's requirements specify that voltage regulation will be the default mode of operation. Under this configuration, the facility's reactive power output and input is adjusted by an automatic control such that the point of interconnection voltage is maintained to a scheduled value, within tolerances. This is specified by ISO to be the default mode because it is generally desirable to maintain a voltage profile in the grid as specified by the transmission operator and is also necessary to adhere to WECC's Minimum Operating Reliability Criteria.[3]

Under a net power factor operating mode, the facility's reactive power output and input is adjusted by an automatic control such that the net power factor at the point of interconnection is maintained at a specified value. The power factor regulation mode is desirable when the facility's rating is too small, relative to the strength of the transmission system at the point of interconnection, to materially affect the point of interconnection voltage. Use of a voltage regulation mode in such a case would cause large variations of the facility's reactive power output due to relatively small changes in voltage at the point of interconnection.

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[3] Section 2.(B)(5) of WECC Minimum Operating Reliability Criteria dated April 6, 2005 at 10. http://www.wecc.biz/Standards/WECC%20Criteria/WECC%20Reliability%20Criteria.pdf

Q. Please explain why it is important for asynchronous generating facilities to regulate voltage levels at the point of interconnection.

A. To provide for secure operation of a transmission system, it is necessary to maintain a voltage schedule prescribed by the transmission operator. Generating facilities connected to the transmission system are the primary means available to control transmission system voltages. Requiring all generating facilities, both asynchronous and synchronous, to regulate their point of interconnection voltage is the fair and technically appropriate means of securing the appropriate participation of all generating plants in the essential objective of maintaining the voltage schedule necessary for secure system operation. Voltage regulation is implemented through variation in a facility's reactive power flow. Regulation of transmission voltage by each plant automatically provides the means to extract the appropriate amount of reactive power from each plant to provide for the transmission system's reactive power requirements. These requirements are not limited to reactive power demand by loads, not otherwise compensated at the distribution level, but also include reactive power consumed by the transmission system as a function of the current flow through the lines and transformers. Much of the reactive power from each generating facility compensates for the reactive power consumption, or losses, on the transmission system caused by the real power output from the generating facility. Regulation of the point of interconnection voltage causes the reactive power flow from the facility to more or less compensate for the reactive losses in the transmission system that facility's output causes.

As with other technical requirements, the rapidly increasing number of asynchronous resources being interconnected to the ISO's grid over the next several years makes it important that these resources provide voltage regulation services in the same manner as already required of conventional generators. Excepting asynchronous generators from these long-standing requirements will result in an increasingly less robust and reliable system in terms of its ability to sustain necessary voltage levels.

Q. How can an asynchronous generating facility regulate voltage through the use of an automatic system?

A. Voltage regulation is achieved by appropriate control of the reactive power flow from, or into, the asynchronous generating facility. Where reactive power is provided by a facility's generating units, it is usually necessary to implement some form of facility level control to coordinate the individual generator unit reactive output. The ISO has proposed voltage regulation tolerances, maximum abrupt voltage change, and response time requirements which have been specifically configured to allow for the use of switched reactive compensation banks to meet the voltage regulation requirements.

Q. Please explain why it is important for asynchronous generating facilities to regulate net power factor at the point of interconnection.

A. Regulation of power factor is used when voltage regulation would otherwise cause large swings in a facility's reactive power output due to small transmission system voltage variations, which may be unrelated to the output of the facility. Regulation of power factor at the point of interconnection, as required by ISO, is not the same as regulating the power factor at individual asynchronous generating units. The collection system of an asynchronous generating facility, particularly transformers, can cause a loss of reactive power. These reactive losses cause the power factor to fluctuate with the loading of the facility, if the power factor is regulated at the unit terminals. Thus, the reactive demand caused by reactive losses within the asynchronous generating facility would shift to the transmission system if power factor regulation were measured at the unit terminals

Therefore, ISO has required that the net power factor at the point of interconnection be regulated to a prescribed value when the power factor regulation mode is enabled. This causes the reactive power flow from the facility to be in constant proportion to the real power output, and causes the facility to compensate for its own internal reactive power losses.

Q. How can an asynchronous generating facility regulate net power factor through the use of an automatic system?

A. The most straightforward means to implement a net power factor regulation system is to use a control system that measures the real and reactive power flow at the point of interconnection, and adjusts the reactive power output of the reactive power sources within the facility in a closed-loop fashion such that the prescribed net power factor is achieved. The reactive power sources could be individual asynchronous generating units, supplemental reactive devices included in the facility balance of plant (e.g., capacitor banks, static var compensator, etc.), or a combination of these. Other means of regulating the net power factor involve measurements of currents and voltages at locations other than the point of interconnection, and mathematically calculating the real and reactive power flow at point of interconnection such that the power factor there can be regulated.

VI. Power Plant Management

Q. What is the purpose of the ISO's proposed power plant requirements for asynchronous generating facilities?

A. The purpose of these requirements is to ensure that asynchronous generating facilities have the capability to reduce or increase output in a controlled manner.

Q. Can you summarize the ISO's proposed requirements for the design of this these generation management systems.

A. The ISO is proposing to require asynchronous generating facilities to implement a power ramp rate and a frequency response requirement. In both cases, the requirement is for a controlled curtailment of output. There is no requirement to supply energy not available from the prime source of an asynchronous generating facility. In other words, there is no need for the asynchronous generator to "hold back" output by spilling wind or sun, except during those periods in which a specific instruction from the ISO directs the resource to activate the generation management controls. In contrast, if there was an under-frequency response requirement, the generator would necessarily have to withhold converting some fuel into power to be able to increase output in response to an under-frequency event. The ISO is proposing asynchronous generating facilities meet these requirements by January 1, 2012.

Q. How, if at all, can asynchronous generating facilities implement power plant ramp rate controls?

A. Controlling ramp rates should occur on a facility-level basis. If an asynchronous generating facility has the means to limit the output of an individual generator unit, or even to switch generator units off and on, then the ramping limit can be achieved using ordinary engineering knowledge and widely available programmable logic control hardware. Ramp rate limitation capability has been required of wind generation by a number of grid codes around the world. The wind industry has responded and plant-level controls are readily available to control the power ramp rates of wind generation facilities. These controls are generally implemented by measurement of the total facility power output, comparison of the rate of change in this output, and control of the output of individual wind turbine generators in order to not exceed the rate-of-change (ramp rate) limit. This requires a means of communication between a central control or measurement point, and the individual turbines, which are dispersed about the facility.

The output of wind turbines is generally implemented through an adjustment of the wind turbine blade pitch such that the amount of power extracted from the wind is varied. For some wind turbine designs, such as “stall-regulated” turbines, energy extraction cannot be regulated. For facilities using turbines of this design, power output is modulated in a stepwise fashion by turning off and turning on individual turbines.

The same means can be applied to limit power ramp rates of solar PV facilities, with perhaps less challenge in comparison to wind generation because there are no mechanical or aerodynamic considerations in the case of solar PV generation. The inverters of a solar PV facility can easily regulate power output. Even where inverters with this capability are not used in a solar PV facility, a power ramp rate limitation capability compliant with the ISO's proposed requirements can still be readily implemented by turning off and on individual inverters within the facility. The ISO's proposed requirements allow step-wise ramps up to 5 MW step size. Facilities can, therefore, implement ramping control by turning on and off individual generating units having less than 5 MW capacity, if the generating unit cannot vary its individual output.

Although pre-engineered plant control packages are available, these should not be necessary because implementing a custom ramp control feature is rather straightforward as an engineering matter. Further, the ISO will allow ramp rates to exceed the prescribed requirements during a loss of the resources fuel source. The ISO will allow the resource to continue to ramp back toward its operating target after a drop in fuel in accordance with the prescribed ramp rate.

Q. Could you please describe the components of a pre-engineered control package?

A. The components of a pre-engineered control package are a central control processor and a communications system to interconnect the central controller with the controls of the individual asynchronous generating units. The central control processor could be a generic programmable controller, on which software specific to the application is loaded, or a purpose-designed controller. The communication system typically uses fiber optic cables, and includes switches and repeaters as necessary to convey the signal and to interface with other control equipment. Typically, some form of communications between individual asynchronous generating units and a central point is installed to facilitate condition monitoring and basic unit control functions, such as placing units on and offline, or to curtail unit output in response to a system emergency. Adding communication capabilities to support closed-loop facility-level controls, such as limitation of facility power output ramp rates, should not entail significant increase in the required communications infrastructure. The pre-engineered control system also needs power system measurements, such as currents and voltages, which are typically derived from instrument transformers primarily installed for metering or protection purposes, and are thus typically not part of the engineered package.

Q. Is it possible for an asynchronous generating facility to maintain a specified output in response to an ISO instruction?

A. Yes, but it should be noted that the ISO has not established a tolerance band and therefore the impact of deviating from the operating target will be the subject of market rules yet to be developed.

Q. How, if at all, can asynchronous generating facilities implement the frequency droop requirement?

A. The ISO's proposed frequency response requirement is similar to the requirement applicable to conventional generators operating today on the

ISO system, except that it requires asynchronous generators to mitigate over-frequency, not under-frequency, excursions. Frequency response can either be implemented by controls at the facility level, using the same approach and hardware as discussed for ramp rate limitation, or by implementation within the generator unit controls.

Q. Has the ISO proposed a limited timeframe for asynchronous generating facilities to provide frequency response.

A. No. Some stakeholders requested that the ISO limit the duration of the frequency response to a couple of seconds or until the ISO's capacity on regulation service responds to the frequency deviation. Setting an artificial temporal limit, however, is imprudent. The generator response should persist until frequency recovers below the threshold level. Otherwise, the relaxation of the generator response would exacerbate the frequency excursion.

I declare under penalty of perjury that the foregoing statements are true and correct to the best of my knowledge, information, and belief.

Executed this 1st day of July, 2010 in Schenectady, New York

Reigh Walling

Appendix A

Appendix A – Publications by Reigh Walling

R. Walling, K. Clark, **Grid Support Functions Implemented in Utility-Scale PV Systems**, Proceedings of the IEEE PES Transmission and Distribution Conference and Exposition, May, 2010.

B. Yang, R. Walling, L. Freeman, J. Skliutas, M. Marshall, ·**Improving Utility Energy Efficiency Through Loss Identification**, Proceedings of the IEEE PES Transmission and Distribution Conference and Exposition, May, 2010.

B. Yang, J. Weiss, R. Walling, L. Freeman, M. Marshall, **The Breakdown and Mitigation of Technical Losses on Distribution Power Systems**, Proceedings of the 2010 DistribuTech Conference, March 23, 2010.

R. Walling, G. Jordan, **Impacts of Wind Generation on Thermal Unit Operation**, Proceedings of 2009 POWER-GEN International Conference, December, 2009.

J. Bebic, R. Walling, K. O'Brien, B. Kroposki, **The Sun Also Rises**, IEEE Power and Energy Magazine, Vol. 7, No. 3, 2009.

R. Walling, **Islanding Issues for Large-Scale Wind Generators Interconnected to Local-Delivery Distribution Systems**, Proceedings of the Power & Energy Society General Meeting, 2009

N. Miller, K. Clark, R. Walling, **WINDINERTIA™: Controlled Inertial Response from GE Wind Turbine Generators**, Proceedings of the 2009 Minnesota Power Systems Conference, Brooklyn Heights, Minnesota, October, 2009.

R. Walling, L. Freeman, W. Lasher, **Regulation Requirements with High Wind Generation Penetration in the ERCOT Market,** Proceedings of the IEEE Power Systems Conference and Exposition, 2009.

R. Walling, M. Reichard, **Short Circuit Behavior of Wind Turbine Generators**, 62nd Annual Conference for Protective Relay Engineers, Texas A&M, 2009

R. Walling, L. Freeman, N. W. Miller, J. Freedman, W. Lasher, **Risks of Extreme Wind Generation Output Changes in the ERCOT Market**, Proceedings of the 8th International Workshop on Large-Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Farms, Bremen, Germany, October, 2009.

E. Camm, R. Walling, et al, **Reactive Power Compensation for Wind Power Plants**, Proceedings of the Power & Energy Society General Meeting, 2009

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R. Walling, L. Freeman, J. Freedman, W. Lasher, **Risks of Extreme Wind Generation Output Changes in the ERCOT Market**, Proceedings of the American Wind Energy Association WindPower'09 Conference, 2009.

R. Walling, P. Riley, C. Gaytan, **Optimization of Wind Turbine Unit Transformer Ratings**, Proceedings of the American Wind Energy Association WindPower'09 Conference, 2009.

E. Camm, R. Walling, et al, ·· **Characteristics of Wind Turbine Generators for Wind Power Plants**, Proceedings of the Power & Energy Society General Meeting, 2009*R. Piwko, E. Camm, A. Ellis, E. Muljadi, R. Zavadil, R. Walling, M. O'Malley, G. Irwin, S. Saylors*, **A Whirl of Activity**, IEEE Power and Energy Magazine, Vol. 7, No. 6, 2009.

R. Walling, **Overvoltage Protection and Arrester Selection for Large Wind Plants**, *Proceedings of the IEEE Transmission and Distribution Conference and Exposition, 2008.*

L. Freeman, M. Marshall, R. Walling, J. Weiss, **Loss Characteristics of Local-Delivery Distribution Systems**, Proceedings of the 20th International Conference on Electricity Distribution, Prague, June 8-11, 2009.

R. Walling, P. Riley, C. Gaytan, **Increasing Wind Plant Energy Output Using High-Efficiency Amorphous-Core Unit Transformers**, Proceedings of the American Wind Energy Association WindPower'08 Conference, 2008.

R. Walling, L. Freeman, N. Miller, G. Jordan, W. Lasher, **Ancillary Services Requirements for Large-Scale Wind Penetration in the ERCOT Grid**, Proceedings of the American Wind Energy Association WindPower'08 Conference, 2008.

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Appendix B

GE

Energy

Technical Requirements for Wind Generation Interconnection and Integration

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November 3, 2009

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Section 1

INTRODUCTION

This report documents current status of wind generation technology and forecasting. It is intended to provide information on important topics related to the interconnection of wind generation facilities to the bulk power system, the operation of the bulk power system with significant amounts of wind generation, and the technology underlying wind generation forecasting and applications to power system operation.

In addition, as requested by ISO-NE, the project team consisting of GE, EnerNex Corporation, and AWS Truewind offers commentary and makes specific recommendations based on their work in the electric power and wind generation industries. It is understood that these recommendations may form some of the basis for ISO-NE policies and practices in anticipation of significant wind generation development in their market footprint. The recommendations (as well as the overall report) focus on the underlying technologies for large-scale wind generation and its interconnection and integration with the bulk power system (BPS). Other issues, such as design of specific energy market mechanisms or financial incentives, are discussed but the details of the architecture and implementation of specific designs are outside the scope of this report.

The report is divided into three major sections:

1. **Wind Turbine and Wind Plant Technology**, which covers aspects of wind plant performance and capabilities relevant to the interconnection with the transmission network and integration with ISO-NE system operations
2. **Wind Generation Forecasting** describes the science and challenge of wind generation forecasting, the commercial state-of-the-art, and prospects for future improvement. Data requirements for forecasting are defined, as well as the latest thinking in how the information generated by a forecasting system should be interfaced with power system operations.
3. **Grid Operations with Significant Wind Generation,** where the fundamental challenges for short-term operational planning and real-time management of systems with substantial wind generation area described, along with mechanisms for minimizing or reducing the technical or economic impacts.

There is some overlap between the background sections. This was intentional, since the three topical areas can be viewed as interconnected. For example, the Wind Generation Forecasting System has critical interfaces with both individual wind plants and the grid operator, who in turn has a direct interface to each individual wind plant. In some cases these interfaces are physical, as in the communications infrastructure used to transmit operating data and control signals. In other cases, the interface involves requirements or specifications, i.e. interconnection requirements that spell out the necessary behavior of a wind plant at the point of interconnection to the bulk transmission system.

The information contained in the main body of the document, as constituted by the three major sections, form the basis for the **Recommendations** to ISO-NE, which is the initial section of the report.

Section 2

RECOMMENDATIONS

The recommendations of sections 2.1, 2.2, and 2.3 are functionally grouped according to requirements to be placed on individual wind plants, the system for forecasting wind generation, and recommendations for Independent System Operator of New England (ISO-NE operations). These recommendations are supported by detailed discussion in Section 3 , Section 4 and Section 5 , respectively.

2.1. RECOMMENDATIONS FOR WIND PLANTS

Recommendations provided in this section are specifically intended to guide requirements that should be placed on interconnecting wind plants. This is distinct from further recommendations, summarized in Section 2.3 below, that provide recommendations on how ISO-NE should use these functions in the operation of the ISO-NE system. Further detailed technical background on each recommendation is provided in Section 3 .

In general, the project team recommends that wind plants to be connected with the bulk transmission network be treated no differently than any other generator in the ISO-NE interconnection queue. Experience from recent years has shown that wind plants can be designed to meet requirements established for conventional generating units and plants; additionally, the current fleet of commercial turbines enables dynamic performance in response to system disturbances that is possibly more benign than the behavior of conventional synchronous generators.

Taking this line of thinking one step further, ISO-NE interconnection requirements must focus on the plant behavior, and how it interacts with the rest of the power system. While wind turbines are an especially important component of wind plants and their capabilities and behavior will influence the necessary plant design to achieve desired performance, interconnection requirements should avoid inferences to the specific behavior of wind turbines.

Wind plants are not simply collections of individual wind turbines. Rather they must be integrated into fully engineered power plants, with many other critical components. The wind industry has been a rather slow to fully recognize that the capabilities and features of a specific wind turbine are only the starting point for design of the plant. With the progress that has been made in this area over the past few years, the project team feels strongly that specifying the terminal behavior of wind plants consistent with what is required for conventional generating facilities is the proper approach.

Integration encompasses the influence of wind plants on and participation in short-term scheduling and real-time operations of the ISO-NE system. Included are the nature of wind energy delivery in real time and the control thereof, mechanisms for coordination of wind plant operation with ISO-NE system operators, and the collection and communication of important operational data.

The general recommendation here adheres to the philosophy for interconnection: Requirements for wind plants in terms of visibility and interoperability with ISO-NE should be as consistent with those for conventional generators as possible. However, the unique characteristics of wind energy production necessitate some special considerations in the operating time frame. Recommendations presented here recognize the different characteristics of wind generation, and are intended to provide requirements to be placed on wind plants that will enable ISO-NE to successfully operate with large amounts of wind power considering the unique nature of the resource.

The focus of these recommendations is on the wind plant as a single entity. Recommendations are functional, rather than providing wind turbine technology specific guidelines. Most important, these are forward looking recommendations, based on current understanding of available and merging technology, and on current understanding of the challenges faced by grid operators for integration of large amount of wind generation. The reality is that technology, practice and understanding are evolving rapidly. ISO-NE must recognize that adjustments to rules and requirements will continuously emerge as the entire industry matures.

Recommendations concerning specific requirements follow.

2.1.1. Voltage and Reactive Power Recommendations

2.1.1.1. Comply with FERC and NERC

Both the FERC (Federal Energy Regulatory Commission) and NERC (National Electricity Reliability Corporation) have been actively engaged in setting rules and recommendations for voltage and reactive power control. FERC Order 661a [1] sets requirements for power factor range and for voltage regulation. These rules, while subject to some interpretation, are still a sound foundation for ISO-NE. NERC activities are summarized in section 2.3.6

2.1.1.2. Pursue 0.95 Power Factor at POI

FERC Order 661a sets a requirement for ±0.95 power factor capability at the point of interconnection. There is a qualifying clause that puts the onus on the host system to prove the need for meeting this range. This is at odds with most NERC regional large generator interconnection rules. Nevertheless, per discussion in Section 3.3, some grids (utilities and/or ISOs) have decided that the language is so vague and that the definitions for the burden of proof so ambiguous, that they waive the power factor range requirement. The 0.95 power factor rule roughly translates to a requirement for ±0.90 power factor at the wind turbine generator terminals, as is typical for synchronous generation. ISO-NE's Large Generator Interconnection Agreement (LGIA, Item 9.6.1) requires that power plants be capable of continuous operation in the range of 0.95 power factor leading to 0.95 power factor lagging. The LGIA presently exempts wind plants from this requirement. The project team recommends that this exemption be eliminated for large wind plants. Today's wind plant technology is fully capable of meeting this power factor range requirement, and reactive power support with closed loop voltage control is essential to the operation and reliability of a power grid.

Voltage and reactive power measurements should be made at the specified point-of-interconnection (usually the transmission side of the wind plant substation transformer)..

However, at the same time, ISO-NE should avoid applying the ±0.95 power factor rules for unreasonable conditions. Specifically, as with other generation, the wind generation equipment should not be required to violate voltage ratings. In practice, this means that wind plants ought not be required to deliver large amounts of reactive power into a system with already high voltages, nor consume reactive power from systems with low voltages. As discussed in Section 3.3.1, some grid codes have made provision for this practical constraint.

2.1.1.3. Specify a minimum level of dynamic reactive power capability

Current rules do not address the nature of the reactive power capability necessary to meet minimum power factor requirements. As discussed in Section 3.3.2.2, some systems require that roughly ½ of the total range be dynamic. Such a requirement may prove to be overly restrictive or expensive for the system needs of New England. It is recommended that ISO-NE system studies be used as a mechanism to dictate the fraction of plant reactive capability that must be dynamics. Requirements should be based on dynamic simulations of voltage performance for system disturbances. Voltage recovery times should be consistent with ISO-NE planning criteria.

2.1.1.4. Enforce prescriptive interpretation of the rules

The language around power factor and voltage regulation in the rules has been subject to two general interpretations that can be widely classified as "permissive" and "prescriptive". The permissive interpretation is that wind plants are required to stay within the ±0.95 power factor range, but are allowed to be anywhere within that range. Whereas, the prescriptive interpretation is that wind plants must provide voltage regulation at the specified point (usually, but not always the point-of-interconnection) by delivering the reactive power required to meet a specified voltage (under control of a voltage regulator) anywhere within the required power factor range. As discussed further in Section 3.3, this later interpretation of the rules is more in line with practice for other types of generation and is more consistent with the reliability needs of the grid.

2.1.1.5. Schedule voltages

ISO-NE's LGIA, Item 9.6.2, requires power plants to have a voltage regulator and to operate in automatic voltage control. Wind plants should be subject to this same requirement, and should respond to voltage setpoint (schedule) signals communicated from the ISO to the wind plant. Wind plants are often connected in weak portion of the grid, and selection of appropriate voltage schedule can improve the performance and security of the system. See Section 3.3 and 3.3.2.1 for additional information about voltage regulation.

2.1.1.6. Avoid power factor control

The default design for many wind plants, the FERC rules notwithstanding, is to provide power factor control. Holding unity power factor is relatively common. This practice evolved because wind plants were originally incapable of providing voltage regulation, and it persists in much of Europe. However, power factor control is inimical to good grid performance in large geographically diverse grids with significant wind generation. Further discussion is provided in Section 3.3.

2.1.1.7. Be careful of control of multiple plants

It is not uncommon for multiple wind plants to be developed in relatively close electrical proximity to each other, and electrically remote from large portions of major grids. This certainly could become the case in New England. Voltage control for multiple power plants in close requires some care and coordination. This applies to wind plants as well. Further discussion is provided in Section 3.3.2.3.

2.1.1.8. Adopt permissive rules for low power

Unlike the vast majority of the thermal power plants, wind plants can typically operate at quite low power levels. Per discussion in Section 3.3.2.4, under low active power conditions, it can be difficult for wind plants to meet tight requirements for voltage and reactive power control. Requirements for voltage regulation should be relaxed or eliminated at low power (less than about 20% of plant rating), and permissive reactive power range should enforced. This permissive interpretation means that a plant may operate anywhere in the reactive power range corresponding to ±0.95 power factor of 20% of plant nameplate whenever the plant power output is below 20% of its nameplate rating. For a wind plant rated at 100 MW, this works out to be ±6.6 MVAr for power levels between zero and 20MW.

2.1.1.9. Consider no-wind VArs

Some wind OEMs offer the capability for wind plants, to provide controllable reactive power even when the wind turbines are not running due to low (or high) wind. This capability can be provided either by wind turbine-generator controls (per Section 3.3.2.5) or by means of separate reactive power devices (e.g. static VAr compensators) within the wind plant (per Section 3.3.1). From a grid operations perspective, this is roughly similar to having a conventional generator run as a synchronous condenser, but with lower losses. ISO-NE should recognize that such capability is available, and may be highly valuable in remote or weak portions of the system. The ancillary service market for reactive support in New England may be sufficient to encourage this functionality. If not, contractual arrangements should be made to enable this capability, where attractive, on a case-by-case basis.

2.1.2. Performance During and After System Disturbances

2.1.2.1. Comply with FERC and NERC

Again, both FERC and NERC have been actively engaged in setting rules and recommendations for fault ride-through capability. The debate is most mature and arguments most settled for low or zero voltage ride-through. NERC Standards Project 2007-09: Generator Verification is updating Standard PRC-024: Generator Performance during Frequency and Voltage Excursions which will establish technology-neutral requirements for all generators concerning voltage and frequency events. Requirements for high voltage ride-through are somewhat less mature, with both language and numerical thresholds still being widely debated. The industry appears to be converging on rules like those shown in Figure 11. These should be satisfactory for New England, as the needs of large interconnected grids for such performance are all similar. ISO-NE should stay engaged with the ongoing NERC debates, and provide inputs as necessary.

2.1.2.2. Avoid divergent fault-ride through specifications

New England should not develop fault-ride through specs that are different from the convergence of the national debate. This will unnecessarily add cost to wind projects in New England, and will have a tendency to block some OEMs (original equipment manufacturers) from participation (per discussion in Section 3.2.1).

2.1.2.3. Frequency ride-through as per NPCC rules

Generally wind plants are quite tolerant of frequency excursions (per discussion in Section 3.2.3). Present NPCC (Northeast Power Coordinating Council) rules for off-nominal frequency for all plants ought to be applied to wind plants. NERC is establishing frequency ride through requirements for all generators as part of standard PRC-024.

2.1.2.4. Do not bother with explicit dF/dt requirements

Some small or isolated grids (per Section 3.2.4) have adopted rate of change of frequency tolerance requirements. These are unnecessarily complicated for large grids like New England, and are likely to be proscriptive for some OEMs. Current US grid code debate is largely silent on this topic. ISO-NE should not specify rate of change of frequency requirements for wind plants.

2.1.2.5. Allow, or even encourage, reduced power output for deep voltage events

During deep voltage depressions, it is physically difficult or impossible to maintain active power injection to the grid. While some grid codes (outside the US) have tried to force wind turbines to take extreme measures to continue to inject active power during deep voltage dips, this is neither necessary nor desirable. Rather, grid performance during and immediately following severe disturbances tends to be better if active power injection is depressed and then allowed to recover over several hundred milliseconds in the post-fault time frame. Thus, in addition to allowing active power to drop during voltage depressions, New England should avoid excessively tight or fast post-fault power recovery requirements. Per discussion in Section 3.2.2.1, recovery to within 90% of pre-disturbance power within ½ second is a reasonable target. Again, current US grid code debate is largely silent on this topic.

2.1.2.6. Allow or encourage increase in reactive power for deep voltage events.

In contrast to active power, delivery of reactive power during voltage depressions is beneficial to the grid because it helps to support voltage and limit the geographic extent of voltage depression. Per discussion in Section 3.2.2.2, in broad terms, wind plants should be encouraged to deliver as much reactive current as the equipment allows during voltage depressions.

2.1.2.7. Avoid over prescribing fault performance

Some grid codes have moved towards extremely detailed prescriptions for active and reactive power (or current) control during disturbances. In practice grid faults are violent, non-linear, and usually unbalanced events. Such tight requirements do little to improve overall system reliability and can add substantially to the cost of wind generation equipment. New England should avoid tight active and reactive power control (e.g. do not require that reactive current be held exactly at 1.0 p.u., as has been proposed elsewhere) and avoid any requirements beyond survival and recovery for very deep events (e.g. <20%). Per discussion in Section 3.2.2., specific fault performance rules are not normally imposed on other types of generation.

2.1.2.8. Prohibit islanding

Wind plants are not suited to islanded operation. It should be standard practice for ISO-NE to prohibit islanded operation of wind plants. ISO-NE should require transfer trip of wind plants for which relay and breaker action can result, even briefly, in a wind plant being separated from the grid with other, non-wind plant customers. In this context, "islanded" refers to a small portion of the power grid, with little or no other synchronous generation, being separated by switching action from the larger grid. It does not refer to inter-regional conditions for which (for example) all of New England separates from the Eastern Interconnection. Further discussion is provided in Section 3.2.6.

2.1.2.9. Specify recovery and re-start rules after system and wind disturbances

Wind plants will typically automatically start when wind conditions and grid voltage are available. Following system disturbances, the restart of wind plants once system voltage has been restored is usually desirable. However, as with other generators, some situations may arise for which automatic restart is undesirable. ISO-NE should require that wind plants be able to accept commands from system operators both to start and to not start or delay start until certain conditions (e.g. another plant has started) are met. Thus, the default practice for ISO-NE should be that wind plants are not allowed to restart after system disturbances. ISO-NE may determine, analytically or otherwise, that certain plants should be allowed to restart automatically.

As discussed above, wind plants cannot operate in islanded mode. Therefore, wind generation cannot provide blackstart capability. Wind plants can help support a partially restored grid, but must not be relied upon to provide primary frequency regulation. System restoration plans should recognize these constraints. Constraints of system short circuit strength, as discussed in Section 3.2.6, should be respected during restoration. US industry does not have well established practice regarding system restoration with wind generation. ISO-NE should stay engaged with ongoing industry activities.

Wind generation that stops due to wind conditions, either low winds or due to high wind speed (per discussion in Section 3.2.5.3) should be allowed to automatically restart, unless specific operating conditions are identified that warrant blocking. However, multiple large wind plants in wind-rich regions coming back too rapidly after a cutout event may cause an unacceptable disturbance to grid operations. ISO-NE may need to engage ramp-rate limiters when curtailment events occur to manage the rate of power recovery after the event.

2.1.2.10. Substation and station service design

Wind plants, like other conventional generation on the ISO-NE system, should be designed such that station service and auxiliary systems are not dependent on in-feed from vulnerable alternative circuits such as unrelated distribution lines. Requirements for station service reliability for wind plants should be the same as for other non-black start ISO-NE generation.

2.1.3. Active Power Control Recommendations

2.1.3.1. Engage with FERC and NERC

Unlike the previous two topics, discussions of various types of active power control are only the earliest stages within the US. Thus, ISO-NE should stay engaged with the nascent NERC debates (e.g. project 2007-5 and 2007-12 per Section 2.3.6), and provide inputs as necessary.

2.1.3.2. Require curtailment capability, but avoid requirements for excessively fast response

Wind generation can respond rapidly to instructions to reduce power output or to relax curtailments. In many cases response is faster than convention thermal or hydro generation. However, there have been cases where proposed grid codes have made excessive requirements for speed of step response to a curtailment order. This is technically challenging and should be avoided. As discussed in Section 3.4.1, Δ10%/second for rate of response to a step command to increase or reduce power output is reasonable. This rate of response to step instructions should not be confused with deliberate imposition of ramp rate limits, as discussed next.

Some conventional generation can reach, or even exceed, these rates. Most cannot. The project team is not aware of any NERC standards that specify rate of response to redispatch commands (of which curtailment is a subset) in this time frame. Typically, plants must respond to economic re dispatch within minutes. ISO-NE may wish to consider markets or other incentives to encourage rapid rate of response from all generating resources.

2.1.3.3. Require capability to limit rate of increase of power output

Wind plants should be required have the capability to limit the rate of power increase. This type of up ramp rate control capability has been required in some other systems (per discussion in section 3.4.2). This function should include the ability to be enabled and disabled by instruction from ISO. Plants must be able to accept commands from ISO-NE to enable pre-selected ramp rate limits. Plants should be designed with recognition that ramp rate limits should not be required under all operating conditions. ISO-NE should not require that wind plants limit power decreases due to declines in wind speed, i.e. down ramp rate limits. However, limits on the rate of either increase or decrease in power output due to other reasons, including curtailment commands, shut-down sequences, response to market conditions and other control actions can be reasonably required.

2.1.3.4. Encourage capability to accept AGC signals

Wind plant technology has advanced to a point where it is possible for wind plants to participate in AGC. However, doing so requires a wind plant to continuously spill a portion of the available wind energy in order to have up-range available in power output.

Wind plant participation in AGC may be justifiable in small island systems where imbalances quickly lead to significant changes in system frequency. However, in large interconnected grids like the eastern interconnection, AGC participation would not be justified in the foreseeable future. In the more distant future when total wind penetration levels approach 15% to 20% energy of the entire interconnection, AGC participation would become more important.

It is recommended that ISO-NE encourage wind plants to have AGC capability or provision for future retrofit of AGC functions.

2.1.3.5. Encourage or mandate reduction of active power in response to high frequencies

ISO-NE should encourage wind plants to provide over-frequency droop response of similar character to that of other synchronous machine governors. Capabilities to provide this function are discussed in Section 3.4.4.2.

2.1.3.6. Consider requiring the capability to provide increase of active power for low frequencies

This is the other face of frequency control. Wind plants should not be required to provide governor-like frequency response for low frequency under normal operating conditions. This is consistent with any conventional power plant operating at full throttle output (i.e. valves wide open). However, ISO-NE should consider requiring that wind plant have the capability to provide this response, and then establish rules, and possibly compensation, for when such controls would be enabled. This presumably would be a rare occurrence, as the economic penalty associated with enabling these controls is high, as discussed in Sections 3.4.4 and 3.4.4.3.

2.1.3.7. Consider requiring inertial response in near future

Some OEMs are now offering inertial response for wind turbines. As discussed in Section 3.4.4.4, this is distinct from the previous two items on frequency response, in that inertial response is faster and strictly transient in nature. Consequently, there is not a significant economic penalty associated with the use of this new feature.

Synchronous generators have inherent inertial response. It is not a design requirement. It is simply a consequence of the physical characteristics of the rotating masses connected to a synchronous generator which is in turn connected to an ac transmission network. With the exception of Hydro-Quebec, inertia response characteristics have not been specified in grid codes or interconnection requirements for wind plants. Furthermore, language describing this functionality in technology-neutral terms and subject to the physical reality of wind generation equipment is not presently available. ISO-NE should consider requiring this function in the future as the technology matures and as grid operators and reliability organizations learn more about the need for inertial response characteristics from wind plants.

2.1.4. Harmonics

It is recommended that ISO-NE specifically include the IEEE (Institute of Electrical and Electronics Engineers) Standard 519 in the interconnection requirements, consistent with LGIA Item 9.7.6. In addition, ISO-NE should work to establish guidance for wind project developers and designers regarding background distortion on the network, and whether it must be taken into consideration during plant design.

This guidance should be the same as that provided by ISO-NE regarding harmonic performance for all generation and industrial interconnections, as well as substation modifications (including and especially the addition of shunt capacitor banks to the system). Harmonics are discussed in Section 3.5.

2.1.5. Modeling

2.1.5.1. Follow forthcoming NERC guidance regarding model requirements

NERC, IEEE, WECC (Western Electricity Coordinating Council) and, in the near future, the IEC (International Electrotechnical Commission) are working on standardization of wind plant models. This includes modeling, verification and testing. Since the technology is continuing to evolve, this is necessarily a work in progress. However, in the past few years, a degree of consensus has emerged on suitable modeling. ISO-NE should stay engaged in this process and follow evolving industry practice (see Section 2.3.6). Modeling cooperation is discussed in Section 3.6.1.

2.1.5.2. Use open structure models, when possible

Proprietary models provided under confidentiality agreements by OEMs are problematic for ISOs and utilities that must exchange data. Best practice for evaluation of individual wind plants is to use OEM specific models, when available. Under circumstances where open models are not available, New England should insist that plant data be provided for the new generic open structure models (as discussed in Section 3.6.1). This will allow exchange of databases with wind plants reasonably represented for ISO-wide and region-wide analysis.

2.1.5.3. Always make sure data is up-to-date

No manufacturer has a single model with fixed parameters. Data must be updated and verified for the specifics of the project being analyzed. It is not acceptable to copy and reuse old data for new projects without express reconfirmation by OEM. Further, New England should stay appraised of the ongoing changes and improvements to available models, both OEM specific and generic. Modeling of wind plants, (per discussion in Section 3.6.1) while significantly advanced has not yet fully matured. Changes are inevitable.

2.1.5.4. Short-Circuit Behavior

Model requirements should cover short-circuit behavior; in general, guidance from the turbine vendor will be needed, and should be required as a provision for interconnection. Perfection with short circuit modeling is not possible, so short circuit modeling should be deliberately conservative. Specifically, assumptions and approximations that bias results towards high current should be used for equipment rating. When appropriate, assumptions that bias results towards low current should be used for protection aspects that are dependent on minimum current.

This is a challenging topic and the industry is presently developing understanding, processes and recommendations related to short circuit currents. The IEEE Power Engineering Society task force on Short Circuit Fault Contribution from Wind Generators is addressing this issue. It is recommended that ISO-NE track the progress of that task force and evaluate the results of its work. It is possible that this task force will recommend a practice whereby wind plant owners would provide short circuit current information to transmission owners, grid operators, and others who need such data. Short circuit modeling is discussed further in Section 3.6.3.

2.1.5.5. Avoid Point-on-Wave modeling

Highly detailed, Electro-magnetic transients program (EMTP)-like simulations are extremely difficult to do correctly and require deep knowledge of wind turbine generator electrical controls. Generally, such models are difficult to obtain and unnecessary for engineering of grid interconnections. In applications that require EMTP-like analysis, (per discussion in Section 3.6.4) individual equipment OEMs should be consulted. Equivalents of wind plants for other types of studies need to be developed on a case-by-case basis. Interaction between wind plants and high power electronics, such as high voltage direct current transmission (HVDC) systems, are not well understood, and should not be done with generic models.

2.1.6. Communications between Wind Plants and ISO-NE Operations

Wind plants typically employ comprehensive data collection system for command and control purposes. These systems link all individual turbines to a common master control and monitoring device, normally located in the substation at the point of interconnection with the power grid. These systems are a critical part of the control and monitoring interface with the local grid operator or ISO.

The project team recommends that the basic requirements for communications and control between the ISO and wind plants be based on existing policy for conventional generators. Communications infrastructure is discussed further in Section 5.4.

2.1.6.1. Wind Plant Operator

Wind plants should be required to have the same level of human operator control and supervision as similar sized conventional power plants, per ISO-NE interconnection agreements. The ISO should have 24/7 access for voice communication with the wind plant operator for the purpose of implementing control orders or dealing with abnormal situations.

It is understood that the wind plant operator may be located remotely from the wind plant, in a facility that monitors and operates multiple wind plants, possibly in multiple operating areas. The point is that ISO-NE should have 24/7 access to a person that has direct and immediate control of the wind plant.

If ISO-NE allows unmanned operation for conventional power plants that have sufficient automated and remote control/monitoring functions, then the same should be applied to wind plants of similar MW ratings.

2.1.6.2. Monitoring signals from wind plant to ISO

The following signals should be sampled at the normal SCADA (system control and data acquisition) update rate.

- Active power (MW)
- Reactive power (MVAr)
- Voltage at point of interconnection

The following wind plant status signals are also recommended, but may be sampled at a slower rate:

- Number of turbines available (or total MW rating of available turbines)
- Number of turbines running and generating power (or total MW rating of turbines on-line and generating power)

- Number of turbines not running due to low wind speed
- Number of turbines not running due to high speed cutout
- Maximum and minimum reactive power capability of plant (for some plants in weak grid locations, it would also be prudent to know how much of the total range is dynamic, as opposed to switched capacitors or reactors)
- Total available wind power (equal to production unless curtailed)
- Average plant wind speed (When wind speeds are high and increasing, operators could anticipate high-speed cutout actions)
- Plant main breaker (binary status)
- Plant in voltage regulation mode (binary status)
- Plant in curtailment (binary status)
- Plant up ramp rate limiter on (binary status)
- Plant down ramp rate limiter on (binary status)
- Plant frequency control function on (binary status)
- Plant auto-restart blocked (on/off)

Additional wind plant monitoring signals that would be required for wind forecasting functions are described in Section 2.2.3.

2.1.6.3. Control signals from ISO to wind plant

The following command signals are recommended from the ISO to wind plants:

- Plant breaker trip command
- Voltage order (kV, setpoint for wind plant voltage regulator)
- Maximum power limit (MW, for curtailment)
- Engage up ramp rate limiter (on/off)
- Engage down ramp rate limiter (on/off)
- Engage frequency control function (on/off)
- Block auto-restart (on/off)

As an alternative approach, predetermined up and down ramp rate setpoints could be programmed into the wind plant controls. Then the ISO would not need to communicate the setpoints, but would still have capability to engage those functions when required.

2.1.6.4. Communication standards

The IEC 61400-25 series of standards should be the basis for wind plant communications and interoperability. It provides a comprehensive specification of wind plant data that may be needed by ISO-NE and its forecasting agent. Application of this standard is not yet widespread in the U.S. wind energy industry. However, there is awareness of the need for such as standard in both the wind energy and electric power industries. The 2009 Utility Wind Integration Group Forecasting Workshop in Phoenix, AZ provides an appropriate illustration. IEC 61400-25 was shown in applications for wind plant operators and energy management systems (EMS) vendors. Given that the object models encapsulate any plant data that would be required for production forecasting or decision support in power system operations, ISO-NE should consider adoption of this standard and timing for that action.

2.1.7. Distribution Connected Wind Generation

Distribution connected wind generation of rating greater than 100kW and less than 10 MW should be subjected to a reduced set of interconnection requirements. Specifically, for the present time, distributed wind generation is subject to the requirements of IEEE Standard 1547 [15]. Distribution connected wind generation must NOT: ride-through faults, regulate voltage or frequency, ever be islanded, and ever be subjected to reclosure action with turbines running. Distribution connected wind generation should be required to: have power factor control; communicate status (on/off), power production and anemometry; accept shut-down commands from the ISO. There is a NERC Integration of Variable Generation Task Force (IVGTF) effort to reconcile FERC Order 661a and IEEE Standard 1547. Further discussion of issues particular to distribution connected wind generation is provided in Section 3.7

2.2. Recommendations for Wind Generation Forecasting

2.2.1. Forecast System Type and Components

2.2.1.1. Centralized (ISO-administered)

The ISO-NE should implement a centralized (ISO-administered) wind power forecasting system. The centralized system is likely to have a lower total cost as well as higher and more uniform quality than forecasts provided for each plant and would allow the ISO to control the availability and utilization of plant data to forecast providers. As with load, effective power production planning requires more accurate forecasts for the aggregate system rather than single plants.

In a centralized system, it is likely that data from all wind generation facilities will be available for use in forecast generation at other facilities. This attribute can occasionally have significant benefit for short-term forecasts since data from an “upstream” facility might be a useful predictor for future variations at a “downstream” facility. The centralized system also provides more opportunity to implement a multi-forecaster ensemble since two or more providers could forecast for all generation facilities.

2.2.1.2. Ramp forecasting

The early warning ramp forecasting system should be viewed as a separate forecasting system. Forecasting techniques optimized to minimize mean absolute error do not do well in forecasting the large, rapid changes in wind speeds that cause the most problematic ramping events. The forecasting system should be designed specifically to forecast and alert operators to the likelihood of ramps events. Therefore, ramp forecasting is best accomplished with a separate methodology and system designed specifically to forecast and alert operators to the likelihood of ramp events.

2.2.1.3. Severe Weather

In addition to the routine and ramp forecast systems, a severe weather warning system that provides operators with information regarding the broader weather situation could be useful, especially with respect to extreme meteorological events that may have a serious impact on wind plant operations.

2.2.1.4. Type of Forecast

Since ISOs typically use only a single predicted power value in routine decision making, deterministic forecasts are likely to be more useful for short-term and day-ahead planning. Because of the nature of extreme events, ramp and severe weather forecasts are better expressed as probabilistic forecasts. Therefore, probabilistic forecasts are recommended for predicting ramps events.

2.2.2. Selection of a Forecast Provider

2.2.2.1. Trial Period

If one provider is to be selected, a one-year trial period of candidate forecasters is recommended. The decision should be based on a high-level of consistent performance across all seasons, weather regimes, and look-ahead time periods for a set of specified metrics.

2.2.2.2. Provider Evaluation

If the ISO feels that it needs assistance in vendor evaluation, it is recommended that a non-commercial organization such as the National Center for Atmospheric Research or National Renewable Energy Laboratory provide advice on conducting the evaluation and selecting forecast providers. If a commercial entity acts as the consultant, then that entity and affiliates should be disqualified from being a wind forecasting vendor.

If no trial forecasting period is used, vendor selection should be based on experience forecasting wind in similar weather regimes and providing forecast services to balancing authorities, as well as capability to customize forecasts for specific ISO applications.

2.2.2.3. Multiple Providers

ISO-NE should consider the use of a two-provider system. The use of two providers ensures a higher level of reliability. With multiple forecast vendors, ISO-NE could select the best performer for a given situation or create an ensemble of forecasts based on the time period or forecast situation. The final product could be either the single best forecast or a weighting of individual forecasts.

Although more than two providers might improve the quality of the forecasts, a cost-benefit study would be needed to determine if the added value justifies the additional costs. In order to take maximum advantage of multiple providers, ISO-NE would need to track and compare vendor performance. At a minimum, the evaluation should include vendor performance over various forecast time periods and months to identify specific trends.

2.2.2.4. Forecast Methods

The selected forecast provider should demonstrate an effective use of appropriate methods for different time periods of routine forecasts. There is no single methodology designed to meet the challenges associated with different look-ahead periods. The recommendation is to leverage the strengths of physical, statistical, and ensemble methods. For example, persistence-regression techniques are most applicable for very short-term forecasts whereas model-based methods are more suitable for periods beyond six hours. Also different methods and types of information should be delivered for ramp forecasts based upon the look-ahead time period.

It is recommended that ensembles be used and constructed in such a manner that the major sources of uncertainty in the forecasts are captured in the modeling system. The major source of uncertainty will vary from location to location and season to season. For example, the source of uncertainty from large scale systems such as fronts is much higher in New England than it would be in southern California.

Similarly, the source of uncertainty from large scale systems would be greater in winter than in summer, even in New England. The forecasts made from the ensembles and provided to the ISO can be either deterministic (made from a weighted average of the ensemble members) or probabilistic with associated uncertainty limits or both can be provided depending on the needs of the ISO.

2.2.2.5. Offshore Forecasting

The selected forecast provider should demonstrate knowledge of marine boundary layers and an ability to forecast their aspects for offshore wind plants. The provider also needs to demonstrate capability to forecast deep and shallow ocean waves. In the cold season, it is a fairly common occurrence to have high waves that would curtail maintenance operations for many days and impact turbine availability for power production. The data requirements for offshore plants would be identical to those for onshore plants with the exception of the need for wave height information.

2.2.3. Forecast Performance Evaluation Issues

2.2.3.1. Methods and Metrics

The recommendation is to evaluate forecast performance for all types of forecasts provided. The most significant issue when setting up the forecast evaluation system is determining which parameter(s) should be used as the metric(s) for forecast performance. The choice of metrics can have a significant impact on the interpretation of forecast performance. Candidate forecast providers should be informed of key metrics and the duration of the forecast evaluation period prior to submitting a proposal. At a minimum, bias, mean absolute error, and root mean square error should be provided for deterministic forecasts. For probabilistic forecasts of ramping events, both missed ramps and false alarms should be tracked as well as the actual frequency of the events that occurred during the forecasting period. When interpreting the results of any forecast evaluation, it is very important to note that forecast performance varies significantly according to the size and diversity of wind plants.

2.2.3.2. Data Requirements

In order to provide the most accurate power production forecast, it is essential that both power production and meteorological data be made available to the forecast providers. It is recommended that wind project owners/operators be meaningfully incentivized to provide high quality data in a timely manner through a secure communication system for use in wind energy forecast production.

Some providers advocate that forecasts can be made successfully with only power generation data. However, experience shows that although these data are extremely valuable, meteorological observations provide significant added value as well. Thus, the recommendation is to include meteorological observations whenever possible.

2.2.3.3. Production Data

The total aggregate plant power production data and plant availability should be sent to the forecast providers for each forecast interval. A minimum frequency should equal the forecast frequency but a desired value would be the nearest integer factor of one half the forecast frequency. The forecast provider should also have knowledge of any non-meteorological factors affecting the power output of the plant such as plant curtailment. Production data should include the following:

Specifications:

- Nameplate capacity
- Turbine model
- Number of turbines
- Turbine hub height
- Coordinates and elevation of individual turbines and met structures (towers or masts)

Operating Conditions:

- Wind plant status and future availability factor
- Number or percentage of turbines on-line
- Plant curtailment status
- Average plant power or total energy produced for the specified time intervals
- Average plant wind speed as measured by nacelle-mounted anemometers
- Average plant wind direction as measured by nacelle-mounted wind vanes or by turbine yaw orientation

The total aggregate plant power production data and plant availability should be sent to the forecast providers for each forecast interval (e.g. hourly).

2.2.3.4. Meteorological Data

Meteorological data should be provided from at least one met tower that is strategically placed so it will not be impacted by plant operations. The met tower should be at turbine hub height or at least within 20 m of hub height. In general, the met structures should be located at well-exposed sites generally upwind of the plant and no closer than two rotor diameters from the nearest wind turbine. As a rough guideline, each turbine in the wind plant should be within 5 km of a met structure.

Meteorological data should include the following.

Meteorological Structure (Tower or Mast) Specifications:

- Dimensions (height, width, depth)

- Type (lattice, tubular, other)
- Sensor makes and models
- Sensor levels (heights above ground) and azimuth orientation of sensor mounting arms
- Coordinates and base elevation (above mean sea level)

Meteorological Conditions:

Data parameters required at two or more levels:

Average (scalar) wind speed (m/s +/-1 m/s)

Peak wind speed (one-, two-, or three-second duration) over measurement interval

Average (vector) wind direction (degrees from True North +/- 5 degrees)

Data parameter required at one or more levels:

Air temperature (°C +/1 °C)

Air pressure (HPa +/- 60 Pa)

Relative humidity (%) or other atmospheric moisture parameter

Wind measurements on the met structure should be taken at two or more levels, with the levels at least 20 m apart. One level should be at hub height. If this level is not feasible, the closest level must be within 20 m of hub height. To improve data quality and reliability, sensor redundancy for wind speed measurement at two levels should be practiced. The redundant wind speed sensor at each applicable level should be mounted at a height within one meter of the primary speed sensor. It is also recommended that at least one of the wind speed sensors nearest the hub-height level be heated to prevent ice accumulation from affecting the accuracy of wind speed measurements.

The met condition data should be provided at intervals that are equal to or less than the intervals for which the power production forecast is desired. For example, if short-term power production forecasts are desired in 15-minute intervals, then meteorological condition data should be provided at intervals of 15 minutes or less. As with the production data, if the met data cannot be provided in real time, it is still valuable and should be provided for verification and model training.

In addition to data from the met structure, wind speed and direction data (as well as temperature and pressure if available) from nacelle-mounted instruments should be provided from a representative selection of turbines. Each turbine should be within 75 m in elevation and five average turbine spacings of a turbine designated to provide nacelle data.

For large geographical areas, typically more than one observation location would be recommended. However, it is challenging to give exact spacing criteria as these depend on factors such as local weather regimes, terrain complexity, and availability of nacelle data. If nacelle data are provided, fewer met towers would be needed and only one may be sufficient. Thus, the recommended number and location of met towers should be based on weather regimes, terrain complexity, and availability of nacelle data.

2.2.4. Operator Considerations

2.2.4.1. Control Room Integration

The wind power forecasting system products should be fully integrated into the ISO control room. In order to maximize grid management efficiency, it is recommended that an operator be dedicated to monitoring all of the renewable (variable) power generation resources. It is also suggested that pooling of wind plants into clusters may make it easier for an optimized integration of wind power. The plant cluster is an aggregate of plants grouped together logically (i.e. experiencing similar wind patterns and performance metrics). This approach would have particular value if there were transmission congestion in an area that required curtailment when a specific aggregate of plants exceeded threshold output.

2.2.4.2. Education and Training

An aggressive training program for all users of the forecasts should be implemented as part of the forecast implementation process. Training topics could address a number of areas such as interpreting error characteristics for deterministic versus probabilistic forecasts of ramps and/or other events. The training should cover the overall forecasting process and a high level review of physical versus statistical models as well as the use of observational data for validation and correcting model biases.

2.2.4.3. Provider/User Communication

An effective mechanism for communication between the forecast providers and users should be established. This exchange should include at least yearly workshops attended by forecast providers and users to address forecast performance and usability issues.

2.3. RECOMMENDATIONS FOR GRID OPERATIONS WITH WIND GENERATION

2.3.1. Applying Results from Wind Integration Studies

The wind integration study currently underway (as of September, 2009) at ISO-NE should provide much more detailed understanding and quantification of the operating challenge with significant amounts of wind generation.

As described in Section 3 modern wind plants can be equipped with a variety of features for modulating production of wind energy. Many of these have been demonstrated in actual plants or prototype installations. However, exploiting many of these features involves spilling wind energy, so questions as to their use and requirement necessarily involve economic evaluation.

The production simulation component of the wind integration study provides a means for assessing the cost of various characteristics of wind energy production as well as the value of measures for mitigation for the wind generation scenarios being studied.

2.3.1.1. Curtailment Policies

As wind generation penetrations grow, selective use of curtailment can be appropriate and economically justified under some operating conditions. ISO-NE should use the results of the current integration studies, along with periodic studies of a similar nature going forward, to develop a basis for its curtailment policy.

The study results need to establish the probability, frequency, duration, and value of curtailment as a mitigation measure for operational problems. Absent such quantification, it is very difficult to justify curtailment as general mitigation strategy because of the uncertainty it can pose to wind project developers and financing.

2.3.1.2. Enabling Ramp Rate Controls

Limiting large increases in production, such as at plant startup under high wind conditions, is an appropriate practice and one that is feasible with the wind generation technology of today. ISO-NE should conduct studies to determine the need for and value of such controls, and adopt them if shown to be of adequate value.

2.3.1.3. Enabling Under-frequency controls

Advanced wind plant control that temporarily increases output in response to a sudden decline in system frequency is a potentially valuable capability as the penetration of wind generation grows. ISO-NE should consider market mechanisms that would encourage this function.

2.3.1.4. Use of AGC and dispatch to wind plants

The ability of advanced wind plants to respond to AGC and dispatch signals much like conventional plants has been demonstrated in field testing by multiple turbine vendors. Above, it is recommended that new wind plants be provided with the capability to accept AGC signals.

In some circumstances, such as island or isolated systems or minimum load conditions at high wind penetration, these capabilities may be crucial for integration.

In larger power pools, however, this is seldom the case. The value of these capabilities must be compared to the cost of the spilled wind energy. The current integration study can help to frame the probable value of such capabilities for the scenarios being studied. In general, the economics will dictate whether such performance is practical. It is not recommended that ISO-NE plan to use such capability until (and if) detailed analysis and operational experience is gained.

2.3.1.5. Start-up and Shut Down

Upon starting a wind plant under normal conditions, wind plant production should be brought up slowly per pre-defined ramp rate limits. Shutdown should be accomplished in a similar manner when possible – i.e. not due to dying winds or high-speed cutouts. ISO-NE should adopt permissive restart of wind plants following shut-down due to grid disturbances using the same policies presently applied to other conventional generation in the footprint.

2.3.2. Wind Plant Scheduling and Congestion

The availability of individual wind turbines is quite high. Because of the large number of small generators however, turbine maintenance within wind plants is an ongoing activity. Shutdown of the entire facility would only be done for maintenance of common facilities such as the facility interconnection transformer, and then during low winds. So while wind plant maintenance scheduling differs from that for conventional plants, it is important for turbine availability to be considered in the development of production forecasts. Consequently, turbine availability – defined as the number of turbines currently or forecast to be in service – is a critical parameter that must be passed from each individual wind plant to the forecasting agent.

The physical capability of the each wind plant – i.e. the maximum generation that would be possible given the number of turbines in service – should also be communicated directly to ISO-NE. With transmission congestion, it is possible that production of individual wind plants will need to be curtailed. The plant physical capability along with meteorological data from the plant would provide a means for calculating the total curtailed energy.

Information on transmission congestion and curtailment must also be provided by ISO-NE to the forecasting agent so that congestion constraints are reflected in the forecasts for the affected plants.

2.3.3. Communications Infrastructure for Managing Wind Generation

Wind plants must provide to ISO-NE all relevant information required of conventional power plants. Other information unique to the wind generation facilities, as identified in other parts of this document, is also required.

The IEC 61400-25 series of standards defines a comprehensive basis for the monitoring and control of wind power plants, including definition of wind plant specific information, mechanisms for information exchange, and mapping to communication protocols, and is compliant with ICCP.

The standard is relatively new, and has not yet been adopted by U.S. ISOs or RTOs. However, it is recommended that ISO-NE strongly consider adopting this standard as a requirement for wind plants, or at a minimum, wind plant control centers.

Adoption would greatly facilitate the later development of tools and algorithms for integration that cannot be anticipated at this time. In addition, such a requirement for distribution system connected turbines would provide the capability for ISO-NE to directly interrogate these installations for support of forecasting or other operational applications.

2.3.4. Operations with Distribution Connected Wind Generation

Information about distributed generation is almost by definition fairly well hidden from system operators. Studies should be conducted to determine the threshold at which distributed generation in the ISO-NE footprint or a specific region could pose some risks for the bulk system. These studies would consider the loss of distributed generation due to transmission system faults and the levels at which ignoring distributed generation production forecasts would begin to affect load forecast accuracy, among other issues.

As the penetration of distributed generation grows, additional application tools and decision support mechanisms for operators to accurately portray potential impacts on the bulk system and the range of mitigation measures available.

2.3.5. Best Practice for Determination of Wind Generation and Wind Plant Capacity Value

The project team feels that capacity valuation methods that use adequate records of historical energy deliveries are most appropriate in the long run. At the same time, it is recognized that methods based on the more rigorous LOLE analysis are superior for evaluating the full spectrum of risks to system reliability from the perspective of resource adequacy, and should also play a role.

2.3.5.1. Recommended Method for Aggregate Wind Generation Capacity Valuation

It is recommended that ISO-NE adopt a method based on **Effective Load-Carrying Capability** (ELCC) for determining the aggregate capacity value of all wind generation facilities in the market footprint.

The evaluation would be conducted periodically. . The LOLE-based method described in Section 5.6.2 should be used, where wind generation is treated as an hourly load modifier, and ELCC is determined by comparison of the "with" and "without" wind cases.

Hourly historical production data should be used to represent existing wind plants. For queue projects, submitted wind speed data or corresponding production data from ISO-NE's adaptation of the NREL mesoscale database for the Eastern Interconnection could be used.

Previous studies have shown a significant variation between annual ELCC results. It is recommended that ELCC results be based on the average of multiple years of historical or simulated data. Initially, a shorter period will have to suffice, unless the mesoscale database is extended. A period of 10 years can be considered a reasonable historical sample.

An advantage of this approach is that the annual assessment will automatically take into consideration the penetration of wind generation in the market footprint. This is important since previous studies have shown that the capacity value of wind generation can decline as the penetration increases. With annual updates, this will be an inherent part of the process.

2.3.5.2. Allocating Aggregate Capacity to Individual Plants

The total capacity contribution determined from the ELCC analysis can be allocated to eligible individual wind generation facilities based on historical production during periods of system stress as defined by ISO-NE.

2.3.6. NERC Activities

NERC will be taking the issue of capacity valuation for renewable and variable resources up in Phase II of the Integrating Variable Generation Task Force. Responsibility for this issue has been assigned to the Resource Issues Subcommittee among others. The IVGTF will also play a role in developing baseline material and making recommendations to relevant committees. ISO-NE should actively participate in these activities, and adapt policies to align with forthcoming NERC recommendations if appropriate.

NERC is constantly updating standards and a number of NERC standards are of specific interest to wind. ISO-NE should actively participate in NERC standards development activities. Specific NERC Standards Projects with implications for wind power include:

- Project 2007-05 – Balancing Authority Controls (potential requirement for all generators to be equipped with AGC)
- Project 2007-09 – Generator Verification (addressing voltage and frequency ride through, exciter [voltage/reactive control] model validation, governor model validation)
- Project 2007-11 – Disturbance Monitoring (possible requirement to monitor each generator breaker)

- Project 2007-12 – Frequency Response (initially collecting data but eventually possibly addressing inertia)
- Project 2008-01 – Voltage and Reactive Control (may address generator status reporting requirements)
- Project 2009-05 – Resource Adequacy Assessment (defining metrics for assessing capacity value)

Section 3

WIND TURBINE AND WIND PLANT TECHNOLOGY

Grid integration of wind power plants is complicated by a number of issues, primarily related to wind variability and uncertainty and the electrical characteristics of wind generators. A typical wind plant appears to the grid as a substantially different generation source than a conventional power plant. The most significant difference is that the wind energy source is inherently uncontrollable. Also, the electrical characteristics of induction, doubly-fed, and full-conversion wind generators have disturbance responses and reactive output characteristics that naturally differ from that of conventional synchronous generators.

Historically, wind plants were allowed to produce real power that varied with the available wind, and was not scheduled in any fashion. Further, like some other generating resources (e.g. nuclear power plants, run-of-river-hydro, combined heat and power plants) wind plants were not required to participate in system frequency regulation, voltage regulation, or control of tie-line interchange.

Such uncontrolled real power output variations can have an impact on the grid, including voltage variations, frequency variations and increased regulation or ramping requirements on conventional generation resources. These are particularly significant issues in weak system applications, island (isolated) systems or in control areas where tie-line interchange is constrained.

In addition, a wind plant in which power output is not controlled inherently cannot participate in regulation of tie-line flows or grid frequency. When wind generation displaces conventional generation, the burden of balancing and frequency regulation placed upon the remaining conventional generators is increased.

Historically, wind plants were also allowed to absorb reactive power from grids, or at best, maintain a prescribed power factor. This is a substantially different operating mode than is required of conventional power plants, which generally regulate their grid interconnection bus voltages. Without coordinated control of wind plant reactive power interchange with the grid, a typical wind plant provides no support or regulation of grid voltage. Furthermore, voltage variations caused by real power variations, as discussed above, cannot be mitigated.

With low penetrations of wind generation, these equipment characteristics and integration approaches did not have significant practical impact. However, wind generation is now reaching substantial penetration levels in many regions, and grid integration has emerged as a potential limit on further development of this environmentally friendly resource. Consequently, interconnecting utilities and regulatory agencies are imposing grid codes that demand performance from wind plants similar to that provided by conventional power plants, i.e., those using steam, gas, and hydro turbines with synchronous generators [1, 2].

In this section, characteristics and capability of modern wind generation, relevant to grid performance, will be examined.

3.1. BASIC TYPES OF WIND TURBINE-GENERATORS (INDIVIDUAL WIND TURBINES)

Wind turbine generator designs vary dramatically from OEM to OEM, and between product lines within OEMs. The industry has begun to group different designs into four groups, described in the following subsections. This grouping is useful to help capture the broad range of performance characteristics that fundamentally affected by basic electrical designs. However, it should be understood that even within the 'types' presented below, there are large differences in capability and performance. These types cover the vast majority of utility scale wind generation, but not all wind generation falls into these categories.

3.1.1. Type 1: Fixed speed Induction Generator

The simplest form of wind turbine-generator (WTG) in common use is comprised of an induction generator with stator circuit connected directly to the grid that is driven through a gearbox, as shown in Figure 1. This type operates within a very narrow speed range dictated by the speed-torque characteristic of the induction generator, as illustrated in Figure 2. As wind speed varies up and down, the electrical power output also varies up and down per the speed-torque characteristic of the induction generator.

In its simplest form, this type of WTG does not include a pitch control system. The blades have a fixed pitch and are aerodynamically designed to stall (i.e., naturally limit their maximum speed). These are called "stall-regulated" turbines. However, more advanced models include a variable blade pitch control system. The stall regulation feature may be implemented passively (blades stall naturally at wind speeds above a certain magnitude) or actively with action by the blade pitch control system.

If the wind speed increases to a level where steady-state electrical power output would exceed the rated power output of the turbine generator, the pitch-angle of the rotor blades is adjusted to limit power output to the rated value. However, the pitch control system is not fast enough to respond to fast wind gusts. If the wind increases rapidly, the electric power output would temporarily increase above rated power (per the torque-speed characteristic), until the pitch control adjusts the blade pitch angle and reduces power output to the rated value.

One advantage of this type of fixed-speed induction generator WTG is its simplicity. A disadvantage is the significant variation in real and reactive power output as wind speed changes. Simple induction generators always consume reactive power, "under-excited" in the convention of grid connected synchronous generators, with the reactive consumption being primarily dependent on the active power production. Thus, management of reactive power must consider this under-excited behavior as well as the reactive power requirements of the grid.

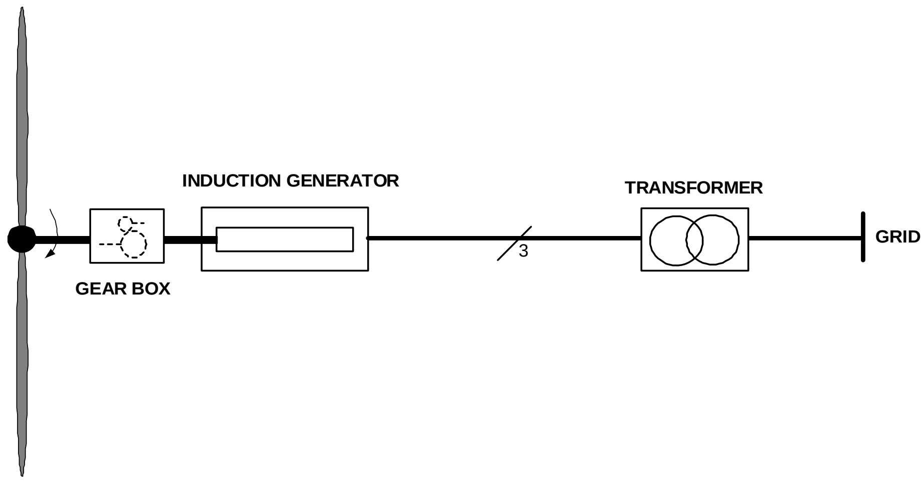

Figure 1: Type 1 WTG; Induction Generator (NEG-Micon, Bonus, traditional Nordex, typical small/residential WTGs)

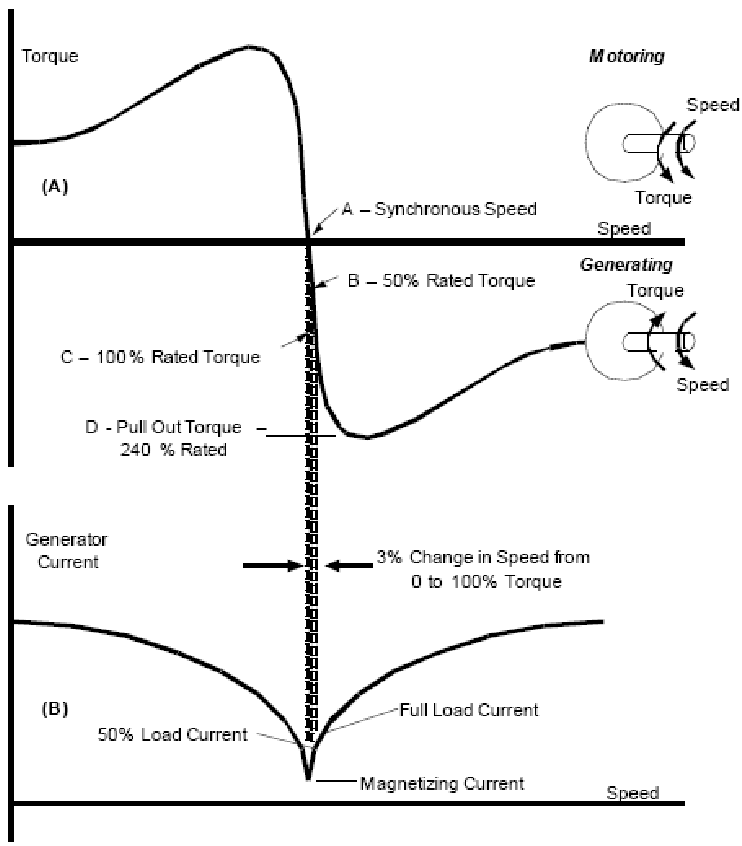

Figure 2: Speed-torque and speed-current characteristics for induction generator. (Source: BEW report for CEC, May 2006)

Figure 3 shows the reactive power at the terminals of a typical induction generator WTG as a function of real power output. The blue trace shows the reactive power consumed by the induction generator. It ranges from about 0.18 pu at no load to nearly 0.50 pu at full load. It is common practice to compensate for the reactive power consumption of the induction generator by installing capacitors at the WTG. One approach is to compensate for the no-load reactive power consumption with a fixed capacitor, as shown by the gray curve. Another approach is to use several capacitors and switch them as a function of load. This type of "step compensation" keeps the net reactive power of the WTG near zero or some other desired value.

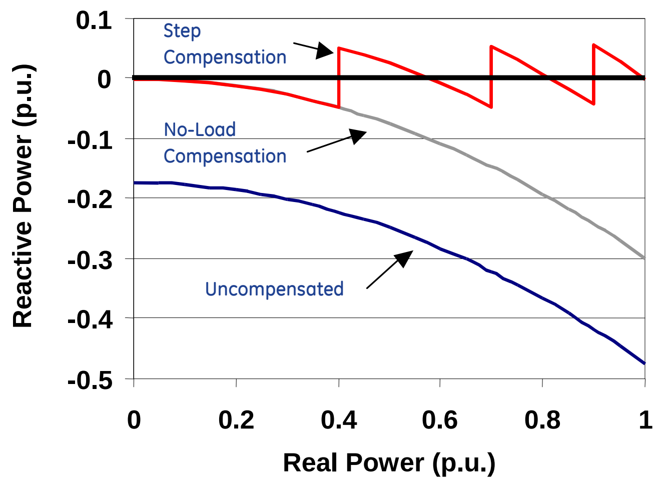

Figure 3: Reactive Power as a function of Real Power for and Induction Generator WTG, with and without compensation using shunt capacitors.

3.1.2. Type 2: Variable-Slip Induction Generator

The variable-slip induction generator WTG is similar to the Type 1 induction generator machine, except that the generator includes a wound rotor and a mechanism to quickly control the current in the rotor by adjusting the apparent resistance of the rotor circuit (see Figure 4). The operating characteristics are similar to the Type 1 induction generator WTG, except that the rotor-current control scheme enables a degree of fast torque control, which improves the response to fast dynamic events and can damp torque oscillations within the drive train.

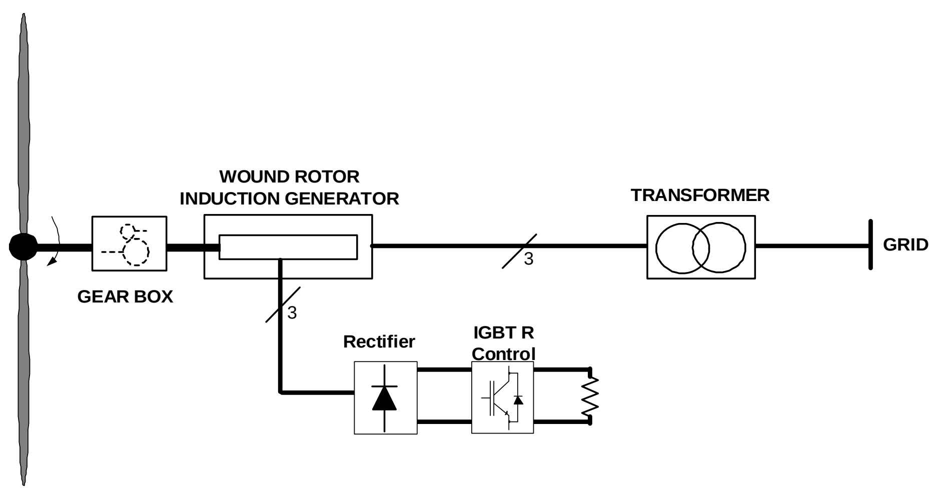

Figure 4: Type 2 WTG; Wound Rotor Induction Generator with Variable Slip (Vestas Opti-Slip®)

3.1.3. Type 3: Double-Fed Asynchronous Generator

The double-fed asynchronous generator (DFAG) type of WTG includes a mechanism that produces a variable-frequency current in the rotor circuit (see Figure 5). This enables the WTG to operate at a variable speed (typically about 2:1 range from max to min speed), which improves the energy capture efficiency and controllability of the WTG. Since the power converters need only be rated to carry a fraction of the total WTG power output, this design is also attractive from an economic perspective.

Although the original incentive for this scheme was variable speed power conversion, the power converters have since evolved to perform reactive power and voltage control functions, similar to those in conventional thermal and hydro power plants. The fast response of the converters also enables dynamic features such as low-voltage ride-through and governor-type functions.

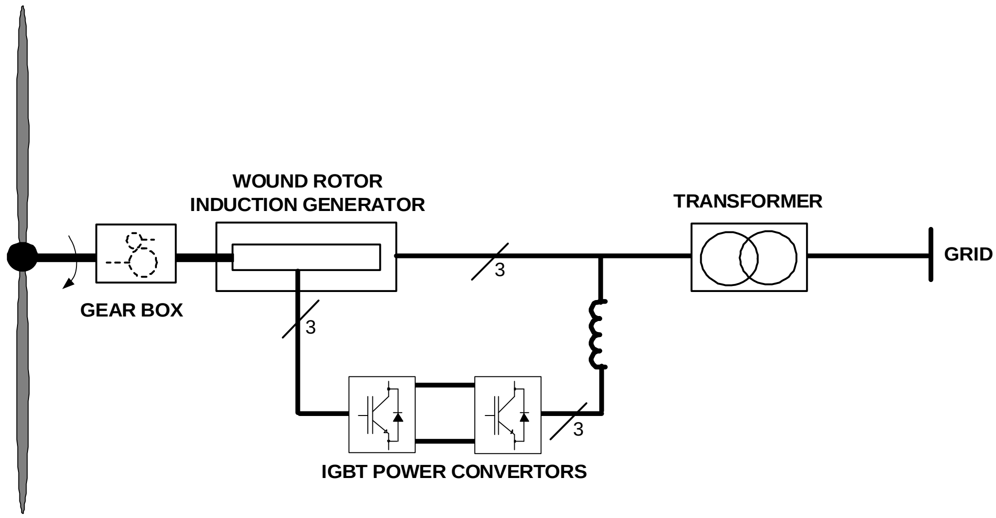

Figure 5: Type 3; Double-Fed Asynchronous Generator, Variable Speed WTG (GE 1.5, RePower, Suzlon, Vestas V80,V90,others)

3.1.4. Type 4: Full Power Conversion variable speed

Another approach to variable speed WTGs is to pass all turbine power through an ac-dc-ac power electronic converter system (see Figure 6). This system has many similar operating characteristics to the DFAG system, including variable speed, reactive power and voltage control, and fast control of power output. It has an additional advantage of totally decoupling the turbine-generator drive train from the electric power grid, which means that dynamics during grid disturbances can be better controlled (LVRT, governor-type functions, etc.). It also reduces dynamic stresses on drive train components when grid disturbances occur.

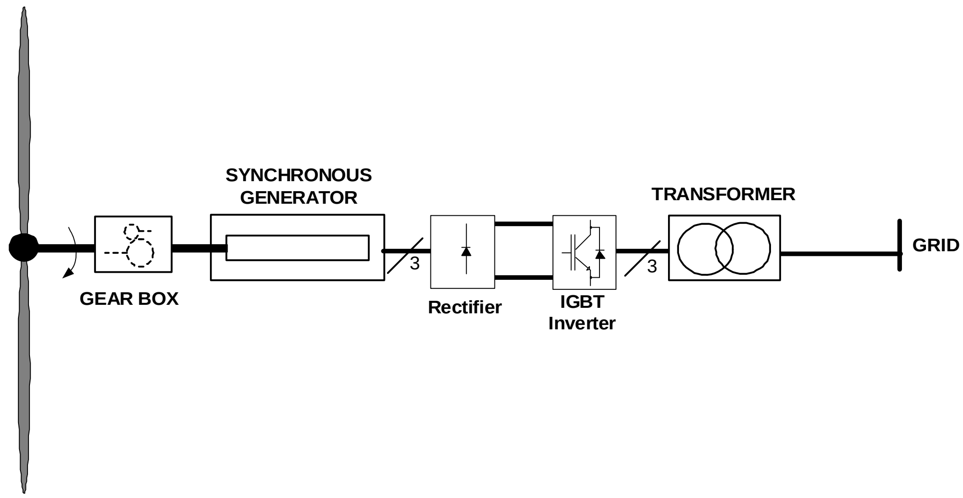

Figure 6: Type 4; Full Power Conversion, Variable Speed WTG (Enercon, Siemens, GE 2.5)

3.2. DISTURBANCE TOLERANCE AND RESPONSE

Wind plants, like all generation, are subject to disturbances in the power system. The response of WTGs to large perturbations in voltage and frequency has been a significant concern in the industry. Different aspects of disturbances, and the ability of WTGs to tolerate them, are described in this section.

3.2.1. Fault-Ride Through / Voltage Tolerance

Low voltage ride-through (LVRT) capability became a common requirement for wind plant interconnection due to both increasing plant sizes and greater wind generation penetration [9]. LVRT requirement evolved over the past 5+ years, starting with a history of deliberate tripping on low voltage. The current FERC Order 661A requires that wind generation not trip for zero voltage (i.e. bolted 3-phase fault) at the POI for 9 cycles. This latest version of the requirement is often called “zero-voltage ride-though.” The standard also requires tolerance of arbitrarily long duration backup cleared single-phase-to-ground faults. Zero voltage ride through (ZVRT) requirements are now standard in much of the world, including most North American systems [10, 11, 12, 13]. As an example, some ZVRT standards require wind plants to remain in-service during normally cleared system faults with zero pu voltage at the point of interconnection for up to 9 cycles. NERC is updating standard PRC-024 for all generators. The current proposal for ZVRT is shown in Figure 11. A uniform North American standard for fault-ride through will eliminate confusion and unnecessary costs associated with localized rules.

3.2.1.1. Low Voltage and Zero Voltage Ride-through

Many OEMs have WTGs that meet these fault tolerance requirements. Since staging faults on operating grids is expensive, risky, and disruptive, testing is usually performed in a more controlled environment.

The following test results were provided by WINDTEST K-M-K GmbH, an independent testing group, for an operating GE 1.5 MW (type 3) wind turbine generator. A 200 ms, 3-phase fault-to-ground was applied to the medium voltage bus. Figure 7 shows the rms voltages for each phase of the faulted bus. Figure 8 shows one of the voltages again, as well as the real power delivered to the medium voltage bus. The wind turbine remains in service during the fault, and power output recovers to the pre-disturbance level at a controlled recovery rate in under 200 msec.

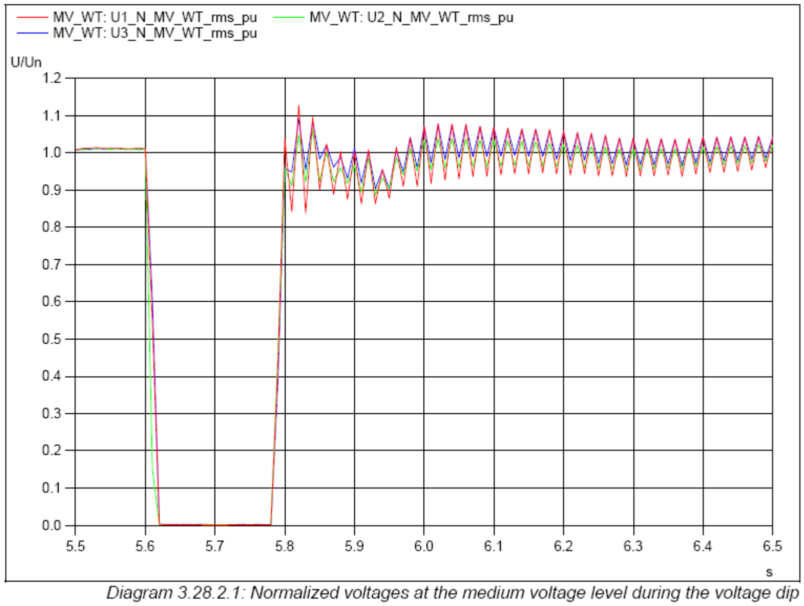

Figure 7: Demonstration of 1.5 MW ZVRT capability (voltage)

Similar ZVRT performance can be provided by a full converter (type 4) wind turbine generator. Test results demonstrating this capability for GE 2.5 MW WTG are shown in Figure 9 and Figure 10. Figure 9 shows the machine is initially operating at near rated power output and near zero reactive power output. A 3-phase fault to ground is then applied for 200 ms, as shown in Figure 10. The wind turbine rides through this fault and returns to normal operation after the fault is removed.

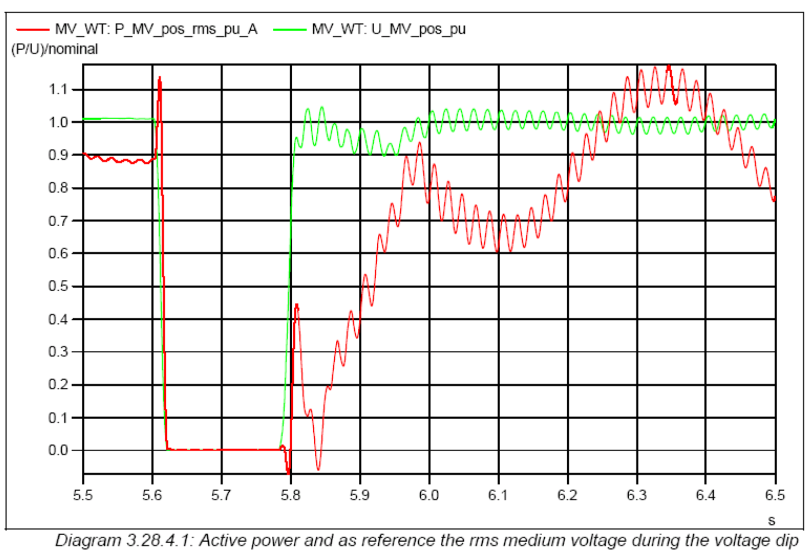

Figure 8: Demonstration of 1.5 MW ZVRT capability (power and voltage)

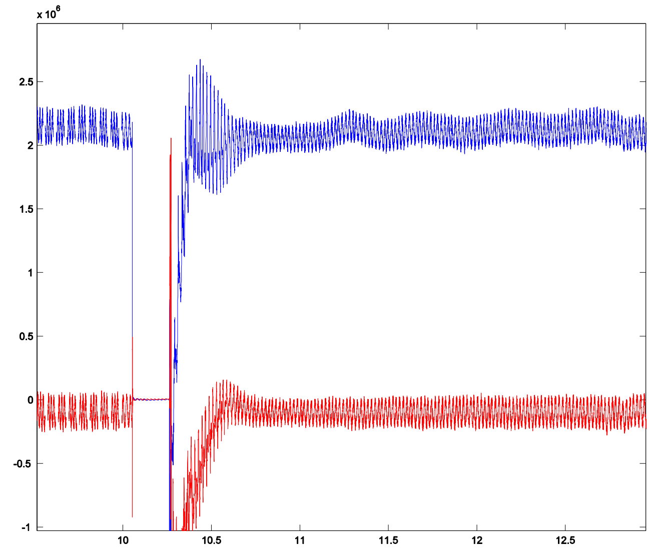

Figure 9: Demonstration of 2.5 MW ZVRT capability (real and reactive power).

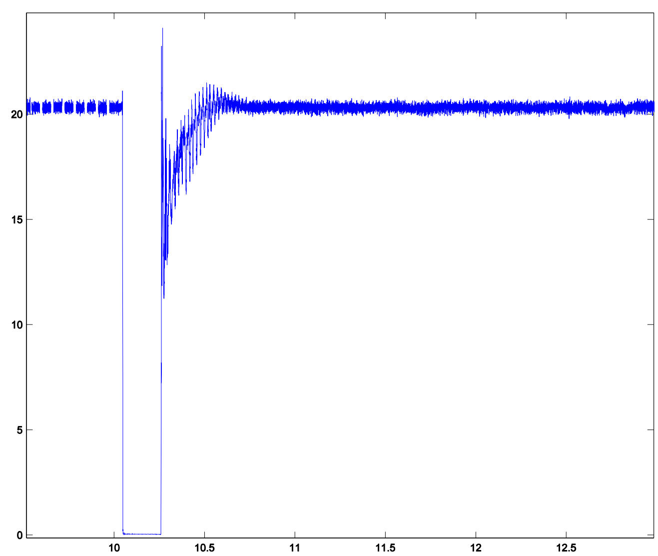

Figure 10: Demonstration of 2.5 MW ZVRT capability (voltage).

3.2.1.2. HVRT

There has been considerable recent discussion on high voltage ride-through (HVRT) requirements. These discussions have not had the depth nor the technical sophistication as the several years of debate about low voltage tolerance.

The proposed limit high-voltage limit (red curve) in Figure 11 is reasonably interpreted as starting when the voltage exceeds 110% of normal (not when a system fault occurs and initiates a voltage depression). The required HVRT tolerance would reasonably be specified as a cumulative duration of withstand, as is the common and accepted practice for other power system equipment, and not be specified as an "envelope" defined by elapsed time from some initiating event. (A realistic overvoltage event typically has multiple short excursions into the overvoltage domain, and only these excursions are relevant for overvoltage performance.) Such a standard would more appropriately reflect the stress that must be endured by the equipment in terms consistent with overvoltage withstand standards applied to other power system equipment.

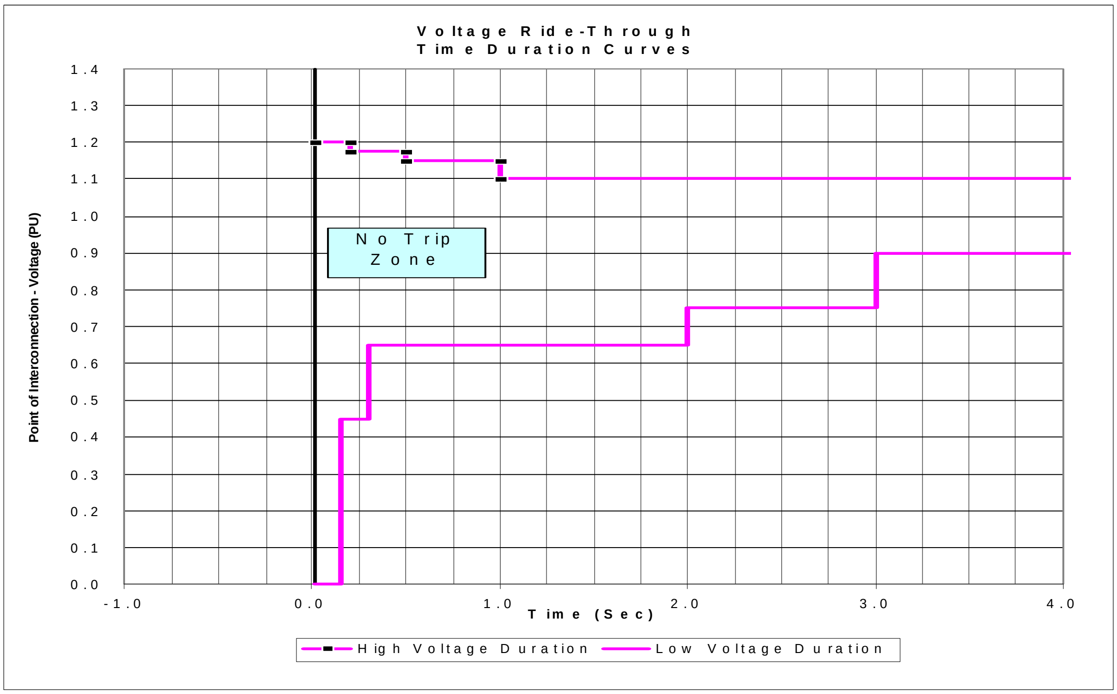

Figure 11: Voltage ride-through criteria from recent proposals by NERC.

3.2.2. During Fault and Post Fault recovery characteristics

Some international grid codes are asking for very specific active and reactive power performance during faults. Typically, but not always, these codes require an increase in reactive current delivery during faults (and deep voltage depressions), and they may also require suppression of active power. Some codes also require rapid recovery of active power after the clearing of faults. Some of these codes are very strict. This has the risk that (a) overly prescriptive during-fault codes are unreasonable in that they are very hard to meet and not necessary, and (b) that excessively fast active power recovery is actually bad for the power system. Excessively fast active power recovery will tend to aggravate post-fault recovery swing and voltage dynamics. Recovery on the order of few hundred milliseconds has worked well in interconnected systems.

3.2.2.1. Low voltage active power limitation and recovery

It is impossible to deliver power through a zero voltage. Utility practice has evolved that recognizes this and that takes into account the inherent electrical behavior of synchronous generators. During system faults, synchronous machines (as dictated by Park's equations) experience drop in electrical power output and accelerate. Once faults are cleared, the accelerated machines must be slowed down and returned to steady-state synchronism with the grid. The active power behavior of synchronous machines during and immediately following grid faults is dominated by this behavior is almost completely uncontrolled (although excitation systems and governor response have some limited capability to affect acceleration and resynchronization). This is well understood by system planners. Much of ISO-NE's planning and operating practice is focused on maintaining system stability. Unlike synchronous machines, type 3 and type 4 wind turbines, are not dependent on turbine speed control to maintain synchronism. Active power can be controlled to a considerable extent by the WTG electronics. Thus, it is possible to reduce active power injection during faults, and to delay or slow the rate of recovery active power injection to the grid following system events. This type of control tends to reduce the severity of system recovery voltage transients and can help other synchronous machines maintain stability (e.g. increase critical clearing times). There is no industry consensus on requiring this behavior. Recovery within ½ second is consistent with the swing dynamics of interconnected systems like ISO-NE. One OEM (GE) limits the active power during deep voltages depressions and limits the recovery to rate of 5.0 p.u. /sec. That has been shown to give good system performance in tests. Some (non-US) grid codes have required extremely fast recovery (e.g. 0.1 s) following grid faults. This is likely to be neither necessary nor beneficial for ISO-NE. Since power behavior of synchronous generation during faults is largely uncontrollable and not subject to grid code requirements, imposing tight controls on wind plants for this is unreasonable and would likely be detrimental to overall grid performance.

3.2.2.2. Low voltage reactive current delivery

It is well understood that reactive current delivered by generators during faults helps moderate the severity and geographic reach of the accompanying voltage depression. Most wind generation technologies can deliver some reactive current during voltage depressions. In general the current delivery is less than that for similarly sized synchronous machines as observed in the short circuit modeling discussion in section 3.6.3. Unlike synchronous machines, the reactive current can be controlled to some extent during faults. Some grid codes have recognized this, and have required stringent control of reactive current during disturbances. This is technically challenging. In so far as specific equipment allows, ISO-NE should encourage wind plants to deliver as much reactive current as is practical with the available equipment during voltage depressions below a nominal level (e.g. 90%). In this context, "practical" means that, for example, equipment controls should be set to deliver as much reactive current as the equipment allows. It does not mean that additional hardware be provided to further increase reactive current beyond this level. Such requirements do not apply to islanded conditions, which must be avoided, as discussed in section 3.2.6 .

3.2.3. Frequency Tolerance

Generally tolerance to (as opposed to 'response to', which is discussed below) grid frequency excursions has not been a major concern for wind generators. Most WTGs are as (or more) tolerant of frequency excursions as conventional synchronous machines. Present NPCC rules as shown in Figure 12 for frequency ride through are well suited to modern wind generation.

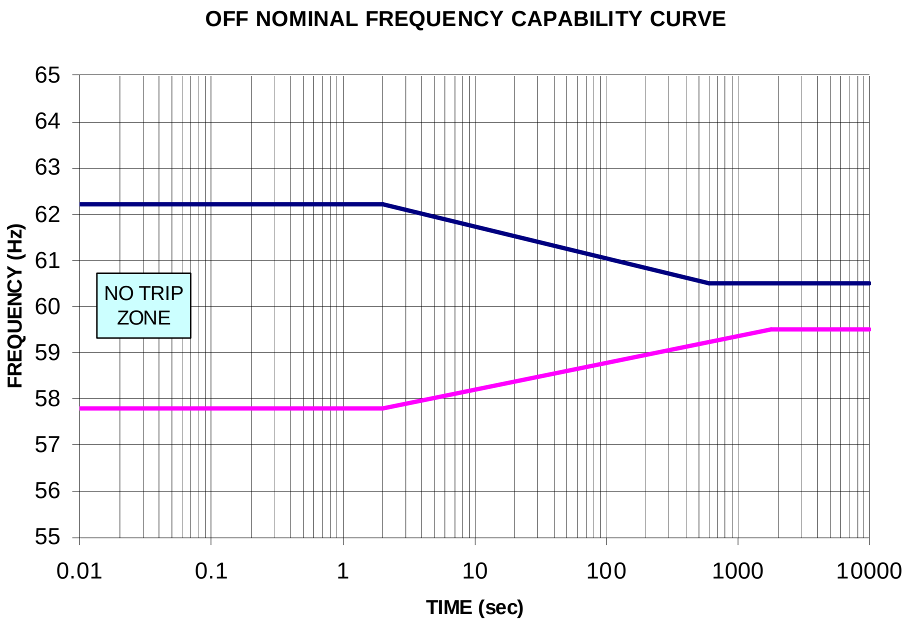

Figure 12: NPCC Frequency tolerance requirements

3.2.4. Rate of change of Frequency

The tolerance of WTGs to rapidly changing frequency has emerged as a concern in some smaller and highly stressed systems recently. Typically, following loss-of-generation events, the power system may experience a rapid drop in frequency. With WTGs (type 3 and 4) being dependent on power conversion systems, the concern is that the equipment be able to track the rapidly changing frequency. Initial drops on the order of 1-2 Hz/sec can be found for severe events in big systems. Some small systems have mandated tolerance to rates as fast as –4Hz/sec, but such rates are only found in small grids. The Irish grid code [13] requires capability to handle ±0.5 hz/sec changes. While this may be a reasonable requirement for ISO-NE, it is not recommended that ISO-NE adopt any rate-of-frequency requirements. It is unlikely that this will be a significant concern for New England. Concerns related to possible breakup and islanding of New England are addressed in section 3.2.6.

3.2.5. Start-up and Shut-down

Starting and stopping a large wind power plant can be disruptive to other generation equipment in a utility system when the power production of the plant is near or at its rated value. Rapid loss of plant output when all the wind turbines are quickly disconnected from the system can create under frequency and power balance problems. Conversely, rapid start-up of a wind plant that has been shut down, for some reason other than lack of wind, can create over frequency and power balance problems. It is appropriate to recognize that there are different circumstances for which plant will start-up and shut-down, and requirements for those circumstances are different.

3.2.5.1.   Normal Start-up and Shut-down

Plants can employ a means to control the rate of change of power when a wind plant is shutdown and disconnected from the grid. An operator can send a shutdown signal to the plant controller initiating a controlled shutdown response. The control immediately interprets the shutdown command to begin reducing the power of the plant and start sequencing off turbines. Similarly, operator command can initiate a start-up sequence. Start-up of a plant where there is significant wind can have ramp limits applied.

Figure 13 depicts a shutdown sequence for the GE site that had 38 available and operating wind turbines and was programmed to shut down over a five minute interval. It shows the power of the plant decreasing to zero over five minutes and the number of on-line generators. Start-up sequences exhibit similar behavior to that shown in Figure 13.

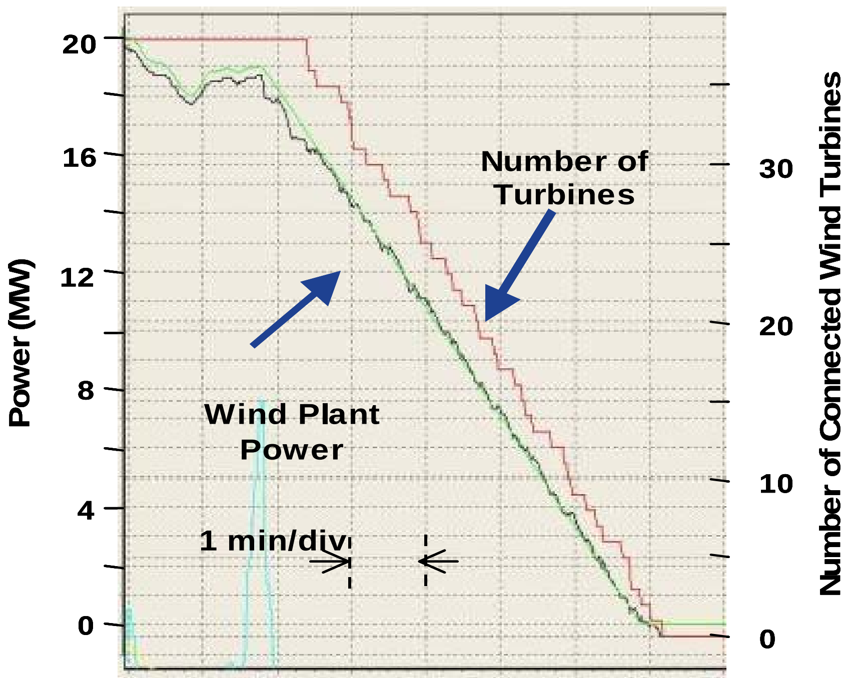

Figure 13: Demonstration of wind plant shutdown sequence

3.2.5.2.   Emergency Shutdown and Post-Emergency Restart

When grid events cause wind plants to shut down, it may be desirable for the ISO to specify performance that is different from that described in the previous section. For example, should system analysis show that the post-disturbance conditions for specific individual (or class of events) are unable to support power transfers from wind plants, then restart should be blocked. It will be incumbent on ISO-NE to determine the conditions for which restart should be blocked[1]. ISO-NE practice for restarting other types of generation tripped by grid events should be applied to wind plants. Wind plants must have the capability to receive commands from the ISO that prevent restart, much as they must accept commands to curtail output. Under no

[1] It is easy to envision a condition for which loss of a critical north-south EHV tie-line in New England could result in a substantial drop in transfer capability. Wind plants could be blocked from restarting under such conditions.

circumstances should wind plants be allowed to try to restart into a black system (as discussed further in the next section.)

The ISO always retains the ability to trip wind plants by opening the plant breaker. This is the same as with other types of generation, and as with other generation, is to be done only at grave need. The wind generation equipment is subjected to considerable mechanical and electrical stresses for a full load rejection. A shutdown command to the plant is greatly preferred.

3.2.5.3. High speed cut-out

A sudden loss of wind generation is perhaps the greatest fear of system operators. Over the past decade, there have been a few well-publicized events where significant wind generation in a balancing area was lost due to very high wind speeds across a large region, such as the ERCOT events of March 15, 2007 and February 26, 2008, or the Danish event of January 8, 2005. Most commercial wind turbines utilize pitch control or other mechanisms to "spill" wind energy when wind speeds exceed the level required for nominal maximum power production. This results in a large region of rated power production over a wide range of wind speeds, which by itself is a highly desirable characteristic. However, at excessive wind speeds, usually 25 m/s or greater, mechanical loads and stresses necessitate a shutdown of turbine operation, also known as high-speed cut-out.

As the events referenced above, illustrate, the loss of large amounts of wind generation over a few hours can place significant demands on operators, or possibly compromise system reliability. The operational implications of loss of generation over hours are different than that associated with discrete plant trip loss-of-generation events. It is a common misconception that large amounts of wind generation can go from full power to off in a single step. This does not happen. While improved wind generation forecasting for operational situational awareness is often cited as a preventative measure, there are modifications to wind turbine operation that may also contribute positively. Figure 14 illustrates the modified power curve for a turbine designed to gradually reduce production in very high winds.

It should be noted that such a modification is not trivial. Continuing operations in very high wind speeds has significant implications for the mechanical and structural design aspects of the turbine; for example, while the "lift" component of the aerodynamic energy capture can be well-controlled through pitching of the blades, the "thrust" component will increase with wind speed, placing higher stresses on the tower, blades, and drive train.

At this time, the complexity and additional stress on the wind generation equipment does not appear to justify this function in a large system like ISO-NE. It is not recommended that this be required.

Regardless of whether such controls are implemented to reduce the impact of high wind speed shut-down, in general wind plants should be allowed to return to service automatically when wind and grid conditions allow. Since both cut-out and recovery events occur over a period of time (like the cases described above), the production variability ought to be within the response capabilities of the ISO-NE grid. The default practice should be that wind plants are allowed to restart after a high wind speed event, unless they are explicitly instructed to curtail by the ISO.

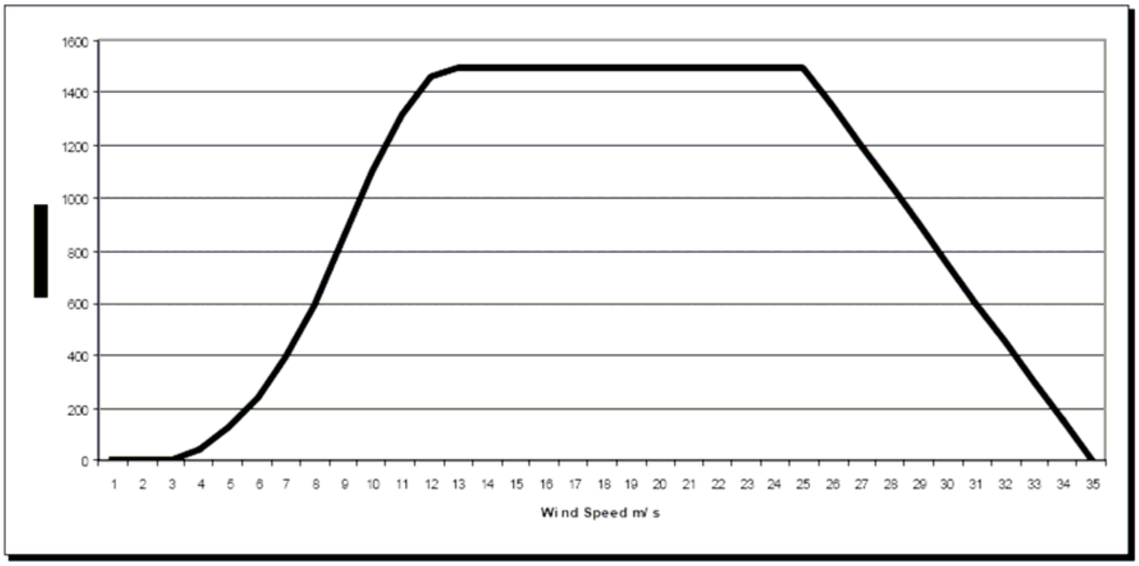

Figure 14: Power curve for advanced wind turbine with gradual high-speed cutout

3.2.6. Islanding and Weak Grid Operations

The technology and controls necessary to allow wind plants to operate in isolation or islanded is not generally available today. In this context, "islanded" refers to a usually small portion of the power grid, with little or no other synchronous generation, being separated by switching action from the larger grid. It does not refer to inter-regional conditions for which (for example) all of New England separates from the Eastern Interconnection. In order to operate in a system with no other sources, generation must have the ability to set system frequency and voltage. While voltage control is available (and should be required for wind plants), isochronous frequency control is not. ISO-NE should not require that wind plants have the ability to operate in islanded mode.

Generally, wind plants and wind turbine-generators are provided with equipment protection (relays, breakers and controls). This equipment is intended to protect the wind generation and related equipment. It is not designed to protect other equipment unrelated to the wind plant. It is therefore ill-advised to rely on the protective action of wind generation to mitigate protective risk to customers. ISO-NE should require that any wind plant or individual wind turbine that has the potential to be islanded with customers have an active relaying scheme, such as transfer trip, that disconnects the wind in event of relay/breaker action that can create that island.

A further consideration is that the majority of wind generation being built in North America is type 3 and type 4 (as discussed in sections 3.1.3 and 3.1.4). These generation types utilize power electronics to interface to the grid. The power electronics of these devices require a minimum level of short-circuit strength to reliably operate. Similarly, type 1 and type 2 generation (per sections 3.1.1 and 3.1.2) typically have shunt capacitors. Islanding or operation into low short circuit strength systems creates a risk of self-excitation, which must be avoided. Usually, other synchronous generation must be running in electrical proximity to the wind plant before it can run. One good metric of proximity is short circuit ratio (SCR), i.e. the ratio of the grid short circuit MVA at the point of interconnect to the wind plant MW rating. Application rules vary by wind OEM, but SCR levels above 5 are typically robust; levels below this should be applied with some care and levels below 2 need considerable care and may be outside of specific wind generation equipment capabilities. In the context of islanding, small subsystems which include some customer load, some other synchronous generation and wind generation should be treated as islands when the short circuit ration of the wind plant drops, due to switching operations, below a minimum threshold. ISO-NE should require that the viability of such subsystems for short circuit ratios below 2.0 be demonstrated, if transfer tripping is not provided.

3.3. VOLTAGE CONTROL AND REACTIVE POWER MANAGEMENT

FERC order 661-A requires -.95 to +.95 power factor at the Point of Interconnection (POI). This is a recent step in an evolution of generator standards that define power factor range requirements at the terminals of individual synchronous generators. Since wind plants consist of multiple WTGs and may include other reactive power equipment, definition of required power factor range at the POI allows technology neutral means of meeting system performance objectives.

It should be noted that the intent of the power factor range requirement is currently open to multiple interpretations. Specifically, one widely used “permissive” interpretation of the rule is that wind plants satisfy the requirement if the plant power factor remains anywhere within this range during operations. The other “prescriptive” interpretation, which we believe is consistent with the intent of the requirement, is that wind plants must be able to deliver controlled reactive power, such that the power factor can be set or controlled to any level within the specified range. This second interpretation is consistent with conventional synchronous generator interconnection. Many wind plants are presently being designed and commissioned subject to the first interpretation in North America.

The other key distinction is that FERC Order 2003a places the onus on the host system to prove the need for wind generation to deliver reactive power. System studies must show that delivery of reactive power from proposed wind plants is necessary for system reliability and operation, before requiring such capability of prospective new wind generators. Unfortunately, there is no established mechanism by which host systems can prove such a need, and this is starkly at odds with the requirements imposed on other types of generators. ISO-NE LGIA Item 9.6.1 requires the full ±0.95 power factor range, but provides an exemption for wind plants. This exemption is no longer warranted.

3.3.1. Wind turbine types and reactive capability

The different types of WTGs described in Section 2.1, have quite different reactive power capabilities.

Type 1 and 2 machines always consume reactive power, as illustrated by Figure 3. Wind plants with Type 1 and 2 WTGs use SVCs or STATCOMs and/or switched capacitors and reactors if controlled reactive power is required.

Type 3 and 4 machines may (or may not) have substantial reactive power capability. That capability may be available at all power levels, or be described as a power factor capability. For example, GE wind turbines have reactive power capability corresponding to a power factor of 0.90 lagging (overexcited) to 0.90 leading (under excited), measured at the machine terminals. The full reactive range of the turbine is available above the cut in speed regardless of the power level, as shown in Figure 15.

As with all other types of generation, wind turbine-generators have voltage limits. Reactive power delivery requirements must be subject to these limits. Generally, it is challenging for any generator to deliver large amounts of reactive power (run over-excited) when their terminal voltages are high, and conversely, to absorb large amounts of reactive power when their terminal voltages are low. Since these conditions make little sense from a grid perspective, there is little concern. Some grid codes explicitly recognize this limitation, and make provision. The UK grid code [14] is a good example.

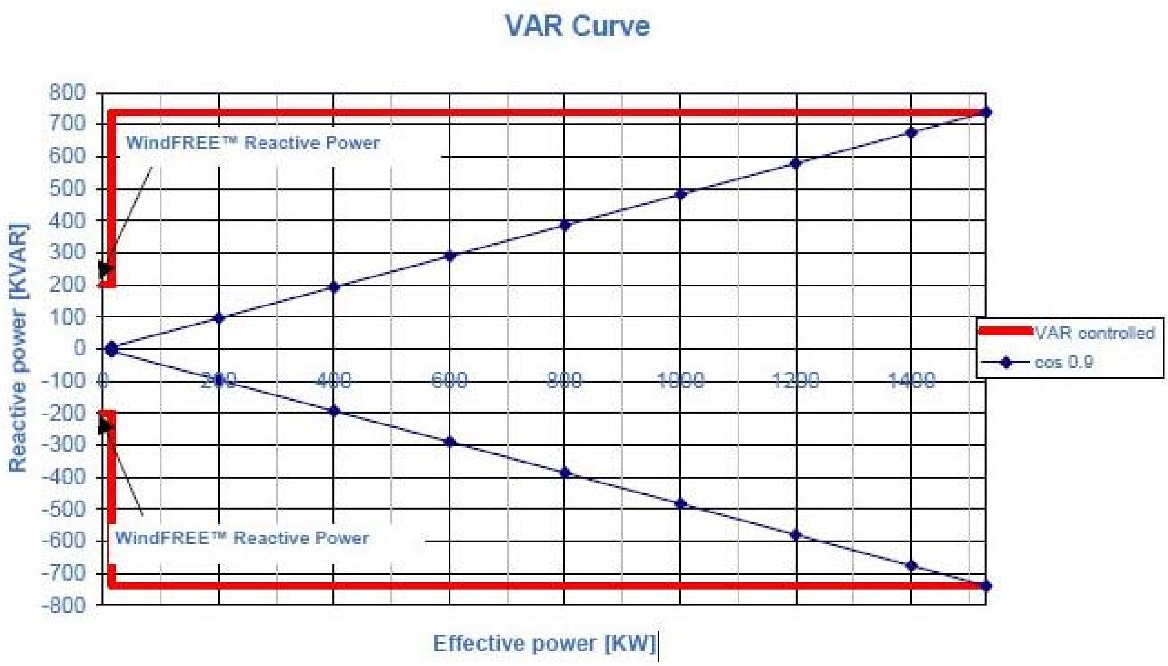

Figure 15: Reactive Capability of GE 1.5 (type 3) WTG

3.3.2. Wind Plant Controls

Some wind plants have supervisory controls that regulate the net real and reactive power interchange of a wind plant with the grid. This allows the wind plant to regulate voltage magnitude of the grid, provide governor frequency response, and minimize rates of power change. In the US, plant level voltage regulation is required.

Wind plant control systems can be hierarchical schemes that control individual wind turbines in order to implement closed-loop regulation of grid parameters such as voltage or power, or grid-interface parameters such as power factor or net power output.

3.3.2.1. Voltage controls

Power plants are normally required to regulate bus voltage at the point of interconnection. This is normally the high-side bus of the plant's step-up transformer. Conventional plants with synchronous generators regulate bus voltage by controlling field current with an excitation system. As with conventional plants, voltage schedules for wind plants should be provided by the grid operator. Anecdotal evidence suggests that grid operators in North America often do *not* provide wind plants with voltage schedules. This practice increases the risk of poor grid voltage performance (both in steady-state and for grid events), and should be avoided.

There are several basic schemes for regulating voltage with a wind plant:

- By using controlled reactive compensation devices (capacitors, reactors, SVC, STATCOM) in the plant substation, or
- By controlling the reactive power output of individual wind turbines, or
- By a combination of both.

Figure 16 shows a typical wind plant with induction generators WTGs (Type 1 or 2). These types of WTGs often operate with each WTG holding a constant power factor. The reactive power exchange at the point of interconnection (POI) is controlled by reactive compensation equipment in the substation, usually connected to the low-voltage bus (a combination of switched capacitors, switched reactors, SVC or STATCOM, depending on interconnection requirements).

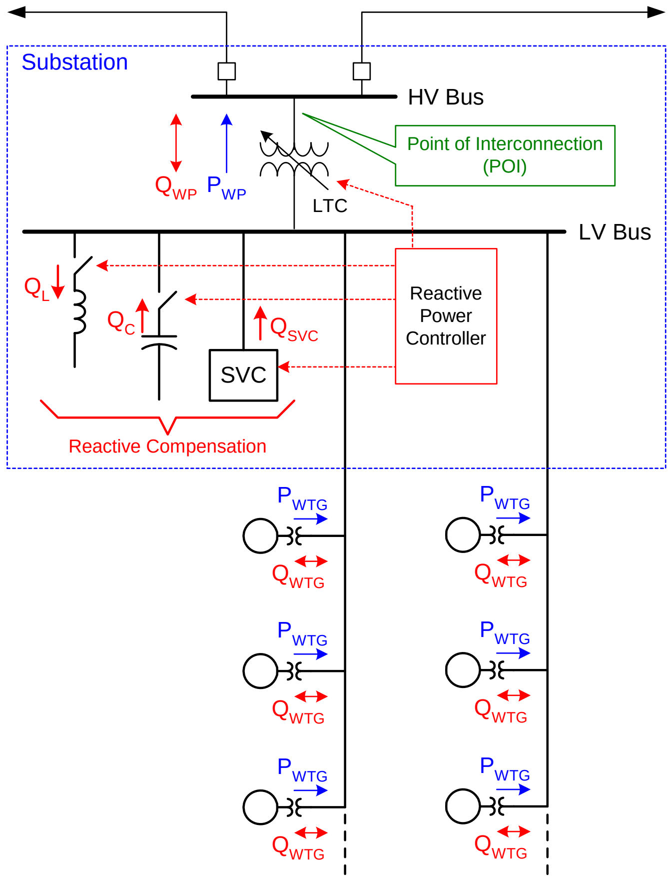

Figure 16: Wind plant with WTGs that operate with constant power factor. Voltage or power factor at POI are controlled by reactive compensation devices in the substation.

Figure 17 shows a typical wind plant with DFAG or full conversion WTGs (Type 3 or 4). These types of WTGs have the capability to quickly and continuously adjust their reactive power output and thereby contribute to regulating voltage at the POI. The scheme depicted in Figure 17 includes a reactive power controller in the substation that measures voltage at the POI and adjusts the reactive power output of the WTGs to regulate the voltage at the POI. Depending on the requirements of the specific plant, this basic control scheme can be supplemented by switched reactors or capacitors, or LTC. Figure 18 shows an example of the performance of this type of voltage control scheme at a 160 MW wind plant in the western US with GE WTGs.

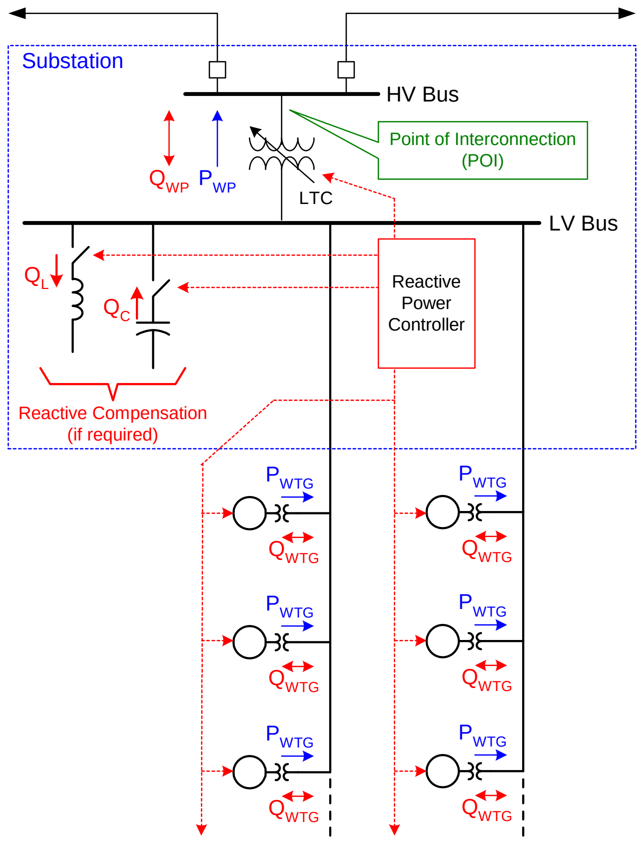

Figure 17: Wind plant with WTGs that can control reactive power output and regulate voltage.

Despite rather large variations in generated power, the voltage at the interconnection bus is quite invariant. The voltage flicker index, Pst, is less than 0.02 for this high stress condition – well within industry expectations. Most of the voltage variations are within a few hundred volts on the 230kV system.

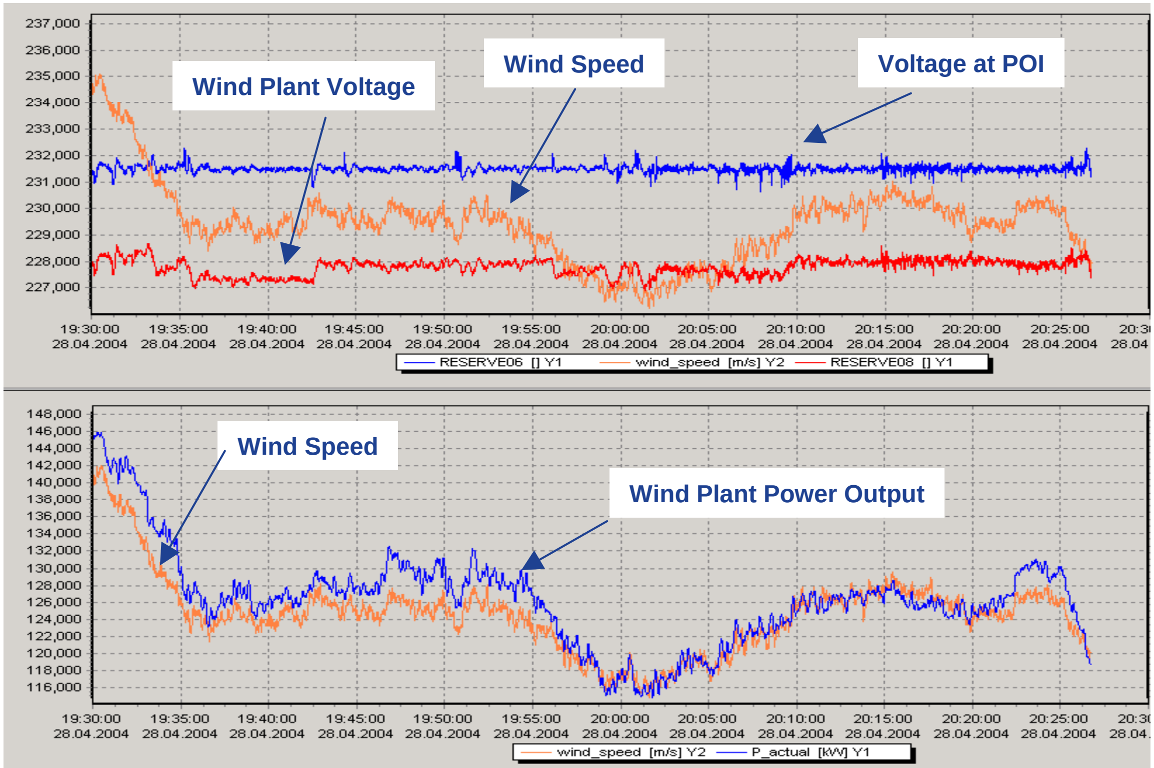

Figure 18: Demonstration of voltage regulation performance during variable power output conditions

3.3.2.2. Optimum mix of dynamic and static reactive capability

System planners and operators recognize that there are operational benefits of fast, smooth reactive power delivery capability. Such capability may come at a price; for example mechanically switched capacitors (MSCs) are much cheaper than SVCs. But SVCs have dynamic characteristics that are superior. (New England Electric would not have built the Chester SVC if simple mechanically switched capacitors had met the system needs.) Grid code developers have recognized this difference, and there have been some attempts to quantify the dynamic performance requirements for wind plants. Considering Figure 16, reactive power is provided from mechanically switched capacitors, SVCs and wind turbines. What is the requisite size of the SVC compared to the rating of the MSCs? Some grid codes have skirted this issue by requiring that wind plants respond to changes in reactive power requirements within a specified period of time. Others have required that a fraction, e.g. for 0.95 lag and 0.985 lead be provided by fast vernier sources [16]. No broad industry consensus has emerged. For the near future, it is recommended that ISO-NE requirements should be based on dynamic simulations of voltage performance for system disturbances. Voltage recovery performance should be consistent with ISO-NE planning criteria.

3.3.2.3. Coordination of Multiple Plants

Since wind plants are often connected in remote and relatively weak portions of grids in North America, it is common for plants to have voltage control strategies that integrate to drive voltages to the provided reference (i.e. no droop). Such controllers have the benefit of providing tight voltage regulation performance over a range of grid conditions. However, as with all power system applications, independent integral controllers cannot have competing control objectives. Thus, when multiple wind plants are to be connected in electrical proximity, coordination of the voltage controls is necessary. This is, of course, fundamentally no different than the need to provide such coordination with other generation. Industry practice with conventional generation usually has individual plants (or generators) using voltage droop. This can be accomplished with proportional-only regulation, line drop compensation, supervisory controls or a combination of these. Planning studies should check that regulators perform satisfactorily together. This includes avoiding divergent reactive power output (one plant over-excited while another nearby plant is under-excited), and reasonable division of reactive power support between plants. In short, multiple wind plants should be treated like multiple unit conventional power plants.

3.3.2.4. Voltage control at low power levels

At low wind plant power levels, operational flexibility may be limited compared to operation at or near full power. At low wind levels, some wind turbines within a plant may not be running (due to low wind speeds). This means that plants that rely on the wind turbines or equipment at the individual turbines for reactive support will have reduced reactive power capability. Thus, requiring a full range of reactive power capability down to low power levels may impose unreasonable burden on the plant. The UK grid code [14] addresses this limitation with a permissive interpretation of the reactive power and voltage control requirement for power levels below 20% of rated. [See Figure 1 on page cc-15 of the code. This permissive interpretation means that a plant may operate anywhere in the reactive power range corresponding to ±0.95 power factor of 20% of plant nameplate, whenever the plant power output is below 20% of its nameplate rating. This works out to be ±6.6 MVAr for power levels between zero and 20MW for a wind plant rated at 100 MW.

Figure 19 illustrates this concept for a 100 MW wind plant. When the plant is operating above 20 MW, it would be required to regulate voltage by controlling its reactive power output between –32.9 MVAr and +32.9 MVAr. But when power output is below 20 MW, the plant would be required to stay within ±6.6 MVAr (the shaded area).

The Electric Reliability Council of Texas (ERCOT) is reportedly considering a similar concept, with a threshold of 10% of rated power.

3.3.2.5. No-wind VAr production and voltage control

A recent advancement in wind turbine generator technology provides controllable reactive power output even when the wind turbine is stopped. All wind turbines stop in response to sustained wind speeds below a minimum threshold or when wind speed exceeds a high speed cut-out. They may also be disconnected from the grid in response to severe system disturbances. In plants that rely on the turbines for reactive power, both real power to serve load and reactive power to support system voltage are lost under such conditions.

Some OEMs offer WTGs that can provide smooth fast voltage regulation by delivering controlled reactive power even when the wind turbines are not generating active power. Such a function cannot normally be provided by conventional (e.g., thermal, hydro) generation, since production of reactive power from these generators requires that the generator (and therefore the turbine) continue to spin at synchronous speed. Continuous voltage support and regulation provides a major grid performance and reliability benefit.

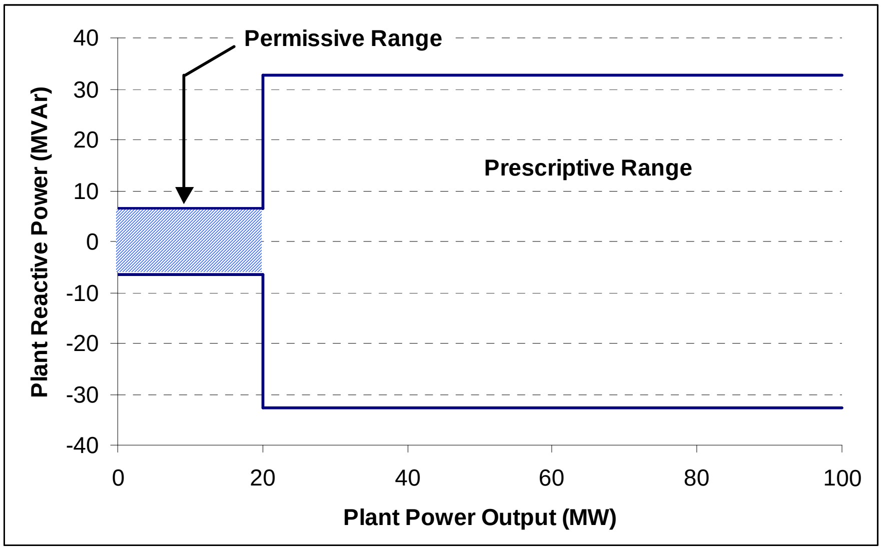

Figure 19: Plant reactive power range as a function of power output

From a systemic perspective, the reactive power capability is similar to that provided by various dynamic reactive devices (e.g., synchronous condenser, SVC, STATCOM [6]), which are used for grid reinforcement where dynamic voltage support is required.

The most significant benefits are observed for systems with substantial dynamic reactive power requirements. This includes very large wind plants, plants that are physically remote with electrically weak connections to the grid, and plants in areas with heavy and variable loads. Wind power plants equipped with this feature will provide effective grid reinforcements by providing continuous voltage regulation.

Type 3 & 4 wind turbine generators use large power converters. This decouples the generator speed from the power system frequency. The power converters rely on two major components: the generator side converter and the line side converter, which connects to the grid. If the line side converter is self-commutating, it may have the capability to independently deliver active and reactive power. When there is no active power available from the turbine, the converter can continue to deliver or absorb reactive power.

Test results for a single (GE type 4) wind turbine operating with this type of control are shown in Figure 20. Initially, the real power output is zero, while the reactive power output is about 1100 kVAr. Then, the wind picks up (at about 527 seconds) and the real power increases, while the reactive power remains constant.

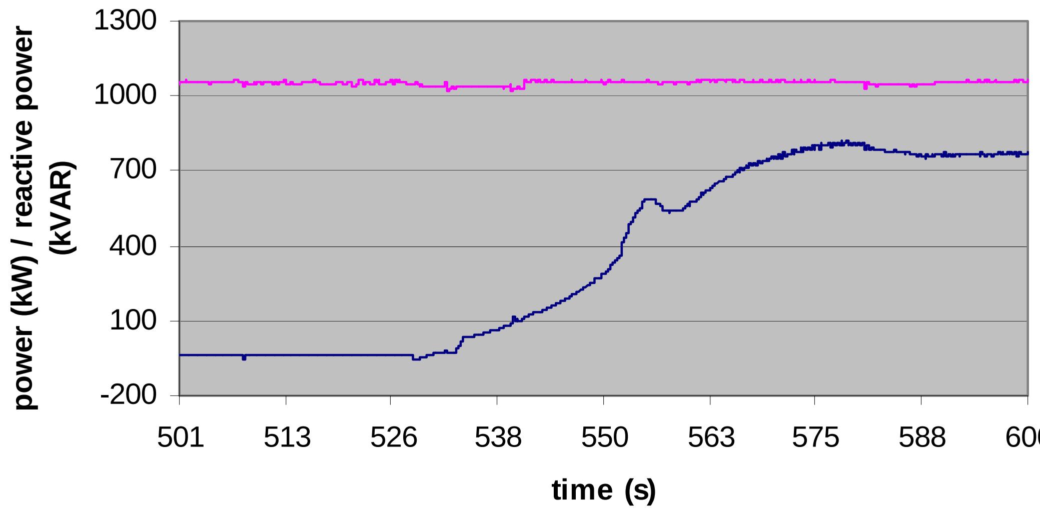

Figure 20: Demonstration of no-wind reactive power capability

3.4. ACTIVE POWER CONTROL

The advanced active power controls offered by some OEMs manage the electric power output of wind turbines and wind plants to achieve various grid-related performance objectives. This capability has implications in different time frames and applications.

Turbines without pitch control cannot limit their power output. However, wind plants with multiple wind turbines can limit or reduce total plant power output by shutting down some of the turbines in the plant.

Turbines with pitch control are capable of curtailing power in response to a real-time signal from an operator by adjusting the pitch of the turbine blades (i.e., "spilling wind"). Wind plants with such turbines are able to limit or regulate their power output to a set level by controlling the power output on individual turbines, as shown by the multiple red traces in Figure 21.

The ability of wind turbines to adjust their active power production by pitch control and, in the case of type 3 and 4 machines, by control of the power converters, has wide implications for grid operation. The discussion provided in this section addresses different aspects of performance and capability as they relate to grid operations.

3.4.1. Curtailment Capability

For most interconnections, curtailment capability is generally required. At the least, wind plants must trip off-line when so instructed by the grid operators. However, curtailment without tripping individual wind turbines is better. It maintains generation in reserve, reduces mechanical stresses on the equipment, and provides the opportunity for curtailed wind generation to provide ancillary services to the grid. While wind generation can respond rapidly, in many cases much faster than convention thermal or hydro generation, there have been cases where proposed grid codes have made excessive requirements for speed of response to step changes in curtailment order [13]. This is technically challenging for the wind turbine electro-mechanical systems and should be avoided. Capability to move active power output at rates on the order of 10%/second in response to step changes in curtailment (or dispatch) appear to be within several, if not most, OEM's capabilities. ISO-NE should monitor developments in this area.

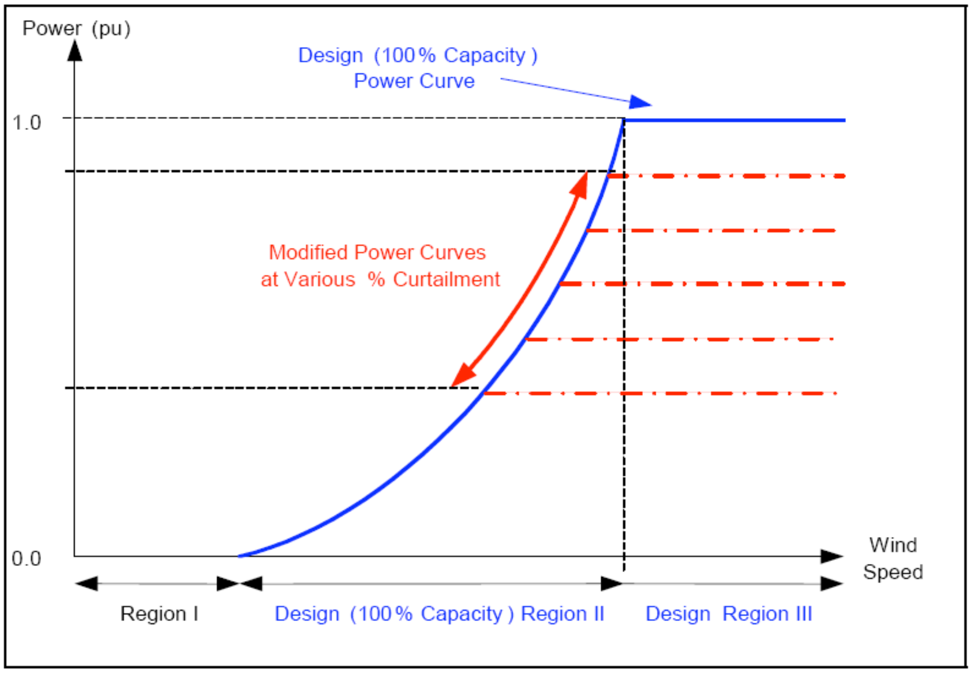

Figure 21: Curtailment of WTG output using blade pitch control (Source: BEW report for CEC, May 2006.

3.4.2. Ramp Rate Controls

Since pitch controlled WTGs can limit their active power output, they are also capable of controlling the rate of change of power output in some circumstances, including:

- Rate of increase of power when wind speed is increasing
- Rate of increase in power when a curtailment of power output is released
- Rate of decrease in power when a curtailment limit is engaged

These functions could be implemented either at an individual turbine level or at a plant level.

Figure 22 demonstrates the power ramp limiter maintaining a specified rate of change in power output for a plant with GE wind turbines. The power ramp limiter is able to track and limit to two simultaneous ramp rates that are measured and averaged over two different time frames. The two ramp rate limits allow targeting of different potential grid operating constraints. Specifically, a short window (typically 1-minute) ramp rate limit addresses possible limitations in system regulation capability. A longer window (typically 10-minutes) addresses possible limitations in grid load-following capability. As with the governor response discussed above, this functionality is most likely to be valuable and economic at times of high wind and light load.

In the figure, initially, the wind power plant is curtailed to 4 MW. Then the curtailment is released, and the plant is allowed to ramp up at a controlled rate of 5% per minute (3 MW/min or 50 kW/s) averaged and measured over a one minute interval. The second longer time frame ramp limit was set at 3.3 %/min (2 MW/min) and averaged and measured over a 10 minute interval (20 MW per ten minutes).

Ramp-rate limits can be set to meet the requirements for specific grids and applications. Ramp-rate limits can be imposed for grid operating conditions that warrant their use, and ought not be continuously enabled. The controller allows for switching in and out of ramp-rate control by either the plant operator or in response to an external command. This ability to enable or disable ramp rate limits is valuable to the grid, as wind energy production is reduced by up ramp rate controls. Industry practice is not mature regarding appropriate limits. The lowest (slowest) limits of which the authors are aware are 5%/minute (on the base of the plant MW rating). This rate limit allows a plant to reach rated power from initial synchronization in 20 minutes. Barring further systemic evidence of a requirement for more severe (i.e. lower) ramp rate limits, ISO-NE should require that ramp rate limiters have the capability to limit ramp rates to 5%/min or more. As the figure suggests, perfect ramp rate controls are challenging. Expectations of perfect ramp controls are not reasonably attainable, and should not be required. Average ramp rates, based on sliding windows of a minimum duration of one-minute, are reasonable.[13]

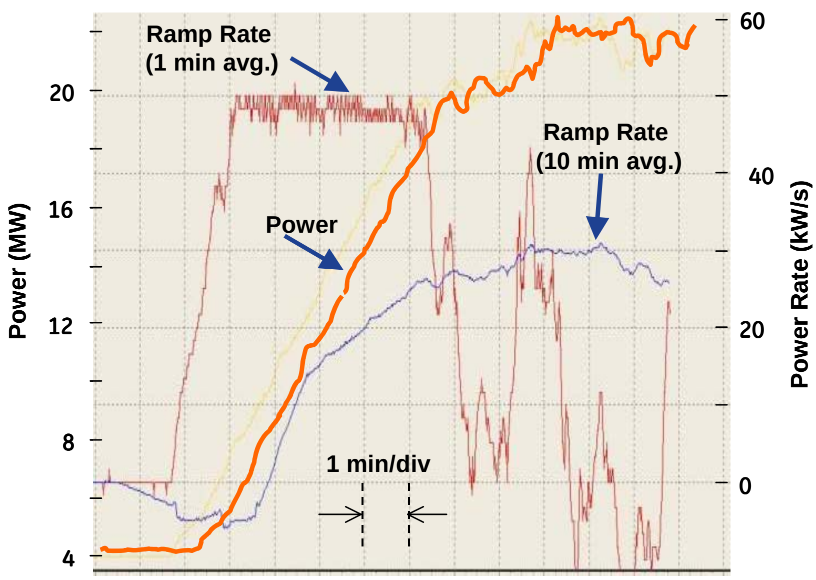

Figure 22: Demonstration of power ramp-rate control performance

Many wind plants have the ability to change active power output quite rapidly. If change in active power output is necessitated by grid events, fast response is good. However, some recent experiences in the US have surprised grid operators when wind plants have responded very rapidly to market signals. For example, wind plants have been reported to very rapidly reduce power output in response to drops in LMP. Such fast response can 'overshoot' in exactly the same fashion that other control systems with high gain can be destabilizing. Some ISOs have moved to create rules which direct or limit the rate at which wind plants are expected to respond to market signals. ISO-NE should create such rules.

3.4.3. Accepting AGC Instructions

The ability of wind plants to curtail output, as discussed in sections 3.4.1 and 3.4.2 presents the, for now theoretical, opportunity for wind plants to participate in AGC. Since wind plants have not, to date, been designed to accept AGC dispatch signals, specific details cannot be provided here. However, wind plants should be required to respond to curtailment, and thus dynamic modification of curtailment set-points has the potential to provide AGC response. The range and minimum speed of response must be consistent with the dynamic characteristics of available wind generation. Unlike large signal frequency events during operation which are relatively rare, rescheduling associated with AGC response will occur constantly. Thus, both the amplitude and speed of response will likely need to be limited considerably compared to large signal frequency response.

3.4.4. Frequency Responsive Controls

Control of frequency is a concern for all power systems. It is a major consideration in isolated systems with no external AC interconnection. Changes in system frequency are caused by imbalances due to spontaneous load variations and mismatches between dispatched generation and the actual load level. In most grid codes for integration of new generation to the system, the primary frequency control is subject to specific requirements. Requirements generally state that all conventional generators (thermal or hydro) synchronized to the transmission system must have a speed governor system to contribute to system frequency control. From a physical perspective, governor controls adjust the amount of mechanical power being delivered to the turbine-generator drive-train. This is accomplished by controlling fuel flows, steam flows, and a familiar range of other mechanical actuations. Governor actions, while rapid, are not instantaneous, typically acting on the order of ones to tens of seconds. For wind power, the physical equivalent is to adjust blade pitch to alter lift, and therefore mechanical torque on the drive-train.

A second aspect of frequency response for synchronous generators is inertia. Inertial response of synchronous machines is due to changes in electrical torque caused by grid frequency changes. It is fast, inherent and uncontrolled. Inertial response, being inherent, is rarely addressed by existing grid codes: it is expected and included in grid stability calculations – regardless of whether the impact is beneficial or detrimental.

In the next few years, a large amount of type 3 and 4 generation are planned to be integrated on power systems, thanks to their ability to maximize power extraction, reduce wind turbine structural loading, and their attributes regarding general system behaviors. When penetration of wind turbines into the power system reaches a critical point (say more than 10% of the total energy generation), the displacement of conventional generators by wind turbines can decrease the effective primary (governor response) and the inertia of the system, resulting in larger frequency deviations, especially in isolated systems and in periods of low load.

A consequence of the above is that additional requirements are likely to be imposed on wind plants by system operators, as is already the case for several utilities including the Nordic grid operators and ESB National Grid (Ireland) who have already added a governor type frequency control requirement in their grid codes and Hydro-Québec, which has added an inertial response requirement. ([4] to [7]).

In the discussion below, governor response and inertial response of wind generation are addressed separately. They have different operational implications and different levels of technical maturity.

3.4.4.1. Governor Response

Many double fed and full conversion wind turbines are capable of adjusting their power output in real time in response to variations in grid frequency. This is an optional control feature, implemented in wind plants where participation in grid frequency regulation is deemed necessary.

When frequency increases above a control deadband, the frequency regulation function reduces power output from the wind turbine, similar to a droop-type governor function in a thermal or hydro generating plant. A wind turbine would always be able to respond to increased grid frequency, since it is always possible to reduce power output below the total available power in the wind.

The frequency regulation function is also capable of increasing power when grid frequency decreases below a deadband, provided that the turbine's power output at nominal frequency is below the total available power in the wind. When operating in this mode (power output curtailed below total available power), the wind turbine would be contributing spinning reserve to the grid.

The Nordic and ESBNG grid operators require wind plants to be able to change the active power production as a function of the network frequency. Wind plants will have to provide frequency control only when the system requires it (e.g. at low load and high wind power output). Whereas the wind plants can make downward regulation of the production while at rated power following a sudden rise of the system frequency, they have to maintain a power margin (reserve margin) that may be called upon during a frequency decline ([4] to [6]). The expected response rate of each available online wind plant to frequency changes is at least 1% of the wind plant rated capacity per second, but could be more.

Since wind plants must 'spill' wind continuously in order to provide spinning reserve, there are substantial commercial implications: maintaining this margin results in 'free' (zero marginal cost of production) wind power being discarded. This means the opportunity cost of providing up reserve with wind plants is equal to the marginal value of that power – roughly the spot price plus tax credits plus renewable credits. Thus, it is only economically justified to *use* this capability under conditions when it is the least cost alternative. Under the vast majority of system operating conditions, providing this service with other conventional generators [2] will be more cost-effective. When the system needs this service from wind plants, they should have the *capability* to provide it.

Examples of overfrequency and underfrequency regulation performance are described below, utilizing data from staged tests at a 60 MW wind farm with forty 1.5 MW double-fed GE wind turbines.

3.4.4.2. Over-Frequency Response

Figure 23 illustrates the power response of the wind plant due to a grid over-frequency condition. For this test, the controller settings correspond to a 4% droop curve and 0.02Hz dead band. During this test, the site was operating unconstrained at prevailing wind conditions. It was producing slightly less than 23MW prior to the over-frequency condition. The system over-frequency condition was created using special test software that added a 2% controlled ramp offset into the measured frequency signal. The resulting simulated frequency (the red trace in Figure 23) increased at a 0.25Hz/sec rate from 60Hz to 61.2 Hz. While the frequency is increasing the plant power (the dark trace in Figure 23) is observed to drop at a rate of 2.4MW/sec. After 4.8 seconds the frequency reaches 61.2 Hz and the power of the plant is reduced by approximately 50%.

The over frequency condition is removed with a controlled ramp down to 60Hz at the same 0.25Hz/sec rate. In response, the plant power increases to its unconstrained power level. This is slightly higher than the unconstrained level prior to the test, due to an increase in the wind speed. The droop and deadband settings for this test are typical values. Settings can be adjusted to meet specific grid and application requirements.

Grid over-frequency events are stressful to power components. Further, temporary high frequency swings can present a reliability concern. For example, in one recent well publicized grid event [3], the high frequency backswing from a major grid disturbance caused power plant trips and aggravated an already severe event. When enabled, the response of the GE WindCONTROL™ will rapidly reduce power output for the duration of the over-frequency event. This behavior is similar to that of governor control on thermal generation, except that it is faster and allows deeper runback of power than is typical of conventional thermal generation.

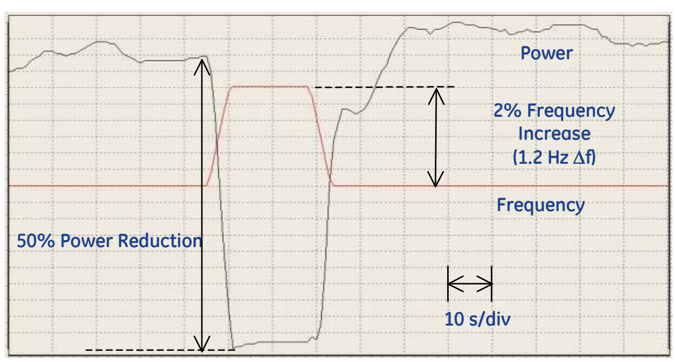

Figure 23: Power response of wind plant to overfrequency condition.

3.4.4.3. Under-Frequency and Power Reserve Response

An under frequency condition is simulated using the same test software and the results are presented in Figure 24. In order to allow for an increase of wind plant active power output in response to an under-frequency condition, some active power production must be kept in reserve. Unlike a conventional power plant, the maximum power production of the wind plant is constrained to that possible with the prevailing wind. For this test, the output of the plant was constrained to 90% of prevailing wind power during nominal frequency conditions, allowing a 10% increase in power with a 4% decrease in frequency. The plant controller continuously calculates the available plant power based on average wind conditions and turbine availability. The controller regulates the output power to 90% (12.4MW) of this calculated value and operates the plant at this level while the system frequency is within +/- 0.02 Hz of nominal frequency (60Hz).

As the system frequency decreases, the control increases the plant power according to the droop schedule. At 57.6 Hz, 4% under frequency, 100% of the calculated available power of the plant is produced (13.8 MW). The power of the plant will remain at this value until either wind conditions reduce or the system frequency increases.

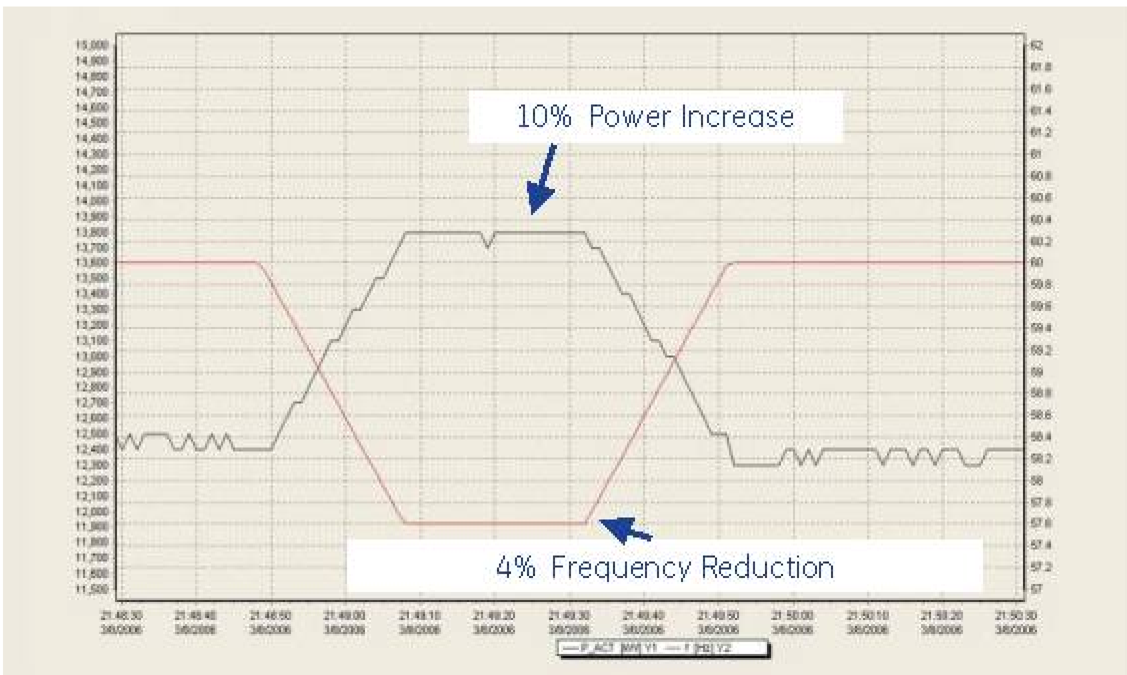

Figure 24: Power response of plant to underfrequency condition

3.4.4.4. Inertial Response

Large interconnected systems generally have large aggregate inertia, which results in small frequency deviations in response to system disturbances. Small isolated systems have much smaller aggregate inertia, and as a result, experience larger frequency deviations when disturbances occur.

The lower the system inertia, the faster the frequency will change and the larger the deviation will be if a variation in load or generation occurs. Thus, the response of bulk power systems to system disturbances is of great concern to those responsible for grid planning and operations. System events that include loss of generation normally result in transient depressions of system frequency. The rate of frequency decline, the depth of the frequency excursion, and time required for system frequency to return to normal are all critical bulk power system performance metrics that are affected by the dynamic characteristics of generation connected to the grid.

As the share of wind power in the system increases, the effective inertia of the system will decrease considering the existing technologies. While conventional synchronous generators inherently add inertia to the system, it is not necessarily the case with wind turbines generators.

In the case of induction machines and the truly synchronous machines, there is a direct connection between the power system and the machine. When there is frequency decay on the power system, the induction machine will increase its output temporarily because of the slip change. The induction machines are then able to contribute to some extent to system inertia while the truly synchronous machines will inherently add inertia to the system the same way a hydro or thermal turbine would [1].

The basic design of converter based technology (Type 3 and 4), however, does not include any inertial response unless explicitly designed to do so. The DFAG and full converter generators employ a back-to-back converter to connect to the power system. For the DFAG design, there is a direct connection between the system and the stator while the rotor is decoupled from the system by the ac\dc\ac converter. It is possible to take advantage of this direct coupling between the frequency of the system and the stator with appropriate control so that a frequency deviation on the power system varies the electromagnetic torque of the DFAG, resulting in a change of its rotational speed and thus modify active power (MW) acting as an inertial response. In the case of the full converter generators, they are completely decoupled from the frequency of the system. A change in the system frequency will not have any effect on the machine. Therefore, the full convertor generators will not by their design contribute to system inertia when there is a frequency deviation on the power system.

Inertial response capability for wind turbines, similar to that of conventional synchronous generators for large under-frequency grid events, is now available from some OEMs. This is new and is not widely recognized or used by the industry yet.

For large under frequency events, the inertial control increases the power output of the wind turbine in the range of 5% to 10% of the rated turbine power. The duration of the power increase is on the order of several seconds. This inertial response is essentially energy neutral. Below rated wind, stored kinetic energy from the turbine-generator rotors is temporarily donated to the grid, but is recovered later. At higher wind speeds, it is possible to increase the captured wind power, using pitch control, to temporarily exceed the steady-state rating of the turbine. Under these conditions, the decline in rotor speed is less and the energy recovery is minimal.

The control utilizes the kinetic energy stored in the rotor to provide an increase in power only when needed. Hence, this feature does not adversely impact annual energy production.

Unlike the inherent response of synchronous machines, inertial WTG response is dependent on active controls and can be tailored, within limits, to the needs of the power system. Further, the response is shared with controlled variations in active power necessary to manage the turbine speed and mechanical stresses. These stress management controls take priority over inertial control. Turbulence may mask the response for individual turbines at any instant in time, but overall plant response will be additive. GE’s inertial control design has sufficient margin over the turbine operating range to meet the equivalent energy (kW-sec) contribution of a synchronous machine with 3.5 sec pu inertia for the initial 10 seconds. This inertia constant is representative of large thermal generation, and is the target inertia included in the Hydro-Québec grid code [18] provision for inertial response.

Hydro-Québec requires that wind plants be able to contribute to reducing large (> 0.5 Hz), short-term (< 10 s) frequency deviations on the power system, as does the inertial response of a conventional synchronous generator whose inertia constant (H) equals 3.5 s. This target is met, for instance, when the system dynamically varies the real power by about 5 % for 10 seconds when a large, short-duration frequency deviation occurs on the power system [7]. It requires that the frequency control is available permanently, i.e. not limited to critical moments. In 2010, Hydro-Québec will integrate the first wind plants equipped with this feature in its network. Hydro-Québec is the only transmission owner currently requiring wind plants to contribute to frequency regulation by using the inertial response.

Given the systemic needs, and the Hydro-Québec requirement, the overall control is designed to provide similar functional response to that of a synchronous machine. Unlike the inherent response of a synchronous machine, the response is not exactly the same under all operating conditions, nor does it provide synchronizing torque. Frequency error is simply the deviation from nominal. A positive frequency error means the frequency is low and extra power is needed. The deadband suppresses response of the controller until the error exceeds a threshold. Thus, the controller only responds to large events. The continuous small perturbations in frequency that characterize normal grid operation are not passed through to the controller.

There are a number of differences between this controlled inertial response, and the inherent inertial response of a synchronous machine. First, and most important, the control is asymmetric: it only responds to low frequencies. High frequency controls are handled separately, by a different controller that can, if necessary, provide sustained response, as discussed in Section 3.4.4.2. Second, the deadband ensures that the controller only responds to large events – those for which inertial response is important to maintain grid stability, and for which seriously disruptive consequences, like under frequency load shedding (UFLS), may result. Finally, a controlled inertial response means the speed of response is a function of the control parameters. In the example shown, the response was tuned to provide good coordination not only with inertial response of other generation on the system, but with governor response of conventional generation as well. The ability to tune inertial response (including shutting it off) provides the planning engineer with an additional tool to manage system stability.

Field test results of the inertial control on a GE WTG for various wind speeds on a single wind turbine are shown in Figure 25. The field data was generated by repeated application of a frequency test signal to the control. The results, at various wind speeds, were then averaged and plotted. Below rated wind speed (<14m/s) the results clearly demonstrate the inertial response and recovery. Above rated wind speed the inertial response is sustained by extracting additional power from the available wind (i.e. short-term overload of the WTG).

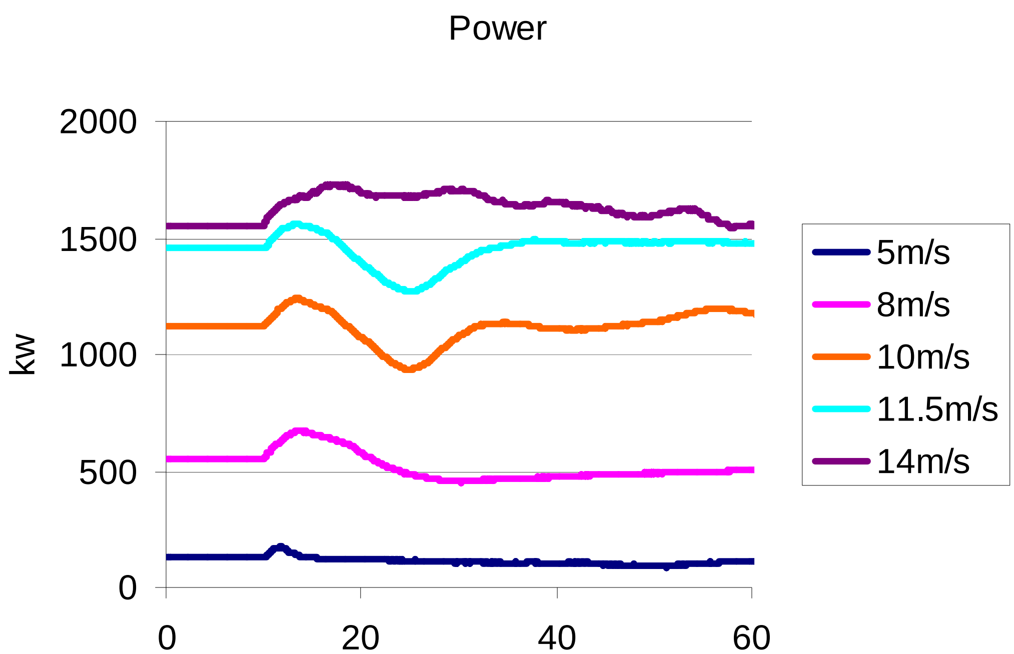

Figure 25: Field demonstration of the GE WindINERTIA™ response.

Ultimately, grid codes may be modified to include some type of inertial response requirement. The development of the GE WindINERTIA™ feature, as well as planned demonstrations by other OEMS, such as Repower (offshore wind plant in Germany in 2009: Alpha Ventus research project), shows that such functionality is, indeed, possible. However, it also shows that inertial response identical to that of synchronous generation is neither possible nor necessary. Controlled inertial response of wind plants is in some ways better than the inherent inertial response of conventional generators. Inertial response of wind generation is limited to large under-frequency events that represent reliability and continuity-of-service risks to the grid. The crafting of new grid codes should therefore proceed cautiously and focus on functional, systemic needs.

3.5. HARMONICS

Most commercially available wind turbines comply with IEEE 519, which if applied on a turbine-by-turbine basis would limit the total harmonic distortion (THD) of the current at the terminals of the machine to 5% (of rated fundamental frequency current) or less. Turbine vendors will usually note this in their product specifications.

This includes turbines in each of the four major topologies. Type III and Type IV machines utilize static power converters, but the quality of the output currents is well within the IEEE 519 limits.

ISO-NE's interest is in the harmonic performance of the entire plant, not the individual turbines. Experience from around the country shows that harmonics can be a serious concern for large wind plants, especially those employing capacitors at medium voltage for reactive power support, or plants with extensive collector networks of underground medium voltage cable. The phenomenon at issue is the interaction of the medium voltage shunt capacitance in series with the interconnection substation transformer inductance. The combination appears as a series filter, and provides a convenient sinks for background harmonics on the transmission system (Figure 26).

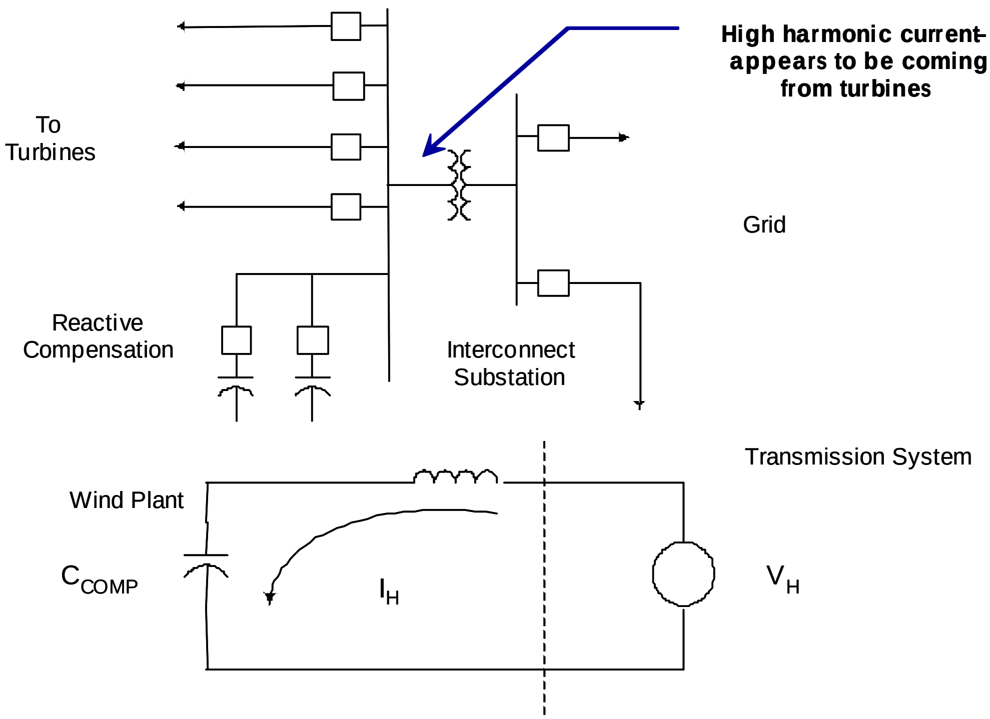

Figure 26: Equivalent circuit showing wind plant as a sink for harmonic distortion from the grid.

The concern regarding interconnection is that it may appear the plant is in violation of the IEEE 519 limits when the root cause is actually background distortion on the transmission system.

3.6. Wind Plant Modeling

Wind turbine and wind plant modeling has been a topic of intense debate, scrutiny and development for the past several years. The availability of good simulation models for wind plants has been limited (and contentious) for a number of reasons. First and foremost, the technology has been evolving very rapidly, and it simply has not been possible for model development to keep up. It is well to remember that the suite of industry accepted models for synchronous generations (i.e. IEEE standard types) took several decades to develop. The time scale for wind is significantly less. Because wind generation technology is developing so rapidly, there are very serious intellectual property issues for the OEMs. Developing, and offering, advanced controls for wind plants are competitive issues, and consequently OEMs tend to be secretive with their technology. Further, to a large extent, there has not been a history of utility grade, standardized modeling in the industry. Some OEMs have adopted the practice of developing and providing proprietary “black box” models for their technology. While these proprietary models may be well suited to system analysis, they become problematic in North America where data must be freely exchanged. Other OEMs (e.g. GE) have produced open structure models, which are openly documented and intended to be exchanged. These models are moderately complex, tend to be specific to the OEM's equipment, and include control features which may not be generally applicable or available on other OEM equipment.

3.6.1. WECC / IEEE Generic Models

International cooperation with generic model development initiated by the WECC provides strong support for continuation of this effort as wind generation technology continues to evolve. The need for widely available and understood models appropriate for steady-state and dynamic studies of the bulk network is not unique to North American utilities. The principal attributes of these models, non-proprietary code and parameters and well-proven behavior, also appear to be a global need. Recent discussions of this topic have been focusing on the steps beyond the initial development of the generic model architectures and the distribution of code embodying these models to a much broader audience of users. There are still questions, for example, about the appropriate use of the simplified models, as well as the converse - which studies fall outside the intended application space for the models, and how should those studies be conducted.

The WECC-led effort considered the four major types of turbines in current commercial applications. Block diagrams for each were developed to encompass the range of behavior and performance across the major commercially-available turbines. However, as capabilities and features are added to the existing fleet of commercial turbines, augmentation of the structures for the generic models may be necessary. In addition, there is the possibility of new wind turbine topologies, as exemplified by the synchronous machine-based turbines now on the market.

In the very near term, the industry must develop accurate representations of existing turbine designs using the current generic structures. This effort will require significant collaboration between the power engineering community and the wind turbine vendors, since the measurement data or detailed simulation results that provide the best opportunities for checking the behavior and adjusting the parameters of the generic models are held by the vendors and not generally available publicly. With the growing number of commercial turbines either in service or on the market, this initial validation process will be a very significant effort.

At present, it is recognized that existing NERC standards are not being applied consistently or uniformly for wind generation. Standards MOD-011 and MOD-012, for example, mandate that reliability organizations provide guidance and requirements for power flow and dynamic models. Given the lack of accepted industry standard models for wind turbines and wind plants, enforcement here has been very difficult. The current situation, with system impact studies based on one-of-a-kind, user-written, or proprietary models, is not tenable in the long term, and has actually become a significant limitation with the current installed wind generation capacity. Development of models is critical in this respect.

Existing NERC modeling standards require Reliability Entities (RE) to develop comprehensive steady-state data requirements and reporting procedures needed to model and analyze the steady-state and dynamic performance of the power system (MOD-011 and MOD-013). Equipment owners are required to provide models to the RE steady state and dynamic models

(MOD-012). This information is required to build a reasonable representation of the interconnection's system for planning purposes, as stated in MOD-014 and MOD-015. In this context, proprietary or user-written models are generally unacceptable. In lieu of the accepted standard models, the common course of action for wind plant owners has been to provide no models at all, which is contrary to the requirement of these standards.

Finally, there are NERC standards that deal with periodic verification of the models, such as MOD-023, which deals with verification of reactive power limits. Again, with the current process broken because of the lack of accepted models, this provision has in essence been ignored for existing wind plants. These same issues are being dealt with in other jurisdictions around the world experiencing rapid development of wind power. The process which has been adopted by National Grid in the UK in this regard is of particular interest, and can be found in a document titled "Guidance Notes for Power Park Developers: Grid Code Connection Conditions Compliance: Testing & Submission of the Compliance Report", dealing with the full scope of grid code compliance testing and model validation. It may be found at:

http://www.nationalgrid.com/NR/rdonlyres/5F1F5F26-FD98-475A-A1EA-C7584FC5C4F7/15040/GuidanceNotesPowerParksRev16.pdf

Much of the current modeling activity surrounds representations of wind turbine technologies and wind plants for positive-sequence analyses, primarily power flow and dynamic simulation. As wind penetration continues to grow, there is a growing realization that other studies and evaluations are needed in the plant design and commissioning process, for some of which the positive sequence steady-state or dynamic representations are inadequate. At present, these studies are generally conducted with a simulation platform for which a relatively detailed transient model of the wind turbine and controls already exists or can be created.

3.6.2. Model data reporting requirements for turbine manufacturers

NERC is in the position to be able to force clarity upon most of the modeling issues that have challenged both transmission planners and wind plant operators. NERC can and should play a significant role in encouraging model development activities being pursued in WECC and IEEE. NERC should clearly re-state the expectation that wind generators comply with the intent of existing standards to the maximum extent possible, recognizing that there are differences that need to be addressed going forward, but setting a fixed timetable for resolution of those differences. In summary, steps that could be taken in this regard include:

1. Clarification of the expectation that wind generators must comply with standards, and a fixed timetable for compliance, with penalties for non-compliance;
2. An assessment of existing standards to determine what modifications to standards (if any) are necessary in consideration of wind generation, especially in the modeling area and including verification of models, given the somewhat unique aspects of wind generation;
3. Definition of appropriate tests for wind plants that considers the unique operational nature; verification of reactive limits for operating plants is an example, where the existing procedure may have to be modified to account for the operational characteristics.

The transition of the generic modeling activity from WECC to the IEEE Power Engineering Society Power System Dynamics Committee should provide a broader forum going forward for the needed work in this area.

3.6.3. Short Circuit Modeling

The short circuit behavior of wind generation with power electronics (type 3 and type 4) is different than that of synchronous generators. Further, the details of the behavior are relatively complex and specific to each wind generator OEM. Most short circuit modeling programs have limited ability to accommodate such non-standard behavior. Consequently, present practice tends to use modeling assumptions that are intended to be conservative. This usually means modeling with equivalent impedances that tend to over state the amount of fault current delivered in the short term. This practice has, so far, generally served the industry satisfactorily. It is anticipated that this issue will continue to receive attention and that modeling will become more sophisticated with time.

This is a challenging topic and the industry is presently developing understanding, processes and recommendations related to short circuit currents. The IEEE PES task force on Short Circuit Fault Contribution from Wind Generators is addressing this issue. It is recommended that ISO-NE track the progress of that task force and evaluate the results of its work. It is possible that this task force will recommend a practice whereby wind plant owners would provide short circuit information to transmission owners, grid operators, and others who need such data.

3.6.4. Transient (point-on-wave) Models

The individual phase transient (e.g. EMTP-like) modeling of wind generation is highly complex. The behavior the power electronics and electromagnetics of wind generators is extremely specific to individual OEMs. Correct modeling absolutely requires access to highly proprietary information about the equipment. Further results are not easy to interpret. Overall, this type of modeling is usually unnecessary for phenomena outside of the wind plant and is to be avoided, if possible. Use of generic point-on-wave models that purport to represent actual wind turbine generators is almost invariably meaningless. Performance is design specific.

In spite of this, situations may arise where detailed modeling and simulation studies may be required. In such circumstances, it is critical to first secure the direct participation of the vendors of the equipment involved (e.g. HVDC converter and wind turbine manufacturer) to support if not conduct the necessary investigation. Results of detailed simulation studies by third parties alone may be absolutely correct given the fidelity of the equipment models used, but could likely miss the major points entirely if those models are generic and not reflective of the actual OEM equipment.

3.7. Distribution Connected Wind Generation

Distribution connected wind generation has a number of performance and economic aspects which require separate consideration and different interconnection requirements. In general, distribution connected wind turbines come in single or small groups of turbines. To date, unlike Europe, distribution connected wind generation represents a small fraction of the total wind generation installed in the US. For this reason, the most serious issues related to distribution connected wind generation have tended to be local power system concerns, not broad systemic operational problem.

The economics of distribution systems make imposition of extensive monitoring and control requirements an unnecessary burden. Many grid codes exempt wind plants of sizes less than 10 MW from many of the requirements imposed on larger, transmission connected plants. ISO-NE should adopt this stance as well.

However, some requirements are needed to assure acceptable performance of the local grid and to allow ISO-NE to incorporate substantial amounts of distribution connected wind, should that scenario evolve. ISO-NE should make a distinction between small, behind-the-meter, wind turbines and installations that connect one or more turbines directly to the grid at distribution level. The exact breakpoint in size can be set by ISO-NE. It is recommended that “small” be defined in the range of less than 100 to 250kW. Small, behind the meter, wind turbines can be handled with existing customer generation connection rules. Installations that are larger than “small”, but lower in rating than a minimum, for which the recommendations above (and ISO-NE’s LGIA) apply, can be termed “medium” for this discussion. The exact size range for “medium” plants should be determined by ISO-NE. The following discussion is focused on issues that accompany these medium size installations when they are connected to distribution systems.

From a control perspective there are number of differences that must be considered. Distribution connected generation, including wind turbines, are subject to IEEE standard 1547. This means that wind turbines must NOT have any of the fault ride-through capabilities described in section 3.2. Wind turbines must trip for significant voltage and frequency events. This requirement may have unfortunate systemic implications should New England reach high levels of distributed wind generation. NERC activities, including efforts by the Integrating Variable Generation Task Force, are currently underway to address this apparent incompatibility.

Another aspect of IEEE 1547 is that distributed generation must NOT regulate voltage. Thus, distribution connected wind generation should be on power factor control. Independent of IEEE 1547, this practice has merit, in that most distribution system voltage management equipment (including switched capacitors, step regulators, etc.) has the potential to misbehave (i.e. hunt or cause unexpectedly high or low voltages) when uncoordinated voltage control is applied downstream on a feeder. In any event, minimizing voltage fluctuations due to active power variations (from, for example wind speed variations) by manipulating reactive power has limited efficacy in low X/R systems, such as would be found in most distribution systems [17].

The discussion of islanding provided in section 3.2.6 applies for distributed generation. Specifically, islanding is prohibited. This includes temporary islanding associated with reclosing. Wind turbines on distribution system should be actively tripped, by transfer trip or some equivalent, when the distribution feeder breaker is to be opened. If reclosing is practiced, the wind turbine must be tripped before the recloser action.

Good engineering practice should be respected in adding wind generation to distribution systems. Feeder protection and breaker rating should be reviewed for adequacy with distributed generation added.

Some information and control of distributed wind generation is, however, appropriate and necessary. Distributed wind generation must have the ability to be shut down by the system operator. Distributed wind generation should provide status information, including whether or how many machines are running, power production, and anemometry.

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Section 4

WIND GENERATION FORECASTING

4.1. THE NEED FOR RELIABLE FORECASTS

The variability of wind energy production presents a special challenge for utility system operations. While conventional power plants can produce a near constant output – barring rare emergency outages – the output of a wind plant fluctuates. In some parts of the U.S., such fluctuations can amount to several hundred megawatts in a matter of an hour or two. To the extent the fluctuations are not predicted, and to the extent that these fluctuations do not match with the balancing area load pattern, they create costs for the electricity system and consumers as well as potential risks to the reliability of electricity supply.

One of the principal mechanisms a grid operator, such as an Independent System Operator (ISO), uses to limit unexpected changes in plant output is to charge suppliers a penalty for "uninstructed deviations" between their forward schedules (i.e. predicted output) and actual generation. This policy encourages suppliers to maintain a high level of reliability while also compensating the system for the costs of having either excess or insufficient generation. Typically, the penalty is designed to motivate good behavior (like a speeding ticket) and is not assessed on the deviation in each hour based on the market-clearing price of the real time market. However, considering the volatility of wind plant output and the fact that the variability is not under the wind plant operator's control, some grid operators recognize that wind energy suppliers could be severely penalized if required to pay for deviations on an hourly basis.

The performance requirements for a forecasting service are dictated by the needs of both the grid operator and the wind generators. From the perspective of wind generators, the priority is to minimize the deviation between forecasted and actual plant output. For an ISO, there are two additional and more demanding priorities.

As with load, effective power production planning requires more accurate forecasts for the aggregate system rather than single plants. Thus, the first priority of power production forecasting systems is to anticipate changes in aggregate wind production as accurately as possible in the very short term (up to a few hours ahead) so the ISO can manage its grid operations and reserve capacity purchase decisions in an optimal fashion. For this purpose, it is natural to consider persistence-type methods. Persistence assumes the current conditions will not change and can be used to forecast the future conditions. If persistence is used to forecast for periods longer than an hour, a diurnal change is typically taken into account. Often, autoregressive statistical techniques, which are designed to forecast from time series data, are combined with the persistence techniques to produce the forecast. For example, a next-day hourly forecast would assume that conditions would be the same as the previous 24 hours.

However, such methods are inherently limited in that they cannot predict changes in plant output that depart radically from recent trends that might occur because of a passing weather front. In order to achieve the highest possible accuracy, the methods should incorporate other data that may signal future trends, such as conventional weather forecasts or meteorological observations from upstream of the wind plants.

The second priority is to forecast the wind generation for the next day so an ISO can schedule reserve capacity and unit commitment as efficiently as possible. In this case, it is less important to accurately forecast the *timing* of changes in wind generation than it is to forecast the *minimum* wind plant output during the peak load hours.

In general, a high degree of reliability and accuracy is required by ISOs and utility systems for aggregate wind generation forecasts. This requirement is consistent with the usual high standard of reliability applied to all utility system operations. It is particularly important for the next-hour forecasts, because their accuracy declines relatively quickly the older the forecast becomes. The accuracy of next-day forecasts, in contrast, is not as sensitive to the age of the forecast.

4.2. THE FORECASTING PROBLEM

The wind energy generation forecasting problem is closely linked to the problem of forecasting the variation of specific atmospheric variables (i.e. wind speed and direction, air density) over short time intervals and small spatial scales. In general, this problem is enormously challenging due to the wide variety of spatial and temporal scales of atmospheric motion that play a role in determining the variation of the key parameters within the targeted forecast volume. In order to understand the different issues involved in wind energy forecasting, it is useful to divide the problem into three time scales:

- very short-term (0-6 hours),
- short-term (6-72 hours), and
- medium range (3-10 days).

The skill in very short-term forecasting is related to the prediction of small-scale atmospheric features (< 200 km in size) in the vicinity of the wind plant. The major issue is that very little data are typically gathered on the scale of these features. As a result, it is usually difficult to define their spatial structure and extent of these features. One viable option is often to infer information about these features using a time series of meteorological and generation data from the wind plant. For this reason, real-time data from the wind plant is usually crucial to producing highly accurate very short-term forecasts. In fact, the 0- to 6-hour time scale has been defined as the period when persistence forecasts will typically outperform wind energy forecasts derived solely from predictions of the regional atmospheric circulation. Thus, the benchmark for the very short-term time scale is a persistence forecast.

The ability to forecast the wind energy generation over short-term time scales is tied to the skill of forecasting regional scale atmospheric features. These features are often referred to as synoptic scale weather systems and are the ones typically depicted in newspaper and TV weather presentations. It is necessary to gather data over a large volume of the atmosphere in order to define the structure of these systems. This process is usually accomplished using in situ or remote sensing measurement devices operated by an agency of a national government (such as the U.S. National Weather Service).

The importance of measurements at the wind plant drastically decreases at the start of this 6-72 hour period. The real-time plant data is able to make some contribution to forecast quality at the start of the period. However, it has little predictive value after about 12 to 18 hours. This is fundamentally because information that determines variations in meteorological parameters for periods greater than 12 hours comes from locations that are hundreds of kilometers away. As a result, the forecast standard shifts from persistence to climatology (i.e. the average conditions for that location and season) during this period. A climatology forecast will typically outperform a persistence forecast for most locations after about 12 to 18 hours.

The skill of medium range forecasts is typically linked with forecasting continental, hemispheric, and global-scale atmospheric circulation systems. However, the regional and local features are superimposed upon these large scale features. At the medium range time scale, it is difficult to accurately predict the evolution of specific local-area or regional features that will affect the forecast target area. Therefore, most of the forecast skill is linked to prediction of general patterns that favor above average or below average winds for a substantial period of time (a day or more). The benchmark for this time scale is a climatological forecast.

It should be noted that the distribution of atmospheric energy across the space and time scales varies substantially by region, season, and atmospheric regime. This variability has important implications for predictability and forecast performance. If there is limited variability over a specific time scale, the absolute forecast performance is likely to be good but with little skill over a simple persistence or climatology forecast. Conversely, a situation with large variability over a given time scale will often result in lower absolute performance but higher relative performance compared with simple persistence or climatology forecasts.

The impact of the various errors ultimately affects the forecast wind speed and the timing of significant changes in wind speed. Both statistical techniques and ensemble forecasting can mitigate such errors. These methods are described in the next section.

4.3. Forecasting Components

There are two fundamental components in the forecasting process, namely, data gathering and processing. Data gathering is performed using a wide range of measuring devices at local, regional, and even the global scales. Data processing transforms measurement data into a forecast for the desired period of time. The tools used for data processing include physical and statistical atmospheric models as well as those describing the relationship between meteorological conditions within the wind plant and plant output (usually referred to as plant output models).

4.3.1. Data Gathering

Due to the wide range of spatial and temporal scales that determine the variations in the wind power generation, it is necessary to use a diverse mix of data sources to achieve the best possible forecast performance. For wind energy forecasting, the most fundamental type of data is the time series of meteorological parameters and power generation from the wind plant itself.

The power generation data can be for the entire plant or for groups of turbines within the plant. The meteorological data typically consist of wind speed and direction and sometimes temperature, pressure, and even humidity data from sensors on one or more meteorological (met) structures that may be towers or masts within the plant boundaries. These data are typically gathered at the hub height of the turbines. The additional details provided from generation data by turbine group and multiple met towers (or masts) can be very beneficial in developing a more accurate relationship between the meteorological conditions and plant output. The availability of this time series data alone is sufficient to make a somewhat skillful very short-term forecast and at least a climatology-level forecast for the short-term and medium range forecast.

In order to achieve a higher level of forecast skill, it is necessary to utilize data from beyond the plant's boundaries. Meteorological observations from in situ sensors deployed and operated by government agencies have been a traditional source of data for wind energy forecasting. These include sensors on surface-based met towers deployed mostly at airports and sensors carried aloft by weather balloons to provide information about the vertical profile of temperature, humidity, winds, and pressure. The main problem with these data is that the spacing between measurements is too large (because of economic constraints) to adequately represent the small or even sometimes medium scale atmospheric features that are responsible for short-term variations in wind energy output. However, these in situ sensor networks do a better job of mapping most of the features that are responsible for the variability over 1- to 2-day ahead time scales. Unfortunately, there are large areas (such as the oceans) where very little in situ data are gathered due to the cost of maintaining such systems in those environments. Therefore, data coverage is not uniform, which sometimes results in poor forecast performance in certain areas such as the west coast of the United States. Forecast performance is often worse there than in the eastern part of the U.S. because a large data sparse region (i.e. the Pacific Ocean) is located in the most frequent upstream direction (to the west) of this area.

The expectation is that remote sensing technology will eventually overcome these limitations of data resolution and coverage. Many types of atmospheric remote sensors have been developed and some have been deployed for operational use. These include Doppler radars, wind profilers (a type of fixed position vertically-pointing Doppler radar), lidars, sodars, and satellite-based radiometers. While all of these technologies have made contributions to the atmospheric forecasting process, each has significant limitations that have impeded their enhancement of atmospheric forecast performance. However, remote sensing technology continues to move forward rapidly and there is still an expectation that the next generation of remote sensors deployed in a few years will have a greater impact on forecast performance.

4.3.2. Data Processing

Data processing is the other major component of the forecast process that is typically performed using mathematical (often called numerical) models to ingest data and generate predictions. There are four fundamental categories of data processing models used in the wind energy forecasting process:

- physical atmospheric,
- statistical atmospheric,

- wind plant output, and
- forecast ensemble models.

There are many types of models within each of these four categories. A particular forecast system may employ one or more types of models.

4.3.3. Physical Atmospheric Models

Physical atmospheric models are based upon the fundamental physical principles of conservation of mass, momentum, and energy as well as the equation of state for air. These models are actually a type of computational fluid dynamic model that has been specially adapted to simulate the atmosphere. They consist of a set of differential equations that are numerically solved on a three-dimensional data grid that has a finite resolution (i.e. the spacing between grid cells). There are many types of models based on the same basic physical principles but differing in how the grids are structured, how the equations are solved numerically, and how sub-grid scale processes are represented (e.g. cloud physics occurring on scales smaller than the grid cells).

Physics-based atmospheric models fall into two broad categories: *prognostic* and *diagnostic*. Prognostic models are formulated to step forward from an initial state and make predictions of the future state of the atmosphere. It is necessary to specify an initial state to start this forecast process. An initial state consists of a value for each model variable at each grid cell that is produced by processing all available raw atmospheric data from the various sensor systems described earlier. There are many three-dimensional prognostic atmospheric models in use. These include the Mesoscale Atmospheric Simulation System model developed by MESO, Inc. and the Weather and Research Forecast model developed by the National Center for Atmospheric Research (NCAR).

Diagnostic models use a similar but often simplified set of physical equations to estimate the values of variables at locations where there are no data from locations where data are available. These models can be used to add more resolution to forecast simulations made with a prognostic model at a lower computational cost than reducing the size of the grid cells of the prognostic models. The simplifying assumptions used to create the diagnostic model will typically limit its performance compared with a prognostic model run at a similar resolution.

4.3.4. Statistical Atmospheric Models

Statistical atmospheric models are simply statistical techniques used for atmospheric applications. They are "atmospheric" models in the sense that atmospheric data are used as input and the output is an atmospheric variable or quantity that is linked to an atmospheric variable (such as wind energy output). Statistical models operate by creating a set of empirical equations from a sample of predictor and predictand data called a "training sample." The form of the equations is dependent on the type of model used. Typically, the equations have numerical coefficients that must be determined.

A statistical modeling procedure uses an optimization scheme to select the coefficient values that yield the "best" relationship between the predictors and the predictand. The meaning of "best" in this context depends upon what optimization criteria are employed. An example of optimization criteria is the lowest mean absolute error or the lowest mean squared error. Once the coefficients are determined from the training sample, the resulting equations can be used to produce a forecast by inserting the current values of the predictors and calculating the value of the predictand. There are an enormous number of statistical models available for this type of application. The most popular ones for atmospheric science applications appear to be multiple linear regression and neural networks.

Statistical models are used in a number of different ways in wind energy forecast systems. In one mode, they can be used to adjust the predictions from the physics-based models. This mode is commonly called Model Output Statistics (MOS). However, they also can be used to make predictions directly from measured data. For example, a time series of power generation data can be used to train a statistical model and make predictions of future generation. In the very short term, statistical models are often used to combine persistence and physical model data.

4.3.5. Wind Plant Output Models

Wind plant output models characterize the relationships between the meteorological variables at the wind plant site and the plant's energy output. They can be formulated as statistical models, physical models, or a hybrid of both types. In a statistical approach, the parameters measured by sensors on the plant met towers or masts typically serve as the predictors and the power generation is the predictand. The simplest plant output model is a relationship between the wind speed measured at a met tower and the total plant output. The result is a plant-scale equivalent to the "power curve" for an individual turbine. This simple model can be extended by developing a separate relationship for ranges of wind directions. This relationship may be useful in accounting for the orientation of the turbine layout relative to the wind direction. For example, the power production may be different when the wind blows *along* versus *across* a row of turbines.

In a physical approach to a wind plant output model, the variations in wind flow within the wind plant, the interaction of the wind with the turbines, and the effect of turbine wakes on other turbines are explicitly modeled. This approach requires detailed information about the layout of turbines in the plant, the properties of the earth's surface (terrain, roughness, etc.) within the plant, and information about the turbine specifications. The physical models have the advantage of being able to produce a power generation forecast without a training sample. They can also explicitly account for changes in the operating structure of a plant, such as turbines out of service, as well as plant-scale variation in wind and its impact on power production. However, these models are typically much more complex than statistical models and require detailed data about the plant that may not be readily available. As with almost all physical models, there are likely to be systematic errors in the forecasts due to simplifying assumptions included in the physics, limited resolution, or the inaccuracies in the input data. In most applications, it is necessary to use a statistical model to adjust the forecasts of a physical plant output model to remove these systematic errors.

The typical use of plant output models in the forecast process is to convert wind speed predictions for one or more met towers or masts to power generation forecasts for the plant. However, it is not necessary to have an explicit wind plant output model in a forecast system since it is possible to go directly from external predictors to a power output forecast through the use of an atmospheric statistical model.

4.3.6. Forecast Ensemble Models

Forecast ensemble models are statistical models that produce an optimal forecast by compositing forecasts from a number of different techniques. The use of forecast ensemble models is based on research demonstrating that a composite of forecasts from an appropriate ensemble is often superior to those produced by any one member of the ensemble. The method is depicted schematically in Figure 27.

The fundamental concept is that if errors in the forecasts produced by the different methods are unbiased and have a low degree of correlation with one another, random errors from individual forecasts will tend to offset each other and result in a composite forecast with lower error than any individual forecast. If all input forecasts are highly correlated, the impact of ensembling will be minimal. This result implies that the underlying forecast methods must produce relatively small, random errors and be different in how they construct relationships between raw observational data and forecasts or the type/amount of input data must be significantly different. This "ensemble effect" is a well-known technique used by meteorologists in short and medium range forecasting. The spread of the ensemble forecasts can characterize forecast uncertainty if differences in the ensemble members are the primary factors that introduce the uncertainty.

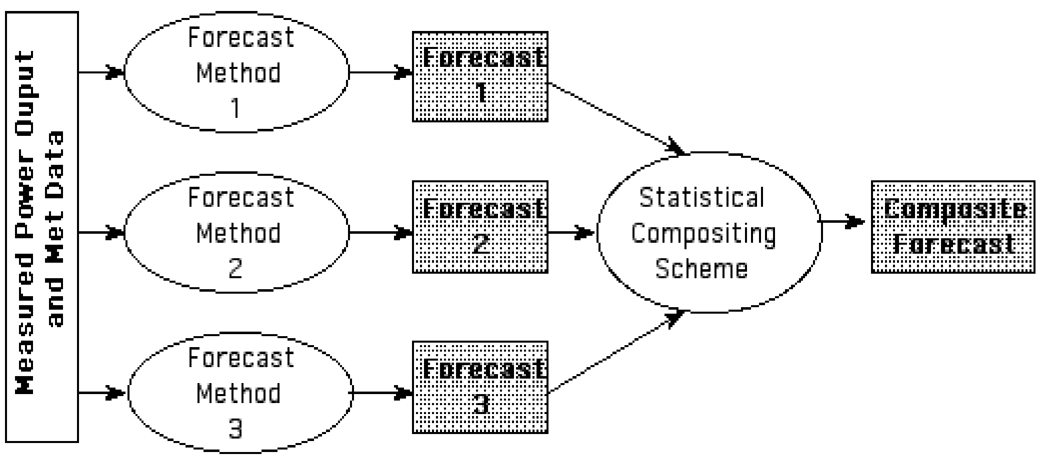

Figure 27: A schematic depiction of the ensemble technique. This arrangement applies to very short-term, short-term and next-day forecasts.

There are two fundamental strategies that can be used to generate an ensemble of forecasts. One strategy is to use the same forecast model and vary the input data within their range of uncertainty. The other is to use the same input data and to employ different forecast models or different configurations of the same model. The relative value of either strategy depends upon the sources of uncertainty in the forecast procedure including sensitivity of the models to initial conditions. In practice, the sources of uncertainty vary with location, season, and other factors. Thus, the choice of the ensemble components and the number of members must be determined from experience and experimentation.

This brief overview of forecast components indicates that there is a large and diverse pool of tools that can be used to generate wind energy forecasts. The challenge is to select the optimal set of tools and configurations for a specific forecast application. There is not one accepted set of specific forecasting methodologies and tools. However, a quality system should combine the strengths of physical, statistical, and ensemble techniques.

4.4. FORECAST EVALUATION

Although it may seem straightforward, there are a number of complex issues associated with the evaluation of wind energy forecasts. The most significant issue is which parameter(s) should be used as the metric(s) for forecast performance. The choice of metrics can have a significant impact on characterizing forecast performance.

A wide variety of metrics is in common use and no doubt many more could be devised. One fundamental distinction is *absolute* versus *relative* performance. An absolute metric provides a measure of the performance of a forecast system that is independent of other forecasts. Examples of absolute performance metrics are root mean square error (RMSE), mean absolute error (MAE) and median error (MDE). A relative performance metric is a measure of the performance of a forecast method relative to another method. Typically the other method is a reference forecast, such as persistence or climatology. A popular relative metric is the persistence-based skill score, which is the percentage reduction in the MAE of a persistence forecast that is achieved by a particular forecast method.

Another distinction in selecting parameters is the sensitivity to different portions of the error frequency distribution. Some parameters are much more sensitive to outliers, i.e. forecasts with anomalously large or small errors. For example, the RMSE is quite sensitive to outliers while the MDE is not. The sensitivity of the MAE parameter is between these two extremes.

In addition to the issue of different metrics providing a different picture of performance, there is also the issue that a forecast system can be tuned to produce better performance for a specific metric while possibly degrading the performance for other metrics. This tuning can be done by formulating a statistical technique to minimize the value of a specified optimization or cost function. Such an approach might be used to customize the forecast system to meet the needs of a specific application. However, the underlying issue is whether the evaluation metric is really linked to the user cost function. If it is, then it probably makes sense to optimize the forecast system for that metric.

An example of the wide range of perspectives provided by different forecast metrics is provided in Table 1. This table lists the values for a suite of forecast metrics for the performance of 1- to 48-hour forecasts of power output and wind speed during the month of October 2001 for a wind plant in the San Gorgonio Pass of California. Different pictures of the absolute and relative forecast performance emerge depending on which metrics are considered. For example, MAE as percentage of the rated capacity is 14.7% for the first 24-hour period. However, the RMSE is 20.8% and the MDE is 10.3%.

Table 1: Power output and wind speed verification statistics for a wind plant in the San Gorgonio Pass of Southern California.

Verification Statistic	Power Output					
	Month:	Oct-01			% Capacity	31.6%
	Hours 1-24			Hours 25-48		
	eWind	Persistence	Climatology	**eWind**	Persistence	Climatology
MAE %Rated	14.7%	22.3%	28.4%	16.0%	32.4%	28.4%
MAE %Mean	46.4%	70.5%	89.7%	50.5%	102.6%	88.5%
MAE % Std Dev	47.7%	72.4%	92.2%	51.9%	105.5%	90.9%
RMSE-% Rated	20.8%	31.0%	31.9%	22.9%	42.1%	31.6%
Median % Rated	10.3%	16.7%	28.4%	10.9%	27.3%	28.3%
Correlation	0.75	0.47	0.11	0.63	0.00	0.11
Skill-Pers	34.1%	0.0%	-27.3%	50.8%	0.0%	13.8%
Skill-Climate	48.3%	21.5%	0.0%	43.0%	-16.0%	0.0%
Verification Statistic	**Wind Speed - Met Tower**					
	Month:	Oct-01			Avg Spd (m/s)	8.83
	Hours 1-24			Hours 25-48		
	eWind	Persistence	Climatology	**eWind**	Persistence	Climatology
MAE	2.52	3.87	3.86	2.70	5.59	3.86
MAE %Mean	28.5%	43.8%	43.7%	30.5%	63.3%	43.7%
MAE % Std Dev	55.8%	85.8%	86.6%	59.8%	123.9%	85.5%
RMSE	3.13	4.90	4.62	3.58	6.91	4.59
Median	2.10	3.10	3.82	2.00	4.70	3.80
Correlation	0.72	0.51	0.04	0.63	-0.07	0.04
Skill-Pers	35.0%	0.0%	0.4%	51.8%	0.0%	31.0%
Skill-Climate	34.8%	-0.4%	0.0%	30.1%	-44.9%	0.0%

4.5. State-of-the-Art Forecasting

The current state-of-the-art forecasting techniques exhibit considerable skill in both very short-term and short-term forecasting. Very short-term (0-6 hrs) hourly forecasts typically outperform a persistence forecast by 10% to 30%. Short-term (1- to 2-day) hourly forecasts usually outperform persistence and climatology by 30% to 50%. At present, medium range (3-10 day) forecasts of the hourly wind energy production typically do not outperform climatology and hence have limited usefulness. However, medium range forecasts of the *average* energy production over a day or half-day usually do outperform climatology out to 6 or 7 days and hence provide some value to the user who can effectively employ that type of information.

It should be noted that forecast performance can vary substantially (5% or more of installed capacity) as a function of location, season, and weather regime. Much of this variability is related to the predictability of specific weather regimes. Some weather regimes are inherently more sensitive to small variations in the initial conditions at the start of the forecast. This sensitivity means that slight differences in the current conditions can give rise to large differences in the future conditions. Forecast performance in these cases is normally much worse than for regimes with less sensitivity.

4.6. General Overview of Forecasting Applications

Several factors influence the accuracy of wind power prediction. The factors include

- accuracy of wind speed prediction,
- dampening and amplification of wind speed prediction error through the nonlinear power curve, and
- wind plant efficiency, including turbine availability and performance [1].

The following key results regarding general wind and power forecast performance were obtained as part of the Alberta Energy System Operator's (AESO) wind power forecasting pilot project conducted from June 2007-April 2008 [1]. During the project, wind and power forecast data were provided for forecast hours 1 through 48 by three independent wind forecasting firms. In the report, they are referred to as Forecaster A, B, and C. The analysis compared the predicted data to measured meteorological power data for seven existing Alberta wind power facilities (labeled Existing Facilities), and measured meteorological data and derived power data for five future Alberta wind power facilities (labeled Future Facilities).

The analysis was carried out by examining available data from each of the forecasts using seven categories as follows: (1) All Facilities (AF), (2) Existing Facilities (EF), (3) Future Facilities (FF), and four geographic regions, (4) South West (SW), (5) South Central (SC), (6) South East (SE), and (7) Central (CE).

The overall accuracy of wind speed prediction for the three forecasters was 1.4 to 3.5 m/s for annualized MAE and 1.9 to 4.7 m/s for annualized RMSE. The general accuracy of power prediction is shown in Figure 28 and Figure 29. The error measures shown are normalized by the rated wind power capacity. Figure 28 shows the annual normalized RMSE at different forecast horizons and regions for the three forecasters while Figure 29 presents the annual normalized MAE results.

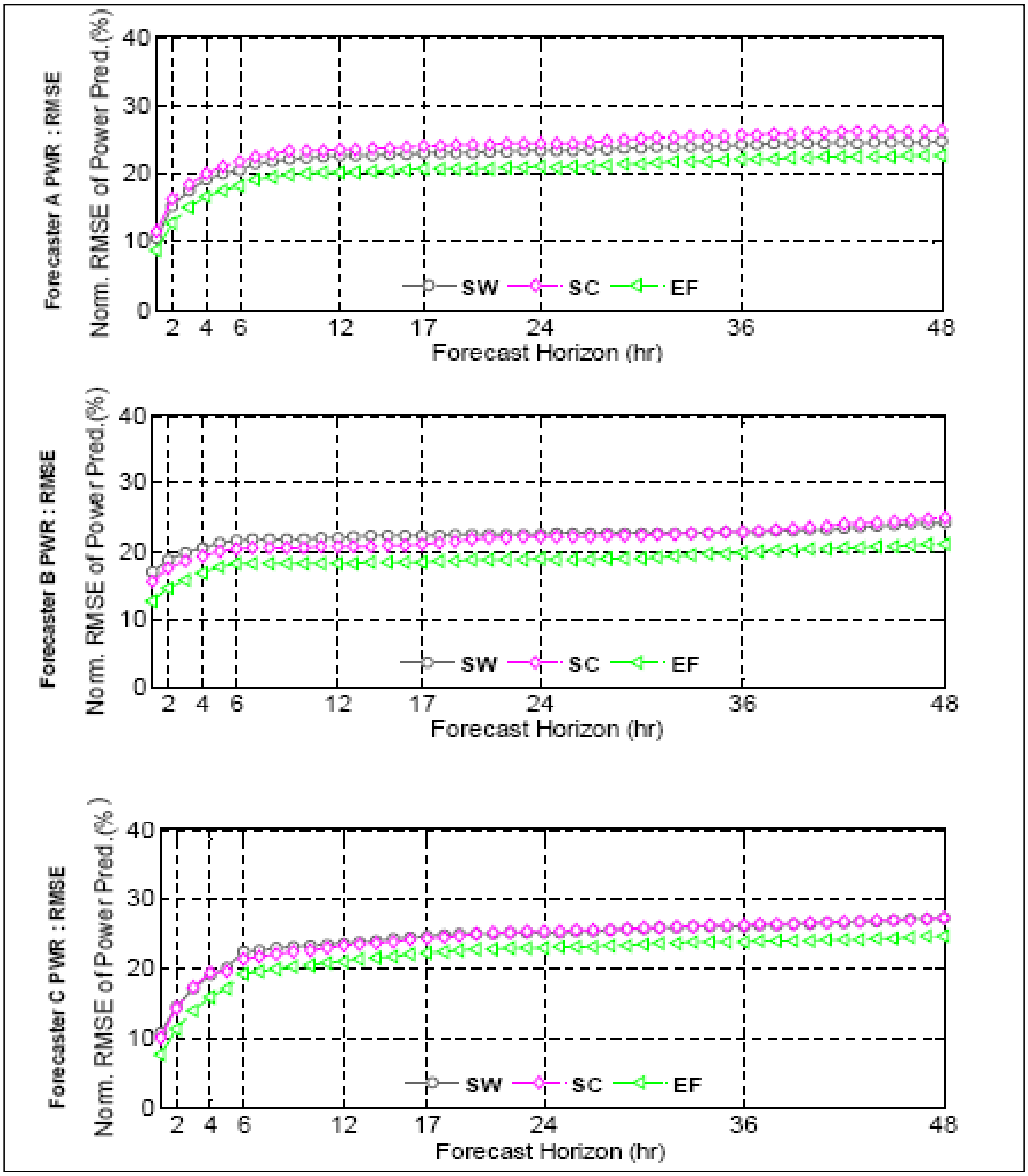

Figure 28: Annual Normalized Root Mean Square Error (RMSE %) of power predictions in South West (SW), South Central (SC), and existing facilities (EF) by three forecasters A, B and C as a function of forecast horizons. Note that the actual errors are normalized by the rated capacity (RC) of the region of power aggregation.

The normalized annual RMSE of the power prediction exhibits a general increase with time, particularly for the first six hours of the forecast horizon (Figure 28). Similar trends are evident for the normalized annual MAE (Figure 29). The normalized RMSE is in the range of 6% to 20% for the first six forecast horizons and 20% to 30% for the remaining forecast times.

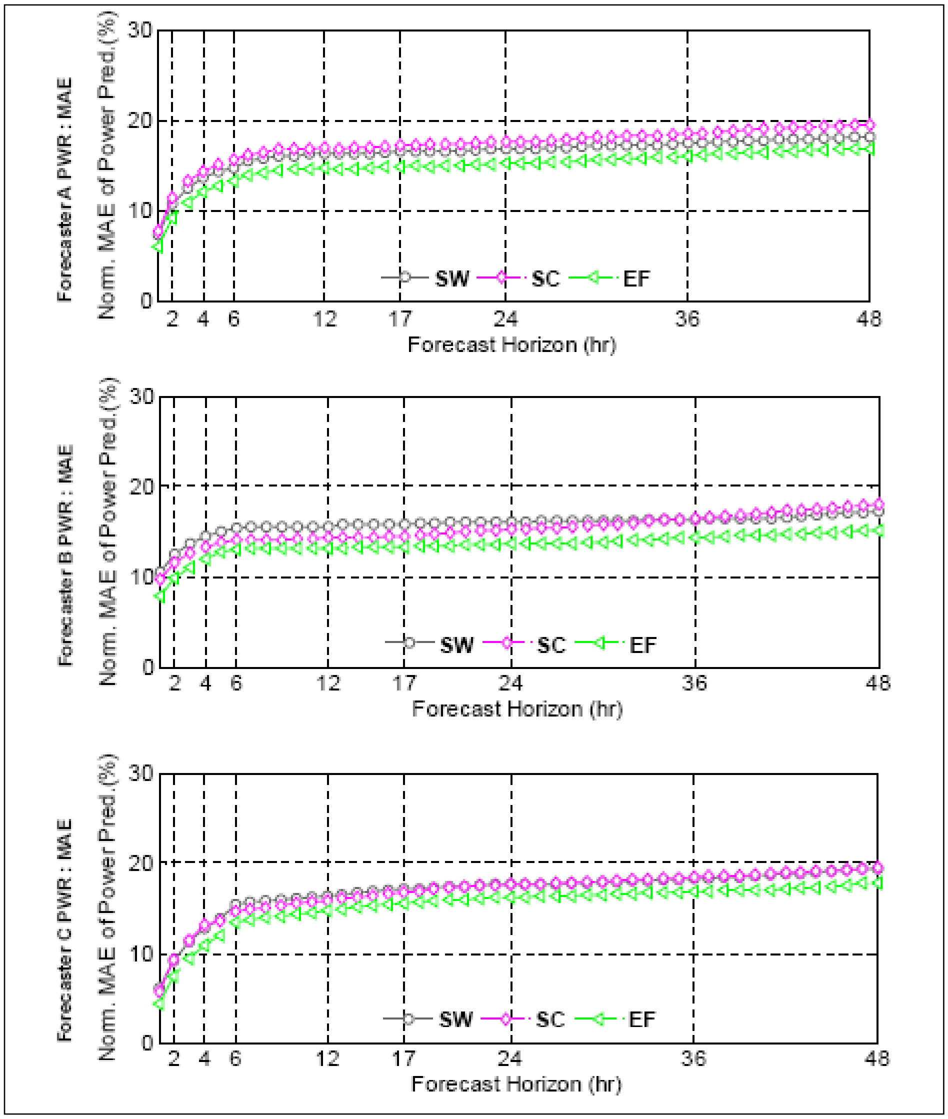

Figure 29: Annual Normalized Mean Absolute Error (MAE %) of power predictions in South West (SW), South Central (SC), and existing facilities (EF) by three forecasters A, B and C as a function of forecast horizons. Note that the MAE is normalized by the rated capacity of the region of aggregation.

It is very important to note that forecast performance varies significantly according to the size and aggregation diversity of wind plants. In the Alberta wind forecasting pilot project, the RMSE for regional day-ahead forecasts was 15-20% lower than for the individual plants, and the RMSE for system-wide day-ahead forecasts was 40-45% lower than for the individual plants (Figure 30).

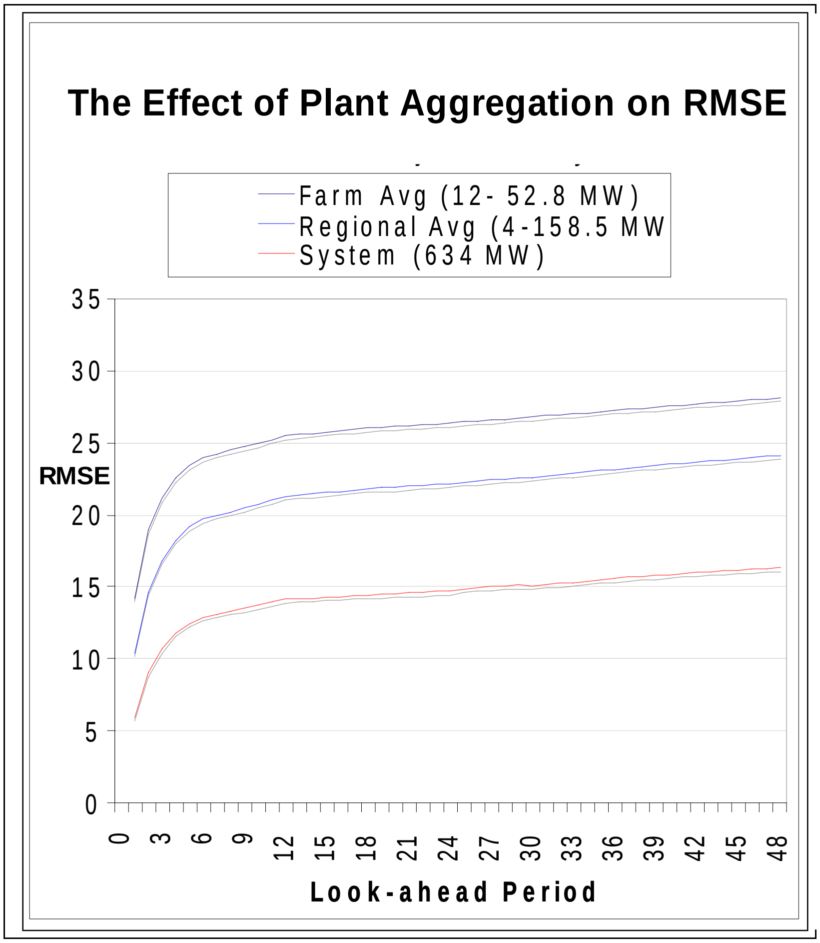

Figure 30: A time series showing the effects of plant aggregation on the RMSE forecast performance over a 48-hour forecasting period.

The impact of plant aggregation often results in a misconception that European forecast providers are much better than their North American counterparts. In reality, forecasts for European sites typically cover very large and diverse systems with low capacity factors. In contrast, North American forecasts are usually generated for smaller, much less diverse systems with higher capacity factors, and often for individual wind plants. For this reason, European forecasts with RMSE of 5% typically seem low by U.S. standards. In head-to-head studies for similar forecast regions, the performance statistics for North American and European forecast providers are very similar. The main point of this observation is that forecasting for larger resources in more uniform environments is easier than individual plants in diverse environments.

Figure 31 provides an estimate of the typical range of MAE (expressed as a percentage of the installed capacity) as a function of the forecast time horizon (look-ahead period) for the 1- to 12-hour forecast period. The MAE of very short-term forecasts is typically in the range of 5% to 15% and the errors increase rapidly (about 1.5% of installed capacity per hour) with an increase in the forecast time horizon. After the very short-term period, the error growth rate decreases to about 0.1% of installed capacity per forecast hour. As a result, the mean absolute forecast errors remain in the 13% to 21% range for 1 to 2 days ahead and rise to the 20% to 25% range that is typical of a climatological forecast after about 3 days (not shown).

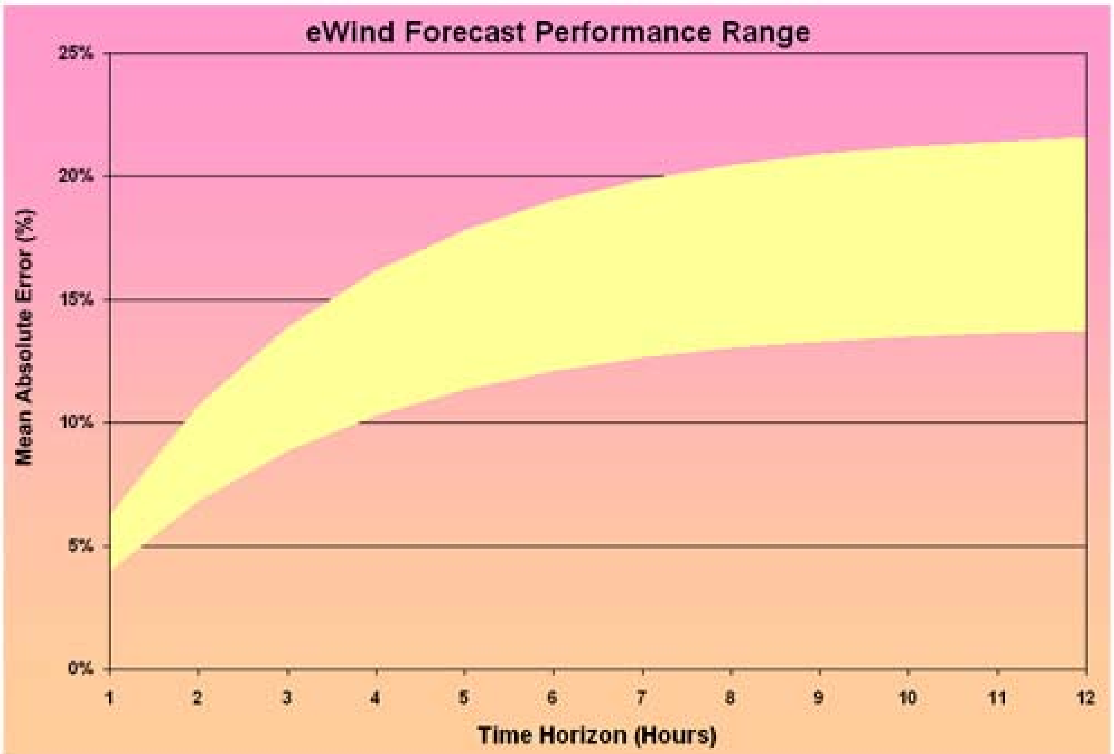

Figure 31: Typical range of current wind energy forecast performance as a function of forecast time horizon. Forecast performance is expressed as a mean absolute error as a percentage of a wind plant's installed capacity.

4.6.1. State-of-the-art: "Next-Hour" Forecasting

There are a wide variety of methods that have been or are being used to produce very short-term ("next-hour") wind energy generation forecasts. Figure 32 provides a schematic depiction with many components of the very short-term forecasting process and the ways they can be linked together to produce forecasts.

The simplest type of very short-term forecasts uses a time series of power generation data from the wind plant and a statistical procedure, such as multiple linear regressions or a neural network, to generate predictions of the future power output. These are often referred to as "persistence" or "autoregressive" models since their only source of information is the history of the plant power output. These models can be enhanced by using a time series of meteorological data from the towers or masts within the wind plant.

The addition of meteorological data from the met towers within the wind plant can be handled in two ways. In the first approach, the meteorological data are added to the pool of predictors and the power generation is predicted directly from the statistical model. In the second approach, the meteorological data are used to forecast the meteorological inputs to a separate wind plant output model. The wind plant output model then uses these inputs to create an energy generation prediction. The second approach may have an advantage if there is more than one met tower within the plant because it may be possible to capture some of the variability in meteorological conditions within the plant and hence produce a better energy generation forecast.

Sophisticated statistical models, such as neural networks, may be able to find more subtle and complex relationships in the time series data and thereby generate better forecasts than simpler models such as linear regression. However, due to the fact that sophisticated statistical models usually have more adjustable parameters, they are prone to "over-fitting" problems if the training sample is not sufficiently large. Ultimately, all of these methods are limited by the fact that the input information is derived only from a history of conditions at the wind plant.

The next level of sophistication is to use multiple external data sources. The additional data sources can be used as input to the same types of statistical models used in the autoregressive approach. However, the number of predictors is larger. The additional sources could include data from nearby met towers or remote sensing systems. Another possibility is to use forecast output from a regional scale physical model. These models provide information about the larger scale trends in meteorological parameters but do not incorporate local area data and typically do not have the ability to resolve the local atmospheric and surface features that are critical to very short-term forecasting. However, some large-scale trends are well correlated with a local-scale response and hence the regional model data can, at times, add skill to the very short-term forecasts.

An approach that has yet to be thoroughly tested for very short-term wind power forecasting is to use a physical model with a high resolution grid to produce very short-term forecast simulations for the local area surrounding the wind plant. In this case, all of the available local-area data are assimilated into the initial state used to start the physical model simulation. This type of procedure has potential to simulate the atmospheric features that cause the wind variations in the vicinity of the wind plant. The output data from this local-area simulation is then fed into a MOS procedure. The MOS algorithm selects the best performing predictors from the large volume of physical model data and generates predictions of the wind speed and direction at the wind plant met towers. These predictions are then fed into a wind plant power output model to generate power output predictions. This method is a local-scale analog of the regional scale forecast procedures that have been used quite successfully for 1- to 2-day forecasting.

Another tool that can be used in the very short-term prediction process is a forecast ensemble model. As noted earlier, this is a statistical model that generates a composite forecast from a series of input forecasts generated by different methods.

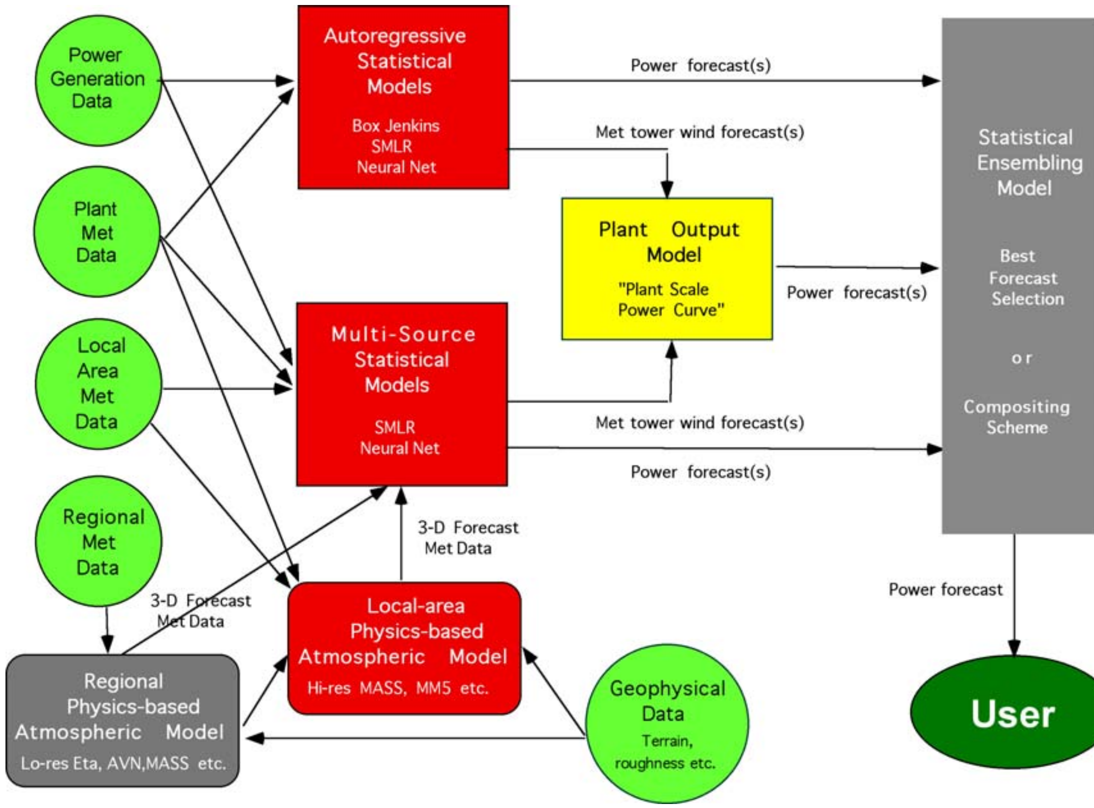

Figure 32: A schematic depiction of the interrelationship of the components of a very short-term forecast system.

After examining various methods that could be used in the very short-term forecast process, the obvious questions are (1) what is the typical level of performance that can be expected from very short-term forecast methods and (2) what is the variation in performance due to differences in methods, locations, seasons, and weather regimes? There have been a few controlled studies (such as the Alberta Project) [1] of forecast performance that included evaluation of very short-term wind energy forecast methods over a diverse mix of atmospheric conditions. However, most of the performance evaluations have been done by forecast providers or researchers and not by independent third parties. Therefore, it is still difficult to draw broad conclusions from the evaluations because the methods, locations, and times are different.

The performance of several very short-term forecasts for a wind plant in the San Gorgonio Pass of California is presented in Figure 33. This performance is somewhat typical for this site and season but experience indicates that there can be large variations in performance from site to site and season to season. In this example, all methods yield a small improvement over persistence during the first couple of hours of the forecast period. The methods that use regional physical model data become significantly better than persistence after about 4 hours.

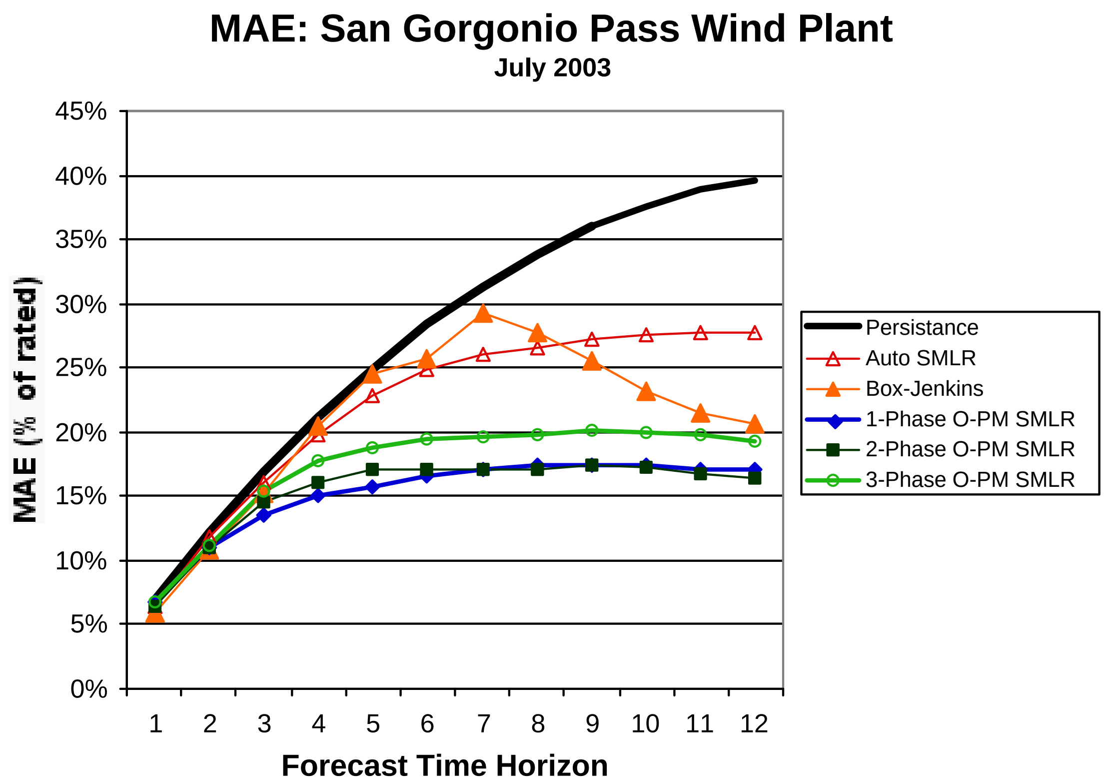

Figure 33: The mean absolute error by forecast hour during July 2003 for five very short-term forecast methods and a simple persistence benchmark forecast for a wind plant in San Gorgonio Pass. The "SMLR" acronym refers to a screening multiple linear regression procedure. "O-PM" refers to the use of both observational and regional physical model data as input to the statistical procedures.

4.6.2. State-of-the-art: "Day-Ahead" Forecasting

Short-term forecast methods use essentially the same tools as very short-term forecast techniques. However, there are two important differences: (1) the importance of real-time data from the wind plant and its immediate environment is significantly reduced; and (2) regional and sub-regional simulations with a physics-based atmospheric model play a much more significant role in the forecast process.

Almost all short-term forecast procedures begin with the grid point output from a regional-scale physics-based atmospheric model. Typically, these models are executed at a national forecast center, such as the National Centers for Environmental Prediction operated by the U.S. National Weather Service, ingest data from a wide variety of sources over a large area, and produce forecasts of regional-scale weather systems for a several day period. However, these models do not resolve the physical processes occurring in the local or mesoscale areas around individual wind plants. (The mesoscale scale is between the large-scale weather systems and the local scale approximately 5 - 100 km). The three-dimensional output data from the regional-scale forecast simulations is the basic input into most short-term wind energy forecast systems.

The forecast methods differ substantially from this point. Some forecast procedures attempt to go directly from the regional-scale forecast data to the local scale through the use of either diagnostic physical models, statistical models, or a combination of both. The Prediktor system developed by the Risoe National Laboratory in Denmark uses this approach. The main drawback of Prediktor is that it misses the processes occurring at the sub-regional or mesoscale.

An alternate approach is to execute sub-regional scale simulations with a physics-based model to account for the mesoscale processes. This is the approach used by AWS Truewind (AWST) in their eWind system and a couple of other North American forecast providers. A schematic depiction of the eWind system is presented in Figure 34. This approach has had considerable success in forecasting the variations in winds attributable to mesoscale processes but it has a much higher computational cost than the regional-to-local forecast schemes. Both the regional-to-local and mesoscale simulation approaches typically employ statistical MOS type models to predict the wind speed and direction at the wind plant's met towers. The predictors are based on either the output from the mesoscale simulations (mesoscale approach) or from the regional or diagnostic physical models (regional-to-local approach).

It is possible to predict the energy generation directly from physical model output through the MOS process. However, most forecast systems are configured to produce wind predictions for the met tower sites from the MOS and then use these predictions to create the energy generation forecasts from a wind plant output model. The wind plant output model can be either physical or statistical. The Prediktor system has the option to use either a physical model in combination with a second MOS procedure to remove any systematic errors or a purely statistical scheme. The eWind system uses a statistical wind plant output model.

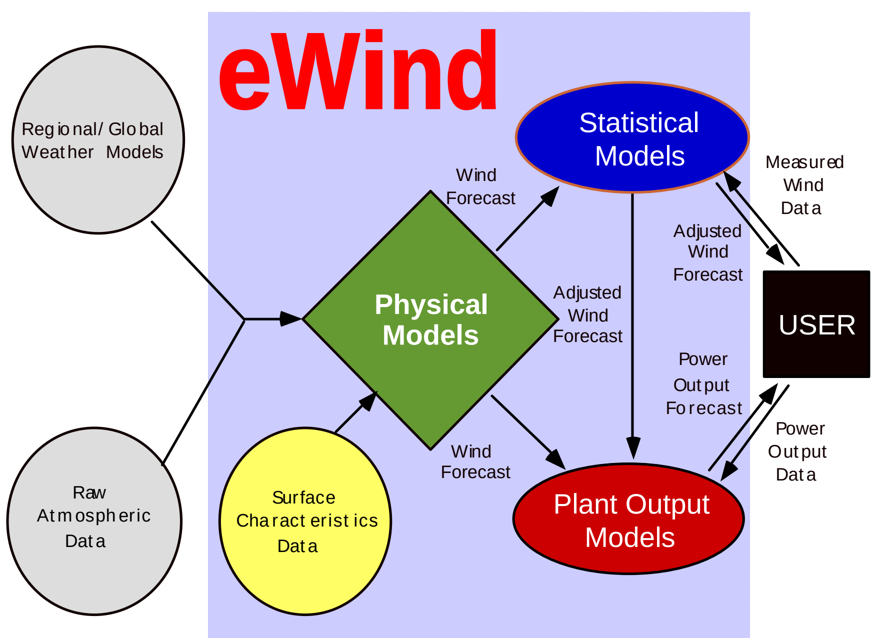

Figure 34: A schematic depiction of the major components of the eWind short-term wind power forecast system

As in the case of very short-term forecast performance, a quantitative assessment of the state of the art in short-term wind energy generation forecast performance is difficult to obtain because most evaluations are done by individual forecast providers and researchers. The methods, locations, and time periods used in these forecast performance evaluations vary substantially. Therefore, it is difficult to determine the causes of performance differences.

There are two "third party" investigations that included the evaluation of short-term day-ahead forecast performance. One project was funded under the Alberta Electric System Operator wind power forecasting pilot project [1]. The other project was funded by the California Energy Commission (CEC) and managed by the Electric Power Research Institute (EPRI) [2].

The objective of the EPRI-funded project was to assess the state-of-the-art in wind energy forecasting for California. Two forecast providers participated in the project. Each used their own forecast system to produce 1- to 48-hour wind energy forecasts for two wind projects in California during a 1-year period from September 2001 to October 2002. One forecast provider was Risoe National Laboratory from Denmark; they used their Prediktor system. The other provider was AWST; they employed the eWind forecast system. One of the participating wind projects was the 66 MW Mountain View wind plant in San Gorgonio Pass, that is located just to the east of the Los Angeles Basin in southern California. The other project was a 90 MW plant located in the Altamont Pass, that is located just to the east of the San Francisco Bay Area in northern California.

A summary of the forecast performance results from this project is presented in Table 2. The performance statistics in this table are for all forecast hours (i.e. 1-48) and for the entire 12–month evaluation period. The MAE as a percentage of installed capacity is in the 14% to 21% range. This range is typical for 1- to 2-day forecast performance. The percentage MAE of both forecast systems was lower for the Altamont Pass plant. However, the Risoe system showed a greater difference in forecast performance between the two plants than the AWST system.

Figure 35 and Figure 36 depict the MAE of the AWST persistence and climatology forecasts by forecast hour for each of the plants. It can be seen that persistence forecasts are best in the first few hours for both plants because no real-time information from the plant or its immediate environment was available for use in the forecast process. After the initial period, the AWST forecast method outperforms the persistence and climatology forecasts by a substantial margin. This result is typical of forecast performance at most sites.

These figures also provide an indication of the forecast error growth rate as a function of forecast look-ahead period. The error growth for the San Gorgonio Pass wind plant (2% of installed capacity per 24 hours) is approximately twice as large as the rate for the Altamont Pass plant. This difference is most likely attributable to the physical properties of the site and its immediate environment as well as differences in weather regimes affecting the two areas over the course of the year.

This study served to document the expected level of performance of short-term wind energy forecast systems. It indicated that state-of-the-art forecasts systems have considerable skill over climatology and persistence forecasts for 1- to 2-day periods. It also demonstrated that 1- to 2-day forecast performance can vary substantially by location, season, and attributes of the forecast system used to generate the predictions.

Table 2: A summary of the forecast performance results from the EPRI-CEC project.

Parameter	Risoe	TrueWind
Mountain View (66 MW rated)		
Mean Error (kWh)	2,888	628
MAE(kWh)	14,305	11,834
MAE(% of rated)	21.7%	17.9%
Skill vs. Persistence (%)	9.5%	32.6%
Skill vs. Climatology (%)	19.8%	33.7%
Altamont (90 MW rated)		
Mean Error (kWh)	702	631
MAE(kWh)	12,985	12,438
MAE(% of rated)	14.4%	13.8%
Skill vs. Persistence (%)	21.6%	30.8%
Skill vs. Climatology (%)	26.2%	29.6%

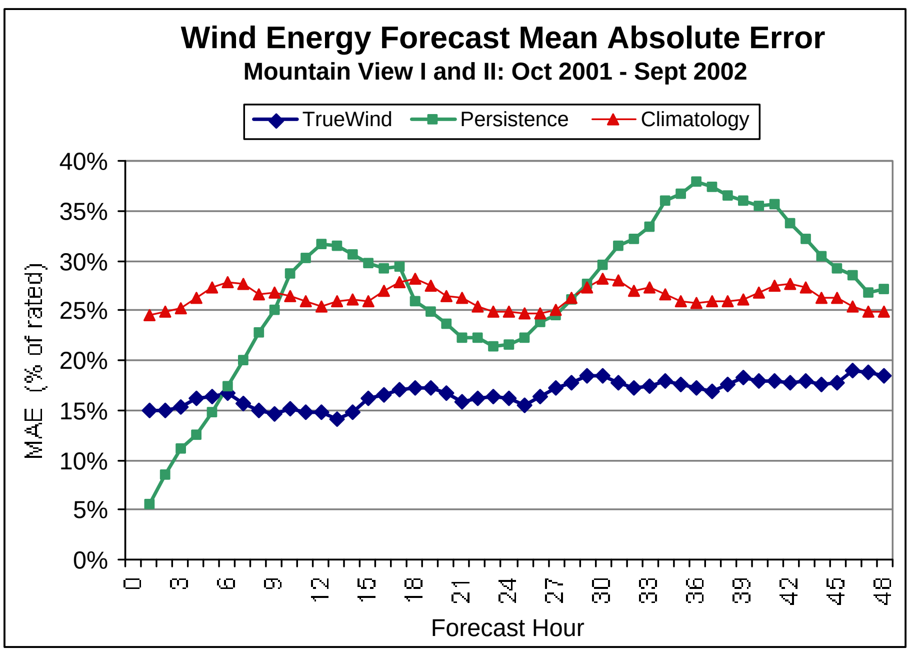

Figure 35: The mean absolute error by forecast hour for 12 months of AWST (eWind), persistence, and climatology energy generation forecasts for a wind plant in San Gorgonio Pass

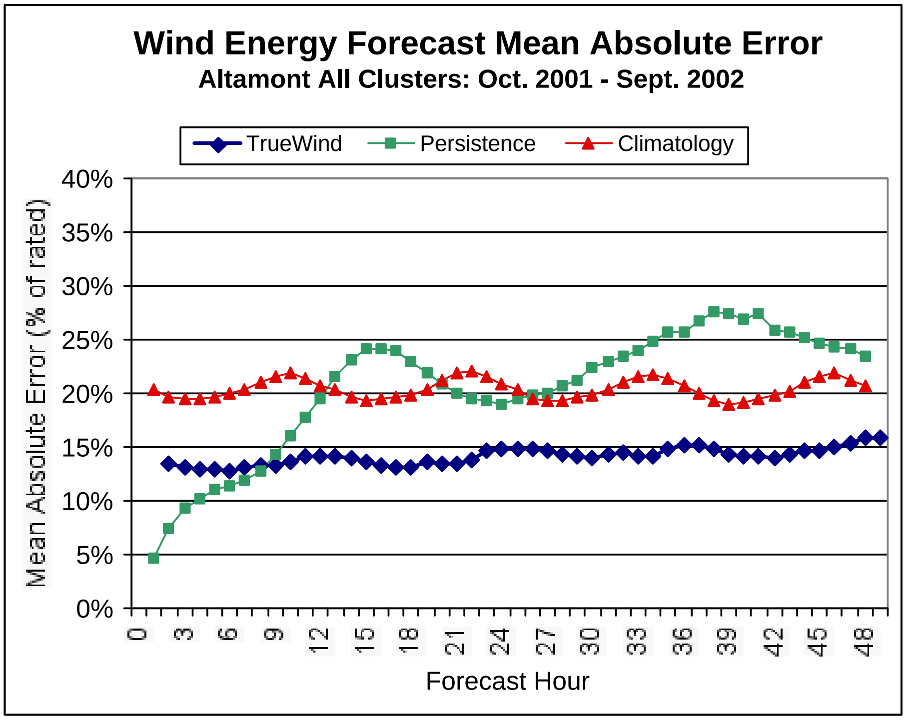

Figure 36: The mean absolute error by forecast hour for 12 months of AWS Truewind (eWind), persistence, and climatology energy generation forecasts for a wind plant in Altamont Pass.

4.6.3. Early Warning Ramp Forecasting System

As the amount of wind generation increases on grid systems, the occurrence of large and rapid changes in power production (ramps) is becoming a significant grid management issue. A good operational ramp definition is *a change in power output that has a high enough amplitude over a short enough period of time to cause short-term grid management issues*. The operators must ensure there is always sufficient conventional generation and/or responsive load ramping capability to compensate for a downward ramp in wind power output. Thus, from a grid management perspective, accurate forecasting of ramps may be more important than minimizing the overall MAE or RMSE of the typical power production forecasts. Upward ramps can be more easily managed by curtailment if necessary; therefore downward ramps are more important. For downward ramps, the wind power must be replaced as it is lost to eliminate the need for more drastic measures, such as load shedding [1].

The forecast of wind ramps is similar to lightning in that both must warn system operators so preparations can be made before the event occurs

Forecasting techniques that are optimized for the typical wind conditions do not do well in forecasting rapid changes in winds that cause power ramps. Since ramps have such a great impact on power production forecasts, ramp forecasting needs to be considered as a separate forecasting problem with a methodology and system put in place that is designed specifically to forecast and alert operators of the likelihood of events. In addition to forecasts of the likelihood of a ramp event, AWST experience suggests that grid operators want the meteorological cause of the event (front, thunderstorm line, etc.) so they can track it in real time.

Ramps in wind power production are caused by several different types of meteorological processes. Each type of ramp has a unique set of characteristics and forecast issues. The data and type of forecast method required to optimally predict each type of ramp event are dependent on the meteorological process that caused them.

The cause of ramps can be divided into two categories:

- Scale of the phenomena: Large scale processes that cause ramps include phenomena such as cold fronts and upper tropospheric shortwave troughs of low pressure. Smaller scale processes include phenomena such as outflow boundaries from thunderstorms, changes in wind direction across a mountain range, and formation or erosion of shallow pools of cold air.
- Processes primarily acting in the horizontal or vertical: Horizontal processes, such as those associated with fronts, tend to move from a location some distance away from the plant into the plant area. These events can be identified and tracked with observing tools, such as meteorological radars and satellite images. Vertical processes that cause ramps include phenomena such as the formation of a shallow pool of cold air or the vertical mixing of the atmosphere. These processes tend to form in place and are therefore more difficult to track and forecast. The vertical profile of wind and temperature is the most useful parameter to monitor for these events.

A ramp forecasting system should alert operators about the occurrence of a ramp at the earliest possible time. For days 3 though 7, only daily probabilities should be given in terms of the likelihood of a ramp being greater than, about the same as, or less than the climatological norm for such an event. The day-head forecast should be more precise giving probabilities of ramp occurrence for each hourly time period. The forecasts needed for the first 24 hours should include the probability, amplitude (magnitude), duration, type, and cause of the event. The 24-hour forecast should also include the meteorological feature causing the ramp in order to aid operators in tracking the event in real time. Finally, the alert system should include hourly ramp forecast updates for situations when a ramp event has been forecasted within 24 hours.

The ramp forecasting system needs to be different from the forecasting system designed to reduce typical errors by minimizing RMSE or other standard metrics. Inevitable phase errors in features causing ramps (such as cold fronts) can produce large errors especially when considering squared quantities such as RMSE. For this reason, a forecast system that minimizes RMSE tends to smooth out power ramps over many hours.

Ramp forecasting systems should be designed to estimate the probability of a ramp occurring in any given hour, the actual amplitude (or a probability distribution of amplitudes), and the uncertainty in timing/duration of the ramp. Inputs to such a system would include amplitude and timing of actual ramps forecasted by physics-based (numerical weather prediction or *NWP*) models, a statistical forecast method, or an optimized ensemble forecast.

In order to forecast ramps, it is necessary to develop ramp climatologies for a region. Using ramp climatologies, the forecast provider then develops algorithms to identify regional or local parameters from available met towers or remote sensing system data that have a statistically significant ability to discriminate between ramp and no-ramp cases, especially during the first 6 hours of a forecast. These data are then analyzed in order to identify the sensitivity of site specific ramp forecasts to making additional measurements at different locations. In order to forecast the needed parameters, a provider could run a real time, regionally-customized rapid-update-cycle NWP-based tool designed for large ramp forecasting applications. NWP models configured with a very high-resolution grid (1-km grid cells) for such applications are initialized every hour and used to make 12-hour forecasts from these initial conditions. The initial state is created by updating the previous 1-hour forecast with the latest wind plant met data as well as other regional met tower and remotely sensed measurements.

One final consideration relates to ramp forecasts for aggregates of wind plants. Ramps will tend to be slower in terms of percent change in capacity for aggregates that include a large number of wind plants distributed over a wide area at locations with varied wind regimes. These types of aggregates tend to include many wind plants that have power time series that are relatively uncorrelated. For this reason, strong upward ramps at some wind plants tend to be offset by downward ramps or at least washed out by weaker ramps or steady production at other plants. However, wind plants are often built in a few relatively small regions to take advantage of the highest climatological wind speeds. This strategy tends to produce aggregates in which the individual plants are highly correlated and are prone to more frequent, large ramps.

4.6.4. Severe Weather Warning System

In addition to the routine and ramp forecast systems, there is a need to provide operators with information regarding the broader weather situation, especially with respect to extreme meteorological events that may have a serious impact on wind plant operations. Information and forecasts of severe weather events such as high winds, thunderstorms, hail, tornadoes, sleet, freezing rain, and heavy snow should be provided. In addition, information on the feature causing the event should be provided so operators can track and verify the actual occurrence in real time.

When there is a potential for severe weather within 24 hours, the severe weather warning system should deliver hourly updates to operators. For the day-ahead, only the general potential of high, moderate, or low risk would be provided for each category of severe weather.

4.6.5. Forecasting for Offshore Wind Plants

Offshore meteorology and its impact on power fluctuations and wind forecasting still requires significant research for offshore power plants. There are two considerations that distinguish forecasting for onshore versus offshore wind plant facilities. The first is forecasting the wind itself and the second is forecasting the waves that can impact various operations associated with the offshore wind plant.

Looking first at wind, there are fundamental differences between conditions over land and water due to the influence of the surface on the flow. The most significant one is the roughness of the sea that is much lower than land areas but varies due to the changing sea state conditions (i.e. waves) [3]. In general, the atmosphere is more often characterized by neutral or stable conditions over water given that the underlying surface does not heat or cool as rapidly.

Offshore near the coastline, there are differences and complexity due to abrupt changes in surface roughness and the surface temperature that lead to important transition effects for the wind blowing from land to water. Other factors such as the shape of the coastline, islands locations, and currents/tides also affect wind speeds over water [4].

If the forecast model is formulated correctly to handle ocean roughness and stability differences, errors in wind forecasting would likely be lower over water than land when the sites are five miles or more offshore. The error could be larger near the coastline because of the complexities associated with the coastal factors similar to that of a complex terrain region over land.

In addition to the complexities of the coastal regions, there are fewer measurements of current wind conditions, surface temperatures, and other meteorological variables over water to initialize forecast models. There is also a problem of observing wind at turbine hub height. Most weather buoys make wind measurements at only three to five meters above the ocean surface whereas modern wind turbine hub heights are 80 meters or more. Tall met towers are needed to collect wind, temperature, and other meteorological data and better characterize the local offshore environment as well as validate forecast models.

Marine operations associated with construction and maintenance of offshore wind plants require accurate wave forecasts. For wind plants located in shallow coastal areas, the wave forecast model needs to consider local bathymetric features and include all shallow water dynamics. Deep water ocean wave forecast models would not meet the shallow wave requirements. When forecasting for offshore sites, providers should include models that accurately represent the marine boundary layer, momentum exchanges between the air-water interface, and deep as well as shallow ocean waves.

4.7. POTENTIAL FOR IMPROVED FORECAST PERFORMANCE

Although both very short-term and short-term forecasts made with state-of-the-art forecasting systems currently exhibit considerable skill relative to benchmark persistence and climatology forecasts, there are still many opportunities for forecast improvement. There is also an opportunity to extend the range of hourly energy forecasts that have skill over climatology to at least 72 hours. This section gives an overview of (1) how forecast improvement at each of the three major time scales is likely to be achieved and (2) provides an estimate of the amount of improvement that may be expected over the next 10 to 15 years.

4.7.1. Medium Range

Current hourly wind forecasts and the associated energy generation forecasts beyond approximately 3 days have very little skill over climatology, although daily average forecasts of wind speed and energy generation do have some skill over climatology out to 6 or 7 days. As forecast technology improves over the next 10 to 15 years, it is likely that forecasts beyond 3 days will become useful to the wind energy community.

The charts in Figure 37 and Figure 38 provide a perspective on the long-term trend in forecast improvement and what it may mean for future performance [5]. Figure 37 depicts the yearly average skill score (S1) for forecasts of the mean sea level pressure gradients made by several different forecast models run by the U.S. National Weather Service during approximately the last 50 years of the 20th century. The 36-hour S1 scores in Figure 37 for mean sea level pressure gradients constitute one of the longest continuous records of forecast verification anywhere. Therefore, it is a metric that can be used to define the trend in forecast performance over a long period of time and provide some guidance about future performance. It should be noted that S1 scores measure the skill in forecasting large-scale features associated with regional and continental scale weather systems and not the smaller scale pressure gradients responsible for variations in local winds around plants.

The S1 scores that are depicted in Figure 37 clearly indicate significant progress in the ability to forecast large-scale sea level pressure gradients. The first numerical weather prediction models went into operational use in the middle 1950s; the S1 scores began to steadily improve after that time. The forecast performance improvements after the 1960s have been attributed to: (1) more observed data; (2) better methods for incorporating data into models; and (3) model enhancements. The improvement was persistent if not dramatic from the early 1960s through the end of the 1990s. Thus, by the mid 1990s, the *72-hour* forecast of the mean sea level pressure gradient was typically about as good as the *36-hour* forecast in 1980.

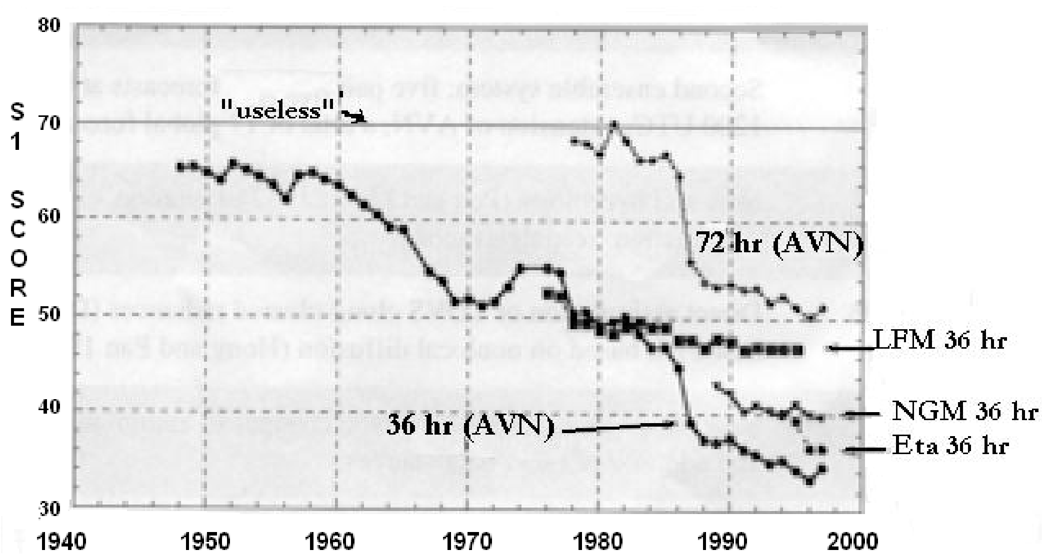

Figure 37: A depiction of the yearly average S1 scores for forecasts of the mean sea level pressure gradient over North America produced by several different U. S. National Weather Service models (AVN, LFM, NGM and Eta) during the second half of the 20th century from [5]. The S1 score is a measure of the relative error of the gradient of a parameter over a specified region. The mean sea level pressure gradient is strongly correlated with the near surface wind speed at most locations within several hundred meters of sea level. A lower score indicates a more accurate forecast. A S1 score of about 70 is generally considered useless while a score of about 20 is almost perfect for most practical applications.

Figure 38 shows the more recent trend of the 500-mb (~ 5000 meter) height forecast performance for global models. Though not directly related to forecasting low-level winds, it does show the same general trend as S1 scores for sea level pressure.

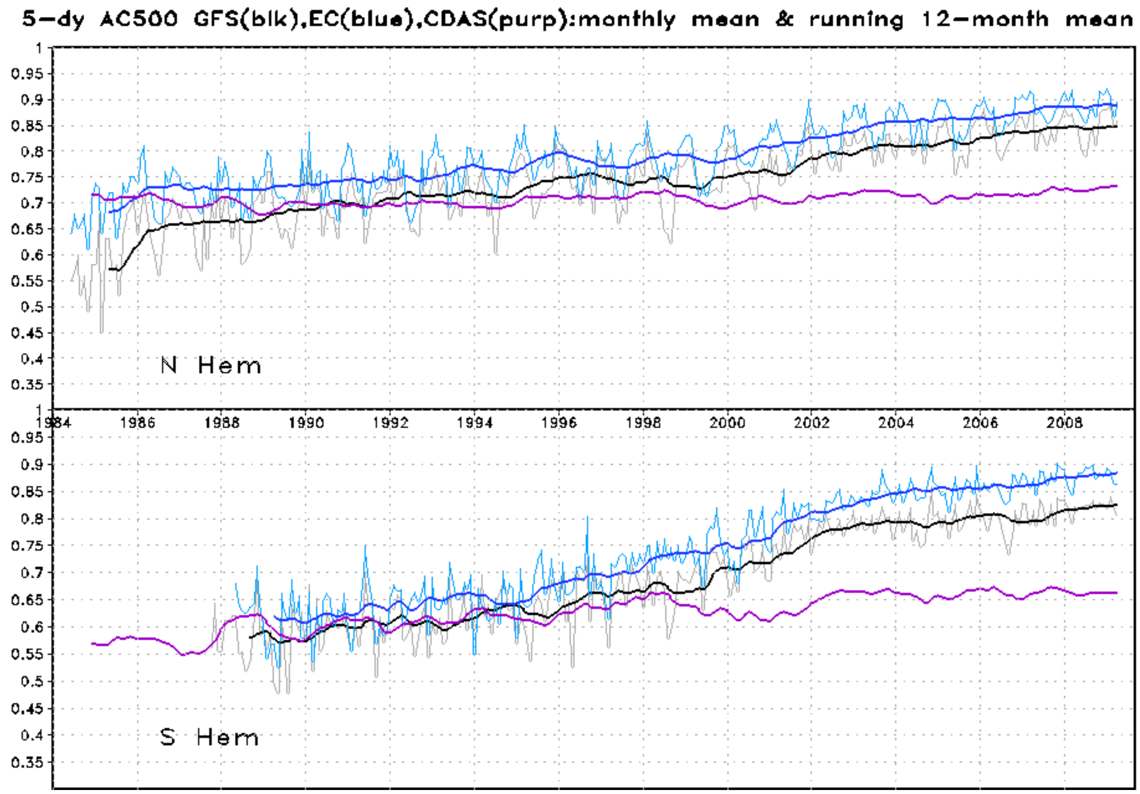

Figure 38: Time series of monthly mean anomaly correlations for 5-day forecasts of 500-hPa heights with 12-month running means plotted at the end of the year for GFS (black), EC (blue), and CDAS frozen model (purple) since 1984, northern hemisphere (top) and southern hemisphere (bottom).

From Figure 37 and Figure 38 it is possible to estimate the likely improvement in wind forecast skill over the next 10 years. The rate of forecast improvement inferred from the S1 data in Figure 37 suggests that the performance level of a 36-hour forecast in the 2003 - 2006 era would be achieved for a 72-hour forecast by approximately 2015; the performance level of the 72-hour forecast in the 2003-2006 period might be achieved for an 108-hr (4.5-day) forecast by 2020.

What does this projection mean for wind energy forecasts? Currently, a typical 36-hour forecast of the hourly energy generation has a mean absolute error of about 13-18% of a plant's installed capacity and a skill score (% reduction in mean absolute error) of about 30% over a climatology forecast. Therefore, this level of performance is likely for a 72-hour forecast by 2015. At present, a 72-hour forecast of the hourly energy output of a wind plant is near the end of the time period for which a forecast has skill over a climatology forecast. At this range, the typical MAE is between 20 and 25% and the skill over climatology is a few percent. This level of performance is a reasonable expectation for a 108-hour (4.5-day) forecast by 2015.

It is likely that these extrapolated improvements in forecast performance will be achieved since research and innovation continues to be very active in all three of the previously mentioned areas that have been driving forces behind the improvements depicted in Figure 37 and Figure 38. The improvements in remote sensing data are accelerating mainly due to advanced instrumentation aboard geostationary and polar-orbiting satellites. Improved techniques of incorporating various types of data into regional and global scale models are also being developed. Finally, the research community continues to develop and improve the physics-based atmospheric numerical models, benefiting particularly from the wide range of modeling groups in the government, university, and private sectors. Underlying these changes is the relentless advance of computing technology, making more powerful machines available at lower costs to execute more sophisticated models. Research is also underway in the development of new forecasting techniques. It has already been shown that the ensemble technique can produce better forecasts than conventional single-simulation forecasts beyond five days. With very active research in this area, it can be expected that the ensemble approach will be more widely used to improve the accuracy of shorter-term forecasts as well.

4.7.2. Short Term (Day-Ahead) Forecasting

The challenges of day-ahead forecasting are conceptually similar to those associated with the medium range forecasting task. However, the manifestation of the issues is different because the time and space scales are different. The skill in day-ahead forecasting is mostly related to the prediction of regional scale and mesoscale atmospheric features. The use of conventional atmospheric data and physics-based atmospheric models has proven to be an effective tool for this application.

The current expectation is that the bulk of future improvements for day-ahead forecasting will come from (1) continued improvements in regional physics-based atmospheric models as well as (2) increasing the amount and quality of data used to initialize the models. The new generation of atmospheric models currently being used and refined (e.g. the Weather Research and Forecasting model) by government and academic agencies employs more advanced representations of atmospheric physics and more sophisticated data assimilation techniques.

The expectation is that more sophisticated satellite-based sensors will be deployed over the next few years. This instrumentation will provide more accurate and detailed data sets describing the state of the regional atmosphere for initializing atmospheric models. Historical trends suggest that better initialization data will result in improved forecasts for wind energy and other applications.

A technique being explored for use in improving wind forecasting for both the day-ahead and hour-ahead forecast period is called “observation targeting.” The objective of observation targeting is to determine the “best” locations and parameters to measure in order to achieve the greatest positive impact on forecast accuracy at a particular site. The best locations are determined by analyzing climatological sensitivity of NWP forecasts to perturbations in the initial state for the look-ahead periods and locations of interest. Observations for locations and parameters that exhibit the greatest sensitivity have the most potential to reduce forecast error. It is still relativity early in the investigations but the hope is that observations can be targeted for specific cases such as large ramp events.

As noted earlier, a third component of the short-term forecast process is the MOS procedure. This scheme links the grid point data that come from the physics-based atmospheric models and the quantities to be predicted. Most current MOS procedures use a fairly traditional multiple linear regression approach to create the relationships. However, forecast accuracy may be improved using a more advanced statistical model such as a neural network for this application.

The ability to simulate more accurately the evolution of mesoscale features for a 24- to 36-hour period will help improve the quality of 1- to 2-day forecasts. A reasonable expectation is that in 10 years the mesoscale features will be forecasted 24 to 36 hours in advance as well as they are now forecasted 6 to 12 hours in advance. Thus, the performance of 36-hour wind energy forecasts in the year 2015 is likely to be as accurate as current 6- to 12-hour forecasts. This translates into an MAE of about 10-15% of installed capacity and a skill score of about 40% over a climatology forecast for a typical wind plant in the middle latitudes.

4.7.3. Very Short-Term (Next-Hour) Forecasting

The skill of very short-term forecasts is mostly limited by the inability to (1) define the initial structure of the atmosphere in the local area (0-200 km) around a wind plant (i.e., what is happening now?) and (2) extract the complex relationships between the measured data that serve as input to the forecast process (i.e. predictors) and the wind energy production (i.e., how is what is happening now related to what will happen in the future?).

The “what is happening now” part can be addressed by obtaining more atmospheric data from the local area surrounding the plant. The issue is determining the most cost-effective way to make such measurements. One suggestion offered numerous times in recent years has been to install "upwind" met towers to provide information about atmospheric features that are approaching a wind plant. A paper presented at the WindPower 2003 Conference demonstrated some forecast skill improvement for a wind plant on the Oregon-Washington border through the use of upstream-type met tower data in the Columbia River Basin [6]. Although there was some success in this case, there are a number of issues including tower location, installation cost, and maintenance.

This approach may be cost effective in an environment where the upstream wind direction is relatively uniform or dominant in one or two sectors. However, it may be less cost effective in an open setting where wind direction is more variable. One way to optimize instrument siting (and associated cost) is to identify the surrounding sites that are highly correlated with the variations in wind at the wind plant and install measuring equipment at only these locations. An alternative approach is to deploy surface-based remote sensing systems such as wind profilers, Doppler radars, or lidars. These instruments provide wind data over a limited atmospheric volume at a relatively high cost. It would not likely be cost effective to install such equipment solely for forecast applications around a wind plant. However, if they are already operating in a region, short-term forecasts could be improved by using data from these sensors.

Another possibility is to use data from satellite-based sensors. These instruments typically measure the amount of radiation coming from the atmosphere in multiple bands or channels that correspond to specific electromagnetic wave frequencies. The radiation measurements can be used to obtain estimates of temperature and moisture profiles of the atmosphere. They also can be used to provide some information about winds by tracking clouds.

The other part of the problem is to develop better relationships between what is happening now and what will happen in the next few hours. One approach is to employ more advanced statistical models and to optimize their type and configuration for the wind energy-forecasting problem. Techniques such as neural networks and fuzzy logic clustering may be able to identify more subtle and complex relationships between the raw input data and the quantities to be predicted. However, these advanced statistical approaches do not always improve forecasts and typically carry a high computational cost.

Another approach to mapping the relationship between the growing volume of input data and the forecast variables is to use a high resolution physics-based model. In this process, the model assimilates local-area data and generates a very short-term three-dimensional representation of the atmospheric conditions surrounding a wind plant. The fundamental principles of physics (i.e. conservation of mass, momentum, etc.) provide the links between the measured data and the forecasted quantity. This approach has never been used to generate very short-term, operational wind energy forecasts mostly because of the high computational cost. However, the steadily declining cost of computing platforms is now making this option economically viable.

Finally, improvements to plant output models could potentially benefit very short-term forecasts as well as longer time scales of wind energy forecasting. The improvements are likely to come from more (1) abundant and higher quality meteorological and energy generation data, (2) sophisticated wind plant data gathering and communications systems, and (3) detailed statistical or physical plant output model formulations.

It is likely that the improvements in forecast models as well as data coverage and quality in the local wind plant environment will yield meaningful improvements in the performance of 0- to 6-hour forecasts over the next 10 years. However, it is difficult to provide a quantitative estimate because the documented history of these very short-term wind energy forecasts is brief and the current state-of-the-art in performance for this time scale has not been as firmly established. A reasonable expectation is that there will be a 15% to 25% reduction in the typical MAE values for 0- to 6-hour forecasts over the next 10 years. This level of MAE reduction would result in an increase in the persistence-based skill score from about 20% at the present time to the 30% to 40% range in the year 2020.

4.8. DATA REQUIREMENTS

Both power production data and meteorological data play an important role in the generation of high quality wind power production forecasts. These data are used for initialization and verification of forecast models. Data from a wind plant serves three purposes in the forecasting process namely to

(1) establish relationships between the meteorological conditions at the plant and concurrent power production,

(2) identify and correct systematic errors, and

(3) provide current and recent atmospheric conditions to initialize the forecast process.

The data are useful for the first and second purposes on all time scales of forecasting. However, the usefulness of data for the third purpose varies substantially with forecast look-ahead period. Some providers advocate that successful forecasts can be made with only power generation data. However, experience shows that although these data are extremely valuable, meteorological observations provide significant added value. For example, when plant output is near rated capacity, power data alone will not indicate whether or not the wind conditions are near the plant's cut-out speed. Thus, the inclusion of meteorological observations to the data requirements is strongly recommended.

The role and importance of the meteorological data varies depending on the time scale of the forecasts, the meteorological conditions at a particular time and the geophysical characteristics (terrain topography etc.) of a particular site. The reason for such variability is that the information that determines the variation of the wind at a point, such as a wind plant, comes from an atmospheric volume of increasing size as the forecast look-ahead period increases. In the very short term (0-6 hours), the atmospheric features that determine most of the evolution of the wind at the wind plant are the small-scale features (such as sea breezes, mountain-valley circulations, etc.) near the facility.

The same concepts apply to day-ahead forecasts but the time and space scales are much different. The critical information for day-ahead forecasts is typically contained in a large atmospheric volume located hundreds of kilometers away at the time the forecast is produced. Thus, the local information from the area surrounding a wind plant is not of much direct value in the day-ahead forecasting process. The most valuable data for very short term forecasts is from the wind plant and its vicinity.

A lower cost and lower risk approach than erecting new towers is to deploy meteorological sensors at one or more sites with existing or new met towers that extend at least to a height that approximates the hub height of typical modern turbines. The issue is where to locate these sensors. One approach is to site them at locations with towers that already exist for other purposes. This strategy may reduce the cost but, except in some fortuitous situations, is not likely to maximize the forecast benefit from a particular set of sensors.

A much better approach is to perform a numerical simulation study to identify the sites that yield the optimal forecast benefit for a particular level of expenditure and forecast application. In such a study, high-resolution physics-based simulations are executed to characterize the flow in the extended vicinity of the wind plant. The output from these simulations is then used to make a map of the time-lagged correlation between meteorological parameters at all the locations in the simulation domain and winds at the plant site. The time lag used in this analysis is set equal to the desired forecast look-ahead period. The resulting maps can identify the best sites to make meteorological measurements for a particular look-ahead period. It is likely that different sites will be best for different look-ahead periods and that more than one site will be needed for a particular look-ahead period to account for varying atmospheric conditions.

Off-site measurements should not be considered as an alternative to wind plant measurements for very short-term forecasts. A network of off-site sensors may provide valuable input for very short-term forecasts at some locations. However, at other locations, sites that represent a concentrated source of predictive information for a particular wind plant may not exist (i.e. the information is scattered over many sites depending on the weather regime). The cost effectiveness of the off-site sensors can vary substantially due to a wide variety of economic, meteorological, and wind plant location factors. It is best to perform a numerical simulation study to determine the sites with the highest benefit/cost ratio or even if sites exist with acceptable benefit/cost ratios.

The day-ahead forecast application presents a different issue. Sensors deployed at the wind plant or even its extended vicinity will have little or no beneficial impact on day-ahead wind forecast performance. Sensors at wind plants will still be valuable for establishing the relationship between the atmospheric conditions and the power production and for reducing systematic errors in the forecasts, but off-site measurements in the vicinity of a wind plant will have little direct value for day-ahead forecasts. However, such sensors may have some value in analyzing day-ahead forecast performance and determining how the forecast system (especially the physics-based models) can be improved.

4.8.1. Data Collection

The successful operation of a centralized wind power production forecast system requires high quality data collection as well as timely and secure communication of input data for the forecasting process and forecasts that result from this process. The exact nature of the data collection and data communication requirements will depend upon the specific objectives and design of the forecast system.

4.8.2. Categories of Information Required

There are two categories of information required from the wind plant: wind plant parameters and meteorology. The wind plant parameters must include a general description of the plant specifications (provided initially) and a quantification of operating conditions (provided continuously at specified intervals). These data should include the following parameters:

Specifications:

- Nameplate capacity
- Turbine model
- Number of turbines
- Turbine hub height
- Coordinates and elevation of individual turbines and met structures (towers or masts) [7]

Operating Conditions:

- Wind plant status and future availability factor
- Number or percentage of turbines on-line
- Plant curtailment status
- Average plant power or total energy produced for the specified time intervals
- Average plant wind speed as measured by nacelle-mounted anemometers
- Average plant wind direction as measured by nacelle-mounted wind vanes or by turbine yaw orientation

The operating condition data should be provided at intervals that are equal to or less than the intervals for which the forecast is desired. Evidence suggests that providing data at shorter intervals than the desired forecast period may be beneficial for very short-term forecast performance. For example, if short-term forecasts are desired in 15-minute intervals, then operating condition data should be provided at intervals of 15 minutes or less. Ideally, the interval should be at most one half the forecast frequency or more often.

The meteorological parameters should consist of a general description of the meteorological measurement system(s) (provided initially) and the monitoring of ongoing environmental conditions (provided continuously at specified intervals). The parameters should be measured at a separate on-site met structure (tower or mast). More than one met structure is often beneficial for wind plants spread over large areas. A rough guideline is that each turbine in the wind plant should be within 5 km of a met structure. However, it is challenging to give exact spacing criteria as they depend on factors such as local weather regimes, terrain complexity, and availability of nacelle data. If nacelle data are provided, fewer met towers would be needed and only one may be sufficient. Thus, the recommended number and location of met towers should be based on weather regimes, terrain complexity, and availability of nacelle data.

In general, the met structures should be located at a well-exposed site generally upwind of the wind plant and no closer than two rotor diameters from the nearest wind turbine. The following parameters should be provided.

Meteorological Structure (Tower or Mast) Specifications:

- Dimensions (height, width, depth)
- Type (lattice, tubular, other)
- Sensor makes and models
- Sensor levels (heights above ground) and azimuth orientation of sensor mounting arms
- Coordinates and base elevation (above mean sea level)

Meteorological Conditions:

Data parameters required at two or more levels:

- Average (scalar) wind speed (m/s +/-1 m/s)
- Peak wind speed (one-, two-, or three-second duration) over measurement interval
- Average (vector) wind direction (degrees from True North +/- 5 degrees)

Data parameter required at one or more levels:

- Air temperature (°C +/1 °C)
- Air pressure (HPa +/- 60 Pa)
- Relative humidity (%) or other atmospheric moisture parameter

Wind measurements on the met structure should be taken at two or more levels, with the levels at least 20 m apart. One level should be at hub height. If this level is not feasible, the closest level must be within 20 m of hub height. To improve data quality and reliability, sensor redundancy for wind speed measurement at two levels should be practiced. The redundant wind speed sensor at each applicable level should be mounted at a height within one meter of the primary speed sensor. It is also recommended that at least one of the wind speed sensors nearest the hub-height level be heated to prevent ice accumulation from affecting the accuracy of wind speed measurements.

The meteorological condition data should be provided at intervals that are equal to or less than the intervals for which the power production forecast is desired. For example, if short-term power production forecasts are desired in 15-minute intervals, then meteorological condition data should be provided at intervals of 15 minutes or less. It is also useful if the met data uses the same interval as the generation data or a factor of the interval (e.g. 5 minute met and 15 minute generation data, but not 10 minute met and 15 minute generation data).

In addition to data from the met structure, wind speed and direction data (as well as temperature and pressure if available) from nacelle-mounted instruments should be provided from a representative selection of turbines. Each turbine should be within 75 m in elevation and five average turbine spacings of a turbine designated to provide nacelle data.

4.8.3. Timely and Secure Communication

All operational wind plant and meteorological conditions should be recorded and communicated by a central computing system (e.g., wind plant supervisory control and data acquisition system, or SCADA). This process will also ensure that the date and time stamps associated with the different parameters are concurrent. The wind plant SCADA system should have adequate computational and storage capabilities along with real time high-speed access to the Internet. These capabilities will empower the system to automatically generate and archive the requested operational information and make it available for use by the forecast provider and ISO. The required frequency of data retrieval will depend on the types of forecasts to be produced. If only day-ahead forecasts are required, it is satisfactory for the data to be transmitted from the plant once per day. In general, short term forecasts are recommended but such a need must be determined by ISO operations. If short-term forecasts are required, then the data must be transmitted at a frequency equal to or less than the forecast update frequency.

A key issue in the performance of wind power production forecasts is the consistent availability of high quality production and meteorological data from wind plants. Experience indicates that the issue has emerged as one of the biggest obstacles to achieving optimal forecast performance. Thus, it is prudent to consider ways in which a high level of data availability and quality can be achieved when designing a forecast system. One important factor is the complexity of the mechanism that communicates data from the wind plants to the forecast provider. Complex protocols or communication schemes provide more opportunities for data transmission failure. Initiation and maintenance of these schemes requires considerable education of all concerned personnel.

Another important factor is the incentive that wind plants have to maintain their wind forecasting related sensor and communication systems. A significant issue in other wind power production forecast applications has been the priority that wind plants place on responding to problems with their meteorological sensor or data communication systems. In some cases, the data flow has been interrupted for a week or more because a computer system needed to be rebooted and no one executed the appropriate command during that period. Thus, data outages that could have easily been limited to hours were extended to more than a week. This issue suggests that a centralized wind power production forecast system should be designed in such a way as to maximize the incentive of wind plants to maintain their sensor and communications equipment and to respond to problems with these systems as quickly as possible.

4.9. CENTRALIZED (ISO) VS. DECENTRALIZED FORECASTING SYSTEM

One of the most basic issues is whether the forecasts should be provided through a centralized or decentralized forecasting system. In a purely *centralized* system, one (or more) providers are contracted through a single central entity (such as the ISO) to provide forecasts for all wind generation facilities within the electric system. The central entity may then provide the forecast information to the individual wind generation resources as well as use the information for its own purposes. In a purely *decentralized* system, each wind generation resource would contract with a forecast provider or potentially produce forecasts internally without a provider. Each generation facility would then supply the forecast (schedule) to the system operator. Both centralized and decentralized systems have advantages and disadvantages but it is certainly possible to have a hybrid approach that incorporates elements of both.

A primary factor is cost. A centralized system is likely to have a lower total cost since the economies of scale would likely enable a provider to deliver forecasts with a lower cost per generation facility. However, it is possible that decentralized costs might approach those of a centralized system if one or two providers were the dominant suppliers for the individual generation facilities and could thereby achieve economies of scale. Of course, there would be no assurance of this outcome if a decentralized system were implemented.

A second factor is forecast quality. Forecasts for larger plant aggregates will tend to be more accurate than those for a single one and forecast providers would have more data from all wind sites. It is not clear which approach (if either) would achieve a better overall forecast performance. In theory, the decentralized approach would encourage a forecast provider to focus more attention on each individual site and possibly develop a higher degree of customization for the site. If the provider did not perform well for that site, the owner/operator of the facility could seek another provider to improve performance. If all owner/operators aggressively sought the best possible forecasts for their site, it could result in the best system-wide forecast as well. However, in practice, there would likely be a large degree of variation in the demand for quality performance for each facility.

Some facilities might pay a lot of attention to this aspect while others might see it advantageous to reduce costs by going with the least expensive provider (regardless of quality) or may even do forecasts themselves. The implementation of system-wide forecast performance standards or penalties for poor scheduling performance might result in the best possible forecasts for each site. However, if the motivation is solely to avoid penalties or meet a minimal performance standard, it is not likely that the owner/operator would be willing to incur an added cost to achieve better performance beyond the minimum standard.

A third factor is data utilization. In a centralized system, it is likely that data from all wind generation facilities will be available for use in forecast generation at other facilities. This attribute can occasionally have significant benefit for short-term forecasts since data from an “upstream” facility might be a useful predictor for future variations at a “downstream” facility. In a decentralized system, it is likely that proprietary issues will prevent a vendor from using data at one facility to benefit forecasts at another facility even if both use the same forecast provider. The situation would be even more difficult if the facilities used different forecast providers [4].

A centralized system will probably ensure more uniform quality. It is also possible that benefits of site-specific customization will not be very significant and that much of the useful customization will be similar at nearby sites. In practice, most customization benefits for individual sites occur for the very short-term look-ahead periods. The centralized system also provides more opportunity to implement a multi-forecaster ensemble since two or more providers could forecast for all generation facilities. This scenario is unlikely to occur in a purely decentralized system. The recommendation is for ISO-NE to implement a centralized forecasting system.

4.10. USE OF MULTIPLE WIND FORECAST VENDORS

There are likely several advantages of using multiple vendors in order to improve the overall confidence in wind power forecasts. One advantage is that certain vendors may employ methods that are better at forecasting for certain time periods. Some vendors may be better at forecasting for certain meteorological situations or seasons. Having multiple forecast vendors gives the ISO an opportunity to select the best single performer for a given situation or create an ensemble of forecasts based on the time period or forecast situation. The final product could be either the single best forecast or a weighting of individual forecasts.

In order to take maximum advantage of multiple providers, the ISO would need to track and compare vendor performance. At a minimum, the evaluation should include vendor performance over various forecast time periods and months to identify specific trends. More sophisticated evaluation methodologies should also be considered. For example performance tracking could be done by meteorological regime (weather pattern). This type of evaluation would be relatively complex to set up but it could yield significant forecast improvements.

Using multiple vendors also gives the ISO redundancy, thus reducing the possibility of a missed forecast. Although a missed forecast should be rare for even one vendor, the redundancy provided by multiple vendors gives the ISO a higher level of reliability than having a single provider. The disadvantages caused by multiple vendors are added cost and increased management overhead. In addition, providers using similar methods will likely produce forecasts that are highly correlated. In this case, multiple forecasts with very similar performance metrics may provide little added value.

Many markets, both in the U.S. and Europe, are now using multiple forecast providers. In Germany, four providers are used to support their power distribution network (grid) operators. AWST recommends using a two-provider centralized system. This configuration ensures a higher level of reliability due to additional redundancy and facilitates the use of ensemble forecasts that, in theory, are likely to have better overall performance than a single forecast. It is also possible that one provider will perform best under some circumstances. Two providers may ensure that the system is quickly updated with new forecasting technology, since there will be some element of competition between the providers. Although more than two providers might be considered, especially if different forecasting methodologies are used, the benefits obtained from additional forecast providers are not likely to justify the cost.

4.11. PROPOSED CONTROL ROOM INTEGRATION OF WIND POWER FORECASTING

The use of wind forecasting in the power system control room will reduce operational impacts and costs. The addition of wind energy to a power system grid will increase the amount of variability and uncertainty in net load as compared to the use of energy produced by conventional means. Accurate weather forecasts can reduce the uncertainty, thereby allowing for more cost efficient use of conventionally produced energy. As the penetration of wind into the power markets increases, the need for a sophisticated integration of wind forecasting for the ISO also increases. The ISO requirements for high reliability and safety make this integration especially challenging. The following factors should be considered when integrating wind power forecast systems into the control room:

- **Routine forecasts:** Routine forecasts would be provided for three look-ahead periods, very-short term, short-term and medium range term.
- **Ramp Warning Forecasts:** A separate ramp potential warning system would be part of the forecasting system. When there is a high probability of a ramp within 24 hours, the system would provide hourly ramp alert updates, giving detailed forecasts that would include the probability, amplitude (magnitude), duration, type, and cause of the ramp event. The day-ahead and beyond forecasts would only provide probabilities of ramp occurrences.
- **Severe Weather Forecasts:** A severe weather warning system would provide the potential for events such has high winds, thunderstorms, icing, and heavy snow for at least the first 48 hours. When there is a potential for severe weather within 24 hours, the warning system would deliver hourly updates to operators. For the day-ahead, only the general potential of high, moderate, or low risk would be provided for each category of severe weather.
- **Offshore Forecasting:** In addition to all other forecasts that onshore plants would need, a wave forecast is critical for offshore plants in order to help schedule plant maintenance.
- **Monitoring:** To enhance both safety and reliability, an operator should be dedicated to the monitoring of all of the renewable (variable) power generations resources (primarily wind and solar).
- **Visualization Tools:** User friendly visualization would be needed for the proper monitoring of events that could cause ramp and/or severe weather impacting individual plants and the grid as a whole.
- **Plant Clustering:** It is suggested that pooling of wind plants into clusters will make it easier for an optimized integration of wind power. The geographically distributed clusters would be treated as one large (virtual) wind power plant. The plant cluster could be viewed as a "super plant". For this purpose, it is suggested that all wind plants that are directly or indirectly connected to one transmission network node will be associated with one wind plant cluster. A wind plant cluster manager would assist the ISO by operating the cluster according to the requirements of the power generation and transmission system. This approach would have particular value if there were transmission congestion in an area that might require curtailment when a specific aggregate of plants exceeded threshold output.
- **Education and training:** During the early stages of integration of renewable (variable) power generation resources with traditional power systems, there is a large need for education and training on how to use wind forecasting effectively. Training topics should address a number of areas such as interpreting error characteristics for deterministic versus probabilistic forecasts of ramps and/or other events. The discussion

should cover the overall forecasting process and a high level review of physical versus statistical models as well as the use of observational data for validation and correcting model biases.

4.12. SUMMARY

Conventional power plants produce a near-constant output except in rare emergency outages, but the variability of wind energy presents a special challenge for utility system operations. The output of a wind plant fluctuates, at times amounting to several hundred megawatts in a matter of an hour or two. If the fluctuations cannot be predicted, they create reliability risks and additional costs for the electricity system and consumers. Wind generation forecasting is an important tool for reducing the effects of wind generation variability and uncertainty on operation of the grid.

In wind energy forecasting it is useful to divide the forecasts into three time scales: (1) very short-term “next-hour” (0-6 hrs); (2) short-term “day-ahead” (6-72 hrs), and (3) medium range (3-10 day). The skill in very short-term forecasting is related to the prediction of small-scale atmospheric features (< 200 km in size) in the vicinity of the wind plant. A major challenge is that there is usually very little data gathered on the scale needed to support the forecasting of very short-term features. There are a wide range of spatial and temporal scales that determine the variations in the wind energy power generation, so it is necessary to use a diverse mix of data sources to achieve the best possible forecast performance.

The main problem with data beyond plant boundaries is that the spacing between measurements is too large (because of economic constraints) to adequately represent the small or even sometimes medium scale atmospheric features that are responsible for short-term variations in wind energy output. Unfortunately, there are large areas where very little in situ data are gathered due to the cost of maintaining such systems. As a result, data coverage is far from uniform and some regions have far less data upstream than others. The expectation is that remote sensing technology will eventually overcome these limitations of data resolution and coverage.

A major component of the forecast process is data processing. Data processing tools known as mathematical or numerical models ingest data and generate predictions. The four fundamental categories used in the wind energy forecasting process are: (1) physical atmospheric models, (2) statistical atmospheric models, (3) wind plant output models, and (4) forecast ensemble models. There are many types of models in each of these major categories and a particular forecast system may employ one or more of each type.

Evaluation of the forecasts is a very important yet complex process. The most significant issue is which parameter(s) should be used as the metric(s) for forecast performance. The choice of metrics can have a significant impact on the interpretation of forecast performance. One fundamental distinction in using metrics is absolute versus relative performance. A second distinction is the sensitivity to different portions of the error frequency distribution. Some parameters are much more sensitive to outliers, i.e. forecasts with anomalously large or small errors. A third issue is that a forecast system can be tuned to produce better performance for a specific metric while possibly degrading the performance for other metrics.

The current state-of-the-art forecasting techniques exhibit considerable skill in both very short-term and short-term forecasting. Very short-term hourly forecasts typically outperform persistence by 10% to 30%. Short-term hourly forecasts usually outperform persistence and climatology by 30% to 50%. At present, for the medium range past day 5, hourly forecasts typically do not outperform climatology so have limited usefulness. However, medium range forecasts of the *average* energy production over a day or half-day usually outperform climatology out to 6 or 7 days thus providing some value. The MAE of very short-term forecasts is typically in the range of 5% to 15% and the errors increase rapidly (about 1.5% of installed capacity per hour) with an increase in the forecast time horizon. After the short-term period, the error growth rate decreases to about 0.1% of installed capacity per forecast hour. This trend indicates that the mean absolute forecast errors remain in the 13% to 21% range for 1 to 2 days ahead and rise to the 20% to 25% range (that is typical of a climatological forecast) after about 3 days.

Forecast performance can vary substantially (5% or more of installed capacity) as a function of location, season, weather regime, and size and diversity of the wind plants. Much of this variability is related to the predictability of specific weather regimes, with some sensitivity to small variations in conditions at the time of the forecast. Forecast performance in these types of regimes is normally much worse than for regimes with less sensitivity.

Studies have also shown that size and diversity of wind plant aggregation can impact forecast statistics. For example, in the Alberta Wind Forecasting Pilot Project the RMSE for regional day-ahead forecasts were 15-20% lower than for the individual farms and the RMSE for system-wide day-ahead forecasts was 40-45% lower than for the individual farms.

In the next 10 years, it is expected that improvements in (1) the quality and quantity of global, regional, and local area atmospheric data, (2) sophisticated statistical and physics-based atmospheric models and data assimilation schemes, and (3) the availability of lower cost computing power will yield substantial improvement in forecast performance. Although there is likely to be some improvement in all forecast time horizons, the most significant improvements are likely to be in the start of the medium range forecasting period (3-5 days) and the start of the short-term forecast period (first 6-18 hours).

As the amount of wind generation increases on grid systems, the occurrence of large and rapid changes in power production (ramps) is becoming a significant grid management issue. Forecasting techniques for typical wind conditions do not do well in forecasting rapid changes in winds that cause large power ramps. Therefore, ramp forecasting requires a separate methodology and system designed specifically to forecast and alert operators of the likelihood of ramp events. Several different types of meteorological processes cause large ramps in wind power production. The data and type of forecast method required to optimally predict each type of ramp event varies.

A ramp forecasting system should alert operators about the occurrence of a ramp at the earliest possible time. Forecasts for the first 24 hours should include the probability, amplitude (magnitude), duration, type and cause of the event. The alert system should include hourly ramp forecast updates when a ramp event has been forecasted within 24 hours. For the day-head, only probabilities of ramp occurrence should be given for each hourly time period. For the medium range forecast, only daily ramp probabilities should be given.

Both power production data and meteorological data play an important role in the generation of high quality wind power production forecasts. The successful operation of a wind power production forecast system requires well orchestrated data collection plus timely, secure communication of the input data for the forecasting process and the resulting forecasts. Two categories of data are required from the wind plant: wind plant parameters and meteorology. Data outages have an adverse impact on forecast performance, especially for the very short-term look-ahead periods.

The data from a wind plant serves three purposes in the forecasting process: (1) it provides information about relationships between the meteorological conditions at the plant and the plant's concurrent power production; (2) it provides information to determine the systematic errors in the forecasts and allows them to be statistically corrected, and (3) it provides information about the current and recent state of the atmosphere which contributes to the starting point of the forecast process. Meteorological sensors should always be present at wind plants to fulfill objectives (1) and (2) above. Off-site measurements should never be considered to be an alternative to wind plant measurements for the very short-term forecasts. The usefulness of data for the third purpose varies substantially with the forecast look-ahead period.

To maximize the performance of very short-term forecasts, it is important to gather as much information as possible in the vicinity of the wind plant. The day-ahead forecast application presents a different issue. Thus information and data needed to make day-ahead forecasts must primarily come from simulations using a physics-based atmospheric model. Sensors deployed at the wind plant or its extended vicinity have little impact on making day-ahead wind forecasts, but are valuable for evaluating the day-ahead forecast performance and determining how the forecast system can be improved.

There is a need to provide operators with information regarding the overall weather situation, especially with respect to extreme meteorological events that may have a serious impact on wind plant operations. Information and forecasts of severe weather events, such as high winds, thunderstorms, and freezing rain should be provided. Information on the feature causing the event should also be provided so operators can track and verify the actual occurrence of the event in real time.

Offshore wind plants will require wind, wind power and wave forecasts that can impact various operations. There are fundamental differences between the wind conditions over land and offshore due to the influence of the surface on the flow. Forecast models must be able to account for ocean-atmosphere interactions, the specific nature of the marine boundary layer, and the fact that observed data will be sparse over the ocean. The wave-forecast model needs to include relevant shallow water dynamics.

Two basic interrelated issues for the ISO to address are selecting between (1) a centralized or decentralized forecasting system and (2) a single or multiple vendor forecasting service. The recommended approach is to implement a two-provider centralized system. This strategy ensures a higher level of reliability due to the redundancy and increases the likelihood of improving the forecast performance over a single provider.

The use of wind forecasting in the ISO control room will likely reduce operational impacts and costs. For optimum management of wind power, it is essential that the wind power forecasting system be fully integrated into the ISO control room. It is suggested that pooling of wind plants into clusters may make it easier for an optimized integration of wind power. It would likely improve grid management efficiency if an operator were dedicated to the monitoring of all of the renewable (variable) power generation resources. Finally, an aggressive training program for all users of forecast information would likely improve the management of the wind resources.

4.13. REFERENCES

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Section 5

GRID OPERATIONS WITH SIGNIFICANT WIND GENERATION

Experience with wind plants from the power system operator's perspective is developing but still rather limited. In the U.S., there are only a handful of areas where the penetration of wind generation has reached the level where operating practices have necessarily evolved in response. ERCOT is perhaps the best example, although the Pacific Northwest, Colorado, Alberta, and New Mexico are not far behind. Continued development over the coming years will bring many more operating areas into this category. MISO might be the best example here. The current installed capacity of around 6 GW is small relative to the resources and loads in its market. However, the concentration of wind generation in the western reaches of the market footprint and prospects for much more development have placed a priority on developing the practices, procedures, and policies that will be critical going forward.

Wind integration studies conducted over the past decade have lead to insights that are proving useful for anticipating challenges for operating power systems with large amounts of wind generation, and for assessing the effectiveness of various measures for mitigating impacts. While some general lessons have been learned, the studies have also shown that the make-up of a particular system – portfolio of resources, nature of loads, amount and location of wind generation, operating rules – has a substantial impact on the magnitude of the challenge.

Actual progress – as measured by the performance of wind plants in the field – is perhaps greater on the interconnection side of the ledger. As illustrated in Section 3 commercial wind turbine technology has advanced considerably in technical capability. Wind plants have been successfully interconnected in very remote and weak areas of the transmission network. With proper engineering, wind plants can exhibit terminal behavior equivalent to conventional power plants in terms of reactive power and voltage control. In some respects, the dynamic behavior of wind generation facilities during and immediately following large disturbances on the transmission network can be superior to that of conventional equipment. Substantial work remains, however, on the development, testing, and validation of the computer models required for this engineering.

The subject of this section is on the design and operation of power grid with significant wind generation, with those responsible for maintaining the very high reliability and economic efficiency the target audience. Topics and information from the previous sections are relevant here, but from the perspective of those with overall responsibility for the grid.

5.1. BACKGROUND

Concerns over how significant amounts of variable wind generation can be integrated into the operation of a control area stem from the inability to predict accurately what the generation level will be in the minutes, hours, or days ahead. The nature of balancing area operations in real-time or in planning for the hours and days ahead is such that increased knowledge of what will happen correlates strongly to better strategies for managing the system. Much of this process is already based on predictions of uncertain quantities. Hour-by-hour forecasts of load for the next day or several days, for example, are critical inputs to the process of deploying electric generating units and scheduling their operation. While it is recognized that load forecasts for future periods can never be 100 percent accurate, they nonetheless are the foundation for all of the procedures and processes for operating the power system. Increasingly sophisticated load forecasting techniques and decades of experience in applying this information have done much to lessen the effects of the inherent uncertainty.

The nature of its fuel supply is what distinguishes wind generation from more traditional means for producing electric energy. The electric power output of a wind turbine generation is primarily a function of the speed of the wind passing over its blades. The speed of this moving air stream exhibits variability on a wide range of time scales – from seconds to hours, days, and seasons. The degree to which these variations can be predicted with some level of accuracy also varies. It should be noted that this is not an entirely unique situation for electric generators. Hydroelectric plants, for example, depend on water storage that can vary from year to year or even seasonally. Generators that rely on natural gas as their sole fuel source can be subject to supply disruptions or storage limitations. That said, the overall effects of the variable fuel supply are significantly larger for wind generation.

Impacts on the operation of the transmission grid and the control area relative to wind generation are dependent on the performance of the wind plants within that area as a whole, as well as on the characteristics of the aggregate system load and the generation fleet that serves it. Large wind generation facilities that are connected directly to the transmission grid employ large numbers of individual wind turbine generators. Individual wind turbine generators that comprise a wind plant are usually spread out over a significant geographical expanse. This has the effect of exposing each turbine to a slightly different fuel supply. This spatial diversity has the beneficial effect of “smoothing out” some of the variations in electrical output. The benefits of spatial diversity are also apparent on larger geographical scales, as the combined output of multiple wind plants will be less variable than with each plant individually.

The system load itself exhibits some unpredictable variations, both within an hour and over the course of the day. Because system operators are concerned with the balance of net load to net generation in their control area, load and wind variations cannot be considered separately. The impact of uncorrelated variations in load and wind over time will be considerably less than the arithmetic sum of the individual variations. This aggregation effect is already a critical part of control area operations, as responding to or balancing the variations in individual system loads, rather than the aggregate, would be exorbitantly complicated and expensive, as well as non-productive.

Wind generation forecasting is acknowledged to be very important for continued growth of the industry. Despite the increasingly sophisticated methods used to forecast wind generation, and the improving accuracy thereof, it is certain that large amounts of wind generation within a grid control area will increase the overall demand for ancillary services.

5.2. MAJOR LESSONS LEARNED FROM U.S. WIND INTEGRATION STUDIES

Within the wind industry and for those transmission system operators who now have significant experience with large wind plants, the attention has turned to not whether wind plants require such support but rather to the type and quantity of such services necessary for successful integration. With respect to the full range of ancillary services, there is a growing emphasis on better understanding how significant wind generation in a control area affects operations in the very short term – i.e., real-time and a few hours ahead – and planning activities for the next day or several days.

Recent studies considering the impact of wind generation facilities on real-time operation and short-term planning for various control areas are summarized in Reference [1]. The methods employed and the characteristics of the power systems analyzed vary substantially. There are some common findings and themes throughout these studies, however, including:

- Despite differing methodologies and levels of detail, ancillary service costs resulting from integrating wind generation facilities are relatively modest for the growth in U.S. wind generation expected over the next three to five years.
- The cost to the operator of the control area to integrate a wind generation facility is obviously non-zero, and increases as the ratio of wind generation to conventional supply sources or the peak load in the control area increases.
- For the penetration levels considered in the studies summarized in the paper (generally less than 20 percent by capacity) the integration costs per MWH of wind energy were relatively modest. As penetration levels begin to approach 20 percent by capacity, however, the costs begin to rise in a non-linear fashion.
- Wind generation is variable and uncertain, but how this variation and uncertainty combines with other uncertainties inherent in power system operation (e.g. variations in load and load forecast uncertainty) is a critical factor in determining integration costs.
- The effect of spatial diversity with large numbers of individual wind turbines is a key factor in smoothing the output of wind plants and reducing their ancillary service requirements from a system-wide perspective.

Understanding and quantifying the impacts of wind plants on utility systems is a critical first step in identifying and solving problems. A number of steps can be taken to improve the ability to integrate increasing amounts of wind capacity on power systems. These include:

- Improvements in wind-turbine and wind-plant models
- Improvements in wind-plant operating characteristics
- Carefully evaluating wind integration operating impacts
- Incorporating wind-plant forecasting into utility control-room operations

- Making better use of physically-available (in contrast with contractually-available) transmission capacity
- Upgrading and expanding transmission systems
- Developing well-functioning hour-ahead and day-ahead markets, and expanding access to those markets
- Adopting market rules and tariff provisions that are more appropriate to weather-driven resources
- Consolidating balancing areas into larger entities or accessing a larger resource base through the use of dynamic scheduling
- Improving the operational flexibility of the entire conventional generation fleet. This includes mechanisms to encourage use of and investment in thermal and hydro generation for increased flexibility.

5.3. ASSESSING SPECIFIC OPERATIONAL ISSUES RELATED TO WIND GENERATION

Integration encompasses the influence of wind plants on and participation in short-term scheduling and real-time operations of the ISO-NE system. Included are the nature of wind energy delivery in real time and the control thereof, mechanisms for coordination of wind plant operation with ISO-NE system operators, and the collection and communication of important operational data.

The findings from previous integration studies of other regions are generally applicable because they directly address issues stemming from variability and uncertainty associated with wind generation. For a specific balancing authority, they may or may not be applicable or possible. Detailed studies, like one initiated by ISO-NE in 2009, are the mechanisms for identifying operational issues and challenges in a given context.

A discussion of specific operational issues related to wind generation follows.

5.3.1. Variability and Uncertainty

As mentioned above, electric demand is highly variable and forecasts have varying levels of uncertainty depending on the time of day or year and the horizon. Wind generation will incrementally increase both of these characteristics.

5.3.1.1. Real-Time Variability

Generation capacity on AGC and assigned to regulation duty is the primary means for matching generation to load in real-time. Over longer periods, sufficient ability to adjust generation up or down in response to trends in the balancing area demand – e.g. morning and evening ramps – must be maintained. Wind generation increases these requirements.

Previous studies are finding that while the output of a wind plant (or multiple plants) exhibits variations across all time scales ranging from seconds onward, the fastest of these fluctuations (tens of seconds) are modest compared to those already exhibited by load. Wind plant output variations on this time scale have been characterized from measurement data as normally-distributed random deviations from a rolling average trend (with an averaging window of 20 to 40 minutes). For a 100 MW wind plant, the standard deviation of the variations is about 1% of the nameplate rating. In addition, the variations from an individual wind plant are uncorrelated to the variations from other plants and from those in the load, which leads to a substantial statistical smoothing effect as the amount of wind generation increases.

System impacts of these variations will obviously depend on the amount of wind generation relative to load, but for the wind penetrations studied to date, the effects are quite modest.

Variations in wind plant output over slightly longer time frames appear to be of more significance for balancing. Electricity demand exhibits a strong and familiar trend over periods of the day, depending of course on season and other factors such as weather. Short-term forecasts of this trend allow flexible generation to be dispatched economically and in advance to "follow" the movement. Fluctuations in wind generation over intervals of five to ten minutes or longer appear not to be so well behaved or predictable. These variations are due to local effects within the wind plant or plants, driven by turbulence, terrain effects, and turbine layout, among other possible factors. Consequently, they are very difficult to predict.

A result is that the errors in the short-term forecast of wind generation will increase the regulation burden, as units following the load via frequent economic dispatch are effectively controlled to the forecast rather than the actual wind.

The analytical approaches employed in wind integration studies have evolved to where it is possible to estimate these impacts on regulation and balancing with the standard data sets developed for these investigations. While not rigorous, it is possible using these techniques to make reasonable estimates of the wind generation impacts on the quantity and quality of flexible resources needed to perform these functions.

5.3.1.2. Extreme Ramps

Large changes in balancing area demand over one or more hours are important periods from an operations perspective. Adequate flexibility in the committed generation – "room to move" – must be available to avoid significant violations of control performance or shedding of load.

Wind generation can enhance these periods of stress on the system by moving in the undesirable direction – down in the morning or up in the evening.

5.3.2. Wind Plant Control

In the future, as wind plants provide an increasing amount of the energy delivered to load, it will become increasingly necessary for them to participate in a more complete range of system operation and control functions, similar to conventional plants. This will be made possible by the increasing capability of wind plant output forecasting systems and the integration of forecasting capability with wind plant control capability in an AGC system. With a fully integrated system, the output of the wind plant can be forecast and scheduled both hour(s) ahead and day ahead, the wind plant can participate in the volt/VAr control system, and it may provide regulating capacity and spinning reserves if called upon to do so. It may also provide a governor response and inertial response if required.

Ramp-rate limits can be set to meet the requirements for specific grids and applications. Ramp-rate limits can be imposed for grid operating conditions that warrant their use, and need not be continuously enabled. The controller allows for switching in and out of ramp-rate control by either the plant operator or in response to an external command.

Again, with the data sets compiled for wind integration studies, impacts of wind generation on ramping can be examined statistically, and the effects on the system determined through chronological production simulations. The need for, and nature of, mitigation measures can also be identified.

Assessing applications for active power control capabilities of modern wind plants must be approached carefully, since some of the features require that wind energy be dumped. For those features that operate infrequently or for very limited durations, the amount of lost energy may be very small or negligible. Ramping controls for start-up or planned shut-down are in this category. At the other end of the spectrum, full participation in AGC requires that potential wind energy be spilled continuously, and may have a significant impact on project economics.

Economics must be a key factor in decisions to use or require wind plant active power controls.

5.3.3. Effects on contingency reserve requirements

The operating experience to date with wind generation, including the detailed integration studies performed over the past decade show, that while very large changes in wind generation in short amounts of time are possible, seldom if ever would they rise to a level that would meet the current definition of a “contingency” event in the U.S. electric power industry. In fact, at least one reserve sharing group in the West has clarified the definition of contingency to require that it be accompanied by a breaker operation or change in operational status of an element of the bulk grid to explicitly exclude changes in wind generation.

Both experience and meso-scale data show that large changes in production, especially in the aggregate production of many individual wind plants, do not occur instantaneously, but rather over periods of hours. Some relatively extreme cases have already been observed; BPA’s challenge with wind generation in the Columbia Gorge, where ramps in aggregate production over periods as short as 30 minutes can be significant, is a prime example. Even here, however, the issue is one of regulation and load following, not contingency reserves.

5.3.4. Minimum Generation Issues and Curtailment

In many parts of the U.S., there is a tendency for wind generation to produce more energy in off-peak hours than on-peak. During light load seasons, high levels of wind production overnight can create problems with minimum generation.

For a defined scenario of wind generation, production simulations can quantify the anticipated frequency and timing of minimum generation constraints. Mitigation measures include de-commitment of conventional units to provide “legroom”, or curtailment of wind generation. The ability to quantify the number of hours over a year in which wind generation curtailment might be invoked is a significant benefit of the production simulation approach.

5.3.5. Forecasting Applications and Implementation

Production forecasts are critical for integrating significant amounts of wind generation. The science of wind generation forecasting and modern implementations of forecasting systems is described in Section 4   The purpose of this section is to provide some additional perspective on the use and implications of those forecasts for power system operation and control.

5.3.5.1. Short-Term Forecasts and Uncertainty

In conventional utility operations, uncertainty about load in the coming minutes and hours translates to additional reserves and regulation. Here the variability and uncertainty of wind plant production become intermingled because it is difficult to accurately forecast short-term variations. Distinguishing between a sharp but temporary drop in production and persistent decline in output that could continue over multiple hours is very difficult. Policies for dealing with normal variations in wind generation must be segregated from those actions that are necessary for the very large and extended but infrequent, changes in production.

5.3.5.2. Longer-Term Forecasts

Wind generation forecast accuracy declines with the forecast horizon. Day-ahead forecast accuracy of 15 to 20% MAE allows for significant hourly and even daily errors. How the forecast is used in day-ahead decision-making is both a technical and economic question: Adequate capacity must be available to meet the expected load, but committing excess capacity degrades economic performance.

The difficulty of the apparent trade-off between security and economic efficiency will depend on the amount of wind generation and the type of resources in the supply portfolio. Integration studies can help to quantify the sensitivity of economic efficiency to the accuracy of wind generation forecasts or the penalty associated with discounting the expected wind generation in a security-constrained unit commitment (SCUC).

The question of economic efficiency also extends to the structure and rules for day-ahead energy markets. There is little experience to date from other ISOs on how wind plays or is required to play in the bidding process, but it has been recognized in those market areas where significant wind generation is anticipated. Consideration of wind energy delivery for the next day should increase the efficiency of the day-ahead market process, but the likely errors due to expected day-ahead wind generation forecast errors must be acknowledged.

5.3.5.3. "Special" Forecasts

Large changes in wind generation over relatively short periods of time are infrequent but can pose serious risks to system reliability. Advance knowledge of such events is the difference between posturing the system defensively thousands of hours per year and incurring the associated cost, or taking appropriate action during only the dozens of hours when there might be risk. The ability to forecast large, sudden changes in wind generation is a key to reducing the cost of integrating wind generation.

As the discussed in Section 4 forecast systems optimized to minimize errors in day-ahead predictions may not be the best approach for predicting large ramps or high-wind cutout events. This fact must be recognized in the development of special forecasts, along with the specific needs and requirements of the operators.

5.3.6. System Steady-State and Dynamic Performance with Wind Generation

The technology for converting energy in a moving airstream to electricity differs significant from that employed in conventional bulk electricity generation. These differences have (and still are) posing some major challenges for power system engineers charged with designing and maintaining reliable systems. As described in Section 3 commercial wind generation technology is quite sophisticated, and capable of exhibiting terminal behavior and performance consistent with good engineering practice.

The focus of the electric power industry to date has been on detailed design studies for the interconnection of individual wind plants. As the penetration of wind continues to grow, evaluations of system-level impacts will become more important. Specific technical issues that will require assessment include:

- Voltage regulation and reactive power dispatch. Control of reactive power at the terminals of a wind plant can be designed to provide the same levels of static and dynamic control as conventional plants, possiblly even better. This is not an inherent feature of wind plants, however – proper engineering of the plant is necessary to achieve these levels of performance. As the number of wind plants with such capability grows, system level studies will be required to prevent undesirable interactions.
- System behavior during and disturbances. The response of the system to large-signal disturbances such as faults will be affected by wind generation. However, it has been shown that the dynamic behavior of wind plants can possibly be “better” than conventional plants due to the sophisticated generation control technologies in commercial wind turbines. In any case, the responses will be different than those form more familiar conventional generators, which increases the importance of adequate and verified models for wind plants.
- Potential reduction in system inertia. The current installed fleet of commercial turbines is mostly insensitive to excursions in system frequency. If wind generation displaces enough conventional generation, the dynamic performance of the system can be altered. In isolated systems, the lower aggregate inertia results in faster and possibly larger excursions in frequency following loss of generation or load. In a large interconnection, lower regional inertia can adversely affect interties following similar disturbances
- System protection. Wind turbines and wind plants do not fit well into the conventional analytical methodology for calculating short-circuit currents because of the generator and control technologies used. It is important, however, that in-feed from wind plants to transmission system faults be characterized so that transmission line protection can be properly designed. With a modest to large number of wind plants, likely concentrated in a single region, careful assessments of system protection will be necessary, for which understanding of the contributions from wind plants is a pre-requisite.

5.4. COMMUNICATIONS INFRASTRUCTURE FOR MANAGING WIND GENERATION

Most wind plants connected to the bulk power system are of significant size, and therefore visible to system operators. Consequently, communication and some types of control are required to achieve necessary levels of interoperability.

Wind plants constructed over the past decade contain a surprising, to those in the utility industry, amount of internal information technology for data collection, communications, and control. Most plants have a high-bandwidth fiber optic connection from each wind turbine to a main control center. Large amounts of data are collected at very frequent intervals to support functions such as power curve verification and maintenance monitoring. Increasing turbine capabilities are being leveraged by this communication infrastructure to achieve advance levels of performance such as ramp rate control, smart curtailment, and voltage control.

A number of vendors have serviced the wind plant SCADA market over the past two decades, most with proprietary and turn-key systems.

Now that wind generation is a noticeable player in the bulk electric generation picture, the information previously confined to the internal plant IT infrastructure and used almost exclusively for proprietary purposes is of much greater interest to the outside world, namely the operators of the bulk transmission system and wholesale energy markets. How the subset of information that should be shared might be accessed is the relevant question.

Communications for electric utility applications has undergone a very substantial transformation over the past twenty years, and has lead to the development of international standards the promise a new generation of interchangeable pieces and parts that speak a common language.

The legacy development of wind turbines in Germany and Denmark, where individual or small clusters of turbines are connected to public distribution networks and therefore nearly invisible to bulk system operators, inspired a movement to develop a wind energy specific communications standard that builds on the developments mentioned above. The result is the IEC 61400-25 series of standards (Figure 39), each known under the general title “Communications for Monitoring and Control of Wind Power Plants”. Key features of the standards series include:

- The standard addresses all communication means between wind power plant **components** such as wind turbines and **actors** such as SCADA systems and dispatch centers.
- Applies to any wind power plant operational concept, i.e., both in individual and integrated operations.
- The application area of IEC 61400-25 covers all components required for the operation of wind power plants including the meteorological subsystem, the electrical subsystem and the wind power plant management system.

IEC 61400-25 defines how to

- model the information,
- perform information exchange,
- map specific communication protocols stacks, and
- perform conformance testing.

The wind power plant specific information given in IEC 61400-25 is built on the common data classes specified in the IEC 61850 series of standards. The standard excludes a definition of how and where to implement the communication interface and thereby enables any topology to be applied. Specific advantages in application of the standard are that it:

- Provides a uniform communication platform for monitoring and control of wind power plants
- Is compliant with ICCP (Inter-Control Center Protocol)
- Minimizes the communication barriers arising from the wide variety of proprietary protocols, data labels, data semantics etc.
- Provides the ability to manage different wind power plants independently of vendor specific SCADA systems
- Enables components from various vendors to easily communicate with other subsystems
- Is more efficient handling and presentation of information from wind power plants
- Maximizes scalability, connectivity, and interoperability in order to reduce total cost of ownership or cost of energy
- Is a common solution within the wind power area secures availability of products and competence at a lower cost

The standard is designed to support a range of current day applications and provide a platform for future applications not yet defined.

The IEC 61400-25 standards are relatively new, and to the project team's knowledge have yet to be adopted by a RTO or ISO in the U.S. However, at a Wind Generation Forecasting Workshop hosted by the Utility Wind Integration Group in February of 2009, it was indicated by two major vendors in presentations to be a key piece of their EMS platform architecture going forward.

The application of IEC 61400-25 is farther along in Europe. Distribution system connection of wind generation has been a major driver. A majority of the wind generation installed in Germany, for example, is comprised of individual or small groups of turbines connected to the public distribution network. They are mostly invisible to the German grid operators. The IEC 61400-25 standards provide a means for grid operators to communicate directly with individual turbines that comply with the standard.

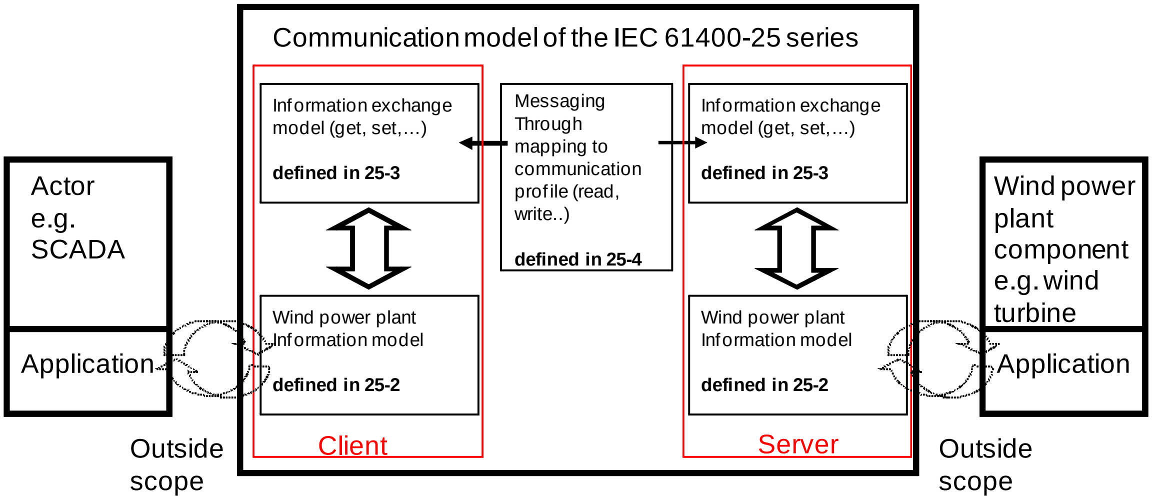

Figure 39: IEC 61400-25 communication model. Actors can include power system control centers and wind generation forecasting systems.

5.5. Operational Considerations for Distributed Wind Generation

Wind generation connected at the distribution system level is generally “invisible” to bulk system operators, but can have impacts if the penetration is large enough on a system or regional level.

The experience in Germany is especially relevant here. The favorable in-feed tariff established by law stimulated the installation of thousands of MW of individual and small groups of wind turbines connected to the public distribution network. Each of these turbines operated autonomously, but the aggregate impact was substantial. As the penetration increased, German grid operators became acutely aware of these impacts when transmission faults lead to the loss of significant amounts of production since turbines at the time were not capable of riding through low voltage events. Bulk system load forecasts became increasingly poor since the aggregate production could not be accounted for. Years of work are now providing solutions, but the situation remains the best illustration of the difficulties associated with substantial distribution system connected generation of any type.

Installations at the distribution level cannot be managed in the same way as bulk wind plants. It is critical for operation of the bulk system, however, to know as best as possible the number of installations, the total capacity by bulk system bus, and the specific geographic location of the individual units. In addition, some knowledge of status is also desirable, but may be difficult to obtain without real-time communications to each unit.

At present, the major bulk system concerns associated with distributed generation are forecasting the aggregate production (possibly by region) and knowing the potential loss of generation for transmission system faults that are observed at the terminals of the individual units.

Provided that status information is available and up-to-date, it should be possible for the bulk system forecasting agent to develop an approximate forecast of production by bulk system bus.

Such forecasts would likely be somewhat less accurate than those for bulk plants, but still reduce the error in the aggregate wind generation forecast.

The sensitivity to bulk system events, especially faults, derives mostly from the assumption that the individual units comply with IEEE 1547, which requires that the units shut down and disconnect from the grid in the event of a voltage disturbance at their terminals. With knowledge of the location and size of the individual generators, bulk system fault studies could be performed to assess the loss of potential distributed generation. The "zone of influence" concept use in voltage sag assessments could be employed here. While not precise, such an approach would at least make some provision for this potentially important bulk system impact.

5.6. ASSESSING WIND PLANT CONTRIBUTIONS TO GENERATION ADEQUACY

Maintaining high levels of electric power system reliability requires that sufficient supply capacity be available to meet demand. Because of lead times associated with the permitting, designing, and constructing new generation resources, planners must look into the future when making this evaluation, using forecasts of future electric demand.

In addition, it must be recognized that individual generating units are not perfectly reliable, and instead are subject to both planned and unplanned outages. The probabilistic nature of both load forecasts for a future year and the likelihood that existing or planned generating units would not be available due to outage necessitates the use of statistics in rigorous assessments of power system reliability.

Perfect reliability would be infinitely expensive, so target reliability levels have been traditionally used to gauge the adequacy of a resource plan for a future year.

Wind generation is primarily a source of electric energy, not capacity. However, because the principal objective of power system planning, engineering, and operations is to assure the necessary high level of system reliability, capacity is a central concept in all of these aspects.

While wind turbines and plants have very high availability, the supply of fuel for driving the turbines is subject to meteorology. Nonetheless, it can be shown by any of the traditional analytical approaches used to measure the contribution of a supply resource to system reliability that the capacity value of wind generation is something greater than zero.

5.6.1. General Approaches for Quantifying System Reliability

LOLP (Loss-of-Load Probability) is the predominant metric in the electric utility industry for assessing the long-term reliability of the bulk power system. It measures, using statistical techniques and calculations, the chance that a projected load on a power system is expected to be greater than the available supply capacity. By securing or building adequate resources - actual generating units, firm capacity imports, interruptible load, etc. – the LOLP of the system can be maintained at or below an acceptable level.

Methods for computing system LOLP take into consideration the historical reliability of specific generating units and de-rating, the nature of load patterns throughout the year or years evaluated, limits on capacity imports from external areas, and energy limitations in certain supply resources like hydro generation.

LOLP is used to characterize the reliability of the bulk power system (BPS), although it does not usually take into consideration specific elements of the transmission network. However, assuming that contingencies are appropriately considered in the design and operation of the transmission system, LOLP will be an indication, though not perfect, of BPS reliability.

In practice, other metrics are used for gauging reliability. Reserve margin - the excess (expressed as a percentage) of total accredited generation capacity over expected load - is another commonly-used to indicate system reliability. In some cases, the required reserve margins are determined from a more detailed LOLP analysis.

5.6.2. Considering Wind Generation in Reliability Evaluations

How wind generation fits into the traditional templates for measuring resource adequacy has been a topic of research and discussion for over 20 years. The National Renewable Energy Laboratory has conducted research into expanding traditional methods for assessing reliability to include consideration of wind generation. Numerous reports and technical papers have been written on the topic ([2][3][4])

Until about ten years ago, the subject was relatively academic, as the total installed capacity of wind both across the country and in any individual operating area was negligible in this regard. In addition, the capacity value question was relatively unimportant, since most wind generation facilities delivered energy under a power purchase agreement to utility purchasers.

The capacity value question did arise, however, in the context of accredited generation capacity for those utilities purchasing wind generation. In many reserve sharing groups, accredited capacity is the metric by which reserve obligations are allocated amongst the participants. Historically, energy-limited resources such as run-of-river hydro were assigned capacity value based on historical energy deliveries during system peak periods. The philosophy behind such accreditation methods was extended to cover wind generation in some reserve sharing groups. The lack of significant historical operate data was an immediate challenge, however.

Such methods have become relatively common in practice. Figure 40 shows daily windows used by various entities in the U.S. to gauge the capacity contribution of wind generation. The windows vary by time of day and season, consistent with the load characteristics in the region.

The peak period methods have some disadvantages. First, they consider only the peak hours, when there may actually be other hours in the year, say during planned maintenance outages of large baseload generation, where the system could be vulnerable. Second, they require an extensive history of production data to achieve a “convergence” in the capacity value, since significant inter-annual variations have been observed to be relatively common. . A variation of this method which considers the wind operation during the top X% of hours has similar advantages and disadvantages. Although the method is easy and straightforward it requires prior knowledge of the hourly load profile in addition to the wind profile. The appropriate percentage also seems to vary year to year from as low as 5% up to 20%. [3] In addition, it also tends to focus only the very highest load hours irrespective of system conditions.

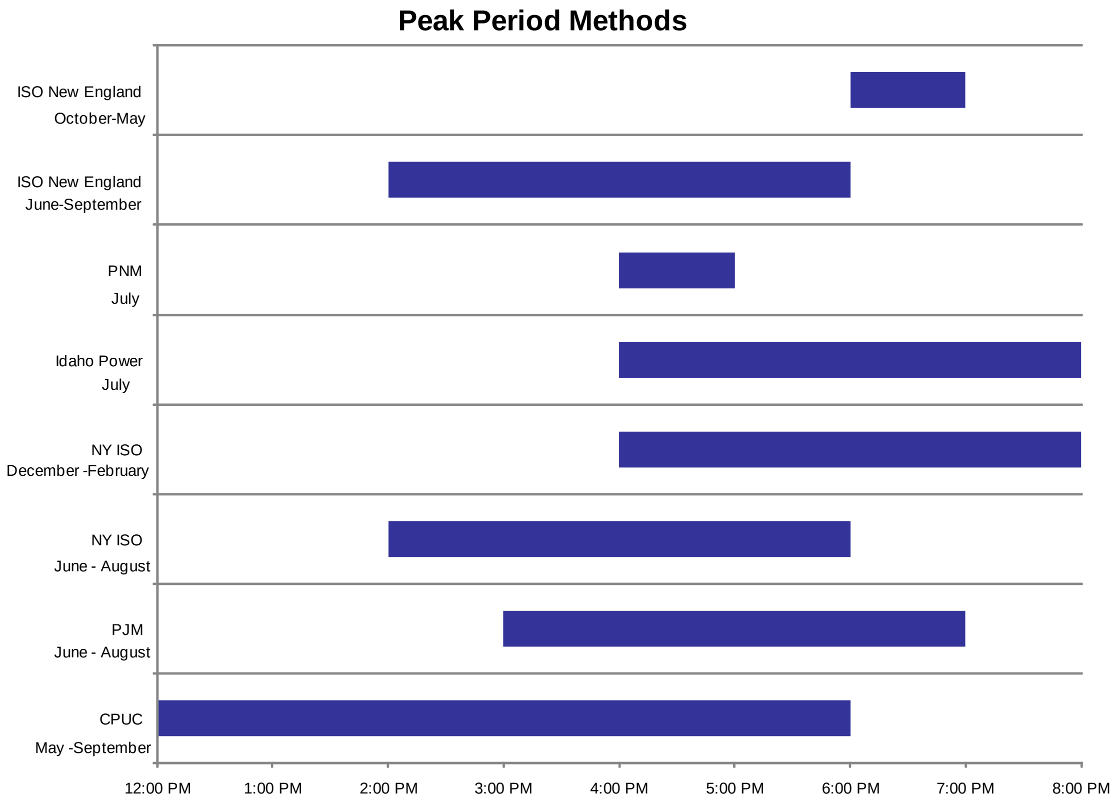

Figure 40: Summary of peak periods used in U.S. to determine wind generation capacity value. (Reference [2])

Many of the wind integration studies conducted over the past ten years have included in their scope an examination of wind generation capacity value. In these studies, the general approach has been to employ rigorous statistical techniques to calculate the change in system LOLE when wind generation is added.

Figure 41 depicts this basic method. Using chronological load profiles for a year or number of years, the LOLE is calculated without wind generation. In some cases, the amount of capacity in the study years is adjusted so that the baseline LOLE without wind generation is at the desired level, usually 1 day in 10 years. Wind is then introduced as a load modifier by simply subtracting the hourly aggregate wind generation from the corresponding load at that hour. The LOLE calculation is then re-run.

Most programs adjust the peak load around the forecast value to produce a series of LOLE results. When this is done with wind generation, a second curve is created. The Effective Load Carrying Capability (ELCC) of wind generation is defined as the incremental load serving capability at the target reliability level.

Although the computational techniques are rigorous, there are a number of shortcomings with their application to wind generation. The most significant of these is the amount and nature of chronological data required to produce a high-confidence result. Inter-annual variability will affect the ELCC calculation as well. Secondly, both wind and load have a common meteorological driver. Therefore, the hourly profiles of load and wind generation must be drawn from the same historical year to preserve any embedded correlations due to weather. Because these calculations are almost always focused on a future year, the procedure used to scale historical hourly load profiles to reflect expected load in a future year is not a precise science. Finally, availability of adequate historical wind profile data is always an issue. Many integration studies (including the Eastern Interconnection Wind Integration and Transmission Study and the ISO-NE wind integration study begun in 2009) utilize mesoscale atmospheric simulations to re-generate data of sufficient resolution for historical years. This data has been utilized for ELCC evaluations, but in general only two or three years of data are available, which can result in widely-varying estimates of annual ELCC for wind generation.

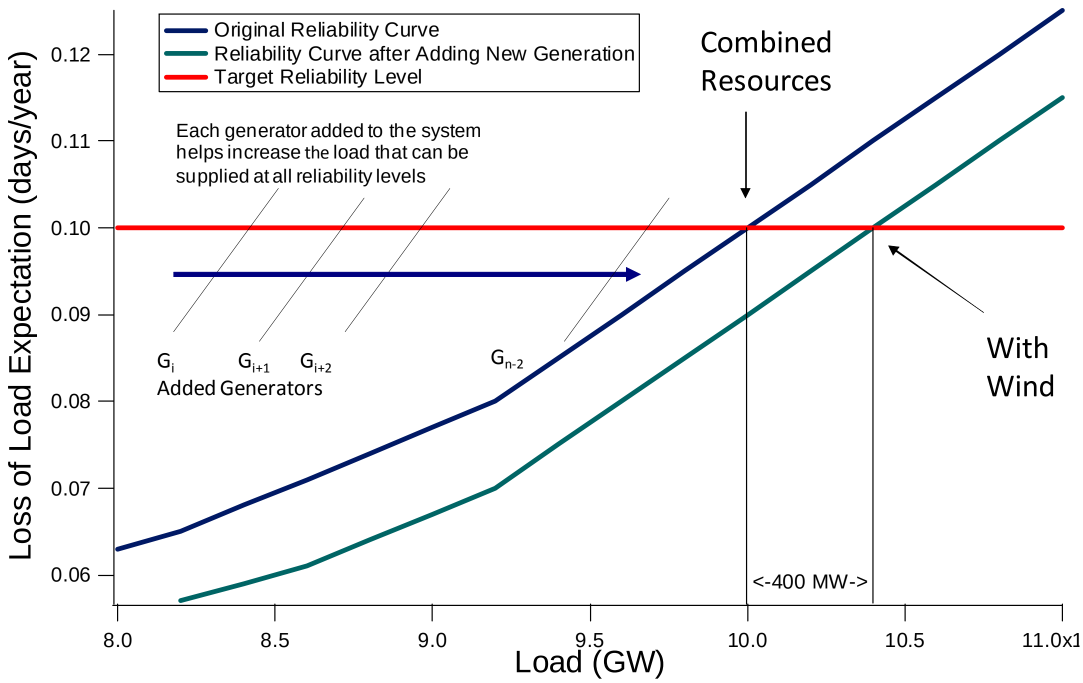

Figure 41: ELCC concept, where increase in peak load that can be served at target reliability level is assigned as the effective capacity of the resource added.

It has been suggested that at least ten years of historical data would be necessary to increase the confidence in the range of annual results. A rolling period of a decade would encompass many of the major weather drivers such as El Nino and La Nina that have recently received much greater attention. Hydro-electric utilities routinely maintain even longer data sets (e.g. 50+ years) as the basis for planning.

The recently-published report from the NERC Integrating Variable Generation Task Force weighs in on this issue. From the report:

> ***NERC Action:*** Consistent and accurate methods are needed to calculate capacity values attributable to variable generation. The NERC Planning Committee should direct the Reliability Assessment Subcommittee to collect the capacity value of variable generation based on their contribution to system capacity during high-risk hours, when performing its seasonal and long-term reliability assessments. As additional data becomes available

(i.e. involving multiple years of hourly-resolution variable generation output data from specific geographic locations and time-synchronized with system demand), NERC should consider adopting the Effective Load Carrying Capability (ELCC) approach.

5.6.3. Perspective on Methods for Determining Wind Generation Capacity Value

Assessments of wind generation capacity value have been part of the scope for many of the wind integration studies conducted over the past decade. From these studies and subsequent discussions, an informal consensus has emerged regarding the appropriateness of the various analytical methods used.

Determining wind generation ELCC from a rigorous LOLE analysis is considered to be the most accurate analytical methodology since it takes into consideration the characteristics of the remainder of the supply portfolio as well as the risk to the system during all hours of the period studied, not just the peak hours. In practical applications, the limited data sets available are recognized as a significant shortcoming. There are ways, however to extend the data set, and it is possible that NREL will be doing just that with the meso-scale data set that underlies the ISO-NE 2009 Wind Integration Study.

Historical performance is seemingly the "gold standard" with respect to characterizing the capacity value of wind generation. The obvious challenge at the present is that this history is quite sparse. So, while more rigorous methods such as LOLE do provide a more comprehensive view of reliability attributes of a given system, the results are only as good as the input data. In the case of hourly wind production data, the input data is insufficient at the moment for production high-confidence results. Going forward the project team believes that a mixture of rigorous calculation and extensive historical data production data will be the pillars upon which the methodologies of the future will rest.

5.7. REFERENCES

[1] IEA Annex 25: "Design and Operation of Power Systems with Large Amounts of Wind Power - State-of-the-Art Report" BTT Working Papers 82, October 2007

[2] Milligan, M., and Porter, K.: "Determining the Capacity Value of Wind: An Updated Survey of Methods and Implementation" Conference Paper NREL/CP-500-43433, June, 2008.

[3] Kueck, John, and Kirby, Brendan: "Measurement Practices for Reliability and Power Quality" ORNL/TM-2004/91, prepared for the U.S. Department of Energy, June, 2004

[4] Kara Clark, Gary A. Jordan, Nicholas W. Miller, Richard J. Piwko "The Effects of Integrating Wind Power on Transmission System Planning, Reliability and Operations" (2005, March.). Available: http://www.nyserda.org/publications/wind_integration_report.pdf

Appendix C

GE Energy

Summary of Commercially Available Photovoltaic Inverters with Claimed Voltage Ride-Through Capability

Prepared for:

California ISO

June 30, 2010

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2. Assumes any liabilities with respect to the use of or for damage resulting from the use of any information, apparatus, method, or process disclosed in this report.

1. INTRODUCTION

CAISO is proposing requirements for all asynchronous generation to have the ability to ride through low-voltage disturbances. Presently, transmission-connected wind generation is already required by FERC Order 661a to have this capability. In order to determine the practical feasibility for solar photovoltaic (PV) facilities to also achieve low-voltage ride-through (LVRT) capability, CAISO requested GE Energy Applications and Systems Engineering to assess the availability of PV inverter equipment that has LVRT capability. This assessment was performed by a review of the claims made by major PV inverter manufacturers in their websites. The detailed results of this survey are provided in Section 3 of this report.

2. CONCLUSIONS

Seven major PV inverter vendors have been identified as claiming that one or more of their inverter products achieve a fault ride-through, low-voltage ride-through, or simply “ride-through” capability. The marketing information does not reveal the details of this capability, but it is implied that the ride-through capability is stated in reference to grid code requirements that have been enacted in Europe, which are generally more stringent than has been required of wind generation in the US by FERC Order 661a.

3. DETAILED SURVEY RESULTS

Vendor: **ABB**

Model: PVS 800

Web Link:
http://www05.abb.com/global/scot/scot351.nsf/veritydisplay/1c7b1207b807931cc12576ba0026fdd7/$File/14856%20Solar_inverters_PVS800_leaflet_0000057380_EN_RevC_lowres.pdf

Quotation or claim from website:

> "Product compliance
>
> Safety and EMC: CE conformity according to LV and EMC directives
>
> Grid compliance: According to country requirements: VDE, RD, DK, CEI
>
> Grid support: Reactive power compensation, Power reduction, Low voltage ride through"

Vendor: **General Electric**

Model: 600KW Solar Inverter

Web Link:
http://www.ge-energy.com/prod_serv/products/solar/en/downloads/GEA17910_SolarInverterBrochure.pdf

Quotation or claim from website:

> "Solar RIDE-THRU" <u>Fault ride through</u> capability
>
> SolarFREE" Reactive power control capability, even at zero active power.
>
> GE's system provides the following capabilities similar to those of a conventional power plant:
>
> • Voltage/PF control: Regulates VARs, reduces voltage variations at point of interconnect (POI)
>
> • Power curtailment: Regulates active power at the POI
>
> • Over frequency droop: Reduces active power in response to frequency increase
>
> • Ramp rate control: Controls MW/sec of generation change
>
> • Start-up/shut-down: Avoids addition or removal of large blocks of power into/out of the grid at once"

Vendor: **SatCon**

Model: Solstice

Web Links:

http://www.satcon.com/downloads/Satcon_PowerGate_Plus_100kW_Solstice_System.pdf

http://www.solardaily.com/reports/Satcon_Powers_Hawaii_Largest_Solar_Farm_999.html

Quotation or claim from website:

"AC Side System Value

- Control of real and reactive power
- Remote system restart
- Controllable ride-thru
- Dynamic VAR generation

- Simplified Utility SCADA system"

Vendor: **Siemens**

Model: Sinverter PVS

Web Link:

http://www.siemens.com/press/pool/de/pressemitteilungen/2010/industry_automation/IIA2010052281e.pdf

Quotation or claim from website:

> "The new Sinvert PVS inverter series can be easily integrated into Scada systems through standardized communication interfaces. A pixel-graphics display with touch screen enables user- friendly local operation of the inverters and visualization of the performance data. The new devices comply with the medium-voltage guidelines of the German Association of Energy and Water Industries with all requirements including FRT (Fault Ride Through) and active power control."

Vendor: **SMA**

Product: Sunny Central

Web Link:
http://www.sma.de/en/products/knowledge-base/sma-inverters-as-grid-managers.html

Quotation or claim from website:

> "3. Dynamic Grid Support with the Sunny Central HE Family…
>
> …With the dynamic grid support, the inverters will have to feed in a short circuit current when the brief disruption occurs. For the so-called "Fault Ride Through" (FRT) event, the exact voltage limits are defined, and if it falls below this limit, the units will be tripped offline…"

Vendor: **SunPower**

Model:Oasis

Web Link:

http://us.sunpowercorp.com/utility/products-services/products/oasis-power-block.php

Quotation or claim from website:

> "Smart Inverter:
>
> > With advanced plant controls, the standardized Oasis inverter features voltage ride-through, curtailment control and dynamic power factor adjustment, enhancing grid interoperability for PV power plants"

Vendor: **Xantrex** (subsidiary of Group Schneider)

Model: GT500E

Web Link:

http://www.xantrex.com/web/id/150/p/1/pt/23/product.asp

Quotation or claim from website:

> "The Xantrex GT500E Grid Tie Inverter is based on a reliable platform that is used in grid-connect photovoltaic and wind turbine applications in North America and Europe. Easy to install and operate, the GT500E automates start up, and shut down. It incorporates advanced Maximum Power Point Tracking Technology to maximize the energy harvested from a PV array. To minimize power losses during the conversion process, the inverter's switching technology uses insulated gate bi-polar transistors. Multiple inverters can be paralleled for large power installations. Designed for European PV installations, the GT500E meets all applicable CE requirements. Key features include low voltage ride through and reactive power control."

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

California Independent System Operator Corporation	))))	**Docket No. ER10-______**

Prepared Testimony of Reigh Walling

I. Introduction and Overview

Q. What is your name?

A. Reigh Walling.

Q. By whom are you employed?

A. I am employed by the Energy Applications and Systems Engineering Department of General Electric International, Inc.

Q. Could you please describe your professional background?

A. I have worked as a consultant to the electric power industry for the 29 years that I have been employed by GE. Much of my recent consulting practice has been in the area of renewable generation systems, particularly renewable generation integration and interconnection. I have published in excess of sixty technical papers and articles, with a number of these papers related to renewable generation integration. I have been elected a Fellow of the Institution of Electrical and Electronic Engineers (IEEE). A list of my publications is attached hereto as Appendix A.

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to describe the interconnection requirements proposed by the ISO for asynchronous generating facilities as well as the commercial availability and cost of equipment that will allow asynchronous generating facilities to design their facilities to meet these requirements.

Q. Please describe asynchronous generating facilities.

A. The ISO has proposed to define asynchronous generating facilities as an induction, doubly-fed or electronic power generating unit(s) that produces 60 Hz (nominal) alternating current. This definition captures the current scope of commercial asynchronous generators. The listed facilities include wind and solar photovoltaic (PV) resources and may also include certain solar thermal resources, such as generators using Stirling engine systems.

Q. Are you familiar with issues facing transmission operators in facilitating the interconnection and operation of asynchronous generating facilities?

A. Yes, this is the primary focus of my consulting practice. I was the director in charge of a GE study concerning the impact of wind generation on the ancillary services requirements of the ERCOT system. GE has performed many of the major wind integration studies in the US, and we are currently performing a major wind integration study for the Independent System Operator of New England.

As part of the wind integration work conducted on behalf of ISO-NE, GE, in conjunction with EnerNex Corporation and AWS Truepower, produced a document titled "Technical Requirements for Wind Generation Interconnection and Integration".[1] A copy of this document is attached as Appendix B. This document describes the performance characteristics of current wind turbine and wind plant technology, the present state of wind forecasting technology, and the impacts on system operations of significant wind generation penetration. In addition to this background information, the document provides detailed recommendations to ISO-NE regarding performance requirements for wind plants interconnecting to that system as well as operating practices that should be adopted to facilitate the reliable operation of the system as additional wind resources interconnect.

However, the ISO-NE document should not be viewed as narrowly applying to wind resources only or ISO-NE's specific system needs. Many

[1] A copy of this document is published on the website of the Integration of Variable Generation Task Force of the North American Reliability Corporation.
http://www.nerc.com/docs/pc/ivgtf/Final_16_Nov_09_Interconnection_req_newis_report.pdf

of the recommendations in the ISO-NE document, and the underlying analysis supporting the recommendations, rest not only on the specific characteristics of wind resources, but rather on the more fundamental characteristics of asynchronous and variable energy generators. As such, the document prepared for ISO-NE served as a foundation for GE's consulting work with the ISO and provides relevant, but certainly not the exclusive, technical support for the currently proposed interconnection requirements applicable to all asynchronous generators, including solar technologies. For example, the recommendations developed by GE and EnerNex for ISO-NE include, among others:

- Power factor range of ±0.95 lead/lag at the point of interconnection on the basis that "[t]oday's wind plant technology is fully capable of meeting this power factor range requirement, and reactive power support with closed loop voltage control is essential to the operation and reliability of a power grid."
- Adoption of a more "prescriptive" interpretation of Order No. 661a that requires wind plants provide voltage regulation at the specified point of interconnection by delivering the reactive power required to meet a specified voltage (under control of a voltage regulator) anywhere within the required power factor range.
- Recognition that under low active power conditions, it can be difficult for wind plants to meet tight requirements for voltage and

reactive power control and therefore requirements for voltage regulation should be relaxed at low power output levels.

- Adoption of both low voltage and frequency ride-through.
- Adoption of the capability to limit the rate of power increase or decrease, except due to a decline in wind speed, along with the recognition that this functionality should not be required under all operating conditions, but may be called upon for curtailment commands, shut-down sequences, response to market conditions and other control actions.

As discussed further below, these recommendations for ISO-NE are consistent with those advanced by the ISO in this proceeding. In both cases, these recommendations strike a balance between system needs, availability of appropriate technology, and economic burden on asynchronous generator owners and developers.

Q. Are similar general system considerations addressed for ISO-NE also relevant to the ISO's efforts to integrate asynchronous generating facilities?

A. Yes. The ISO is projecting that a large amount of variable generation in the form of wind and solar PV will interconnect to the transmission system it operates during the next several years. The need to develop performance requirements for asynchronous generating facilities anticipated to interconnect to the ISO is more acute than ISO-NE given the larger volume of resources seeking to interconnect to the ISO transmission grid as compared to the ISO-NE system.

Q. Please identify the proposed interconnection requirements to which your prepared testimony applies.

A. My testimony discusses the following proposed interconnection requirements: low voltage ride through capability, frequency disturbance ride-through capability, power factor design and operation, voltage regulation and reactive power control, and power plant management.

II. Low Voltage Ride Through Capability

Q. What is the purpose of the ISO's proposed low voltage ride through capability requirements for asynchronous generating facilities?

A. The purpose of the ISO's proposed requirements is to expand the pool of resources that can sustain the operation of the electric system when contingencies occur. If asynchronous generating facilities do not have low voltage ride through capability, they are likely to trip during disturbances, especially disturbances on adjacent substations and disturbances that cause major voltage depression. The loss of these real power resources during a contingency may trigger cascading events.

Q. Are there existing low voltage ride through standards for solar PV generating facilities?

A. No, not for facilities interconnected to the transmission grid. The solar PV industry has strong roots in the distributed generation application of their equipment, where individual facilities are small and connected to distribution systems. Almost all distribution feeders in North America are of radial configuration. Faults on these feeders are cleared by tripping the feeders, and there is a risk that any distributed generation connected to a tripped feeder could cause the uncontrolled energization of the feeder ("islanding"), and exposure of utility customers to abnormal voltage and frequency, as well as potential exposure of utility workers and the general public to continued energization of a feeder that should not be energized.

The scope of the IEEE 1547 is specifically limited to facilities having an aggregate capacity of 10 MVA or less, and which are interconnected at primary or secondary distribution voltages. Thus, this standard does not apply to transmission-interconnected asynchronous generating facilities, with an aggregate capacity of 20 MVA or greater, which is the scope of facilities subject to the proposed ISO requirements. IEEE Standard 1547 was adopted, in part, to minimize this risk of distribution feeder islanding" by requiring that a distributed generator trip in response to a system disturbance.. However, this disturbance "non-ride-through" requirement is in direct conflict with the performance that should be provided by large transmission-connected facilities that are covered by the ISO's proposed tariff amendment. Without explicit low-voltage ride-through requirements, many transmission connected solar resources will tend to use inverters designed originally for the distributed generation market, where the provisions of IEEE Standard 1547 apply. The wind industry has matured from what was once considered to be an insignificant resource that should immediately trip at the first signs of system disturbance to a resource that is considered critical to grid support and therefore must not trip during ordinary contingencies. Likewise, the solar PV industry must mature if it is to participate as a transmission-connected resource.

Q. What low voltage ride through requirements is the ISO proposing to apply to asynchronous generating facilities?

A. The ISO is proposing to extend the low voltage ride through requirements established by FERC for wind generators to all asynchronous generating facilities. These proposed requirements track the specific low voltage ride through provisions adopted by FERC with some modifications.

Q. Notwithstanding that FERC previously elected to limit the low voltage ride through requirements to wind generators, is there a justification for the ISO to limit the proposed requirement to asynchronous generating facilities and not apply it to all generator types?

A. A significant issue for synchronous generator fault ride through is maintaining synchronism with the grid; often referred to as "maintaining stability". The ability to maintain synchronism, and thus ride-through faults, is adequately covered by existing NERC and WECC planning criteria. A key step performed in interconnection studies is to confirm generating plant stability for defined fault contingencies. As such, low voltage ride through capacities already exist for conventional generators. The ISO's proposed requirements merely extend the general requirements already applicable to wind generators to other asynchronous generating facilities.

Q. Can you please describe the specific modifications the ISO is proposing to the low voltage ride through requirements that FERC adopted for wind generators?

A. The modifications are intended to maintain the original intent and function of the FERC Order No. 661a standard, while providing additional clarity to aid in enforceability and consistency of system design. The specific changes are as follows:

1. The ISO has separated the ride-through requirements for single-phase faults with delayed clearing from the requirements applicable to all normally cleared faults. This language makes unambiguous the requirement that the asynchronous generating facility must ride through the subsequent post-fault voltage recovery for single-phase

faults with delayed clearing. The wording of the language from FERC's Order No. 661a could be interpreted as requiring ride-through of post-fault voltage recovery only in the case of normally-cleared three-phase faults. It is important from a grid reliability standpoint that asynchronous generators have the ability to ride-through both single- and multi-phase faults.

2. The ISO is requiring asynchronous generating facilities to ride through all normally-cleared faults. The requirement to ride through normally cleared three-phase faults has been clarified in the ISO's proposed language to include all types of normally-cleared faults generally considered inclusive of the more severe three-phased fault (*e.g.*, phase-to-phase and double phase faults). However, is the ISO's proposal also acknowledges that for some asynchronous generating technologies, ride through of unbalanced faults, such as two-phase faults, can be more difficult than three-phase faults. This change is intended to ensure generation is not lost as a consequence of single-contingency faults.

3. The ISO's proposed language establishes criteria to define which circuit breaker clearing times set the "normal" fault clearing time. Faults in a range of locations in the transmission system, potentially including a number of different lines and transformers, may result in

a large voltage decrease at an asynchronous generation facility's Point of interconnection. Under normal circumstances, each fault location will be detected by a specific protection system and will be cleared by a given set of circuit breakers. Thus, there is a range of possible clearing times associated with all the possible faults that could affect an asynchronous generating facility. The ISO's proposed language defines the *normal* clearing time duration as the longest normal clearing time (not to exceed nine cycles, or 150 milliseconds) for any three phase fault causing the asynchronous generation facility point of interconnection voltage to drop below 0.2 per-unit of nominal voltage. The *delayed* clearing time duration for the purpose of ride-through requirements is defined to be the longest delayed clearing time for any single-phase fault causing at least one phase voltage at the point of interconnection to drop below 0.2 per-unit of nominal voltage. This language clarifies the requirements of FERC Order 661a, which do not specify the means to determine the applicable normal and delayed clearing times.

4. The ISO proposed language provides a definition for "remaining on line" that is useful when applied to inverters with the capability to be blocked from power conversion without opening any circuit breaker, and which also can instantly resume operation through control of the power electronics without any switchgear closing time. The

material requirement for voltage ride-through performance is post-fault support,. This requirement is permissive of strategies that could potentially be employed to protect an inverter from the stress of operating into a transmission fault, while still providing grid support from the inverter immediately after the fault clears.

5. The ISO's proposed language clarifies that the ride-through requirement is a facility requirement, and does not necessarily require that individual generating units that comprise the facility have this capability. Auxiliary equipment within the facility can be used to provide or complement the capabilities of individual generating units. This provides generators with greater flexibility in meeting the ride-through requirements, thereby promoting more cost-efficient solutions.

6. The ISO clarifies that its proposed ride-through requirements do not require asynchronous generators to ride-through multiple fault events, such as an unsuccessful reclosing attempt. FERC's Order 661a does not address this issue. The ISO's proposed language prevents a utility form interpreting the FERC's 661a requirements to apply to a very large number of successive faults over a short period of time, which could be considered to be an unreasonable requirement for equipment to endure.

Q. Why is the ISO proposing these changes?

A. The ISO needs to apply objective low voltage ride through requirements to a wide range of asynchronous generation technologies. The explicit performance requirements proposed by the ISO should provide clear expectations to market participants, decreasing the need for transmission owners, participating transmission owners and interconnection customers to interpret the requirements.

Q. Can asynchronous generating facilities practically design their systems to meet these proposed requirements?

A. Yes, asynchronous generating facilities can meet the ISO's proposed low voltage ride through requirements through the purchase of inverters or generators for individual generating units, or with the use of supplemental equipment that compensates for voltage levels through which a facility must continue to operate.

Q. What is an inverter?

A. An inverter is a device that converts direct current to alternating current.

Q. Are inverters also commercially available for solar PV generation facilities that will allow these asynchronous generating facilities to continue to operate during low voltage conditions indentified in the ISO's proposed requirements?

A. Yes. Inverters intended for solar PV application are readily available that can meet the low voltage ride through capability requirements proposed by the ISO.

Q. Have you conducted a survey of manufacturers of solar PV inverters to confirm whether equipment is commercially available to satisfy the ISO's proposed requirements?

A. Yes, inverters that allow for low voltage ride through characteristics are available from at least the following manufactures, based on their publicly disclosed websites:

- ABB
- GE Energy
- SATCON
- Siemens AG
- SMA
- Sun Power
- Xantrex, a subsidiary of Group Schneider

Most of these manufacturers claim that their equipment provides the low-voltage ride-through capability required to meet certain European grid codes. The low-voltage ride-through requirements of these grid codes are generally at least as demanding as those set forth in FERC Order No. 661a and as reflected in the proposed ISO requirements. Appendix C to my testimony contains a summary of different inverters and their capabilities that are available.

Q. What are the cost impacts, if any, for asynchronous generating facilities that need to procure inverters capable of meeting the ISO's proposed low voltage ride through requirements?

A. Although low-voltage ride-through has been particularly challenging for the wind generation industry due to the mechanical impacts on the wind turbines, and the induction generation technology used in some wind turbines, achieving this performance in a solar PV inverter is significantly less challenging. This performance in a solar PV inverter can be achieved by appropriate control design, with little to no change needed in the power components. Thus, the incremental cost for low-voltage ride-through functionality to the project developer is not driven so much by material costs, but by the market value of the intellectual property made by the inverter equipment manufacturer. With multiple vendors offering this capability, the competitive market should inherently drive the incremental costs down to a rather low level, if not de minimis, in proportion to total project costs.

Q. What other equipment, if any, can asynchronous generating facilities use to meet the proposed low voltage ride through requirements?

A. Asynchronous generating facilities may install equipment such as static synchronous compensators or static VAR compensators, to modify the voltages through which a facility must operate. The wind industry has widely relied on such equipment to allow low-voltage ride through capability in cases where a generator was not capable of riding through a specified voltage level at the point of interconnection.

Q. Can you describe the estimated costs of using this type of equipment?

A. The costs for such equipment are generally on the order of $100 - $200 per injected continuous kVAR. Some technologies permit short-term kVAR injection to be several times the continuous rating. The amount of injected kVAR to ride through low voltage conditions, however, depends on a number of factors, including system conditions, the specifics of the plant design and the terminal voltage constraints for the asynchronous generating facility. The cost will increase to the extent additional kVARs are necessary to boost voltage at the generating unit terminals.

Q. Are there other balance of plant changes that must also be made to ensure the facility is able to ride-through a voltage dip?

A. Yes. Certain balance of plant equipment can boost voltage within a plant, thus allowing generator units to ride through a point of interconnection voltage drop that is less than the minimum terminal voltage ride-through capability of individual generating units. This equipment includes, for example, static synchronous compensators (STATCOM) and static var compensators (SVC).

III. Frequency Disturbance Ride Through Capability

Q. What is the purpose of the ISO's proposed frequency disturbance ride through capability requirements for asynchronous generating facilities?

A. The frequency on the power system is related to the amount of load and generation that are connected. When the load and generation are precisely balanced, the frequency will be 60 Hz. In the event that generation is lost through an unplanned or forced outage (e.g., a generating unit trips off line), the frequency will deviate below the nominal of 60 Hz. Immediately following a frequency disturbance, the governors on the remaining generation units will adjust to attempt to arrest the frequency decline. During this transition time, it is essential for the system generators to remain on line. If additional generators trip during the transition, the system frequency will continue to deteriorate, and frequency restoration will be more difficult.

Similar to voltage ride through capabilities, the purpose of the ISO's proposed requirements is to expand the pool of resources that can sustain the operation of the electric system when contingencies occur. If asynchronous generating facilities do not have frequency disturbance ride through capability, they are likely to trip during frequency disturbances, especially disturbances on adjacent substations and disturbances that cause major frequency deviations. The loss of these real power resources during a contingency may trigger cascading events.

Unlike voltage, however, the frequency at the terminals of generating units that are part of an asynchronous generating facility must remain the same as the frequency at the point of interconnection. There is no effective means of meeting frequency ride-through requirements other than to ensure generating units maintain the same frequency range as specified at the point of interconnection.

Q. Is the ISO's proposed frequency disturbance ride through requirement a new interconnection requirement?

A. No. The ISO's existing Large Generator Interconnection Agreement requires the interconnection customer to design high and low frequency ride through, as required by Western Electric Coordinating Council (WECC).[2] The ISO is proposing only to clarify that these requirements also apply to asynchronous generating facilities. These frequency-ride through requirements are set forth in the WECC Off-Nominal Frequency Plan. The ride-through requirements are also discussed in the WECC Under-frequency Load Shedding Relay Application Guide, which is available at the following website:

[2] ISO Tariff , Appendices V and Z at Article 9.7.3.

http://www.wecc.biz/committees/StandingCommittees/OC/TOS/RWG/Shared%20Documents/UFLS%20Relay%20Application%20Guide.pdf

Q. Can you summarize the frequency disturbance ride through requirements?

A. Yes, the following chart specifies both the under frequency and over frequency requirements that apply to all generators in the western interconnection.

WECC Generator Off-Nominal Frequency Performance Requirement

Under-frequency Limit	Over-frequency Limit	WECC Minimum Time
> 59.4 Hz	60 Hz to < 60.6 Hz	N/A (continuous operation)
≤ 59.4 Hz	≥60.6 Hz	3 minutes
≤ 58.4 Hz	≥61.6 Hz	30 seconds
≤ 57.8 Hz	-	7.5 seconds
≤ 57.3 Hz	-	45 cycles
≤ 57 Hz	>61.7 Hz	Instantaneous trip

Q, How are the frequency ride-through requirements met?

A. An existing inverter design should meet these frequency ride-through requirements. Alternatively, minor design modifications should enable an existing non-compliant inverter to achieve compliance. An inverter must be able to operate at the frequency of the grid. Accommodating a small range of variability in grid frequency in the conversion process itself is easily achievable. It is generally just a software issue. There also are magnetic power devices in a typical inverter. Magnetic devices are limited by a volts-per-Hertz capability. A decrease in frequency could potentially require an increase in the rating of these devices, if the device is selected to operate at fundamental frequency with absolutely no design margin. An increase in frequency can slightly increase losses in the power electronics and in any magnetic devices**.**

IV. Power Factor Design and Operating Requirements

Q. What is the purpose of the ISO's proposed power factor design and operating requirements for asynchronous generating facilities?

A. The ISO has proposed a power factor requirement for asynchronous generating facilities seeking to interconnect to the ISO. The purpose of requiring this reactive capability is to maintain adequate voltage control on the system.

Q. What do you mean by the term power factor?

A. The term power factor refers to the ratio of the real power to the total "apparent power". Apparent power includes both the real power and the reactive power, and it is a measure of the loading of transformers and lines. Only real power can perform useful work, and only real power derives revenue in the present market. Reactive power, however, is necessary to support the transmission system voltage; it is effectively a facilitator of the transmission of real power..

Q. Please describe the ISO's proposed requirements?

A. The ISO has specified a power factor range of 0.95 leading (under-excited) to 0.95 lagging (overexcited) at the point of interconnection for asynchronous generating facilities. The ISO's proposal requires an asynchronous generating facility to have a net reactive power range in Figure 1 below as a function of the voltage at the facility's point of interconnection.

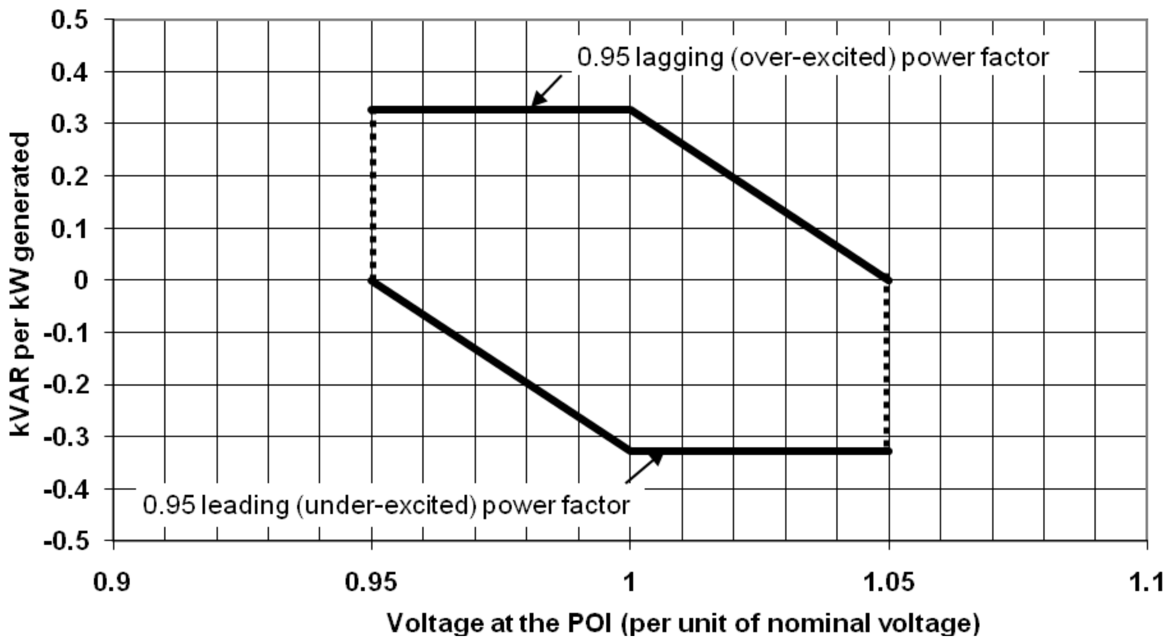

Figure 1

Figure 1 specifies that an asynchronous generating facility need only provide a sufficient power factor (KVAR per KW generated) as voltage levels at the point of interconnection increase or decrease. The ISO is not proposing that asynchronous generating facilities be required to provide full reactive capability during high and low voltage conditions. Instead, the ISO's proposed power factor requirement is proportional to the voltage level at the point of interconnection.

A large amount of reactive power export (overexcited power factor) when the transmission system voltage is high tends to result in terminal voltages at generating units located at the remote ends of wind and solar farm collector systems that are even higher on a per-unit basis. Often, the voltages of such units will exceed the generating unit terminal voltage limits. To avoid this, it would be necessary to specify on-load tap changers on the facility substation transformers, at a large incremental capital and maintenance expense. At the same time, it is rarely ever the case that the transmission system would need such reactive power supply from the asynchronous generating facility during high voltage conditions.

There is also no need for a facility to have maximum reactive power absorption (underexcited power factor) during low transmission voltage conditions. Therefore, the ISO has adopted the requirements shown in Figure 1 to exclude any unneeded and expensive "corner" requirements on the part of asynchronous generators. A similar reactive power capability requirement applies to wind generation facilities in the United Kingdom.

Q. What other power factor design requirements is the ISO proposing?

A. The ISO's proposed language would require the design of asynchronous generating facilities to vary their reactive power output without creating a significant abrupt change in voltage at the Point of Interconnection. The ISO has limited any such voltage change to 0.02 per unit of the nominal voltage. The ISO requirements have been written such that use of discrete capacitor and reactor banks can be used to achieve the reactive power capability of the asynchronous generating facility, unless specific studies indicate that dynamic reactive capability is required for transmission system reliability. Without any bounds imposed by the ISO, the entire reactive power output could be in one switchable compensation bank. Switching a large bank could result in an abrupt change in voltage that could be objectionable to power users, and could also impose undesirable stress on power generating equipment. The rationale for this requirement is thus to impose a bound on the size of reactive compensation banks, not measured in terms of reactive power rating, but rather on the basis of the grid impact that bank switching could cause. The chosen value of 0.02 per unit of nominal voltage is based on a number of considerations, including common engineering practice, standards for consumer power quality, and consideration of the granularity to which compensation in a facility would need to be divided.

The ISO has also proposed several operational requirements related to reactive power capabilities of asynchronous generating facilities. These proposed requirements establish the required reactive support expected from asynchronous generating facilities, including the net reactive power range based on the real power output delivered at the point of interconnection, the need for the ISO curtail power output if reactive power capability is unavailable, as well as the conditions during which an asynchronous generating facility must absorb reactive power and conditions when it must provide reactive power. The ISO's proposed requirements are intended to provide objective parameters to allow for the design of asynchronous generating facilities.

Q. Are these requirements technically feasible for asynchronous generating facilities?

A. Yes. Asynchronous generating facilities can meet this requirement by three different means:

- Provide reactive power control via the aggregate capability of the generating units that comprise the asynchronous generating facility;

- Rely solely on switched or variable reactive compensation devices within the facility, with the generating units limited to unity power factor, or other fixed power factor, operation; or

- A hybrid of the first two options.

To apply the first option, the generating units must have a lagging power factor less than 0.95 at high load levels in order to compensate for reactive power losses in the collection system. At low power, the generating units may need a leading power factor less than 0.95 to compensate for the collector feeder cable capacitive charging current. An asynchronous generating facility must typically increase the rating of the generating unit power conversion equipment in order to provide this reactive capability. The approximate increase is the reciprocal of the minimum power factor, minus one. An important consideration is that this increase applies only to the rating of the power conversion equipment (*e.g.*, the generator or inverter) and not the prime mover (wind turbine or PV panels) of the generating units.

Q. Can you confirm whether equipment is commercially available to satisfy the ISO's proposed reactive power requirements?

A. The equipment is readily available. As noted above, the reactive power sources used to comply with this design requirement include: (1) the inverters associated with the asynchronous generation, (2) switched capacitors and reactors (inductors) or static devices (such as a STATCOM), or (3) a combination of these sources. Appendix C to my testimony provides a survey of inverter manufacturers that represent they can provide reactive power. Capacitors and reactors have been used extensively for many years to provide reactive power support to the power system. Capacitors are readily available and the application to the power grid is well understood by power system engineers. As such, applying these requirements are not expected to result in material engineering changes by the developer, delays in permitting, or the need to delay or reassess any existing ISO interconnection studies. The issue for developers of asynchronous generating facilities is merely one of cost.

Q. Can you describe the range of costs that asynchronous generating units will incur in order to meet the ISO's proposed power factor requirements?

A. The costs related to the increase power conversion, needed to meet the ISO requirements are generally modest regardless of which option a developer chooses in order to meet the power factor requirements. In a typical plant design, the minimum power factor for a generating unit needed to compensate for the facilities reactive losses is on the order of 0.90. The mega volt-ampere rating needs to be increased approximately 11%, with a resulting cost increase of this amount or less. Power conversion costs typically range between $100/kVA to $200/kVA. The resulting costs, calculated by applying the 11% increase to the power conversion cost range, are on the order of $11 - $22 per kW of plant rating. The Phase 2A Working Subgroup of the California Renewable Energy Transmission Initiative (RETI) recently posted a draft Project

Characteristics and Cost Calculator spreadsheet that informs that group's transmission planning efforts. The listed capital costs for fixed and tracking photovoltaic projects are assumed to be $3800 kW and $4500 kW, respectively. Wind project capital costs also have a range, but the lowest value is assumed to be $2160 kW. See RETI materials on the California Energy Commission website at http://www.energy.ca.gov/reti/steering/workgroups/phase2A_update/. Based on the RETI draft estimates of capital costs, the compliance cost for meeting the ISO requirement through this mechanism for solar PV is likely to be in a range from 0.25% to 0.58% of the total plant cost depending on the underlying solar technology, including the primary energy equipment (prime mover, but exclusive of transmission related costs). For wind generators using the lowest RETI project capital cost estimate, compliance will be approximately 1% or less of total plant cost. Thus, the cost of compliance is relatively small in relation to the total capital cost of wind and solar PV projects.

Except where dynamic reactive compensation range is identified as a necessity by a specific interconnection study, simple switched shunt reactive compensation banks can be used to implement the second option. The proposed ISO requirements specifically allow for the use of low-cost switched compensation as a means of providing net reactive power range, relieving the need for generating unit equipment with reactive capability.

Where dynamic reactive compensation is required, this capability can be provided by static synchronous compensators (STATCOM) or static var compensators (SVC) connected to the facility. These compensators are available from a number of different vendors, and are widely used in wind plant applications. The installed costs for shunt capacitive compensation is on the order of $10-$15/kVAR, including the necessary switchgear and substation infrastructure. The installed costs for shunt inductive compensation may also fall in the range of $15 - $20/kVAR. Because bi-directional reactive capability is required, both shunt capacitive and inductive compensation banks would be needed. The cost of implementing reactive power range compliance solely with switched compensation banks is on the order of $8 - $12 per kW of plant rating. This option tends to be less expensive than uprating power conversion equipment, but it does not have the same degree of controllability. Again, using the RETI capital cost assumptions, the cost of compliance under this option is approximately 0.32% or less of the total plant cost for solar PV or wind facilities.

A hybrid of switched compensation and dynamic compensation provided by generating units provides the capability to provide a continuously variable reactive power supply while extending the range of the generating units. Continuous variability can be accomplished if the reactive outputs of the generating units are coordinated with the shunt reactive bank switching such that the step change at bank switching is compensated by an opposing shift in the output of the generating range. In this way, asynchronous generating facilities can design the most cost-effective means of meeting the ISO's proposed requirements.

V. Voltage Regulation and Reactive Power Control Requirements

Q. What is the purpose of the ISO's proposed voltage regulation and reactive power control requirements for asynchronous generating facilities?

A. The purpose of the ISO proposed requirements is to ensure that asynchronous generating facilities have an automatic system to regulate voltage levels and reactive power at the point of interconnection.

Q. Can you summarize the ISO's proposed requirements for the design of these automatic systems.

A. The ISO's proposed design for these automatic systems requires asynchronous generating facilities to regulate voltage levels and the net power factor level within tolerance bands at the point of interconnection depending on the facility's operating mode.

Q. What operating modes must an asynchronous generating facility meet under the ISO's proposed requirements?

A. Under the ISO's requirements, an asynchronous generator must have a voltage regulation operating mode and a net power factor regulation operating mode. The ISO's requirements specify that voltage regulation will be the default mode of operation. Under this configuration, the facility's reactive power output and input is adjusted by an automatic control such that the point of interconnection voltage is maintained to a scheduled value, within tolerances. This is specified by ISO to be the default mode because it is generally desirable to maintain a voltage profile in the grid as specified by the transmission operator and is also necessary to adhere to WECC's Minimum Operating Reliability Criteria.[3]

Under a net power factor operating mode, the facility's reactive power output and input is adjusted by an automatic control such that the net power factor at the point of interconnection is maintained at a specified value. The power factor regulation mode is desirable when the facility's rating is too small, relative to the strength of the transmission system at the point of interconnection, to materially affect the point of interconnection voltage. Use of a voltage regulation mode in such a case would cause large variations of the facility's reactive power output due to relatively small changes in voltage at the point of interconnection.

[3] Section 2.(B)(5) of WECC Minimum Operating Reliability Criteria dated April 6, 2005 at 10. http://www.wecc.biz/Standards/WECC%20Criteria/WECC%20Reliability%20Criteria.pdf

Q. Please explain why it is important for asynchronous generating facilities to regulate voltage levels at the point of interconnection.

A. To provide for secure operation of a transmission system, it is necessary to maintain a voltage schedule prescribed by the transmission operator. Generating facilities connected to the transmission system are the primary means available to control transmission system voltages. Requiring all generating facilities, both asynchronous and synchronous, to regulate their point of interconnection voltage is the fair and technically appropriate means of securing the appropriate participation of all generating plants in the essential objective of maintaining the voltage schedule necessary for secure system operation. Voltage regulation is implemented through variation in a facility's reactive power flow. Regulation of transmission voltage by each plant automatically provides the means to extract the appropriate amount of reactive power from each plant to provide for the transmission system's reactive power requirements. These requirements are not limited to reactive power demand by loads, not otherwise compensated at the distribution level, but also include reactive power consumed by the transmission system as a function of the current flow through the lines and transformers. Much of the reactive power from each generating facility compensates for the reactive power consumption, or losses, on the transmission system caused by the real power output from the generating facility. Regulation of the point of interconnection voltage causes the reactive power flow from the facility to more or less compensate for the reactive losses in the transmission system that facility's output causes.

As with other technical requirements, the rapidly increasing number of asynchronous resources being interconnected to the ISO's grid over the next several years makes it important that these resources provide voltage regulation services in the same manner as already required of conventional generators. Excepting asynchronous generators from these long-standing requirements will result in an increasingly less robust and reliable system in terms of its ability to sustain necessary voltage levels.

Q. How can an asynchronous generating facility regulate voltage through the use of an automatic system?

A. Voltage regulation is achieved by appropriate control of the reactive power flow from, or into, the asynchronous generating facility. Where reactive power is provided by a facility's generating units, it is usually necessary to implement some form of facility level control to coordinate the individual generator unit reactive output. The ISO has proposed voltage regulation tolerances, maximum abrupt voltage change, and response time requirements which have been specifically configured to allow for the use of switched reactive compensation banks to meet the voltage regulation requirements.

Q. Please explain why it is important for asynchronous generating facilities to regulate net power factor at the point of interconnection.

A. Regulation of power factor is used when voltage regulation would otherwise cause large swings in a facility's reactive power output due to small transmission system voltage variations, which may be unrelated to the output of the facility. Regulation of power factor at the point of interconnection, as required by ISO, is not the same as regulating the power factor at individual asynchronous generating units. The collection system of an asynchronous generating facility, particularly transformers, can cause a loss of reactive power. These reactive losses cause the power factor to fluctuate with the loading of the facility, if the power factor is regulated at the unit terminals. Thus, the reactive demand caused by reactive losses within the asynchronous generating facility would shift to the transmission system if power factor regulation were measured at the unit terminals

Therefore, ISO has required that the net power factor at the point of interconnection be regulated to a prescribed value when the power factor regulation mode is enabled. This causes the reactive power flow from the facility to be in constant proportion to the real power output, and causes the facility to compensate for its own internal reactive power losses.

Q. How can an asynchronous generating facility regulate net power factor through the use of an automatic system?

A. The most straightforward means to implement a net power factor regulation system is to use a control system that measures the real and reactive power flow at the point of interconnection, and adjusts the reactive power output of the reactive power sources within the facility in a closed-loop fashion such that the prescribed net power factor is achieved. The reactive power sources could be individual asynchronous generating units, supplemental reactive devices included in the facility balance of plant (e.g., capacitor banks, static var compensator, etc.), or a combination of these. Other means of regulating the net power factor involve measurements of currents and voltages at locations other than the point of interconnection, and mathematically calculating the real and reactive power flow at point of interconnection such that the power factor there can be regulated.

VI. Power Plant Management

Q. What is the purpose of the ISO's proposed power plant requirements for asynchronous generating facilities?

A. The purpose of these requirements is to ensure that asynchronous generating facilities have the capability to reduce or increase output in a controlled manner.

Q. Can you summarize the ISO's proposed requirements for the design of this these generation management systems.

A. The ISO is proposing to require asynchronous generating facilities to implement a power ramp rate and a frequency response requirement. In both cases, the requirement is for a controlled curtailment of output. There is no requirement to supply energy not available from the prime source of an asynchronous generating facility. In other words, there is no need for the asynchronous generator to "hold back" output by spilling wind or sun, except during those periods in which a specific instruction from the ISO directs the resource to activate the generation management controls. In contrast, if there was an under-frequency response requirement, the generator would necessarily have to withhold converting some fuel into power to be able to increase output in response to an under-frequency event. The ISO is proposing asynchronous generating facilities meet these requirements by January 1, 2012.

Q. How, if at all, can asynchronous generating facilities implement power plant ramp rate controls?

A. Controlling ramp rates should occur on a facility-level basis. If an asynchronous generating facility has the means to limit the output of an individual generator unit, or even to switch generator units off and on, then the ramping limit can be achieved using ordinary engineering knowledge and widely available programmable logic control hardware. Ramp rate limitation capability has been required of wind generation by a number of grid codes around the world. The wind industry has responded and plant-level controls are readily available to control the power ramp rates of wind generation facilities. These controls are generally implemented by measurement of the total facility power output, comparison of the rate of change in this output, and control of the output of individual wind turbine generators in order to not exceed the rate-of-change (ramp rate) limit. This requires a means of communication between a central control or measurement point, and the individual turbines, which are dispersed about the facility.

The output of wind turbines is generally implemented through an adjustment of the wind turbine blade pitch such that the amount of power extracted from the wind is varied. For some wind turbine designs, such as "stall-regulated" turbines, energy extraction cannot be regulated. For facilities using turbines of this design, power output is modulated in a stepwise fashion by turning off and turning on individual turbines.

The same means can be applied to limit power ramp rates of solar PV facilities, with perhaps less challenge in comparison to wind generation because there are no mechanical or aerodynamic considerations in the case of solar PV generation. The inverters of a solar PV facility can easily regulate power output. Even where inverters with this capability are not used in a solar PV facility, a power ramp rate limitation capability compliant with the ISO's proposed requirements can still be readily implemented by turning off and on individual inverters within the facility. The ISO's proposed requirements allow step-wise ramps up to 5 MW step size. Facilities can, therefore, implement ramping control by turning on and off individual generating units having less than 5 MW capacity, if the generating unit cannot vary its individual output.

Although pre-engineered plant control packages are available, these should not be necessary because implementing a custom ramp control feature is rather straightforward as an engineering matter. Further, the ISO will allow ramp rates to exceed the prescribed requirements during a loss of the resources fuel source. The ISO will allow the resource to continue to ramp back toward its operating target after a drop in fuel in accordance with the prescribed ramp rate.

Q. Could you please describe the components of a pre-engineered control package?

A. The components of a pre-engineered control package are a central control processor and a communications system to interconnect the central controller with the controls of the individual asynchronous generating units. The central control processor could be a generic programmable controller, on which software specific to the application is loaded, or a purpose-designed controller. The communication system typically uses fiber optic cables, and includes switches and repeaters as necessary to convey the signal and to interface with other control equipment. Typically, some form of communications between individual asynchronous generating units and a central point is installed to facilitate condition monitoring and basic unit control functions, such as placing units on and offline, or to curtail unit output in response to a system emergency. Adding communication capabilities to support closed-loop facility-level controls, such as limitation of facility power output ramp rates, should not entail significant increase in the required communications infrastructure. The pre-engineered control system also needs power system measurements, such as currents and voltages, which are typically derived from instrument transformers primarily installed for metering or protection purposes, and are thus typically not part of the engineered package.

Q. Is it possible for an asynchronous generating facility to maintain a specified output in response to an ISO instruction?

A. Yes, but it should be noted that the ISO has not established a tolerance band and therefore the impact of deviating from the operating target will be the subject of market rules yet to be developed.

Q. How, if at all, can asynchronous generating facilities implement the frequency droop requirement?

A. The ISO's proposed frequency response requirement is similar to the requirement applicable to conventional generators operating today on the

ISO system, except that it requires asynchronous generators to mitigate over-frequency, not under-frequency, excursions. Frequency response can either be implemented by controls at the facility level, using the same approach and hardware as discussed for ramp rate limitation, or by implementation within the generator unit controls.

Q. Has the ISO proposed a limited timeframe for asynchronous generating facilities to provide frequency response.

A. No. Some stakeholders requested that the ISO limit the duration of the frequency response to a couple of seconds or until the ISO's capacity on regulation service responds to the frequency deviation. Setting an artificial temporal limit, however, is imprudent. The generator response should persist until frequency recovers below the threshold level. Otherwise, the relaxation of the generator response would exacerbate the frequency excursion.

I declare under penalty of perjury that the foregoing statements are true and correct to the best of my knowledge, information, and belief.

Executed this 1st day of July, 2010 in Schenectady, New York

Reigh Walling

Appendix A

Appendix A – Publications by Reigh Walling

R. Walling, K. Clark, **Grid Support Functions Implemented in Utility-Scale PV Systems**, Proceedings of the IEEE PES Transmission and Distribution Conference and Exposition, May, 2010.

B. Yang, R. Walling, L. Freeman, J. Skliutas, M. Marshall, ·**Improving Utility Energy Efficiency Through Loss Identification**, Proceedings of the IEEE PES Transmission and Distribution Conference and Exposition, May, 2010.

B. Yang, J. Weiss, R. Walling, L. Freeman, M. Marshall, **The Breakdown and Mitigation of Technical Losses on Distribution Power Systems**, Proceedings of the 2010 DistribuTech Conference, March 23, 2010.

R. Walling, G. Jordan, **Impacts of Wind Generation on Thermal Unit Operation**, Proceedings of 2009 POWER-GEN International Conference, December, 2009.

J. Bebic, R. Walling, K. O'Brien, B. Kroposki, **The Sun Also Rises**, IEEE Power and Energy Magazine, Vol. 7, No. 3, 2009.

R. Walling, **Islanding Issues for Large-Scale Wind Generators Interconnected to Local-Delivery Distribution Systems**, Proceedings of the Power & Energy Society General Meeting, 2009

N. Miller, K. Clark, R. Walling, **WINDINERTIA™: Controlled Inertial Response from GE Wind Turbine Generators**, Proceedings of the 2009 Minnesota Power Systems Conference, Brooklyn Heights, Minnesota, October, 2009.

R. Walling, L. Freeman, W. Lasher, **Regulation Requirements with High Wind Generation Penetration in the ERCOT Market,** Proceedings of the IEEE Power Systems Conference and Exposition, 2009.

R. Walling, M. Reichard, **Short Circuit Behavior of Wind Turbine Generators**, 62nd Annual Conference for Protective Relay Engineers, Texas A&M, 2009

R. Walling, L. Freeman, N. W. Miller, J. Freedman, W. Lasher, **Risks of Extreme Wind Generation Output Changes in the ERCOT Market**, Proceedings of the 8th International Workshop on Large-Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Farms, Bremen, Germany, October, 2009.

E. Camm, R. Walling, et al, **Reactive Power Compensation for Wind Power Plants**, Proceedings of the Power & Energy Society General Meeting, 2009

E. Camm, R. Walling, et al, **Wind Power Plant Substation and Collector System Redundancy, Reliability, and Economics**, Proceedings of the Power & Energy Society General Meeting, 2009

E. Camm, R. Walling, et al, **·Wind Power Plant Collector System Design Considerations**, Proceedings of the Power & Energy Society General Meeting, 2009

E. Camm, R. Walling, et al, **·Wind Power Plant Grounding, Overvoltage Protection, and Insulation Coordination**, Proceedings of the Power & Energy Society General Meeting, 2009

R. Walling, L. Freeman, J. Freedman, W. Lasher, **Risks of Extreme Wind Generation Output Changes in the ERCOT Market**, Proceedings of the American Wind Energy Association WindPower'09 Conference, 2009.

R. Walling, P. Riley, C. Gaytan, **Optimization of Wind Turbine Unit Transformer Ratings**, Proceedings of the American Wind Energy Association WindPower'09 Conference, 2009.

E. Camm, R. Walling, et al, ·· **Characteristics of Wind Turbine Generators for Wind Power Plants**, Proceedings of the Power & Energy Society General Meeting, 2009*R. Piwko, E. Camm, A. Ellis, E. Muljadi, R. Zavadil, R. Walling, M. O'Malley, G. Irwin, S. Saylors*, **A Whirl of Activity**, IEEE Power and Energy Magazine, Vol. 7, No. 6, 2009.

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Appendix B

GE

Energy

Technical Requirements for Wind Generation Interconnection and Integration

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November 3, 2009

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Section 1
INTRODUCTION

This report documents current status of wind generation technology and forecasting. It is intended to provide information on important topics related to the interconnection of wind generation facilities to the bulk power system, the operation of the bulk power system with significant amounts of wind generation, and the technology underlying wind generation forecasting and applications to power system operation.

In addition, as requested by ISO-NE, the project team consisting of GE, EnerNex Corporation, and AWS Truewind offers commentary and makes specific recommendations based on their work in the electric power and wind generation industries. It is understood that these recommendations may form some of the basis for ISO-NE policies and practices in anticipation of significant wind generation development in their market footprint. The recommendations (as well as the overall report) focus on the underlying technologies for large-scale wind generation and its interconnection and integration with the bulk power system (BPS). Other issues, such as design of specific energy market mechanisms or financial incentives, are discussed but the details of the architecture and implementation of specific designs are outside the scope of this report.

The report is divided into three major sections:

1. **Wind Turbine and Wind Plant Technology**, which covers aspects of wind plant performance and capabilities relevant to the interconnection with the transmission network and integration with ISO-NE system operations
2. **Wind Generation Forecasting** describes the science and challenge of wind generation forecasting, the commercial state-of-the-art, and prospects for future improvement. Data requirements for forecasting are defined, as well as the latest thinking in how the information generated by a forecasting system should be interfaced with power system operations.
3. **Grid Operations with Significant Wind Generation,** where the fundamental challenges for short-term operational planning and real-time management of systems with substantial wind generation area described, along with mechanisms for minimizing or reducing the technical or economic impacts.

There is some overlap between the background sections. This was intentional, since the three topical areas can be viewed as interconnected. For example, the Wind Generation Forecasting System has critical interfaces with both individual wind plants and the grid operator, who in turn has a direct interface to each individual wind plant. In some cases these interfaces are physical, as in the communications infrastructure used to transmit operating data and control signals. In other cases, the interface involves requirements or specifications, i.e. interconnection requirements that spell out the necessary behavior of a wind plant at the point of interconnection to the bulk transmission system.

The information contained in the main body of the document, as constituted by the three major sections, form the basis for the **Recommendations** to ISO-NE, which is the initial section of the report.

Section 2

RECOMMENDATIONS

The recommendations of sections 2.1, 2.2, and 2.3 are functionally grouped according to requirements to be placed on individual wind plants, the system for forecasting wind generation, and recommendations for Independent System Operator of New England (ISO-NE operations). These recommendations are supported by detailed discussion in Section 3 , Section 4 and Section 5 , respectively.

2.1. RECOMMENDATIONS FOR WIND PLANTS

Recommendations provided in this section are specifically intended to guide requirements that should be placed on interconnecting wind plants. This is distinct from further recommendations, summarized in Section 2.3 below, that provide recommendations on how ISO-NE should use these functions in the operation of the ISO-NE system. Further detailed technical background on each recommendation is provided in Section 3 .

In general, the project team recommends that wind plants to be connected with the bulk transmission network be treated no differently than any other generator in the ISO-NE interconnection queue. Experience from recent years has shown that wind plants can be designed to meet requirements established for conventional generating units and plants; additionally, the current fleet of commercial turbines enables dynamic performance in response to system disturbances that is possibly more benign than the behavior of conventional synchronous generators.

Taking this line of thinking one step further, ISO-NE interconnection requirements must focus on the plant behavior, and how it interacts with the rest of the power system. While wind turbines are an especially important component of wind plants and their capabilities and behavior will influence the necessary plant design to achieve desired performance, interconnection requirements should avoid inferences to the specific behavior of wind turbines.

Wind plants are not simply collections of individual wind turbines. Rather they must be integrated into fully engineered power plants, with many other critical components. The wind industry has been a rather slow to fully recognize that the capabilities and features of a specific wind turbine are only the starting point for design of the plant. With the progress that has been made in this area over the past few years, the project team feels strongly that specifying the terminal behavior of wind plants consistent with what is required for conventional generating facilities is the proper approach.

Integration encompasses the influence of wind plants on and participation in short-term scheduling and real-time operations of the ISO-NE system. Included are the nature of wind energy delivery in real time and the control thereof, mechanisms for coordination of wind plant operation with ISO-NE system operators, and the collection and communication of important operational data.

The general recommendation here adheres to the philosophy for interconnection: Requirements for wind plants in terms of visibility and interoperability with ISO-NE should be as consistent with those for conventional generators as possible. However, the unique characteristics of wind energy production necessitate some special considerations in the operating time frame. Recommendations presented here recognize the different characteristics of wind generation, and are intended to provide requirements to be placed on wind plants that will enable ISO-NE to successfully operate with large amounts of wind power considering the unique nature of the resource.

The focus of these recommendations is on the wind plant as a single entity. Recommendations are functional, rather than providing wind turbine technology specific guidelines. Most important, these are forward looking recommendations, based on current understanding of available and merging technology, and on current understanding of the challenges faced by grid operators for integration of large amount of wind generation. The reality is that technology, practice and understanding are evolving rapidly. ISO-NE must recognize that adjustments to rules and requirements will continuously emerge as the entire industry matures.

Recommendations concerning specific requirements follow.

2.1.1. Voltage and Reactive Power Recommendations

2.1.1.1. Comply with FERC and NERC

Both the FERC (Federal Energy Regulatory Commission) and NERC (National Electricity Reliability Corporation) have been actively engaged in setting rules and recommendations for voltage and reactive power control. FERC Order 661a [1] sets requirements for power factor range and for voltage regulation. These rules, while subject to some interpretation, are still a sound foundation for ISO-NE. NERC activities are summarized in section 2.3.6

2.1.1.2. Pursue 0.95 Power Factor at POI

FERC Order 661a sets a requirement for $\pm$0.95 power factor capability at the point of interconnection. There is a qualifying clause that puts the onus on the host system to prove the need for meeting this range. This is at odds with most NERC regional large generator interconnection rules. Nevertheless, per discussion in Section 3.3, some grids (utilities and/or ISOs) have decided that the language is so vague and that the definitions for the burden of proof so ambiguous, that they waive the power factor range requirement. The 0.95 power factor rule roughly translates to a requirement for $\pm$0.90 power factor at the wind turbine generator terminals, as is typical for synchronous generation. ISO-NE's Large Generator Interconnection Agreement (LGIA, Item 9.6.1) requires that power plants be capable of continuous operation in the range of 0.95 power factor leading to 0.95 power factor lagging. The LGIA presently exempts wind plants from this requirement. The project team recommends that this exemption be eliminated for large wind plants. Today's wind plant technology is fully capable of meeting this power factor range requirement, and reactive power support with closed loop voltage control is essential to the operation and reliability of a power grid.

Voltage and reactive power measurements should be made at the specified point-of-interconnection (usually the transmission side of the wind plant substation transformer)..

However, at the same time, ISO-NE should avoid applying the ±0.95 power factor rules for unreasonable conditions. Specifically, as with other generation, the wind generation equipment should not be required to violate voltage ratings. In practice, this means that wind plants ought not be required to deliver large amounts of reactive power into a system with already high voltages, nor consume reactive power from systems with low voltages. As discussed in Section 3.3.1, some grid codes have made provision for this practical constraint.

2.1.1.3. Specify a minimum level of dynamic reactive power capability

Current rules do not address the nature of the reactive power capability necessary to meet minimum power factor requirements. As discussed in Section 3.3.2.2, some systems require that roughly ½ of the total range be dynamic. Such a requirement may prove to be overly restrictive or expensive for the system needs of New England. It is recommended that ISO-NE system studies be used as a mechanism to dictate the fraction of plant reactive capability that must be dynamics. Requirements should be based on dynamic simulations of voltage performance for system disturbances. Voltage recovery times should be consistent with ISO-NE planning criteria.

2.1.1.4. Enforce prescriptive interpretation of the rules

The language around power factor and voltage regulation in the rules has been subject to two general interpretations that can be widely classified as "permissive" and "prescriptive". The permissive interpretation is that wind plants are required to stay within the ±0.95 power factor range, but are allowed to be anywhere within that range. Whereas, the prescriptive interpretation is that wind plants must provide voltage regulation at the specified point (usually, but not always the point-of-interconnection) by delivering the reactive power required to meet a specified voltage (under control of a voltage regulator) anywhere within the required power factor range. As discussed further in Section 3.3, this later interpretation of the rules is more in line with practice for other types of generation and is more consistent with the reliability needs of the grid.

2.1.1.5. Schedule voltages

ISO-NE's LGIA, Item 9.6.2, requires power plants to have a voltage regulator and to operate in automatic voltage control. Wind plants should be subject to this same requirement, and should respond to voltage setpoint (schedule) signals communicated from the ISO to the wind plant. Wind plants are often connected in weak portion of the grid, and selection of appropriate voltage schedule can improve the performance and security of the system. See Section 3.3 and 3.3.2.1 for additional information about voltage regulation.

2.1.1.6. Avoid power factor control

The default design for many wind plants, the FERC rules notwithstanding, is to provide power factor control. Holding unity power factor is relatively common. This practice evolved because wind plants were originally incapable of providing voltage regulation, and it persists in much of Europe. However, power factor control is inimical to good grid performance in large geographically diverse grids with significant wind generation. Further discussion is provided in Section 3.3.

2.1.1.7. Be careful of control of multiple plants

It is not uncommon for multiple wind plants to be developed in relatively close electrical proximity to each other, and electrically remote from large portions of major grids. This certainly could become the case in New England. Voltage control for multiple power plants in close requires some care and coordination. This applies to wind plants as well. Further discussion is provided in Section 3.3.2.3.

2.1.1.8. Adopt permissive rules for low power

Unlike the vast majority of the thermal power plants, wind plants can typically operate at quite low power levels. Per discussion in Section 3.3.2.4, under low active power conditions, it can be difficult for wind plants to meet tight requirements for voltage and reactive power control. Requirements for voltage regulation should be relaxed or eliminated at low power (less than about 20% of plant rating), and permissive reactive power range should enforced. This permissive interpretation means that a plant may operate anywhere in the reactive power range corresponding to ±0.95 power factor of 20% of plant nameplate whenever the plant power output is below 20% of its nameplate rating. For a wind plant rated at 100 MW, this works out to be ±6.6 MVAr for power levels between zero and 20MW.

2.1.1.9. Consider no-wind VArs

Some wind OEMs offer the capability for wind plants, to provide controllable reactive power even when the wind turbines are not running due to low (or high) wind. This capability can be provided either by wind turbine-generator controls (per Section 3.3.2.5) or by means of separate reactive power devices (e.g. static VAr compensators) within the wind plant (per Section 3.3.1). From a grid operations perspective, this is roughly similar to having a conventional generator run as a synchronous condenser, but with lower losses. ISO-NE should recognize that such capability is available, and may be highly valuable in remote or weak portions of the system. The ancillary service market for reactive support in New England may be sufficient to encourage this functionality. If not, contractual arrangements should be made to enable this capability, where attractive, on a case-by-case basis.

2.1.2. Performance During and After System Disturbances

2.1.2.1. Comply with FERC and NERC

Again, both FERC and NERC have been actively engaged in setting rules and recommendations for fault ride-through capability. The debate is most mature and arguments most settled for low or zero voltage ride-through. NERC Standards Project 2007-09: Generator Verification is updating Standard PRC-024: Generator Performance during Frequency and Voltage Excursions which will establish technology-neutral requirements for all generators concerning voltage and frequency events. Requirements for high voltage ride-through are somewhat less mature, with both language and numerical thresholds still being widely debated. The industry appears to be converging on rules like those shown in Figure 11. These should be satisfactory for New England, as the needs of large interconnected grids for such performance are all similar. ISO-NE should stay engaged with the ongoing NERC debates, and provide inputs as necessary.

2.1.2.2. *Avoid divergent fault-ride through specifications*

New England should not develop fault-ride through specs that are different from the convergence of the national debate. This will unnecessarily add cost to wind projects in New England, and will have a tendency to block some OEMs (original equipment manufacturers) from participation (per discussion in Section 3.2.1).

2.1.2.3. *Frequency ride-through as per NPCC rules*

Generally wind plants are quite tolerant of frequency excursions (per discussion in Section 3.2.3). Present NPCC (Northeast Power Coordinating Council) rules for off-nominal frequency for all plants ought to be applied to wind plants. NERC is establishing frequency ride through requirements for all generators as part of standard PRC-024.

2.1.2.4. *Do not bother with explicit dF/dt requirements*

Some small or isolated grids (per Section 3.2.4) have adopted rate of change of frequency tolerance requirements. These are unnecessarily complicated for large grids like New England, and are likely to be proscriptive for some OEMs. Current US grid code debate is largely silent on this topic. ISO-NE should not specify rate of change of frequency requirements for wind plants.

2.1.2.5. *Allow, or even encourage, reduced power output for deep voltage events*

During deep voltage depressions, it is physically difficult or impossible to maintain active power injection to the grid. While some grid codes (outside the US) have tried to force wind turbines to take extreme measures to continue to inject active power during deep voltage dips, this is neither necessary nor desirable. Rather, grid performance during and immediately following severe disturbances tends to be better if active power injection is depressed and then allowed to recover over several hundred milliseconds in the post-fault time frame. Thus, in addition to allowing active power to drop during voltage depressions, New England should avoid excessively tight or fast post-fault power recovery requirements. Per discussion in Section 3.2.2.1, recovery to within 90% of pre-disturbance power within ½ second is a reasonable target. Again, current US grid code debate is largely silent on this topic.

2.1.2.6. *Allow or encourage increase in reactive power for deep voltage events.*

In contrast to active power, delivery of reactive power during voltage depressions is beneficial to the grid because it helps to support voltage and limit the geographic extent of voltage depression. Per discussion in Section 3.2.2.2, in broad terms, wind plants should be encouraged to deliver as much reactive current as the equipment allows during voltage depressions.

2.1.2.7. *Avoid over prescribing fault performance*

Some grid codes have moved towards extremely detailed prescriptions for active and reactive power (or current) control during disturbances. In practice grid faults are violent, non-linear, and usually unbalanced events. Such tight requirements do little to improve overall system reliability and can add substantially to the cost of wind generation equipment. New England should avoid tight active and reactive power control (e.g. do not require that reactive current be held exactly at 1.0 p.u., as has been proposed elsewhere) and avoid any requirements beyond survival and recovery for very deep events (e.g. <20%). Per discussion in Section 3.2.2., specific fault performance rules are not normally imposed on other types of generation.

2.1.2.8. Prohibit islanding

Wind plants are not suited to islanded operation. It should be standard practice for ISO-NE to prohibit islanded operation of wind plants. ISO-NE should require transfer trip of wind plants for which relay and breaker action can result, even briefly, in a wind plant being separated from the grid with other, non-wind plant customers. In this context, "islanded" refers to a small portion of the power grid, with little or no other synchronous generation, being separated by switching action from the larger grid. It does not refer to inter-regional conditions for which (for example) all of New England separates from the Eastern Interconnection. Further discussion is provided in Section 3.2.6.

2.1.2.9. Specify recovery and re-start rules after system and wind disturbances

Wind plants will typically automatically start when wind conditions and grid voltage are available. Following system disturbances, the restart of wind plants once system voltage has been restored is usually desirable. However, as with other generators, some situations may arise for which automatic restart is undesirable. ISO-NE should require that wind plants be able to accept commands from system operators both to start and to not start or delay start until certain conditions (e.g. another plant has started) are met. Thus, the default practice for ISO-NE should be that wind plants are not allowed to restart after system disturbances. ISO-NE may determine, analytically or otherwise, that certain plants should be allowed to restart automatically.

As discussed above, wind plants cannot operate in islanded mode. Therefore, wind generation cannot provide blackstart capability. Wind plants can help support a partially restored grid, but must not be relied upon to provide primary frequency regulation. System restoration plans should recognize these constraints. Constraints of system short circuit strength, as discussed in Section 3.2.6, should be respected during restoration. US industry does not have well established practice regarding system restoration with wind generation. ISO-NE should stay engaged with ongoing industry activities.

Wind generation that stops due to wind conditions, either low winds or due to high wind speed (per discussion in Section 3.2.5.3) should be allowed to automatically restart, unless specific operating conditions are identified that warrant blocking. However, multiple large wind plants in wind-rich regions coming back too rapidly after a cutout event may cause an unacceptable disturbance to grid operations. ISO-NE may need to engage ramp-rate limiters when curtailment events occur to manage the rate of power recovery after the event.

2.1.2.10. Substation and station service design

Wind plants, like other conventional generation on the ISO-NE system, should be designed such that station service and auxiliary systems are not dependent on in-feed from vulnerable alternative circuits such as unrelated distribution lines. Requirements for station service reliability for wind plants should be the same as for other non-black start ISO-NE generation.

2.1.3. Active Power Control Recommendations

2.1.3.1. Engage with FERC and NERC

Unlike the previous two topics, discussions of various types of active power control are only the earliest stages within the US. Thus, ISO-NE should stay engaged with the nascent NERC debates (e.g. project 2007-5 and 2007-12 per Section 2.3.6), and provide inputs as necessary.

2.1.3.2. Require curtailment capability, but avoid requirements for excessively fast response

Wind generation can respond rapidly to instructions to reduce power output or to relax curtailments. In many cases response is faster than convention thermal or hydro generation. However, there have been cases where proposed grid codes have made excessive requirements for speed of step response to a curtailment order. This is technically challenging and should be avoided. As discussed in Section 3.4.1, Δ10%/second for rate of response to a step command to increase or reduce power output is reasonable. This rate of response to step instructions should not be confused with deliberate imposition of ramp rate limits, as discussed next.

Some conventional generation can reach, or even exceed, these rates. Most cannot. The project team is not aware of any NERC standards that specify rate of response to redispatch commands (of which curtailment is a subset) in this time frame. Typically, plants must respond to economic re dispatch within minutes. ISO-NE may wish to consider markets or other incentives to encourage rapid rate of response from all generating resources.

2.1.3.3. Require capability to limit rate of increase of power output

Wind plants should be required have the capability to limit the rate of power increase. This type of up ramp rate control capability has been required in some other systems (per discussion in section 3.4.2). This function should include the ability to be enabled and disabled by instruction from ISO. Plants must be able to accept commands from ISO-NE to enable pre-selected ramp rate limits. Plants should be designed with recognition that ramp rate limits should not be required under all operating conditions. ISO-NE should not require that wind plants limit power decreases due to declines in wind speed, i.e. down ramp rate limits. However, limits on the rate of either increase or decrease in power output due to other reasons, including curtailment commands, shut-down sequences, response to market conditions and other control actions can be reasonably required.

2.1.3.4. Encourage capability to accept AGC signals

Wind plant technology has advanced to a point where it is possible for wind plants to participate in AGC. However, doing so requires a wind plant to continuously spill a portion of the available wind energy in order to have up-range available in power output.

Wind plant participation in AGC may be justifiable in small island systems where imbalances quickly lead to significant changes in system frequency. However, in large interconnected grids like the eastern interconnection, AGC participation would not be justified in the foreseeable future. In the more distant future when total wind penetration levels approach 15% to 20% energy of the entire interconnection, AGC participation would become more important.

It is recommended that ISO-NE encourage wind plants to have AGC capability or provision for future retrofit of AGC functions.

2.1.3.5. Encourage or mandate reduction of active power in response to high frequencies

ISO-NE should encourage wind plants to provide over-frequency droop response of similar character to that of other synchronous machine governors. Capabilities to provide this function are discussed in Section 3.4.4.2.

2.1.3.6. Consider requiring the capability to provide increase of active power for low frequencies

This is the other face of frequency control. Wind plants should not be required to provide governor-like frequency response for low frequency under normal operating conditions. This is consistent with any conventional power plant operating at full throttle output (i.e. valves wide open). However, ISO-NE should consider requiring that wind plant have the capability to provide this response, and then establish rules, and possibly compensation, for when such controls would be enabled. This presumably would be a rare occurrence, as the economic penalty associated with enabling these controls is high, as discussed in Sections 3.4.4 and 3.4.4.3.

2.1.3.7. Consider requiring inertial response in near future

Some OEMs are now offering inertial response for wind turbines. As discussed in Section 3.4.4.4, this is distinct from the previous two items on frequency response, in that inertial response is faster and strictly transient in nature. Consequently, there is not a significant economic penalty associated with the use of this new feature.

Synchronous generators have inherent inertial response. It is not a design requirement. It is simply a consequence of the physical characteristics of the rotating masses connected to a synchronous generator which is in turn connected to an ac transmission network. With the exception of Hydro-Quebec, inertia response characteristics have not been specified in grid codes or interconnection requirements for wind plants. Furthermore, language describing this functionality in technology-neutral terms and subject to the physical reality of wind generation equipment is not presently available. ISO-NE should consider requiring this function in the future as the technology matures and as grid operators and reliability organizations learn more about the need for inertial response characteristics from wind plants.

2.1.4. Harmonics

It is recommended that ISO-NE specifically include the IEEE (Institute of Electrical and Electronics Engineers) Standard 519 in the interconnection requirements, consistent with LGIA Item 9.7.6. In addition, ISO-NE should work to establish guidance for wind project developers and designers regarding background distortion on the network, and whether it must be taken into consideration during plant design.

This guidance should be the same as that provided by ISO-NE regarding harmonic performance for all generation and industrial interconnections, as well as substation modifications (including and especially the addition of shunt capacitor banks to the system). Harmonics are discussed in Section 3.5.

2.1.5. Modeling

2.1.5.1. Follow forthcoming NERC guidance regarding model requirements

NERC, IEEE, WECC (Western Electricity Coordinating Council) and, in the near future, the IEC (International Electrotechnical Commission) are working on standardization of wind plant models. This includes modeling, verification and testing. Since the technology is continuing to evolve, this is necessarily a work in progress. However, in the past few years, a degree of consensus has emerged on suitable modeling. ISO-NE should stay engaged in this process and follow evolving industry practice (see Section 2.3.6). Modeling cooperation is discussed in Section 3.6.1.

2.1.5.2. Use open structure models, when possible

Proprietary models provided under confidentiality agreements by OEMs are problematic for ISOs and utilities that must exchange data. Best practice for evaluation of individual wind plants is to use OEM specific models, when available. Under circumstances where open models are not available, New England should insist that plant data be provided for the new generic open structure models (as discussed in Section 3.6.1). This will allow exchange of databases with wind plants reasonably represented for ISO-wide and region-wide analysis.

2.1.5.3. Always make sure data is up-to-date

No manufacturer has a single model with fixed parameters. Data must be updated and verified for the specifics of the project being analyzed. It is not acceptable to copy and reuse old data for new projects without express reconfirmation by OEM. Further, New England should stay appraised of the ongoing changes and improvements to available models, both OEM specific and generic. Modeling of wind plants, (per discussion in Section 3.6.1) while significantly advanced has not yet fully matured. Changes are inevitable.

2.1.5.4. Short-Circuit Behavior

Model requirements should cover short-circuit behavior; in general, guidance from the turbine vendor will be needed, and should be required as a provision for interconnection. Perfection with short circuit modeling is not possible, so short circuit modeling should be deliberately conservative. Specifically, assumptions and approximations that bias results towards high current should be used for equipment rating. When appropriate, assumptions that bias results towards low current should be used for protection aspects that are dependent on minimum current.

This is a challenging topic and the industry is presently developing understanding, processes and recommendations related to short circuit currents. The IEEE Power Engineering Society task force on Short Circuit Fault Contribution from Wind Generators is addressing this issue. It is recommended that ISO-NE track the progress of that task force and evaluate the results of its work. It is possible that this task force will recommend a practice whereby wind plant owners would provide short circuit current information to transmission owners, grid operators, and others who need such data. Short circuit modeling is discussed further in Section 3.6.3.

2.1.5.5. Avoid Point-on-Wave modeling

Highly detailed, Electro-magnetic transients program (EMTP)-like simulations are extremely difficult to do correctly and require deep knowledge of wind turbine generator electrical controls. Generally, such models are difficult to obtain and unnecessary for engineering of grid interconnections. In applications that require EMTP-like analysis, (per discussion in Section 3.6.4) individual equipment OEMs should be consulted. Equivalents of wind plants for other types of studies need to be developed on a case-by-case basis. Interaction between wind plants and high power electronics, such as high voltage direct current transmission (HVDC) systems, are not well understood, and should not be done with generic models.

2.1.6. Communications between Wind Plants and ISO-NE Operations

Wind plants typically employ comprehensive data collection system for command and control purposes. These systems link all individual turbines to a common master control and monitoring device, normally located in the substation at the point of interconnection with the power grid. These systems are a critical part of the control and monitoring interface with the local grid operator or ISO.

The project team recommends that the basic requirements for communications and control between the ISO and wind plants be based on existing policy for conventional generators. Communications infrastructure is discussed further in Section 5.4.

2.1.6.1. Wind Plant Operator

Wind plants should be required to have the same level of human operator control and supervision as similar sized conventional power plants, per ISO-NE interconnection agreements. The ISO should have 24/7 access for voice communication with the wind plant operator for the purpose of implementing control orders or dealing with abnormal situations.

It is understood that the wind plant operator may be located remotely from the wind plant, in a facility that monitors and operates multiple wind plants, possibly in multiple operating areas. The point is that ISO-NE should have 24/7 access to a person that has direct and immediate control of the wind plant.

If ISO-NE allows unmanned operation for conventional power plants that have sufficient automated and remote control/monitoring functions, then the same should be applied to wind plants of similar MW ratings.

2.1.6.2. Monitoring signals from wind plant to ISO

The following signals should be sampled at the normal SCADA (system control and data acquisition) update rate.

- Active power (MW)
- Reactive power (MVAr)
- Voltage at point of interconnection

The following wind plant status signals are also recommended, but may be sampled at a slower rate:

- Number of turbines available (or total MW rating of available turbines)
- Number of turbines running and generating power (or total MW rating of turbines on-line and generating power)

- Number of turbines not running due to low wind speed
- Number of turbines not running due to high speed cutout
- Maximum and minimum reactive power capability of plant (for some plants in weak grid locations, it would also be prudent to know how much of the total range is dynamic, as opposed to switched capacitors or reactors)
- Total available wind power (equal to production unless curtailed)
- Average plant wind speed (When wind speeds are high and increasing, operators could anticipate high-speed cutout actions)
- Plant main breaker (binary status)
- Plant in voltage regulation mode (binary status)
- Plant in curtailment (binary status)
- Plant up ramp rate limiter on (binary status)
- Plant down ramp rate limiter on (binary status)
- Plant frequency control function on (binary status)
- Plant auto-restart blocked (on/off)

Additional wind plant monitoring signals that would be required for wind forecasting functions are described in Section 2.2.3.

2.1.6.3. Control signals from ISO to wind plant

The following command signals are recommended from the ISO to wind plants:

- Plant breaker trip command
- Voltage order (kV, setpoint for wind plant voltage regulator)
- Maximum power limit (MW, for curtailment)
- Engage up ramp rate limiter (on/off)
- Engage down ramp rate limiter (on/off)
- Engage frequency control function (on/off)
- Block auto-restart (on/off)

As an alternative approach, predetermined up and down ramp rate setpoints could be programmed into the wind plant controls. Then the ISO would not need to communicate the setpoints, but would still have capability to engage those functions when required.

2.1.6.4. Communication standards

The IEC 61400-25 series of standards should be the basis for wind plant communications and interoperability. It provides a comprehensive specification of wind plant data that may be needed by ISO-NE and its forecasting agent. Application of this standard is not yet widespread in the U.S. wind energy industry. However, there is awareness of the need for such as standard in both the wind energy and electric power industries. The 2009 Utility Wind Integration Group Forecasting Workshop in Phoenix, AZ provides an appropriate illustration. IEC 61400-25 was shown in applications for wind plant operators and energy management systems (EMS) vendors. Given that the object models encapsulate any plant data that would be required for production forecasting or decision support in power system operations, ISO-NE should consider adoption of this standard and timing for that action.

2.1.7. Distribution Connected Wind Generation

Distribution connected wind generation of rating greater than 100kW and less than 10 MW should be subjected to a reduced set of interconnection requirements. Specifically, for the present time, distributed wind generation is subject to the requirements of IEEE Standard 1547 [15]. Distribution connected wind generation must NOT: ride-through faults, regulate voltage or frequency, ever be islanded, and ever be subjected to reclosure action with turbines running. Distribution connected wind generation should be required to: have power factor control; communicate status (on/off), power production and anemometry; accept shut-down commands from the ISO. There is a NERC Integration of Variable Generation Task Force (IVGTF) effort to reconcile FERC Order 661a and IEEE Standard 1547. Further discussion of issues particular to distribution connected wind generation is provided in Section 3.7

2.2. RECOMMENDATIONS FOR WIND GENERATION FORECASTING

2.2.1. Forecast System Type and Components

2.2.1.1. Centralized (ISO-administered)

The ISO-NE should implement a centralized (ISO-administered) wind power forecasting system. The centralized system is likely to have a lower total cost as well as higher and more uniform quality than forecasts provided for each plant and would allow the ISO to control the availability and utilization of plant data to forecast providers. As with load, effective power production planning requires more accurate forecasts for the aggregate system rather than single plants.

In a centralized system, it is likely that data from all wind generation facilities will be available for use in forecast generation at other facilities. This attribute can occasionally have significant benefit for short-term forecasts since data from an “upstream” facility might be a useful predictor for future variations at a “downstream” facility. The centralized system also provides more opportunity to implement a multi-forecaster ensemble since two or more providers could forecast for all generation facilities.

2.2.1.2. Ramp forecasting

The early warning ramp forecasting system should be viewed as a separate forecasting system. Forecasting techniques optimized to minimize mean absolute error do not do well in forecasting the large, rapid changes in wind speeds that cause the most problematic ramping events. The forecasting system should be designed specifically to forecast and alert operators to the likelihood of ramps events. Therefore, ramp forecasting is best accomplished with a separate methodology and system designed specifically to forecast and alert operators to the likelihood of ramp events.

2.2.1.3. Severe Weather

In addition to the routine and ramp forecast systems, a severe weather warning system that provides operators with information regarding the broader weather situation could be useful, especially with respect to extreme meteorological events that may have a serious impact on wind plant operations.

2.2.1.4. Type of Forecast

Since ISOs typically use only a single predicted power value in routine decision making, deterministic forecasts are likely to be more useful for short-term and day-ahead planning. Because of the nature of extreme events, ramp and severe weather forecasts are better expressed as probabilistic forecasts. Therefore, probabilistic forecasts are recommended for predicting ramps events.

2.2.2. Selection of a Forecast Provider

2.2.2.1. Trial Period

If one provider is to be selected, a one-year trial period of candidate forecasters is recommended. The decision should be based on a high-level of consistent performance across all seasons, weather regimes, and look-ahead time periods for a set of specified metrics.

2.2.2.2. Provider Evaluation

If the ISO feels that it needs assistance in vendor evaluation, it is recommended that a non-commercial organization such as the National Center for Atmospheric Research or National Renewable Energy Laboratory provide advice on conducting the evaluation and selecting forecast providers. If a commercial entity acts as the consultant, then that entity and affiliates should be disqualified from being a wind forecasting vendor.

If no trial forecasting period is used, vendor selection should be based on experience forecasting wind in similar weather regimes and providing forecast services to balancing authorities, as well as capability to customize forecasts for specific ISO applications.

2.2.2.3. Multiple Providers

ISO-NE should consider the use of a two-provider system. The use of two providers ensures a higher level of reliability. With multiple forecast vendors, ISO-NE could select the best performer for a given situation or create an ensemble of forecasts based on the time period or forecast situation. The final product could be either the single best forecast or a weighting of individual forecasts.

Although more than two providers might improve the quality of the forecasts, a cost-benefit study would be needed to determine if the added value justifies the additional costs. In order to take maximum advantage of multiple providers, ISO-NE would need to track and compare vendor performance. At a minimum, the evaluation should include vendor performance over various forecast time periods and months to identify specific trends.

2.2.2.4. Forecast Methods

The selected forecast provider should demonstrate an effective use of appropriate methods for different time periods of routine forecasts. There is no single methodology designed to meet the challenges associated with different look-ahead periods. The recommendation is to leverage the strengths of physical, statistical, and ensemble methods. For example, persistence-regression techniques are most applicable for very short-term forecasts whereas model-based methods are more suitable for periods beyond six hours. Also different methods and types of information should be delivered for ramp forecasts based upon the look-ahead time period.

It is recommended that ensembles be used and constructed in such a manner that the major sources of uncertainty in the forecasts are captured in the modeling system. The major source of uncertainty will vary from location to location and season to season. For example, the source of uncertainty from large scale systems such as fronts is much higher in New England than it would be in southern California.

Similarly, the source of uncertainty from large scale systems would be greater in winter than in summer, even in New England. The forecasts made from the ensembles and provided to the ISO can be either deterministic (made from a weighted average of the ensemble members) or probabilistic with associated uncertainty limits or both can be provided depending on the needs of the ISO.

2.2.2.5. Offshore Forecasting

The selected forecast provider should demonstrate knowledge of marine boundary layers and an ability to forecast their aspects for offshore wind plants. The provider also needs to demonstrate capability to forecast deep and shallow ocean waves. In the cold season, it is a fairly common occurrence to have high waves that would curtail maintenance operations for many days and impact turbine availability for power production. The data requirements for offshore plants would be identical to those for onshore plants with the exception of the need for wave height information.

2.2.3. Forecast Performance Evaluation Issues

2.2.3.1. Methods and Metrics

The recommendation is to evaluate forecast performance for all types of forecasts provided. The most significant issue when setting up the forecast evaluation system is determining which parameter(s) should be used as the metric(s) for forecast performance. The choice of metrics can have a significant impact on the interpretation of forecast performance. Candidate forecast providers should be informed of key metrics and the duration of the forecast evaluation period prior to submitting a proposal. At a minimum, bias, mean absolute error, and root mean square error should be provided for deterministic forecasts. For probabilistic forecasts of ramping events, both missed ramps and false alarms should be tracked as well as the actual frequency of the events that occurred during the forecasting period. When interpreting the results of any forecast evaluation, it is very important to note that forecast performance varies significantly according to the size and diversity of wind plants.

2.2.3.2. Data Requirements

In order to provide the most accurate power production forecast, it is essential that both power production and meteorological data be made available to the forecast providers. It is recommended that wind project owners/operators be meaningfully incentivized to provide high quality data in a timely manner through a secure communication system for use in wind energy forecast production.

Some providers advocate that forecasts can be made successfully with only power generation data. However, experience shows that although these data are extremely valuable, meteorological observations provide significant added value as well. Thus, the recommendation is to include meteorological observations whenever possible.

2.2.3.3. Production Data

The total aggregate plant power production data and plant availability should be sent to the forecast providers for each forecast interval. A minimum frequency should equal the forecast frequency but a desired value would be the nearest integer factor of one half the forecast frequency. The forecast provider should also have knowledge of any non-meteorological factors affecting the power output of the plant such as plant curtailment. Production data should include the following:

Specifications:

- Nameplate capacity
- Turbine model
- Number of turbines
- Turbine hub height
- Coordinates and elevation of individual turbines and met structures (towers or masts)

Operating Conditions:

- Wind plant status and future availability factor
- Number or percentage of turbines on-line
- Plant curtailment status
- Average plant power or total energy produced for the specified time intervals
- Average plant wind speed as measured by nacelle-mounted anemometers
- Average plant wind direction as measured by nacelle-mounted wind vanes or by turbine yaw orientation

The total aggregate plant power production data and plant availability should be sent to the forecast providers for each forecast interval (e.g. hourly).

2.2.3.4. Meteorological Data

Meteorological data should be provided from at least one met tower that is strategically placed so it will not be impacted by plant operations. The met tower should be at turbine hub height or at least within 20 m of hub height. In general, the met structures should be located at well-exposed sites generally upwind of the plant and no closer than two rotor diameters from the nearest wind turbine. As a rough guideline, each turbine in the wind plant should be within 5 km of a met structure.

Meteorological data should include the following.

Meteorological Structure (Tower or Mast) Specifications:

- Dimensions (height, width, depth)

- Type (lattice, tubular, other)
- Sensor makes and models
- Sensor levels (heights above ground) and azimuth orientation of sensor mounting arms
- Coordinates and base elevation (above mean sea level)

Meteorological Conditions:

Data parameters required at two or more levels:

Average (scalar) wind speed (m/s +/-1 m/s)

Peak wind speed (one-, two-, or three-second duration) over measurement interval

Average (vector) wind direction (degrees from True North +/- 5 degrees)

Data parameter required at one or more levels:

Air temperature (°C +/1 °C)

Air pressure (HPa +/- 60 Pa)

Relative humidity (%) or other atmospheric moisture parameter

Wind measurements on the met structure should be taken at two or more levels, with the levels at least 20 m apart. One level should be at hub height. If this level is not feasible, the closest level must be within 20 m of hub height. To improve data quality and reliability, sensor redundancy for wind speed measurement at two levels should be practiced. The redundant wind speed sensor at each applicable level should be mounted at a height within one meter of the primary speed sensor. It is also recommended that at least one of the wind speed sensors nearest the hub-height level be heated to prevent ice accumulation from affecting the accuracy of wind speed measurements.

The met condition data should be provided at intervals that are equal to or less than the intervals for which the power production forecast is desired. For example, if short-term power production forecasts are desired in 15-minute intervals, then meteorological condition data should be provided at intervals of 15 minutes or less. As with the production data, if the met data cannot be provided in real time, it is still valuable and should be provided for verification and model training.

In addition to data from the met structure, wind speed and direction data (as well as temperature and pressure if available) from nacelle-mounted instruments should be provided from a representative selection of turbines. Each turbine should be within 75 m in elevation and five average turbine spacings of a turbine designated to provide nacelle data.

For large geographical areas, typically more than one observation location would be recommended. However, it is challenging to give exact spacing criteria as these depend on factors such as local weather regimes, terrain complexity, and availability of nacelle data. If nacelle data are provided, fewer met towers would be needed and only one may be sufficient. Thus, the recommended number and location of met towers should be based on weather regimes, terrain complexity, and availability of nacelle data.

2.2.4. Operator Considerations

2.2.4.1. Control Room Integration

The wind power forecasting system products should be fully integrated into the ISO control room. In order to maximize grid management efficiency, it is recommended that an operator be dedicated to monitoring all of the renewable (variable) power generation resources. It is also suggested that pooling of wind plants into clusters may make it easier for an optimized integration of wind power. The plant cluster is an aggregate of plants grouped together logically (i.e. experiencing similar wind patterns and performance metrics). This approach would have particular value if there were transmission congestion in an area that required curtailment when a specific aggregate of plants exceeded threshold output.

2.2.4.2. Education and Training

An aggressive training program for all users of the forecasts should be implemented as part of the forecast implementation process. Training topics could address a number of areas such as interpreting error characteristics for deterministic versus probabilistic forecasts of ramps and/or other events. The training should cover the overall forecasting process and a high level review of physical versus statistical models as well as the use of observational data for validation and correcting model biases.

2.2.4.3. Provider/User Communication

An effective mechanism for communication between the forecast providers and users should be established. This exchange should include at least yearly workshops attended by forecast providers and users to address forecast performance and usability issues.

2.3. RECOMMENDATIONS FOR GRID OPERATIONS WITH WIND GENERATION

2.3.1. Applying Results from Wind Integration Studies

The wind integration study currently underway (as of September, 2009) at ISO-NE should provide much more detailed understanding and quantification of the operating challenge with significant amounts of wind generation.

As described in Section 3 modern wind plants can be equipped with a variety of features for modulating production of wind energy. Many of these have been demonstrated in actual plants or prototype installations. However, exploiting many of these features involves spilling wind energy, so questions as to their use and requirement necessarily involve economic evaluation.

The production simulation component of the wind integration study provides a means for assessing the cost of various characteristics of wind energy production as well as the value of measures for mitigation for the wind generation scenarios being studied.

2.3.1.1. Curtailment Policies

As wind generation penetrations grow, selective use of curtailment can be appropriate and economically justified under some operating conditions. ISO-NE should use the results of the current integration studies, along with periodic studies of a similar nature going forward, to develop a basis for its curtailment policy.

The study results need to establish the probability, frequency, duration, and value of curtailment as a mitigation measure for operational problems. Absent such quantification, it is very difficult to justify curtailment as general mitigation strategy because of the uncertainty it can pose to wind project developers and financing.

2.3.1.2. Enabling Ramp Rate Controls

Limiting large increases in production, such as at plant startup under high wind conditions, is an appropriate practice and one that is feasible with the wind generation technology of today. ISO-NE should conduct studies to determine the need for and value of such controls, and adopt them if shown to be of adequate value.

2.3.1.3. Enabling Under-frequency controls

Advanced wind plant control that temporarily increases output in response to a sudden decline in system frequency is a potentially valuable capability as the penetration of wind generation grows. ISO-NE should consider market mechanisms that would encourage this function.

2.3.1.4. Use of AGC and dispatch to wind plants

The ability of advanced wind plants to respond to AGC and dispatch signals much like conventional plants has been demonstrated in field testing by multiple turbine vendors. Above, it is recommended that new wind plants be provided with the capability to accept AGC signals.

In some circumstances, such as island or isolated systems or minimum load conditions at high wind penetration, these capabilities may be crucial for integration.

In larger power pools, however, this is seldom the case. The value of these capabilities must be compared to the cost of the spilled wind energy. The current integration study can help to frame the probable value of such capabilities for the scenarios being studied. In general, the economics will dictate whether such performance is practical. It is not recommended that ISO-NE plan to use such capability until (and if) detailed analysis and operational experience is gained.

2.3.1.5. Start-up and Shut Down

Upon starting a wind plant under normal conditions, wind plant production should be brought up slowly per pre-defined ramp rate limits. Shutdown should be accomplished in a similar manner when possible – i.e. not due to dying winds or high-speed cutouts. ISO-NE should adopt permissive restart of wind plants following shut-down due to grid disturbances using the same policies presently applied to other conventional generation in the footprint.

2.3.2. Wind Plant Scheduling and Congestion

The availability of individual wind turbines is quite high. Because of the large number of small generators however, turbine maintenance within wind plants is an ongoing activity. Shutdown of the entire facility would only be done for maintenance of common facilities such as the facility interconnection transformer, and then during low winds. So while wind plant maintenance scheduling differs from that for conventional plants, it is important for turbine availability to be considered in the development of production forecasts. Consequently, turbine availability – defined as the number of turbines currently or forecast to be in service – is a critical parameter that must be passed from each individual wind plant to the forecasting agent.

The physical capability of the each wind plant – i.e. the maximum generation that would be possible given the number of turbines in service – should also be communicated directly to ISO-NE. With transmission congestion, it is possible that production of individual wind plants will need to be curtailed. The plant physical capability along with meteorological data from the plant would provide a means for calculating the total curtailed energy.

Information on transmission congestion and curtailment must also be provided by ISO-NE to the forecasting agent so that congestion constraints are reflected in the forecasts for the affected plants.

2.3.3. Communications Infrastructure for Managing Wind Generation

Wind plants must provide to ISO-NE all relevant information required of conventional power plants. Other information unique to the wind generation facilities, as identified in other parts of this document, is also required.

The IEC 61400-25 series of standards defines a comprehensive basis for the monitoring and control of wind power plants, including definition of wind plant specific information, mechanisms for information exchange, and mapping to communication protocols, and is compliant with ICCP.

The standard is relatively new, and has not yet been adopted by U.S. ISOs or RTOs. However, it is recommended that ISO-NE strongly consider adopting this standard as a requirement for wind plants, or at a minimum, wind plant control centers.

Adoption would greatly facilitate the later development of tools and algorithms for integration that cannot be anticipated at this time. In addition, such a requirement for distribution system connected turbines would provide the capability for ISO-NE to directly interrogate these installations for support of forecasting or other operational applications.

2.3.4. Operations with Distribution Connected Wind Generation

Information about distributed generation is almost by definition fairly well hidden from system operators. Studies should be conducted to determine the threshold at which distributed generation in the ISO-NE footprint or a specific region could pose some risks for the bulk system. These studies would consider the loss of distributed generation due to transmission system faults and the levels at which ignoring distributed generation production forecasts would begin to affect load forecast accuracy, among other issues.

As the penetration of distributed generation grows, additional application tools and decision support mechanisms for operators to accurately portray potential impacts on the bulk system and the range of mitigation measures available.

2.3.5. Best Practice for Determination of Wind Generation and Wind Plant Capacity Value

The project team feels that capacity valuation methods that use adequate records of historical energy deliveries are most appropriate in the long run. At the same time, it is recognized that methods based on the more rigorous LOLE analysis are superior for evaluating the full spectrum of risks to system reliability from the perspective of resource adequacy, and should also play a role.

2.3.5.1. Recommended Method for Aggregate Wind Generation Capacity Valuation

It is recommended that ISO-NE adopt a method based on **Effective Load-Carrying Capability** (ELCC) for determining the aggregate capacity value of all wind generation facilities in the market footprint.

The evaluation would be conducted periodically. . The LOLE-based method described in Section 5.6.2 should be used, where wind generation is treated as an hourly load modifier, and ELCC is determined by comparison of the “with” and “without” wind cases.

Hourly historical production data should be used to represent existing wind plants. For queue projects, submitted wind speed data or corresponding production data from ISO-NE’s adaptation of the NREL mesoscale database for the Eastern Interconnection could be used.

Previous studies have shown a significant variation between annual ELCC results. It is recommended that ELCC results be based on the average of multiple years of historical or simulated data. Initially, a shorter period will have to suffice, unless the mesoscale database is extended. A period of 10 years can be considered a reasonable historical sample.

An advantage of this approach is that the annual assessment will automatically take into consideration the penetration of wind generation in the market footprint. This is important since previous studies have shown that the capacity value of wind generation can decline as the penetration increases. With annual updates, this will be an inherent part of the process.

2.3.5.2. Allocating Aggregate Capacity to Individual Plants

The total capacity contribution determined from the ELCC analysis can be allocated to eligible individual wind generation facilities based on historical production during periods of system stress as defined by ISO-NE.

2.3.6. NERC Activities

NERC will be taking the issue of capacity valuation for renewable and variable resources up in Phase II of the Integrating Variable Generation Task Force. Responsibility for this issue has been assigned to the Resource Issues Subcommittee among others. The IVGTF will also play a role in developing baseline material and making recommendations to relevant committees. ISO-NE should actively participate in these activities, and adapt policies to align with forthcoming NERC recommendations if appropriate.

NERC is constantly updating standards and a number of NERC standards are of specific interest to wind. ISO-NE should actively participate in NERC standards development activities. Specific NERC Standards Projects with implications for wind power include:

- Project 2007-05 – Balancing Authority Controls (potential requirement for all generators to be equipped with AGC)
- Project 2007-09 – Generator Verification (addressing voltage and frequency ride through, exciter [voltage/reactive control] model validation, governor model validation)
- Project 2007-11 – Disturbance Monitoring (possible requirement to monitor each generator breaker)

- Project 2007-12 – Frequency Response (initially collecting data but eventually possibly addressing inertia)
- Project 2008-01 – Voltage and Reactive Control (may address generator status reporting requirements)
- Project 2009-05 – Resource Adequacy Assessment (defining metrics for assessing capacity value)

Section 3

WIND TURBINE AND WIND PLANT TECHNOLOGY

Grid integration of wind power plants is complicated by a number of issues, primarily related to wind variability and uncertainty and the electrical characteristics of wind generators. A typical wind plant appears to the grid as a substantially different generation source than a conventional power plant. The most significant difference is that the wind energy source is inherently uncontrollable. Also, the electrical characteristics of induction, doubly-fed, and full-conversion wind generators have disturbance responses and reactive output characteristics that naturally differ from that of conventional synchronous generators.

Historically, wind plants were allowed to produce real power that varied with the available wind, and was not scheduled in any fashion. Further, like some other generating resources (e.g. nuclear power plants, run-of-river-hydro, combined heat and power plants) wind plants were not required to participate in system frequency regulation, voltage regulation, or control of tie-line interchange.

Such uncontrolled real power output variations can have an impact on the grid, including voltage variations, frequency variations and increased regulation or ramping requirements on conventional generation resources. These are particularly significant issues in weak system applications, island (isolated) systems or in control areas where tie-line interchange is constrained.

In addition, a wind plant in which power output is not controlled inherently cannot participate in regulation of tie-line flows or grid frequency. When wind generation displaces conventional generation, the burden of balancing and frequency regulation placed upon the remaining conventional generators is increased.

Historically, wind plants were also allowed to absorb reactive power from grids, or at best, maintain a prescribed power factor. This is a substantially different operating mode than is required of conventional power plants, which generally regulate their grid interconnection bus voltages. Without coordinated control of wind plant reactive power interchange with the grid, a typical wind plant provides no support or regulation of grid voltage. Furthermore, voltage variations caused by real power variations, as discussed above, cannot be mitigated.

With low penetrations of wind generation, these equipment characteristics and integration approaches did not have significant practical impact. However, wind generation is now reaching substantial penetration levels in many regions, and grid integration has emerged as a potential limit on further development of this environmentally friendly resource. Consequently, interconnecting utilities and regulatory agencies are imposing grid codes that demand performance from wind plants similar to that provided by conventional power plants, i.e., those using steam, gas, and hydro turbines with synchronous generators [1, 2].

In this section, characteristics and capability of modern wind generation, relevant to grid performance, will be examined.

3.1. Basic Types of Wind Turbine-Generators (individual wind turbines)

Wind turbine generator designs vary dramatically from OEM to OEM, and between product lines within OEMs. The industry has begun to group different designs into four groups, described in the following subsections. This grouping is useful to help capture the broad range of performance characteristics that fundamentally affected by basic electrical designs. However, it should be understood that even within the 'types' presented below, there are large differences in capability and performance. These types cover the vast majority of utility scale wind generation, but not all wind generation falls into these categories.

3.1.1. Type 1: Fixed speed Induction Generator

The simplest form of wind turbine-generator (WTG) in common use is comprised of an induction generator with stator circuit connected directly to the grid that is driven through a gearbox, as shown in Figure 1. This type operates within a very narrow speed range dictated by the speed-torque characteristic of the induction generator, as illustrated in Figure 2. As wind speed varies up and down, the electrical power output also varies up and down per the speed-torque characteristic of the induction generator.

In its simplest form, this type of WTG does not include a pitch control system. The blades have a fixed pitch and are aerodynamically designed to stall (i.e., naturally limit their maximum speed). These are called "stall-regulated" turbines. However, more advanced models include a variable blade pitch control system. The stall regulation feature may be implemented passively (blades stall naturally at wind speeds above a certain magnitude) or actively with action by the blade pitch control system.

If the wind speed increases to a level where steady-state electrical power output would exceed the rated power output of the turbine generator, the pitch-angle of the rotor blades is adjusted to limit power output to the rated value. However, the pitch control system is not fast enough to respond to fast wind gusts. If the wind increases rapidly, the electric power output would temporarily increase above rated power (per the torque-speed characteristic), until the pitch control adjusts the blade pitch angle and reduces power output to the rated value.

One advantage of this type of fixed-speed induction generator WTG is its simplicity. A disadvantage is the significant variation in real and reactive power output as wind speed changes. Simple induction generators always consume reactive power, "under-excited" in the convention of grid connected synchronous generators, with the reactive consumption being primarily dependent on the active power production. Thus, management of reactive power must consider this under-excited behavior as well as the reactive power requirements of the grid.

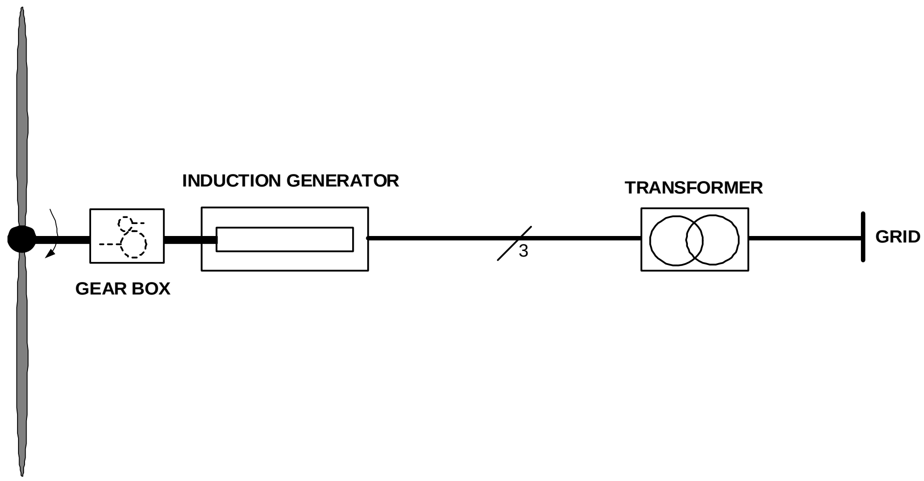

Figure 1: Type 1 WTG; Induction Generator (NEG-Micon, Bonus, traditional Nordex, typical small/residential WTGs)

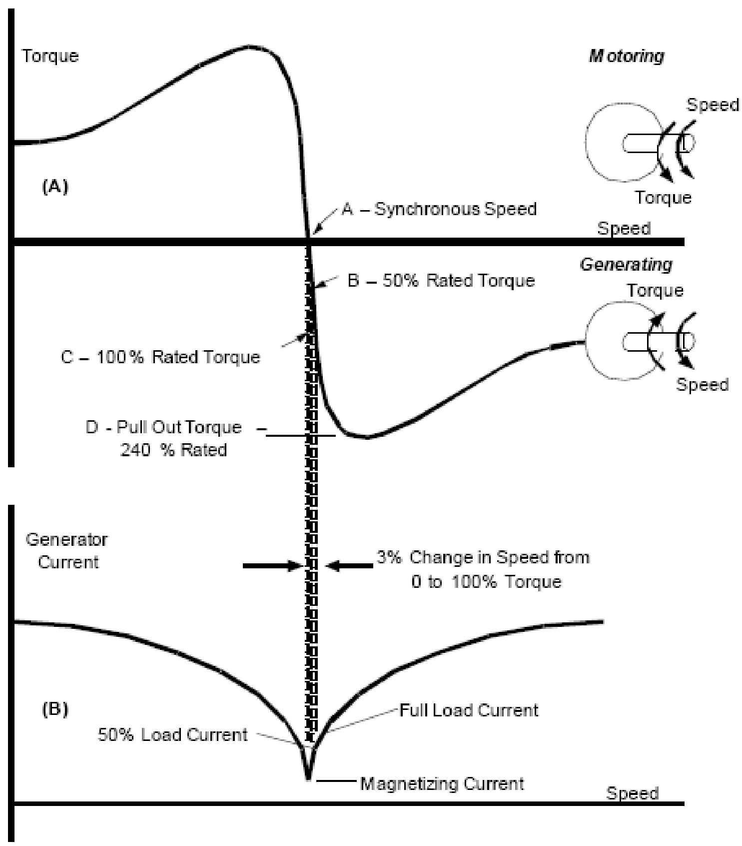

Figure 2: Speed-torque and speed-current characteristics for induction generator. (Source: BEW report for CEC, May 2006)

Figure 3 shows the reactive power at the terminals of a typical induction generator WTG as a function of real power output. The blue trace shows the reactive power consumed by the induction generator. It ranges from about 0.18 pu at no load to nearly 0.50 pu at full load. It is common practice to compensate for the reactive power consumption of the induction generator by installing capacitors at the WTG. One approach is to compensate for the no-load reactive power consumption with a fixed capacitor, as shown by the gray curve. Another approach is to use several capacitors and switch them as a function of load. This type of "step compensation" keeps the net reactive power of the WTG near zero or some other desired value.

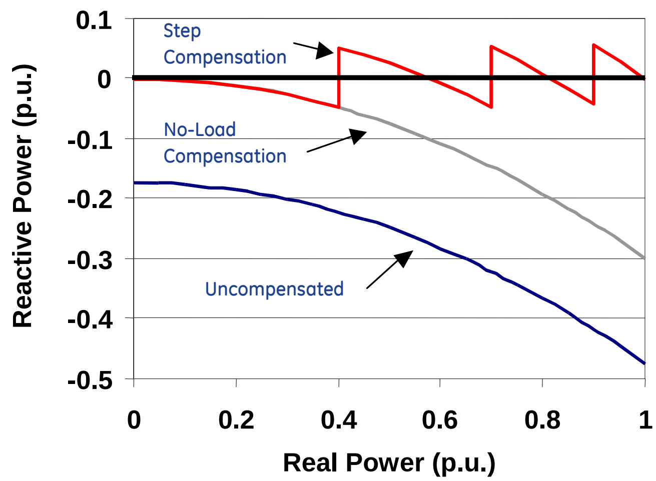

Figure 3: Reactive Power as a function of Real Power for and Induction Generator WTG, with and without compensation using shunt capacitors.

3.1.2. Type 2: Variable-Slip Induction Generator

The variable-slip induction generator WTG is similar to the Type 1 induction generator machine, except that the generator includes a wound rotor and a mechanism to quickly control the current in the rotor by adjusting the apparent resistance of the rotor circuit (see Figure 4). The operating characteristics are similar to the Type 1 induction generator WTG, except that the rotor-current control scheme enables a degree of fast torque control, which improves the response to fast dynamic events and can damp torque oscillations within the drive train.

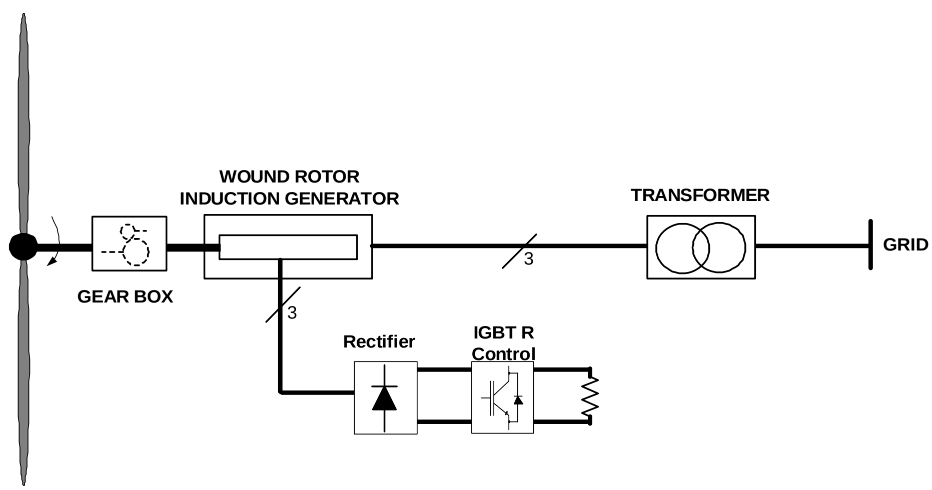

Figure 4: Type 2 WTG; Wound Rotor Induction Generator with Variable Slip (Vestas Opti-Slip®)

3.1.3. Type 3: Double-Fed Asynchronous Generator

The double-fed asynchronous generator (DFAG) type of WTG includes a mechanism that produces a variable-frequency current in the rotor circuit (see Figure 5). This enables the WTG to operate at a variable speed (typically about 2:1 range from max to min speed), which improves the energy capture efficiency and controllability of the WTG. Since the power converters need only be rated to carry a fraction of the total WTG power output, this design is also attractive from an economic perspective.

Although the original incentive for this scheme was variable speed power conversion, the power converters have since evolved to perform reactive power and voltage control functions, similar to those in conventional thermal and hydro power plants. The fast response of the converters also enables dynamic features such as low-voltage ride-through and governor-type functions.

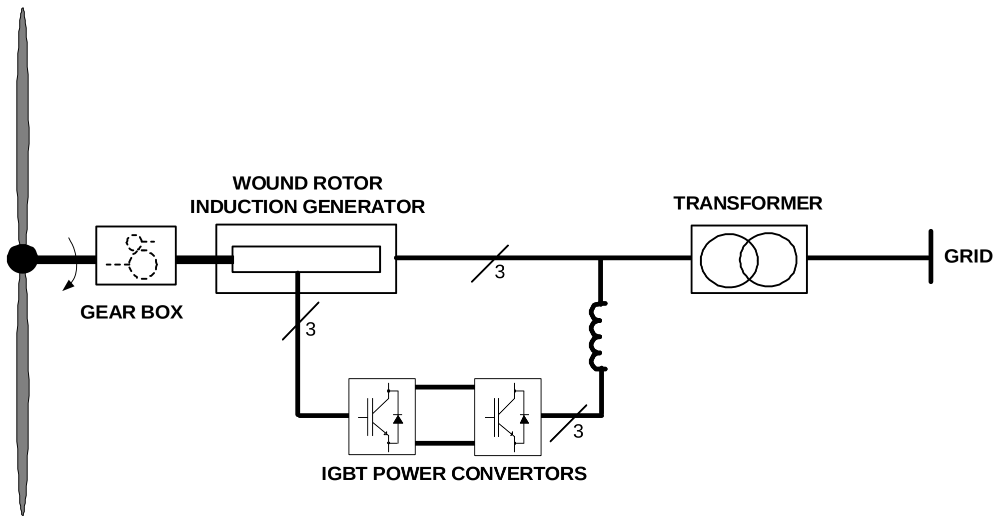

Figure 5: Type 3; Double-Fed Asynchronous Generator, Variable Speed WTG (GE 1.5, RePower, Suzlon, Vestas V80,V90,others)

3.1.4. Type 4: Full Power Conversion variable speed

Another approach to variable speed WTGs is to pass all turbine power through an ac-dc-ac power electronic converter system (see Figure 6). This system has many similar operating characteristics to the DFAG system, including variable speed, reactive power and voltage control, and fast control of power output. It has an additional advantage of totally decoupling the turbine-generator drive train from the electric power grid, which means that dynamics during grid disturbances can be better controlled (LVRT, governor-type functions, etc.). It also reduces dynamic stresses on drive train components when grid disturbances occur.

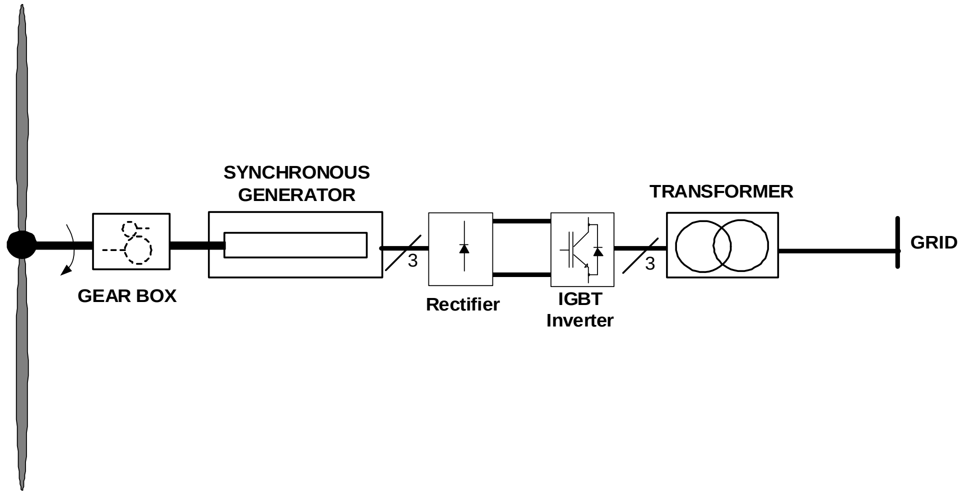

Figure 6: Type 4; Full Power Conversion, Variable Speed WTG (Enercon, Siemens, GE 2.5)

3.2. DISTURBANCE TOLERANCE AND RESPONSE

Wind plants, like all generation, are subject to disturbances in the power system. The response of WTGs to large perturbations in voltage and frequency has been a significant concern in the industry. Different aspects of disturbances, and the ability of WTGs to tolerate them, are described in this section.

3.2.1. Fault-Ride Through / Voltage Tolerance

Low voltage ride-through (LVRT) capability became a common requirement for wind plant interconnection due to both increasing plant sizes and greater wind generation penetration [9]. LVRT requirement evolved over the past 5+ years, starting with a history of deliberate tripping on low voltage. The current FERC Order 661A requires that wind generation not trip for zero voltage (i.e. bolted 3-phase fault) at the POI for 9 cycles. This latest version of the requirement is often called “zero-voltage ride-though.” The standard also requires tolerance of arbitrarily long duration backup cleared single-phase-to-ground faults. Zero voltage ride through (ZVRT) requirements are now standard in much of the world, including most North American systems [10, 11, 12, 13]. As an example, some ZVRT standards require wind plants to remain in-service during normally cleared system faults with zero pu voltage at the point of interconnection for up to 9 cycles. NERC is updating standard PRC-024 for all generators. The current proposal for ZVRT is shown in Figure 11. A uniform North American standard for fault-ride through will eliminate confusion and unnecessary costs associated with localized rules.

3.2.1.1. Low Voltage and Zero Voltage Ride-through

Many OEMs have WTGs that meet these fault tolerance requirements. Since staging faults on operating grids is expensive, risky, and disruptive, testing is usually performed in a more controlled environment.

The following test results were provided by WINDTEST K-M-K GmbH, an independent testing group, for an operating GE 1.5 MW (type 3) wind turbine generator. A 200 ms, 3-phase fault-to-ground was applied to the medium voltage bus. Figure 7 shows the rms voltages for each phase of the faulted bus. Figure 8 shows one of the voltages again, as well as the real power delivered to the medium voltage bus. The wind turbine remains in service during the fault, and power output recovers to the pre-disturbance level at a controlled recovery rate in under 200 msec.

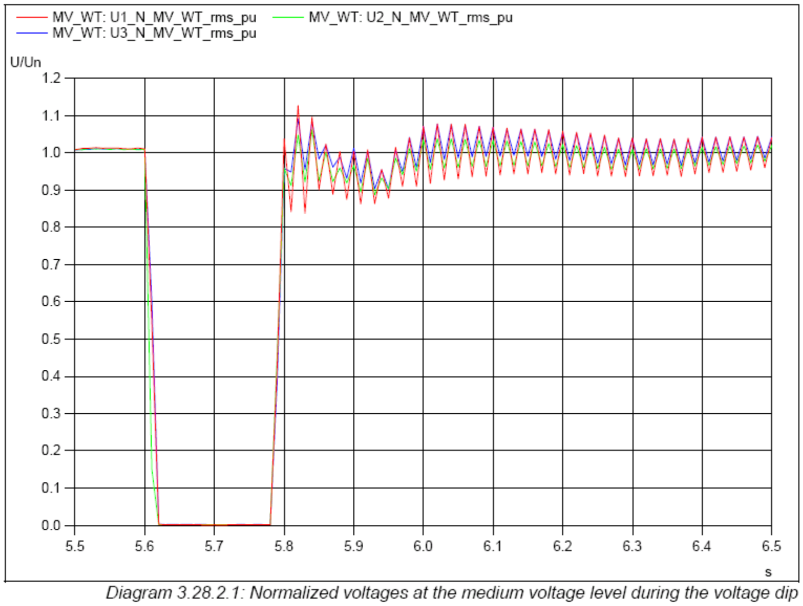

Figure 7: Demonstration of 1.5 MW ZVRT capability (voltage)

Similar ZVRT performance can be provided by a full converter (type 4) wind turbine generator. Test results demonstrating this capability for GE 2.5 MW WTG are shown in Figure 9 and Figure 10. Figure 9 shows the machine is initially operating at near rated power output and near zero reactive power output. A 3-phase fault to ground is then applied for 200 ms, as shown in Figure 10. The wind turbine rides through this fault and returns to normal operation after the fault is removed.

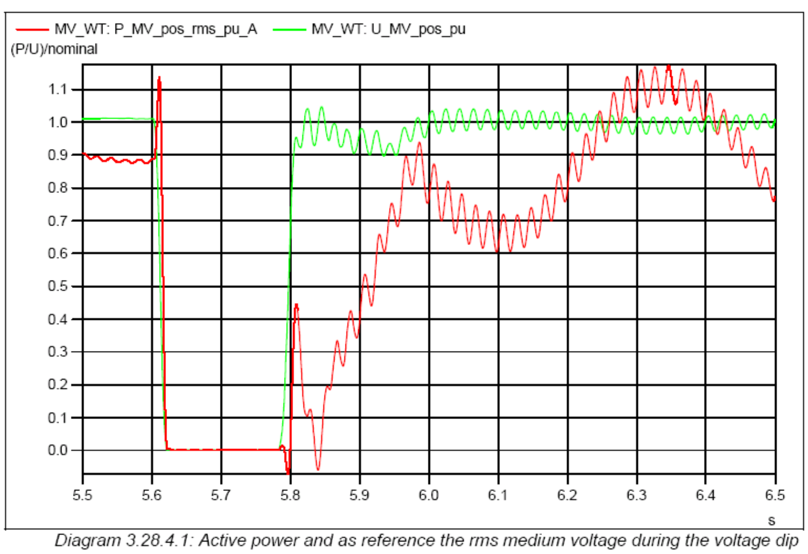

Figure 8: Demonstration of 1.5 MW ZVRT capability (power and voltage)

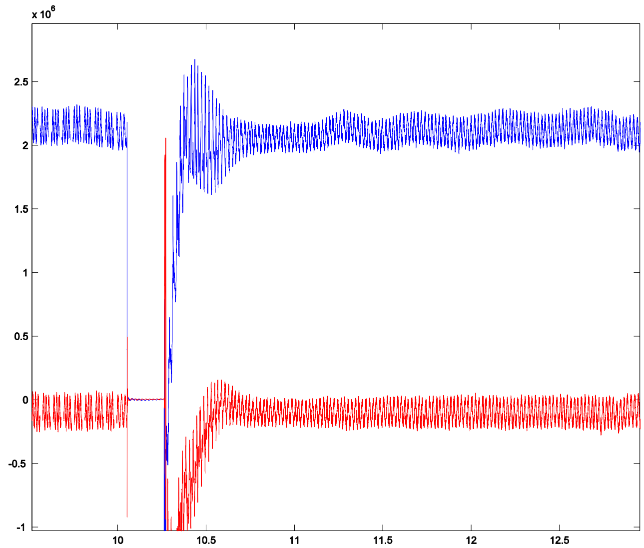

Figure 9: Demonstration of 2.5 MW ZVRT capability (real and reactive power).

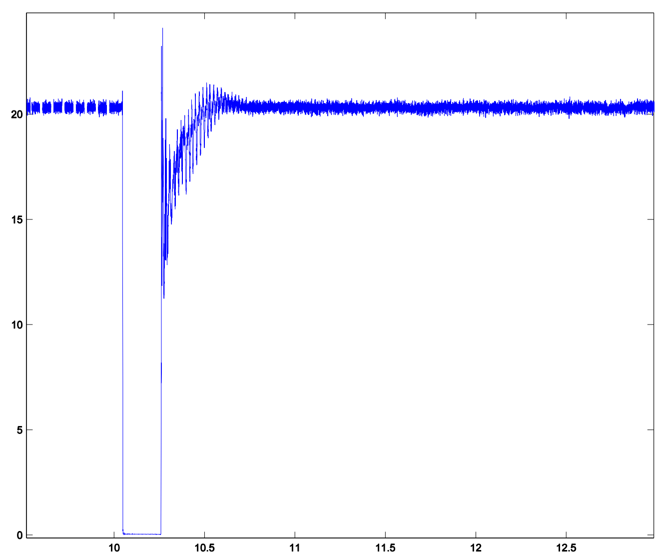

Figure 10: Demonstration of 2.5 MW ZVRT capability (voltage).

3.2.1.2. HVRT

There has been considerable recent discussion on high voltage ride-through (HVRT) requirements. These discussions have not had the depth nor the technical sophistication as the several years of debate about low voltage tolerance.

The proposed limit high-voltage limit (red curve) in Figure 11 is reasonably interpreted as starting when the voltage exceeds 110% of normal (not when a system fault occurs and initiates a voltage depression). The required HVRT tolerance would reasonably be specified as a cumulative duration of withstand, as is the common and accepted practice for other power system equipment, and not be specified as an "envelope" defined by elapsed time from some initiating event. (A realistic overvoltage event typically has multiple short excursions into the overvoltage domain, and only these excursions are relevant for overvoltage performance.) Such a standard would more appropriately reflect the stress that must be endured by the equipment in terms consistent with overvoltage withstand standards applied to other power system equipment.

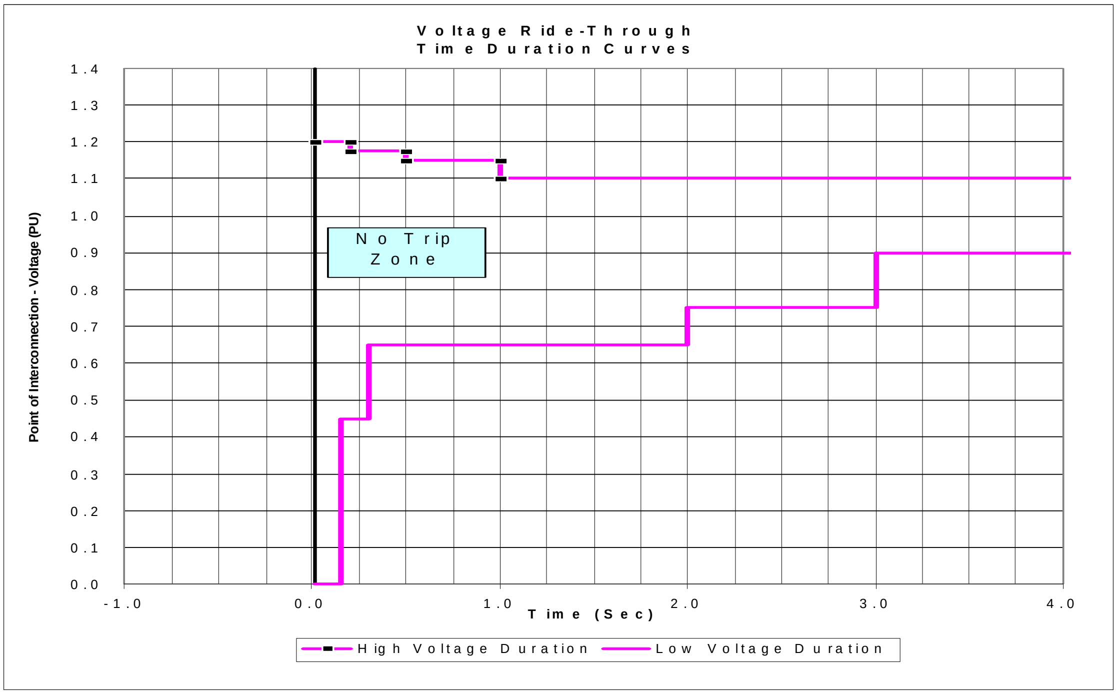

Figure 11: Voltage ride-through criteria from recent proposals by NERC.

3.2.2. During Fault and Post Fault recovery characteristics

Some international grid codes are asking for very specific active and reactive power performance during faults. Typically, but not always, these codes require an increase in reactive current delivery during faults (and deep voltage depressions), and they may also require suppression of active power. Some codes also require rapid recovery of active power after the clearing of faults. Some of these codes are very strict. This has the risk that (a) overly prescriptive during-fault codes are unreasonable in that they are very hard to meet and not necessary, and (b) that excessively fast active power recovery is actually bad for the power system. Excessively fast active power recovery will tend to aggravate post-fault recovery swing and voltage dynamics. Recovery on the order of few hundred milliseconds has worked well in interconnected systems.

3.2.2.1. Low voltage active power limitation and recovery

It is impossible to deliver power through a zero voltage. Utility practice has evolved that recognizes this and that takes into account the inherent electrical behavior of synchronous generators. During system faults, synchronous machines (as dictated by Park's equations) experience drop in electrical power output and accelerate. Once faults are cleared, the accelerated machines must be slowed down and returned to steady-state synchronism with the grid. The active power behavior of synchronous machines during and immediately following grid faults is dominated by this behavior is almost completely uncontrolled (although excitation systems and governor response have some limited capability to affect acceleration and resynchronization). This is well understood by system planners. Much of ISO-NE's planning and operating practice is focused on maintaining system stability. Unlike synchronous machines, type 3 and type 4 wind turbines, are not dependent on turbine speed control to maintain synchronism. Active power can be controlled to a considerable extent by the WTG electronics. Thus, it is possible to reduce active power injection during faults, and to delay or slow the rate of recovery active power injection to the grid following system events. This type of control tends to reduce the severity of system recovery voltage transients and can help other synchronous machines maintain stability (e.g. increase critical clearing times). There is no industry consensus on requiring this behavior. Recovery within ½ second is consistent with the swing dynamics of interconnected systems like ISO-NE. One OEM (GE) limits the active power during deep voltages depressions and limits the recovery to rate of 5.0 p.u. /sec. That has been shown to give good system performance in tests. Some (non-US) grid codes have required extremely fast recovery (e.g. 0.1 s) following grid faults. This is likely to be neither necessary nor beneficial for ISO-NE. Since power behavior of synchronous generation during faults is largely uncontrollable and not subject to grid code requirements, imposing tight controls on wind plants for this is unreasonable and would likely be detrimental to overall grid performance.

3.2.2.2. Low voltage reactive current delivery

It is well understood that reactive current delivered by generators during faults helps moderate the severity and geographic reach of the accompanying voltage depression. Most wind generation technologies can deliver some reactive current during voltage depressions. In general the current delivery is less than that for similarly sized synchronous machines as observed in the short circuit modeling discussion in section 3.6.3. Unlike synchronous machines, the reactive current can be controlled to some extent during faults. Some grid codes have recognized this, and have required stringent control of reactive current during disturbances. This is technically challenging. In so far as specific equipment allows, ISO-NE should encourage wind plants to deliver as much reactive current as is practical with the available equipment during voltage depressions below a nominal level (e.g. 90%). In this context, "practical" means that, for example, equipment controls should be set to deliver as much reactive current as the equipment allows. It does not mean that additional hardware be provided to further increase reactive current beyond this level. Such requirements do not apply to islanded conditions, which must be avoided, as discussed in section 3.2.6 .

3.2.3. Frequency Tolerance

Generally tolerance to (as opposed to 'response to', which is discussed below) grid frequency excursions has not been a major concern for wind generators. Most WTGs are as (or more) tolerant of frequency excursions as conventional synchronous machines. Present NPCC rules as shown in Figure 12 for frequency ride through are well suited to modern wind generation.

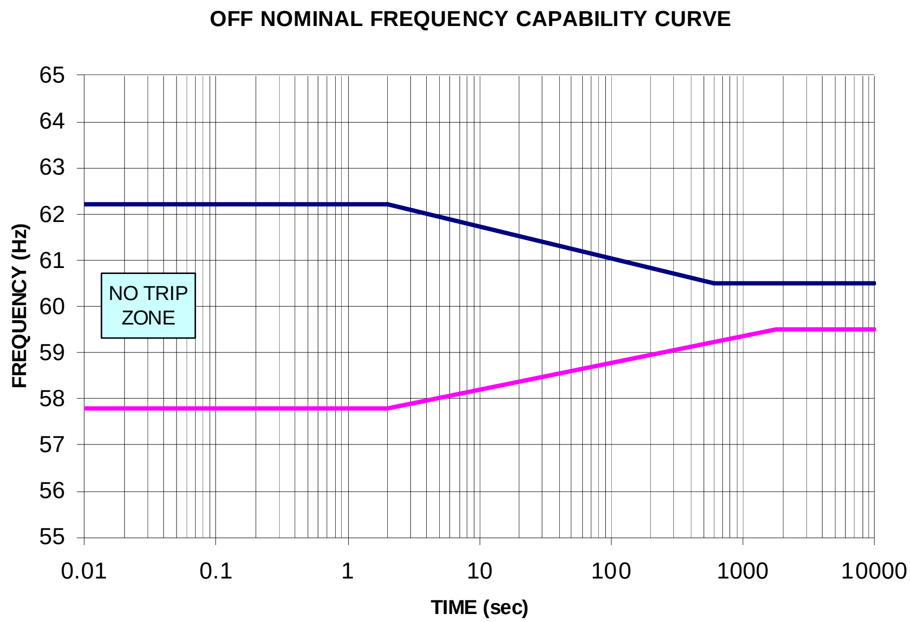

Figure 12: NPCC Frequency tolerance requirements

3.2.4. Rate of change of Frequency

The tolerance of WTGs to rapidly changing frequency has emerged as a concern in some smaller and highly stressed systems recently. Typically, following loss-of-generation events, the power system may experience a rapid drop in frequency. With WTGs (type 3 and 4) being dependent on power conversion systems, the concern is that the equipment be able to track the rapidly changing frequency. Initial drops on the order of 1-2 Hz/sec can be found for severe events in big systems. Some small systems have mandated tolerance to rates as fast as –4Hz/sec, but such rates are only found in small grids. The Irish grid code [13] requires capability to handle ±0.5 hz/sec changes. While this may be a reasonable requirement for ISO-NE, it is not recommended that ISO-NE adopt any rate-of-frequency requirements. It is unlikely that this will be a significant concern for New England. Concerns related to possible breakup and islanding of New England are addressed in section 3.2.6.

3.2.5. Start-up and Shut-down

Starting and stopping a large wind power plant can be disruptive to other generation equipment in a utility system when the power production of the plant is near or at its rated value. Rapid loss of plant output when all the wind turbines are quickly disconnected from the system can create under frequency and power balance problems. Conversely, rapid start-up of a wind plant that has been shut down, for some reason other than lack of wind, can create over frequency and power balance problems. It is appropriate to recognize that there are different circumstances for which plant will start-up and shut-down, and requirements for those circumstances are different.

3.2.5.1. Normal Start-up and Shut-down

Plants can employ a means to control the rate of change of power when a wind plant is shutdown and disconnected from the grid. An operator can send a shutdown signal to the plant controller initiating a controlled shutdown response. The control immediately interprets the shutdown command to begin reducing the power of the plant and start sequencing off turbines. Similarly, operator command can initiate a start-up sequence. Start-up of a plant where there is significant wind can have ramp limits applied.

Figure 13 depicts a shutdown sequence for the GE site that had 38 available and operating wind turbines and was programmed to shut down over a five minute interval. It shows the power of the plant decreasing to zero over five minutes and the number of on-line generators. Start-up sequences exhibit similar behavior to that shown in Figure 13.

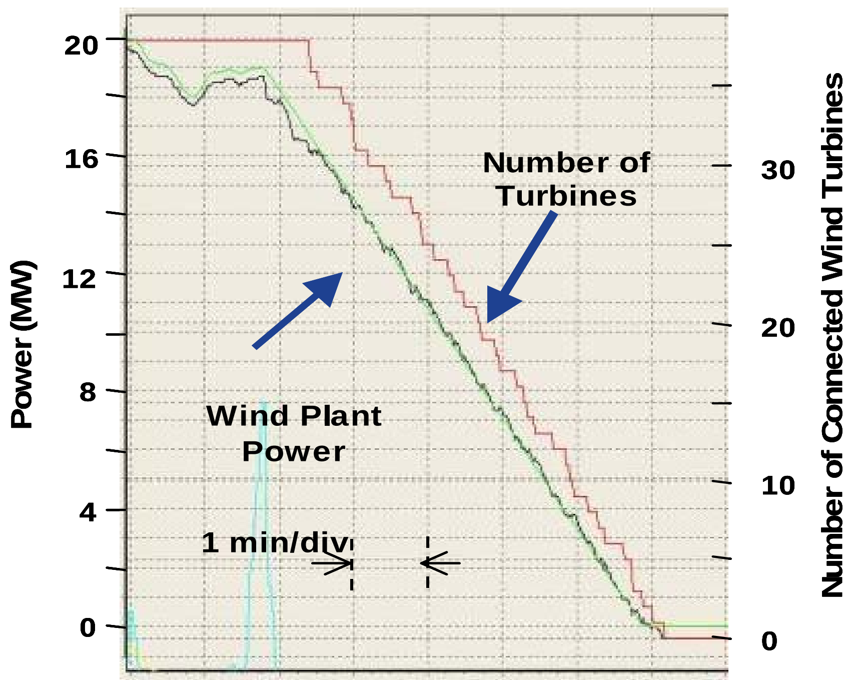

Figure 13: Demonstration of wind plant shutdown sequence

3.2.5.2. Emergency Shutdown and Post-Emergency Restart

When grid events cause wind plants to shut down, it may be desirable for the ISO to specify performance that is different from that described in the previous section. For example, should system analysis show that the post-disturbance conditions for specific individual (or class of events) are unable to support power transfers from wind plants, then restart should be blocked. It will be incumbent on ISO-NE to determine the conditions for which restart should be blocked[1]. ISO-NE practice for restarting other types of generation tripped by grid events should be applied to wind plants. Wind plants must have the capability to receive commands from the ISO that prevent restart, much as they must accept commands to curtail output. Under no

[1] It is easy to envision a condition for which loss of a critical north-south EHV tie-line in New England could result in a substantial drop in transfer capability. Wind plants could be blocked from restarting under such conditions.

circumstances should wind plants be allowed to try to restart into a black system (as discussed further in the next section.)

The ISO always retains the ability to trip wind plants by opening the plant breaker. This is the same as with other types of generation, and as with other generation, is to be done only at grave need. The wind generation equipment is subjected to considerable mechanical and electrical stresses for a full load rejection. A shutdown command to the plant is greatly preferred.

3.2.5.3. High speed cut-out

A sudden loss of wind generation is perhaps the greatest fear of system operators. Over the past decade, there have been a few well-publicized events where significant wind generation in a balancing area was lost due to very high wind speeds across a large region, such as the ERCOT events of March 15, 2007 and February 26, 2008, or the Danish event of January 8, 2005. Most commercial wind turbines utilize pitch control or other mechanisms to "spill" wind energy when wind speeds exceed the level required for nominal maximum power production. This results in a large region of rated power production over a wide range of wind speeds, which by itself is a highly desirable characteristic. However, at excessive wind speeds, usually 25 m/s or greater, mechanical loads and stresses necessitate a shutdown of turbine operation, also known as high-speed cut-out.

As the events referenced above, illustrate, the loss of large amounts of wind generation over a few hours can place significant demands on operators, or possibly compromise system reliability. The operational implications of loss of generation over hours are different than that associated with discrete plant trip loss-of-generation events. It is a common misconception that large amounts of wind generation can go from full power to off in a single step. This does not happen. While improved wind generation forecasting for operational situational awareness is often cited as a preventative measure, there are modifications to wind turbine operation that may also contribute positively. Figure 14 illustrates the modified power curve for a turbine designed to gradually reduce production in very high winds.

It should be noted that such a modification is not trivial. Continuing operations in very high wind speeds has significant implications for the mechanical and structural design aspects of the turbine; for example, while the "lift" component of the aerodynamic energy capture can be well-controlled through pitching of the blades, the "thrust" component will increase with wind speed, placing higher stresses on the tower, blades, and drive train.

At this time, the complexity and additional stress on the wind generation equipment does not appear to justify this function in a large system like ISO-NE. It is not recommended that this be required.

Regardless of whether such controls are implemented to reduce the impact of high wind speed shut-down, in general wind plants should be allowed to return to service automatically when wind and grid conditions allow. Since both cut-out and recovery events occur over a period of time (like the cases described above), the production variability ought to be within the response capabilities of the ISO-NE grid. The default practice should be that wind plants are allowed to restart after a high wind speed event, unless they are explicitly instructed to curtail by the ISO.

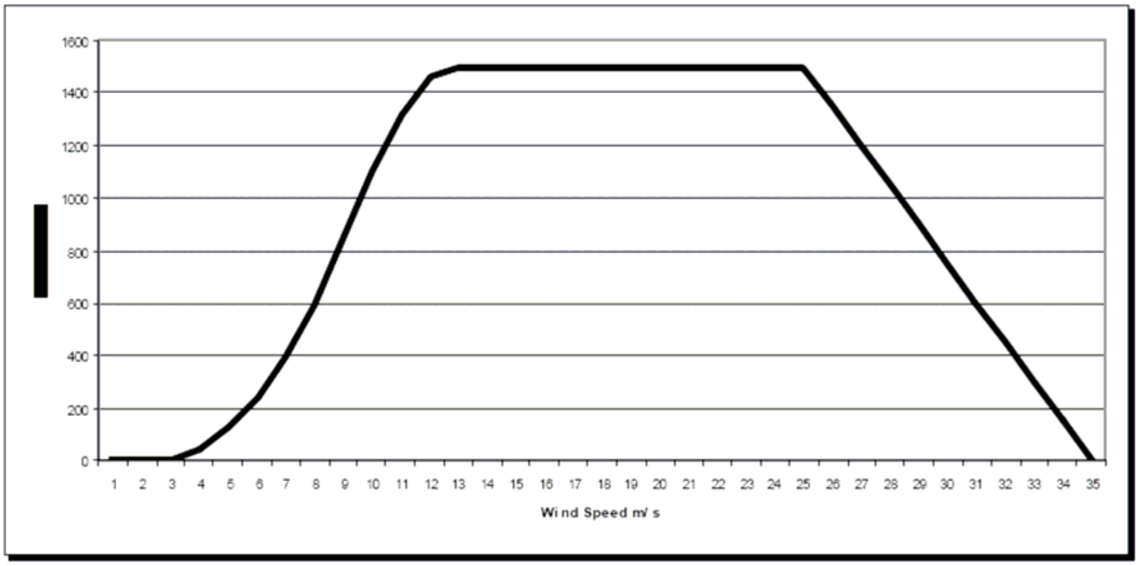

Figure 14: Power curve for advanced wind turbine with gradual high-speed cutout

3.2.6. Islanding and Weak Grid Operations

The technology and controls necessary to allow wind plants to operate in isolation or islanded is not generally available today. In this context, “islanded” refers to a usually small portion of the power grid, with little or no other synchronous generation, being separated by switching action from the larger grid. It does not refer to inter-regional conditions for which (for example) all of New England separates from the Eastern Interconnection. In order to operate in a system with no other sources, generation must have the ability to set system frequency and voltage. While voltage control is available (and should be required for wind plants), isochronous frequency control is not. ISO-NE should not require that wind plants have the ability to operate in islanded mode.

Generally, wind plants and wind turbine-generators are provided with equipment protection (relays, breakers and controls). This equipment is intended to protect the wind generation and related equipment. It is not designed to protect other equipment unrelated to the wind plant. It is therefore ill-advised to rely on the protective action of wind generation to mitigate protective risk to customers. ISO-NE should require that any wind plant or individual wind turbine that has the potential to be islanded with customers have an active relaying scheme, such as transfer trip, that disconnects the wind in event of relay/breaker action that can create that island.

A further consideration is that the majority of wind generation being built in North America is type 3 and type 4 (as discussed in sections 3.1.3 and 3.1.4). These generation types utilize power electronics to interface to the grid. The power electronics of these devices require a minimum level of short-circuit strength to reliably operate. Similarly, type 1 and type 2 generation (per sections 3.1.1 and 3.1.2) typically have shunt capacitors. Islanding or operation into low short circuit strength systems creates a risk of self-excitation, which must be avoided. Usually, other synchronous generation must be running in electrical proximity to the wind plant before it can run. One good metric of proximity is short circuit ratio (SCR), i.e. the ratio of the grid short circuit MVA at the point of interconnect to the wind plant MW rating. Application rules vary by wind OEM, but SCR levels above 5 are typically robust; levels below this should be applied with some care and levels below 2 need considerable care and may be outside of specific wind generation equipment capabilities. In the context of islanding, small subsystems which include some customer load, some other synchronous generation and wind generation should be treated as islands when the short circuit ration of the wind plant drops, due to switching operations, below a minimum threshold. ISO-NE should require that the viability of such subsystems for short circuit ratios below 2.0 be demonstrated, if transfer tripping is not provided.

3.3. VOLTAGE CONTROL AND REACTIVE POWER MANAGEMENT

FERC order 661-A requires -.95 to +.95 power factor at the Point of Interconnection (POI). This is a recent step in an evolution of generator standards that define power factor range requirements at the terminals of individual synchronous generators. Since wind plants consist of multiple WTGs and may include other reactive power equipment, definition of required power factor range at the POI allows technology neutral means of meeting system performance objectives.

It should be noted that the intent of the power factor range requirement is currently open to multiple interpretations. Specifically, one widely used “permissive” interpretation of the rule is that wind plants satisfy the requirement if the plant power factor remains anywhere within this range during operations. The other “prescriptive” interpretation, which we believe is consistent with the intent of the requirement, is that wind plants must be able to deliver controlled reactive power, such that the power factor can be set or controlled to any level within the specified range. This second interpretation is consistent with conventional synchronous generator interconnection. Many wind plants are presently being designed and commissioned subject to the first interpretation in North America.

The other key distinction is that FERC Order 2003a places the onus on the host system to prove the need for wind generation to deliver reactive power. System studies must show that delivery of reactive power from proposed wind plants is necessary for system reliability and operation, before requiring such capability of prospective new wind generators. Unfortunately, there is no established mechanism by which host systems can prove such a need, and this is starkly at odds with the requirements imposed on other types of generators. ISO-NE LGIA Item 9.6.1 requires the full ±0.95 power factor range, but provides an exemption for wind plants. This exemption is no longer warranted.

3.3.1. Wind turbine types and reactive capability

The different types of WTGs described in Section 2.1, have quite different reactive power capabilities.

Type 1 and 2 machines always consume reactive power, as illustrated by Figure 3. Wind plants with Type 1 and 2 WTGs use SVCs or STATCOMs and/or switched capacitors and reactors if controlled reactive power is required.

Type 3 and 4 machines may (or may not) have substantial reactive power capability. That capability may be available at all power levels, or be described as a power factor capability. For example, GE wind turbines have reactive power capability corresponding to a power factor of 0.90 lagging (overexcited) to 0.90 leading (under excited), measured at the machine terminals. The full reactive range of the turbine is available above the cut in speed regardless of the power level, as shown in Figure 15.

As with all other types of generation, wind turbine-generators have voltage limits. Reactive power delivery requirements must be subject to these limits. Generally, it is challenging for any generator to deliver large amounts of reactive power (run over-excited) when their terminal voltages are high, and conversely, to absorb large amounts of reactive power when their terminal voltages are low. Since these conditions make little sense from a grid perspective, there is little concern. Some grid codes explicitly recognize this limitation, and make provision. The UK grid code [14] is a good example.

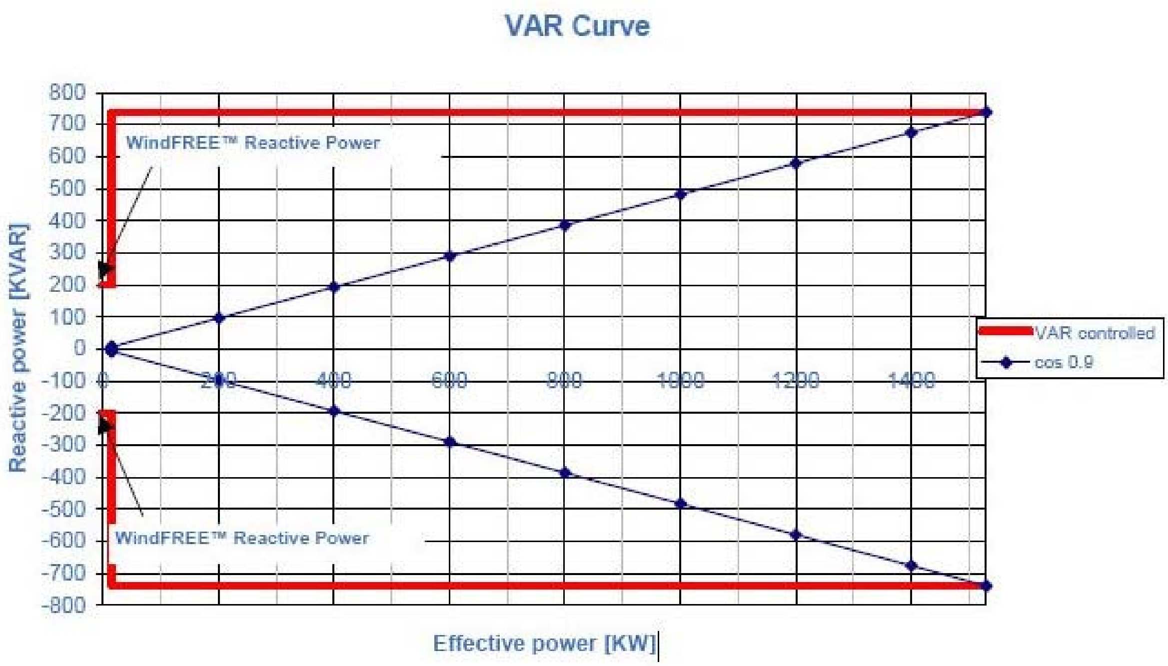

Figure 15: Reactive Capability of GE 1.5 (type 3) WTG

3.3.2. Wind Plant Controls

Some wind plants have supervisory controls that regulate the net real and reactive power interchange of a wind plant with the grid. This allows the wind plant to regulate voltage magnitude of the grid, provide governor frequency response, and minimize rates of power change. In the US, plant level voltage regulation is required.

Wind plant control systems can be hierarchical schemes that control individual wind turbines in order to implement closed-loop regulation of grid parameters such as voltage or power, or grid-interface parameters such as power factor or net power output.

3.3.2.1. Voltage controls

Power plants are normally required to regulate bus voltage at the point of interconnection. This is normally the high-side bus of the plant's step-up transformer. Conventional plants with synchronous generators regulate bus voltage by controlling field current with an excitation system. As with conventional plants, voltage schedules for wind plants should be provided by the grid operator. Anecdotal evidence suggests that grid operators in North America often do *not* provide wind plants with voltage schedules. This practice increases the risk of poor grid voltage performance (both in steady-state and for grid events), and should be avoided.

There are several basic schemes for regulating voltage with a wind plant:

- By using controlled reactive compensation devices (capacitors, reactors, SVC, STATCOM) in the plant substation, or
- By controlling the reactive power output of individual wind turbines, or
- By a combination of both.

Figure 16 shows a typical wind plant with induction generators WTGs (Type 1 or 2). These types of WTGs often operate with each WTG holding a constant power factor. The reactive power exchange at the point of interconnection (POI) is controlled by reactive compensation equipment in the substation, usually connected to the low-voltage bus (a combination of switched capacitors, switched reactors, SVC or STATCOM, depending on interconnection requirements).

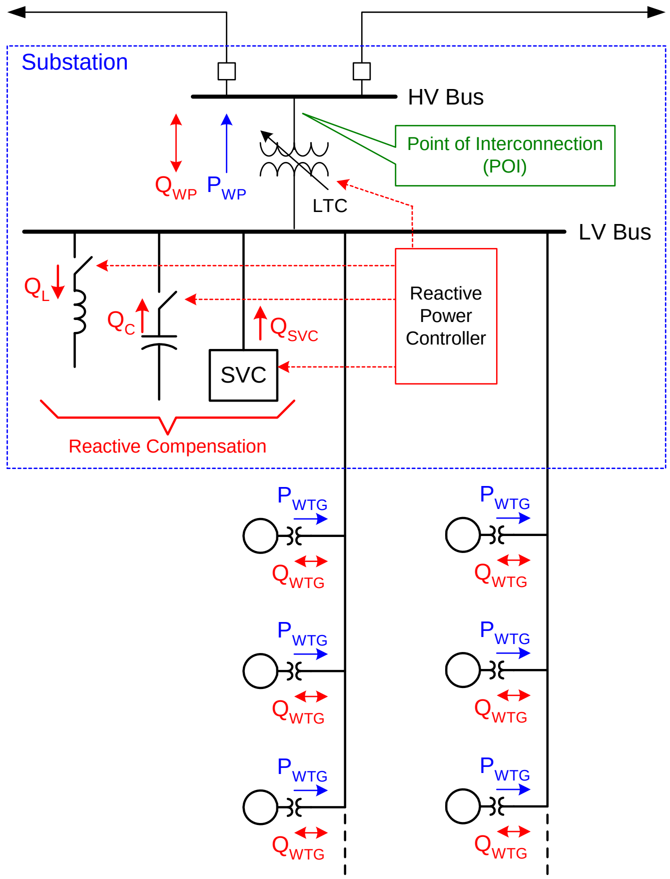

Figure 16: Wind plant with WTGs that operate with constant power factor. Voltage or power factor at POI are controlled by reactive compensation devices in the substation.

Figure 17 shows a typical wind plant with DFAG or full conversion WTGs (Type 3 or 4). These types of WTGs have the capability to quickly and continuously adjust their reactive power output and thereby contribute to regulating voltage at the POI. The scheme depicted in Figure 17 includes a reactive power controller in the substation that measures voltage at the POI and adjusts the reactive power output of the WTGs to regulate the voltage at the POI. Depending on the requirements of the specific plant, this basic control scheme can be supplemented by switched reactors or capacitors, or LTC. Figure 18 shows an example of the performance of this type of voltage control scheme at a 160 MW wind plant in the western US with GE WTGs.

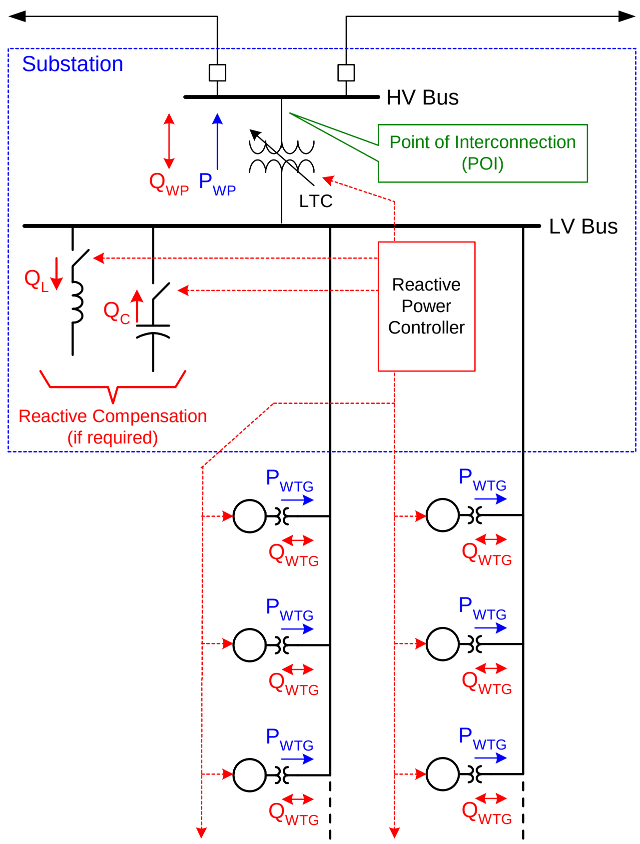

Figure 17: Wind plant with WTGs that can control reactive power output and regulate voltage.

Despite rather large variations in generated power, the voltage at the interconnection bus is quite invariant. The voltage flicker index, Pst, is less than 0.02 for this high stress condition – well within industry expectations. Most of the voltage variations are within a few hundred volts on the 230kV system.

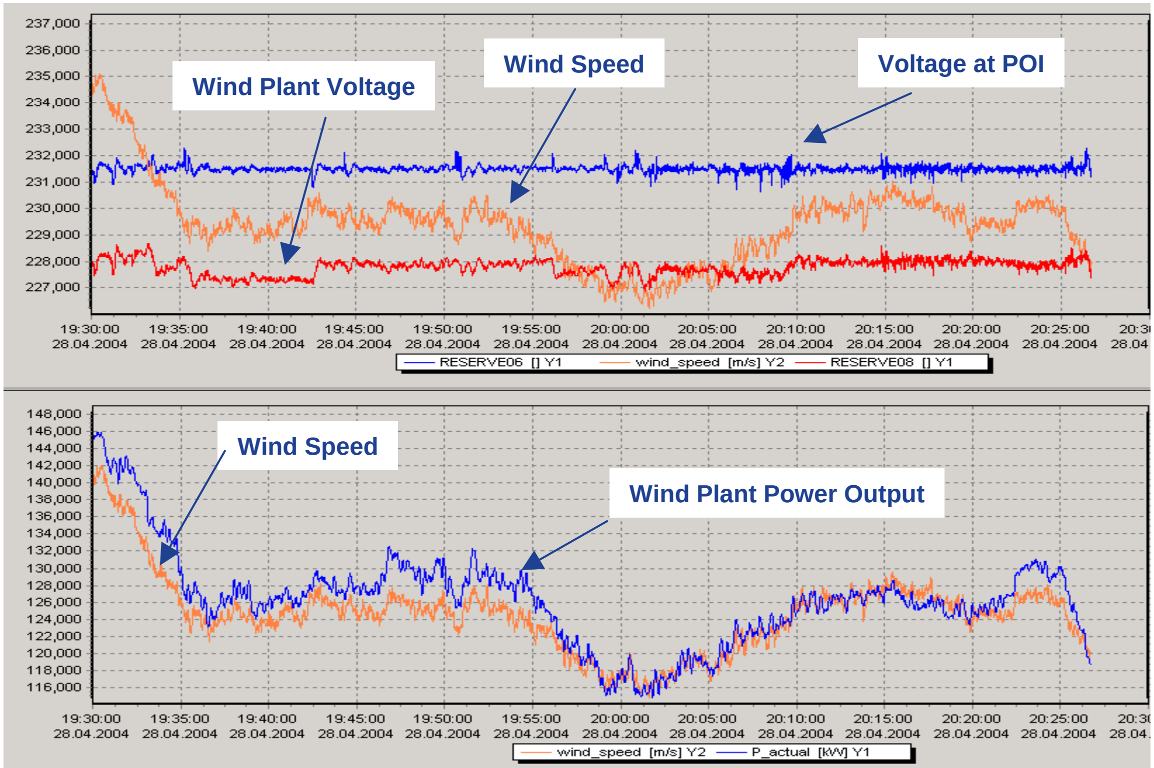

Figure 18: Demonstration of voltage regulation performance during variable power output conditions

3.3.2.2. Optimum mix of dynamic and static reactive capability

System planners and operators recognize that there are operational benefits of fast, smooth reactive power delivery capability. Such capability may come at a price; for example mechanically switched capacitors (MSCs) are much cheaper than SVCs. But SVCs have dynamic characteristics that are superior. (New England Electric would not have built the Chester SVC if simple mechanically switched capacitors had met the system needs.) Grid code developers have recognized this difference, and there have been some attempts to quantify the dynamic performance requirements for wind plants. Considering Figure 16, reactive power is provided from mechanically switched capacitors, SVCs and wind turbines. What is the requisite size of the SVC compared to the rating of the MSCs? Some grid codes have skirted this issue by requiring that wind plants respond to changes in reactive power requirements within a specified period of time. Others have required that a fraction, e.g. for 0.95 lag and 0.985 lead be provided by fast vernier sources [16]. No broad industry consensus has emerged. For the near future, it is recommended that ISO-NE requirements should be based on dynamic simulations of voltage performance for system disturbances. Voltage recovery performance should be consistent with ISO-NE planning criteria.

3.3.2.3. Coordination of Multiple Plants

Since wind plants are often connected in remote and relatively weak portions of grids in North America, it is common for plants to have voltage control strategies that integrate to drive voltages to the provided reference (i.e. no droop). Such controllers have the benefit of providing tight voltage regulation performance over a range of grid conditions. However, as with all power system applications, independent integral controllers cannot have competing control objectives. Thus, when multiple wind plants are to be connected in electrical proximity, coordination of the voltage controls is necessary. This is, of course, fundamentally no different than the need to provide such coordination with other generation. Industry practice with conventional generation usually has individual plants (or generators) using voltage droop. This can be accomplished with proportional-only regulation, line drop compensation, supervisory controls or a combination of these. Planning studies should check that regulators perform satisfactorily together. This includes avoiding divergent reactive power output (one plant over-excited while another nearby plant is under-excited), and reasonable division of reactive power support between plants. In short, multiple wind plants should be treated like multiple unit conventional power plants.

3.3.2.4. Voltage control at low power levels

At low wind plant power levels, operational flexibility may be limited compared to operation at or near full power. At low wind levels, some wind turbines within a plant may not be running (due to low wind speeds). This means that plants that rely on the wind turbines or equipment at the individual turbines for reactive support will have reduced reactive power capability. Thus, requiring a full range of reactive power capability down to low power levels may impose unreasonable burden on the plant. The UK grid code [14] addresses this limitation with a permissive interpretation of the reactive power and voltage control requirement for power levels below 20% of rated. [See Figure 1 on page cc-15 of the code. This permissive interpretation means that a plant may operate anywhere in the reactive power range corresponding to ±0.95 power factor of 20% of plant nameplate, whenever the plant power output is below 20% of its nameplate rating. This works out to be ±6.6 MVAr for power levels between zero and 20MW for a wind plant rated at 100 MW.

Figure 19 illustrates this concept for a 100 MW wind plant. When the plant is operating above 20 MW, it would be required to regulate voltage by controlling its reactive power output between –32.9 MVAr and +32.9 MVAr. But when power output is below 20 MW, the plant would be required to stay within ±6.6 MVAr (the shaded area).

The Electric Reliability Council of Texas (ERCOT) is reportedly considering a similar concept, with a threshold of 10% of rated power.

3.3.2.5. No-wind VAr production and voltage control

A recent advancement in wind turbine generator technology provides controllable reactive power output even when the wind turbine is stopped. All wind turbines stop in response to sustained wind speeds below a minimum threshold or when wind speed exceeds a high speed cut-out. They may also be disconnected from the grid in response to severe system disturbances. In plants that rely on the turbines for reactive power, both real power to serve load and reactive power to support system voltage are lost under such conditions.

Some OEMs offer WTGs that can provide smooth fast voltage regulation by delivering controlled reactive power even when the wind turbines are not generating active power. Such a function cannot normally be provided by conventional (e.g., thermal, hydro) generation, since production of reactive power from these generators requires that the generator (and therefore the turbine) continue to spin at synchronous speed. Continuous voltage support and regulation provides a major grid performance and reliability benefit.

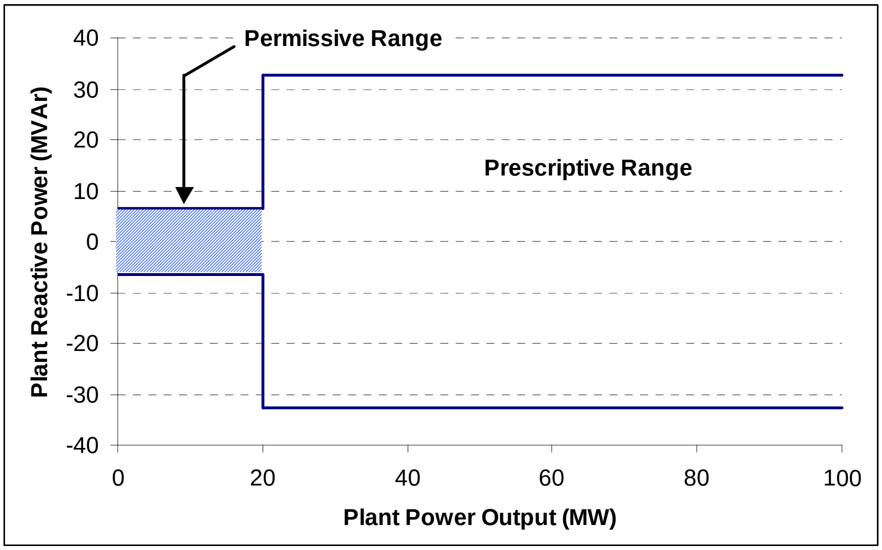

Figure 19: Plant reactive power range as a function of power output

From a systemic perspective, the reactive power capability is similar to that provided by various dynamic reactive devices (e.g., synchronous condenser, SVC, STATCOM [6]), which are used for grid reinforcement where dynamic voltage support is required.

The most significant benefits are observed for systems with substantial dynamic reactive power requirements. This includes very large wind plants, plants that are physically remote with electrically weak connections to the grid, and plants in areas with heavy and variable loads. Wind power plants equipped with this feature will provide effective grid reinforcements by providing continuous voltage regulation.

Type 3 & 4 wind turbine generators use large power converters. This decouples the generator speed from the power system frequency. The power converters rely on two major components: the generator side converter and the line side converter, which connects to the grid. If the line side converter is self-commutating, it may have the capability to independently deliver active and reactive power. When there is no active power available from the turbine, the converter can continue to deliver or absorb reactive power.

Test results for a single (GE type 4) wind turbine operating with this type of control are shown in Figure 20. Initially, the real power output is zero, while the reactive power output is about 1100 kVAr. Then, the wind picks up (at about 527 seconds) and the real power increases, while the reactive power remains constant.

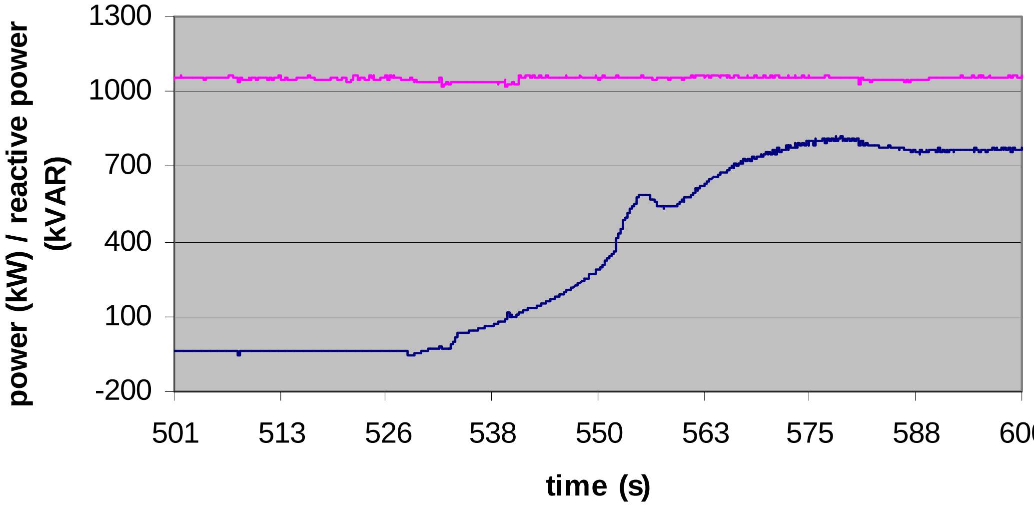

Figure 20: Demonstration of no-wind reactive power capability

3.4. Active Power Control

The advanced active power controls offered by some OEMs manage the electric power output of wind turbines and wind plants to achieve various grid-related performance objectives. This capability has implications in different time frames and applications.

Turbines without pitch control cannot limit their power output. However, wind plants with multiple wind turbines can limit or reduce total plant power output by shutting down some of the turbines in the plant.

Turbines with pitch control are capable of curtailing power in response to a real-time signal from an operator by adjusting the pitch of the turbine blades (i.e., “spilling wind”). Wind plants with such turbines are able to limit or regulate their power output to a set level by controlling the power output on individual turbines, as shown by the multiple red traces in Figure 21.

The ability of wind turbines to adjust their active power production by pitch control and, in the case of type 3 and 4 machines, by control of the power converters, has wide implications for grid operation. The discussion provided in this section addresses different aspects of performance and capability as they relate to grid operations.

3.4.1. Curtailment Capability

For most interconnections, curtailment capability is generally required. At the least, wind plants must trip off-line when so instructed by the grid operators. However, curtailment without tripping individual wind turbines is better. It maintains generation in reserve, reduces mechanical stresses on the equipment, and provides the opportunity for curtailed wind generation to provide ancillary services to the grid. While wind generation can respond rapidly, in many cases much faster than convention thermal or hydro generation, there have been cases where proposed grid codes have made excessive requirements for speed of response to step changes in curtailment order [13]. This is technically challenging for the wind turbine electro-mechanical systems and should be avoided. Capability to move active power output at rates on the order of 10%/second in response to step changes in curtailment (or dispatch) appear to be within several, if not most, OEM's capabilities.   ISO-NE should monitor developments in this area.

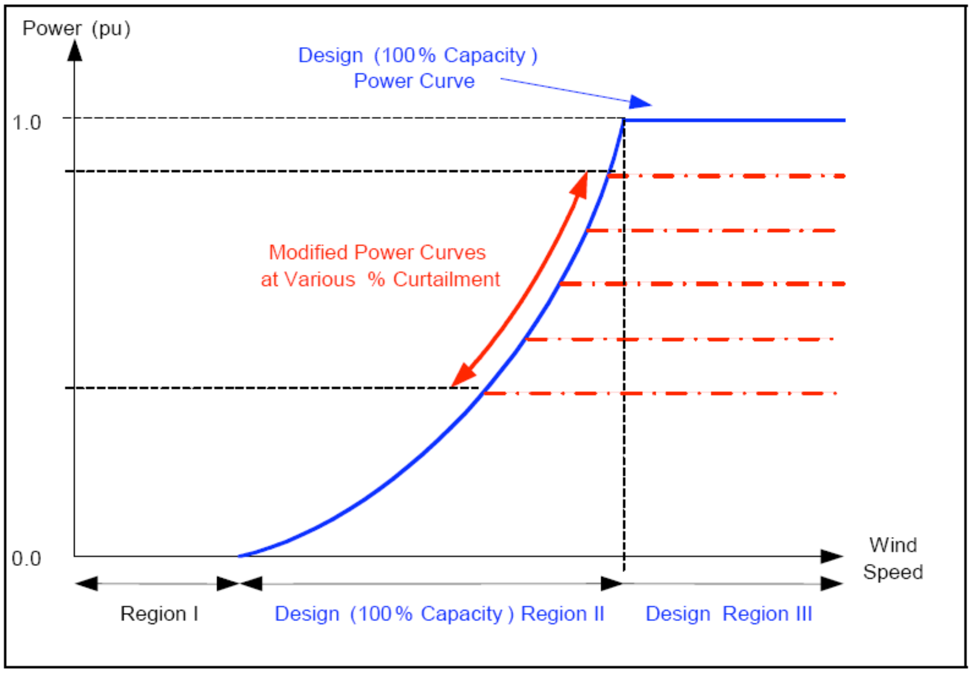

Figure 21:   Curtailment of WTG output using blade pitch control (Source: BEW report for CEC, May 2006.

3.4.2. Ramp Rate Controls

Since pitch controlled WTGs can limit their active power output, they are also capable of controlling the rate of change of power output in some circumstances, including:

- Rate of increase of power when wind speed is increasing
- Rate of increase in power when a curtailment of power output is released
- Rate of decrease in power when a curtailment limit is engaged

These functions could be implemented either at an individual turbine level or at a plant level.

Figure 22 demonstrates the power ramp limiter maintaining a specified rate of change in power output for a plant with GE wind turbines. The power ramp limiter is able to track and limit to two simultaneous ramp rates that are measured and averaged over two different time frames. The two ramp rate limits allow targeting of different potential grid operating constraints. Specifically, a short window (typically 1-minute) ramp rate limit addresses possible limitations in system regulation capability. A longer window (typically 10-minutes) addresses possible limitations in grid load-following capability. As with the governor response discussed above, this functionality is most likely to be valuable and economic at times of high wind and light load.

In the figure, initially, the wind power plant is curtailed to 4 MW. Then the curtailment is released, and the plant is allowed to ramp up at a controlled rate of 5% per minute (3 MW/min or 50 kW/s) averaged and measured over a one minute interval. The second longer time frame ramp limit was set at 3.3 %/min (2 MW/min) and averaged and measured over a 10 minute interval (20 MW per ten minutes).

Ramp-rate limits can be set to meet the requirements for specific grids and applications. Ramp-rate limits can be imposed for grid operating conditions that warrant their use, and ought not be continuously enabled. The controller allows for switching in and out of ramp-rate control by either the plant operator or in response to an external command. This ability to enable or disable ramp rate limits is valuable to the grid, as wind energy production is reduced by up ramp rate controls. Industry practice is not mature regarding appropriate limits. The lowest (slowest) limits of which the authors are aware are 5%/minute (on the base of the plant MW rating). This rate limit allows a plant to reach rated power from initial synchronization in 20 minutes. Barring further systemic evidence of a requirement for more severe (i.e. lower) ramp rate limits, ISO-NE should require that ramp rate limiters have the capability to limit ramp rates to 5%/min or more. As the figure suggests, perfect ramp rate controls are challenging. Expectations of perfect ramp controls are not reasonably attainable, and should not be required. Average ramp rates, based on sliding windows of a minimum duration of one-minute, are reasonable.[13]

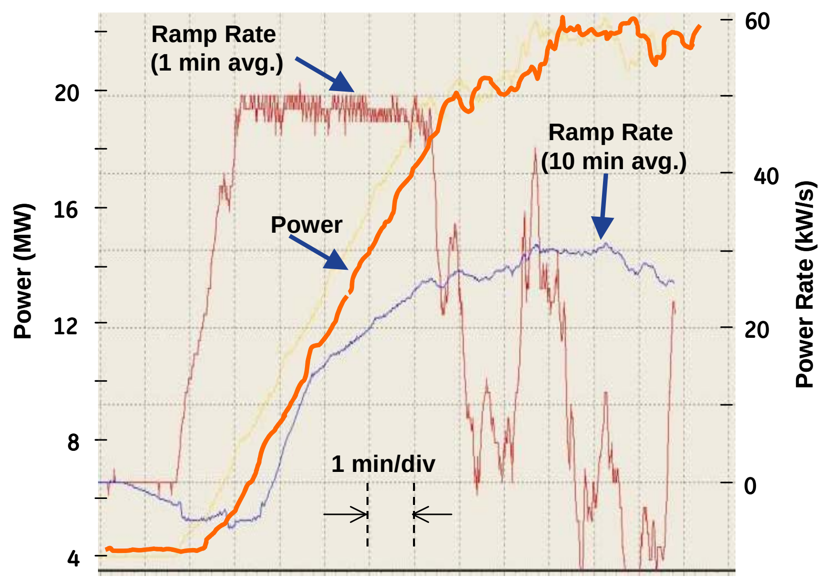

Figure 22: Demonstration of power ramp-rate control performance

Many wind plants have the ability to change active power output quite rapidly. If change in active power output is necessitated by grid events, fast response is good. However, some recent experiences in the US have surprised grid operators when wind plants have responded very rapidly to market signals. For example, wind plants have been reported to very rapidly reduce power output in response to drops in LMP. Such fast response can 'overshoot' in exactly the same fashion that other control systems with high gain can be destabilizing. Some ISOs have moved to create rules which direct or limit the rate at which wind plants are expected to respond to market signals. ISO-NE should create such rules.

3.4.3. Accepting AGC Instructions

The ability of wind plants to curtail output, as discussed in sections 3.4.1 and 3.4.2 presents the, for now theoretical, opportunity for wind plants to participate in AGC. Since wind plants have not, to date, been designed to accept AGC dispatch signals, specific details cannot be provided here. However, wind plants should be required to respond to curtailment, and thus dynamic modification of curtailment set-points has the potential to provide AGC response. The range and minimum speed of response must be consistent with the dynamic characteristics of available wind generation. Unlike large signal frequency events during operation which are relatively rare, rescheduling associated with AGC response will occur constantly. Thus, both the amplitude and speed of response will likely need to be limited considerably compared to large signal frequency response.

3.4.4. Frequency Responsive Controls

Control of frequency is a concern for all power systems. It is a major consideration in isolated systems with no external AC interconnection. Changes in system frequency are caused by imbalances due to spontaneous load variations and mismatches between dispatched generation and the actual load level. In most grid codes for integration of new generation to the system, the primary frequency control is subject to specific requirements. Requirements generally state that all conventional generators (thermal or hydro) synchronized to the transmission system must have a speed governor system to contribute to system frequency control. From a physical perspective, governor controls adjust the amount of mechanical power being delivered to the turbine-generator drive-train. This is accomplished by controlling fuel flows, steam flows, and a familiar range of other mechanical actuations. Governor actions, while rapid, are not instantaneous, typically acting on the order of ones to tens of seconds. For wind power, the physical equivalent is to adjust blade pitch to alter lift, and therefore mechanical torque on the drive-train.

A second aspect of frequency response for synchronous generators is inertia. Inertial response of synchronous machines is due to changes in electrical torque caused by grid frequency changes. It is fast, inherent and uncontrolled. Inertial response, being inherent, is rarely addressed by existing grid codes: it is expected and included in grid stability calculations – regardless of whether the impact is beneficial or detrimental.

In the next few years, a large amount of type 3 and 4 generation are planned to be integrated on power systems, thanks to their ability to maximize power extraction, reduce wind turbine structural loading, and their attributes regarding general system behaviors. When penetration of wind turbines into the power system reaches a critical point (say more than 10% of the total energy generation), the displacement of conventional generators by wind turbines can decrease the effective primary (governor response) and the inertia of the system, resulting in larger frequency deviations, especially in isolated systems and in periods of low load.

A consequence of the above is that additional requirements are likely to be imposed on wind plants by system operators, as is already the case for several utilities including the Nordic grid operators and ESB National Grid (Ireland) who have already added a governor type frequency control requirement in their grid codes and Hydro-Québec, which has added an inertial response requirement. ([4] to [7]).

In the discussion below, governor response and inertial response of wind generation are addressed separately. They have different operational implications and different levels of technical maturity.

3.4.4.1. Governor Response

Many double fed and full conversion wind turbines are capable of adjusting their power output in real time in response to variations in grid frequency. This is an optional control feature, implemented in wind plants where participation in grid frequency regulation is deemed necessary.

When frequency increases above a control deadband, the frequency regulation function reduces power output from the wind turbine, similar to a droop-type governor function in a thermal or hydro generating plant. A wind turbine would always be able to respond to increased grid frequency, since it is always possible to reduce power output below the total available power in the wind.

The frequency regulation function is also capable of increasing power when grid frequency decreases below a deadband, provided that the turbine's power output at nominal frequency is below the total available power in the wind. When operating in this mode (power output curtailed below total available power), the wind turbine would be contributing spinning reserve to the grid.

The Nordic and ESBNG grid operators require wind plants to be able to change the active power production as a function of the network frequency. Wind plants will have to provide frequency control only when the system requires it (e.g. at low load and high wind power output). Whereas the wind plants can make downward regulation of the production while at rated power following a sudden rise of the system frequency, they have to maintain a power margin (reserve margin) that may be called upon during a frequency decline ([4] to [6]). The expected response rate of each available online wind plant to frequency changes is at least 1% of the wind plant rated capacity per second, but could be more.

Since wind plants must 'spill' wind continuously in order to provide spinning reserve, there are substantial commercial implications: maintaining this margin results in 'free' (zero marginal cost of production) wind power being discarded. This means the opportunity cost of providing up reserve with wind plants is equal to the marginal value of that power – roughly the spot price plus tax credits plus renewable credits. Thus, it is only economically justified to *use* this capability under conditions when it is the least cost alternative. Under the vast majority of system operating conditions, providing this service with other conventional generators [2] will be more cost-effective. When the system needs this service from wind plants, they should have the *capability* to provide it.

Examples of overfrequency and underfrequency regulation performance are described below, utilizing data from staged tests at a 60 MW wind farm with forty 1.5 MW double-fed GE wind turbines.

3.4.4.2. Over-Frequency Response

Figure 23 illustrates the power response of the wind plant due to a grid over-frequency condition. For this test, the controller settings correspond to a 4% droop curve and 0.02Hz dead band. During this test, the site was operating unconstrained at prevailing wind conditions. It was producing slightly less than 23MW prior to the over-frequency condition. The system over-frequency condition was created using special test software that added a 2% controlled ramp offset into the measured frequency signal. The resulting simulated frequency (the red trace in Figure 23) increased at a 0.25Hz/sec rate from 60Hz to 61.2 Hz. While the frequency is increasing the plant power (the dark trace in Figure 23) is observed to drop at a rate of 2.4MW/sec. After 4.8 seconds the frequency reaches 61.2 Hz and the power of the plant is reduced by approximately 50%.

The over frequency condition is removed with a controlled ramp down to 60Hz at the same 0.25Hz/sec rate. In response, the plant power increases to its unconstrained power level. This is slightly higher than the unconstrained level prior to the test, due to an increase in the wind speed. The droop and deadband settings for this test are typical values. Settings can be adjusted to meet specific grid and application requirements.

Grid over-frequency events are stressful to power components. Further, temporary high frequency swings can present a reliability concern. For example, in one recent well publicized grid event [3], the high frequency backswing from a major grid disturbance caused power plant trips and aggravated an already severe event. When enabled, the response of the GE WindCONTROL™ will rapidly reduce power output for the duration of the over-frequency event. This behavior is similar to that of governor control on thermal generation, except that it is faster and allows deeper runback of power than is typical of conventional thermal generation.

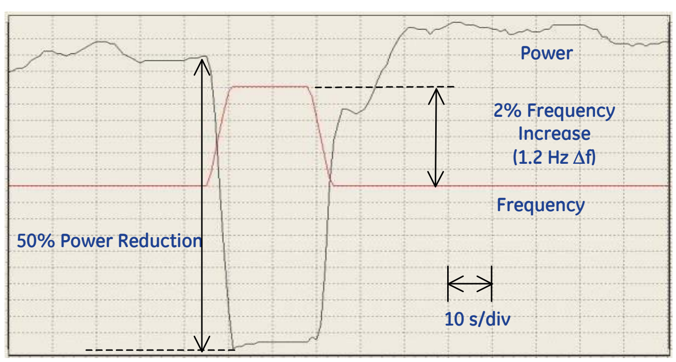

Figure 23: Power response of wind plant to overfrequency condition.

3.4.4.3. Under-Frequency and Power Reserve Response

An under frequency condition is simulated using the same test software and the results are presented in Figure 24. In order to allow for an increase of wind plant active power output in response to an under-frequency condition, some active power production must be kept in reserve. Unlike a conventional power plant, the maximum power production of the wind plant is constrained to that possible with the prevailing wind. For this test, the output of the plant was constrained to 90% of prevailing wind power during nominal frequency conditions, allowing a 10% increase in power with a 4% decrease in frequency. The plant controller continuously calculates the available plant power based on average wind conditions and turbine availability. The controller regulates the output power to 90% (12.4MW) of this calculated value and operates the plant at this level while the system frequency is within +/- 0.02 Hz of nominal frequency (60Hz).

As the system frequency decreases, the control increases the plant power according to the droop schedule. At 57.6 Hz, 4% under frequency, 100% of the calculated available power of the plant is produced (13.8 MW). The power of the plant will remain at this value until either wind conditions reduce or the system frequency increases.

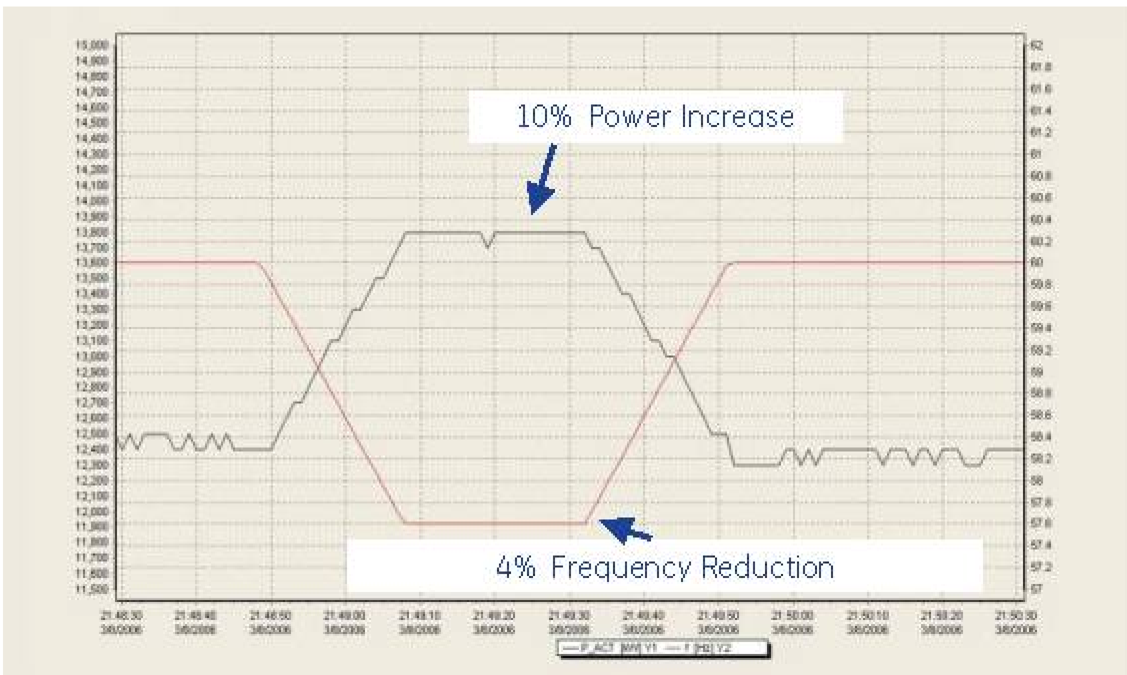

Figure 24:   Power response of plant to underfrequency condition

3.4.4.4.   Inertial Response

Large interconnected systems generally have large aggregate inertia, which results in small frequency deviations in response to system disturbances. Small isolated systems have much smaller aggregate inertia, and as a result, experience larger frequency deviations when disturbances occur.

The lower the system inertia, the faster the frequency will change and the larger the deviation will be if a variation in load or generation occurs. Thus, the response of bulk power systems to system disturbances is of great concern to those responsible for grid planning and operations. System events that include loss of generation normally result in transient depressions of system frequency. The rate of frequency decline, the depth of the frequency excursion, and time required for system frequency to return to normal are all critical bulk power system performance metrics that are affected by the dynamic characteristics of generation connected to the grid.

As the share of wind power in the system increases, the effective inertia of the system will decrease considering the existing technologies. While conventional synchronous generators inherently add inertia to the system, it is not necessarily the case with wind turbines generators.

In the case of induction machines and the truly synchronous machines, there is a direct connection between the power system and the machine. When there is frequency decay on the power system, the induction machine will increase its output temporarily because of the slip change. The induction machines are then able to contribute to some extent to system inertia while the truly synchronous machines will inherently add inertia to the system the same way a hydro or thermal turbine would [1].

The basic design of converter based technology (Type 3 and 4), however, does not include any inertial response unless explicitly designed to do so. The DFAG and full converter generators employ a back-to-back converter to connect to the power system. For the DFAG design, there is a direct connection between the system and the stator while the rotor is decoupled from the system by the ac\dc\ac converter. It is possible to take advantage of this direct coupling between the frequency of the system and the stator with appropriate control so that a frequency deviation on the power system varies the electromagnetic torque of the DFAG, resulting in a change of its rotational speed and thus modify active power (MW) acting as an inertial response. In the case of the full converter generators, they are completely decoupled from the frequency of the system. A change in the system frequency will not have any effect on the machine. Therefore, the full convertor generators will not by their design contribute to system inertia when there is a frequency deviation on the power system.

Inertial response capability for wind turbines, similar to that of conventional synchronous generators for large under-frequency grid events, is now available from some OEMs. This is new and is not widely recognized or used by the industry yet.

For large under frequency events, the inertial control increases the power output of the wind turbine in the range of 5% to 10% of the rated turbine power. The duration of the power increase is on the order of several seconds. This inertial response is essentially energy neutral. Below rated wind, stored kinetic energy from the turbine-generator rotors is temporarily donated to the grid, but is recovered later. At higher wind speeds, it is possible to increase the captured wind power, using pitch control, to temporarily exceed the steady-state rating of the turbine. Under these conditions, the decline in rotor speed is less and the energy recovery is minimal.

The control utilizes the kinetic energy stored in the rotor to provide an increase in power only when needed. Hence, this feature does not adversely impact annual energy production.

Unlike the inherent response of synchronous machines, inertial WTG response is dependent on active controls and can be tailored, within limits, to the needs of the power system. Further, the response is shared with controlled variations in active power necessary to manage the turbine speed and mechanical stresses. These stress management controls take priority over inertial control. Turbulence may mask the response for individual turbines at any instant in time, but overall plant response will be additive. GE’s inertial control design has sufficient margin over the turbine operating range to meet the equivalent energy (kW-sec) contribution of a synchronous machine with 3.5 sec pu inertia for the initial 10 seconds. This inertia constant is representative of large thermal generation, and is the target inertia included in the Hydro-Québec grid code [18] provision for inertial response.

Hydro-Québec requires that wind plants be able to contribute to reducing large (> 0.5 Hz), short-term (< 10 s) frequency deviations on the power system, as does the inertial response of a conventional synchronous generator whose inertia constant (H) equals 3.5 s. This target is met, for instance, when the system dynamically varies the real power by about 5 % for 10 seconds when a large, short-duration frequency deviation occurs on the power system [7]. It requires that the frequency control is available permanently, i.e. not limited to critical moments. In 2010, Hydro-Québec will integrate the first wind plants equipped with this feature in its network. Hydro-Québec is the only transmission owner currently requiring wind plants to contribute to frequency regulation by using the inertial response.

Given the systemic needs, and the Hydro-Québec requirement, the overall control is designed to provide similar functional response to that of a synchronous machine. Unlike the inherent response of a synchronous machine, the response is not exactly the same under all operating conditions, nor does it provide synchronizing torque. Frequency error is simply the deviation from nominal. A positive frequency error means the frequency is low and extra power is needed. The deadband suppresses response of the controller until the error exceeds a threshold. Thus, the controller only responds to large events. The continuous small perturbations in frequency that characterize normal grid operation are not passed through to the controller.

There are a number of differences between this controlled inertial response, and the inherent inertial response of a synchronous machine. First, and most important, the control is asymmetric: it only responds to low frequencies. High frequency controls are handled separately, by a different controller that can, if necessary, provide sustained response, as discussed in Section 3.4.4.2. Second, the deadband ensures that the controller only responds to large events – those for which inertial response is important to maintain grid stability, and for which seriously disruptive consequences, like under frequency load shedding (UFLS), may result. Finally, a controlled inertial response means the speed of response is a function of the control parameters. In the example shown, the response was tuned to provide good coordination not only with inertial response of other generation on the system, but with governor response of conventional generation as well. The ability to tune inertial response (including shutting it off) provides the planning engineer with an additional tool to manage system stability.

Field test results of the inertial control on a GE WTG for various wind speeds on a single wind turbine are shown in Figure 25. The field data was generated by repeated application of a frequency test signal to the control. The results, at various wind speeds, were then averaged and plotted. Below rated wind speed (<14m/s) the results clearly demonstrate the inertial response and recovery. Above rated wind speed the inertial response is sustained by extracting additional power from the available wind (i.e. short-term overload of the WTG).

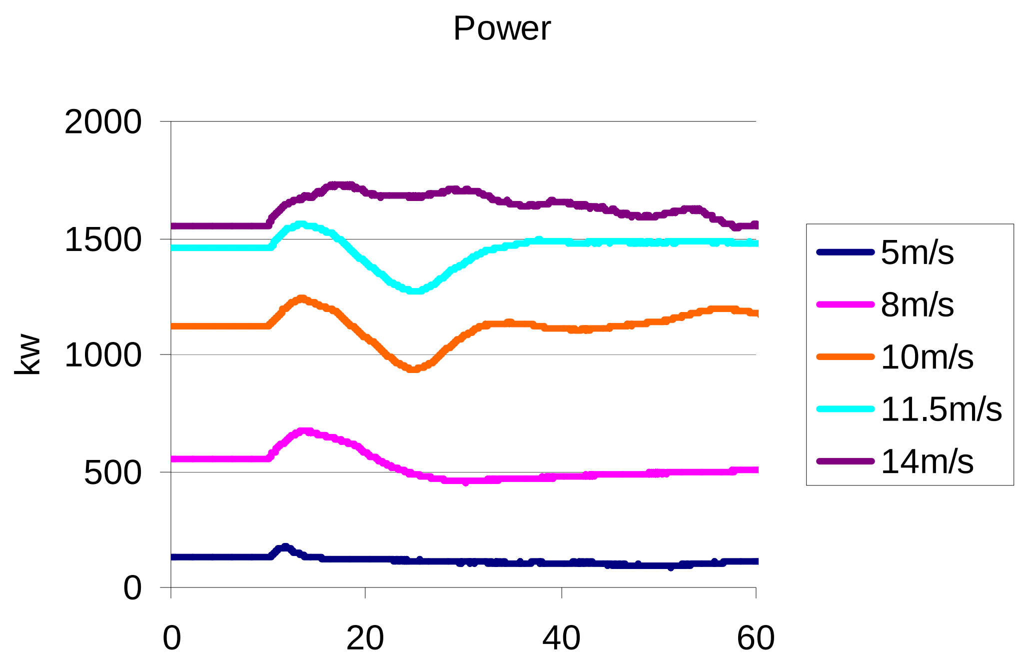

Figure 25: Field demonstration of the GE WindINERTIA™ response.

Ultimately, grid codes may be modified to include some type of inertial response requirement. The development of the GE WindINERTIA™ feature, as well as planned demonstrations by other OEMS, such as Repower (offshore wind plant in Germany in 2009: Alpha Ventus research project), shows that such functionality is, indeed, possible. However, it also shows that inertial response identical to that of synchronous generation is neither possible nor necessary. Controlled inertial response of wind plants is in some ways better than the inherent inertial response of conventional generators. Inertial response of wind generation is limited to large under-frequency events that represent reliability and continuity-of-service risks to the grid. The crafting of new grid codes should therefore proceed cautiously and focus on functional, systemic needs.

3.5. Harmonics

Most commercially available wind turbines comply with IEEE 519, which if applied on a turbine-by-turbine basis would limit the total harmonic distortion (THD) of the current at the terminals of the machine to 5% (of rated fundamental frequency current) or less. Turbine vendors will usually note this in their product specifications.

This includes turbines in each of the four major topologies. Type III and Type IV machines utilize static power converters, but the quality of the output currents is well within the IEEE 519 limits.

ISO-NE's interest is in the harmonic performance of the entire plant, not the individual turbines. Experience from around the country shows that harmonics can be a serious concern for large wind plants, especially those employing capacitors at medium voltage for reactive power support, or plants with extensive collector networks of underground medium voltage cable. The phenomenon at issue is the interaction of the medium voltage shunt capacitance in series with the interconnection substation transformer inductance. The combination appears as a series filter, and provides a convenient sinks for background harmonics on the transmission system (Figure 26).

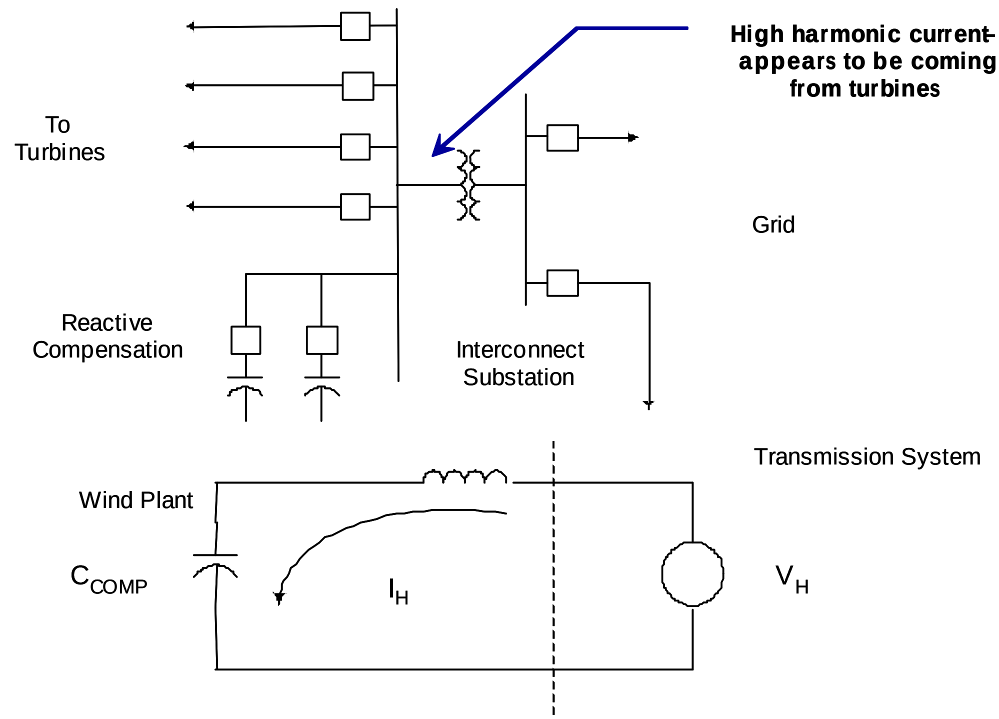

Figure 26: Equivalent circuit showing wind plant as a sink for harmonic distortion from the grid.

The concern regarding interconnection is that it may appear the plant is in violation of the IEEE 519 limits when the root cause is actually background distortion on the transmission system.

3.6. WIND PLANT MODELING

Wind turbine and wind plant modeling has been a topic of intense debate, scrutiny and development for the past several years. The availability of good simulation models for wind plants has been limited (and contentious) for a number of reasons. First and foremost, the technology has been evolving very rapidly, and it simply has not been possible for model development to keep up. It is well to remember that the suite of industry accepted models for synchronous generations (i.e. IEEE standard types) took several decades to develop. The time scale for wind is significantly less. Because wind generation technology is developing so rapidly, there are very serious intellectual property issues for the OEMs. Developing, and offering, advanced controls for wind plants are competitive issues, and consequently OEMs tend to be secretive with their technology. Further, to a large extent, there has not been a history of utility grade, standardized modeling in the industry. Some OEMs have adopted the practice of developing and providing proprietary "black box" models for their technology. While these proprietary models may be well suited to system analysis, they become problematic in North America where data must be freely exchanged. Other OEMs (e.g. GE) have produced open structure models, which are openly documented and intended to be exchanged. These models are moderately complex, tend to be specific to the OEM's equipment, and include control features which may not be generally applicable or available on other OEM equipment.

3.6.1. WECC / IEEE Generic Models

International cooperation with generic model development initiated by the WECC provides strong support for continuation of this effort as wind generation technology continues to evolve. The need for widely available and understood models appropriate for steady-state and dynamic studies of the bulk network is not unique to North American utilities. The principal attributes of these models, non-proprietary code and parameters and well-proven behavior, also appear to be a global need. Recent discussions of this topic have been focusing on the steps beyond the initial development of the generic model architectures and the distribution of code embodying these models to a much broader audience of users. There are still questions, for example, about the appropriate use of the simplified models, as well as the converse - which studies fall outside the intended application space for the models, and how should those studies be conducted.

The WECC-led effort considered the four major types of turbines in current commercial applications. Block diagrams for each were developed to encompass the range of behavior and performance across the major commercially-available turbines. However, as capabilities and features are added to the existing fleet of commercial turbines, augmentation of the structures for the generic models may be necessary. In addition, there is the possibility of new wind turbine topologies, as exemplified by the synchronous machine-based turbines now on the market.

In the very near term, the industry must develop accurate representations of existing turbine designs using the current generic structures. This effort will require significant collaboration between the power engineering community and the wind turbine vendors, since the measurement data or detailed simulation results that provide the best opportunities for checking the behavior and adjusting the parameters of the generic models are held by the vendors and not generally available publicly. With the growing number of commercial turbines either in service or on the market, this initial validation process will be a very significant effort.

At present, it is recognized that existing NERC standards are not being applied consistently or uniformly for wind generation. Standards MOD-011 and MOD-012, for example, mandate that reliability organizations provide guidance and requirements for power flow and dynamic models. Given the lack of accepted industry standard models for wind turbines and wind plants, enforcement here has been very difficult. The current situation, with system impact studies based on one-of-a-kind, user-written, or proprietary models, is not tenable in the long term, and has actually become a significant limitation with the current installed wind generation capacity. Development of models is critical in this respect.

Existing NERC modeling standards require Reliability Entities (RE) to develop comprehensive steady-state data requirements and reporting procedures needed to model and analyze the steady-state and dynamic performance of the power system (MOD-011 and MOD-013). Equipment owners are required to provide models to the RE steady state and dynamic models

(MOD-012). This information is required to build a reasonable representation of the interconnection's system for planning purposes, as stated in MOD-014 and MOD-015. In this context, proprietary or user-written models are generally unacceptable. In lieu of the accepted standard models, the common course of action for wind plant owners has been to provide no models at all, which is contrary to the requirement of these standards.

Finally, there are NERC standards that deal with periodic verification of the models, such as MOD-023, which deals with verification of reactive power limits. Again, with the current process broken because of the lack of accepted models, this provision has in essence been ignored for existing wind plants. These same issues are being dealt with in other jurisdictions around the world experiencing rapid development of wind power. The process which has been adopted by National Grid in the UK in this regard is of particular interest, and can be found in a document titled "Guidance Notes for Power Park Developers: Grid Code Connection Conditions Compliance: Testing & Submission of the Compliance Report", dealing with the full scope of grid code compliance testing and model validation. It may be found at:

http://www.nationalgrid.com/NR/rdonlyres/5F1F5F26-FD98-475A-A1EA-C7584FC5C4F7/15040/GuidanceNotesPowerParksRev16.pdf

Much of the current modeling activity surrounds representations of wind turbine technologies and wind plants for positive-sequence analyses, primarily power flow and dynamic simulation. As wind penetration continues to grow, there is a growing realization that other studies and evaluations are needed in the plant design and commissioning process, for some of which the positive sequence steady-state or dynamic representations are inadequate. At present, these studies are generally conducted with a simulation platform for which a relatively detailed transient model of the wind turbine and controls already exists or can be created.

3.6.2. Model data reporting requirements for turbine manufacturers

NERC is in the position to be able to force clarity upon most of the modeling issues that have challenged both transmission planners and wind plant operators. NERC can and should play a significant role in encouraging model development activities being pursued in WECC and IEEE. NERC should clearly re-state the expectation that wind generators comply with the intent of existing standards to the maximum extent possible, recognizing that there are differences that need to be addressed going forward, but setting a fixed timetable for resolution of those differences. In summary, steps that could be taken in this regard include:

1. Clarification of the expectation that wind generators must comply with standards, and a fixed timetable for compliance, with penalties for non-compliance;
2. An assessment of existing standards to determine what modifications to standards (if any) are necessary in consideration of wind generation, especially in the modeling area and including verification of models, given the somewhat unique aspects of wind generation;
3. Definition of appropriate tests for wind plants that considers the unique operational nature; verification of reactive limits for operating plants is an example, where the existing procedure may have to be modified to account for the operational characteristics.

The transition of the generic modeling activity from WECC to the IEEE Power Engineering Society Power System Dynamics Committee should provide a broader forum going forward for the needed work in this area.

3.6.3. Short Circuit Modeling

The short circuit behavior of wind generation with power electronics (type 3 and type 4) is different than that of synchronous generators. Further, the details of the behavior are relatively complex and specific to each wind generator OEM. Most short circuit modeling programs have limited ability to accommodate such non-standard behavior. Consequently, present practice tends to use modeling assumptions that are intended to be conservative. This usually means modeling with equivalent impedances that tend to over state the amount of fault current delivered in the short term. This practice has, so far, generally served the industry satisfactorily. It is anticipated that this issue will continue to receive attention and that modeling will become more sophisticated with time.

This is a challenging topic and the industry is presently developing understanding, processes and recommendations related to short circuit currents. The IEEE PES task force on Short Circuit Fault Contribution from Wind Generators is addressing this issue. It is recommended that ISO-NE track the progress of that task force and evaluate the results of its work. It is possible that this task force will recommend a practice whereby wind plant owners would provide short circuit information to transmission owners, grid operators, and others who need such data.

3.6.4. Transient (point-on-wave) Models

The individual phase transient (e.g. EMTP-like) modeling of wind generation is highly complex. The behavior the power electronics and electromagnetics of wind generators is extremely specific to individual OEMs. Correct modeling absolutely requires access to highly proprietary information about the equipment. Further results are not easy to interpret. Overall, this type of modeling is usually unnecessary for phenomena outside of the wind plant and is to be avoided, if possible. Use of generic point-on-wave models that purport to represent actual wind turbine generators is almost invariably meaningless. Performance is design specific.

In spite of this, situations may arise where detailed modeling and simulation studies may be required. In such circumstances, it is critical to first secure the direct participation of the vendors of the equipment involved (e.g. HVDC converter and wind turbine manufacturer) to support if not conduct the necessary investigation. Results of detailed simulation studies by third parties alone may be absolutely correct given the fidelity of the equipment models used, but could likely miss the major points entirely if those models are generic and not reflective of the actual OEM equipment.

3.7. Distribution Connected Wind Generation

Distribution connected wind generation has a number of performance and economic aspects which require separate consideration and different interconnection requirements. In general, distribution connected wind turbines come in single or small groups of turbines. To date, unlike Europe, distribution connected wind generation represents a small fraction of the total wind generation installed in the US. For this reason, the most serious issues related to distribution connected wind generation have tended to be local power system concerns, not broad systemic operational problem.

The economics of distribution systems make imposition of extensive monitoring and control requirements an unnecessary burden. Many grid codes exempt wind plants of sizes less than 10 MW from many of the requirements imposed on larger, transmission connected plants. ISO-NE should adopt this stance as well.

However, some requirements are needed to assure acceptable performance of the local grid and to allow ISO-NE to incorporate substantial amounts of distribution connected wind, should that scenario evolve. ISO-NE should make a distinction between small, behind-the-meter, wind turbines and installations that connect one or more turbines directly to the grid at distribution level. The exact breakpoint in size can be set by ISO-NE. It is recommended that "small" be defined in the range of less than 100 to 250kW. Small, behind the meter, wind turbines can be handled with existing customer generation connection rules. Installations that are larger than "small", but lower in rating than a minimum, for which the recommendations above (and ISO-NE's LGIA) apply, can be termed "medium" for this discussion. The exact size range for "medium" plants should be determined by ISO-NE. The following discussion is focused on issues that accompany these medium size installations when they are connected to distribution systems.

From a control perspective there are number of differences that must be considered. Distribution connected generation, including wind turbines, are subject to IEEE standard 1547. This means that wind turbines must NOT have any of the fault ride-through capabilities described in section 3.2. Wind turbines must trip for significant voltage and frequency events. This requirement may have unfortunate systemic implications should New England reach high levels of distributed wind generation. NERC activities, including efforts by the Integrating Variable Generation Task Force, are currently underway to address this apparent incompatibility.

Another aspect of IEEE 1547 is that distributed generation must NOT regulate voltage. Thus, distribution connected wind generation should be on power factor control. Independent of IEEE 1547, this practice has merit, in that most distribution system voltage management equipment (including switched capacitors, step regulators, etc.) has the potential to misbehave (i.e. hunt or cause unexpectedly high or low voltages) when uncoordinated voltage control is applied downstream on a feeder. In any event, minimizing voltage fluctuations due to active power variations (from, for example wind speed variations) by manipulating reactive power has limited efficacy in low X/R systems, such as would be found in most distribution systems [17].

The discussion of islanding provided in section 3.2.6 applies for distributed generation. Specifically, islanding is prohibited. This includes temporary islanding associated with reclosing. Wind turbines on distribution system should be actively tripped, by transfer trip or some equivalent, when the distribution feeder breaker is to be opened. If reclosing is practiced, the wind turbine must be tripped before the recloser action.

Good engineering practice should be respected in adding wind generation to distribution systems. Feeder protection and breaker rating should be reviewed for adequacy with distributed generation added.

Some information and control of distributed wind generation is, however, appropriate and necessary. Distributed wind generation must have the ability to be shut down by the system operator. Distributed wind generation should provide status information, including whether or how many machines are running, power production, and anemometry.

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Section 4

WIND GENERATION FORECASTING

4.1. THE NEED FOR RELIABLE FORECASTS

The variability of wind energy production presents a special challenge for utility system operations. While conventional power plants can produce a near constant output – barring rare emergency outages – the output of a wind plant fluctuates. In some parts of the U.S., such fluctuations can amount to several hundred megawatts in a matter of an hour or two. To the extent the fluctuations are not predicted, and to the extent that these fluctuations do not match with the balancing area load pattern, they create costs for the electricity system and consumers as well as potential risks to the reliability of electricity supply.

One of the principal mechanisms a grid operator, such as an Independent System Operator (ISO), uses to limit unexpected changes in plant output is to charge suppliers a penalty for "uninstructed deviations" between their forward schedules (i.e. predicted output) and actual generation. This policy encourages suppliers to maintain a high level of reliability while also compensating the system for the costs of having either excess or insufficient generation. Typically, the penalty is designed to motivate good behavior (like a speeding ticket) and is not assessed on the deviation in each hour based on the market-clearing price of the real time market. However, considering the volatility of wind plant output and the fact that the variability is not under the wind plant operator's control, some grid operators recognize that wind energy suppliers could be severely penalized if required to pay for deviations on an hourly basis.

The performance requirements for a forecasting service are dictated by the needs of both the grid operator and the wind generators. From the perspective of wind generators, the priority is to minimize the deviation between forecasted and actual plant output. For an ISO, there are two additional and more demanding priorities.

As with load, effective power production planning requires more accurate forecasts for the aggregate system rather than single plants. Thus, the first priority of power production forecasting systems is to anticipate changes in aggregate wind production as accurately as possible in the very short term (up to a few hours ahead) so the ISO can manage its grid operations and reserve capacity purchase decisions in an optimal fashion. For this purpose, it is natural to consider persistence-type methods. Persistence assumes the current conditions will not change and can be used to forecast the future conditions. If persistence is used to forecast for periods longer than an hour, a diurnal change is typically taken into account. Often, autoregressive statistical techniques, which are designed to forecast from time series data, are combined with the persistence techniques to produce the forecast. For example, a next-day hourly forecast would assume that conditions would be the same as the previous 24 hours.

However, such methods are inherently limited in that they cannot predict changes in plant output that depart radically from recent trends that might occur because of a passing weather front. In order to achieve the highest possible accuracy, the methods should incorporate other data that may signal future trends, such as conventional weather forecasts or meteorological observations from upstream of the wind plants.

The second priority is to forecast the wind generation for the next day so an ISO can schedule reserve capacity and unit commitment as efficiently as possible. In this case, it is less important to accurately forecast the *timing* of changes in wind generation than it is to forecast the *minimum* wind plant output during the peak load hours.

In general, a high degree of reliability and accuracy is required by ISOs and utility systems for aggregate wind generation forecasts. This requirement is consistent with the usual high standard of reliability applied to all utility system operations. It is particularly important for the next-hour forecasts, because their accuracy declines relatively quickly the older the forecast becomes. The accuracy of next-day forecasts, in contrast, is not as sensitive to the age of the forecast.

4.2. THE FORECASTING PROBLEM

The wind energy generation forecasting problem is closely linked to the problem of forecasting the variation of specific atmospheric variables (i.e. wind speed and direction, air density) over short time intervals and small spatial scales. In general, this problem is enormously challenging due to the wide variety of spatial and temporal scales of atmospheric motion that play a role in determining the variation of the key parameters within the targeted forecast volume. In order to understand the different issues involved in wind energy forecasting, it is useful to divide the problem into three time scales:

- very short-term (0-6 hours),
- short-term (6-72 hours), and
- medium range (3-10 days).

The skill in very short-term forecasting is related to the prediction of small-scale atmospheric features (< 200 km in size) in the vicinity of the wind plant. The major issue is that very little data are typically gathered on the scale of these features. As a result, it is usually difficult to define their spatial structure and extent of these features. One viable option is often to infer information about these features using a time series of meteorological and generation data from the wind plant. For this reason, real-time data from the wind plant is usually crucial to producing highly accurate very short-term forecasts. In fact, the 0- to 6-hour time scale has been defined as the period when persistence forecasts will typically outperform wind energy forecasts derived solely from predictions of the regional atmospheric circulation. Thus, the benchmark for the very short-term time scale is a persistence forecast.

The ability to forecast the wind energy generation over short-term time scales is tied to the skill of forecasting regional scale atmospheric features. These features are often referred to as synoptic scale weather systems and are the ones typically depicted in newspaper and TV weather presentations. It is necessary to gather data over a large volume of the atmosphere in order to define the structure of these systems. This process is usually accomplished using in situ or remote sensing measurement devices operated by an agency of a national government (such as the U.S. National Weather Service).

The importance of measurements at the wind plant drastically decreases at the start of this 6-72 hour period. The real-time plant data is able to make some contribution to forecast quality at the start of the period. However, it has little predictive value after about 12 to 18 hours. This is fundamentally because information that determines variations in meteorological parameters for periods greater than 12 hours comes from locations that are hundreds of kilometers away. As a result, the forecast standard shifts from persistence to climatology (i.e. the average conditions for that location and season) during this period. A climatology forecast will typically outperform a persistence forecast for most locations after about 12 to 18 hours.

The skill of medium range forecasts is typically linked with forecasting continental, hemispheric, and global-scale atmospheric circulation systems. However, the regional and local features are superimposed upon these large scale features. At the medium range time scale, it is difficult to accurately predict the evolution of specific local-area or regional features that will affect the forecast target area. Therefore, most of the forecast skill is linked to prediction of general patterns that favor above average or below average winds for a substantial period of time (a day or more). The benchmark for this time scale is a climatological forecast.

It should be noted that the distribution of atmospheric energy across the space and time scales varies substantially by region, season, and atmospheric regime. This variability has important implications for predictability and forecast performance. If there is limited variability over a specific time scale, the absolute forecast performance is likely to be good but with little skill over a simple persistence or climatology forecast. Conversely, a situation with large variability over a given time scale will often result in lower absolute performance but higher relative performance compared with simple persistence or climatology forecasts.

The impact of the various errors ultimately affects the forecast wind speed and the timing of significant changes in wind speed. Both statistical techniques and ensemble forecasting can mitigate such errors. These methods are described in the next section.

4.3. Forecasting Components

There are two fundamental components in the forecasting process, namely, data gathering and processing. Data gathering is performed using a wide range of measuring devices at local, regional, and even the global scales. Data processing transforms measurement data into a forecast for the desired period of time. The tools used for data processing include physical and statistical atmospheric models as well as those describing the relationship between meteorological conditions within the wind plant and plant output (usually referred to as plant output models).

4.3.1. Data Gathering

Due to the wide range of spatial and temporal scales that determine the variations in the wind power generation, it is necessary to use a diverse mix of data sources to achieve the best possible forecast performance. For wind energy forecasting, the most fundamental type of data is the time series of meteorological parameters and power generation from the wind plant itself.

The power generation data can be for the entire plant or for groups of turbines within the plant. The meteorological data typically consist of wind speed and direction and sometimes temperature, pressure, and even humidity data from sensors on one or more meteorological (met) structures that may be towers or masts within the plant boundaries. These data are typically gathered at the hub height of the turbines. The additional details provided from generation data by turbine group and multiple met towers (or masts) can be very beneficial in developing a more accurate relationship between the meteorological conditions and plant output. The availability of this time series data alone is sufficient to make a somewhat skillful very short-term forecast and at least a climatology-level forecast for the short-term and medium range forecast.

In order to achieve a higher level of forecast skill, it is necessary to utilize data from beyond the plant's boundaries. Meteorological observations from in situ sensors deployed and operated by government agencies have been a traditional source of data for wind energy forecasting. These include sensors on surface-based met towers deployed mostly at airports and sensors carried aloft by weather balloons to provide information about the vertical profile of temperature, humidity, winds, and pressure. The main problem with these data is that the spacing between measurements is too large (because of economic constraints) to adequately represent the small or even sometimes medium scale atmospheric features that are responsible for short-term variations in wind energy output. However, these in situ sensor networks do a better job of mapping most of the features that are responsible for the variability over 1- to 2-day ahead time scales. Unfortunately, there are large areas (such as the oceans) where very little in situ data are gathered due to the cost of maintaining such systems in those environments. Therefore, data coverage is not uniform, which sometimes results in poor forecast performance in certain areas such as the west coast of the United States. Forecast performance is often worse there than in the eastern part of the U.S. because a large data sparse region (i.e. the Pacific Ocean) is located in the most frequent upstream direction (to the west) of this area.

The expectation is that remote sensing technology will eventually overcome these limitations of data resolution and coverage. Many types of atmospheric remote sensors have been developed and some have been deployed for operational use. These include Doppler radars, wind profilers (a type of fixed position vertically-pointing Doppler radar), lidars, sodars, and satellite-based radiometers. While all of these technologies have made contributions to the atmospheric forecasting process, each has significant limitations that have impeded their enhancement of atmospheric forecast performance. However, remote sensing technology continues to move forward rapidly and there is still an expectation that the next generation of remote sensors deployed in a few years will have a greater impact on forecast performance.

4.3.2. Data Processing

Data processing is the other major component of the forecast process that is typically performed using mathematical (often called numerical) models to ingest data and generate predictions. There are four fundamental categories of data processing models used in the wind energy forecasting process:

- physical atmospheric,
- statistical atmospheric,

- wind plant output, and
- forecast ensemble models.

There are many types of models within each of these four categories. A particular forecast system may employ one or more types of models.

4.3.3. Physical Atmospheric Models

Physical atmospheric models are based upon the fundamental physical principles of conservation of mass, momentum, and energy as well as the equation of state for air. These models are actually a type of computational fluid dynamic model that has been specially adapted to simulate the atmosphere. They consist of a set of differential equations that are numerically solved on a three-dimensional data grid that has a finite resolution (i.e. the spacing between grid cells). There are many types of models based on the same basic physical principles but differing in how the grids are structured, how the equations are solved numerically, and how sub-grid scale processes are represented (e.g. cloud physics occurring on scales smaller than the grid cells).

Physics-based atmospheric models fall into two broad categories: *prognostic* and *diagnostic*. Prognostic models are formulated to step forward from an initial state and make predictions of the future state of the atmosphere. It is necessary to specify an initial state to start this forecast process. An initial state consists of a value for each model variable at each grid cell that is produced by processing all available raw atmospheric data from the various sensor systems described earlier. There are many three-dimensional prognostic atmospheric models in use. These include the Mesoscale Atmospheric Simulation System model developed by MESO, Inc. and the Weather and Research Forecast model developed by the National Center for Atmospheric Research (NCAR).

Diagnostic models use a similar but often simplified set of physical equations to estimate the values of variables at locations where there are no data from locations where data are available. These models can be used to add more resolution to forecast simulations made with a prognostic model at a lower computational cost than reducing the size of the grid cells of the prognostic models. The simplifying assumptions used to create the diagnostic model will typically limit its performance compared with a prognostic model run at a similar resolution.

4.3.4. Statistical Atmospheric Models

Statistical atmospheric models are simply statistical techniques used for atmospheric applications. They are "atmospheric" models in the sense that atmospheric data are used as input and the output is an atmospheric variable or quantity that is linked to an atmospheric variable (such as wind energy output). Statistical models operate by creating a set of empirical equations from a sample of predictor and predictand data called a "training sample." The form of the equations is dependent on the type of model used. Typically, the equations have numerical coefficients that must be determined.

A statistical modeling procedure uses an optimization scheme to select the coefficient values that yield the "best" relationship between the predictors and the predictand. The meaning of "best" in this context depends upon what optimization criteria are employed. An example of optimization criteria is the lowest mean absolute error or the lowest mean squared error. Once the coefficients are determined from the training sample, the resulting equations can be used to produce a forecast by inserting the current values of the predictors and calculating the value of the predictand. There are an enormous number of statistical models available for this type of application. The most popular ones for atmospheric science applications appear to be multiple linear regression and neural networks.

Statistical models are used in a number of different ways in wind energy forecast systems. In one mode, they can be used to adjust the predictions from the physics-based models. This mode is commonly called Model Output Statistics (MOS). However, they also can be used to make predictions directly from measured data. For example, a time series of power generation data can be used to train a statistical model and make predictions of future generation. In the very short term, statistical models are often used to combine persistence and physical model data.

4.3.5. Wind Plant Output Models

Wind plant output models characterize the relationships between the meteorological variables at the wind plant site and the plant's energy output. They can be formulated as statistical models, physical models, or a hybrid of both types. In a statistical approach, the parameters measured by sensors on the plant met towers or masts typically serve as the predictors and the power generation is the predictand. The simplest plant output model is a relationship between the wind speed measured at a met tower and the total plant output. The result is a plant-scale equivalent to the "power curve" for an individual turbine. This simple model can be extended by developing a separate relationship for ranges of wind directions. This relationship may be useful in accounting for the orientation of the turbine layout relative to the wind direction. For example, the power production may be different when the wind blows *along* versus *across* a row of turbines.

In a physical approach to a wind plant output model, the variations in wind flow within the wind plant, the interaction of the wind with the turbines, and the effect of turbine wakes on other turbines are explicitly modeled. This approach requires detailed information about the layout of turbines in the plant, the properties of the earth's surface (terrain, roughness, etc.) within the plant, and information about the turbine specifications. The physical models have the advantage of being able to produce a power generation forecast without a training sample. They can also explicitly account for changes in the operating structure of a plant, such as turbines out of service, as well as plant-scale variation in wind and its impact on power production. However, these models are typically much more complex than statistical models and require detailed data about the plant that may not be readily available. As with almost all physical models, there are likely to be systematic errors in the forecasts due to simplifying assumptions included in the physics, limited resolution, or the inaccuracies in the input data. In most applications, it is necessary to use a statistical model to adjust the forecasts of a physical plant output model to remove these systematic errors.

The typical use of plant output models in the forecast process is to convert wind speed predictions for one or more met towers or masts to power generation forecasts for the plant. However, it is not necessary to have an explicit wind plant output model in a forecast system since it is possible to go directly from external predictors to a power output forecast through the use of an atmospheric statistical model.

4.3.6. Forecast Ensemble Models

Forecast ensemble models are statistical models that produce an optimal forecast by compositing forecasts from a number of different techniques. The use of forecast ensemble models is based on research demonstrating that a composite of forecasts from an appropriate ensemble is often superior to those produced by any one member of the ensemble. The method is depicted schematically in Figure 27.

The fundamental concept is that if errors in the forecasts produced by the different methods are unbiased and have a low degree of correlation with one another, random errors from individual forecasts will tend to offset each other and result in a composite forecast with lower error than any individual forecast. If all input forecasts are highly correlated, the impact of ensembling will be minimal. This result implies that the underlying forecast methods must produce relatively small, random errors and be different in how they construct relationships between raw observational data and forecasts or the type/amount of input data must be significantly different. This "ensemble effect" is a well-known technique used by meteorologists in short and medium range forecasting. The spread of the ensemble forecasts can characterize forecast uncertainty if differences in the ensemble members are the primary factors that introduce the uncertainty.

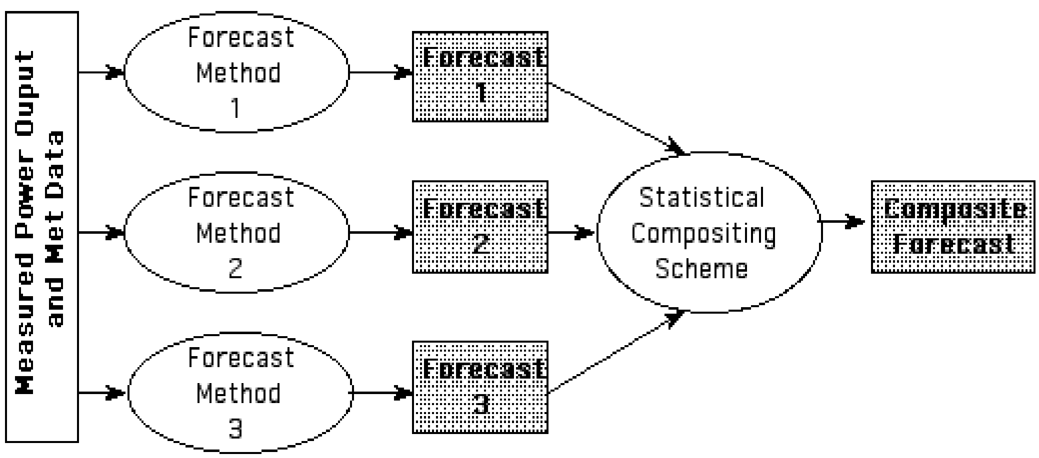

Figure 27: A schematic depiction of the ensemble technique. This arrangement applies to very short-term, short-term and next-day forecasts.

There are two fundamental strategies that can be used to generate an ensemble of forecasts. One strategy is to use the same forecast model and vary the input data within their range of uncertainty. The other is to use the same input data and to employ different forecast models or different configurations of the same model. The relative value of either strategy depends upon the sources of uncertainty in the forecast procedure including sensitivity of the models to initial conditions. In practice, the sources of uncertainty vary with location, season, and other factors. Thus, the choice of the ensemble components and the number of members must be determined from experience and experimentation.

This brief overview of forecast components indicates that there is a large and diverse pool of tools that can be used to generate wind energy forecasts. The challenge is to select the optimal set of tools and configurations for a specific forecast application. There is not one accepted set of specific forecasting methodologies and tools. However, a quality system should combine the strengths of physical, statistical, and ensemble techniques.

4.4. FORECAST EVALUATION

Although it may seem straightforward, there are a number of complex issues associated with the evaluation of wind energy forecasts. The most significant issue is which parameter(s) should be used as the metric(s) for forecast performance. The choice of metrics can have a significant impact on characterizing forecast performance.

A wide variety of metrics is in common use and no doubt many more could be devised. One fundamental distinction is *absolute* versus *relative* performance. An absolute metric provides a measure of the performance of a forecast system that is independent of other forecasts. Examples of absolute performance metrics are root mean square error (RMSE), mean absolute error (MAE) and median error (MDE). A relative performance metric is a measure of the performance of a forecast method relative to another method. Typically the other method is a reference forecast, such as persistence or climatology. A popular relative metric is the persistence-based skill score, which is the percentage reduction in the MAE of a persistence forecast that is achieved by a particular forecast method.

Another distinction in selecting parameters is the sensitivity to different portions of the error frequency distribution. Some parameters are much more sensitive to outliers, i.e. forecasts with anomalously large or small errors. For example, the RMSE is quite sensitive to outliers while the MDE is not. The sensitivity of the MAE parameter is between these two extremes.

In addition to the issue of different metrics providing a different picture of performance, there is also the issue that a forecast system can be tuned to produce better performance for a specific metric while possibly degrading the performance for other metrics. This tuning can be done by formulating a statistical technique to minimize the value of a specified optimization or cost function. Such an approach might be used to customize the forecast system to meet the needs of a specific application. However, the underlying issue is whether the evaluation metric is really linked to the user cost function. If it is, then it probably makes sense to optimize the forecast system for that metric.

An example of the wide range of perspectives provided by different forecast metrics is provided in Table 1. This table lists the values for a suite of forecast metrics for the performance of 1- to 48-hour forecasts of power output and wind speed during the month of October 2001 for a wind plant in the San Gorgonio Pass of California. Different pictures of the absolute and relative forecast performance emerge depending on which metrics are considered. For example, MAE as percentage of the rated capacity is 14.7% for the first 24-hour period. However, the RMSE is 20.8% and the MDE is 10.3%.

Table 1: Power output and wind speed verification statistics for a wind plant in the San Gorgonio Pass of Southern California.

Verification Statistic	Power Output					
	Month:	Oct-01			% Capacity	31.6%
	Hours 1-24			Hours 25-48		
	eWind	Persistence	Climatology	**eWind**	Persistence	Climatology
MAE %Rated	14.7%	22.3%	28.4%	16.0%	32.4%	28.4%
MAE %Mean	46.4%	70.5%	89.7%	50.5%	102.6%	88.5%
MAE % Std Dev	47.7%	72.4%	92.2%	51.9%	105.5%	90.9%
RMSE-% Rated	20.8%	31.0%	31.9%	22.9%	42.1%	31.6%
Median % Rated	10.3%	16.7%	28.4%	10.9%	27.3%	28.3%
Correlation	0.75	0.47	0.11	0.63	0.00	0.11
Skill-Pers	34.1%	0.0%	-27.3%	50.8%	0.0%	13.8%
Skill-Climate	48.3%	21.5%	0.0%	43.0%	-16.0%	0.0%
Verification Statistic	**Wind Speed - Met Tower**					
	Month:	Oct-01			Avg Spd (m/s)	8.83
	Hours 1-24			Hours 25-48		
	eWind	Persistence	Climatology	**eWind**	Persistence	Climatology
MAE	2.52	3.87	3.86	2.70	5.59	3.86
MAE %Mean	28.5%	43.8%	43.7%	30.5%	63.3%	43.7%
MAE % Std Dev	55.8%	85.8%	86.6%	59.8%	123.9%	85.5%
RMSE	3.13	4.90	4.62	3.58	6.91	4.59
Median	2.10	3.10	3.82	2.00	4.70	3.80
Correlation	0.72	0.51	0.04	0.63	-0.07	0.04
Skill-Pers	35.0%	0.0%	0.4%	51.8%	0.0%	31.0%
Skill-Climate	34.8%	-0.4%	0.0%	30.1%	-44.9%	0.0%

4.5. STATE-OF-THE-ART FORECASTING

The current state-of-the-art forecasting techniques exhibit considerable skill in both very short-term and short-term forecasting. Very short-term (0-6 hrs) hourly forecasts typically outperform a persistence forecast by 10% to 30%. Short-term (1- to 2-day) hourly forecasts usually outperform persistence and climatology by 30% to 50%. At present, medium range (3-10 day) forecasts of the hourly wind energy production typically do not outperform climatology and hence have limited usefulness. However, medium range forecasts of the *average* energy production over a day or half-day usually do outperform climatology out to 6 or 7 days and hence provide some value to the user who can effectively employ that type of information.

It should be noted that forecast performance can vary substantially (5% or more of installed capacity) as a function of location, season, and weather regime. Much of this variability is related to the predictability of specific weather regimes. Some weather regimes are inherently more sensitive to small variations in the initial conditions at the start of the forecast. This sensitivity means that slight differences in the current conditions can give rise to large differences in the future conditions. Forecast performance in these cases is normally much worse than for regimes with less sensitivity.

4.6. GENERAL OVERVIEW OF FORECASTING APPLICATIONS

Several factors influence the accuracy of wind power prediction. The factors include

- accuracy of wind speed prediction,
- dampening and amplification of wind speed prediction error through the nonlinear power curve, and
- wind plant efficiency, including turbine availability and performance [1].

The following key results regarding general wind and power forecast performance were obtained as part of the Alberta Energy System Operator's (AESO) wind power forecasting pilot project conducted from June 2007-April 2008 [1]. During the project, wind and power forecast data were provided for forecast hours 1 through 48 by three independent wind forecasting firms. In the report, they are referred to as Forecaster A, B, and C. The analysis compared the predicted data to measured meteorological power data for seven existing Alberta wind power facilities (labeled Existing Facilities), and measured meteorological data and derived power data for five future Alberta wind power facilities (labeled Future Facilities).

The analysis was carried out by examining available data from each of the forecasts using seven categories as follows: (1) All Facilities (AF), (2) Existing Facilities (EF), (3) Future Facilities (FF), and four geographic regions, (4) South West (SW), (5) South Central (SC), (6) South East (SE), and (7) Central (CE).

The overall accuracy of wind speed prediction for the three forecasters was 1.4 to 3.5 m/s for annualized MAE and 1.9 to 4.7 m/s for annualized RMSE. The general accuracy of power prediction is shown in Figure 28 and Figure 29. The error measures shown are normalized by the rated wind power capacity. Figure 28 shows the annual normalized RMSE at different forecast horizons and regions for the three forecasters while Figure 29 presents the annual normalized MAE results.

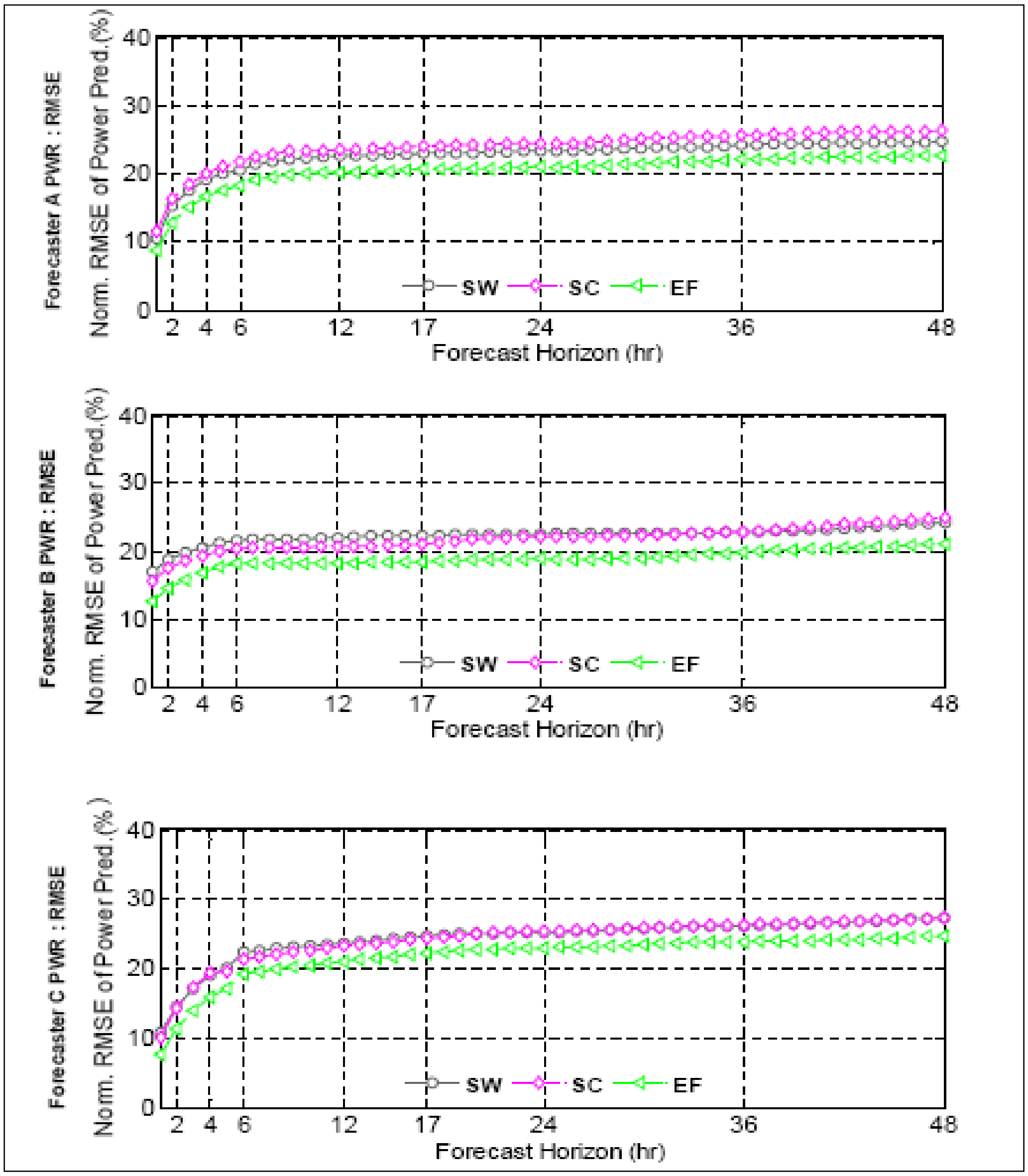

Figure 28: Annual Normalized Root Mean Square Error (RMSE %) of power predictions in South West (SW), South Central (SC), and existing facilities (EF) by three forecasters A, B and C as a function of forecast horizons. Note that the actual errors are normalized by the rated capacity (RC) of the region of power aggregation.

The normalized annual RMSE of the power prediction exhibits a general increase with time, particularly for the first six hours of the forecast horizon (Figure 28). Similar trends are evident for the normalized annual MAE (Figure 29). The normalized RMSE is in the range of 6% to 20% for the first six forecast horizons and 20% to 30% for the remaining forecast times.

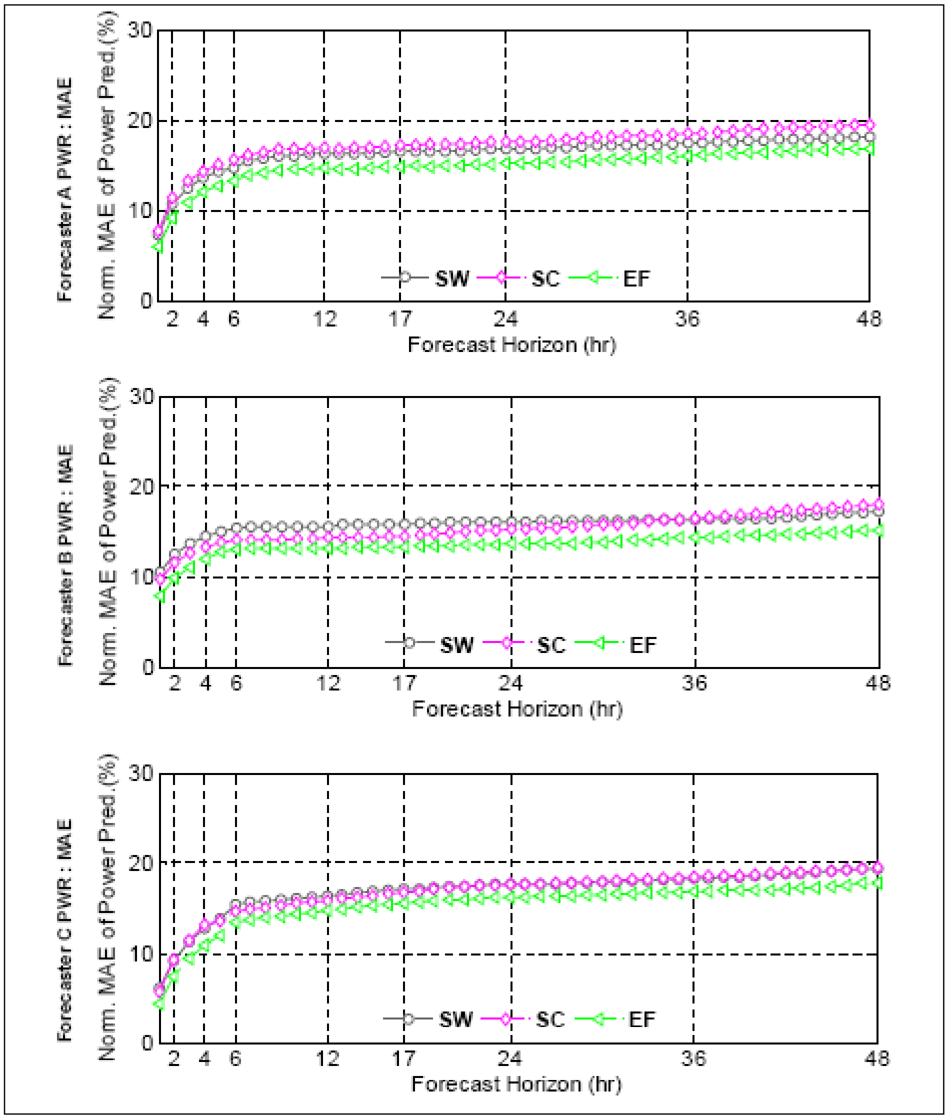

Figure 29: Annual Normalized Mean Absolute Error (MAE %) of power predictions in South West (SW), South Central (SC), and existing facilities (EF) by three forecasters A, B and C as a function of forecast horizons. Note that the MAE is normalized by the rated capacity of the region of aggregation.

It is very important to note that forecast performance varies significantly according to the size and aggregation diversity of wind plants. In the Alberta wind forecasting pilot project, the RMSE for regional day-ahead forecasts was 15-20% lower than for the individual plants, and the RMSE for system-wide day-ahead forecasts was 40-45% lower than for the individual plants (Figure 30).

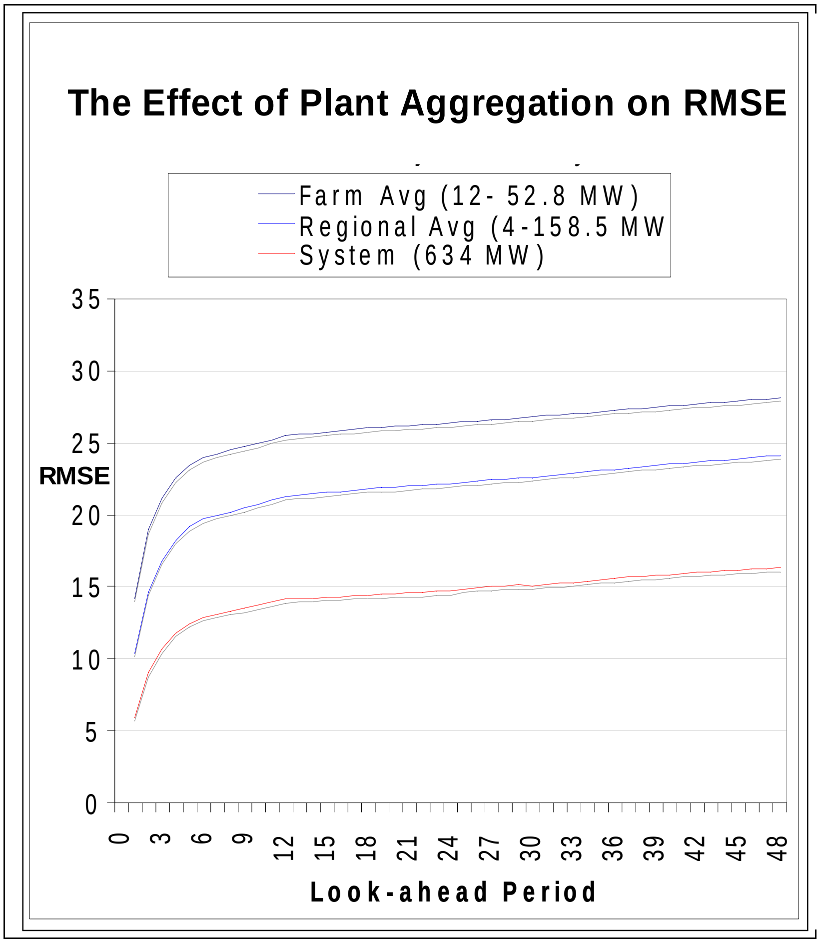

Figure 30: A time series showing the effects of plant aggregation on the RMSE forecast performance over a 48-hour forecasting period.

The impact of plant aggregation often results in a misconception that European forecast providers are much better than their North American counterparts. In reality, forecasts for European sites typically cover very large and diverse systems with low capacity factors. In contrast, North American forecasts are usually generated for smaller, much less diverse systems with higher capacity factors, and often for individual wind plants. For this reason, European forecasts with RMSE of 5% typically seem low by U.S. standards. In head-to-head studies for similar forecast regions, the performance statistics for North American and European forecast providers are very similar. The main point of this observation is that forecasting for larger resources in more uniform environments is easier than individual plants in diverse environments.

Figure 31 provides an estimate of the typical range of MAE (expressed as a percentage of the installed capacity) as a function of the forecast time horizon (look-ahead period) for the 1- to 12-hour forecast period. The MAE of very short-term forecasts is typically in the range of 5% to 15% and the errors increase rapidly (about 1.5% of installed capacity per hour) with an increase in the forecast time horizon. After the very short-term period, the error growth rate decreases to about 0.1% of installed capacity per forecast hour. As a result, the mean absolute forecast errors remain in the 13% to 21% range for 1 to 2 days ahead and rise to the 20% to 25% range that is typical of a climatological forecast after about 3 days (not shown).

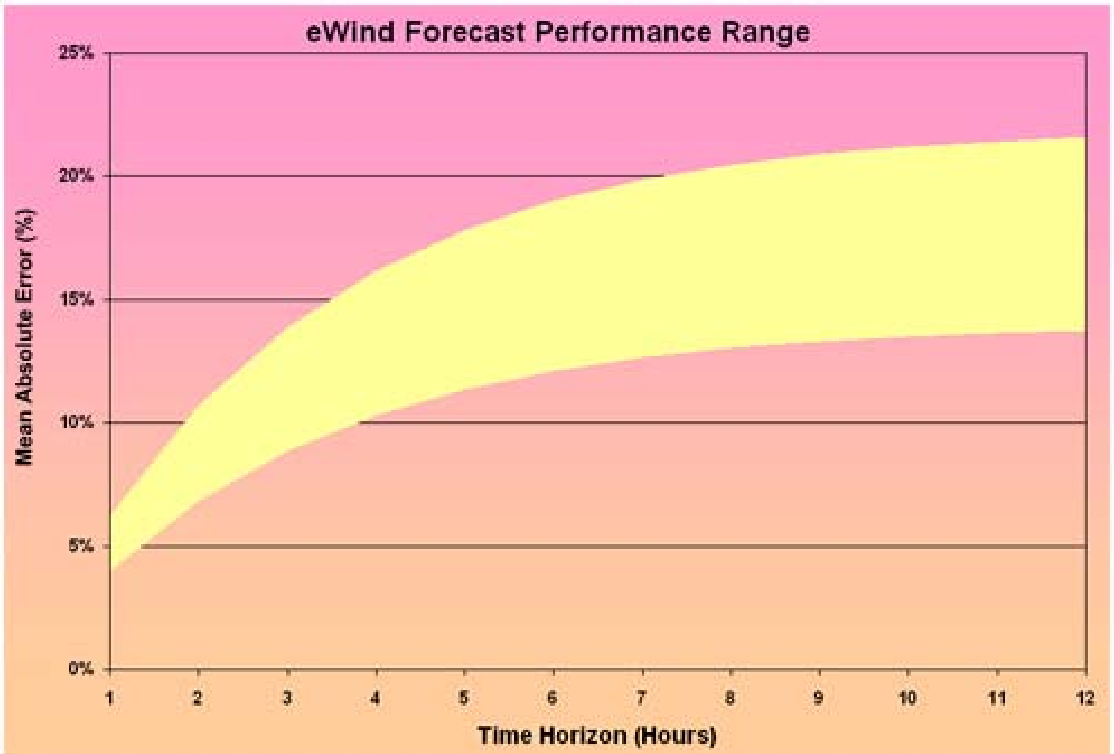

Figure 31: Typical range of current wind energy forecast performance as a function of forecast time horizon. Forecast performance is expressed as a mean absolute error as a percentage of a wind plant's installed capacity.

4.6.1. State-of-the-art: "Next-Hour" Forecasting

There are a wide variety of methods that have been or are being used to produce very short-term ("next-hour") wind energy generation forecasts. Figure 32 provides a schematic depiction with many components of the very short-term forecasting process and the ways they can be linked together to produce forecasts.

The simplest type of very short-term forecasts uses a time series of power generation data from the wind plant and a statistical procedure, such as multiple linear regressions or a neural network, to generate predictions of the future power output. These are often referred to as "persistence" or "autoregressive" models since their only source of information is the history of the plant power output. These models can be enhanced by using a time series of meteorological data from the towers or masts within the wind plant.

The addition of meteorological data from the met towers within the wind plant can be handled in two ways. In the first approach, the meteorological data are added to the pool of predictors and the power generation is predicted directly from the statistical model. In the second approach, the meteorological data are used to forecast the meteorological inputs to a separate wind plant output model. The wind plant output model then uses these inputs to create an energy generation prediction. The second approach may have an advantage if there is more than one met tower within the plant because it may be possible to capture some of the variability in meteorological conditions within the plant and hence produce a better energy generation forecast.

Sophisticated statistical models, such as neural networks, may be able to find more subtle and complex relationships in the time series data and thereby generate better forecasts than simpler models such as linear regression. However, due to the fact that sophisticated statistical models usually have more adjustable parameters, they are prone to “over-fitting” problems if the training sample is not sufficiently large. Ultimately, all of these methods are limited by the fact that the input information is derived only from a history of conditions at the wind plant.

The next level of sophistication is to use multiple external data sources. The additional data sources can be used as input to the same types of statistical models used in the autoregressive approach. However, the number of predictors is larger. The additional sources could include data from nearby met towers or remote sensing systems. Another possibility is to use forecast output from a regional scale physical model. These models provide information about the larger scale trends in meteorological parameters but do not incorporate local area data and typically do not have the ability to resolve the local atmospheric and surface features that are critical to very short-term forecasting. However, some large-scale trends are well correlated with a local-scale response and hence the regional model data can, at times, add skill to the very short-term forecasts.

An approach that has yet to be thoroughly tested for very short-term wind power forecasting is to use a physical model with a high resolution grid to produce very short-term forecast simulations for the local area surrounding the wind plant. In this case, all of the available local-area data are assimilated into the initial state used to start the physical model simulation. This type of procedure has potential to simulate the atmospheric features that cause the wind variations in the vicinity of the wind plant. The output data from this local-area simulation is then fed into a MOS procedure. The MOS algorithm selects the best performing predictors from the large volume of physical model data and generates predictions of the wind speed and direction at the wind plant met towers. These predictions are then fed into a wind plant power output model to generate power output predictions. This method is a local-scale analog of the regional scale forecast procedures that have been used quite successfully for 1- to 2-day forecasting.

Another tool that can be used in the very short-term prediction process is a forecast ensemble model. As noted earlier, this is a statistical model that generates a composite forecast from a series of input forecasts generated by different methods.

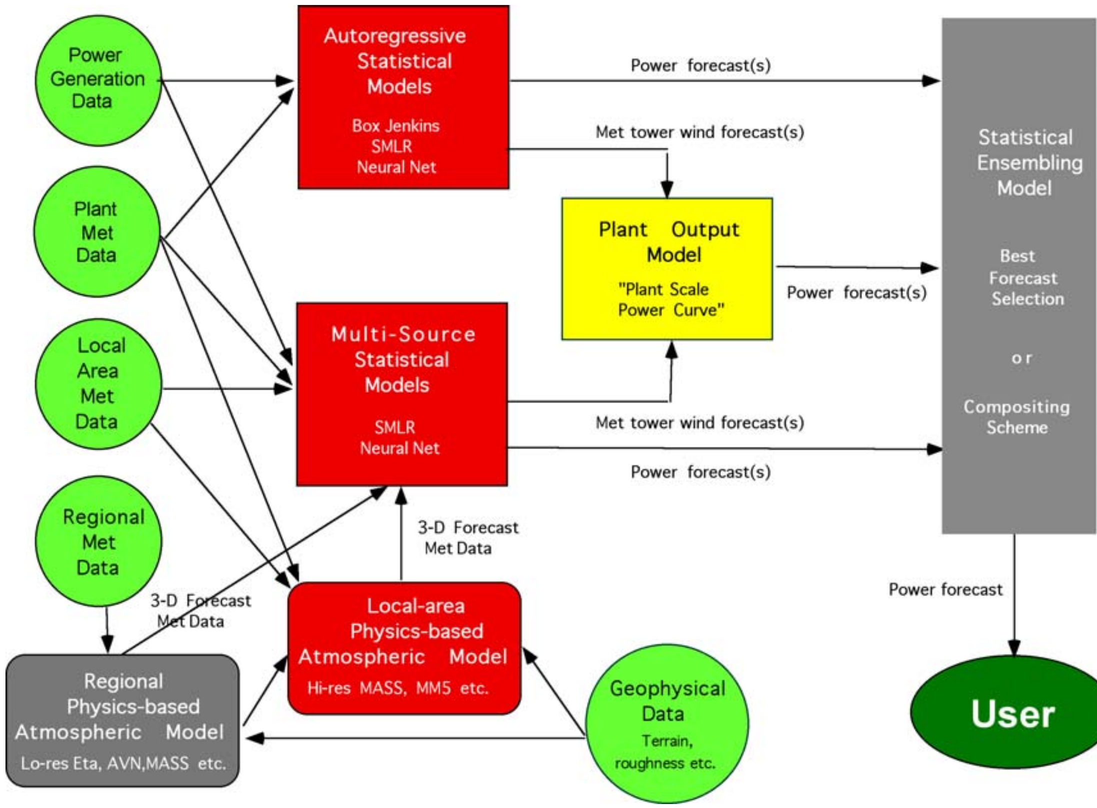

Figure 32: A schematic depiction of the interrelationship of the components of a very short-term forecast system.

After examining various methods that could be used in the very short-term forecast process, the obvious questions are (1) what is the typical level of performance that can be expected from very short-term forecast methods and (2) what is the variation in performance due to differences in methods, locations, seasons, and weather regimes? There have been a few controlled studies (such as the Alberta Project) [1] of forecast performance that included evaluation of very short-term wind energy forecast methods over a diverse mix of atmospheric conditions. However, most of the performance evaluations have been done by forecast providers or researchers and not by independent third parties. Therefore, it is still difficult to draw broad conclusions from the evaluations because the methods, locations, and times are different.

The performance of several very short-term forecasts for a wind plant in the San Gorgonio Pass of California is presented in Figure 33. This performance is somewhat typical for this site and season but experience indicates that there can be large variations in performance from site to site and season to season. In this example, all methods yield a small improvement over persistence during the first couple of hours of the forecast period. The methods that use regional physical model data become significantly better than persistence after about 4 hours.

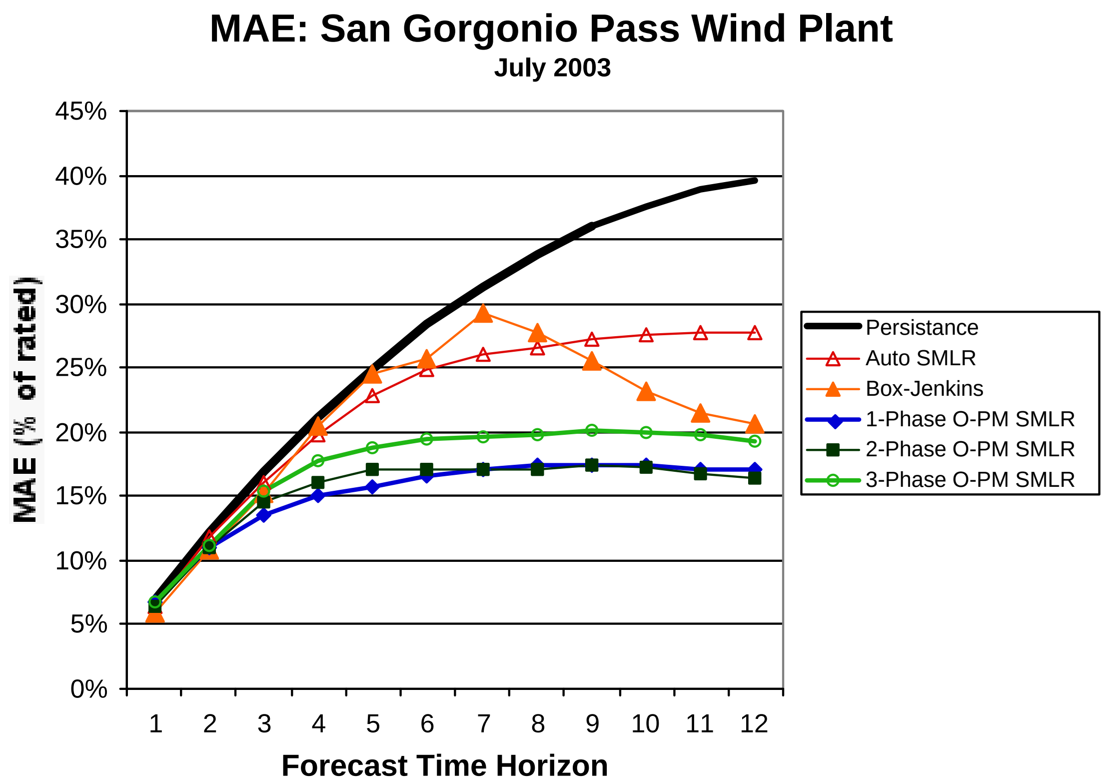

Figure 33: The mean absolute error by forecast hour during July 2003 for five very short-term forecast methods and a simple persistence benchmark forecast for a wind plant in San Gorgonio Pass. The "SMLR" acronym refers to a screening multiple linear regression procedure. "O-PM" refers to the use of both observational and regional physical model data as input to the statistical procedures.

4.6.2. State-of-the-art: "Day-Ahead" Forecasting

Short-term forecast methods use essentially the same tools as very short-term forecast techniques. However, there are two important differences: (1) the importance of real-time data from the wind plant and its immediate environment is significantly reduced; and (2) regional and sub-regional simulations with a physics-based atmospheric model play a much more significant role in the forecast process.

Almost all short-term forecast procedures begin with the grid point output from a regional-scale physics-based atmospheric model. Typically, these models are executed at a national forecast center, such as the National Centers for Environmental Prediction operated by the U.S. National Weather Service, ingest data from a wide variety of sources over a large area, and produce forecasts of regional-scale weather systems for a several day period. However, these models do not resolve the physical processes occurring in the local or mesoscale areas around individual wind plants. (The mesoscale scale is between the large-scale weather systems and the local scale approximately 5 - 100 km). The three-dimensional output data from the regional-scale forecast simulations is the basic input into most short-term wind energy forecast systems.

The forecast methods differ substantially from this point. Some forecast procedures attempt to go directly from the regional-scale forecast data to the local scale through the use of either diagnostic physical models, statistical models, or a combination of both. The Prediktor system developed by the Risoe National Laboratory in Denmark uses this approach. The main drawback of Prediktor is that it misses the processes occurring at the sub-regional or mesoscale.

An alternate approach is to execute sub-regional scale simulations with a physics-based model to account for the mesoscale processes. This is the approach used by AWS Truewind (AWST) in their eWind system and a couple of other North American forecast providers. A schematic depiction of the eWind system is presented in Figure 34. This approach has had considerable success in forecasting the variations in winds attributable to mesoscale processes but it has a much higher computational cost than the regional-to-local forecast schemes. Both the regional-to-local and mesoscale simulation approaches typically employ statistical MOS type models to predict the wind speed and direction at the wind plant's met towers. The predictors are based on either the output from the mesoscale simulations (mesoscale approach) or from the regional or diagnostic physical models (regional-to-local approach).

It is possible to predict the energy generation directly from physical model output through the MOS process. However, most forecast systems are configured to produce wind predictions for the met tower sites from the MOS and then use these predictions to create the energy generation forecasts from a wind plant output model. The wind plant output model can be either physical or statistical. The Prediktor system has the option to use either a physical model in combination with a second MOS procedure to remove any systematic errors or a purely statistical scheme. The eWind system uses a statistical wind plant output model.

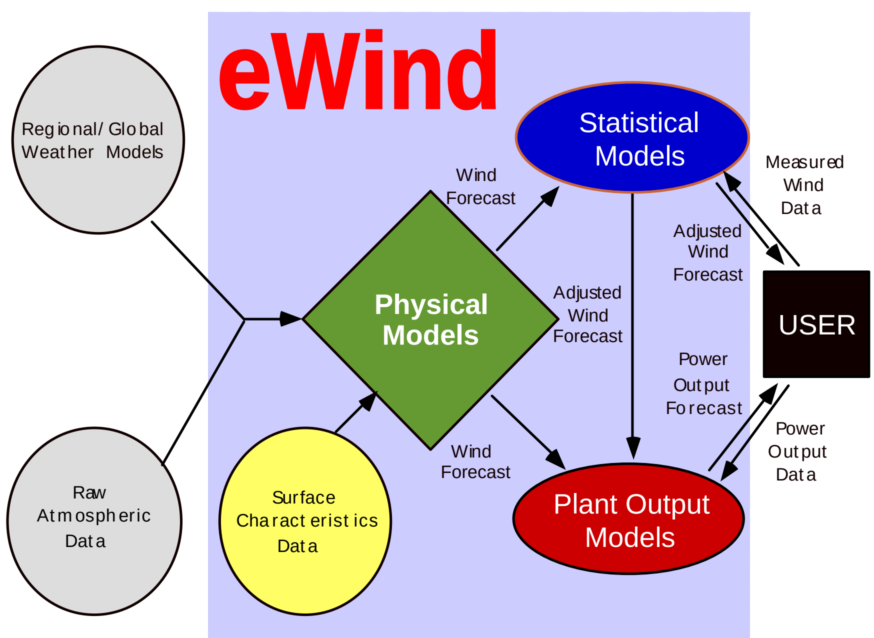

Figure 34: A schematic depiction of the major components of the eWind short-term wind power forecast system

As in the case of very short-term forecast performance, a quantitative assessment of the state of the art in short-term wind energy generation forecast performance is difficult to obtain because most evaluations are done by individual forecast providers and researchers. The methods, locations, and time periods used in these forecast performance evaluations vary substantially. Therefore, it is difficult to determine the causes of performance differences.

There are two "third party" investigations that included the evaluation of short-term day-ahead forecast performance. One project was funded under the Alberta Electric System Operator wind power forecasting pilot project [1]. The other project was funded by the California Energy Commission (CEC) and managed by the Electric Power Research Institute (EPRI) [2].

The objective of the EPRI-funded project was to assess the state-of-the-art in wind energy forecasting for California. Two forecast providers participated in the project. Each used their own forecast system to produce 1- to 48-hour wind energy forecasts for two wind projects in California during a 1-year period from September 2001 to October 2002. One forecast provider was Risoe National Laboratory from Denmark; they used their Prediktor system. The other provider was AWST; they employed the eWind forecast system. One of the participating wind projects was the 66 MW Mountain View wind plant in San Gorgonio Pass, that is located just to the east of the Los Angeles Basin in southern California. The other project was a 90 MW plant located in the Altamont Pass, that is located just to the east of the San Francisco Bay Area in northern California.

A summary of the forecast performance results from this project is presented in Table 2. The performance statistics in this table are for all forecast hours (i.e. 1-48) and for the entire 12–month evaluation period. The MAE as a percentage of installed capacity is in the 14% to 21% range. This range is typical for 1- to 2-day forecast performance. The percentage MAE of both forecast systems was lower for the Altamont Pass plant. However, the Risoe system showed a greater difference in forecast performance between the two plants than the AWST system.

Figure 35 and Figure 36 depict the MAE of the AWST persistence and climatology forecasts by forecast hour for each of the plants. It can be seen that persistence forecasts are best in the first few hours for both plants because no real-time information from the plant or its immediate environment was available for use in the forecast process. After the initial period, the AWST forecast method outperforms the persistence and climatology forecasts by a substantial margin. This result is typical of forecast performance at most sites.

These figures also provide an indication of the forecast error growth rate as a function of forecast look-ahead period. The error growth for the San Gorgonio Pass wind plant (2% of installed capacity per 24 hours) is approximately twice as large as the rate for the Altamont Pass plant. This difference is most likely attributable to the physical properties of the site and its immediate environment as well as differences in weather regimes affecting the two areas over the course of the year.

This study served to document the expected level of performance of short-term wind energy forecast systems. It indicated that state-of-the-art forecasts systems have considerable skill over climatology and persistence forecasts for 1- to 2-day periods. It also demonstrated that 1- to 2-day forecast performance can vary substantially by location, season, and attributes of the forecast system used to generate the predictions.

Table 2: A summary of the forecast performance results from the EPRI-CEC project.

Parameter	Risoe	TrueWind
Mountain View (66 MW rated)		
Mean Error (kWh)	2,888	628
MAE(kWh)	14,305	11,834
MAE(% of rated)	21.7%	17.9%
Skill vs. Persistence (%)	9.5%	32.6%
Skill vs. Climatology (%)	19.8%	33.7%
Altamont (90 MW rated)		
Mean Error (kWh)	702	631
MAE(kWh)	12,985	12,438
MAE(% of rated)	14.4%	13.8%
Skill vs. Persistence (%)	21.6%	30.8%
Skill vs. Climatology (%)	26.2%	29.6%

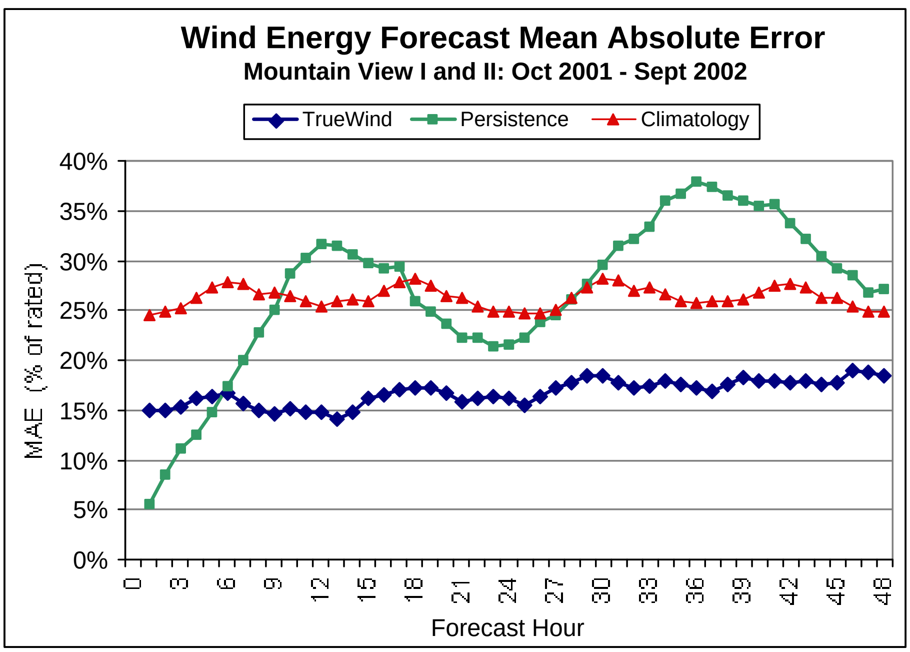

Figure 35: The mean absolute error by forecast hour for 12 months of AWST (eWind), persistence, and climatology energy generation forecasts for a wind plant in San Gorgonio Pass

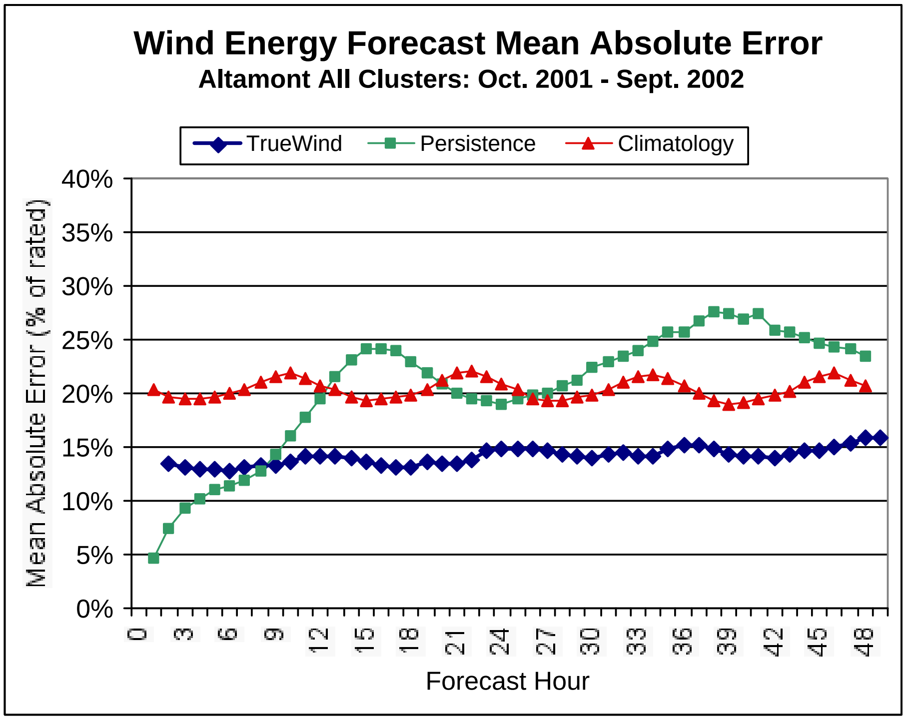

Figure 36: The mean absolute error by forecast hour for 12 months of AWS Truewind (eWind), persistence, and climatology energy generation forecasts for a wind plant in Altamont Pass.

4.6.3. Early Warning Ramp Forecasting System

As the amount of wind generation increases on grid systems, the occurrence of large and rapid changes in power production (ramps) is becoming a significant grid management issue. A good operational ramp definition is *a change in power output that has a high enough amplitude over a short enough period of time to cause short-term grid management issues*. The operators must ensure there is always sufficient conventional generation and/or responsive load ramping capability to compensate for a downward ramp in wind power output. Thus, from a grid management perspective, accurate forecasting of ramps may be more important than minimizing the overall MAE or RMSE of the typical power production forecasts. Upward ramps can be more easily managed by curtailment if necessary; therefore downward ramps are more important. For downward ramps, the wind power must be replaced as it is lost to eliminate the need for more drastic measures, such as load shedding [1].

The forecast of wind ramps is similar to lightning in that both must warn system operators so preparations can be made before the event occurs

Forecasting techniques that are optimized for the typical wind conditions do not do well in forecasting rapid changes in winds that cause power ramps. Since ramps have such a great impact on power production forecasts, ramp forecasting needs to be considered as a separate forecasting problem with a methodology and system put in place that is designed specifically to forecast and alert operators of the likelihood of events. In addition to forecasts of the likelihood of a ramp event, AWST experience suggests that grid operators want the meteorological cause of the event (front, thunderstorm line, etc.) so they can track it in real time.

Ramps in wind power production are caused by several different types of meteorological processes. Each type of ramp has a unique set of characteristics and forecast issues. The data and type of forecast method required to optimally predict each type of ramp event are dependent on the meteorological process that caused them.

The cause of ramps can be divided into two categories:

- Scale of the phenomena: Large scale processes that cause ramps include phenomena such as cold fronts and upper tropospheric shortwave troughs of low pressure. Smaller scale processes include phenomena such as outflow boundaries from thunderstorms, changes in wind direction across a mountain range, and formation or erosion of shallow pools of cold air.
- Processes primarily acting in the horizontal or vertical: Horizontal processes, such as those associated with fronts, tend to move from a location some distance away from the plant into the plant area. These events can be identified and tracked with observing tools, such as meteorological radars and satellite images. Vertical processes that cause ramps include phenomena such as the formation of a shallow pool of cold air or the vertical mixing of the atmosphere. These processes tend to form in place and are therefore more difficult to track and forecast. The vertical profile of wind and temperature is the most useful parameter to monitor for these events.

A ramp forecasting system should alert operators about the occurrence of a ramp at the earliest possible time. For days 3 though 7, only daily probabilities should be given in terms of the likelihood of a ramp being greater than, about the same as, or less than the climatological norm for such an event. The day-head forecast should be more precise giving probabilities of ramp occurrence for each hourly time period. The forecasts needed for the first 24 hours should include the probability, amplitude (magnitude), duration, type, and cause of the event. The 24-hour forecast should also include the meteorological feature causing the ramp in order to aid operators in tracking the event in real time. Finally, the alert system should include hourly ramp forecast updates for situations when a ramp event has been forecasted within 24 hours.

The ramp forecasting system needs to be different from the forecasting system designed to reduce typical errors by minimizing RMSE or other standard metrics. Inevitable phase errors in features causing ramps (such as cold fronts) can produce large errors especially when considering squared quantities such as RMSE. For this reason, a forecast system that minimizes RMSE tends to smooth out power ramps over many hours.

Ramp forecasting systems should be designed to estimate the probability of a ramp occurring in any given hour, the actual amplitude (or a probability distribution of amplitudes), and the uncertainty in timing/duration of the ramp. Inputs to such a system would include amplitude and timing of actual ramps forecasted by physics-based (numerical weather prediction or *NWP*) models, a statistical forecast method, or an optimized ensemble forecast.

In order to forecast ramps, it is necessary to develop ramp climatologies for a region. Using ramp climatologies, the forecast provider then develops algorithms to identify regional or local parameters from available met towers or remote sensing system data that have a statistically significant ability to discriminate between ramp and no-ramp cases, especially during the first 6 hours of a forecast. These data are then analyzed in order to identify the sensitivity of site specific ramp forecasts to making additional measurements at different locations. In order to forecast the needed parameters, a provider could run a real time, regionally-customized rapid-update-cycle NWP-based tool designed for large ramp forecasting applications. NWP models configured with a very high-resolution grid (1-km grid cells) for such applications are initialized every hour and used to make 12-hour forecasts from these initial conditions. The initial state is created by updating the previous 1-hour forecast with the latest wind plant met data as well as other regional met tower and remotely sensed measurements.

One final consideration relates to ramp forecasts for aggregates of wind plants. Ramps will tend to be slower in terms of percent change in capacity for aggregates that include a large number of wind plants distributed over a wide area at locations with varied wind regimes. These types of aggregates tend to include many wind plants that have power time series that are relatively uncorrelated. For this reason, strong upward ramps at some wind plants tend to be offset by downward ramps or at least washed out by weaker ramps or steady production at other plants. However, wind plants are often built in a few relatively small regions to take advantage of the highest climatological wind speeds. This strategy tends to produce aggregates in which the individual plants are highly correlated and are prone to more frequent, large ramps.

4.6.4. Severe Weather Warning System

In addition to the routine and ramp forecast systems, there is a need to provide operators with information regarding the broader weather situation, especially with respect to extreme meteorological events that may have a serious impact on wind plant operations. Information and forecasts of severe weather events such as high winds, thunderstorms, hail, tornadoes, sleet, freezing rain, and heavy snow should be provided. In addition, information on the feature causing the event should be provided so operators can track and verify the actual occurrence in real time.

When there is a potential for severe weather within 24 hours, the severe weather warning system should deliver hourly updates to operators. For the day-ahead, only the general potential of high, moderate, or low risk would be provided for each category of severe weather.

4.6.5. Forecasting for Offshore Wind Plants

Offshore meteorology and its impact on power fluctuations and wind forecasting still requires significant research for offshore power plants. There are two considerations that distinguish forecasting for onshore versus offshore wind plant facilities. The first is forecasting the wind itself and the second is forecasting the waves that can impact various operations associated with the offshore wind plant.

Looking first at wind, there are fundamental differences between conditions over land and water due to the influence of the surface on the flow. The most significant one is the roughness of the sea that is much lower than land areas but varies due to the changing sea state conditions (i.e. waves) [3]. In general, the atmosphere is more often characterized by neutral or stable conditions over water given that the underlying surface does not heat or cool as rapidly.

Offshore near the coastline, there are differences and complexity due to abrupt changes in surface roughness and the surface temperature that lead to important transition effects for the wind blowing from land to water. Other factors such as the shape of the coastline, islands locations, and currents/tides also affect wind speeds over water [4].

If the forecast model is formulated correctly to handle ocean roughness and stability differences, errors in wind forecasting would likely be lower over water than land when the sites are five miles or more offshore. The error could be larger near the coastline because of the complexities associated with the coastal factors similar to that of a complex terrain region over land.

In addition to the complexities of the coastal regions, there are fewer measurements of current wind conditions, surface temperatures, and other meteorological variables over water to initialize forecast models. There is also a problem of observing wind at turbine hub height. Most weather buoys make wind measurements at only three to five meters above the ocean surface whereas modern wind turbine hub heights are 80 meters or more. Tall met towers are needed to collect wind, temperature, and other meteorological data and better characterize the local offshore environment as well as validate forecast models.

Marine operations associated with construction and maintenance of offshore wind plants require accurate wave forecasts. For wind plants located in shallow coastal areas, the wave forecast model needs to consider local bathymetric features and include all shallow water dynamics. Deep water ocean wave forecast models would not meet the shallow wave requirements. When forecasting for offshore sites, providers should include models that accurately represent the marine boundary layer, momentum exchanges between the air-water interface, and deep as well as shallow ocean waves.

4.7. POTENTIAL FOR IMPROVED FORECAST PERFORMANCE

Although both very short-term and short-term forecasts made with state-of-the-art forecasting systems currently exhibit considerable skill relative to benchmark persistence and climatology forecasts, there are still many opportunities for forecast improvement. There is also an opportunity to extend the range of hourly energy forecasts that have skill over climatology to at least 72 hours. This section gives an overview of (1) how forecast improvement at each of the three major time scales is likely to be achieved and (2) provides an estimate of the amount of improvement that may be expected over the next 10 to 15 years.

4.7.1. Medium Range

Current hourly wind forecasts and the associated energy generation forecasts beyond approximately 3 days have very little skill over climatology, although daily average forecasts of wind speed and energy generation do have some skill over climatology out to 6 or 7 days. As forecast technology improves over the next 10 to 15 years, it is likely that forecasts beyond 3 days will become useful to the wind energy community.

The charts in Figure 37 and Figure 38 provide a perspective on the long-term trend in forecast improvement and what it may mean for future performance [5]. Figure 37 depicts the yearly average skill score (S1) for forecasts of the mean sea level pressure gradients made by several different forecast models run by the U.S. National Weather Service during approximately the last 50 years of the 20th century. The 36-hour S1 scores in Figure 37 for mean sea level pressure gradients constitute one of the longest continuous records of forecast verification anywhere. Therefore, it is a metric that can be used to define the trend in forecast performance over a long period of time and provide some guidance about future performance. It should be noted that S1 scores measure the skill in forecasting large-scale features associated with regional and continental scale weather systems and not the smaller scale pressure gradients responsible for variations in local winds around plants.

The S1 scores that are depicted in Figure 37 clearly indicate significant progress in the ability to forecast large-scale sea level pressure gradients. The first numerical weather prediction models went into operational use in the middle 1950s; the S1 scores began to steadily improve after that time. The forecast performance improvements after the 1960s have been attributed to: (1) more observed data; (2) better methods for incorporating data into models; and (3) model enhancements. The improvement was persistent if not dramatic from the early 1960s through the end of the 1990s. Thus, by the mid 1990s, the *72-hour* forecast of the mean sea level pressure gradient was typically about as good as the *36-hour* forecast in 1980.

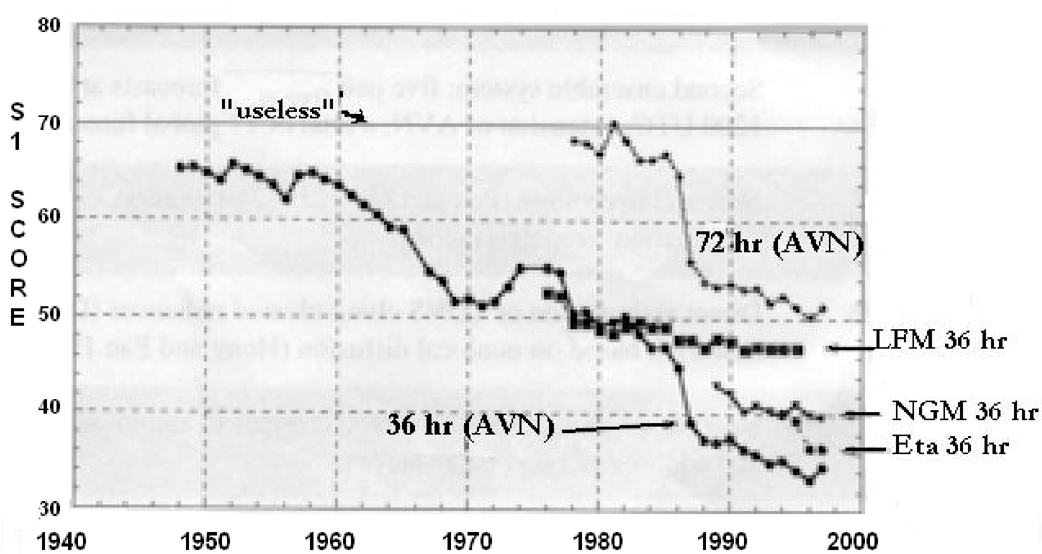

Figure 37: A depiction of the yearly average S1 scores for forecasts of the mean sea level pressure gradient over North America produced by several different U. S. National Weather Service models (AVN, LFM, NGM and Eta) during the second half of the 20th century from [5]. The S1 score is a measure of the relative error of the gradient of a parameter over a specified region. The mean sea level pressure gradient is strongly correlated with the near surface wind speed at most locations within several hundred meters of sea level. A lower score indicates a more accurate forecast. A S1 score of about 70 is generally considered useless while a score of about 20 is almost perfect for most practical applications.

Figure 38 shows the more recent trend of the 500-mb (~ 5000 meter) height forecast performance for global models. Though not directly related to forecasting low-level winds, it does show the same general trend as S1 scores for sea level pressure.

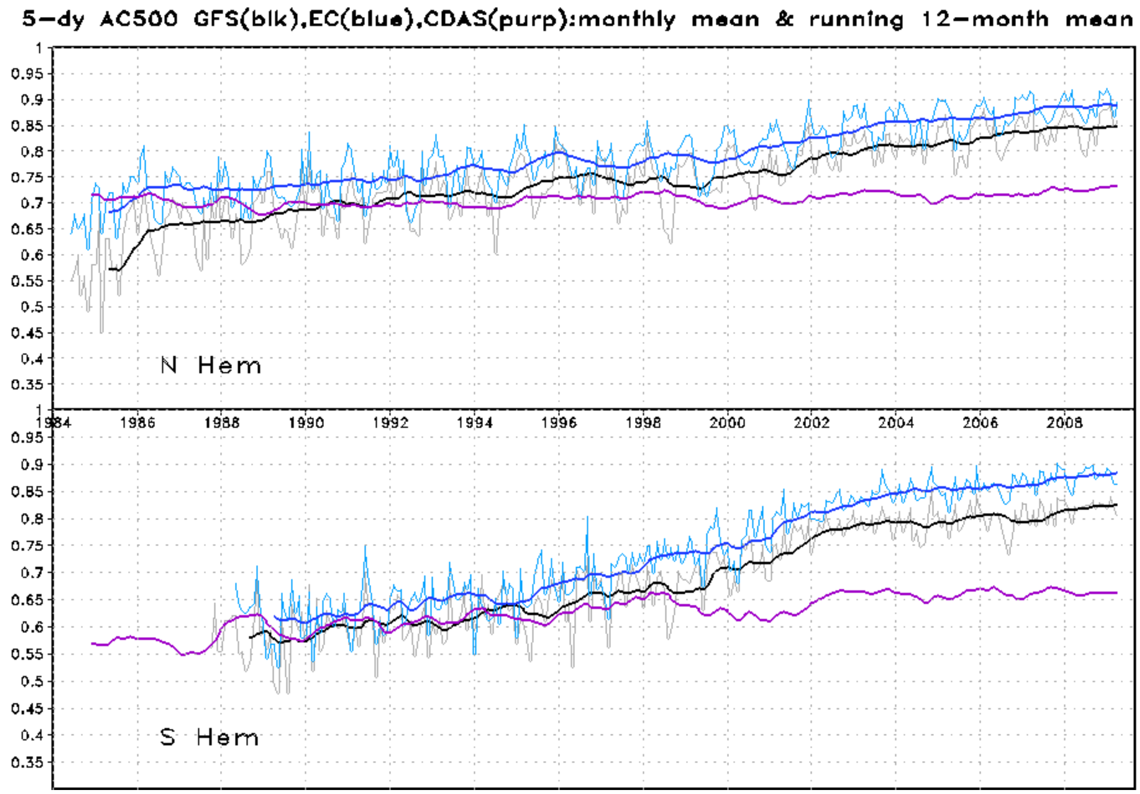

Figure 38: Time series of monthly mean anomaly correlations for 5-day forecasts of 500-hPa heights with 12-month running means plotted at the end of the year for GFS (black), EC (blue), and CDAS frozen model (purple) since 1984, northern hemisphere (top) and southern hemisphere (bottom).

From Figure 37 and Figure 38 it is possible to estimate the likely improvement in wind forecast skill over the next 10 years. The rate of forecast improvement inferred from the S1 data in Figure 37 suggests that the performance level of a 36-hour forecast in the 2003 - 2006 era would be achieved for a 72-hour forecast by approximately 2015; the performance level of the 72-hour forecast in the 2003-2006 period might be achieved for an 108-hr (4.5-day) forecast by 2020.

What does this projection mean for wind energy forecasts? Currently, a typical 36-hour forecast of the hourly energy generation has a mean absolute error of about 13-18% of a plant's installed capacity and a skill score (% reduction in mean absolute error) of about 30% over a climatology forecast. Therefore, this level of performance is likely for a 72-hour forecast by 2015. At present, a 72-hour forecast of the hourly energy output of a wind plant is near the end of the time period for which a forecast has skill over a climatology forecast. At this range, the typical MAE is between 20 and 25% and the skill over climatology is a few percent. This level of performance is a reasonable expectation for a 108-hour (4.5-day) forecast by 2015.

It is likely that these extrapolated improvements in forecast performance will be achieved since research and innovation continues to be very active in all three of the previously mentioned areas that have been driving forces behind the improvements depicted in Figure 37 and Figure 38. The improvements in remote sensing data are accelerating mainly due to advanced instrumentation aboard geostationary and polar-orbiting satellites. Improved techniques of incorporating various types of data into regional and global scale models are also being developed. Finally, the research community continues to develop and improve the physics-based atmospheric numerical models, benefiting particularly from the wide range of modeling groups in the government, university, and private sectors. Underlying these changes is the relentless advance of computing technology, making more powerful machines available at lower costs to execute more sophisticated models. Research is also underway in the development of new forecasting techniques. It has already been shown that the ensemble technique can produce better forecasts than conventional single-simulation forecasts beyond five days. With very active research in this area, it can be expected that the ensemble approach will be more widely used to improve the accuracy of shorter-term forecasts as well.

4.7.2. Short Term (Day-Ahead) Forecasting

The challenges of day-ahead forecasting are conceptually similar to those associated with the medium range forecasting task. However, the manifestation of the issues is different because the time and space scales are different. The skill in day-ahead forecasting is mostly related to the prediction of regional scale and mesoscale atmospheric features. The use of conventional atmospheric data and physics-based atmospheric models has proven to be an effective tool for this application.

The current expectation is that the bulk of future improvements for day-ahead forecasting will come from (1) continued improvements in regional physics-based atmospheric models as well as (2) increasing the amount and quality of data used to initialize the models. The new generation of atmospheric models currently being used and refined (e.g. the Weather Research and Forecasting model) by government and academic agencies employs more advanced representations of atmospheric physics and more sophisticated data assimilation techniques.

The expectation is that more sophisticated satellite-based sensors will be deployed over the next few years. This instrumentation will provide more accurate and detailed data sets describing the state of the regional atmosphere for initializing atmospheric models. Historical trends suggest that better initialization data will result in improved forecasts for wind energy and other applications.

A technique being explored for use in improving wind forecasting for both the day-ahead and hour-ahead forecast period is called “observation targeting.” The objective of observation targeting is to determine the “best” locations and parameters to measure in order to achieve the greatest positive impact on forecast accuracy at a particular site. The best locations are determined by analyzing climatological sensitivity of NWP forecasts to perturbations in the initial state for the look-ahead periods and locations of interest. Observations for locations and parameters that exhibit the greatest sensitivity have the most potential to reduce forecast error. It is still relativity early in the investigations but the hope is that observations can be targeted for specific cases such as large ramp events.

As noted earlier, a third component of the short-term forecast process is the MOS procedure. This scheme links the grid point data that come from the physics-based atmospheric models and the quantities to be predicted. Most current MOS procedures use a fairly traditional multiple linear regression approach to create the relationships. However, forecast accuracy may be improved using a more advanced statistical model such as a neural network for this application.

The ability to simulate more accurately the evolution of mesoscale features for a 24- to 36-hour period will help improve the quality of 1- to 2-day forecasts. A reasonable expectation is that in 10 years the mesoscale features will be forecasted 24 to 36 hours in advance as well as they are now forecasted 6 to 12 hours in advance. Thus, the performance of 36-hour wind energy forecasts in the year 2015 is likely to be as accurate as current 6- to 12-hour forecasts. This translates into an MAE of about 10-15% of installed capacity and a skill score of about 40% over a climatology forecast for a typical wind plant in the middle latitudes.

4.7.3. Very Short-Term (Next-Hour) Forecasting

The skill of very short-term forecasts is mostly limited by the inability to (1) define the initial structure of the atmosphere in the local area (0-200 km) around a wind plant (i.e., what is happening now?) and (2) extract the complex relationships between the measured data that serve as input to the forecast process (i.e. predictors) and the wind energy production (i.e., how is what is happening now related to what will happen in the future?).

The “what is happening now” part can be addressed by obtaining more atmospheric data from the local area surrounding the plant. The issue is determining the most cost-effective way to make such measurements. One suggestion offered numerous times in recent years has been to install "upwind" met towers to provide information about atmospheric features that are approaching a wind plant. A paper presented at the WindPower 2003 Conference demonstrated some forecast skill improvement for a wind plant on the Oregon-Washington border through the use of upstream-type met tower data in the Columbia River Basin [6]. Although there was some success in this case, there are a number of issues including tower location, installation cost, and maintenance.

This approach may be cost effective in an environment where the upstream wind direction is relatively uniform or dominant in one or two sectors. However, it may be less cost effective in an open setting where wind direction is more variable. One way to optimize instrument siting (and associated cost) is to identify the surrounding sites that are highly correlated with the variations in wind at the wind plant and install measuring equipment at only these locations. An alternative approach is to deploy surface-based remote sensing systems such as wind profilers, Doppler radars, or lidars. These instruments provide wind data over a limited atmospheric volume at a relatively high cost. It would not likely be cost effective to install such equipment solely for forecast applications around a wind plant. However, if they are already operating in a region, short-term forecasts could be improved by using data from these sensors.

Another possibility is to use data from satellite-based sensors. These instruments typically measure the amount of radiation coming from the atmosphere in multiple bands or channels that correspond to specific electromagnetic wave frequencies. The radiation measurements can be used to obtain estimates of temperature and moisture profiles of the atmosphere. They also can be used to provide some information about winds by tracking clouds.

The other part of the problem is to develop better relationships between what is happening now and what will happen in the next few hours. One approach is to employ more advanced statistical models and to optimize their type and configuration for the wind energy-forecasting problem. Techniques such as neural networks and fuzzy logic clustering may be able to identify more subtle and complex relationships between the raw input data and the quantities to be predicted. However, these advanced statistical approaches do not always improve forecasts and typically carry a high computational cost.

Another approach to mapping the relationship between the growing volume of input data and the forecast variables is to use a high resolution physics-based model. In this process, the model assimilates local-area data and generates a very short-term three-dimensional representation of the atmospheric conditions surrounding a wind plant. The fundamental principles of physics (i.e. conservation of mass, momentum, etc.) provide the links between the measured data and the forecasted quantity. This approach has never been used to generate very short-term, operational wind energy forecasts mostly because of the high computational cost. However, the steadily declining cost of computing platforms is now making this option economically viable.

Finally, improvements to plant output models could potentially benefit very short-term forecasts as well as longer time scales of wind energy forecasting. The improvements are likely to come from more (1) abundant and higher quality meteorological and energy generation data, (2) sophisticated wind plant data gathering and communications systems, and (3) detailed statistical or physical plant output model formulations.

It is likely that the improvements in forecast models as well as data coverage and quality in the local wind plant environment will yield meaningful improvements in the performance of 0- to 6-hour forecasts over the next 10 years. However, it is difficult to provide a quantitative estimate because the documented history of these very short-term wind energy forecasts is brief and the current state-of-the-art in performance for this time scale has not been as firmly established. A reasonable expectation is that there will be a 15% to 25% reduction in the typical MAE values for 0- to 6-hour forecasts over the next 10 years. This level of MAE reduction would result in an increase in the persistence-based skill score from about 20% at the present time to the 30% to 40% range in the year 2020.

4.8. DATA REQUIREMENTS

Both power production data and meteorological data play an important role in the generation of high quality wind power production forecasts. These data are used for initialization and verification of forecast models. Data from a wind plant serves three purposes in the forecasting process namely to

(1) establish relationships between the meteorological conditions at the plant and concurrent power production,

(2) identify and correct systematic errors, and

(3) provide current and recent atmospheric conditions to initialize the forecast process.

The data are useful for the first and second purposes on all time scales of forecasting. However, the usefulness of data for the third purpose varies substantially with forecast look-ahead period. Some providers advocate that successful forecasts can be made with only power generation data. However, experience shows that although these data are extremely valuable, meteorological observations provide significant added value. For example, when plant output is near rated capacity, power data alone will not indicate whether or not the wind conditions are near the plant's cut-out speed. Thus, the inclusion of meteorological observations to the data requirements is strongly recommended.

The role and importance of the meteorological data varies depending on the time scale of the forecasts, the meteorological conditions at a particular time and the geophysical characteristics (terrain topography etc.) of a particular site. The reason for such variability is that the information that determines the variation of the wind at a point, such as a wind plant, comes from an atmospheric volume of increasing size as the forecast look-ahead period increases. In the very short term (0-6 hours), the atmospheric features that determine most of the evolution of the wind at the wind plant are the small-scale features (such as sea breezes, mountain-valley circulations, etc.) near the facility.

The same concepts apply to day-ahead forecasts but the time and space scales are much different. The critical information for day-ahead forecasts is typically contained in a large atmospheric volume located hundreds of kilometers away at the time the forecast is produced. Thus, the local information from the area surrounding a wind plant is not of much direct value in the day-ahead forecasting process. The most valuable data for very short term forecasts is from the wind plant and its vicinity.

A lower cost and lower risk approach than erecting new towers is to deploy meteorological sensors at one or more sites with existing or new met towers that extend at least to a height that approximates the hub height of typical modern turbines. The issue is where to locate these sensors. One approach is to site them at locations with towers that already exist for other purposes. This strategy may reduce the cost but, except in some fortuitous situations, is not likely to maximize the forecast benefit from a particular set of sensors.

A much better approach is to perform a numerical simulation study to identify the sites that yield the optimal forecast benefit for a particular level of expenditure and forecast application. In such a study, high-resolution physics-based simulations are executed to characterize the flow in the extended vicinity of the wind plant. The output from these simulations is then used to make a map of the time-lagged correlation between meteorological parameters at all the locations in the simulation domain and winds at the plant site. The time lag used in this analysis is set equal to the desired forecast look-ahead period. The resulting maps can identify the best sites to make meteorological measurements for a particular look-ahead period. It is likely that different sites will be best for different look-ahead periods and that more than one site will be needed for a particular look-ahead period to account for varying atmospheric conditions.

Off-site measurements should not be considered as an alternative to wind plant measurements for very short-term forecasts. A network of off-site sensors may provide valuable input for very short-term forecasts at some locations. However, at other locations, sites that represent a concentrated source of predictive information for a particular wind plant may not exist (i.e. the information is scattered over many sites depending on the weather regime). The cost effectiveness of the off-site sensors can vary substantially due to a wide variety of economic, meteorological, and wind plant location factors. It is best to perform a numerical simulation study to determine the sites with the highest benefit/cost ratio or even if sites exist with acceptable benefit/cost ratios.

The day-ahead forecast application presents a different issue. Sensors deployed at the wind plant or even its extended vicinity will have little or no beneficial impact on day-ahead wind forecast performance. Sensors at wind plants will still be valuable for establishing the relationship between the atmospheric conditions and the power production and for reducing systematic errors in the forecasts, but off-site measurements in the vicinity of a wind plant will have little direct value for day-ahead forecasts. However, such sensors may have some value in analyzing day-ahead forecast performance and determining how the forecast system (especially the physics-based models) can be improved.

4.8.1. Data Collection

The successful operation of a centralized wind power production forecast system requires high quality data collection as well as timely and secure communication of input data for the forecasting process and forecasts that result from this process. The exact nature of the data collection and data communication requirements will depend upon the specific objectives and design of the forecast system.

4.8.2. Categories of Information Required

There are two categories of information required from the wind plant: wind plant parameters and meteorology. The wind plant parameters must include a general description of the plant specifications (provided initially) and a quantification of operating conditions (provided continuously at specified intervals). These data should include the following parameters:

Specifications:

- Nameplate capacity
- Turbine model
- Number of turbines
- Turbine hub height
- Coordinates and elevation of individual turbines and met structures (towers or masts) [7]

Operating Conditions:

- Wind plant status and future availability factor
- Number or percentage of turbines on-line
- Plant curtailment status
- Average plant power or total energy produced for the specified time intervals
- Average plant wind speed as measured by nacelle-mounted anemometers
- Average plant wind direction as measured by nacelle-mounted wind vanes or by turbine yaw orientation

The operating condition data should be provided at intervals that are equal to or less than the intervals for which the forecast is desired. Evidence suggests that providing data at shorter intervals than the desired forecast period may be beneficial for very short-term forecast performance. For example, if short-term forecasts are desired in 15-minute intervals, then operating condition data should be provided at intervals of 15 minutes or less. Ideally, the interval should be at most one half the forecast frequency or more often.

The meteorological parameters should consist of a general description of the meteorological measurement system(s) (provided initially) and the monitoring of ongoing environmental conditions (provided continuously at specified intervals). The parameters should be measured at a separate on-site met structure (tower or mast). More than one met structure is often beneficial for wind plants spread over large areas. A rough guideline is that each turbine in the wind plant should be within 5 km of a met structure. However, it is challenging to give exact spacing criteria as they depend on factors such as local weather regimes, terrain complexity, and availability of nacelle data. If nacelle data are provided, fewer met towers would be needed and only one may be sufficient. Thus, the recommended number and location of met towers should be based on weather regimes, terrain complexity, and availability of nacelle data.

In general, the met structures should be located at a well-exposed site generally upwind of the wind plant and no closer than two rotor diameters from the nearest wind turbine. The following parameters should be provided.

Meteorological Structure (Tower or Mast) Specifications:

- Dimensions (height, width, depth)
- Type (lattice, tubular, other)
- Sensor makes and models
- Sensor levels (heights above ground) and azimuth orientation of sensor mounting arms
- Coordinates and base elevation (above mean sea level)

Meteorological Conditions:

Data parameters required at two or more levels:

- Average (scalar) wind speed (m/s +/-1 m/s)
- Peak wind speed (one-, two-, or three-second duration) over measurement interval
- Average (vector) wind direction (degrees from True North +/- 5 degrees)

Data parameter required at one or more levels:

- Air temperature (°C +/1 °C)
- Air pressure (HPa +/- 60 Pa)
- Relative humidity (%) or other atmospheric moisture parameter

Wind measurements on the met structure should be taken at two or more levels, with the levels at least 20 m apart. One level should be at hub height. If this level is not feasible, the closest level must be within 20 m of hub height. To improve data quality and reliability, sensor redundancy for wind speed measurement at two levels should be practiced. The redundant wind speed sensor at each applicable level should be mounted at a height within one meter of the primary speed sensor. It is also recommended that at least one of the wind speed sensors nearest the hub-height level be heated to prevent ice accumulation from affecting the accuracy of wind speed measurements.

The meteorological condition data should be provided at intervals that are equal to or less than the intervals for which the power production forecast is desired. For example, if short-term power production forecasts are desired in 15-minute intervals, then meteorological condition data should be provided at intervals of 15 minutes or less. It is also useful if the met data uses the same interval as the generation data or a factor of the interval (e.g. 5 minute met and 15 minute generation data, but not 10 minute met and 15 minute generation data).

In addition to data from the met structure, wind speed and direction data (as well as temperature and pressure if available) from nacelle-mounted instruments should be provided from a representative selection of turbines. Each turbine should be within 75 m in elevation and five average turbine spacings of a turbine designated to provide nacelle data.

4.8.3. Timely and Secure Communication

All operational wind plant and meteorological conditions should be recorded and communicated by a central computing system (e.g., wind plant supervisory control and data acquisition system, or SCADA). This process will also ensure that the date and time stamps associated with the different parameters are concurrent. The wind plant SCADA system should have adequate computational and storage capabilities along with real time high-speed access to the Internet. These capabilities will empower the system to automatically generate and archive the requested operational information and make it available for use by the forecast provider and ISO. The required frequency of data retrieval will depend on the types of forecasts to be produced. If only day-ahead forecasts are required, it is satisfactory for the data to be transmitted from the plant once per day. In general, short term forecasts are recommended but such a need must be determined by ISO operations. If short-term forecasts are required, then the data must be transmitted at a frequency equal to or less than the forecast update frequency.

A key issue in the performance of wind power production forecasts is the consistent availability of high quality production and meteorological data from wind plants. Experience indicates that the issue has emerged as one of the biggest obstacles to achieving optimal forecast performance. Thus, it is prudent to consider ways in which a high level of data availability and quality can be achieved when designing a forecast system. One important factor is the complexity of the mechanism that communicates data from the wind plants to the forecast provider. Complex protocols or communication schemes provide more opportunities for data transmission failure. Initiation and maintenance of these schemes requires considerable education of all concerned personnel.

Another important factor is the incentive that wind plants have to maintain their wind forecasting related sensor and communication systems. A significant issue in other wind power production forecast applications has been the priority that wind plants place on responding to problems with their meteorological sensor or data communication systems. In some cases, the data flow has been interrupted for a week or more because a computer system needed to be rebooted and no one executed the appropriate command during that period. Thus, data outages that could have easily been limited to hours were extended to more than a week. This issue suggests that a centralized wind power production forecast system should be designed in such a way as to maximize the incentive of wind plants to maintain their sensor and communications equipment and to respond to problems with these systems as quickly as possible.

4.9. Centralized (ISO) vs. Decentralized Forecasting System

One of the most basic issues is whether the forecasts should be provided through a centralized or decentralized forecasting system. In a purely *centralized* system, one (or more) providers are contracted through a single central entity (such as the ISO) to provide forecasts for all wind generation facilities within the electric system. The central entity may then provide the forecast information to the individual wind generation resources as well as use the information for its own purposes. In a purely *decentralized* system, each wind generation resource would contract with a forecast provider or potentially produce forecasts internally without a provider. Each generation facility would then supply the forecast (schedule) to the system operator. Both centralized and decentralized systems have advantages and disadvantages but it is certainly possible to have a hybrid approach that incorporates elements of both.

A primary factor is cost. A centralized system is likely to have a lower total cost since the economies of scale would likely enable a provider to deliver forecasts with a lower cost per generation facility. However, it is possible that decentralized costs might approach those of a centralized system if one or two providers were the dominant suppliers for the individual generation facilities and could thereby achieve economies of scale. Of course, there would be no assurance of this outcome if a decentralized system were implemented.

A second factor is forecast quality. Forecasts for larger plant aggregates will tend to be more accurate than those for a single one and forecast providers would have more data from all wind sites. It is not clear which approach (if either) would achieve a better overall forecast performance. In theory, the decentralized approach would encourage a forecast provider to focus more attention on each individual site and possibly develop a higher degree of customization for the site. If the provider did not perform well for that site, the owner/operator of the facility could seek another provider to improve performance. If all owner/operators aggressively sought the best possible forecasts for their site, it could result in the best system-wide forecast as well. However, in practice, there would likely be a large degree of variation in the demand for quality performance for each facility.

Some facilities might pay a lot of attention to this aspect while others might see it advantageous to reduce costs by going with the least expensive provider (regardless of quality) or may even do forecasts themselves. The implementation of system-wide forecast performance standards or penalties for poor scheduling performance might result in the best possible forecasts for each site. However, if the motivation is solely to avoid penalties or meet a minimal performance standard, it is not likely that the owner/operator would be willing to incur an added cost to achieve better performance beyond the minimum standard.

A third factor is data utilization. In a centralized system, it is likely that data from all wind generation facilities will be available for use in forecast generation at other facilities. This attribute can occasionally have significant benefit for short-term forecasts since data from an "upstream" facility might be a useful predictor for future variations at a "downstream" facility. In a decentralized system, it is likely that proprietary issues will prevent a vendor from using data at one facility to benefit forecasts at another facility even if both use the same forecast provider. The situation would be even more difficult if the facilities used different forecast providers [4].

A centralized system will probably ensure more uniform quality. It is also possible that benefits of site-specific customization will not be very significant and that much of the useful customization will be similar at nearby sites. In practice, most customization benefits for individual sites occur for the very short-term look-ahead periods. The centralized system also provides more opportunity to implement a multi-forecaster ensemble since two or more providers could forecast for all generation facilities. This scenario is unlikely to occur in a purely decentralized system. The recommendation is for ISO-NE to implement a centralized forecasting system.

4.10. USE OF MULTIPLE WIND FORECAST VENDORS

There are likely several advantages of using multiple vendors in order to improve the overall confidence in wind power forecasts. One advantage is that certain vendors may employ methods that are better at forecasting for certain time periods. Some vendors may be better at forecasting for certain meteorological situations or seasons. Having multiple forecast vendors gives the ISO an opportunity to select the best single performer for a given situation or create an ensemble of forecasts based on the time period or forecast situation. The final product could be either the single best forecast or a weighting of individual forecasts.

In order to take maximum advantage of multiple providers, the ISO would need to track and compare vendor performance. At a minimum, the evaluation should include vendor performance over various forecast time periods and months to identify specific trends. More sophisticated evaluation methodologies should also be considered. For example performance tracking could be done by meteorological regime (weather pattern). This type of evaluation would be relatively complex to set up but it could yield significant forecast improvements.

Using multiple vendors also gives the ISO redundancy, thus reducing the possibility of a missed forecast. Although a missed forecast should be rare for even one vendor, the redundancy provided by multiple vendors gives the ISO a higher level of reliability than having a single provider. The disadvantages caused by multiple vendors are added cost and increased management overhead. In addition, providers using similar methods will likely produce forecasts that are highly correlated. In this case, multiple forecasts with very similar performance metrics may provide little added value.

Many markets, both in the U.S. and Europe, are now using multiple forecast providers. In Germany, four providers are used to support their power distribution network (grid) operators. AWST recommends using a two-provider centralized system. This configuration ensures a higher level of reliability due to additional redundancy and facilitates the use of ensemble forecasts that, in theory, are likely to have better overall performance than a single forecast. It is also possible that one provider will perform best under some circumstances. Two providers may ensure that the system is quickly updated with new forecasting technology, since there will be some element of competition between the providers. Although more than two providers might be considered, especially if different forecasting methodologies are used, the benefits obtained from additional forecast providers are not likely to justify the cost.

4.11. PROPOSED CONTROL ROOM INTEGRATION OF WIND POWER FORECASTING

The use of wind forecasting in the power system control room will reduce operational impacts and costs. The addition of wind energy to a power system grid will increase the amount of variability and uncertainty in net load as compared to the use of energy produced by conventional means. Accurate weather forecasts can reduce the uncertainty, thereby allowing for more cost efficient use of conventionally produced energy. As the penetration of wind into the power markets increases, the need for a sophisticated integration of wind forecasting for the ISO also increases. The ISO requirements for high reliability and safety make this integration especially challenging. The following factors should be considered when integrating wind power forecast systems into the control room:

- **Routine forecasts:** Routine forecasts would be provided for three look-ahead periods, very-short term, short-term and medium range term.
- **Ramp Warning Forecasts:** A separate ramp potential warning system would be part of the forecasting system. When there is a high probability of a ramp within 24 hours, the system would provide hourly ramp alert updates, giving detailed forecasts that would include the probability, amplitude (magnitude), duration, type, and cause of the ramp event. The day-ahead and beyond forecasts would only provide probabilities of ramp occurrences.
- **Severe Weather Forecasts:** A severe weather warning system would provide the potential for events such has high winds, thunderstorms, icing, and heavy snow for at least the first 48 hours. When there is a potential for severe weather within 24 hours, the warning system would deliver hourly updates to operators. For the day-ahead, only the general potential of high, moderate, or low risk would be provided for each category of severe weather.
- **Offshore Forecasting:** In addition to all other forecasts that onshore plants would need, a wave forecast is critical for offshore plants in order to help schedule plant maintenance.
- **Monitoring:** To enhance both safety and reliability, an operator should be dedicated to the monitoring of all of the renewable (variable) power generations resources (primarily wind and solar).
- **Visualization Tools:** User friendly visualization would be needed for the proper monitoring of events that could cause ramp and/or severe weather impacting individual plants and the grid as a whole.
- **Plant Clustering:** It is suggested that pooling of wind plants into clusters will make it easier for an optimized integration of wind power. The geographically distributed clusters would be treated as one large (virtual) wind power plant. The plant cluster could be viewed as a "super plant". For this purpose, it is suggested that all wind plants that are directly or indirectly connected to one transmission network node will be associated with one wind plant cluster. A wind plant cluster manager would assist the ISO by operating the cluster according to the requirements of the power generation and transmission system. This approach would have particular value if there were transmission congestion in an area that might require curtailment when a specific aggregate of plants exceeded threshold output.
- **Education and training:** During the early stages of integration of renewable (variable) power generation resources with traditional power systems, there is a large need for education and training on how to use wind forecasting effectively. Training topics should address a number of areas such as interpreting error characteristics for deterministic versus probabilistic forecasts of ramps and/or other events. The discussion

should cover the overall forecasting process and a high level review of physical versus statistical models as well as the use of observational data for validation and correcting model biases.

4.12. SUMMARY

Conventional power plants produce a near-constant output except in rare emergency outages, but the variability of wind energy presents a special challenge for utility system operations. The output of a wind plant fluctuates, at times amounting to several hundred megawatts in a matter of an hour or two. If the fluctuations cannot be predicted, they create reliability risks and additional costs for the electricity system and consumers. Wind generation forecasting is an important tool for reducing the effects of wind generation variability and uncertainty on operation of the grid.

In wind energy forecasting it is useful to divide the forecasts into three time scales: (1) very short-term “next-hour” (0-6 hrs); (2) short-term “day-ahead” (6-72 hrs), and (3) medium range (3-10 day). The skill in very short-term forecasting is related to the prediction of small-scale atmospheric features (< 200 km in size) in the vicinity of the wind plant. A major challenge is that there is usually very little data gathered on the scale needed to support the forecasting of very short-term features. There are a wide range of spatial and temporal scales that determine the variations in the wind energy power generation, so it is necessary to use a diverse mix of data sources to achieve the best possible forecast performance.

The main problem with data beyond plant boundaries is that the spacing between measurements is too large (because of economic constraints) to adequately represent the small or even sometimes medium scale atmospheric features that are responsible for short-term variations in wind energy output. Unfortunately, there are large areas where very little in situ data are gathered due to the cost of maintaining such systems. As a result, data coverage is far from uniform and some regions have far less data upstream than others. The expectation is that remote sensing technology will eventually overcome these limitations of data resolution and coverage.

A major component of the forecast process is data processing. Data processing tools known as mathematical or numerical models ingest data and generate predictions. The four fundamental categories used in the wind energy forecasting process are: (1) physical atmospheric models, (2) statistical atmospheric models, (3) wind plant output models, and (4) forecast ensemble models. There are many types of models in each of these major categories and a particular forecast system may employ one or more of each type.

Evaluation of the forecasts is a very important yet complex process. The most significant issue is which parameter(s) should be used as the metric(s) for forecast performance. The choice of metrics can have a significant impact on the interpretation of forecast performance. One fundamental distinction in using metrics is absolute versus relative performance. A second distinction is the sensitivity to different portions of the error frequency distribution. Some parameters are much more sensitive to outliers, i.e. forecasts with anomalously large or small errors. A third issue is that a forecast system can be tuned to produce better performance for a specific metric while possibly degrading the performance for other metrics.

The current state-of-the-art forecasting techniques exhibit considerable skill in both very short-term and short-term forecasting. Very short-term hourly forecasts typically outperform persistence by 10% to 30%. Short-term hourly forecasts usually outperform persistence and climatology by 30% to 50%. At present, for the medium range past day 5, hourly forecasts typically do not outperform climatology so have limited usefulness. However, medium range forecasts of the *average* energy production over a day or half-day usually outperform climatology out to 6 or 7 days thus providing some value. The MAE of very short-term forecasts is typically in the range of 5% to 15% and the errors increase rapidly (about 1.5% of installed capacity per hour) with an increase in the forecast time horizon. After the short-term period, the error growth rate decreases to about 0.1% of installed capacity per forecast hour. This trend indicates that the mean absolute forecast errors remain in the 13% to 21% range for 1 to 2 days ahead and rise to the 20% to 25% range (that is typical of a climatological forecast) after about 3 days.

Forecast performance can vary substantially (5% or more of installed capacity) as a function of location, season, weather regime, and size and diversity of the wind plants. Much of this variability is related to the predictability of specific weather regimes, with some sensitivity to small variations in conditions at the time of the forecast. Forecast performance in these types of regimes is normally much worse than for regimes with less sensitivity.

Studies have also shown that size and diversity of wind plant aggregation can impact forecast statistics. For example, in the Alberta Wind Forecasting Pilot Project the RMSE for regional day-ahead forecasts were 15-20% lower than for the individual farms and the RMSE for system-wide day-ahead forecasts was 40-45% lower than for the individual farms.

In the next 10 years, it is expected that improvements in (1) the quality and quantity of global, regional, and local area atmospheric data, (2) sophisticated statistical and physics-based atmospheric models and data assimilation schemes, and (3) the availability of lower cost computing power will yield substantial improvement in forecast performance. Although there is likely to be some improvement in all forecast time horizons, the most significant improvements are likely to be in the start of the medium range forecasting period (3-5 days) and the start of the short-term forecast period (first 6-18 hours).

As the amount of wind generation increases on grid systems, the occurrence of large and rapid changes in power production (ramps) is becoming a significant grid management issue. Forecasting techniques for typical wind conditions do not do well in forecasting rapid changes in winds that cause large power ramps. Therefore, ramp forecasting requires a separate methodology and system designed specifically to forecast and alert operators of the likelihood of ramp events. Several different types of meteorological processes cause large ramps in wind power production. The data and type of forecast method required to optimally predict each type of ramp event varies.

A ramp forecasting system should alert operators about the occurrence of a ramp at the earliest possible time. Forecasts for the first 24 hours should include the probability, amplitude (magnitude), duration, type and cause of the event. The alert system should include hourly ramp forecast updates when a ramp event has been forecasted within 24 hours. For the day-head, only probabilities of ramp occurrence should be given for each hourly time period. For the medium range forecast, only daily ramp probabilities should be given.

Both power production data and meteorological data play an important role in the generation of high quality wind power production forecasts. The successful operation of a wind power production forecast system requires well orchestrated data collection plus timely, secure communication of the input data for the forecasting process and the resulting forecasts. Two categories of data are required from the wind plant: wind plant parameters and meteorology. Data outages have an adverse impact on forecast performance, especially for the very short-term look-ahead periods.

The data from a wind plant serves three purposes in the forecasting process: (1) it provides information about relationships between the meteorological conditions at the plant and the plant's concurrent power production; (2) it provides information to determine the systematic errors in the forecasts and allows them to be statistically corrected, and (3) it provides information about the current and recent state of the atmosphere which contributes to the starting point of the forecast process. Meteorological sensors should always be present at wind plants to fulfill objectives (1) and (2) above. Off-site measurements should never be considered to be an alternative to wind plant measurements for the very short-term forecasts. The usefulness of data for the third purpose varies substantially with the forecast look-ahead period.

To maximize the performance of very short-term forecasts, it is important to gather as much information as possible in the vicinity of the wind plant. The day-ahead forecast application presents a different issue. Thus information and data needed to make day-ahead forecasts must primarily come from simulations using a physics-based atmospheric model. Sensors deployed at the wind plant or its extended vicinity have little impact on making day-ahead wind forecasts, but are valuable for evaluating the day-ahead forecast performance and determining how the forecast system can be improved.

There is a need to provide operators with information regarding the overall weather situation, especially with respect to extreme meteorological events that may have a serious impact on wind plant operations. Information and forecasts of severe weather events, such as high winds, thunderstorms, and freezing rain should be provided. Information on the feature causing the event should also be provided so operators can track and verify the actual occurrence of the event in real time.

Offshore wind plants will require wind, wind power and wave forecasts that can impact various operations. There are fundamental differences between the wind conditions over land and offshore due to the influence of the surface on the flow. Forecast models must be able to account for ocean-atmosphere interactions, the specific nature of the marine boundary layer, and the fact that observed data will be sparse over the ocean. The wave-forecast model needs to include relevant shallow water dynamics.

Two basic interrelated issues for the ISO to address are selecting between (1) a centralized or decentralized forecasting system and (2) a single or multiple vendor forecasting service. The recommended approach is to implement a two-provider centralized system. This strategy ensures a higher level of reliability due to the redundancy and increases the likelihood of improving the forecast performance over a single provider.

The use of wind forecasting in the ISO control room will likely reduce operational impacts and costs. For optimum management of wind power, it is essential that the wind power forecasting system be fully integrated into the ISO control room. It is suggested that pooling of wind plants into clusters may make it easier for an optimized integration of wind power. It would likely improve grid management efficiency if an operator were dedicated to the monitoring of all of the renewable (variable) power generation resources. Finally, an aggressive training program for all users of forecast information would likely improve the management of the wind resources.

4.13. REFERENCES

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Section 5

GRID OPERATIONS WITH SIGNIFICANT WIND GENERATION

Experience with wind plants from the power system operator's perspective is developing but still rather limited. In the U.S., there are only a handful of areas where the penetration of wind generation has reached the level where operating practices have necessarily evolved in response. ERCOT is perhaps the best example, although the Pacific Northwest, Colorado, Alberta, and New Mexico are not far behind. Continued development over the coming years will bring many more operating areas into this category. MISO might be the best example here. The current installed capacity of around 6 GW is small relative to the resources and loads in its market. However, the concentration of wind generation in the western reaches of the market footprint and prospects for much more development have placed a priority on developing the practices, procedures, and policies that will be critical going forward.

Wind integration studies conducted over the past decade have lead to insights that are proving useful for anticipating challenges for operating power systems with large amounts of wind generation, and for assessing the effectiveness of various measures for mitigating impacts. While some general lessons have been learned, the studies have also shown that the make-up of a particular system – portfolio of resources, nature of loads, amount and location of wind generation, operating rules – has a substantial impact on the magnitude of the challenge.

Actual progress – as measured by the performance of wind plants in the field – is perhaps greater on the interconnection side of the ledger. As illustrated in Section 3 commercial wind turbine technology has advanced considerably in technical capability. Wind plants have been successfully interconnected in very remote and weak areas of the transmission network. With proper engineering, wind plants can exhibit terminal behavior equivalent to conventional power plants in terms of reactive power and voltage control. In some respects, the dynamic behavior of wind generation facilities during and immediately following large disturbances on the transmission network can be superior to that of conventional equipment. Substantial work remains, however, on the development, testing, and validation of the computer models required for this engineering.

The subject of this section is on the design and operation of power grid with significant wind generation, with those responsible for maintaining the very high reliability and economic efficiency the target audience. Topics and information from the previous sections are relevant here, but from the perspective of those with overall responsibility for the grid.

5.1. BACKGROUND

Concerns over how significant amounts of variable wind generation can be integrated into the operation of a control area stem from the inability to predict accurately what the generation level will be in the minutes, hours, or days ahead. The nature of balancing area operations in real-time or in planning for the hours and days ahead is such that increased knowledge of what will happen correlates strongly to better strategies for managing the system. Much of this process is already based on predictions of uncertain quantities. Hour-by-hour forecasts of load for the next day or several days, for example, are critical inputs to the process of deploying electric generating units and scheduling their operation. While it is recognized that load forecasts for future periods can never be 100 percent accurate, they nonetheless are the foundation for all of the procedures and processes for operating the power system. Increasingly sophisticated load forecasting techniques and decades of experience in applying this information have done much to lessen the effects of the inherent uncertainty.

The nature of its fuel supply is what distinguishes wind generation from more traditional means for producing electric energy. The electric power output of a wind turbine generation is primarily a function of the speed of the wind passing over its blades. The speed of this moving air stream exhibits variability on a wide range of time scales – from seconds to hours, days, and seasons. The degree to which these variations can be predicted with some level of accuracy also varies. It should be noted that this is not an entirely unique situation for electric generators. Hydroelectric plants, for example, depend on water storage that can vary from year to year or even seasonally. Generators that rely on natural gas as their sole fuel source can be subject to supply disruptions or storage limitations. That said, the overall effects of the variable fuel supply are significantly larger for wind generation.

Impacts on the operation of the transmission grid and the control area relative to wind generation are dependent on the performance of the wind plants within that area as a whole, as well as on the characteristics of the aggregate system load and the generation fleet that serves it. Large wind generation facilities that are connected directly to the transmission grid employ large numbers of individual wind turbine generators. Individual wind turbine generators that comprise a wind plant are usually spread out over a significant geographical expanse. This has the effect of exposing each turbine to a slightly different fuel supply. This spatial diversity has the beneficial effect of "smoothing out" some of the variations in electrical output. The benefits of spatial diversity are also apparent on larger geographical scales, as the combined output of multiple wind plants will be less variable than with each plant individually.

The system load itself exhibits some unpredictable variations, both within an hour and over the course of the day. Because system operators are concerned with the balance of net load to net generation in their control area, load and wind variations cannot be considered separately. The impact of uncorrelated variations in load and wind over time will be considerably less than the arithmetic sum of the individual variations. This aggregation effect is already a critical part of control area operations, as responding to or balancing the variations in individual system loads, rather than the aggregate, would be exorbitantly complicated and expensive, as well as non-productive.

Wind generation forecasting is acknowledged to be very important for continued growth of the industry. Despite the increasingly sophisticated methods used to forecast wind generation, and the improving accuracy thereof, it is certain that large amounts of wind generation within a grid control area will increase the overall demand for ancillary services.

5.2. MAJOR LESSONS LEARNED FROM U.S. WIND INTEGRATION STUDIES

Within the wind industry and for those transmission system operators who now have significant experience with large wind plants, the attention has turned to not whether wind plants require such support but rather to the type and quantity of such services necessary for successful integration. With respect to the full range of ancillary services, there is a growing emphasis on better understanding how significant wind generation in a control area affects operations in the very short term – i.e., real-time and a few hours ahead – and planning activities for the next day or several days.

Recent studies considering the impact of wind generation facilities on real-time operation and short-term planning for various control areas are summarized in Reference [1]. The methods employed and the characteristics of the power systems analyzed vary substantially. There are some common findings and themes throughout these studies, however, including:

- Despite differing methodologies and levels of detail, ancillary service costs resulting from integrating wind generation facilities are relatively modest for the growth in U.S. wind generation expected over the next three to five years.
- The cost to the operator of the control area to integrate a wind generation facility is obviously non-zero, and increases as the ratio of wind generation to conventional supply sources or the peak load in the control area increases.
- For the penetration levels considered in the studies summarized in the paper (generally less than 20 percent by capacity) the integration costs per MWH of wind energy were relatively modest. As penetration levels begin to approach 20 percent by capacity, however, the costs begin to rise in a non-linear fashion.
- Wind generation is variable and uncertain, but how this variation and uncertainty combines with other uncertainties inherent in power system operation (e.g. variations in load and load forecast uncertainty) is a critical factor in determining integration costs.
- The effect of spatial diversity with large numbers of individual wind turbines is a key factor in smoothing the output of wind plants and reducing their ancillary service requirements from a system-wide perspective.

Understanding and quantifying the impacts of wind plants on utility systems is a critical first step in identifying and solving problems. A number of steps can be taken to improve the ability to integrate increasing amounts of wind capacity on power systems. These include:

- Improvements in wind-turbine and wind-plant models
- Improvements in wind-plant operating characteristics
- Carefully evaluating wind integration operating impacts
- Incorporating wind-plant forecasting into utility control-room operations

- Making better use of physically-available (in contrast with contractually-available) transmission capacity
- Upgrading and expanding transmission systems
- Developing well-functioning hour-ahead and day-ahead markets, and expanding access to those markets
- Adopting market rules and tariff provisions that are more appropriate to weather-driven resources
- Consolidating balancing areas into larger entities or accessing a larger resource base through the use of dynamic scheduling
- Improving the operational flexibility of the entire conventional generation fleet. This includes mechanisms to encourage use of and investment in thermal and hydro generation for increased flexibility.

5.3. ASSESSING SPECIFIC OPERATIONAL ISSUES RELATED TO WIND GENERATION

Integration encompasses the influence of wind plants on and participation in short-term scheduling and real-time operations of the ISO-NE system. Included are the nature of wind energy delivery in real time and the control thereof, mechanisms for coordination of wind plant operation with ISO-NE system operators, and the collection and communication of important operational data.

The findings from previous integration studies of other regions are generally applicable because they directly address issues stemming from variability and uncertainty associated with wind generation. For a specific balancing authority, they may or may not be applicable or possible. Detailed studies, like one initiated by ISO-NE in 2009, are the mechanisms for identifying operational issues and challenges in a given context.

A discussion of specific operational issues related to wind generation follows.

5.3.1. Variability and Uncertainty

As mentioned above, electric demand is highly variable and forecasts have varying levels of uncertainty depending on the time of day or year and the horizon. Wind generation will incrementally increase both of these characteristics.

5.3.1.1. Real-Time Variability

Generation capacity on AGC and assigned to regulation duty is the primary means for matching generation to load in real-time. Over longer periods, sufficient ability to adjust generation up or down in response to trends in the balancing area demand – e.g. morning and evening ramps – must be maintained. Wind generation increases these requirements.

Previous studies are finding that while the output of a wind plant (or multiple plants) exhibits variations across all time scales ranging from seconds onward, the fastest of these fluctuations (tens of seconds) are modest compared to those already exhibited by load. Wind plant output variations on this time scale have been characterized from measurement data as normally-distributed random deviations from a rolling average trend (with an averaging window of 20 to 40 minutes). For a 100 MW wind plant, the standard deviation of the variations is about 1% of the nameplate rating. In addition, the variations from an individual wind plant are uncorrelated to the variations from other plants and from those in the load, which leads to a substantial statistical smoothing effect as the amount of wind generation increases.

System impacts of these variations will obviously depend on the amount of wind generation relative to load, but for the wind penetrations studied to date, the effects are quite modest.

Variations in wind plant output over slightly longer time frames appear to be of more significance for balancing. Electricity demand exhibits a strong and familiar trend over periods of the day, depending of course on season and other factors such as weather. Short-term forecasts of this trend allow flexible generation to be dispatched economically and in advance to "follow" the movement. Fluctuations in wind generation over intervals of five to ten minutes or longer appear not to be so well behaved or predictable. These variations are due to local effects within the wind plant or plants, driven by turbulence, terrain effects, and turbine layout, among other possible factors. Consequently, they are very difficult to predict.

A result is that the errors in the short-term forecast of wind generation will increase the regulation burden, as units following the load via frequent economic dispatch are effectively controlled to the forecast rather than the actual wind.

The analytical approaches employed in wind integration studies have evolved to where it is possible to estimate these impacts on regulation and balancing with the standard data sets developed for these investigations. While not rigorous, it is possible using these techniques to make reasonable estimates of the wind generation impacts on the quantity and quality of flexible resources needed to perform these functions.

5.3.1.2. Extreme Ramps

Large changes in balancing area demand over one or more hours are important periods from an operations perspective. Adequate flexibility in the committed generation – "room to move" – must be available to avoid significant violations of control performance or shedding of load.

Wind generation can enhance these periods of stress on the system by moving in the undesirable direction – down in the morning or up in the evening.

5.3.2. Wind Plant Control

In the future, as wind plants provide an increasing amount of the energy delivered to load, it will become increasingly necessary for them to participate in a more complete range of system operation and control functions, similar to conventional plants. This will be made possible by the increasing capability of wind plant output forecasting systems and the integration of forecasting capability with wind plant control capability in an AGC system. With a fully integrated system, the output of the wind plant can be forecast and scheduled both hour(s) ahead and day ahead, the wind plant can participate in the volt/VAr control system, and it may provide regulating capacity and spinning reserves if called upon to do so. It may also provide a governor response and inertial response if required.

Ramp-rate limits can be set to meet the requirements for specific grids and applications. Ramp-rate limits can be imposed for grid operating conditions that warrant their use, and need not be continuously enabled. The controller allows for switching in and out of ramp-rate control by either the plant operator or in response to an external command.

Again, with the data sets compiled for wind integration studies, impacts of wind generation on ramping can be examined statistically, and the effects on the system determined through chronological production simulations. The need for, and nature of, mitigation measures can also be identified.

Assessing applications for active power control capabilities of modern wind plants must be approached carefully, since some of the features require that wind energy be dumped. For those features that operate infrequently or for very limited durations, the amount of lost energy may be very small or negligible. Ramping controls for start-up or planned shut-down are in this category. At the other end of the spectrum, full participation in AGC requires that potential wind energy be spilled continuously, and may have a significant impact on project economics.

Economics must be a key factor in decisions to use or require wind plant active power controls.

5.3.3. Effects on contingency reserve requirements

The operating experience to date with wind generation, including the detailed integration studies performed over the past decade show, that while very large changes in wind generation in short amounts of time are possible, seldom if ever would they rise to a level that would meet the current definition of a "contingency" event in the U.S. electric power industry. In fact, at least one reserve sharing group in the West has clarified the definition of contingency to require that it be accompanied by a breaker operation or change in operational status of an element of the bulk grid to explicitly exclude changes in wind generation.

Both experience and meso-scale data show that large changes in production, especially in the aggregate production of many individual wind plants, do not occur instantaneously, but rather over periods of hours. Some relatively extreme cases have already been observed; BPA's challenge with wind generation in the Columbia Gorge, where ramps in aggregate production over periods as short as 30 minutes can be significant, is a prime example. Even here, however, the issue is one of regulation and load following, not contingency reserves.

5.3.4. Minimum Generation Issues and Curtailment

In many parts of the U.S., there is a tendency for wind generation to produce more energy in off-peak hours than on-peak. During light load seasons, high levels of wind production overnight can create problems with minimum generation.

For a defined scenario of wind generation, production simulations can quantify the anticipated frequency and timing of minimum generation constraints. Mitigation measures include de-commitment of conventional units to provide "legroom", or curtailment of wind generation. The ability to quantify the number of hours over a year in which wind generation curtailment might be invoked is a significant benefit of the production simulation approach.

5.3.5. Forecasting Applications and Implementation

Production forecasts are critical for integrating significant amounts of wind generation. The science of wind generation forecasting and modern implementations of forecasting systems is described in Section 4   The purpose of this section is to provide some additional perspective on the use and implications of those forecasts for power system operation and control.

5.3.5.1. Short-Term Forecasts and Uncertainty

In conventional utility operations, uncertainty about load in the coming minutes and hours translates to additional reserves and regulation. Here the variability and uncertainty of wind plant production become intermingled because it is difficult to accurately forecast short-term variations. Distinguishing between a sharp but temporary drop in production and persistent decline in output that could continue over multiple hours is very difficult. Policies for dealing with normal variations in wind generation must be segregated from those actions that are necessary for the very large and extended but infrequent, changes in production.

5.3.5.2. Longer-Term Forecasts

Wind generation forecast accuracy declines with the forecast horizon. Day-ahead forecast accuracy of 15 to 20% MAE allows for significant hourly and even daily errors. How the forecast is used in day-ahead decision-making is both a technical and economic question: Adequate capacity must be available to meet the expected load, but committing excess capacity degrades economic performance.

The difficulty of the apparent trade-off between security and economic efficiency will depend on the amount of wind generation and the type of resources in the supply portfolio. Integration studies can help to quantify the sensitivity of economic efficiency to the accuracy of wind generation forecasts or the penalty associated with discounting the expected wind generation in a security-constrained unit commitment (SCUC).

The question of economic efficiency also extends to the structure and rules for day-ahead energy markets. There is little experience to date from other ISOs on how wind plays or is required to play in the bidding process, but it has been recognized in those market areas where significant wind generation is anticipated. Consideration of wind energy delivery for the next day should increase the efficiency of the day-ahead market process, but the likely errors due to expected day-ahead wind generation forecast errors must be acknowledged.

5.3.5.3. "Special" Forecasts

Large changes in wind generation over relatively short periods of time are infrequent but can pose serious risks to system reliability. Advance knowledge of such events is the difference between posturing the system defensively thousands of hours per year and incurring the associated cost, or taking appropriate action during only the dozens of hours when there might be risk. The ability to forecast large, sudden changes in wind generation is a key to reducing the cost of integrating wind generation.

As the discussed in Section 4 forecast systems optimized to minimize errors in day-ahead predictions may not be the best approach for predicting large ramps or high-wind cutout events. This fact must be recognized in the development of special forecasts, along with the specific needs and requirements of the operators.

5.3.6. System Steady-State and Dynamic Performance with Wind Generation

The technology for converting energy in a moving airstream to electricity differs significant from that employed in conventional bulk electricity generation. These differences have (and still are) posing some major challenges for power system engineers charged with designing and maintaining reliable systems. As described in Section 3 commercial wind generation technology is quite sophisticated, and capable of exhibiting terminal behavior and performance consistent with good engineering practice.

The focus of the electric power industry to date has been on detailed design studies for the interconnection of individual wind plants. As the penetration of wind continues to grow, evaluations of system-level impacts will become more important. Specific technical issues that will require assessment include:

- Voltage regulation and reactive power dispatch. Control of reactive power at the terminals of a wind plant can be designed to provide the same levels of static and dynamic control as conventional plants, possiblly even better. This is not an inherent feature of wind plants, however – proper engineering of the plant is necessary to achieve these levels of performance. As the number of wind plants with such capability grows, system level studies will be required to prevent undesirable interactions.
- System behavior during and disturbances. The response of the system to large-signal disturbances such as faults will be affected by wind generation. However, it has been shown that the dynamic behavior of wind plants can possibly be "better" than conventional plants due to the sophisticated generation control technologies in commercial wind turbines. In any case, the responses will be different than those form more familiar conventional generators, which increases the importance of adequate and verified models for wind plants.
- Potential reduction in system inertia. The current installed fleet of commercial turbines is mostly insensitive to excursions in system frequency. If wind generation displaces enough conventional generation, the dynamic performance of the system can be altered. In isolated systems, the lower aggregate inertia results in faster and possibly larger excursions in frequency following loss of generation or load. In a large interconnection, lower regional inertia can adversely affect interties following similar disturbances
- System protection. Wind turbines and wind plants do not fit well into the conventional analytical methodology for calculating short-circuit currents because of the generator and control technologies used. It is important, however, that in-feed from wind plants to transmission system faults be characterized so that transmission line protection can be properly designed. With a modest to large number of wind plants, likely concentrated in a single region, careful assessments of system protection will be necessary, for which understanding of the contributions from wind plants is a pre-requisite.

5.4. COMMUNICATIONS INFRASTRUCTURE FOR MANAGING WIND GENERATION

Most wind plants connected to the bulk power system are of significant size, and therefore visible to system operators. Consequently, communication and some types of control are required to achieve necessary levels of interoperability.

Wind plants constructed over the past decade contain a surprising, to those in the utility industry, amount of internal information technology for data collection, communications, and control. Most plants have a high-bandwidth fiber optic connection from each wind turbine to a main control center. Large amounts of data are collected at very frequent intervals to support functions such as power curve verification and maintenance monitoring. Increasing turbine capabilities are being leveraged by this communication infrastructure to achieve advance levels of performance such as ramp rate control, smart curtailment, and voltage control.

A number of vendors have serviced the wind plant SCADA market over the past two decades, most with proprietary and turn-key systems.

Now that wind generation is a noticeable player in the bulk electric generation picture, the information previously confined to the internal plant IT infrastructure and used almost exclusively for proprietary purposes is of much greater interest to the outside world, namely the operators of the bulk transmission system and wholesale energy markets. How the subset of information that should be shared might be accessed is the relevant question.

Communications for electric utility applications has undergone a very substantial transformation over the past twenty years, and has lead to the development of international standards the promise a new generation of interchangeable pieces and parts that speak a common language.

The legacy development of wind turbines in Germany and Denmark, where individual or small clusters of turbines are connected to public distribution networks and therefore nearly invisible to bulk system operators, inspired a movement to develop a wind energy specific communications standard that builds on the developments mentioned above. The result is the IEC 61400-25 series of standards (Figure 39), each known under the general title "Communications for Monitoring and Control of Wind Power Plants". Key features of the standards series include:

- The standard addresses all communication means between wind power plant **components** such as wind turbines and **actors** such as SCADA systems and dispatch centers.
- Applies to any wind power plant operational concept, i.e., both in individual and integrated operations.
- The application area of IEC 61400-25 covers all components required for the operation of wind power plants including the meteorological subsystem, the electrical subsystem and the wind power plant management system.

IEC 61400-25 defines how to

- model the information,
- perform information exchange,
- map specific communication protocols stacks, and
- perform conformance testing.

The wind power plant specific information given in IEC 61400-25 is built on the common data classes specified in the IEC 61850 series of standards. The standard excludes a definition of how and where to implement the communication interface and thereby enables any topology to be applied.   Specific advantages in application of the standard are that it:

- Provides a uniform communication platform for monitoring and control of wind power plants
- Is compliant with ICCP (Inter-Control Center Protocol)
- Minimizes the communication barriers arising from the wide variety of proprietary protocols, data labels, data semantics etc.
- Provides the ability to manage different wind power plants independently of vendor specific SCADA systems
- Enables components from various vendors to easily communicate with other subsystems
- Is more efficient handling and presentation of information from wind power plants
- Maximizes scalability, connectivity, and interoperability in order to reduce total cost of ownership or cost of energy
- Is a common solution within the wind power area secures availability of products and competence at a lower cost

The standard is designed to support a range of current day applications and provide a platform for future applications not yet defined.

The IEC 61400-25 standards are relatively new, and to the project team's knowledge have yet to be adopted by a RTO or ISO in the U.S. However, at a Wind Generation Forecasting Workshop hosted by the Utility Wind Integration Group in February of 2009, it was indicated by two major vendors in presentations to be a key piece of their EMS platform architecture going forward.

The application of IEC 61400-25 is farther along in Europe. Distribution system connection of wind generation has been a major driver. A majority of the wind generation installed in Germany, for example, is comprised of individual or small groups of turbines connected to the public distribution network. They are mostly invisible to the German grid operators. The IEC 61400-25 standards provide a means for grid operators to communicate directly with individual turbines that comply with the standard.

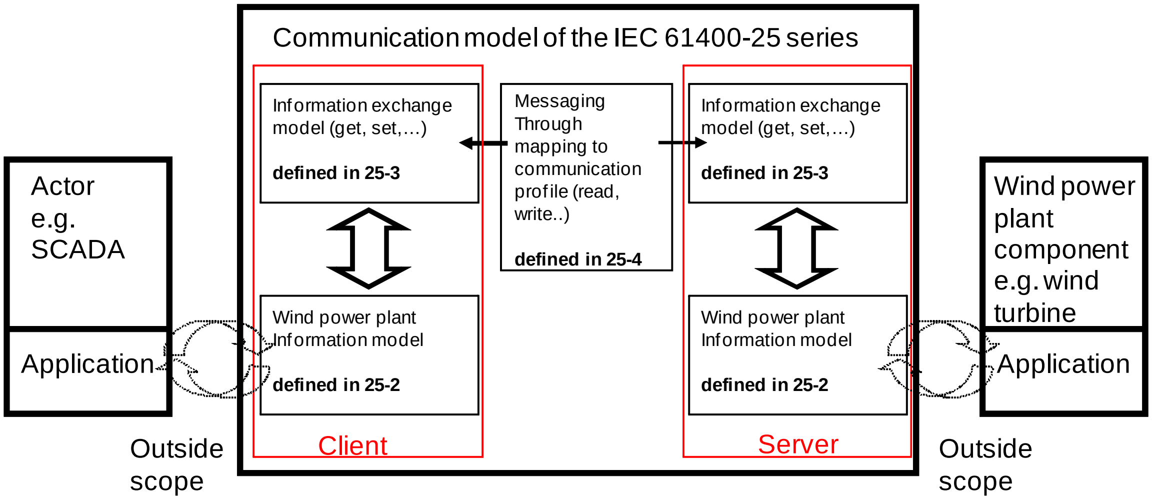

Figure 39: IEC 61400-25 communication model. Actors can include power system control centers and wind generation forecasting systems.

5.5. Operational Considerations for Distributed Wind Generation

Wind generation connected at the distribution system level is generally "invisible" to bulk system operators, but can have impacts if the penetration is large enough on a system or regional level.

The experience in Germany is especially relevant here. The favorable in-feed tariff established by law stimulated the installation of thousands of MW of individual and small groups of wind turbines connected to the public distribution network. Each of these turbines operated autonomously, but the aggregate impact was substantial. As the penetration increased, German grid operators became acutely aware of these impacts when transmission faults lead to the loss of significant amounts of production since turbines at the time were not capable of riding through low voltage events. Bulk system load forecasts became increasingly poor since the aggregate production could not be accounted for. Years of work are now providing solutions, but the situation remains the best illustration of the difficulties associated with substantial distribution system connected generation of any type.

Installations at the distribution level cannot be managed in the same way as bulk wind plants. It is critical for operation of the bulk system, however, to know as best as possible the number of installations, the total capacity by bulk system bus, and the specific geographic location of the individual units. In addition, some knowledge of status is also desirable, but may be difficult to obtain without real-time communications to each unit.

At present, the major bulk system concerns associated with distributed generation are forecasting the aggregate production (possibly by region) and knowing the potential loss of generation for transmission system faults that are observed at the terminals of the individual units.

Provided that status information is available and up-to-date, it should be possible for the bulk system forecasting agent to develop an approximate forecast of production by bulk system bus.

Such forecasts would likely be somewhat less accurate than those for bulk plants, but still reduce the error in the aggregate wind generation forecast.

The sensitivity to bulk system events, especially faults, derives mostly from the assumption that the individual units comply with IEEE 1547, which requires that the units shut down and disconnect from the grid in the event of a voltage disturbance at their terminals. With knowledge of the location and size of the individual generators, bulk system fault studies could be performed to assess the loss of potential distributed generation. The "zone of influence" concept use in voltage sag assessments could be employed here. While not precise, such an approach would at least make some provision for this potentially important bulk system impact.

5.6. ASSESSING WIND PLANT CONTRIBUTIONS TO GENERATION ADEQUACY

Maintaining high levels of electric power system reliability requires that sufficient supply capacity be available to meet demand. Because of lead times associated with the permitting, designing, and constructing new generation resources, planners must look into the future when making this evaluation, using forecasts of future electric demand.

In addition, it must be recognized that individual generating units are not perfectly reliable, and instead are subject to both planned and unplanned outages. The probabilistic nature of both load forecasts for a future year and the likelihood that existing or planned generating units would not be available due to outage necessitates the use of statistics in rigorous assessments of power system reliability.

Perfect reliability would be infinitely expensive, so target reliability levels have been traditionally used to gauge the adequacy of a resource plan for a future year.

Wind generation is primarily a source of electric energy, not capacity. However, because the principal objective of power system planning, engineering, and operations is to assure the necessary high level of system reliability, capacity is a central concept in all of these aspects.

While wind turbines and plants have very high availability, the supply of fuel for driving the turbines is subject to meteorology. Nonetheless, it can be shown by any of the traditional analytical approaches used to measure the contribution of a supply resource to system reliability that the capacity value of wind generation is something greater than zero.

5.6.1. General Approaches for Quantifying System Reliability

LOLP (Loss-of-Load Probability) is the predominant metric in the electric utility industry for assessing the long-term reliability of the bulk power system. It measures, using statistical techniques and calculations, the chance that a projected load on a power system is expected to be greater than the available supply capacity. By securing or building adequate resources - actual generating units, firm capacity imports, interruptible load, etc. – the LOLP of the system can be maintained at or below an acceptable level.

Methods for computing system LOLP take into consideration the historical reliability of specific generating units and de-rating, the nature of load patterns throughout the year or years evaluated, limits on capacity imports from external areas, and energy limitations in certain supply resources like hydro generation.

LOLP is used to characterize the reliability of the bulk power system (BPS), although it does not usually take into consideration specific elements of the transmission network. However, assuming that contingencies are appropriately considered in the design and operation of the transmission system, LOLP will be an indication, though not perfect, of BPS reliability.

In practice, other metrics are used for gauging reliability. Reserve margin - the excess (expressed as a percentage) of total accredited generation capacity over expected load - is another commonly-used to indicate system reliability. In some cases, the required reserve margins are determined from a more detailed LOLP analysis.

5.6.2. Considering Wind Generation in Reliability Evaluations

How wind generation fits into the traditional templates for measuring resource adequacy has been a topic of research and discussion for over 20 years. The National Renewable Energy Laboratory has conducted research into expanding traditional methods for assessing reliability to include consideration of wind generation. Numerous reports and technical papers have been written on the topic ([2][3][4])

Until about ten years ago, the subject was relatively academic, as the total installed capacity of wind both across the country and in any individual operating area was negligible in this regard. In addition, the capacity value question was relatively unimportant, since most wind generation facilities delivered energy under a power purchase agreement to utility purchasers.

The capacity value question did arise, however, in the context of accredited generation capacity for those utilities purchasing wind generation. In many reserve sharing groups, accredited capacity is the metric by which reserve obligations are allocated amongst the participants. Historically, energy-limited resources such as run-of-river hydro were assigned capacity value based on historical energy deliveries during system peak periods. The philosophy behind such accreditation methods was extended to cover wind generation in some reserve sharing groups. The lack of significant historical operate data was an immediate challenge, however.

Such methods have become relatively common in practice. Figure 40 shows daily windows used by various entities in the U.S. to gauge the capacity contribution of wind generation. The windows vary by time of day and season, consistent with the load characteristics in the region.

The peak period methods have some disadvantages. First, they consider only the peak hours, when there may actually be other hours in the year, say during planned maintenance outages of large baseload generation, where the system could be vulnerable. Second, they require an extensive history of production data to achieve a “convergence” in the capacity value, since significant inter-annual variations have been observed to be relatively common. . A variation of this method which considers the wind operation during the top X% of hours has similar advantages and disadvantages. Although the method is easy and straightforward it requires prior knowledge of the hourly load profile in addition to the wind profile. The appropriate percentage also seems to vary year to year from as low as 5% up to 20%. [3] In addition, it also tends to focus only the very highest load hours irrespective of system conditions.

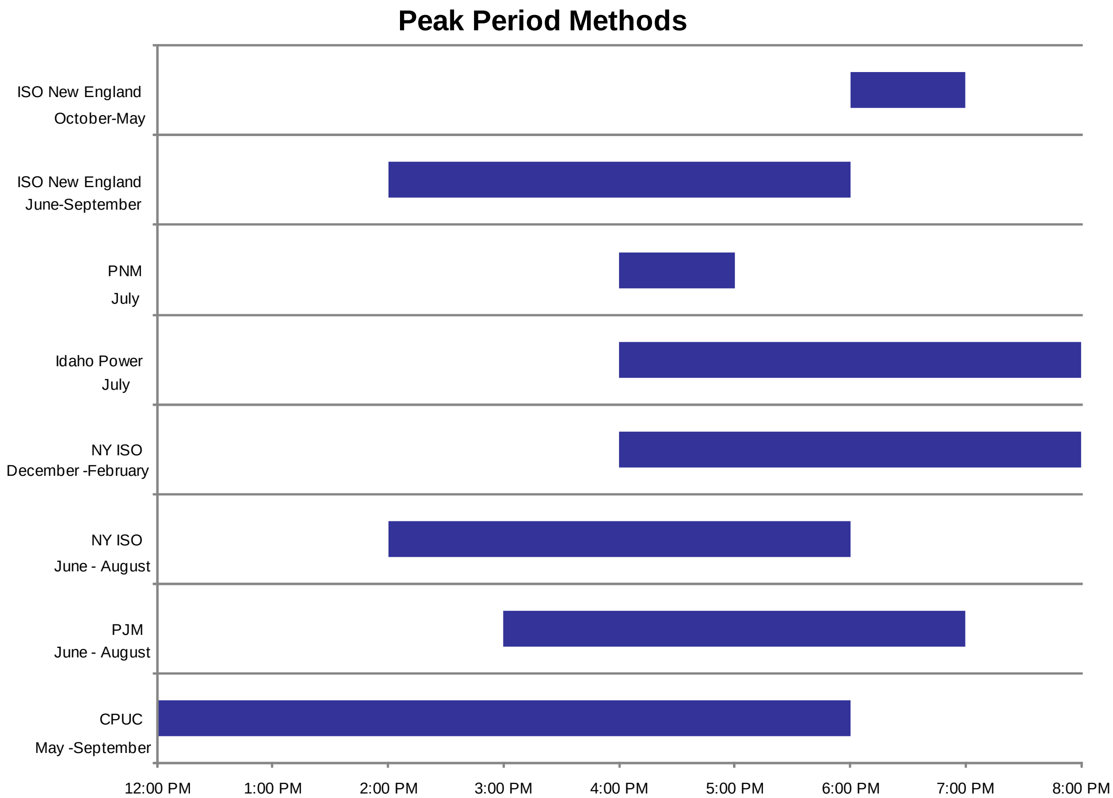

Figure 40: Summary of peak periods used in U.S. to determine wind generation capacity value. (Reference [2])

Many of the wind integration studies conducted over the past ten years have included in their scope an examination of wind generation capacity value. In these studies, the general approach has been to employ rigorous statistical techniques to calculate the change in system LOLE when wind generation is added.

Figure 41 depicts this basic method. Using chronological load profiles for a year or number of years, the LOLE is calculated without wind generation. In some cases, the amount of capacity in the study years is adjusted so that the baseline LOLE without wind generation is at the desired level, usually 1 day in 10 years. Wind is then introduced as a load modifier by simply subtracting the hourly aggregate wind generation from the corresponding load at that hour. The LOLE calculation is then re-run.

Most programs adjust the peak load around the forecast value to produce a series of LOLE results. When this is done with wind generation, a second curve is created. The Effective Load Carrying Capability (ELCC) of wind generation is defined as the incremental load serving capability at the target reliability level.

Although the computational techniques are rigorous, there are a number of shortcomings with their application to wind generation. The most significant of these is the amount and nature of chronological data required to produce a high-confidence result. Inter-annual variability will affect the ELCC calculation as well. Secondly, both wind and load have a common meteorological driver. Therefore, the hourly profiles of load and wind generation must be drawn from the same historical year to preserve any embedded correlations due to weather. Because these calculations are almost always focused on a future year, the procedure used to scale historical hourly load profiles to reflect expected load in a future year is not a precise science. Finally, availability of adequate historical wind profile data is always an issue. Many integration studies (including the Eastern Interconnection Wind Integration and Transmission Study and the ISO-NE wind integration study begun in 2009) utilize mesoscale atmospheric simulations to re-generate data of sufficient resolution for historical years. This data has been utilized for ELCC evaluations, but in general only two or three years of data are available, which can result in widely-varying estimates of annual ELCC for wind generation.

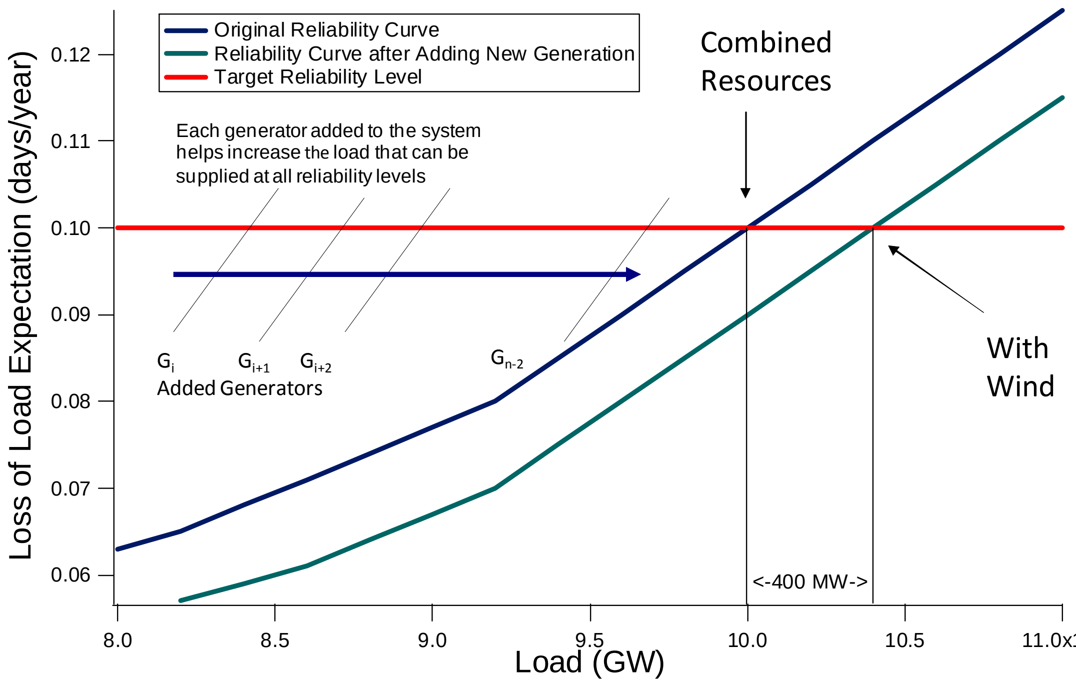

Figure 41: ELCC concept, where increase in peak load that can be served at target reliability level is assigned as the effective capacity of the resource added.

It has been suggested that at least ten years of historical data would be necessary to increase the confidence in the range of annual results. A rolling period of a decade would encompass many of the major weather drivers such as El Nino and La Nina that have recently received much greater attention. Hydro-electric utilities routinely maintain even longer data sets (e.g. 50+ years) as the basis for planning.

The recently-published report from the NERC Integrating Variable Generation Task Force weighs in on this issue. From the report:

> ***NERC Action:*** Consistent and accurate methods are needed to calculate capacity values attributable to variable generation. The NERC Planning Committee should direct the Reliability Assessment Subcommittee to collect the capacity value of variable generation based on their contribution to system capacity during high-risk hours, when performing its seasonal and long-term reliability assessments. As additional data becomes available

(i.e. involving multiple years of hourly-resolution variable generation output data from specific geographic locations and time-synchronized with system demand), NERC should consider adopting the Effective Load Carrying Capability (ELCC) approach.

5.6.3. Perspective on Methods for Determining Wind Generation Capacity Value

Assessments of wind generation capacity value have been part of the scope for many of the wind integration studies conducted over the past decade. From these studies and subsequent discussions, an informal consensus has emerged regarding the appropriateness of the various analytical methods used.

Determining wind generation ELCC from a rigorous LOLE analysis is considered to be the most accurate analytical methodology since it takes into consideration the characteristics of the remainder of the supply portfolio as well as the risk to the system during all hours of the period studied, not just the peak hours. In practical applications, the limited data sets available are recognized as a significant shortcoming. There are ways, however to extend the data set, and it is possible that NREL will be doing just that with the meso-scale data set that underlies the ISO-NE 2009 Wind Integration Study.

Historical performance is seemingly the "gold standard" with respect to characterizing the capacity value of wind generation. The obvious challenge at the present is that this history is quite sparse. So, while more rigorous methods such as LOLE do provide a more comprehensive view of reliability attributes of a given system, the results are only as good as the input data. In the case of hourly wind production data, the input data is insufficient at the moment for production high-confidence results. Going forward the project team believes that a mixture of rigorous calculation and extensive historical data production data will be the pillars upon which the methodologies of the future will rest.

5.7. References

[1] IEA Annex 25: "Design and Operation of Power Systems with Large Amounts of Wind Power - State-of-the-Art Report" BTT Working Papers 82, October 2007

[2] Milligan, M., and Porter, K.: "Determining the Capacity Value of Wind: An Updated Survey of Methods and Implementation" Conference Paper NREL/CP-500-43433, June, 2008.

[3] Kueck, John, and Kirby, Brendan: "Measurement Practices for Reliability and Power Quality" ORNL/TM-2004/91, prepared for the U.S. Department of Energy, June, 2004

[4] Kara Clark, Gary A. Jordan, Nicholas W. Miller, Richard J. Piwko "The Effects of Integrating Wind Power on Transmission System Planning, Reliability and Operations" (2005, March.). Available: http://www.nyserda.org/publications/wind_integration_report.pdf

Appendix C

GE Energy

Summary of Commercially Available Photovoltaic Inverters with Claimed Voltage Ride-Through Capability

Prepared for:

California ISO

June 30, 2010

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2. Assumes any liabilities with respect to the use of or for damage resulting from the use of any information, apparatus, method, or process disclosed in this report.

1. INTRODUCTION

CAISO is proposing requirements for all asynchronous generation to have the ability to ride through low-voltage disturbances. Presently, transmission-connected wind generation is already required by FERC Order 661a to have this capability. In order to determine the practical feasibility for solar photovoltaic (PV) facilities to also achieve low-voltage ride-through (LVRT) capability, CAISO requested GE Energy Applications and Systems Engineering to assess the availability of PV inverter equipment that has LVRT capability. This assessment was performed by a review of the claims made by major PV inverter manufacturers in their websites. The detailed results of this survey are provided in Section 3 of this report.

2. CONCLUSIONS

Seven major PV inverter vendors have been identified as claiming that one or more of their inverter products achieve a fault ride-through, low-voltage ride-through, or simply “ride-through” capability. The marketing information does not reveal the details of this capability, but it is implied that the ride-through capability is stated in reference to grid code requirements that have been enacted in Europe, which are generally more stringent than has been required of wind generation in the US by FERC Order 661a.

3. DETAILED SURVEY RESULTS

Vendor: **ABB**

Model: PVS 800

Web Link:
http://www05.abb.com/global/scot/scot351.nsf/veritydisplay/1c7b1207b807931cc12576ba0026fdd7/$File/14856%20Solar_inverters_PVS800_leaflet_0000057380_EN_RevC_lowres.pdf

Quotation or claim from website:

> “Product compliance
>
> Safety and EMC: CE conformity according to LV and EMC directives
>
> Grid compliance: According to country requirements: VDE, RD, DK, CEI
>
> Grid support: Reactive power compensation, Power reduction, Low voltage ride through”

Vendor: **General Electric**

Model: 600KW Solar Inverter

Web Link:
http://www.ge-energy.com/prod_serv/products/solar/en/downloads/GEA17910_SolarInverterBrochure.pdf

Quotation or claim from website:

"Solar RIDE-THRU" Fault ride through capability

SolarFREE" Reactive power control capability, even at zero active power.

GE's system provides the following capabilities similar to those of a conventional power plant:

- Voltage/PF control: Regulates VARs, reduces voltage variations at point of interconnect (POI)
- Power curtailment: Regulates active power at the POI
- Over frequency droop: Reduces active power in response to frequency increase
- Ramp rate control: Controls MW/sec of generation change
- Start-up/shut-down: Avoids addition or removal of large blocks of power into/out of the grid at once"

Vendor: **SatCon**

Model: Solstice

Web Links:

http://www.satcon.com/downloads/Satcon_PowerGate_Plus_100kW_Solstice_System.pdf

http://www.solardaily.com/reports/Satcon_Powers_Hawaii_Largest_Solar_Farm_999.html

Quotation or claim from website:

> "AC Side System Value
>
> - Control of real and reactive power
> - Remote system restart
> - Controllable ride-thru
> - Dynamic VAR generation
>
> \- Simplified Utility SCADA system"

Vendor: **Siemens**

Model: Sinverter PVS

Web Link:

http://www.siemens.com/press/pool/de/pressemitteilungen/2010/industry_automation/IIA2010052281e.pdf

Quotation or claim from website:

> "The new Sinvert PVS inverter series can be easily integrated into Scada systems through standardized communication interfaces. A pixel-graphics display with touch screen enables user- friendly local operation of the inverters and visualization of the performance data. The new devices comply with the medium-voltage guidelines of the German Association of Energy and Water Industries with all requirements including FRT (Fault Ride Through) and active power control."

Vendor: **SMA**

Product: Sunny Central

Web Link:
http://www.sma.de/en/products/knowledge-base/sma-inverters-as-grid-managers.html

Quotation or claim from website:

> “3. Dynamic Grid Support with the Sunny Central HE Family…
>
> …With the dynamic grid support, the inverters will have to feed in a short circuit current when the brief disruption occurs. For the so-called “Fault Ride Through” (FRT) event, the exact voltage limits are defined, and if it falls below this limit, the units will be tripped offline…”

Vendor: **SunPower**

Model:Oasis

Web Link:

http://us.sunpowercorp.com/utility/products-services/products/oasis-power-block.php

Quotation or claim from website:

> “Smart Inverter:
>
> > With advanced plant controls, the standardized Oasis inverter features voltage ride-through, curtailment control and dynamic power factor adjustment, enhancing grid interoperability for PV power plants”

Vendor: **Xantrex** (subsidiary of Group Schneider)

Model: GT500E

Web Link:

http://www.xantrex.com/web/id/150/p/1/pt/23/product.asp

Quotation or claim from website:

> "The Xantrex GT500E Grid Tie Inverter is based on a reliable platform that is used in grid-connect photovoltaic and wind turbine applications in North America and Europe. Easy to install and operate, the GT500E automates start up, and shut down. It incorporates advanced Maximum Power Point Tracking Technology to maximize the energy harvested from a PV array. To minimize power losses during the conversion process, the inverter's switching technology uses insulated gate bi-polar transistors. Multiple inverters can be paralleled for large power installations. Designed for European PV installations, the GT500E meets all applicable CE requirements. Key features include low voltage ride through and reactive power control."

Attachment E

Prepared Testimony of Nisar Shah and Appendix A to Testimony

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

California Independent System Operator Corporation	))))	**Docket No. ER10-______**

Prepared Testimony of Nisar Shah

I. Introduction and Overview

Q. What is your name?

A. Nisar Shah

Q. By whom are you employed?

A. I am employed by the California Independent System Operator Corporation (ISO) as a Senior Regional Transmission Engineer.

Q. Could you please describe your professional background?

A, I have a Masters of Science degree in Electrical Engineering with emphasis in power systems. I am also a registered professional engineer in the State of California. I have over 30 years of professional experience in the electric industry most of which is in the area of power system planning, including approximately five years in power system protection.

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to explain the purpose of reactive power in connection with the ISO's operation of the transmission system under its control and why it is appropriate to require all asynchronous generating facilities seeking to interconnect to the ISO controlled grid to provide reactive power to support voltage control.

II. Description and Purpose of Reactive Power

Q. Please explain the term reactive power?

A. Electric power that flows on to transmission and distribution lines is composed of two components: real power and reactive power. Real power is measured in Watts (W) and reactive power is measured in Volt Amp Reactive (VAR). More commonly used units are kilowatts (kW) or megawatts (MW) for real power, and kilovar (kVAR) or megavar (MVAR) for reactive power. Real power does the actual work such as keeping the lights on or running an air conditioner. Reactive power, on the other hand, maintains voltage levels to allow real power to do its job. Both real and reactive power work together in an Alternating Current (AC) electric system.

Q. Please describe the importance of reactive power in the electric system.

A. Reactive power is an essential component of alternating current electric power. It is needed to maintain magnetic fields in electric transformers and induction motors. Transformers step-up or step-down voltages from one level to another through this magnetic field. Induction motors operate as a result of rotating fields (magnetic flux) created by reactive power. Reactive power is also a vital component to preserve and improve voltages in the transmission and distribution system.

Q. What are the consequences, if any, of not having sufficient reactive power on the electric system?

A. Electric generators are the primary source of reactive power on the transmission system. If electric generators do not supply sufficient reactive power to the interconnected grid for whatever reason, the electric grid may come to a standstill. The Northeast blackout that occurred August 2003 resulted from a severe shortage of reactive power, which triggered outages of power plants and transmission lines that, in turn, further decreased reactive power supply and deteriorated voltages thereby ultimately causing a blackout.[1] The PJM system came close to a voltage collapse in 1999 as a result of reactive power problems.[2] The blackout in the western United States in the summer of 1996 was also the result of significant voltage drops related to reactive power shortages.[3] While these examples reflect severe consequences, they remain an unacceptable possibility if there is insufficient reactive power supply. In addition to severe consequences, a lack of reactive power can create instability issues at a localized level requiring a transmission operator to disconnect portions of the electric grid in order to avoid cascading problems.

Q. From a planning perspective why, if at all, must a transmission operator ensure there is a sufficient supply of reactive power?

---

1 http://www.nerc.com/filez/blackout.html, see chapter 2, page 17

2 http://www.nerc.com/page.php?cid=5|66, see 1999 System Disturbances, page 15

3 http://www.nerc.com/page.php?cid=5|66, see 1996 System Disturbances, page 22

A. Abundant supply of reactive power not only ensures integrity of the electric system, it also ensures compliance with NERC and WECC reliability standards (TPL-001 through TPL -004, VAR-001 and VAR-002). These standards require adequate reactive power supply to maintain acceptable system performance under all projected customer demand levels and under all potential contingency conditions.

Transmission Planning Standard TPL-002, for example, under requirement 1.3.9 states that studies should "include Reactive Power resources to ensure that adequate reactive resources are available to meet system performance".

Voltage and Reactive Control Standard VAR-001, requirement R2 states, "[e]ach Transmission Operator shall acquire sufficient reactive resources within its area to protect voltage levels under normal and contingency conditions. This includes the Transmission Operator's share of the reactive requirements of interconnecting transmission circuits."

WECC Planning Standards (Table W-1) require maintaining voltage deviations to within 5% for single contingencies and within 10% for double contingencies.

ISO operators have to comply with the above NERC and WECC standards at all times, while also handling the real time emergencies not necessarily anticipated by planning studies. Having sufficient reactive power capability at hand simply ensures that the system can be operated reliably even when unanticipated contingencies occur during the daily load cycle.

Q. From an operating perspective why, if at all, must a transmission operator ensure there is a sufficient supply of reactive power?

A. Generators with reactive power “boosting” capability help sustain robust transmission and distribution voltages under heavy load conditions. Generators with reactive power “bucking” capability help control voltages from getting too high during light load conditions (*e.g*. in middle of the night). Transmission operators use this reactive power supply and absorption capability to regulate voltages on various buses in the system during the daily load cycle.

Q. Why, if at all, must asynchronous generating facilities supply reactive power?

A. Asynchronous generating facilities are primarily wind and solar generating facilities. Once this renewable generation interconnects to the ISO system and becomes operational, the ISO will be required to back down or not dispatch existing conventional generation to maintain load- generation balance assuming the objective is to maximize energy from renewable resources to comply with California’s renewable portfolio standard (RPS) targets. The ISO will accordingly lose a portion of the reactive power supply provided by the displaced conventional generators. Renewable resources must operate to maintain the same level of reactive power supply in the system. The ISO does not know which renewable generator will replace which conventional generator during the course of any operating day. It is therefore prudent to require renewable generators interconnecting to the ISO system to include reactive power capabilities, so they can contribute to grid reliability at least in the areas of reactive power control and voltage regulation.

III. Recent ISO interconnection studies and conclusions

Q. What studies, if any, has the ISO completed that demonstrate the need for renewable generators to provide reactive power?

A. As part of a recent system impact study of solar projects in the Carrizo Plains, which is part of the transmission system owned by Pacific Gas and Electric Company, the ISO identified that this area may experience a voltage collapse following a double contingency, if no additional reactive power is available. The ISO determined that if solar projects in this area are equipped with + 0.95 power factor capability, the projected voltage collapse is largely avoided. The ISO is currently preparing a report on the Carrizo Plains interconnection study that will require the interconnection customers to provide reactive power.

A similar study of wind projects in Tehachapi area, which is part of the transmission system owned by Southern California Edison, concluded that wind projects must have + 0.95 power factor capability to avoid generation dropping under certain contingency conditions. A copy of that study report is attached to my testimony as Appendix A

IV. Shortcomings of system impact studies as a tool to project reactive power needs beyond 5 years

Q. What conditions make it necessary to require all asynchronous generating facilities to provide reactive power?

A. A significant number of conventional resources in California may face retirement in the next 1- to 15 years as a result of reaching the end of their useful life or having to comply with state environmental policies such as water quality policies governing the use of coastal or estuarine waters for power plant cooling. These generators are among today's major fleet of real (MW) and reactive power (MVAR) resources to maintain robust voltages on the ISO controlled grid.

California's aggressive RPS aims to provide 33 percent of power deliveries from renewable resources by the year 2020 and future years. This requirement will necessarily displace other conventional generators that can provide reactive power. These renewable resources, especially solar technologies, will aggressively compete with existing conventional resources during peak load conditions. It is this time of the day when reactive power support is needed the most to sustain satisfactory voltages on the grid under normal as well as under contingency conditions. When new renewable resources displace existing conventional resources reactive power support must now come from the renewable resources. Any compromise in this area would mean operating the grid with less reactive capability and thus putting the system at risk under major disturbances. The ISO expects a significant reactive power deficiency will likely arise unless it requires renewable resources to provide adequate reactive power capability.

Q. If the ISO can identify reactive power needs through system impact studies, why is it necessary to require all asynchronous generating facilities to provide reactive power?

A. While system impact studies may at times identify the need for reactive power capability from individual generating facilities, they are insufficient to assess system needs 10 or more years from now. System impact studies generally look five years into the future. Ten year studies are also performed, but those are for screening purposes or for reliability standard compliance purposes only. Five year look-ahead studies only model generation resources and associated network upgrades that are expected to be in service within the next five years.

Results of a five year study, although relatively accurate, provide transmission operators only short term solutions. While the electric grid may remain strong over the next five years, as the electric demand increases, aging conventional plants start to retire, and a large number of renewable resources interconnect to the electric system, the reactive power requirements of the grid will change significantly. System impact studies do not accurately capture these long term changes and corresponding impacts.

Long term system impact studies (10 years or longer), suffer from other flaws because too many uncertainties exist, including accuracy of future load forecast, projected network upgrades, amount of new generation, location and size of new generation, and future technologies. Each of these uncertainties can have significant influence on study results. In the interest of maintaining grid reliability for a broad range of possible future system conditions, it is prudent to require all renewable resources interconnecting to the ISO controlled grid to provide adequate reactive power capability.

I declare under penalty of perjury that the foregoing statements are true and correct to the best of my knowledge, information, and belief.

Executed this 1st day of July, 2010 in Folsom, California

[signature]

Nisar Shah

Appendix A

PACIFIC WIND, LLC
PACIFIC WIND GENERATION PROJECT

TEHACHAPI QUEUE CLUSTER WINDOW
SYSTEM IMPACT STUDY

September 24, 2007

SOUTHERN CALIFORNIA
EDISON
An *EDISON INTERNATIONAL*[SM] Company

Prepared by

Jorge Chacon

Southern California Edison Company

Steven E. Mavis
Manager, Generation
Interconnection Planning

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September 24, 2007

I. INTRODUCTION

Southern California Edison Company (SCE) has performed a number of studies, as requested by Pacific Wind, LLC to identify the impacts associated with interconnection of a new 255 megawatt (MW) wind generation project referred to as the Pacific Wind Generation Project (Pacific Wind Project). The Pacific Wind Project consists of one hundred and seventy individual wind generation turbines. An initial System Impact Study was completed and provided to the CAISO for initial review prior to submitting to project developer when a 200 MW project ahead in queue withdrew their application. As a result, the CAISO indicated that the initial System Impact Study report should be revised prior to releasing to project developer. Consequently, a restudy effort was going to be commenced to evaluate effects of the queued ahead project withdrawal but the effort was placed on hold while studies to assess, on a regional basis, three major transmission expansion projects that directly affect the required transmission for the Pacific Wind Project were completed through the CAISO South Regional Transmission Plan (CSRTP) for 2006. In particular, the required studies involved the review of and modification to the transmission plan of service developed by the Tehachapi Collaborative Study Group[1] (TCSG) for integrating up to 4,500 MW of total area generation.

Upon completion of all studies necessary to support the development of a transmission plan of service which thermally accommodates up to 4,500 MW of total area generation, the CAISO filed a request for a one-time waiver of the CAISO Open Access Transmission Tariff (OATT). This request was made in order to change the established 180-day Queue Cluster Window to conduct a clustered Interconnection System Impact Study (ISIS) of the Tehachapi Wind Resource Area (TWRA)[2]. The CAISO also requested a waiver of the 180-day advance notice on its website of a change to the established opening and closing dates of the Queue Cluster Window. The request for the creation of a Queue Cluster Window for projects requesting interconnection in the TWRA between September 4, 2003 and May 24, 2006, which includes the Pacific Wind Project, was approved by FERC[3] on March 20, 2007. Consequently, this study report completes the restudy efforts for the Pacific Wind Project and provides the results in accordance with the established Queue Cluster Window.

[1] The California Public Utilities Commission (CPUC) ordered the formation of a study group to develop a rational transmission plan of service for integrating over 4,000 MW of total area generation, most of which is wind (D.04-06-010)
[2] The Tehachapi Wind Resource Area (TWRA) is located within Southern California Edison Company's service territory, in Kern County, between Bakersfield and Mohave, California.
[3] http://elibrary.ferc.gov/idmws/doc_info.asp?document_id=13507202

Please be aware that a restudy may be required to reflect the system configuration if a higher queued generation or transmission project that was modeled in the Queue Cluster Window SIS withdraws or is modified in accordance with applicable tariff allowances.

II. CONCLUSION

Power Flow Study

With both the Antelope Transmission Project (ATP) and Tehachapi Renewable Transmission Project (TRTP) in service, the Pacific Wind Project can be integrated in the system without the need for additional upgrades. However, the Pacific Wind Project will need to wait until specific TRTP upgrades are constructed and placed in-service.

Post-Transient Voltage Stability

The Queue Cluster Window Interconnection System Impact Study determined that under specific outage conditions, a Special Protection System to automatically trip generation resources may be needed. The amount of generation tripping for post-transient voltage conditions was determined to be highly dependant on the amount of power factor correction installed at each of the wind generation projects. With all TWRA Queue Cluster wind generation providing for up to 0.95 power factor correction as metered at the point of interconnect, such need is mitigated.

Transient Stability

With both the ATP and TRTP in service, the Pacific Wind Project did not result in any transient stability problems. Further, utilizing the proposed GE 1.5 MW wind generators resulted in the Pacific Wind Project meeting the required low-voltage ride-through performance criteria.

Short-Circuit Duty

The short-circuit duty study identified three 500 kV, thirteen 230 kV, and one 115 kV substation locations under the three-phase-to-ground short-circuit duty that require specific breaker evaluation for replacement. Under the single-phase-to-ground short-circuit duty, the study identified four 500 kV and nine 230 kV substation locations that require specific breaker evaluation for replacement.

Facility Study Required

Based on the results of the Tehachapi Queue Cluster Window Interconnection System Impact Study, a Facility Study will be required to:

1. Evaluate circuit breaker locations at the identified substation locations and develop cost estimates for any circuit breaker identified to require upgrade or replacement

2. Refine specific costs for required Cottonwind equipment including equipping a 230 kV gen-tie position with tie circuit breaker for the Pacific project.

3. Identify specific cost for other direct assign facilities (i.e. telecomm and system protection to support project radial gen-tie)

III. STUDY CONDITIONS AND ASSUMPTIONS

A. PLANNING CRITERIA

The Queue Cluster Window Interconnection System Impact Study was conducted by applying the Southern California Edison and California Independent System Operator (CAISO) Reliability Criteria. Specifically, the criteria applicable to this study are described below with further discussion in Attachment A – Detailed Cluster Window Study Report.

Power Flow Assessment

The following contingencies are considered for transmission lines and 500/230 kV transformer banks ("AA-Banks"):

- Single Contingencies (loss of one line **or** one AA-Bank)
- Double Contingencies (loss of two lines **or** one line and one AA-Bank)
- Outages of two AA-Banks is beyond the Planning Criteria

The following loading criteria are used:

Transmission Lines	Base Case	Limiting Component Normal Rating
	N-1	Limiting Component A-Rating
	N-2	Limiting Component B-Rating
500/230 kV Transformer Banks	Base Case	Normal Loading Limit
	Long-Term & Short-Term	As defined by SCE Operating Bulletin No.33

B. LOAD ASSUMPTIONS

To simulate the SCE transmission system for analysis, the study used databases that were used to conduct the SCE Annual CAISO Controlled Facilities Expansion Program assuming load forecast for year 2014. Additional details are provided in Attachment A – Detailed Cluster Window Study Report.

C. GENERATION ASSUMPTIONS

The Big Creek Corridor consists of diverse existing and planned generation resources as summarized below in Table 1-1 and Table 1-2 respectively. The Queue Cluster Window studies included all of these generation resources.

TABLE 1-1
BIG CREEK CORRIDOR EXISTING LOCAL AREA GENERATION

Generation Unit	Type	Size (MW)
Big Creek	Hydro	1,000
Pastoria Energy Facility and Pandol	Market	806
Antelope-Bailey 66 kV & Sagebrush Partnership	Qualifying Facility	630
Omar & Sycamore	Qualifying Facility	600
Antelope-Bailey 66 kV & CDWR	Hydro	110
Sagebrush	RPS Wind Project	65
Ultragen	Qualifying Facility	41
	Total	3,252

TABLE 1-2
BIG CREEK CORRIDOR
TEHACHAPI QUEUE CLUSTER WINDOW

CAISO Queue Position	Type	O.D	Size (MW)
CAISO Queue #20	New Wind Project	07/01/2009	300
CAISO Queue #31	New Wind Project	12/31/2009	201
CAISO Queue #34	New Wind Project	12/31/2009	300
CAISO Queue #41	Combustion Turbine	07/31/2006	159
SCE WDAT#190	Combustion Turbine	05/01/2007	50
CAISO Queue #73	**Pacific Wind Project**	12/31/2008	250
CAISO Queue #79	New Wind Project	12/15/2009	51
CAISO Queue #84	New Wind Project	12/31/2009	400
CAISO Queue #85	New Wind Project	12/31/2007	120
CAISO Queue #86 A	New Wind Project	11/01/2008	33
CAISO Queue #86 B	New Wind Project	11/01/2008	34
CAISO Queue #91	New Wind Project	03/31/2010	51
CAISO Queue #92	Combined Cycle	08/01/2010	570
CAISO Queue #93	New Wind Project	12/31/2008	220
CAISO Queue #94	New Wind Project	12/31/2008	180
CAISO Queue #95	New Wind Project	12/31/2009	550
CAISO Queue #96	New Wind Project	12/31/2009	600
CAISO Queue #97	New Wind Project	12/31/2009	160
CAISO Queue #100	Alternative to Queue #85	12/31/2007	-
		Total Tehachapi Cluster	4,229

D. PACIFIC WIND GENERATION PROJECT

The Pacific Wind Generation Project is geographically located in southern Kern County north of State Highway 138 approximately 18 miles northwest of the existing Antelope Substation. The Pacific Wind Generation Project is to be connected by a radial gen-tie (constructed, owned, maintained, and operated by the project developer) to a new SCE 230 kV substation, referred to in this report as "Cottonwind", which is to be permitted through Kern County as part of a queued ahead wind generation project (CAISO queue position No.20). The Pacific Wind Project developer proposes to utilize 170 individual GE 1.5 MW wind turbine generators (WTG) for a total of 255 MW connected by ten 34.5 kV distribution feeders to the Pacific Wind Substation as shown below in Figure 3. Note that the project developer requested interconnection for only 250 MW.

The GE 1.5 MW WTG is basically a conventional wound rotor induction (WRI) machine with the key distinction that the machine is equipped with a solid-state voltage-source converter AC excitation system. The AC excitation is supplied through an ac-dc-ac converter. This converter is connected directly at the stator winding voltage ("doubly-fed") and thus has a different behavior than either conventional synchronous or induction machines. In practice, the electrical behavior of the converter is that of a current-regulated voltage-source inverter. Similar to STATCOMs, the WTG converter synthesizes an internal voltage behind a transformer reactance (machine rotor and stator windings), which results in the desired active and reactive current being delivered to the device terminals.

Reactive power output of a doubly-fed machine can be controlled by varying the magnitude of the rotor currents. This allows the GE 1.5 MW WTG the voltage regulation capability of a synchronous generator but with greater speed of response. This control of active and reactive power is handled by fast, high bandwidth regulators within the converter controls with a time response in sub-cycles. Wind farms with GE WTGs normally include a Wind Park Management System (WPMS). The Wind Volt-Ampere-Reactive (Wind Var) control system is part of the WPMS and has the function of interacting with the individual machines through the electrical controls. The Wind VAR control system is typically structured to measure the voltage at a particular bus, often the point of interconnection with the transmission system, and regulate this voltage by sending a reactive power command to all of the WTGs. Line drop compensation may be used to regulate the voltage at a point some distance from the voltage measurement bus. Reactive power of a large wind farm to support system voltages can therefore be managed by the Wind VAR control system.

Figure 1-1 provides the single line diagram illustrating Pacific. Figure 1-2 provides the geographical point of connection relative to the TWRA. Specific electrical parameters for each distribution feeder have not been provided by the project developer. This information as well as as-built diagrams will be required prior to energizing the Pacific Wind Project.

Figure 1-1
Pacific Wind Generation Project

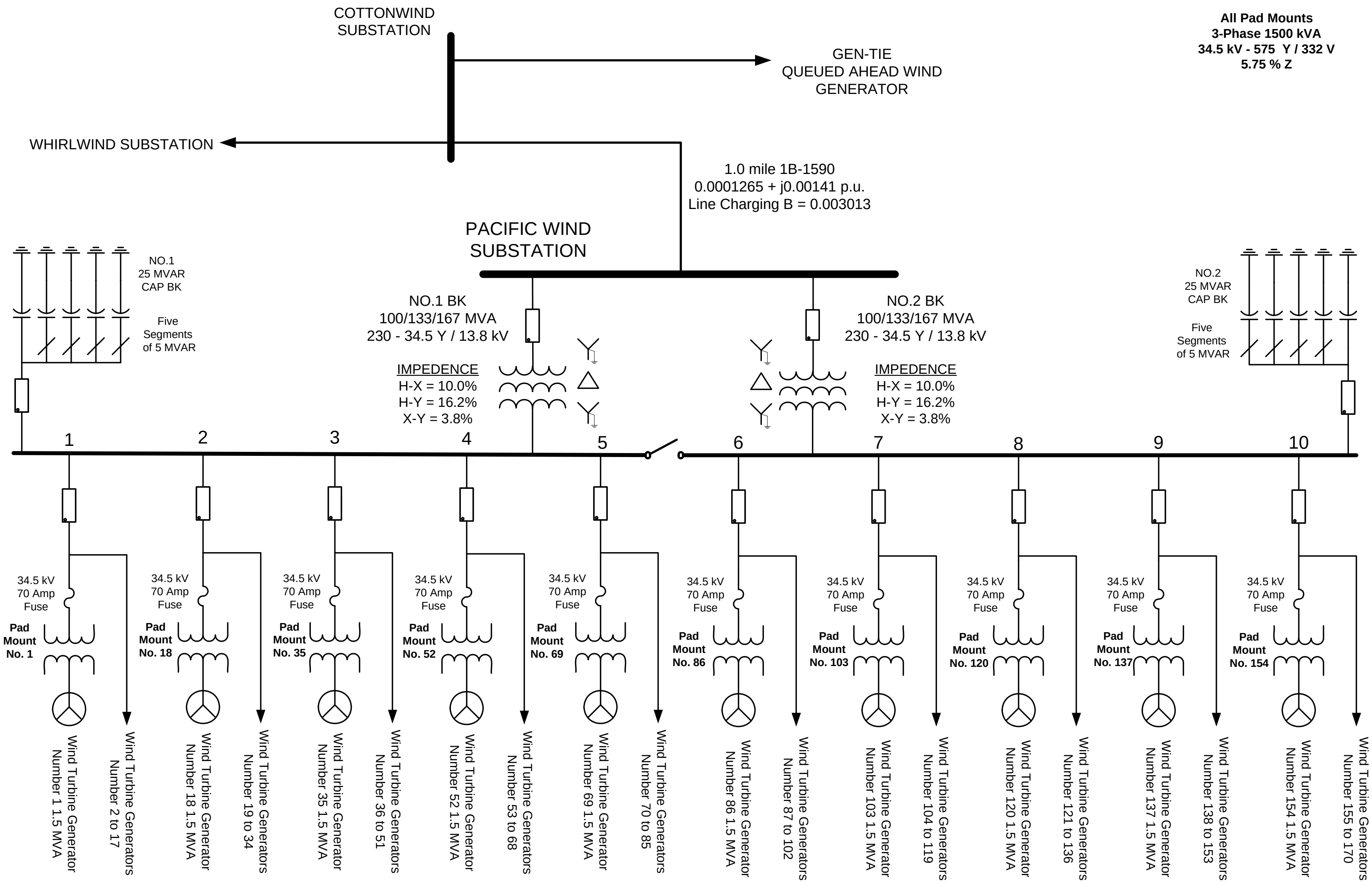
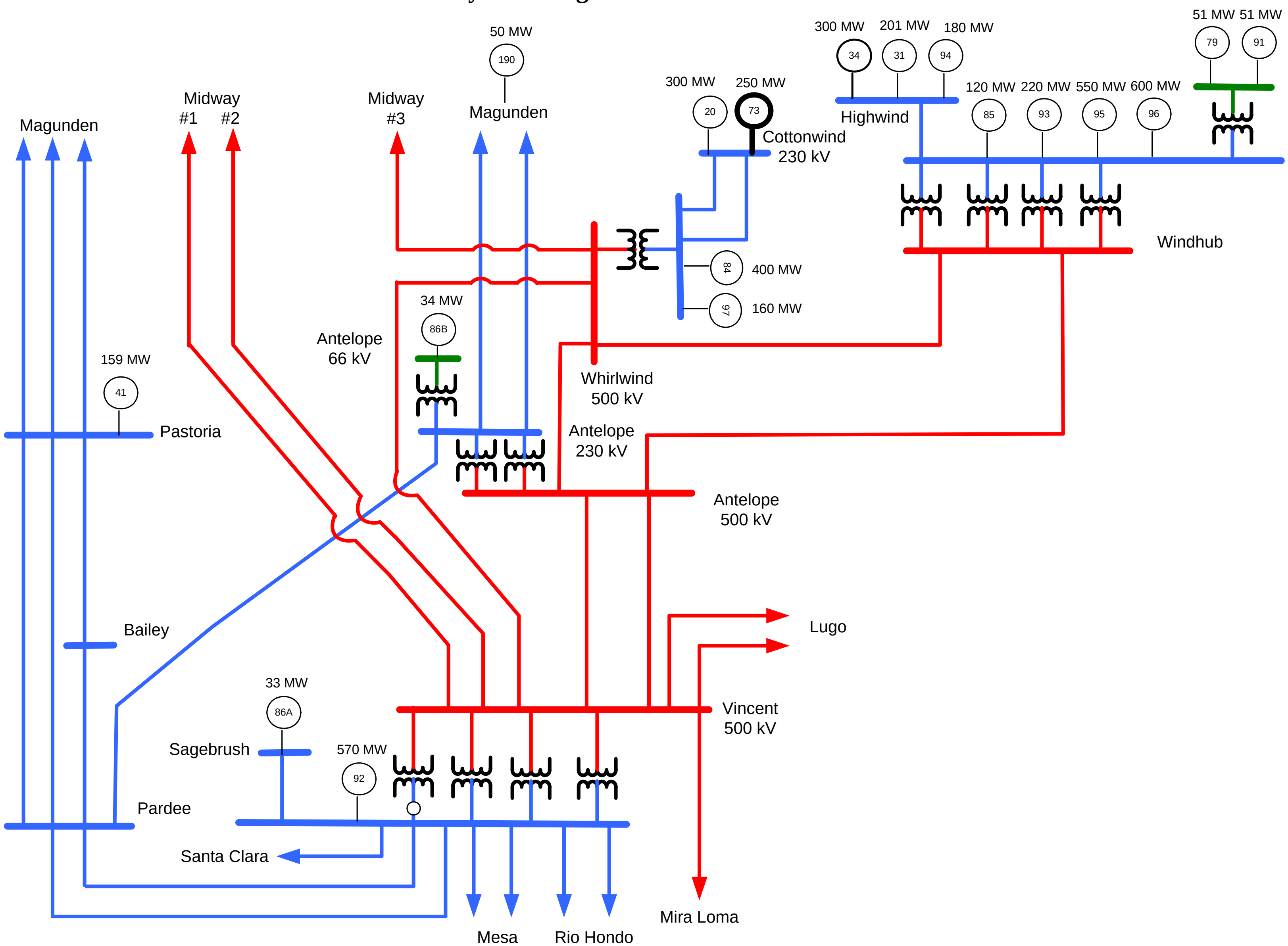


Figure 1-2
Tehachapi Wind Resource Area
System Diagram with Pacific Wind



SOUTHERN CALIFORNIA EDISON PROTECTED MATERIALS, CONFIDENTIAL: Contains Critical Energy Infrastructure Information (CEII)

E. THE ANTELOPE TRANSMISSION PROJECT

The Antelope Transmission Project (ATP) consists of new transmission between Antelope and Pardee, between Antelope and Vincent, and between Antelope and Tehachapi. The project also includes the addition of two new substations in the TWRA. Applications for Certificates for Public Convenience and Necessity (CPCN) for the Antelope-Pardee 500 kV (Segment 1), Antelope-Vincent 500 kV (Segment 2), and Antelope-Tehachapi (Segment 3) 500 kV transmission lines were submitted to the California Public Utilities Commission (CPUC) on December 9, 2004. A supplemental filing for the Antelope-Vincent 500 kV and Antelope-Tehachapi 500 kV transmission lines was submitted on September 30, 2005. The CPUC has issued approvals for these CPCN applications. SCE is currently working with the Angeles National Forest (ANF) to obtain final use permits in order to commence construction of the Antelope-Pardee transmission line. With the addition of the Antelope Transmission Project, the maximum amount of increased system capability has been identified to be 700 MW, as limited by transmission south of Antelope. The corresponding system limitations are shown below in Table 1-3.

F. THE TEHACHAPI RENEWABLE TRANSMISSION PROJECT

The Tehachapi Renewable Transmission Project (TRTP) is the final plan of service developed to interconnect new planned generation resources, above the 700 MW provided by the ATP, in the TWRA. These facilities, needed to interconnect and transmit the electrical power from the new planned generation resources, have been identified through a collaborative planning process held as part of the CAISO South Regional Transmission Plan. SCE filed for a CPCN for these facilities with CPUC on June 29, 2007. Summarized below are the major components of these facilities with the corresponding system limitations shown below in Table 1-3.

<u>Segment 4</u>

- Two new 230 kilovolt (kV) transmission lines traveling approximately 4 miles over new right-of-way (R-O-W) from the Cottonwind Substation to the proposed new Whirlwind Substation.
- A new 500 kV transmission line, initially energized to 230 kV, traveling approximately 16 miles over expanded R-O-W from the proposed new Whirlwind Substation to the existing Antelope Substation.
- New 500 kV transmission lines to loop existing Midway-Vincent No.3 500 kV line in and out of proposed Whirlwind (part of Segment 9) substation.
- Whirlwind 500/230 kV switchyard equipment required to support loop-in and lines to Cottonwind.

Segment 5

- A rebuild of approximately 18 miles of the existing Antelope – Vincent 230 kV T/L and the existing Antelope – Mesa 230 kV T/L to a second single Antelope-Vincent 500 kV T/L over existing R-O-W between the existing Antelope Substation and the existing Vincent Substation.
- Increase operating voltage of initial Antelope-Vincent 500 kV T/L

Segment 6

- A rebuild of approximately 32 miles of existing 230 kV transmission line to 500 kV standards from existing Vincent Substation to the southern boundary of the Angeles National Forest (ANF). This segment includes the rebuild of approximately 27 miles of the existing Antelope – Mesa 230 kV T/L and approximately 5 miles of the existing Rio Hondo – Vincent 230 No. 2 T/L.

Segment 7

- A rebuild of approximately 16 miles of existing 230 kV transmission line to 500 kV standards from the southern boundary of the ANF to the existing Mesa Substation. This segment would replace the existing Antelope – Mesa 230 kV T/L.

Segment 8

- A rebuild of approximately 33 miles of existing 230 kV transmission line to 500 kV standards from a point approximately 2 miles east of the existing Mesa Substation (the "San Gabriel Junction") to the existing Mira Loma Substation. This segment would also include the rebuild of approximately 7 miles of the existing Chino – Mira Loma No. 1 line from single-circuit to double-circuit 230 kV structures.

Segment 9

- Whirlwind Substation, a new 500/230 kV substation located approximately 4 to 5 miles south of the Cottonwind Substation near the intersection of 170th Street and Holiday Avenue in Kern County in the TWRA.
- Upgrade of the existing Antelope, Vincent, Mesa, Gould, and Mira Loma Substations to accommodate new transmission line construction and system compensation elements.

Segment 10

- A new 500 kV transmission line traveling approximately 17 miles over new R-O-W between the Windhub Substation and the proposed new Whirlwind Substation.

Segment 11

- A rebuild of approximately 19 miles of existing 230 kV transmission line to 500 kV standards between the existing Vincent and Gould Substations. This segment would also include the addition of a new 230 kV circuit on the vacant side of the existing double-circuit structures of the Eagle Rock – Mesa 230 kV T/L between the existing Gould Substation and the existing Mesa Substation.

G. EXISTING SPECIAL PROTECTION SYSTEMS

The existing system has several existing Special Protection Systems (SPS) for single and double element outage conditions. The relevant existing SPS that may be impacted by Pacific include the Big Creek SPS, Pastoria Energy Facility SPS, and Path 26 SPS. Additional details are provided in Attachment A – Detailed Cluster Window Study Report.

H. POWER FLOW STUDY

The Queue Cluster Window Interconnection System Impact Study considered two power flow study scenarios. Further description of the case assumptions follows:

1. SCE System under 2014 heavy summer with all currently planned transmission upgrades (ATP and TRTP) and generation projects in the Tehachapi Queue Cluster Window including the proposed Pacific Wind Generation Project, Case 1.

   The Queue Cluster Window upgraded the existing system to include the already CPUC approved Antelope Transmission Project as well as the planned Tehachapi Renewable Transmission Project. The study considered high internal generation in the SCE northern area electrical system and 4,000 MW on Path 26. Generation included: Regulatory must-take, all existing generation in the SCE Big Creek corridor, and all other proposed generation projects in Queue Cluster Window which includes the proposed Pacific Wind Generation Project. Generation patterns were maximized in the SCE northern area in order to identify extent of potential congestion.

2. Big Creek Corridor under 2014 light load with the rest of the SCE system modeled as heavy summer with all currently planned transmission upgrades (ATP and TRTP) and generation projects in the Tehachapi Queue Cluster Window including the proposed Pacific Wind Generation Project, Case 2.

   To reflect light load conditions while stressing north to south power transfers, a sensitivity case was developed which reduces loads in the area of interest. To model this condition, loads in the area of interest in Case 1 were adjusted by 50 percent while loads in the rest of the system were left unchanged.

   Additional details of both of these power flow cases are provided in Attachment A – Detailed Cluster Window Study Report.

TABLE 1-3
ANTELOPE TRANSMISSION PROJECT (ATP) AND TEHACHAPI RENEWABLE TRANSMISSION PROJECT (TRTP) TRANSFER CAPABILITIES

Segment	High Level Description	O.D.	Maximum Tehachapi Whirlwind Area Wind Generation	Maximum Tehachapi Windhub Area Wind Generation	Maximum South of Antelope Transfer Capability	Maximum South of Vincent Transfer Capability	Tehachapi Generation Delivered To Pardee, Whirlwind & Vincent	Maximum Tehachapi Generation Delivered to So. Calif.	Limitations
	CAISO Queue #20 Early Interconnection	07/09	150 MW	0 MW	150 MW	1100 MW	150 MW	150 MW	South of Cottonwind Limit (Antelope-Cottonwind Line)
ATP 1	Antelope-Pardee 500 kV and Antelope Expansion	12/08	150 MW	0 MW	300 MW	1100 MW	150 MW	150 MW	South of Cottonwind Limit (Antelope-Cottonwind Line)
ATP 2	Antelope-Vincent No. 1 500 kV T/L	1/09	150 MW	0 MW	700 MW	1100 MW	150 MW	700 MW	South of Cottonwind Limit (Antelope-Cottonwind Line)
ATP 3	Antelope-Windhub 500 kV & WindHub-Highwind 230 kV	3/09	150 MW	1100 MW	700 MW	1100 MW	700 MW	700 MW	South of Antelope Limit (Antelope-Mesa Line)
TRTP 5	Antelope-Vincent No. 2 500 kV T/L	3/11	150 MW	1100 MW	Greater than 1,400 MW	1100 MW 1250 MW W/Nomogram	1100 MW 1250 MW W/Nomogram	1100 MW 1250 MW W/Nomogram	South of Vincent Limit, N-1 Criteria at Windhub, & Early Interconnect
TRTP 4	Whirlwind 500 kV and 230 kV Transmission Elements	8/11	1100 MW	1100 MW	Greater than 1,400 MW	1100 MW 2200 MW W/Nomogram	1100 MW 2200 MW W/Nomogram	1100 MW 2200 MW W/Nomogram	South of Vincent Limit, N-1 Criteria at Windhub
TRTP 9	Increase Operation to 500 kV/Transformer Banks/Substation Equipments	8/11	1100 MW	1100 MW	4,500 MW w/ N-2 SPS	1100 MW 2200 MW W/Nomogram	1100 MW 2200 MW W/Nomogram	1100 MW 2200 MW W/Nomogram	South of Vincent Limit, N-1 Criteria at Windhub
TRTP 10	New Whirlwind-WindHub 500 kV T/L	10/11	1100 MW	3400 MW w/ N-1 SPS	4,500 MW w/ N-2 SPS	1100 MW 2200 MW (Nomogram)	4500 MW with SPS	1100 MW 2200 MW (Nomogram)	South of Vincent Limit, PG&E Import Limits May Reduce CA Delivery
TRTP 6	New Replacement Vincent-Rio Hondo No. 2 T/L	11/11	1100 MW	3400 MW w/ N-1 SPS	4,500 MW w/ N-2 SPS	1100 MW 2200 MW W/Nomogram	4500 MW with SPS	1100 MW 2200 MW W/Nomogram	South of Vincent Limit, PG&E Import Limits May Reduce CA Delivery
TRTP 7	New Vincent-Mira Loma 500 kV T/L (Vincent-Mesa Area)	4/12	1100 MW	3400 MW w/ N-1 SPS	4,500 MW w/ N-2 SPS	1100 MW 2200 MW W/Nomogram	4500 MW with SPS	1100 MW 2200 MW W/Nomogram	South of Vincent Limit, PG&E Import Limits May Reduce CA Delivery
TRTP 8	New Vincent-Mira Loma 500 kV T/L (Mesa Area-Mira Loma)	4/12	1100 MW	3400 MW w/ N-1 SPS	4,500 MW w/ N-2 SPS	1100 MW 2200 MW (Nomogram)	4500 MW with SPS	1100 MW 2200 MW (Nomogram)	South of Vincent Limit, PG&E Import Limits May Reduce CA Delivery
TRTP 11	New Vincent-Mesa (via Gould) 500/230 kV T/L	11/13	1100 MW	3400 MW w/ N-1 SPS	4,500 MW w/ N-2 SPS	4500 MW	4500 MW with SPS	4500 MW with SPS	South of Vincent Limit

I. POST-TRANSIENT VOLTAGE STABILITY STUDY

Those contingencies that show significant voltage deviations in the power flow analysis are selected for further analysis using governor power flow analysis. The voltage deviations are compared to the SCE guidelines of 7% for single contingency outages and 10% for double contingency outages.

J. TRANSIENT STABILITY STUDY

For transient stability evaluation, three-phase faults with normal clearing are studied for single contingencies; single-line-to-ground faults with delayed clearing are studied for double contingencies according to NERC/WECC planning criteria.

WECC currently is in the process of adopting Generator Electrical Grid Fault Ride-Through Capability Criteria. SCE currently supports a Low Voltage Ride-Through Criteria to ensure continued reliable service. A proposed Criteria that SCE supports, is as follows:

1. Generator is to remain in-service during system faults (three phase faults with normal clearing and single-line-to-ground with delayed clearing) unless clearing the fault effectively disconnects the generator from the system.

2. During the transient period, generator is required to remain in-service for the low voltage and frequency excursions specified in WECC Table W-1 (provided below) as applied to load bus constraint. These performance criteria are applied to the generator interconnection point, not the generator terminals.

3. Generators may be tripped after the fault period if this action is intended as part of a special protection scheme.

4. This Standard will not apply to individual units or to a site where the sum of the installed capabilities of all machines is less than 10 MVA, unless it can be proven that reliability concerns exist.

5. The performance criteria of this Standard may be satisfied with performance of the generators or by installing equipment to satisfy the performance criteria.

6. The performance criterion of this Standard applies to any generation independent of the interconnected voltage level.

7. No exemption from this Standard will be given because of minor impact to the interconnected system.

8. Existing generators that go through any refurbishments or any replacements are then required to meet this Standard.

Table W-1
WECC DISTURBANCE-PERFORMANCE TABLE (in addition to NERC requirements)
OF ALLOWABLE EFFECTS ON OTHER SYSTEMS

NERC and WECC Categories	Outage Frequency Associated with the Performance Category (Outage/Year)	Transient Voltage Dip Standard	Minimum Transient Frequency Standard	Post-Transient Voltage Deviation Standard (See Note 2)
A	Not Applicable	Nothing in Addition to NERC		
B	≥ 0.33	Not to exceed **25%** at load buses or **30%** at non-load buses. Not to exceed **20% for more than 20 cycles** at load buses.	Not below **59.6 Hz** for 6 cycles or more at a load bus	Not to exceed **5%** at any bus
C	0.033 – 0.33	Not to exceed 30% at any bus. Not to exceed **20% for more than 40 cycles** at load buses.	Not below **59.0 Hz** for 6 cycles or more at a load bus	Not to exceed **10%** at any bus
D	< 0.033	Nothing in Addition to NERC		

Note 2: As an example in applying the WECC Disturbance-Performance Table, Category B disturbance in one system shall not cause a transient voltage dip in another system that is greater than 20% for more than 20 cycles at load buses, or exceed 25% at load buses or 30% at non-load buses at any time other than during the fault.

K. SHORT-CIRCUIT DUTY STUDY

To determine the impact on short-circuit duty, within SCE, after inclusion of Pacific Wind Project and the portion of the Tehachapi Renewable Transmission Plan identified to be required, the study calculated the maximum symmetrical three-phase-to-ground short-circuit duties at the most critical locations. Bus locations where short-circuit duty is increased with the proposed Pacific Wind Project and any necessary facility upgrades by at least 0.1 kA and the duty is in excess of 60% of the minimum breaker nameplate rating are flagged for further review. Generation and transformer data as provided by the customer was used according to the generator and transformer data sheets. Other WECC entities may request specific information within the WECC process to evaluate potential impact within their respective systems of this project addition.

IV. GENERATOR ELECTRIC GRID FAULT RIDE-THROUGH CAPABILITY CRITERIA AND POWER FACTOR CRITERIA (FERC ORDER 661)

FERC adopted a Generator Electrical Grid Fault Ride-Through Capability Criteria (FERC Order 661). The purpose of this Low Voltage Ride-Through Capability and Power Factor Criteria is to ensure continued reliable service. The criteria were used in Tehachapi Queue Cluster Window Interconnection System Impact Study for evaluating generator performance and are summarized as follows:

A. Low-Voltage Ride Through Requirements

1. Wind generating plants are required to remain in-service during system faults (three phase faults with normal clearing and single-line-to-ground with delayed clearing) and subsequent post-fault voltage recovery to pre-fault voltage unless clearing the fault effectively disconnects the generator(s) from the system.

2. The maximum clearing time the wind plant shall be required to withstand a three-phase fault shall be 9 cycles, after which, if the fault remains following the location-specific normal clearing time for three-phase faults, the wind generating plant may disconnect from the transmission system.

3. A wind generating plant shall remain interconnected during such a fault on the transmission system for a voltage level as low as zero volts as measured at the high side of the wind generating plant step-up transformer.

B. Power Factor Design Criteria

1. A wind generating plant shall maintain a power factor within the range of 0.95 leading to 0.95 lagging as measured at the Point of Interconnection, if the Transmission Provider's System Impact Study shows that such a requirement is necessary to ensure safety or reliability.

2. The Power Factor standard can be met by using, for example, power electronics designed to supply this level of reactive capability (taking into account any limitations due to voltage level, real power output, etc.) or fixed and switched capacitors if agreed to by the Transmission Provider, or a combination of the two.

3. Wind plants shall also be able to provide sufficient dynamic voltage support in lieu of the power system stabilizer and automatic voltage regulation at the generator excitation system if the System Impact Study shows this to be a required for system safety or reliability

V. STUDY RESULTS

LOAD FLOW RESULTS

With both the Antelope Transmission Project (ATP) and Tehachapi Renewable Transmission Project (TRTP) in service, the Pacific Wind Project can be integrated in the system without the need for additional upgrades. Detailed power flow study results are presented in Attachment A – Detailed Cluster Window Study Report.

POST-TRANSIENT VOLTAGE STABILITY

The Queue Cluster Window Interconnection System Impact Study determined that under specific outage conditions, the need for a Special Protection System to automatically trip generation resources may be needed. The amount of generation tripping for post-transient voltage conditions was determined to be highly dependant on the amount of power factor correction installed at each of the wind generation projects. With all TWRA Queue Cluster wind generation providing for up to 0.95 power factor correction as metered at the point of interconnect, such need is mitigated. Detailed study results are presented in Attachment A – Detailed Cluster Window Study Report.

TRANSIENT STABILITY

With both the ATP and TRTP in service, the Pacific Wind Project did not result in any transient stability problems. Detailed study results are presented in Attachment A – Detailed Cluster Window Study Report.

UNDER VOLTAGE RIDE-THROUGH AND POWER FACTOR CORRECTION

The study identified that the Pacific Wind Project will be required to install reactive support necessary to meet a 0.95 power factor boost at the point of interconnection. The study identified significant increases in reactive losses both on the system and within the Pacific Wind Project. This increase in reactive losses results in degraded system voltages, especially under outage conditions as demonstrate in the post-transient study.

As part of the Tehachapi Renewable Transmission Project, over 1,300 MVAR of mechanically switched and 800 MVAR of dynamic high-voltage reactive support will be installed to provide for a significant amount of the required reactive support necessary to transmit the energy to the load centers. However, this reactive support is not intended to provide for the losses identified internal to each wind park (see Attachment A – Detailed Cluster Window Study Report) nor is it sufficient to maintain adequate voltages without all Queue Cluster Window generation projects providing power factor correction up 0.95 boost at the point of interconnection. To minimize the amount of generation tripping, the Pacific Wind Project will be required to provide up to 0.95 boost power factor correction as metered at the point of interconnection (Cottonwind 230 kV bus).

As far as under voltage ride-through, the study also identified that the use of the GE 1.5 MW wind turbines meets the under voltage ride-through requirements as mandated by FERC Order 661. Use of a different wind generation turbine will require reevaluation to ensure wind generation facilities meet FERC Order 661 requirements.

SHORT-CIRCUIT DUTY RESULTS

The short-circuit duty study was performed based on the customer provided data including the necessary transmission to interconnect the Pacific Wind Project. Because the first project in queue also connects to the same substation (Cottonwind 230 kV) and a temporary interconnection for a portion of this initial project was approved by the CAISO without substantial upgrades, additional facilities required to accommodate the Pacific Wind Project and the portion of project authorized for early interconnection have been assigned in the same queue position as the Pacific Wind Project.

As shown below in Table 2-1, the three-phase-to-ground short-circuit duty study identified three existing 500 kV, thirteen existing 230 kV substation and one existing 115 kV substation locations that require specific breaker evaluation for replacement. Shown below in Table 2-2, the single-phase-to-ground short-circuit duty study identified four existing 500 kV and nine existing 230 kV substation locations that require specific breaker evaluation for replacement. These locations were flagged based on the review criteria of the project increasing short-circuit duty by more than 0.1 kA at locations where duty is in excess of 60% of the minimum circuit breaker rating. These locations will need to be reviewed as part of the Facilities Study

Table 2-1
Three-Phase (3PH) Short-Circuit Duty Study Results at Existing Substations

Bus Name	Bus KV	PRE CASE		POST CASE		DELTA KA
		X/R	KA	X/R	KA	
MIRALOMA	500	24.3	35.3	23.6	38.1	2.8
SERRANO	500	24.6	31.7	24.3	32.4	0.7
VINCENT	500	17.1	34.5	17.0	36.5	2.0
ANTELOPE	230	12.6	28.8	17.6	33.4	4.6
BARRE	230	19.1	49.7	19.3	49.8	0.1
CHINO	230	16.9	48.9	16.9	49.8	0.9
DEVERS	230	16.1	47.8	16.0	47.9	0.1
ETIWANDA	230	25.9	59.2	25.8	59.9	0.7
LEWIS	230	21.5	44.7	21.6	44.9	0.2
MRLOMA E	230	22.9	62.9	23.0	64.3	1.4
MRLOMA W	230	19.9	51.0	20.0	52.1	1.1
S.ONOFRE	230	30.0	41.1	30.0	41.2	0.1
SANBRDNO	230	20.5	40.3	20.5	40.4	0.1
SERRANO	230	25.6	53.7	25.8	54.2	0.5
VILLA PK	230	22.6	46.8	22.7	47.1	0.3
VISTA	230	19.0	49.3	18.9	49.6	0.3
VALLEY A	115	53.4	20.5	53.5	20.6	0.1

Table 2-2
Single-Phase-to-Ground (1PH) Short-Circuit Duty Study Results

Bus Name	Bus KV	PRE CASE		POST CASE		DELTA KA
		X/R	KA	X/R	KA	
LUGO	500	13.2	39.3	13.1	39.4	0.1
MIRALOMA	500	11.3	32.7	10.9	35.1	2.4
SERRANO	500	13.6	27.8	13.5	28.2	0.4
VINCENT	500	14.1	24.6	12.9	26.5	1.9
ANTELOPE	230	14.1	25.7	18.4	28.2	2.5
CHINO	230	12.5	39.6	12.5	40.1	0.5
ETIWANDA	230	17.0	59.4	16.8	60.0	0.6
LEWIS	230	15.2	39.5	15.2	39.7	0.2
MRLOMA E	230	12.6	54.2	12.8	55.2	1.0
MRLOMA W	230	11.9	61.6	11.7	63.0	1.4
SERRANO	230	18.8	55.5	18.8	55.9	0.4
VILLA PK	230	16.0	42.9	16.0	43.1	0.2
VISTA	230	13.6	42.8	13.6	42.9	0.1

In addition, as shown below in Table 2-3, the 3PH study identified four proposed 500 kV and five proposed 230 kV substation locations where the project increases short-circuit duty contributions by more than 0.1 kA. The 1PH study identified one proposed 500 kV and one proposed 230 kV substation locations where the project increases short-circuit duty contributions by more than 0.1 kA. Design of these proposed substation sites should utilize circuit breakers with sufficient duty ratings to eliminate these locations from requiring upgrades.

Table 2-3
Three-Phase (3PH) Short-Circuit Duty Study Results at Proposed Substations

Bus Name	Bus KV	PRE CASE		POST CASE		DELTA KA
		X/R	KA	X/R	KA	
LEAPS	500	21.5	17.4	21.4	17.5	0.1
LEELAKE	500	21.9	21.7	21.8	21.8	0.1
R VISTA	500	28.4	27.1	28.1	27.4	0.3
WHIRLWND	500	0.0	0.0	10.8	17.6	17.6
HIGHWIND	230	23.5	7.7	25.6	7.9	0.2
JURUPA	230	12.8	24.7	12.8	24.8	0.1
R VISTA	230	26.0	59.6	25.8	60.4	0.8
WHIRLWND	230	0.0	0.0	21.4	24.4	24.4
WINDHUB	230	23.9	8.7	26.8	8.9	0.2

Table 2-4
Three-Phase (3PH) Short-Circuit Duty Study Results at Proposed Substations

Bus Name	Bus KV	PRE CASE		POST CASE		DELTA KA
		X/R	KA	X/R	KA	
R VISTA	500	8.8	24.7	8.5	24.9	0.2
R VISTA	230	16.9	60.9	16.6	61.5	0.6

VI. COST ESTIMATE

With both the Antelope Transmission Project (ATP) and Tehachapi Renewable Transmission Project (TRTP) in service, the Pacific Wind Project can be integrated in the system without the need for additional network upgrades, except for any circuit breaker upgrades or replacements to be identified as part of the Facilities Study. Consequently, cost estimates for the facilities required to interconnect the Pacific Wind Project (excluding any circuit breaker upgrades/replacements and the project's direct assign facilities) is embedded within the total cost estimate for both the ATP and TRTP. This cost is currently estimated to be approximately $1.8 billion.

Based on the relative queue position and geographic location of the Pacific Wind Project, the portions of upgrades required for the Pacific Wind Project involve portions of Segment 4 and portions of Segment 9 of the TRTP. Because the Pacific Wind Project is connecting to the same substation as the first project in the Queue Cluster Window, the same system constraints that affect this project also affect the Pacific Wind Project. As shown in Table 1-3, the addition of all of Segment 4 increases the overall system capability to accommodate generation in the Whirlwind Substation area from 150 MW up to 1,100 MW which is also the maximum available south of Vincent capability without implementing any upgrades south of Vincent or utilizing an operating nomogram, subject to CAISO concurrence. It's important to note that the incremental project impacts on the South of Lugo flow will be mitigated with the addition of Segment 6, 7, and 8 of TRTP.

Cost estimates were developed based on the transmission facilities needed to support the full 1,260 MW in the Queue Cluster Window up to and including the Pacific Wind Project. These facilities include portions of the TRTP for which SCE has filed a CPCN application on June 29, 2007 seeking CPUC approval. It is SCE's expectation that these upgrades will be approved by the CPUC including all the necessary back-stop provision associated with P.U. Code Section 399.25. Consequently, SCE anticipates upfront funding the costs associated with the portions of upgrades of Segments 4 and 9 required for interconnecting the full Pacific Wind Project that are part of the TRTP. Therefore, the cost estimates provided below in Table 2-3 for such portions of Segments 4 and 9 are for informational purposes only and will only become the up-front cost responsibility of the Pacific Wind project if rate recovery assurances under P.U. Code 399.25 are not provided or if the final decision is challenged at court and the decision is reversed and specific project in the Tehachapi Queue Cluster Window who trigger or exacerbate the need for these upgrades withdraw. Since SCE would have been pursuing development of Segment 6, 7, and 8 (Vincent-Mira Loma 500 kV T/L), irrespective of generation development in the TWRA, costs associated with these segments are not provided and would not be the responsibility of Pacific Wind for up-front funding under any scenario.

Table 2-5
Cost Estimates* Provided in Millions

	Triggering Generator	
Facility Upgrade	CAISO #20	Pacific
TRTP 9: Whirlwind 500 / 230 kV Substation	$68.5	None
TRTP 4: Whirlwind 500 / 230 kV Switchyard Equipment	$24.5	None
TRTP 4: Loop Path 26 into Whirlwind (requires one double-circuit or two sets of single-circuit transmission of approximately one mile in length)	$8.7	None
TRTP 4: New four mile Whirlwind-Cottonwind 230 kV T/L (one of two lines)	$10.9	None
Other: Add Tie CB at Cottonwind for Pacific Gen-Tie	-	$1.5
Possible Circuit-Breaker Replacements (TBD)	Unknown	Unknown
Total	$112.6**	$1.5**

*** Note:** These costs were extracted from the total cost developed for the Tehachapi Renewable Transmission Project and are subject to change if assignment of up-front funding for specific elements is ultimately required (i.e. project estimates may include specific equipment that is not part of the cost estimates derived for TRTP). Under such conditions, a restudy of the System Impact Study is recommended to clearly identify exactly which facilities within each Segment is required on an individual project basis. In addition, these costs are also subject to change based on detailed engineering review, environmental mitigations, and ultimate routing and do not include the cost of new right-of-way, if required.

** Excluding any required circuit breaker upgrade/replacement costs and direct assign facility costs

VII. OPERATIONAL REQUIREMENTS

Based on the information provided by generator developers with projects in the Queue Cluster Window, a significant number of projects desire to be interconnected in advance of completing the construction of the required facility upgrades. Consequently, operating protocols and/or exceptions to established planning criteria will need to be developed if all projects are to be interconnected by the requested in-service date, assuming that the facilities required to interconnect the projects can be constructed in time. Table 2-6 provides the interconnection requests in the Queue Cluster Window reordered based on most recent in-service operating dates requested by the Interconnection Customers while Table 2-7 provides a summary based on year.

The Pacific Wind Project is part of the five projects identified with a requested in-service date in 2008. This date cannot be satisfied for this interconnection because the interconnection point requested is part of the Tehachapi Renewable Transmission Project and the current timeline for completing the construction of the interconnection substation is fourth quarter of 2011. Consequently, it should be understood that the proposed commercial operating date for this project should be modified to reflect a fourth quarter 2011 in-service date. An earlier in-service date may be feasible if the TRTP permitting process timelines for the TRTP are expedited by the regulatory agencies.

TABLE 2-6
QUEUE CLUSTER WINDOW REORDERED BY REQUESTED IN-SERVICE YEAR

CAISO Queue Position	**Type**	**O.D**	**Size (MW)**
CAISO Queue #41	Combustion Turbine	07/31/2006	159
SCE WDAT#190	Combustion Turbine	05/01/2007	50
CAISO Queue #85	New Wind Project	12/31/2007	120
CAISO Queue #100	Alternative to Queue #85	12/31/2007	-
CAISO Queue #73	**Pacific Wind Project**	12/31/2008	250
CAISO Queue #86 A	New Wind Project	11/01/2008	33
CAISO Queue #86 B	New Wind Project	11/01/2008	34
CAISO Queue #93	New Wind Project	12/31/2008	220
CAISO Queue #94	New Wind Project	12/31/2008	180
CAISO Queue #20	New Wind Project	07/01/2009	300
CAISO Queue #31	New Wind Project	12/31/2009	201
CAISO Queue #34	New Wind Project	12/31/2009	300
CAISO Queue #79	New Wind Project	12/15/2009	51
CAISO Queue #84	New Wind Project	12/31/2009	400
CAISO Queue #95	New Wind Project	12/31/2009	550
CAISO Queue #96	New Wind Project	12/31/2009	600
CAISO Queue #97	New Wind Project	12/31/2009	160
CAISO Queue #91	New Wind Project	03/31/2010	51
CAISO Queue #92	Combined Cycle	08/01/2010	570

TABLE 2-7
SUMMARY OF QUEUE CLUSTER WINDOW
TOTALS BY IN-SERVICE YEAR

Year	No. of Requests	Amount of MW
2006	1	159
2007	2	170
2008	5	717
2009	8	2,562
2010	2	621

To determine the exact nature of potential system problems in order to identify the minimum mitigation measures required to allow interconnection of specific projects in a specific order, a detailed operational evaluation will be required. The specific order should be based on the relative queue position as well as the customer provided commercial operating date taking into account other factors. These factors can include evidence of land control, project permitting status at Kern County or the California Energy Commission (which ever is applicable), Power Purchase Agreements, construction schedules for new facilities to support the direct interconnect (i.e., Whirlwind Substation required for interconnecting specific projects in this area is part of the Tehachapi Renewable Transmission Project and is not expected to be in service until October, 2010), and potential Special Protection System requirements including SPS Design Guidelines.

Attachment F

Memorandum

To: ISO Board of Governors

From: Keith Casey, Vice-President, Market & Infrastructure Development

Date: May 10, 2010

Re: **Decision on Interconnection Requirements Reform for Renewable Resources**

This memorandum requires Board action.

EXECUTIVE SUMMARY

Variable energy resources will increasingly displace conventional resources as California advances toward satisfying its aggressive renewable portfolio standard targets. In so doing, certain technical characteristics either inherent in, or historically required from, conventional resources will also be displaced. As a consequence, the extent to which the grid can successfully integrate variable generation will be significantly influenced by the ability and extent to which variable generation also contribute the basic technical characteristics embodied by interconnection requirements. [1] The ISO, in coordination with its expert consultant, GE Energy Applications and Systems Engineering, believes that the proper approach to supporting large-scale penetration of variable renewable generation is to specify performance standards, design features, and capabilities comparable, whenever practical, to those required from conventional generators. This philosophy is consistent with the approach adopted by NERC's Integration of Variable Generation Task Force, among others. Accordingly, the recommendations on proposed refinements to interconnection requirements apply largely, but not exclusively, to variable renewable resources.

In conducting this initiative, the ISO has balanced reliability considerations against the potential disruption to renewable energy development, including those projects seeking financial benefits under the American Recovery and Reinvestment Act. This required the ISO to weigh several

[1] Large generating facilities under ISO interconnection procedures are those greater than 20 MW of gross capacity. Further, the ISO's interconnection authority generally extends to generating facilities seeking to interconnect to transmission facilities under ISO operational control. Thus, the requirements discussed herein are not intended to apply to generating facilities seeking to interconnect at the distribution system level under rules and procedures other than the ISO's Large Generator Interconnection Procedures (LGIP). In addition, generating facilities with gross capacity of 20 MW or less are governed by the ISO's Small Generator Interconnection Procedures, which are also not implicated by this initiative.

considerations. First, the ISO assessed the efficacy of deferring to similar efforts pending at the national level through NERC and at the regional level through WECC given the value to variable generation developers and their original equipment manufacturers of uniform requirements. Second, the ISO evaluated the feasibility and timing of compliance with the revised requirements in light of the current or impending availability from original equipment manufacturers of the necessary equipment and technology. Third, the ISO recognized that any new requirements should not disrupt the timing of the ISO's scheduled completion of ongoing interconnection studies. Lastly, the ISO considered the financial impact of additional interconnection costs on those projects with executed or tendered power purchase agreements, whose terms may not permit recovery of the incremental cost of complying with the new requirements.

As discussed more fully below, the ISO believes the correct balance has been struck. Efforts have been made to limit the initiative's scope to those interconnection requirements most important to maintaining reliability. The ISO has also maximized reliance on existing requirements where possible, assured the technical feasibility and commercial availability of equipment and systems to comply with the recommendations, and considered cost implications in determining the scope of projects subject to the recommendations. As a result, the ISO believes it has reasonably mitigated the risk of inconsistency with potential future national or regional mandates and of material impacts to project viability. In this latter regard, the ISO has further attempted to reduce the commercial impact of this initiative by excluding from its scope those with projects with executed or tendered interconnection agreements or that can demonstrate a pre-existing binding commitment to purchase specific types of non-compliant equipment.

Moreover, while these interconnection requirements are an important and necessary step towards reliable integration of renewable resources, the ISO will continue to conduct stakeholder initiatives to assess the operational impacts of renewable integration, and notes that these efforts could lead to additional obligations placed on renewable generation resources.

The following documents are attached to this memorandum for the Board's reference:

- GE comments on interconnections requirements for large generating facilities review initiative (Attachment A)
- ISO stakeholder matrix (Attachment B)
- Summary table of recommendations and how they relate to existing standards (Attachment C)
- Letters and equipment specifications from original equipment managers (Attachment D)

RECOMMENDATION

Management recommends that the Board approve the following motion:

> ***Moved, that the ISO Board of Governors approves the proposal to modify existing tariff requirements to interconnect large generating facilities to the***

ISO controlled grid, as detailed in the memorandum dated May 10, 2010; and

Moved, that the ISO Board of Governors authorizes Management to make all necessary and appropriate filings with the Federal Energy Regulatory Commission to implement the proposed tariff change.

DISCUSSION AND ANALYSIS

The Stakeholder Process Has Been Expedited to Protect Reliability and Minimize Project Development Disruption

The ISO conducted this initiative on an expedited basis. There are 83 renewable variable energy projects, totaling nearly 20,000 MW of capacity in the "serial group" and "transition cluster" portions of the ISO interconnection queue. Of the total in the ISO interconnection queue, 25 - predominantly serial group projects - representing approximately 6,000 MW of capacity have either executed interconnection agreements or have been tendered an interconnection agreement for negotiation. For the remaining capacity, the interconnection studies are nearing completion or are being accelerated to finish by June 2010 in order to accommodate potential funding opportunities under the American Recovery and Reinvestment Act.

A consequence of the ISO's decision to accelerate the interconnection studies is a corresponding need to accelerate this interconnection requirements stakeholder process. Moreover, given the vast amount of renewable generation capacity currently in the ISO interconnection process, the ISO cannot defer policy decisions on interconnection requirements to ongoing efforts occurring at the national level through NERC and the regional level through WECC. Those efforts simply will not be concluded in time to incorporate their outcomes into interconnection agreements of the generation currently in the interconnection queues. Thus, the urgency for this initiative rests in the possible loss of a future opportunity for the ISO to require basic interconnection performance capabilities from any resource that did not incorporate those requirements into a binding contractual arrangement in the form of an executed large generator interconnection agreement (LGIA).

The Power Factor and Voltage Regulation Requirements are Technically Feasible and Rest on Concepts of Fairness in Providing for Grid Reliability

- ***Recommendations - Extend Existing Wind Requirements to Solar Photovoltaic Facilities so as to Place Asynchronous Variable Energy Generators on an Equal Footing with Other Generators***

The ISO recommendations rely on extending and clarifying existing power factor and voltage control requirements, while accommodating the special characteristics of asynchronous generators. The specific salient recommendations are as follows:

1. Extend wind standard of 0.95 lag/lead, measured at point of interconnection, to all asynchronous generators. This serves to treat asynchronous solar photovoltaic generators

similar to asynchronous modern wind turbines, rather than as synchronous conventional resources.

2. No reactive support will be required from the asynchronous variable energy generators whenever the resource is exporting less than 20% of the maximum rated power to the point of interconnection. This accounts for the fact that under low active power conditions, it can be difficult for asynchronous machines composed of individual generators interconnected via an extensive collector system to control voltage and reactive power.

3. The maximum amount of reactive support will be determined by the amount of power exported to the point of interconnection. Example, a VER is exporting 10 MW to the point of interconnection. The VER should be capable of injecting or absorbing up to 3.3 Mvar at the point of interconnection.

4. The reactive power requirement will apply without the need to perform an interconnection study. This constitutes a deviation from recent FERC precedent.

5. Install an automatic voltage control system so that the generating facility can help regulate the transmission voltage at the point of interconnection both under steady state and disturbance conditions, as per the voltage schedule provided, which is simply a clarification of the existing requirement.

6. All reactive power devices used to vary the generating facility's reactive power output should be under the control of the automatic voltage control system.

7. Scope of exemptions or transition periods:

    a. Wind resources with signed or tendered LGIAs that do not incorporate a power factor requirement.

    b. Solar photovoltaic resources with a signed or tendered LGIA can select which standard to meet.

- ***Reactive Power is Fundamental to Maintaining Voltage Stability***

Reactive power is necessary to energize and transmit power in an alternating current system. Without reactive power, system voltage cannot be maintained. There are various sources of reactive power in a transmission system, but the most controllable and robust source of reactive power has been synchronous generators. Displacement of conventional generation therefore threatens to leave the system deficient of reactive power resources. Displacement of conventional generation by asynchronous wind and solar facilities could also potentially reduce the voltage regulation capability otherwise provided by the conventional generator. This will decrease the voltage stability of the system. Thus, the ISO believes that it is critical to ensure replacement of the lost reactive power and voltage regulation capability that will result from high penetration levels of asynchronous variable energy generators.

- ***Position of the Parties***

The main concerns raised by stakeholders regarding the reactive power and voltage regulation requirements do not rest on technical feasibility or costs. Instead, the issues relate to who should bear the burden of these costs – asynchronous generators and their customers or transmission users – and should one category of generators be excluded from providing this grid support capability unless the ISO demonstrates the specific need on a study-by-study basis. (See Attachment B)

As noted in the summary table (Attachment C), all generators, other than wind turbines, are required to provide reactive power under the tariff of 0.90 lag to 0.95 lead. This means that the generator must be able to both absorb and provide reactive power for the grid. For conventional synchronous machines, providing this reactive capability inherently increases the cost of the generator, which must generally be designed to carry more armature current than otherwise necessary. Wind generators have a separate standard under the tariff pursuant to FERC Order No. 661-A, issued in December 2005. Under Order No. 661-A, wind facilities have been required to meet power factor and voltage regulation functionality if required by the transmission operator, such as the ISO. This has been accomplished routinely either through inverter designs that produce reactive power combined with other control equipment or through auxiliary equipment, including switched capacitors or static VAR compensators. There does not appear to be any commercial or technical reason why the approaches adopted by the wind industry cannot apply equally for the solar photovoltaic industry.

Notwithstanding the technical capability of providing the critical reactive power and voltage regulation capability, current FERC precedent does not impose an absolute obligation on wind resources to do so. As noted, Order No. 661-A places the burden on the ISO to prove the need for reactive power from each studied resource. FERC recently applied the Order No. 661-A approach to a solar photovoltaic facility being developed by Sempra Generation. The ISO proposal deviates from current FERC precedent by requiring all asynchronous generators to be required to meet power factor and voltage regulation functionality.

One of the inherent justifications for Order No. 661-A is no longer pertinent – asynchronous machines can inherently satisfy power factor requirements. (Attachments A and D) Similar to other conventional generators on the system, which have had to incur costs to provide this grid support function, asynchronous machines can do so based on commercially available technology. Moreover, there is a fundamental need for all asynchronous resources to satisfy these power factor capabilities as evident in renewable integration studies. For example, the ISO's 2007 Integration of Renewable Resources study concluded that all new wind generation units must have the capability to meet ± 0.95 power factor, notwithstanding the installation of shunt capacitors and static VAR compensation on the transmission grid. More recent analyses of the Carrizo Plains area in PG&E's service territory and the Devers area in SCE's service territory similarly conclude that generation in those remote regions require reactive power support from proposed asynchronous generation to support voltage.

Discussions on this issue also raised a fundamental policy question of whether the asynchronous generation owner and its customers should bear the obligation of providing reactive power services or whether it should be provided through transmission level solutions where the costs are socialized to all grid users. The ISO believes the latter arrangement is suboptimal because it increases the risk of lower grid performance until a problem actually occurs, and potentially increases the cost of a deferred solution. (See Attachment A)

Ride-Through Requirements Increase Stability of the Grid to Withstand Disturbances

- ***Recommendation is to Extend Existing FERC Order No. 661-A Standard for Voltage and WECC Criteria for Frequency***

The specific recommendations are:

1. Extend the low/zero voltage ride-through requirement adopted by FERC in 2007 in Order No. 661-A for just wind resources to all generators. The ISO is not currently including a high voltage ride-through requirement in its standards because of the technical hurdles to developing this capability in the near-term. The ISO intends to pursue this issue either through a subsequent ISO process or through the national standards process at NERC.

2. Clarify that all generating facilities and, in particular, asynchronous generators, comply with current specifications in the WECC Under-Frequency Load Shedding Relay Application Guide. This recommendation to follow the WECC frequency ride-through requirement is consistent with current ISO LGIA and therefore simply re-iterates that all new generators, including all variable energy generators, must comply with this requirement.

3. Scope of exemptions or transition periods:
   a. Exempt resources with executed LGIAs or tendered LGIAs that do not include the requirement, i.e., wind resources prior to effective date of Order No. 661-A.
   b. Asynchronous generators that can demonstrate a binding financial commitment to procure inverter equipment covering greater than 30% of the projects ultimate capacity and that is incompatible with this requirement by the date approved by the Board will also not be subject to the requirement.

- ***It is critical to grid reliability that all new resources be designed with fault ride-through capability***.

Sympathetic tripping[2] off-line of wind plants and solar facilities is a known issue for faults near generating stations. Immediately after a fault occurs, the voltage will typically collapse on the faulted

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[2] The term "sympathetic tripping" refers to a generation plant tripping off-line in response to a grid disturbance that causes a deviation in voltage or frequency.

phase or phases. Typically most transmission system faults will be cleared within several cycles. However, if new generation facilities are not designed with ride-through capability to withstand the temporary low voltage conditions during the fault inception and clearing periods, then generation facilities will trip and stay offline even after the fault is cleared. The result is that generation will be lost.

WECC policy states that a control area operator should be able to withstand the loss of the largest generator by procuring sufficient spinning reserves. One consequence of regularly losing all or part of the generation due to sympathetic tripping from the outage of transmission lines or other generators is the adverse impact on control area performance. A fault that trips a nearby generation unit plus a significant amount of wind or solar generation (via sympathetic tripping) would result in a more severe system imbalance on the control area. This could potentially increase the magnitude of the largest single contingency, which has both reliability and financial implications.

Similarly, the frequency on the power system is related to the amount of load and generation that are connected. When the load and generation are precisely balanced, the frequency will be 60 Hz. In the event that generation is lost through an unplanned or forced outage (e.g., a generating unit trips off line), the frequency will deviate below the nominal of 60 Hz. Immediately following the disturbance, the governors on the remaining generation units will adjust to attempt to arrest the frequency decline. It may be necessary for the ISO's capacity on automatic generation control to make adjustments to bring the system frequency back to 60 Hz. During this transition time, it is essential for the system generators to remain on line. If additional generators trip during the transition, the system frequency will continue to deteriorate, and frequency restoration will be more difficult.

- ***Position of the Parties and ISO Response***

The primary issues with the ride-through requirements are technical feasibility and cost impacts. (Attachment B) As a general matter, conventional synchronous machines have ride-through capability and this requirement simply renders the obligation explicit for this category of resources. Wind generators also have been required to provide for disturbance ride-through capability since adoption of Order No. 661-A by FERC in 2007. Thus, the ISO's proposal regarding voltage ride-through does not represent any change in requirements for wind technology.

The primary motivation for the requirement is to require the solar photovoltaic industry to abandon use of distribution oriented inverters that have been designed to trip off-line in compliance with set standards. However, based on information provided by GE, the inverters used by the photovoltaic industry are substantially similar to inverters used in modern wind turbines that are ride-through compliant. Several original equipment manufacturers have confirmed that their inverters for solar facilities either currently do, or will soon have, the ability to comply with the Order 661-A ride-through requirements. (See Attachment D) Thus, the main technical feasibility issue confronting compliance by solar facilities is whether their "balance of plant" systems, such as cooling systems, will not trip-off or can restart following a ride-through event. The ISO believes these issues are manageable and, in any event, that the reliability need outweighs any burden in performing the necessary modifications.

By omitting a high-voltage ride-through requirement, the ISO has avoided most of the technical and cost concerns raised by stakeholders. GE has stated that the costs for achieving low voltage ride-through capability *may* involve relatively little cost for most generators. (See Attachment A) As a general matter, the ISO concludes that the potential additional costs of ride-through capabilities are outweighed by the potential need for the ISO to carry additional contingency reserves to account for the possible tripping of additional generation. Further, it is inequitable to burden classes of variable generation, i.e., solar thermal and wind, and exempt other similarly situated generation, i.e., solar photovoltaic. Nevertheless, to account for the fact that certain solar photovoltaic projects may have significant compliance costs, the ISO is exempting those projects that can demonstrate financially binding commitments to procure incompatible inverters as of the date of this Board of Governors meeting.

Generation Power Management Allows for Greater Control over Grid Operation

- ***Recommendations for Generation Power Management Requirements***

The ISO's proposed generation power management capabilities are modeled after recommendations developed by GE and Alberta Electric System Operator pursuant to extensive stakeholder discussions, which are consistent with pending recommendations by ISO New England. Those recommendations are:

1. Variable energy generators must have the ability to limit their active power output in response to a dispatch instruction or operating order from the ISO. This ability should apply to the resource's full range of potential output so that the resource's reduction in output can range from incremental to full curtailment.
2. The capability must be able to reduce active power output on step-sizes in no greater than 5 MW increments, which also should not result in voltage steps greater than 2% under normal system conditions.
3. The variable energy generator is expected to interface with the ISO in a manner similar to any other generating facility. As such, the resource must be able to receive and respond to automated dispatch system instructions and any other form of communication authorized by the tariff and in conformance with the time periods prescribed by the tariff.
4. If a variable energy generator is ordered off-line or curtailed, the plant operator must not reconnect the plant to the grid or increase output without prior approval from ISO operating personnel similar to other generating resources.
5. Variable energy generators must be able to limit and control their ramp rates at the request of the ISO, except for downward ramps resulting from the loss of wind or sun to fuel the generating facility. The ramp rate limiter should have the ability to set their ramp rate between a range of 5% and 20% of rated capacity/minute with a default setting of 10%.
6. Variable energy generators must have an over frequency control system that continuously monitors the frequency of the transmission system and automatically reduces the real power output of the generator in the event of over frequency. An intentional dead band of up to 0.036 Hz can be designed for the over frequency control system. The over frequency response

design requires a droop setting of 5%, which means that a generator will change its output 100% for a 5% (3 Hz) change in system frequency.

7. Scope of exemptions or transition periods:
    a. Variable energy generators with executed LGIAs or tendered LGIAs as of the date this policy is approved by the Board.
    b. Accommodation for non-exempt resources that have purchased non-compliant equipment. ISO will coordinate with the project to develop requirements consistent with the capability of the control equipment and will submit this LGIA as a non-conforming agreement, i.e., independent review and approval by FERC.
    c. Transition date – all non-exempt resources must comply with the requirements for generation power management by the later of January 1, 2012 or their commercial operation date.

- ***Generation Power Management is Needed and Consistent with Existing Tariff Obligations***

Under section 4.2 of the tariff, a participating generator, regardless of technology, "shall comply fully and promptly with dispatch instructions and operating orders." Exceptions are permitted only if compliance would impair public health or safety or is "physically impossible." The ISO has generally interpreted the physically impossible exception to be restricted to real-time operating circumstances, such as forced outages, start-up times, and, in the case of many renewable resources, lack of fuel, but not predetermined design limitations. Modern variable energy generators, including solar photovoltaics, are physically capable of controlling output, to varying degrees, as dictated by available wind or sun and the equipment rating. Thus, current tariff provisions require all generating facilities with Participating Generator Agreements to operate such that the ISO can control their output under both normal and emergency conditions. The generation power management recommendations, therefore, do not impose a new obligation, but rather clarify existing requirements for variable energy generators. The ISO believes this clarification is necessary to unambiguously establish the expectations for variable energy generators, which historically have not provided generation power management capability or flexibility commensurate with their anticipated importance in the State's future energy portfolio.

The need for generation power management functionality from variable energy generators is supported by good utility practice, experience, and recent ISO analysis. Grid operators must be able to reduce the output of generators in cases where the grid is experiencing over-frequency conditions caused by system-wide over-generation, local transmission congestion caused by contingencies, planned clearances, or unexpected generation output, or for any other threat to system security that may be alleviated by reducing real power output. In short, situations will occur where the system cannot absorb all available generation. The ISO recognizes that variable energy generators use clean, low to no cost fuel, so curtailing such resources may not constitute the most economical or environmental solution to solving many system wide conditions. Nevertheless, circumstances will arise where, due to location, variable energy generators may be the only source of generation capable of efficiently mitigating the problem, or able to contribute to the solution because other dispatchable resources are operating at minimum levels, must maintain their operating capability for subsequent time periods, or for other reliability services, i.e., localized voltage support, frequency response, etc. The requirement that variable energy generators have the capability of controlling their output is common to many systems with significant penetration levels of such technologies.

In addition, the ISO in coordination with the consulting firm KEMA, Inc., prepared a report for the California Energy Commission in 2009 that quantified changes in system frequency, area control error and the corresponding impact on system performance resulting from the aggregate increase in system volatility under 20% and 33% RPS scenarios. The report concluded, among other things, that the degradation of system performance appears to be predominantly caused by renewable resource ramping in the morning and evening along with traditional morning and evening load ramps.

A significant quantity of additional regulation and balancing capacity of up to 10 times that needed currently may be required to maintain system performance under the studied scenarios. Consequently, the report recommends investigating appropriate protocols and incentives for altering or controlling the ramp rate of wind and solar resources for known ramp events. As discussed further below, the ISO has committed to commencing a stakeholder process to address possible protocols and incentives, but without the foundational generation power management capability, the efficacy of the outcome of this process is likely be significantly impaired.

- ***Position of Parties and ISO Response***

The primary concern raised by stakeholders over adoption of a generation power management requirement did not relate to the recommended capabilities themselves, but rather centered on the ultimate use of those capabilities. (Attachment B) For instance, the concerns targeted questions such as under what circumstances will the capability be triggered, what operational or market protocols will govern the hierarchy of generation reduction, and what, if any, market rules will apply to compensate for the curtailment or incent voluntary reduction of output in response to price signals. How and when generation power management capabilities may be used will be explored fully in subsequent stakeholder processes. The ISO commits to deferring any use of the active power control capabilities until after a stakeholder process has resulted in identified market rules and procedures. Consistent with this commitment, the compliance date for non-exempt resources has been set for January 1, 2012 to accommodate the anticipated timing of the stakeholder process and any transition requirements.

Until the final rules on the application of generation power management are finalized in a subsequent stakeholder process, some uncertainty over their impact on resource production levels will exist. The ISO is aware that this uncertainty has the potential to affect project financing. The ISO has attempted to mitigate this impact by clarifying that the generation power management requirements do not: (1) apply where the ability to comply is limited by a lack of sufficient primary energy source, i.e., wind or sun, (2) otherwise require the resource to install any storage mechanism, or (3) generally require reservation of generating capability, i.e., "spilling" wind or sun, to permit the resource to *increase* output to supply a grid service. In other words, the ISO is not requiring capabilities, such as under-frequency governor response, that would prevent the resource from generally operating at full capability.

The ISO has also modified its proposal to be more consistent with existing control capabilities of variable energy generators. (Attachment B) To address power curtailment, there are generally two solutions. One solution is to have a coordinated plant control system manage the reduction in output and ramp rate. Alternatively, for facilities that do not select a coordinated plant control solution, manual reduction can occur by shutting down individual generators or feeders. This usually results in a "stair-step" reduction capability because it works by dropping discrete blocks of generation. The ISO acknowledged this solution by increasing the reduction incremental from 1 MW to 5 MW. In doing so, the ISO modified its requirement to allow for both types of curtailment mechanisms.

The proposed exemption and transition recommendations for generation power management rest on the understanding that such capability is currently available from multiple original equipment manufacturers for both wind and solar photovoltaic technologies. (See Attachments A and D) Given the commercial availability, coupled with the ISO's understanding that equipment procurement generally follows LGIA execution, the ISO believes the proposed requirements will not impact development timing. However, to the extent a non-exempt facility can demonstrate a binding commitment to purchase non-compliant equipment of as of this meeting date, the ISO will consider the specific capability of the resource's equipment and develop requirements for the individual project that are consistent with that capability. Such projects will be subject to submission of a non-conforming LGIA. The ISO anticipates that the universe of potential projects in this category will be small to non-existent based on the sequencing of development events and the relatively short lead time for delivery of control equipment.

CONCLUSION

The extent to which the grid can successfully integrate variable generation will be significantly influenced by the ability and extent to which variable generation also contribute the basic technical characteristics embodied by interconnection requirements. The ISO, in coordination with its expert consultant, GE Energy Applications and Systems Engineering, believes that the proper approach to supporting large-scale penetration of variable renewable generation is to specify performance standards, design features, and capabilities comparable, whenever practical, to those required from conventional generators. This philosophy is consistent with the approach adopted by NERC's Integration of Variable Generation Task Force, among others. Accordingly, the recommendations on proposed refinements to interconnection requirements apply largely, but not exclusively, on variable renewable resources.

In developing these proposed interconnection requirements and exemption provisions, the ISO has sought to balance the application and scope of the requirements with concerns over not unduly obstructing the development schedule and commercial arrangements for resources currently in the interconnection process. To that end, the ISO believes it has struck the right balance and the final proposal limits the requirements to those most important to maintaining reliability. The ISO has also maximized reliance on existing requirements where possible, considered the technical feasibility and commercial availability of equipment and systems to comply with the recommendations, and considered cost implications in determining the scope of projects subject to the recommendations. While these interconnection requirements are an important and necessary step towards reliable integration of renewable resources, the ISO will continue to conduct stakeholder initiatives to assess the operational impacts of renewable integration, and notes that these efforts could lead to additional obligations placed on renewable generation resources.

GE Energy

Interconnections Standards Review Initiative

Prepared for:
California ISO

In response to:

Interim Interconnection Requirements for Large Generator Facilities Review Initiative

Draft Final Straw Proposal

April 20, 2010

April 28, 2010

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This document was prepared by General Electric International, Inc. acting through its Energy Applications & Systems Engineering department in Schenectady, New York, USA, sponsored by California Independent System Operator Corporation. It represents expert technical opinion on power system operation, reliability and economic operation implications of the subject proposal, "Interim Interconnection Requirements for Large Generator Facilities Review Initiative, Draft Final Straw Proposal, April 20, 2010," by CAISO.

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1 INTRODUCTION

California ISO (CAISO) has developed proposed interim interconnection requirements for large generator facilities. This document offers the expert opinion of GE Energy's Energy Applications and Systems Engineering (GE EA&SE) consulting group regarding the appropriateness of the proposed requirements. GE EA&SE is a leading resource for power system analysis knowledge, modeling expertise and consulting services in the US. As a consulting practice, EA&SE has been a leader in the study of renewable generation integration into the North American power grid. A summary of our expertise is provided as an attachment to this document.

1.1 Philosophy of Grid Integration

A fundamental mission of CAISO is to maintain system reliability. The performance, and thus the reliability, of power grids is a function of the technical characteristics of its constituent elements. Power generation resources are the class of system elements having the greatest impact on reliability. Over the past century, the power grid has developed based on the core assumption that generation resources are provided by synchronous generators, and these generators are that are generally dispatchable. The recent emergence of variable energy resources (VER) has challenged this established paradigm, causing the introduction of new generation technologies that have characteristics differing from that of conventional generation. Despite the greater variety of generation technologies now connecting to the grid, maintaining grid reliability must remain a fundamental imperative.

As VER achieve greater penetration in the grid, it is inevitable that these resources will displace other conventional resources that have a greater marginal cost of operation. Although the power market is built around the supply of real power to the grid, including ancillary services, conventional generation resources have, as a matter of course, provided services and technical characteristics that are essential to the reliable operation of the grid. With the displacement of conventional resources, it is necessary that some means be provided to replace the functional support that these displaced conventional resources had previously provided. One alternative could be for the transmission provider to install dedicated equipment on the transmission system solely to replace the lost grid support. However, such an approach would be inefficient because, by the adoption of appropriate and available technology, VERs can provide most necessary grid support functions at a much lower incremental cost than required for the installation of dedicated transmission equipment to achieve the same functions. It is fair that all generation resources, where practical, provide a proportional share of grid support function. Therefore, it is reasonable, efficient, and prudent for CAISO to establish certain functional performance requirements, or grid code, as a condition for interconnection of all generation resources.

Many types of VER are composed of many individual generation units (e.g. wind turbines) interconnected to the transmission system by a dedicated collection system. Many such VER plants have non-generation devices as part of the plant design, such as capacitor banks and static VAR compensators, solely to produce a desired plant performance characteristic. While individual generation units are an especially important component of these VER plants and their capabilities and behavior will influence the plant design necessary to achieve desired performance, interconnection requirements should avoid inferences to the specific behavior of individual units. Instead, the requirements should be placed at the point of transmission interconnection, as CAISO has proposed in the interim interconnection requirements.

VER plants are not simply collections of individual generation units. Rather they must be integrated into fully engineered power plants, with many other critical components. With the progress that has been made in this area over the past few years, GE feels strongly that specifying a functional behavior of VER plants consistent with what is required for conventional generating facilities, to the maximum practical degree, is the proper approach. GE has provided detailed recommendations to others, most notably ISO New England [1], for standards to be imposed on future wind generation. Many of those recommendations, which are presently under stakeholder review, are consistent with the CAISO proposal.

1.2 Transition

Adoption of new requirements is inherently disruptive. Although this disruption is reduced by an extended transition time to new rules, this reduced disruption must be balanced against the system reliability impacts of the delay. VER interconnection are progressing at a rapid rate, and an extended transition time increases the amount of VER capacity that will be interconnected without performance capabilities judged to be necessary for grid reliability.

Long delays in implementing necessary reliability requirements increase the risk that retroactive requirements may need to be imposed in the future on non-conforming VER plants. In Spain, VER penetration has reached the levels where legacy VER plants, installed prior to the imposition of the current grid code, must necessarily be retrofitted with certain grid support functionality in order to maintain secure and reliable operation of the Spanish grid. Similarly, there is action underway to require certain key grid performance characteristics of existing plants in ERCOT on a retroactive basis. With the rapid growth of VER penetration in California, it is reasonable for CAISO to have proceeded with development of the proposed requirements on an expedited basis. In the long run, this may save VER plant owners from having to make very expensive plant retrofits in the future.

There are other generation performance standards under development by WECC and NERC. In an ideal sense, it would be desirable for the CAISO grid performance requirements to be coordinated with the requirements of these other standards. However, the formal consensus standards development process is inherently slow. There are unique conditions of VER development in California that could imperil grid reliability there far sooner than in the average region within WECC or across the U.S. This includes extreme local penetration levels of VER in certain areas, and the potential for very large VER plants having extremely rapid power ramp rates. CAISO is ultimately responsible for the reliability of its own grid, and in our opinion, is justified to move ahead with interim requirements to address its own vulnerabilities without waiting for completion of WECC and NERC standards.

In the question of balance between speed and disruption¸ an important question is how fast can the VER industry reasonably implement modifications to generator and plant designs to meet the requirements. Experience in the wind industry suggests that new control and other grid related technologies have had rule-to-compliance times on the order of 6 to 18 months. For example, provision of low-voltage ride-through (LVRT) functionality at the New Mexico Wind Energy plant was delivered and commissioned within about nine months from the time that the systemic need for this capability was identified. The solar industry has not yet advanced to the level of the wind industry in terms of achieving grid support functionality across the range of major equipment vendors. However, the fundamental similarity of the power conversion equipment used in various non-wind VER with conversion equipment used in wind generators (specifically, Type 3 and Type 4 wind generators) indicates that there is no fundamental reason that the non-wind VER could not achieve similar functionality. Therefore, the compliance date of January 1, 2012, proposed by CAISO seems both reasonable, prudent, and achievable.

1.3 Alternatives

There is a natural desire on the part of those making capital investments to avoid incurring costs that do not result in commensurate revenues. Certainly the cost of providing of most of the functionality proposed by CAISO falls into this category in the eyes of prospective developers. However, there is practical precedent for making a uniform minimum standard of interconnection mandatory. Pushing all remedies on to the grid, while technically possible is at odds with other historical application of interconnection requirements and with good utility practice. In short, there are always alternatives. Rules governing interconnection of synchronous generation could be changed or eliminated by the same logic. For example, voltage control and reactive compensation could be provided entirely by grid/transmission resources, allowing generators to run at unity power factor. However, the loss of operational flexibility, the capital costs and the reliability penalties make such an approach impractical. CAISO may wish to allow VERs to contractually arrange for equivalent functionality to be purchased from other resources. The onus for demonstrating functional equivalence must fall on the VER, not the ISO.

2 Reactive Power and Voltage Regulation Capability

Reactive power is necessary to energize and transmit power in an ac system. Without reactive power, the system voltage cannot be maintained. There are various sources of reactive power in a transmission system, but the most controllable and robust source has been the synchronous generators connected to the grid.

Conventional synchronous generation has always provided the ability to supply or absorb reactive power, and this capability is routinely used to regulate the transmission system voltage. Providing this reactive capability inherently increases the costs of the generator. For example, a synchronous generator with a typical 0.85 power factor rating must be designed to carry armature current that is 15% greater than if the machine were to be designed for unity power factor operation. Thus, reactive capability has never come "free" for conventional generation, but has always been specified as an expectation.

Displacement of conventional generation by VER leaves the system deficient of reactive power resources. Also lost is the voltage regulation capability provided by each displaced synchronous generator, thus decreasing the voltage stability of the system. It is our opinion that replacement of the lost reactive power and voltage regulation capability is essential to grid security and reliability, and that demanding similar support from VER plants is fair, reasonable, and economically efficient.

2.1 Reactive Capability of VER Plants

Wind generation plants have been required for a number of years by FERC 661a to provide a 0.95 leading to 0.95 lagging power factor range at the point of interconnection, and voltage regulation functionality. These requirements have been met by two basic approaches. The first approach is the application of wind generator units capable of providing sufficient reactive range to deliver the required reactive power, combined with plant-level controls that coordinate the reactive outputs of the individual units to achieve the desired reactive output or voltage regulation at the point of transmission interconnection. The second approach has been to include auxiliary reactive power equipment in the wind plant design. This auxiliary equipment includes switched capacitor and shunt reactor banks, static var compensators, and STATCOMs.

Combinations of the two approaches are common as well. In some cases, the latter devices are also applied to achieve the low-voltage ride-through functionality required by FERC 661a, as well.

The ability to deliver and consume reactive power in all VER plants can take functionally similar forms to those adopted by the wind industry. In many cases, the individual generation units are, or could be made to be, capable of reactive power supply. For example, the final power conversion process in photovoltaic generation units is provided by an inverter. The type of inverter commonly used is a voltage-source converter, of functionally similar design to the inverters used in Type 4 wind generators. In wind applications, these inverters are used to provide the wind plant's reactive power requirements and there is no fundamental reason that the same approach cannot be used in photovoltaic plants to achieve the same functionality. The reason that many PV inverter designs do not do so presently stems from the roots of many of these inverter designs in small distributed generation applications, where IEEE Std 1547 forbids voltage regulation functionality on distribution systems. Also, providing reactive power requires incremental current-carrying capacity in the inverters. This is identical to the current rating increase that has always been designed into synchronous generators to facilitate reactive power capability. The historical fact that many PV inverter designs do not provide for reactive power capability is not a reflection of the practical potential to do so, but rather is an indication of the relative immaturity of this industry. As the non-wind VER mature into significant bulk generation resources connected to the transmission grid, it is essential that equipment designs must also mature toward having functional capabilities consistent with grid reliability needs. The reactive power and voltage regulation requirements proposed by CAISO should serve to prod the less-mature VER technologies away from an IEEE 1547-compliant, distributed generation focus, toward functional capabilities consistent with becoming a mature bulk generation resource.

Arguments that certain VER generation technologies are inherently incapable of reactive power and voltage regulation functionality fall short when held up against the experience of the wind industry. Specifically stand alone shunt devices, including shunt capacitors, shunt reactors, and static devices (such as STATCOMs) are commercially available and can be controlled and protected to meet the proposed rule. Both the FERC 661a requirements for wind, and the proposed CAISO requirement for all VER, are at the plant level as measured at the point of interconnection. Many wind plants use Type 1 and Type 2 wind turbines, which are individually incapable of providing reactive capability. Because the requirements are at the plant level, the widely applied solution for wind plants with individually non-compliant generation units is to apply auxiliary equipment within the plant to generate and absorb reactive power, and to provide voltage regulation functionality. CAISO, in the proposed requirements, specifically allows this solution.

2.2 Financial Impact

The real issues are not the technical capability of VER to achieve the proposed reactive power and voltage regulation capabilities, but are rather the financial impact on the VER projects. In this case, the balance is between subjecting the VER owner with the costs related to the grid reliability resources lost due to displacement of the conventional synchronous generators by the VER, or socializing these impacts across all grid users. As a matter of fairness, the former approach, as chosen by CAISO, seems in our opinion to be fair and reasonable.

Furthermore, CAISO's proposed requirements are rather permissive in allowing the use of shunt capacitor and reactor banks to meet this objective, rather than requiring all or part of the reactive supply to be produced by a smoothly-variable dynamic reactive source, similar to the variable output of synchronous generators displaced by the VER. Reactive capability provided by passive capacitors and reactors can be installed at a cost that is nearly an order of magnitude less, per MVAR, than dynamic sources like SVCs or STATCOMs.

2.3 Point of Requirement

The purpose of the requirement for VER plant reactive capability is to support the transmission grid and regulate the transmission voltage. Therefore, only reactive power delivered to, or removed from, the transmission system is relevant to this goal; reactive power losses or gains within the VER plant are irrelevant to this end. The proposed rule is aimed at the overall installation and the reactive power requirements are correctly applied at the point of interconnection. This allows developers and plant designers a broad range of options to meet the requirements, and is not prescriptive of technology. A plant design, for example, can include stand-alone devices to achieve the requirements independent of the reactive capabilities of the generation unit equipment that they have chosen to apply. Thus, in our opinion, applying the reactive power requirements for VER plants to be at the point of transmission interconnection seems both reasonable and justified.

The disparate requirement for power factor of conventional synchronous generators has historical roots. However, such plants are interconnected to the transmission system by a transformer with an impedance almost always falling within a known range, and without a complex collection system. These generators also are almost never applied with stand-alone reactive devices, which would be functionally unnecessary. With the broader power factor range required of synchronous generators more than compensating for step-up transformer reactive losses, the reactive requirements imposed on VER and conventional plants are functionally near equivalent, with the synchronous generator requirements perhaps a slight amount more demanding in practice from the standpoint of net reactive power to the grid.

3 Disturbance Ride-Through Capability

3.1 Systemic Need for Generation Ride-Through

A fundamental expectation in transmission system planning is that a normal fault event should not cause consequential loss of a generation resource, unless the fault event results in the loss of a radial connection to the resource. Conventional synchronous generation has been assumed to able to remain connected to the grid during and following fault disturbances, unless the severity of the event causes the generator to slip out of synchronism with the grid (transient or dynamic instability). There are specific planning criteria regarding the transmission contingencies for which the synchronous generation must remain stable and connected, and these are applied during the plant interconnection studies for new synchronous generation plants. If a plant is not able to remain stable for contingencies within the planning criteria, then the plant's developer is required to pay for sufficient reinforcements to provide the required stability performance.

Historically, VER had been treated as insignificant and non-essential to grid resource requirements. The VER had been allowed, or even desired, to trip off line in response to a grid event. Some types of VER have had their initial applications at the distribution level where a behavior of trip response to faults is required by IEEE Standard 1547.

As VER has matured and grown in penetration, it can no longer be considered an insignificant contributor to grid resource requirements. A transmission fault can cause depression of voltage over a wide area. If this voltage depression causes a large amount of VER to trip, the loss of operating generation capacity can exacerbate the severity of the initial fault disturbance, and may seriously imperil grid security and reliability. Frequency variations are seen across an entire interconnection (e.g., WECC), and a frequency event caused by loss of generation would be increased in severity if other generation, including VER, were to trip off in response to an underfrequency event. Such sympathetic tripping could easily result in cascading of a survivable event into an interconnection-wide blackout having massive economic consequences.

The need for wind generation to ride through grid disturbances began to be recognized in vulnerable areas of the transmission grid, such as New Mexico and Colorado, early in the prior decade. This awareness culminated in the imposition of disturbance ride-through requirements for wind VER in FER Orders 661 and 661a. The extension of disturbance ride-through requirements by CAISO to all types of VER is, in our opinion, a fair and reasonable requirement that is necessary to maintain grid security and reliability as the penetration of VER grows in their system.

3.2 Practicality of Disturbance Ride-Through Capability

The wind industry has been required to provide for disturbance ride-through capability in wind plant designs, either through the capabilities of the individual generators, or through the addition of auxiliary wind plant equipment. Compared to most other types of VER using asynchronous generation, the inherent technical challenge for providing this ride-through capability for wind generation is considerably more challenging. This is due to the need to manage mechanical stresses and the inherent performance issues of Type 1 and Type 2 (induction) wind turbines, which are not an issue for photovoltaic, and many other types of VER.

The major issue for many photovoltaic inverters is that manufacturers have chosen to design inverters for compliance with distribution-oriented IEEE 1547 and UL-1741 standards, and developers have chosen to apply these inverter designs for bulk, transmission-connected PV plants. These inverters are substantially similar to inverters used in Type 4 wind turbines, that are disturbance ride-through compliant. There is no inherent technical reason that ride-through capability cannot be added to other inverter-interfaced VER. For most types of non-wind VER, particularly PV, this should not be a substantial technical challenge because there are no mechanical issues involved. Although not expected to be a technical challenge, significant control modifications of many VER designs is recognized to be necessary to achieve compliance with the proposed CASIO disturbance ride-through requirements. It is our opinion that this is a necessary step in the evolution of these various segments of the non-wind VER industry away from a distribution focus towards becoming a transmission-connected bulk power resource.

3.3 Cost Implications

Wind generation, which has the greatest inherent technical costs of meeting ride-through requirements, has already addressed the issue in response to FERC 661a. The costs for achieving the ride-through capability proposed by CAISO may involve relatively little cost for most types of non-wind VER, including PV, for clean-slate new designs. Adaptation of existing designs may involve somewhat more cost and time. These costs need to be weighed against the cost of the alternative, which is to maintain extra spinning reserves in the CAISO market in order to cover for potential VER tripout during faults. The costs for VER plant modification for ride-through functionality pale in comparison to the high costs of spinning reserves. Also, it is our opinion that burdening the entire market with extra costs to mitigate the performance characteristics of one class of generation resource would be unfair.

4 Active Power Control

4.1 Systemic Needs for Active Power Control

Conventional synchronous generation has always had the ability to control active power output as a result of 1) a dispatch command from the system operator or 2) a change in system frequency that initiates an automatic response of the governor control to modulate fuel valve or inlet gate position. The systemic need for active power control is driven by the inherent necessity for power grid operators to keep transmission infrastructure (transmission lines, transformers and other serial devices) within thermal and stable operating limits and to maintain system frequency within prescribed bounds. Managing the system to meet these constraints is a key element of overall network reliability. One big risk to network reliability comes in the form of system-wide cascading outages due to self-protective tripping caused by overloaded and sagging transmission lines, overloaded transformers, and frequency excursions. A key method to manage flows around the network and avoid the aforementioned is controlled curtailment of generation through voice-communicated or automatic dispatch commands. Another key method is to employ automatic governor control. It is reasonable to expect that these functional requirements apply to all forms of generation (including VER) connected to the network.

4.2 Technical Feasibility and Technology Availability

Today's wind technology has matured to the point of having the physical capability of providing a wide range of active power control and regulation functions with only marginal increases in equipment cost to do so. Unlike voltage regulation and fault-ride through, US industry rules and practice for active power control of wind plants are less refined and uniform. All US wind plants are subject to curtailment: they must accept instructions from grid operators to reduce power output. The details of how each plant responds to such commands and the circumstances under which the host ISO may invoke these curtailment commands varies considerably. At present, instructions are issued on a purely manual basis.

US industry is just starting to address the need for more automated behavior from wind plants. Response of wind plants to frequency variation using functionality similar to that of conventional generation governors is not required in the US, but is in several other countries (e.g. Ireland) that have reached or are soon to reach relatively high levels of wind penetration.

To address power curtailment needs, one solution is to have a coordinated plant control manage plant curtailment and ramp rate command. The curtailment control can be executed at the plant level based on a SCADA signal from the grid operator or a change in set point by the plant operator. Alternatively, for plants who select generation equipment from OEMs that do not supply a coordinated plant control, manual curtailment of wind turbines is possible by shutting down individual generators or feeders one at a time. This is less ideal because a plant operator does this curtailment manually in discreet blocks and the transition is not as controlled as a coordinated plant management system could do, but the curtailment requirement may still be met by using this method. The ability to selectively disconnect individual generators or feeders in response to commands issued by CAISO will provide a step-wise response. As long as the steps are within reason, this can meet the systemic needs that are the reason for the standard. "Within reason," of course, is problematic. Step sizes must be accordance with good utility practice in terms of the resultant voltage step. Under normal circumstances, the resultant voltage steps should be on the order of 1-2%, and should not exceed 3% under any normal system conditions (per IEEE std). Further, the total MW switched should be consistent with system balancing needs; this is a grid level concern so fine steps are not needed. Generally, steps of 10 MW should be acceptable, and not impose undue capital cost burden on the plants. Justification for a specific maximum step in MW needs further investigation. The ISO does not necessarily need continuous control, although it would be highly welcome. From the perspective of the plant owner, continuous control is preferred as well, since fine control of MW should always result in less energy loss than block curtailment.

In principle, active power control of PV systems can be provided by control of the inverters without substantively affecting the inverter ratings. As mentioned earlier, this requires controls to do so, which are not generally provided today by PV OEMs. Development of those controls will be needed. However, very similar to wind, other remedies exist to meet the intent of this requirement. Large PV plants will rely on multiple inverters of moderate rating. Most systems today are sub-MW size. The ability to selectively disconnect individual inverters or strings of inverters in response to commands issued by CAISO will provide a step-wise response. The same argument for wind earlier also applies to solar regarding curtailment in discreet blocks and reasonable step-size.

Our opinion is concurrent with CAISO regarding the need for active power curtailment capability. From a reliability standpoint, it is straightforward and rests on sound utility practice and commonsense.

Due to the nature of wind turbine controls, capabilities and physical size, changes in active power due to changes in wind speed can be significantly large and fast; in many cases, much faster than conventional generation. This is also true for solar generation with changes in sunlight. Ramp rate controls, especially to limit large and sudden swells of power due to increasing wind and sun, are also especially important for VER due to the non-controllable nature of fuel source. It is our belief that, with today's available control technology, it is reasonable to expect ramp rate limits be executed at the plant level of VER to control the rate of change of power for all situations except the loss of fuel.

For over-frequency excursions on the grid, it is reasonable to expect all connected generation to respond by automatically and dynamically curtailing power output to mitigate the excursion. To assure that all connected generation fairly shares the burden to correct over-frequency, is it reasonable (and also standard industry practice) to allow a governor droop function to coordinate active power response between all plants experiencing the excursion. Wind and solar technology available from some OEMs has the capability of accepting a function to control frequency with droop as a part of the plant control logic. While most wind plants have this capability already, solar technology does not, primarily due to its distribution-connected history. It should be possible for this requirement be met by adding control logic to solar inverters. For VER that do not already have it, addition of control logic to allow frequency regulation is expected to have relatively minor implications to cost of equipment and insignificant cost implications due to lost revenue during the frequency excursion.

As the CAISO report rightfully pointed out, under-frequency response would require spilling wind or sun during normal operation to keep a certain percentage of available power in reserve and dynamically increase power to mitigate the excursion. While this may have only minor cost implications to add control logic to equipment, it has significant cost implications due to lost revenue. Therefore, we concurrently believe under-frequency response is should not be required at this time.

4.3 Cost Implications and Market Rules

Any action by the ISO that causes VER generation to reduce power output below that possible with the available fuel source (wind or sunlight) has the potential to have significant revenue impacts for generation owner. VER owners irrevocably lose the energy sale when wind or solar (or hydro) power is "spilled", and as such they have very legitimate concerns about the requirement for VER plants to be equipped with control features that enable such curtailments. However, it is worth noting that any grid operator, including CAISO, *always* has the ability to curtail (up to an including disconnecting) any generator for reliability reasons. That is true today. If power producers want to connect, they are subject to this now. The proposed technology rule will, in fact, reduce risk to large PV producers by providing CAISO with a mechanism that can be used with more finesse, and therefore affecting less potential energy production, than the present in-place requirement that will result in CAISO just opening the plant breaker.

4.3.1 Market Rules

The discussion of systemic need and technical feasibility leaves unaddressed the issue of financial impact on VERs. The technical interconnection rules proposed by CAISO are rightly not intended to address market and contractual issues. It is entirely appropriate that CAISO prudently require that VER plants have the *capability* to meet these active power control requirements. Nevertheless, the potential for VERs to suffer from the *use* of these capabilities is great. It is incumbent on CAISO and the relevant regulating entities to establish clear criteria under which these active power limiting features may be invoked. While the details may vary, the fundamental premise must be that the benefit produced by active power control of theVERs *cannot* be meet less expensively by other means. In practice, this probably means that VERs should be treated as price takers, and that market prices (LMPs) should be allowed to go substantially negative. Further, procurement of ancillary services that could mitigate reliability impacts of, for example, fast ramping of VERs, must be the first line of defense for the ISO. California must must pay attention to the flexibility of the entire generation fleet in order to successfully integrate large amounts of VER generation [2],[3].

5 Conclusions

Increased penetration of VER in the CAISO system has the potential of compromising grid security and reliability, if measures are not enacted to require technical performance capabilities of the VER that are compatible with achieving the minimum negative impact. It is our opinion that CAISO must act promptly, and cannot afford to continue interconnection of VER without regard to future grid performance. The performance required by CAISO's proposal are within the capabilities of available technology, and the costs to implement are favorable with respect to the overall societal benefit. We conclude that CAISO's proposed requirements are practical, prudent, and fair.

References:

1. ISO New England, "Technical Requirements for Wind Generation Interconnection and Integration", November 3, 2010.
2. California Energy Commission's Intermittency Analysis Project Study "Appendix B - Impact of Intermittent Generation on Operation of California Power Grid" http://www.energy.ca.gov/2007publications/CEC-500-2007-081/CEC-500-2007-081-APB.PDF
3. International Electricity Agency (IEA), "Empowering Variable Renewables: Options for Flexible Electricity Systems", 2008, IEA Head of Communication and Information Office, 9 rue de la Fédération, 75739 Paris Cedex 15, France

Attachment - GE Expertise

The foundational strength of GE's Energy Applications and Systems Engineering consulting group lies in the experience and expertise of its employees, a total staff of approximately 112 employees, with most having advanced degrees in engineering disciplines, including ten with doctorate degrees. Their total experience spans over 1500 man-years. EA&SE is distinguished by having six engineers presently on staff who have been elevated to the esteemed status of IEEE Fellow, the highest honor bestowed by IEEE.

Cumulatively, EA&SE engineers have published hundreds of technical papers and authored or co-authored many textbooks. Our engineers on the team play an important role in the power industry by leading and participating in a number of industry organizations, including thirty IEEE Committees, Subcommittees and Working Groups, and five CIGRE Working Groups as well as international standards committees, such as IEC.

GE EA&SE has made major contributions to the development and application of technology for transmission planning and analysis. GE EA&SE is a leading resource for power system analysis knowledge, modeling expertise and consulting services in the US. As a consulting practice, EA&SE has frequently been called upon to draft, interpret and apply the NERC reliability criteria. In the recent past, there have been dozens of instances in which EA&SE has utilized these rules in performing studies of the impact of proposed generation or transmission projects on transmission reliability.

GE EA&SE has also made major contributions to analyzing North American power grids with the intent of identifying technical, operational and economic improvements required to accommodate higher penetrations of renewable generation. This analysis includes areas such as New York, California, Ontario, Texas, New England and the WestConnect region of WECC.

Attachment B

Stakeholder Process: Interim Interconnection Requirements Initiative

Summary of Submitted Comments

Stakeholders submitted three rounds of written comments to the ISO on the following dates:

- Round One – March 3, 2010
- Round Two – April 8, 2010
- Round Three – April 30, 2010

Stakeholder comments are posted at: http://www.caiso.com/1c51/1c51c7946a480.html

Other stakeholder efforts include:

- Publish Initial Issues Presentation – February 16, 2010
- Stakeholder conference call – February 19, 2010
- Publish draft Straw Proposal – March 25, 2010
- Stakeholder meeting – April 1, 2010
- Publish draft Final Straw Proposal – April 20, 2010
- Stakeholder conference call – April 28, 2010
- Publish Final Straw Proposal – May 10, 2010

Management Proposal or Stakeholder Issue	Renewable Developers and Developer Associations*	SCE	Division of Ratepayer Advocates	Calpine	Management Response
ISO proposes to modify specific interconnection standards prior to conclusion of pending efforts at NERC and WECC	Oppose ISO should not risk jeopardizing uniform standards	Support	Conditional Should work closely with NERC/WECC to maximize consistency and not impose overly stringent requirements	Support Imposing requirements retroactively on approved or financed projects may have greater disruption and financial consequences.	The ISO agrees that uniform standards are important but the ISO cannot rely on ongoing national and regional processes to address immediate ISO needs. These processes do not offer any certainty that they would apply to the significant quantity of renewable capacity currently seeking to interconnect to the ISO grid. The ISO is sensitive to potential conflicts between its requirements and national or regional standards and has modified its proposal in some respects, i.e. LVRT, to minimize inconsistency.
The ISO proposes to apply the current FERC Order No. 661-A power factor requirement for wind resources to solar photovoltaic resources. However, unlike Order No. 661-A, the requirement will apply regardless of resource specific need determination through a system impact study.	Oppose ISO should be required to demonstrate need for reactive power through studies before imposing additional costs on renewable development. ISO can protect reliability through an efficient “clustering” study process. Large Scale Solar Association (LSA) – there is no reason why intermittent resources should be required to provide these services, including power factor, when others are not required to do so.	No Comment	Identify Response: Conditional	Support Non-variable generation typically provide the requirements without clear compensation for these necessary reliability obligations. Current application is discriminatory.	Power factor is a needed capability to maintain grid reliability. The ISO recognizes that the current Order No. 661-A structure does provide the ISO with authority to compel reactive power requirements. However, the ISO's position rests on several factors. First, the system currently functions reliably, in part, based on the reactive power contribution from conventional generators. The conversion to different generating technologies does not fundamentally change the need for reactive capability and modern renewable resources have this capability similar to conventional generation. As renewable resources displace the conventional generation, the sources of reactive power will also diminish. The quality of reactive power from generators, in contrast to static devices, is preferable and while the ISO will allow the developer to comply with the power factor requirement in the least costly means available, the renewable industry must continue to mature in a manner commensurate with its future role in providing power. The ISO has not required (as have some other jurisdictions) that a minimum fraction of the reactive power capability of the VER plant be provided as 'dynamic' vars, i.e. fast, continuously variable reactive resources. In this sense, the requirement is less stringent than one that would require absolute functional parity with conventional synchronous generation. It is difficult to study ahead of time potential transmission configurations and maximum VER capacity installation under all credible operating scenarios. Also, as more VERs displace conventional resources, the ability to control voltages

Management Proposal or Stakeholder Issue	Renewable Developers and Developer Associations*	SCE	Division of Ratepayer Advocates	Calpine	Management Response
					diminishes under certain operating conditions. In lieu of retroactively requesting these requirements, the ISO must, in the interest of maintaining reliability for a broad range of possible future system conditions, ensure that all resources be built to contribute to reactive power needs.
The ISO proposes to measure power factor at the point of interconnection and allow interconnecting facilities to meet the power factor through the least cost means possible by permitting the use of static devices.	Oppose Should allow projects to meet their reactive power obligations by installing reactive power control equipment wherever it is most cost effective, i.e., at the POI or elsewhere on the grid. Projects should be allowed to coordinate with other projects to share costs. Exceptions to the point of measurement should be allowed based on the length of the inter-tie to the point of interconnection.	No Comment	No Comment	Support	The ISO agrees in large part. Reactive support can be supplied with capacitors, or by the VER inverters should that capability be selected by the resource. However, given that the purpose of the reactive power requirement is to support the transmission grid, measuring the power factor requirement at POI is appropriate regardless of the distance between the generator and the point of interconnection. Nevertheless, the ISO has recognized there may be circumstances where allowing the power factor to be measured at an alternative point may be more consistent with efficient voltage regulation when multiple generators are connected at the same bus. In either case, the ISO expects the reactive power supplied to the grid to be equivalent. With respect to allowing projects to share costs, the ISO's proposal is to require power factor from each project and therefore does not preclude a sharing of costs by the project developers outside the ISO tariff.
The ISO proposes to restrict the power factor requirement to when the generating facility is producing at greater than 20% of its active power	Conditional If full reactive power output must be provided at a real power output less than full load, it could	No comment	No comment	No Comment	Based on input from its consultant, GE, the ISO modified its proposal to account for the special characteristics of generating facilities that link multiple small generators through a large and complex collector system.

Management Proposal or Stakeholder Issue	Renewable Developers and Developer Associations*	SCE	Division of Ratepayer Advocates	Calpine	Management Response
output.	require generators to install additional (compensation) at additional cost.				
The ISO proposes to extend the FERC Order No. 661-A low voltage ride-through capability to all generators.	Oppose High Voltage Ride Through: Inverters currently provide 10% over voltage. Compliance with 20% will be costly. We recommend allowing the 10% until the issue is vetted by NERC. Low Voltage Ride Through: The solar industry is currently moving in this direction. The proposed standard would also require review /re-design of the balance of system. A transition period will be necessary. The ISO did not adequately consider commercial impacts.	No comment	No comment	Support As the penetration rates of VERs increase, the ISO's ability to ignore their reliability impacts - or actively seek that they disconnect from the grid when system stress occurs - diminishes.	The ISO has withdrawn the initial recommendation to follow the pending NERC standard and therefore avoids mandating a high-voltage ride through requirement greater than 10% as suggested. Also by modifying the LVRT requirement to comport with Order No. 661-A applicable to wind, the ISO understands from OEMs that the capability currently exists. Given that most facilities subject to the new requirement will not be operational for a significant period of time, the ISO again believes that the balance of system issues can be timely resolved. The ISO has attempted to consider commercial impacts by adopting standards consistent with current OEM capability and therefore represent only incremental costs of development. The ISO has provided, as recommended by stakeholders, proof from at least OEMs that the capability is available. For this reason, the ISO has not proposed uniformly exempting projects with signed power purchase agreements. Finally, by exempting projects that have entered into LGIAs and/or purchased equipment, in some cases, the ISO is attempting to recognize that new requirements may disproportionately disadvantage such projects. The ISO has also attempted to clarify the conditions under which an equipment purchase qualifies, i.e., procurement of invertors that will manage 30% or more of the project's maximum capacity as set forth in the interconnection application.
The ISO proposes to require all variable energy generators to meet the existing WECC frequency ride-through requirements.	Support Enforcement and monitoring should also be through WECC.	No comment	No comment	No Comment	The ISO agrees that compliance of existing WECC requirements will be through that organization. In general, the ISO does not propose any new compliance requirements based on this initiative. Either compliance will be similar to existing interconnecting generation in terms of proof of capability or, in the context of generation power management, the implications of not complying, in large part, be determined by market rules developed in subsequent stakeholder processes.
The ISO proposes to require new variable energy generators have the	Oppose Discussion of capabilities	No comment	Conditional This is a critical	Support	The ISO proposal focuses on critical capability, namely, the ability whenever fuel is available to adjust output in a downward direction in response to a dispatch instruction or

Management Proposal or Stakeholder Issue	Renewable Developers and Developer Associations*	SCE	Division of Ratepayer Advocates	Calpine	Management Response
capability to curtail output in response to existing communication protocols. Resources must be capable of curtailing in increments of 5 MW and at a ramp rate of between 5-20% of rated capacity/min, with a default setting of 10%.	regarding generation power management should not be decoupled from discussion of the market and operational rules used to apply the capabilities. In this regard, variable energy generators should be allowed to offer curtailment bids and the ISO should compensate the wind generators accordingly. VER projects normally produce the maximum output achievable under any given operating conditions. As a result, VERs generally are not able to respond to dispatch instructions for increased output. A response for reduced output is possible. Such an instruction should be given only for the purpose of preserving grid reliability. Many VERs do not have the ability to ramp down in a continuous, governor controlled manner. However, some projects will have the ability to provide instantaneous output reductions in multiple controlled steps. LSA indicated that steps of the greater of 5 MW or 5% is reasonable.		technical issue that should not wait, but must reflect current capabilities and balance cost impacts.		operating order, be able to trip the plant remotely, and control the ramp rate after engagement or disengagement of a curtailment instruction. The ISO recognizes that absent storage, such resources cannot respond to instructions to increase output and therefore such capability is not part of the proposal. Moreover, the ISO has committed not to apply this capability until after conclusion of a subsequent stakeholder process to discuss market rules, including compensation for curtailment bids. The ISO has recognized that some resources will reduce output in a step-wise manner. As such, the generation management requirements have been modified to allow for less granular step reductions of 5 MW, which is consistent with a recommendation made by the development community. The ISO has attempted to accommodate commercial considerations by confirming that the capability is offered by multiple OEMs and by identifying a reasonable transition period of January 1, 2012. Finally, this obligation will not apply to resources that have existing or tendered LGIAs.

Management Proposal or Stakeholder Issue	Renewable Developers and Developer Associations*	SCE	Division of Ratepayer Advocates	Calpine	Management Response
	The capability to implement the requirements do not exist or are commercially impracticable.				
The ISO proposes to require all variable energy generators to meet the existing WECC over frequency droop response requirements.	Oppose The application of the droop requirement…to wind generators… should be based on a demonstration of need as determined in studies. There should be a provision for a 0.05 Hz deadband. The total requirement should be allocated to individual generators based on their MW size. ISO should not require an under frequency response.	No comment	No comment	Support	The application for droop control is currently a WECC requirement identified in MORC. A dead band has been included in the proposal. Use of droop control ensures the requirement that generators share in reduction based on their MW size. The droop characteristic is an automated process. In the case of VER, the response being requested is for + 0.036 Hz similar to all other resources. This requirement should not be limited temporally because all resources should be participating to reduce high frequency. AGC would kick in to help restore frequency but at any given time, there is a finite amount of regulating capacity available, which may not be adequate to lower the frequency. In other words, the over-frequency response should persist until AGC and/or other market dispatch reduce frequency below the threshold reliability level.

*Unless otherwise indicated the entities within this group include: Independent Energy Producers, CalWEA, Large Solar Association and Solar Alliance, NRG Energy, Inc., Sempra Generation, and NextEra.

Attachment C

Summary Table of Recommendations

Requirement	What is in place today?	What is proposed?
Power factor requirement	Two standards: • All generators, *<u>except wind</u>*, must meet 0.9 lag/0.95 lead, measured at the generator terminals. • Wind generators must meet 0.95 lag/0.95 lead, measured at point of interconnection , *<u>but only if</u>* explicitly required by a system impact study. • Does not prescribe the means to satisfy the standard and allows for developer to adopt least cost solution, including the use of auxiliary equipment, such as switched capacitors or static VAR compensators.	Keep two standards: • Maintain existing power factor requirement of 0.9 lag/0.95 lead at generator terminals for all <u>synchronous</u> generators, including most solar thermal technologies. • Extend wind standard of 0.95 lag/lead, measured at the point of interconnection, to all <u>asynchronous</u> generators, including wind generators, solar PV, Stirling engines. • Continues to allow for least cost solutions. • Establish the asynchronous power factor requirement as a default, rather than on a study-by-study basis.
Voltage Regulation	• Article 9.6.2 of LGIA establishes the requirement for <u>all</u> generators to maintain voltage schedules.	• Clarify the existing voltage requirement for all new variable energy resources generators to install an automatic voltage control system to regulate voltage at the point of interconnection, within the reactive capability of the generator facility.
Voltage and Frequency Ride-through	• Voltage - only explicit standard applies to wind through FERC Order No. 661-A • Frequency – WECC criteria set forth in Under-frequency Load Shedding Relay Application Guide.	• Extend Order No. 661-A voltage ride-through requirement to *all new generators.* • Clarify requirement for all generators to comply with the existing WECC frequency ride-through criteria.
Generator Power Management	• Active Power Management - tariff sections 4.6.1.1, 7.1.3, 7.6.1, and 7.7.2.3 require all generating facilities with Participating Generator Agreements to operate such that the ISO can control their output under both normal and emergency conditions. • Ramp Rate Limits and Control – Currently, there is no reference to the need for ramp rate limit/control in the tariff. Conventional fossil fuel source machines typically have "gradual" ramp rates, whereas wind and solar resources	• Require all variable energy generators to install control systems that provide for the ability to reduce output to a targeted set-point. • Require ramp rates controls that allow for a range of 5% and 20% of rated capacity per minute, with a default setting of 10%, subject to availability of renewable fuel resource (e.g., wind or sunlight). • Extend WECC MORC 5% droop criteria for over frequency only to all variable energy generators.

Requirement	What is in place today?	What is proposed?
	exhibit “steep” ramp rates. • Frequency Response – WECC MORC criteria require all synchronous machines to design a 5% droop setting to provide over-frequency & under-frequency governor response. Currently there is no requirement for VERs to provide any frequency response.	
Power System Stabilizers Requirement	• Article 5.4 of ISO LGIA requires power system stabilizers for all generators except induction type wind plants.	• Create an exception for all asynchronous generators, including induction type wind plants and asynchronous solar plants.
Use of Standard Models	• None	• Developers requesting interconnection must use WECC approved standard models when available.

SIEMENS **Industry**

Siemens AG, I IA CE S PV, Würzburger Str. 121, 90766 Fuerth

Grant Rosenblum
Mgr, Renewable Integration
CAISO

151 Blue Ravine Road
Folson, CA 95630

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Our reference	BP
Date	2010-04-30

Interconnection standards initiative
Draft straw proposal dated March 25, 2010

Dear Grant,

Siemens has reviewed CAISO's draft proposal for new variable energy resource interconnection standards and agrees with the intent and direction of the proposed rules.

Siemens will present this year the SINVERT PVS inverter together with our standard plant control system "PVS Control Box" to enable utility scale PV plants meet the proposed requirements put forth by CAISO.

SINVERT PVS inverter provides low voltage, zero voltage and high voltage ride-through and frequency ride-through capabilities. Since these capabilities are adjustable in a wide range it is our expectation that the final NERC/WECC ride-through requirements will be met.

Our plant level control system "PVS Control Box" provides for the following functions:

- Closed loop power factor control (e.g. power factor control with defined setpoint, voltage control based on Q(U) characteristic curve)
- Active power management for power limitation
- Restrict power ramp rates, both up and down, consistent with available insolation
- Over frequency droop functionality
- Interfaces for direct communication with ISO/TSO to receive setpoints (e.g. power limitation, reactive power) and commands and sends data

It is our intention to offer these capabilities to our customers regardless of whether CAISO imposes this performance requirement.

Siemens is well aware of the reliability and operability challenges that come with the integration of renewable generation to the grid. Siemens agrees with the intent and direction of the CAISO proposed requirements and will offer products this year to meet the intent and direction of the proposed requirements.

Please let us know if you have additional questions.

Best Regards

i. V.

Daniela Klein

SMA Solar Technology America, LLC.
4031 Alvis Court, Rocklin, CA 95677
www.SMA-America.com

May 7, 2010

To: Mr. Grant Rosenblum
Manager, Renewable Integration,
CAISO
151 Blue Ravine Road
Folsom, CA 95630

Subject: Interconnection standards initiative Draft straw proposal dated March 25, 2010

Dear Grant,

SMA Solar Technology America, LLC, a subsidiary of SMA Solar Technology AG (hereinafter referred to as SMA), has reviewed the document stated in the Subject line and as the world leader in inverter technology and installed PV capacity of over 7GW, SMA is pleased to endorse its support to the proposed interconnection requirements set forth by CAISO.

Since the summer of 2008, and thanks to the German Market MV Directive, SMA has taken steps to ensure that its products are compliant with various European interconnection standards to ensure "reliable PV penetration" on the grid. In light of these standards, our high efficiency Sunny Central line of inverters now being offered to the US market are already equipped with the following Grid Management features and Plant Control mechanism that we believe are in compliance with the interconnection standards being proposed in the Subject document:

- Active Power Curtailment and Control (set point control by Grid Operator)
- Power Factor Control and Adjustments (closed loop): the ability to control and adjust the Power Factor at the point of interconnection via various means:
  - Static or Fixed Setting
  - Dynamic Setting by the Grid Operator (set point command)
  - Automatic Adjustment based on Grid Voltage
  - Automatic Adjustment based on a pre-defined voltage schedule
- ZVRT, LVRT and HVRT capabilities
- Frequency Droop Control
- Ramp Rate Limiting with flexibility for different "ramp up" and "ramp down" values (assuming availability of sunlight and no intent to employ Energy Storage)
- Availability of SMA Dynamic Models in both PSLF and PSSE software for Dynamic Stability studies
- SCADA interface to EMS control centers for point telemetry and remote control
- OPC interface to Historian Systems for data archive and storage

We are also pleased to share with you that SMA has met with various US utilities (some of which are CAISO participants and most of which are WECC members) and reliability coordinators within the NERC region and they welcome the Grid Management features that our utility scale PV products are able to provide to make their system more reliable. Some utilities even expressed desire to have these standards implemented on Distributed Generation Systems if a high level of variable generation is to penetrate their network.

SMA Solar Technology America, LLC.
4031 Alvis Court, Rocklin, CA 95677
www.SMA-America.com

As the world leader in power conditioning systems, and now that the market has shifted from the PV business to being in the energy generation business, SMA is well aware of the operational, resource scheduling/coordination, and transmission challenges that utilities, ISOs and Reliability Coordinators are faced with in order to ensure a high level of variable generation penetration on the grid. While we still intend to comply with the current set standards by IEEE and UL, we also intend to keep offering our Grid Management features as a value proposition to our clients regardless of whether CAISO imposes these performance standards. We believe in the Smart Grid of the future and our value proposition in the form of the Grid Management features listed herein and which are in accordance with the CAISO proposed standards, is an essential building block of the Grid of the Future.

Should you have any questions, please feel free to contact our SMA America team anytime.

Kind Regards;

Elie J. Nasr
Business Development
Utility Scale Projects

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May 10, 2010

Grant Rosenblum
Manager, Renewable Integration
California ISO
151 Blue Ravine Road
Folsom, CA 95630

Re: Interconnection Standards Initiative
"Draft Straw Proposal" - March 25, 2010

Mr. Rosenblum,

Advanced Energy (AE) has reviewed CAISO's draft proposal for the new variable energy resource grid interconnection standards. AE agrees with the intent and direction of the proposed requirements.

In 2010, Advance Energy intends to introduce a PV site utility control system and Solaron Grid-Tied Inverter options with the goal of enabling utility scale PV installations to meet the proposed requirements put forth in the CAISO "Draft Straw Proposal" as well as the requirements of utility regulatory agencies around the world.

The Solaron Grid-Tied Inverters are planned to be equipped with Low-Voltage, High Voltage, and Zero Voltage Ride-Through as well as frequency ride-through capabilities. When implemented, these features will be adjustable to meet local grid interconnection standards and we expect that all CAISO requirements will be met.

The AE PV site utility control system is slated to provide:

- Interfaces to receive remote commands for Active and Reactive set point control
- Active Power Management (limitation and curtailment)
- Reactive Power (power factor) Control
- Ramp Rate Restrictions

AE understands the challenges of integrating variable energy sources with the grid. AE will be offering solutions that will enable our customers to meet the proposed CAISO interconnection requirements.

Best regards,

Ken Christensen
Solaron Product Management

GE Energy
Minesh Shah
Renewable System
Platform Leader
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E: minesh.shah@ge.com

Date: April 13, 2010

To: Grant Rosenblum
Mgr, Renewable Integration,
CAISO
151 Blue Ravine Road
Folson, CA 95630

Subject: Interconnection standards initiative
Draft straw proposal dated March 25, 2010

Dear Grant,

GE Renewable Energy, a division of GE Power & Water, GE Energy, has reviewed CAISO's draft proposal for new variable energy resource interconnection standards. GE has consistently taken the legitimate reliability concerns and operating challenges posed by variable renewable generation seriously, and we agree with the intent and direction of the proposed rules.

GE's wind turbines are in operation around the world and meet a broad range of voltage and frequency ride through requirements, similar to the rules proposed by CAISO. In addition to supplying wind turbines, GE presently offers plant level control systems that provide automatic voltage regulation and active power management at the point of interconnection (POI). In most cases the capabilities of GE's wind turbine and wind plants, on its own, enable owners and/or developers of wind plants to meet the requirements at the POI, as outlined in the proposal by CAISO. The plant level control system also has the ability to provide coordinated control of balance of plant equipment (e.g., capacitor banks) if such equipment is needed to meet the requirements at the POI.

In reference to utility scale solar PV plants, GE presently offers the Brilliance™ inverter and SunIQ, a plant level control and monitoring platform, to enable utility scale solar plants meet the proposed requirements put forth by CAISO. The GE Brilliance™ inverter provides low voltage, zero voltage and high voltage ride-through and frequency ride-through capabilities. While final resolution of NERC/WECC ride-through requirements are on-going, it is GE's expectation that the requirements can be met.

The SunIQ platform, which is a plant level control and monitoring system, provides for the following function:

1) Closed loop voltage (or power factor) control at the point of interconnection,
2) Active power management for power curtailment
3) Restrict power ramp rates, both up and down, *consistent with available sunlight.* (GE does not intend to include energy storage as a standard feature.)
4) Over frequency droop functionality
5) Interfaces for direct communication with ISO/TSO to receive data and send commands (e.g., power curtailment)

As indicated in the CAISO's draft proposal, grid integration capabilities at the present time do not apply to PV installations that are embedded with load on distribution systems. GE believes further industry resolution of conflicts between existing IEEE and UL standards and grid interconnection requirements of this type must be made even in distribution systems.

While GE understands the intent of the proposed standard, it is our intention to commercially provide these capabilities in our products *regardless of whether CAISO imposes this performance requirement*. GE believes that "grid friendly" solar power plants are a cost competitive offering for the utility scale solar PV plant in comparison with lower functionality, non-grid friendly PV plant offerings. In addition to the benefits of these features to the grid, GE also believes there is substantial value to our customers, those owning and operation PV plants, in terms of improved voltage management, reduced plant equipment stress, and reduced risk of excessive power curtailment for reliability reasons.

As indicated earlier, GE does recognize the reliability and operability challenges posed by variable renewable generation and the need for grid regulations to continue to promote the integration of renewable generation to the grid. As an OEM of renewable power generation equipment, GE agrees with the intent and direction of the CAISO proposed requirements, and GE offers products today to meet the intent and direction of the proposed requirements.

If there are questions, the GE team is available to answer the questions.

Best regards,
Minesh Shah
Platform Leader, Renewable Systems
GE Energy

Board of Governors May 17-18, 2010 **Decision on Revised Transmission Planning Process**

Motion

Moved, that the ISO Board of Governors approves the proposal to revise the transmission planning process, as detailed in the memorandum dated May 10, 2010; and

Moved, that the ISO Board of Governors authorizes Management to make all necessary and appropriate filings with the Federal Energy Regulatory Commission to implement the proposed tariff change.

Moved: Habashi Second: Hafner

Board Action: **Passed**	Vote Count: **4-0-0**
Doll	**Y**
Foster	**Not present**
Habashi	**Y**
Hafner	**Y**
Willrich	**Y**

Motion Number: 2010-05-G8

Attachment G

Key Dates in Interconnection Requirements Stakeholder Process

Materials provided by the ISO and stakeholders in the stakeholder process are available on the ISO's website at http://www.caiso.com/1c51/1c51c7946a480.html, with the exception that ISO Board of Governors materials are available on the ISO's website at http://www.caiso.com/2793/279385c753bb0.html.

Date	Event/Due Date
February 19, 2010	ISO hosts stakeholder conference call that includes ISO presentation entitled "Interconnection Standards Review for Renewable Integration" and discussion on interconnection requirements issues
February 26, 2010	Due date for written stakeholder comments on matters discussed on February 29, 2010, conference call
March 25, 2010	ISO issues paper entitled "Interconnection Standards Review Initiative – Draft Straw Proposal" for discussion at April 1, 1010, meeting
April 1, 2010	ISO hosts stakeholder meeting that includes ISO presentation entitled "Interconnection Standards Review Initiative" and discussion on interconnection requirements issues
April 8, 2010	Due date for written stakeholder comments on matters discussed at April 1, 2010, meeting
April 20, 2010	ISO issues paper entitled "Interim Interconnection Requirements for Large Generator Facilities Review Initiative – Draft Final Straw Proposal" for discussion on April 28, 2010, conference call
April 28, 2010	ISO hosts stakeholder conference call that includes ISO presentation entitled "Interconnections Requirements Review Initiative" and discussion on interconnection requirements issues
April 30, 2010	Due date for written stakeholder comments on matters discussed on April 28, 2010, conference call
May 7, 2010	ISO issues paper entitled "Interim Interconnection Requirements for Large Generator Facilities Review Initiative – Final Draft Straw Proposal"
May 10, 2010	Keith Casey, Vice President, Market & Infrastructure Development provides memorandum to ISO Board of Governors regarding "Decision on Interconnection Requirements Reform for Renewable Resources"
May 14, 2010	ISO issues matrix of responses to stakeholder comments provided to this point in the stakeholder process
May 18, 2010	ISO Board of Governors authorizes ISO to make all filings

Date	Event/Due Date
	necessary to implement revised interconnection requirements
May 25, 2010	ISO issues, for stakeholder review, draft tariff language to implement revised interconnection requirements
June 1, 2010	ISO hosts stakeholder conference call to discuss draft tariff language issued on May 25, 2010
June 3, 2010	Due date for written stakeholder comments on matters discussed at June 1, 2010, meeting
July 1, 2010	ISO files tariff amendment to implement revised interconnection requirements