California Independent
System Operator Corporation

California ISO

Renewable Resources and the California Electric Power Industry: System Operations, Wholesale Markets and Grid Planning

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Prepared by: California ISO

Table of Contents

1) Introduction

The State of California is considering an ambitious increase to its statutory renewable portfolio standard (RPS) from 20 percent by 2010 to 33 percent by 2020. The 33 percent RPS was incorporated into the California Air Resource Board's (ARB) scoping plan for achieving the state's AB 32 targets for greenhouse gas reductions and advanced by other state agencies pursuant to related executive order issued by Governor Arnold Schwarzenegger issued in November 2008 (Order S 14-08).

Along with the state agencies, the electric power industry and the California Independent System Operator Corporation (the ISO) are mobilizing to prepare for the substantial planning, along with the operational, technological and market changes, needed in the power sector to accommodate higher levels of renewables.

The ISO is an independent system operator that provides open access to the transmission system under its control while simultaneously operating the grid and markets for energy, ancillary services[1] and congestion revenue rights.[2] On April 1, 2009, the ISO launched a new market that has the capability to significantly facilitate renewable integration. The new design introduces both day-ahead and real-time markets that use state-of-the-art software to assist in optimizing the use of system resources, while accounting for key constraints on electric power production such as transmission congestion and losses. During the operating day, the ISO now has more accurate procedures to adjust the commitment and output of market resources in response to changing real-time conditions, with dispatch instructions sent every five minutes. This allows for more efficient use of system resources in following the output of variable generation renewable resources, like wind and solar. As a result, the new market will allow more renewable energy to be delivered over the transmission system and less fossil generation will be needed to keep the system in balance.

Because of its experience with reliable system operations and the properties and capabilities of power system infrastructure, the ISO is in a position to clarify and validate the operational requirements, and implement technological solutions, to support higher levels of renewable integration. As a grid planner, the ISO also evaluates and approves options for expanding California's transmission infrastructure in support of renewables at minimum cost to ratepayers, while maintaining compliance with mandatory reliability standards.

New types of technologies and technical specifications are necessary to reliably and efficiently operate the system with high levels of renewables. Technical specifications

[1] Ancillary services refer to a range of additional services needed for system reliability, including operating reserves and regulation, that the ISO procures, or accounts for, when operating the power system. For more details, see Box 2, below.

[2] Congestion revenue rights are financial rights allocated to load-serving entities that provide a hedge against transmission congestion charges.

(or grid codes) that improve reliability and controllability of variable generation renewable resources are one example. There is also a need for additional energy storage that can adjust its output rapidly in response to the variability of renewable output, including providing regulation services, and take advantage of the potential surplus of wind energy in the overnight (off-peak) hours to store energy for release in the peak hours. Additionally, load shifting and demand response capabilities are needed in response to market prices, along with greatly improved coordination and control of these demand side and storage capabilities and more efficient use of transmission infrastructure through advanced operational technologies, such as envisioned for a “smart grid.”

This paper introduces aspects of the ISO core functions and its role in accommodating the state’s RPS goal. Section 2, which follows, provides background on the policy and regulatory drivers and the interdependencies among renewables and other policy initiatives. Section 3 provides information on the status of renewables in the California resource mix, with projections to 2020. Section 4 explains how the ISO operational and market systems are being adapted to support renewable integration. Section 5 reviews technological solutions needed for renewable integration over the coming decade and how the ISO plans to facilitate them. Section 6 focuses on the development of generation and transmission infrastructure. This section also discusses the ISO role in ensuring supply adequacy through the state’s Resource Adequacy program as well as how renewable resources are considered in the ISO generation interconnection and transmission planning processes. Finally, Section 7 briefly introduces the important regional dimension to renewables development and integration.

2) Policy Background

The California Energy Commission (CEC), the California Public Utilities Commission (CPUC), and Local Regulatory Authorities, such as the governing boards of municipal utilities and irrigation districts, share responsibility for implementing the RPS program. The CEC role is principally to certify renewable resources for RPS eligibility[3] and develop a tracking and verification system to ensure that renewable energy output is counted only once for RPS compliance. The CPUC and local regulatory authorities focus on procurement activities of their respective jurisdictional retail sellers of electricity. The CPUC for instance, reviews and approves renewable energy procurement plans (and long-term procurement plans that include renewable integration capabilities), reviews contracts for RPS eligibility, establishes standard terms and conditions for renewable energy contracts, and establishes compliance rules and procedures for investor-owned utilities, electricity service providers, and community choice aggregators. Currently, local regulatory authorities perform similar functions.

The CEC, in coordination with the Western Governors’ Association, established the Western Renewable Energy Generation Information System (WREGIS), as the means to comply with its mandate to develop a renewable energy registry and tracking system. The generation information system tracks generation from registered units using

[3] Renewables Portfolio Standard Eligibility (third ed.), http://www.energy.ca.gov/2007publications/CEC-300-2007-006/CEC-300-2007-006-ED3-CMF.PDF

verifiable data and creates renewable energy certificates (RECs) for this generation. The renewable certificates are intended verify compliance with state and provincial regulatory requirements throughout the western interconnection and in voluntary market programs. RECs and energy from a qualified renewable resource procured together as a "bundled" commodity are currently eligible for California RPS compliance purposes. Renewable certificates sold separately from the underlying energy are "tradable" and are not presently eligible for RPS compliance, although the CPUC has statutory authority to permit the use of tradable RECs.

Other Policy Drivers and Interdependencies

Renewable energy policy is increasingly closely tied to climate policy. In 2006, California enacted Assembly Bill 32, which requires that the state reduce its GHG emissions to 1990 levels by 2020. AB 32 envisions reducing GHG emissions across several economic sectors, including from the electric power and transportation sectors, with a cap-and-trade system to allow for efficient reduction options. The first compliance year is 2012. Emissions from electric power plants, including imports, comprise about 23 percent of total California GHG emissions. While imports account for about 22 percent of the total electricity consumed in the state, they account for about 50 percent of the GHG emissions associated with electric power.

AB 32 directs ARB to develop specific reductions by sector and establish the mechanisms to achieve the goals. The ARB Scoping Plan has three major measures that substantially affect the power sector:[4]

- 33 percent RPS, which is estimated to result in 21.3 million metric tons of carbon dioxide equivalent (mmte) reductions or approximately 14.5 percent of reductions from the capped sectors.
- Energy efficiency requirements, which are estimated to result in 26.6 mmte reductions or approximately 18 percent of reductions from the capped sectors.
- A cap and trade system developed through the Western Climate Initiative, which will assign an emissions cap to all emitting generation within California and all imports, based on rules that are still in development.

Other measures that will affect the electric power sector include ship electrification in ports (up to 3.7 mmte) and California's million solar roofs initiative (2.1 mmte). Electrification of vehicles will also shift emissions from the transportation sector to the electric power sector with the goal of a net reduction in emissions, in part because of the opportunity to charge vehicles using renewable energy.

To the extent that increases in portfolio standards are used to achieve greenhouse gas reductions, the success of the effort will require substantial innovation in regulatory mechanisms, planning and markets. For example, demand response, storage technology, and, in later years, increased use of electric vehicles have the potential to facilitate the integration of variable generation ***and*** reduce GHG emissions. Success in developing

[4] The ARB scoping plan is available at http://www.arb.ca.gov/cc/scopingplan/scopingplan.htm.

and deploying these and other new tools and technologies is critical. Similarly, it will require an extraordinary effort to transform the electric transmission system and drive significant changes in how the ISO operates the system in compliance with federal reliability standards. Complicating the integration effort are other important environmental objectives such as limiting the use of once-through cooling (OTC) technology in coastal power plants and reducing air emissions in southern California. This paper discusses the range of technology, market and transmission infrastructure issues so essential to the state's success in this critical effort.

3) Renewables in the California Resource Mix to 2020

For perspective on the magnitude of the investment to achieve current and proposed RPS goals and the potential implications of cap and trade or other carbon pricing mechanisms, once-through-cooling limitations, and other policy choices, it is helpful to understand the current resource mix used to meet California's system needs. The following table, developed by the CEC, summarizes the sources of total system electric energy for the state in 2008.

2008 Total System Electric Energy in Gigawatt Hours					
Fuel Type	**In-State Generation[1]**	**Northwest Imports[2]**	**Southwest Imports[2]**	**Total System Power**	**Percent of Total System Power**
Coal*	3,977	8,581	43,271	55,829	18.2%
Large Hydro	21,040	9,334	3,359	33,733	11.0%
Natural Gas	122,216	2,939	15,060	140,215	45.7%
Nuclear	32,482	747	11,039	44,268	14.5%
Renewables	28,804	2,344	1,384	32,532	10.6%
Biomass	5,720	654	3	6,377	2.1%
Geothermal	12,907	0	755	13,662	4.5%
Small Hydro	3,729	674	13	4,416	1.4%
Solar	724	0	22	746	0.2%
Wind	5,724	1,016	591	7,331	2.4%
Total	**208,519**	**23,945**	**74,113**	**306,577**	**100.0%**

Note: In earlier years, the in-state coal number included coal fired power plants owned by California utilities located out-of-state.

1. In-state generation: Reported generation from units 1 MW and larger.
2. Net electricity imports are based on metered power flows between California and out-of-state balancing authorities.
3. The resource mix is based on utility power source disclosure claims, contract information and calculated estimates on the remaining balance of net imports.

In 2008, the three large IOUs supplied approximately 13.7 percent of their total sales from eligible renewable resources.[5] Even accounting for the economic downturn, it is clear that California utilities must nearly double the quantity of energy supplied from renewable resources simply to meet the near-term 20 percent RPS target. The CPUC has acknowledged that the gap between the current contribution from renewable resources and the statutory objective is unlikely to close until 2012-2013,[6] assuming that generation under contract actually materializes. .

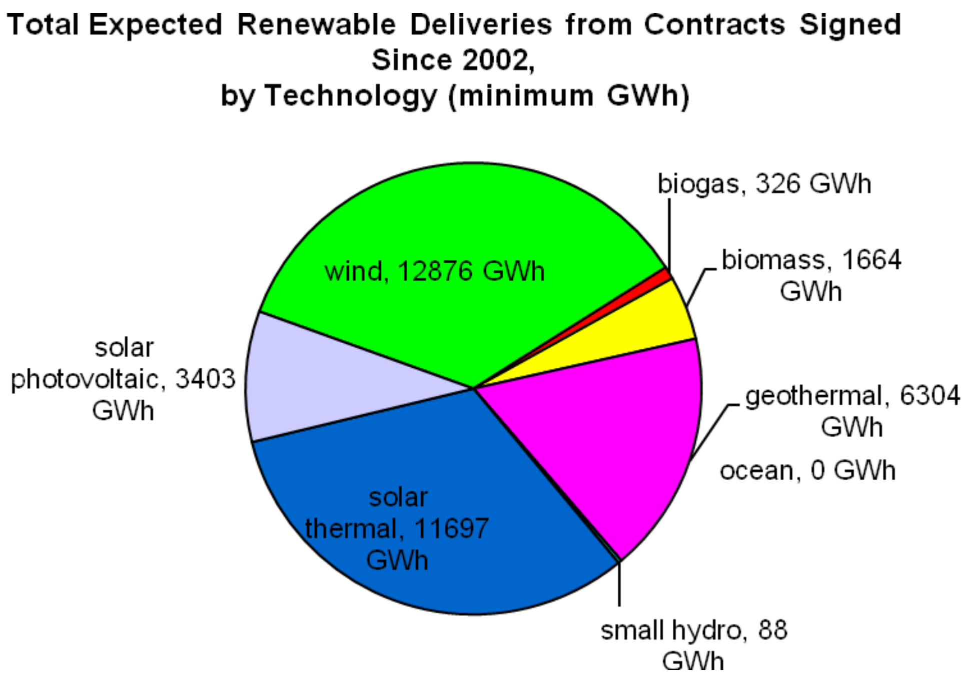

Figure1 [7]

The current IOU renewables contracts include substantial technological and geographic diversity. As shown in Figure 1 above, wind and solar resources represent roughly equal components of the total capacity under contract, with nearly 50 percent of the total wind capacity under contract from out-of-state resources. Only 14 percent of the overall amount under contract is online and incorporated into the energy output calculated in Figure 2.[8]

From a system operations perspective, the geographic and technological diversity of the contracted resources provides benefits by reducing the variability of the renewable

[5] See http://www.cpuc.ca.gov/NR/rdonlyres/9BFE4B8B-BBD7-405D-A58A-0155083578E7/0/090210CPUCPresentationforSenEUChearingofSB14.pdf

[6] See http://docs.cpuc.ca.gov/word_pdf/REPORT/85936.pdf

[7] The source for Figure 2 is the CEC at http://www.energy.ca.gov/portfolio/contracts_database.html.

[8] See http://www.energy.ca.gov/portfolio/contracts_database.html.

resources. Diversity mitigates variability to some extent because wind and solar radiation patterns vary over large geographic regions and while wind production peaks at night on average, solar resources peak during the day (although not at peak demand hours during some times of year in California). However, as noted by the CPUC, the heavy reliance on largely untested, but transformational, technology, in the portfolios currently under contract such as solar thermal resources, contributes to implementation delays and may not strike the correct balance between in-state job creation and consumer costs.

To establish an analytical framework to evaluate policy considerations and provide an initial quantitative analysis of the costs and risks of alternative means of achieving a 33 percent RPS by 2020, including timing considerations, the CPUC has developed and studied four possible renewable resource portfolios scenarios:[9]

- **33 percent RPS Reference Case** – This represents current renewable procurement practices, which include significant reliance on solar thermal technologies.
- **High Wind Case** – This demonstrates less reliance on in-state solar and more reliance on wind.
- **High Out-Of-State Delivered Case** – This places greater reliance on out-of-state renewable resources and includes the construction of new transmission lines to deliver the energy to California. This scenario does not assume the ability to use tradable RECs to meet RPS obligations.
- **High Distributed Generation Case** – This relies on large penetrations of smaller-scale renewable generation connected at the distribution level.

The underlying resource mix will have a profound impact on achieving California's policy objectives. Each resource strategy performs differently when measured against regulatory or policy criteria, including local air quality, land use impacts, cost minimization and timing of implementation. For example, as evaluated by the CPUC, the high distributed generation case has cost and operational reliability considerations that are not well understood, but it would reduce the need for high-voltage transmission infrastructure and its potential political and environmental risks. In contrast, the high wind case may trigger operational concerns due to substantial over-production in the off-peak hours. Integrating renewables under this scenario would require significant coordination with energy efficiency and storage technologies (see discussion below), to shift energy consumption to periods of high wind production.

The ISO is currently updating existing and developing new statistical and production simulation methodologies to evaluate these portfolios. Some of this analysis will help state agencies clarify their own objectives in the transition from 20 percent to 33 percent RPS. The focus of this analysis is both the operational requirements that the portfolios are likely to entail (see discussion in the next section) as well as determining the portfolio of generation resources and integration technologies that would be most cost-effective. As discussed in the transmission planning section, the ISO is also engaged with renewable transmission planning to achieve the 33 percent RPS.

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[9] This report can be found at http://www.cpuc.ca.gov/PUC/energy/Renewables/hot/33implementation.htm.

4) System Operations and Wholesale Markets in Renewable Integration

The remainder of this paper addresses the core functions of the ISO and its role in renewable integration. Two of the ISO's core functions are the reliable operation of the power system concurrent with the operation of spot markets that provide energy and other services and capabilities to ensure reliability.

ISO power spot markets are a specialized type of commodity market in that any trading must be consistent with: (a) the physical laws that govern power flows, (b) the need to balance the system second-by-second, and (c) management of the many physical and reliability constraints that affect the operation of both generation and transmission facilities — particularly the congestion and losses associated with transmission use. Because of these features, the ISO conducts many of its operational and market functions through fully integrated processes. As will be described further below, the ISO markets are in fact largely designed around system operations, and the prices generated in those markets provide information relevant to future operational needs.

In April 2009, the ISO implemented a redesigned wholesale market for energy and ancillary services along with upgrades of software and information technology systems. So now, energy prices are calculated a day-ahead and during the operating day for over 3,000 locations on the 75 percent of the California grid operated by the ISO. Market power and market gaming are carefully mitigated. The new market and system operational capabilities will be particularly useful in the next decade given that renewable integration will likely become the major driver of operational needs on the power system. ISO market prices and energy procurement will guide efficient use of California's power system infrastructure, especially when supported by new technologies such as those making up the smart grid. The ISO markets are complementary to the long-term bilateral contracts entered into by load-serving entities, which are governed by the CPUC's Long-Term Procurement Plan. As with other commodity markets, spot prices for each service transacted in the ISO markets will influence the forward prices for power and capacity negotiated in bilateral contracts.

Operating Characteristics of Wind and Solar Resources

Before considering how ISO system and market operations will assist in renewable integration, it is important to understand the properties of the major types of renewable resources – especially the "intermittent" or "variable generation" wind and solar resources.[10] These properties are: variability of their output; and the uncertainty over their output prior to actual performance, as reflected in the errors associated with wind

[10] "Variable generation" has become the latest terminology for resources whose output is based on a fuel source that has variable performance. See NERC, *Special Report: Accommodating High Levels of Variable Generation to ensure the reliability of the bulk power system*, April 2009. Available at www.nerc.com.

and solar forecasts. Figure 2 shows the variability of wind output in a typical month by hour of the day. Figure 3 shows the variability of a solar PV panel due to transitory cloud cover. Another aspect of wind variability and uncertainty is the possibility of sharp, and difficult to predict, spikes in wind output. Figure 4 shows such a spike during a storm, plotted with the magenta line, which illustrates a 360 MW jump in 20 minutes.

The adaptation of power system operations to high levels of variable generation renewables has just begun in the United States. System operators have many years of experience with the variability of *demand* over different operational time-frames but do not have the same experience with supply. The output of conventional generation is extremely predictable and subject to operator control. Unplanned outages and deratings (or lowering the capacity of generation and transmission) are factored into reliable system operations, and failure to respond to dispatch instructions is subject to penalties. In contrast, wind and solar generation vary over short periods of time with changes in the weather, and they largely lack controllability (although, as discussed below, modern wind and solar technology can have substantial control capabilities). These issues pose challenges that the ISO is addressing through a variety of technology, market and planning initiatives described in the next sections of this paper.

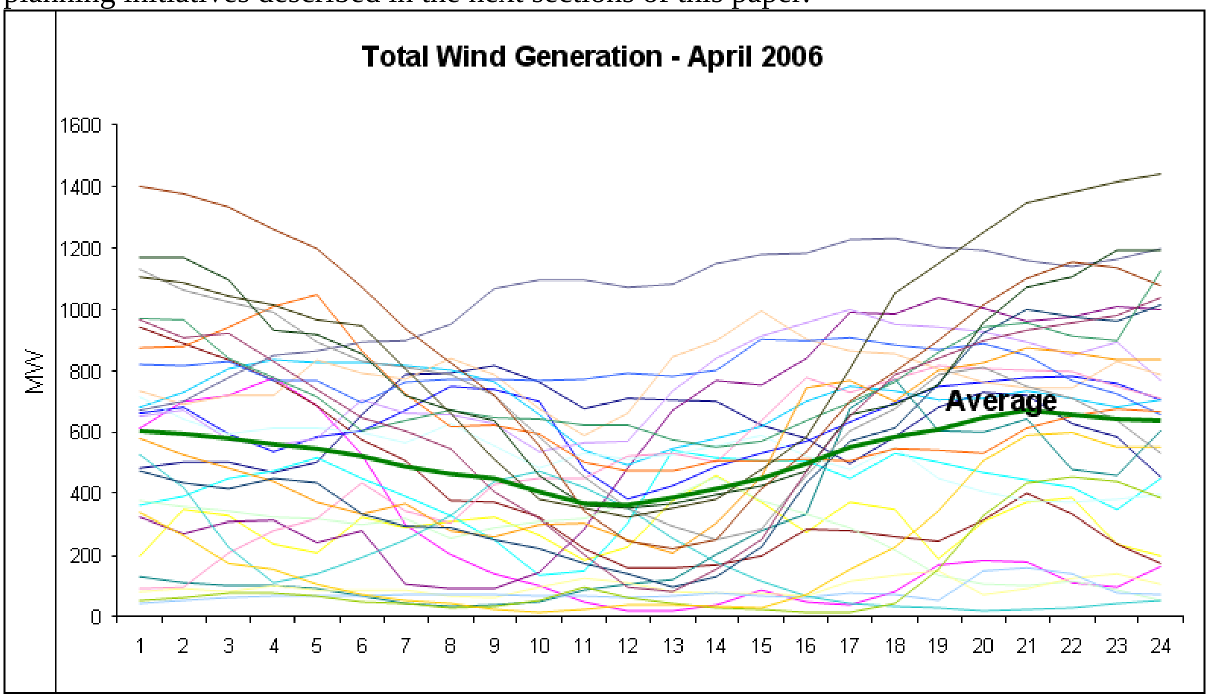

Figure 2

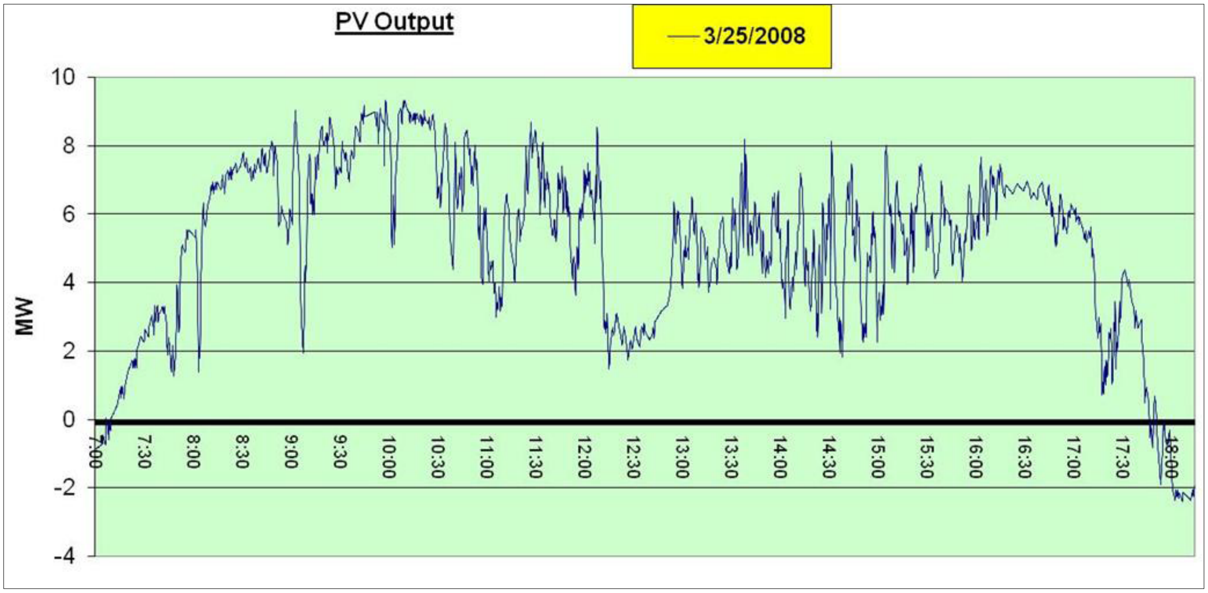

Figure 3

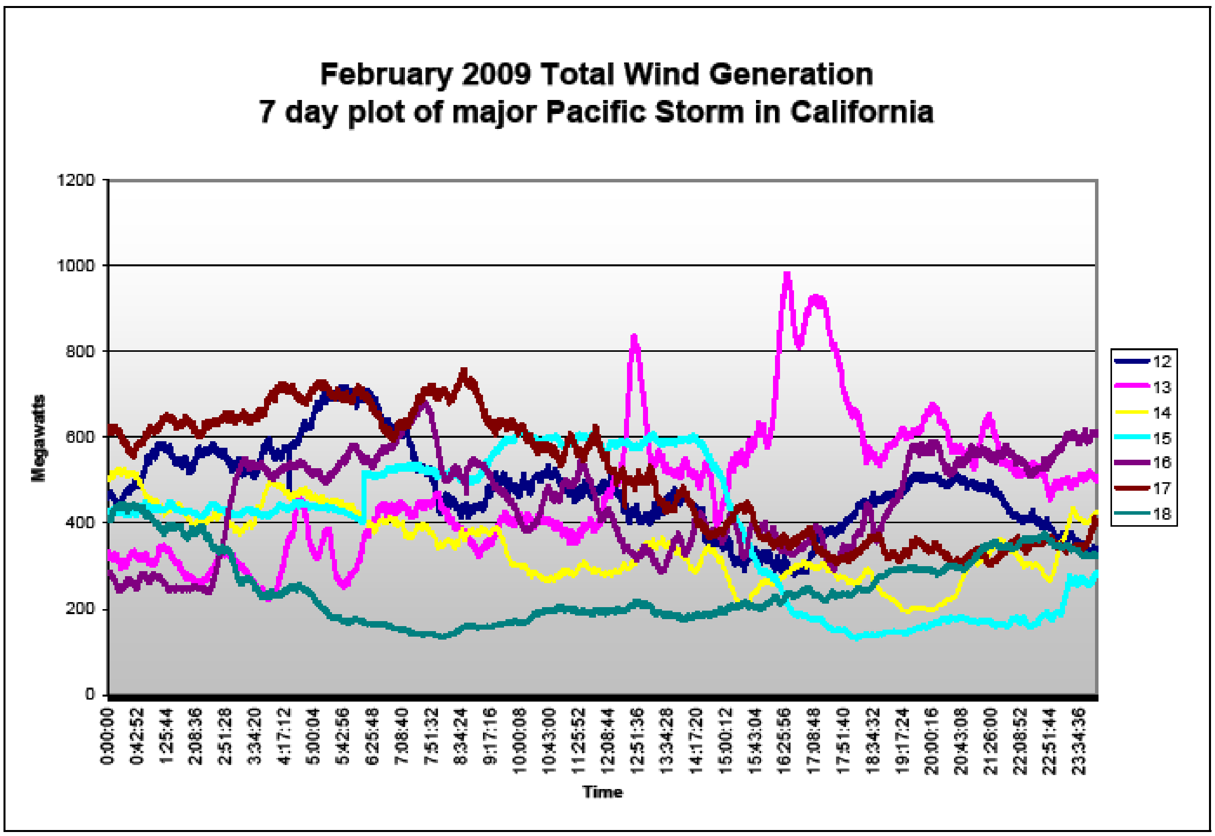

Figure 4

Improved Forecasts Facilitate Renewable Integration

Wind and solar output forecasts take place in several time-frames, including prior day, those that take place between one and several hours before the operating hour, and much shorter term forecasts that are used within the operating hour. Improving forecasts will clearly support more efficient renewable integration by allowing the ISO to commit and dispatch other types of generators more accurately to account for renewable variability. Less accurate forecasts will result in over-scheduling of thermal resources due to uncertainty of wind production, leading to higher energy and ancillary service costs and possibly higher GHG emissions.

Forecasting quality improvement comes from better input data regarding the day ahead forecasted wind speed and the wind direction at the 80 meter level for each of the large wind generation areas.

A second forecast issue is the difficulty in predicting large energy ramps, both up and down, from variable generation resources, as shown in Figure 4 above. Wind generators can quickly shut down when wind speeds exceed safe operating limits. As a result, a big storm front with high wind gusts can first result in a substantial spike in output, followed by the loss of hundreds of megawatts energy from wind generation over a short period of 10 to 20 minutes. Also wind shear conditions at a wind facility may result in the units going from zero to full output within a few minutes when the wind shear condition changes and the wind hits the turbines instead of passing above the units. The ISO is working with the Bonneville Power Administration and forecasting companies to improve the tools for predicting these types of energy spikes and to make this information available to ISO operators.

Operational Requirements For Renewable Integration

In its 2007 study of renewable integration (see Box 2, below), the ISO developed methodologies to quantify additional operational capabilities needed to support variable generation renewables.[11] These included estimates of changes in load following[12] capacity and ramp, regulation capacity and ramp, and the morning and evening energy ramps. Ramp refers to the rate of change in output of one or more generators or other resources, typically measured in megawatts per minute or megawatts per hour. The requirements were developed under a scenario of the 20 percent RPS being achieved through additional wind resources at Tehachapi. Some of the findings are summarized in Box 1, below.

The ISO concluded that some prior integration studies had underestimated certain operational requirements. For example, the 2007 study estimated that the ISO's procurement of regulation services[13] could more than double in certain hours of the day

[11] The study is available at http://www.caiso.com/1c51/1c51c7946a480.html.
[12] Load following is defined as the difference between a unit's hourly schedule for energy and the deviation from that schedule that operators instruct in each five minute dispatch interval.
[13] Regulation is an ancillary service that provides continuous balancing necessary to compensate when the energy dispatched by the system operator, along with interchange schedules, every 5 minutes does not

to account for unexpected wind variability. This estimate, based on analysis of actual operating data, is much higher than prior studies.

A further recommendation of the report was that renewable integration, especially at higher levels, requires increased flexibility of system resources, including increased participation by storage and demand response. The generation fleet needs lower minimum operating levels (to reduce over-generation conditions), faster ramp capability, and additional Regulation capacity. Characteristics of other resources are described below. The power system also needs to maintain sufficient inertial response, especially as thermal generators are potentially displaced at higher levels of renewables.

Analysis of operational requirements must further verify that the generation commitment and dispatch itself is able to meet these requirements under different scenarios of renewable resources, and given the uncertainty created by forecast error. To evaluate these scenarios, the ISO recently conducted unit commitment simulations with a 20 percent RPS that also considered day-ahead and hour-ahead forecast errors as well as 10 minute dispatch intervals to approximate real-time conditions. Initial findings suggest that, within the assumptions and limitations of the simulation, the generation fleet can be optimized to operate without violating regulation capacity or ramp constraints. However, there are certain limitations of the analysis, such as the inability to account for intra-hour forecast error. The ISO is evaluating next steps needed to verify the operational capabilities of the system with 20 percent and higher RPS.

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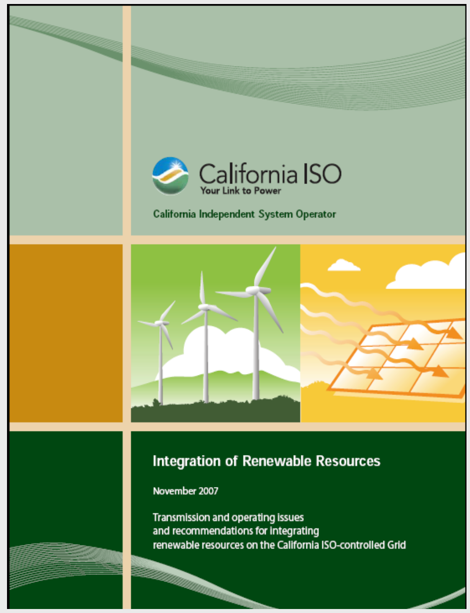
balance actual demand in that interval. The mismatch could be caused by short-term load forecast errors and/or other changes on the system.

Box 1. Transmission and Operating Issues Associated with Renewable Resource Integration



In November 2007, California ISO released a study of the transmission and operating issues associated with achieving a 20 percent RPS, largely through additions of wind resources in the Tehachapi area. The study consists of several components. Transmission system analysis includes transient stability and post-transient voltage stability of the ISO grid; evaluation of wind plant function characteristics necessary to achieve acceptable static and dynamic performance. The operational issues analysis includes assessment of overall ramping requirements (MW/min), load-following capacity (MW) and ramping requirements, and regulation capacity and ramping requirements. The study also evaluated over-generation issues and potential solutions.

Among the major findings of the analysis was that the transmission upgrades for the Tehachapi area are sufficient to support up to 4,200 MW of additional wind resources. Moreover, up to an additional 800 MW/hr of generating capacity and ramping capability will be required to meet the multi-hour ramps, along with substantial increases in regulation procurement. The ISO has to have the authority to curtail wind generation during overgeneration conditions. The study and follow-up projects to support its conclusions and extend the analysis can be found at http://www.caiso.com/1c51/1c51c7946a480.html.

ISO Market and System Operations Processes Facilitate Renewable Integration

The California ISO, like all U.S. independent system operators, has an integrated approach to market and system operations that facilitates scheduling and dispatch of renewable and non-renewable resources.[14] By "integrated", we refer to the fact that the physical constraints and state of the infrastructure on the system to which grid operations must adhere – generator operating constraints, transmission constraints, generation and transmission outages or deratings, and so on – are considered when setting schedules and prices for energy and ancillary services in the ISO's day-ahead and real-time wholesale markets. More information on these markets and system operations can be found in the ISO's business practice manuals;[15] this section provides information to explain features applicable to renewable integration.

[14] For a survey of how ISOs facilitate renewable integration, see ISO/RTO Council, "Increasing Renewable Resources: How ISOs and RTOs Are Helping Meet This Public Policy Objective," October 16, 2007, available at www.isorto.org.

[15] See in particular the BPM for market instruments and the BPM for market operations. These are available at http://www.caiso.com/17ba/17baa8bc1ce20.html.

Day-Ahead Market: Anticipating Demand and Operating Requirements

Because generation resources have different start-up times (ranging from more than 24 hours for large steam units to under 10 minutes for gas turbines), all system operators must begin the process of scheduling generation before the operating day. The ISO first lets the day-ahead market provide this schedule and then makes adjustments using its own load forecasts. The day-ahead market and scheduling procedures begin at 10 a.m. on the day prior to the operating day. That is the deadline for submitting price and quantity bids ($/MWh) from generation or demand response that can potentially supply spot energy or ancillary services – regulation and operating reserves (see Box 2). In addition, all bids to buy energy ($/MWh) to serve the next day's load and non-price schedules, or self-schedules (MWh) – requests to inject and withdraw power independent of the market price – must be submitted at the same time.[16] If the ISO was to procure the additional regulation requirements identified in the 2007 report for renewable integration, it would take place in this market.

> **Box 2. What are Ancillary Services?**
>
> Ancillary services are additional services provided by generation and, increasingly, non-generation resources, such as demand response and storage, that are needed for power system reliability. As discussed elsewhere in this report, ancillary service procurement may increase with additional renewables. Two types of ancillary services are procured by the ISO through the wholesale markets: operating reserves and regulation. Operating reserves are essentially capacity retained on generators that can be converted to energy in a short period of time in order to responds to contingencies such as the loss of a generating resource or a transmission line. There are two types of operating reserves in the ISO markets: ten-minute spinning reserves, provided by resources that are synchronized to the grid, and ten-minute non-spinning reserves, provided by resources that are not synchronized but can start and provide energy within ten minutes. Regulation is energy provided on a second-by-second basis for system balancing by resources equipped with automatic controls. Currently provided by thermal generators and hydro systems, regulation could be supplied also by demand response and storage technologies. The ISO also meets other ancillary services requirements that are not procured through the markets, such as voltage support and black-start.

Following a procedure to mitigate generator bids for market power if necessary, and to pre-position certain generation units that are needed for local reliability,[17] the bids and schedules are co-optimized through an auction called the integrated forward market. "Co-optimized" means that the auction algorithm allows for the optimal use of a generator – to provide the most cost-effective mix of energy and regulation and operating reserves – in each hour of the day. The forward market results in day-ahead hourly

[16] These types of non-price schedules, which can be submitted by supply and demand resources, are given a scheduling priority in the market, are price-takers for settlement purpose, and are only altered when the market is unable to clear based only on price-quantity bids.

[17] Local reliability includes capacity requirements and transmission system requirements, such as voltage support, that must be provided by generators at particular locations on the grid. More information on local reliability assessment procedures and Reliability Must Run contracts can be found at http://www.caiso.com/docs/2001/10/15/2001101510100413037.html

schedules for generators whose bids were accepted by the market and ensures that self-schedules are feasible. It also calculates prices applicable to each generator location, called locational marginal prices and averaged prices for load in the service territories of the investor-owned utilities (and other entities that request such prices), called load aggregation points. Prices and schedules are determined simultaneously and reflect congestion and losses at each location. A market participant that offered to sell 100 MWh of energy at $50/MWh at its location will be scheduled for those hours in the next day in which power at its location is worth $50/MWh or more, but not for those hours in which power at its location can be delivered from other generators for less than $50/MWh.[18] Generally, more than 90 percent of next-day demand is cleared through the forward market.[19]

Currently, there is no requirement, and only weak financial incentives, for renewable resources to schedule or offer their power into the forward market (as discussed below, most renewable resources today bid or schedule only in the real-real time market, which occurs hourly in advance of the operating hour). There is some scheduling day-ahead of wind resources, but little compared to expected next-day output. As the ISO sees additional renewable energy generation at higher RPS levels, this lack of day-ahead scheduling will lead to increased over-commitment of thermal generation (to minimize the risk of a supply shortfall) and a divergence of prices between the day-ahead and real-time market. Hence, a need exists to change in the incentives for renewable resources to schedule day ahead, or possibly the participation in the forward market by financial entities that can anticipate next-day renewable output.

After the forward market, the ISO conducts the first of several adjustments to the next-day schedule for energy and capacity in its residual unit commitment process. This uses the ISO's next day load forecast for each hour and commits any additional resources needed. The ISO may also "decommit" resources after the unit commitment process if it appears that the forward market scheduled an excess of supply. With the development of its improved day-ahead wind forecast, the ISO anticipates that the unit commitment process will be adjusted to compensate for expected wind output in the operating day. The unit commitment is the last formal step of the day-ahead process to prepare the power system for the operating day.

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[18] A generator's start-up cost ($) and cost to produce at its minimum operating level ($/MWh) are also considered in the auction solution. Hence, if a generator has a high start-up cost compared other generators with similar Energy bid prices, it may not be scheduled to run even when its Energy bid price is at or lower than the cost of Energy at its location.

[19] The forward market has certain bidding and scheduling requirements on supply and demand. Most non-hydro and non-renewable generators that are listed as resource adequacy generators under the CPUC's resource adequacy program have to schedule or offer their full amount of resource adequacy capacity into the forward market. On the demand side, load-serving entities have to schedule most of their load or be subject to penalties for under-scheduling. In addition, load that was not scheduled in the forward market and shows up in real-time will pay for the costs of starting additional generation units and may be exposed to more volatile energy prices for supply. Given these incentives, the ISO expects that the supply and demand cleared in the forward market will reasonably approximate the actual next day demand. However, there is no obligation on load-serving entities to fully schedule in the forward market, which is why the RUC procedure based on the load forecast, described below, is needed to ensure sufficient unit commitment for the next day.

The Real-Time Operational Procedures and Markets: Adjusting to Actual System Conditions

With the day-ahead schedules finalized, the ISO begins a series of interlocking procedures that conduct further adjustments to the schedules prior to the operating hour. These are called collectively the real-time market, although calculation of actual market prices is the last step in this process. A single bid submission that closes 75 minutes prior to each operating hour is used for all components of the real-time market. The first step is the hour-ahead scheduling process, which takes place 60 minutes prior to the operating hour and whose main function is to schedule power across the ISO interties (that is, imports and exports). This hourly procedure is needed because interchange schedules between the ISO and its neighbors are typically established for a full hour. The hour-ahead timeframe is also when the ISO finalizes output schedules for the operating hour for its wind resources. This process is described in more detail below.

Following the hour -ahead scheduling process, the ISO next conducts several look-ahead forecasts to commit additional generation units that can start in the time horizon being evaluated. These procedures can also procure any additional ancillary services needed on a 15-minute interval basis.

Finally, for every 5 minutes of the operating hour, the ISO sends dispatch instructions to generators, to increase or decrease their energy output. The 5-minute dispatch is a particularly useful mechanism to support renewable integration because the smaller the time-step of the dispatch, the better the ISO can adjust the output of non-renewable generators needed to balance wind or solar variability. Within the 5-minute dispatch interval – that is, in between the dispatch instructions – any differences between the actual load and the energy produced by responses to dispatch instructions and interchange schedules is made up by generators on regulation. These units provide regulation services through automatic generation controls. As discussed below, the ISO envisions the development of new storage and demand response regulation energy capabilities to meet regulation requirements when more renewable generation is on-line.

In the future, the ISO and other power system operators will also explore new algorithms that account for the uncertain nature of renewable output in the unit commitment process and real-time commitment decisions. Such algorithms will further improve market efficiency.

Participating Intermittent Resource Program: Reducing the Cost of Selling Wind Power

Because of the variability of wind, and to some degree, solar generation, these renewable resources experience significant differences between their scheduled and actual output, called an “imbalance.” For example, based on its hour-ahead forecast, a wind farm with 120 MW of capacity could schedule to produce 100 MW over the hour between 8 am and 9 am, but then actually produce in a range between 50 MW and 120 MW in any particular 5-minute dispatch interval during the hour. When a wind resource is producing below its scheduled output, the ISO has to increase the output of other generation for that period; and when it is producing more than its scheduled output, the ISO may have to back down some other generation, which may also incur costs if that generation has already been paid for its output in the day-ahead market.

In the early 2000s, the financial risk of being exposed to the wholesale market costs of these energy imbalances was seen as a significant impediment to wind resource development. To address this issue, the ISO and market participants fashioned a program in 2003 and 2004, called the Participating Intermittent Resources Program. This program had two primary aims: first, to obtain telemetry from wind resources for purposes of establishing a more accurate forecast for those resources, and second, to reduce the imbalance costs to those resources that provided the telemetry. Participating resources provide telemetry to a wind forecast vendor, which provides them with an hour-ahead wind schedule that they in turn submit to the ISO. Resources that submit these schedules are charged a monthly averaged energy imbalance charge.[20] The result is a small subsidy to the wind resources from the buyers in the real-time wholesale market (who pay for all real-time energy at its actual cost), and a large reduction in the financial risk of participation in the market for wind generators.

However, as the amount of wind and other variable renewable energy on the system increases, the market and operating implications of the difference between scheduled and actual output could become larger, depending on the capabilities of other resources on the system, such as storage. The ISO will work with stakeholders to develop the correct incentives to achieve a higher degree of day-ahead scheduling of renewable output, as well as more capability on the part of variable generation renewables to respond to market-based dispatch instructions and price signals. Done correctly, these changes will actually increase the ability of the power system to absorb renewable energy.

Developing and Enhancing the ISO Wholesale Markets

The ISO's priority for 2009 has been to start the redesigned markets for energy and ancillary services and resolve any initial implementation issues. As the ISO obtains experience with these markets, and as the operational requirements of renewable integration become clearer, the ISO will initiate any market design changes needed to achieve the state's renewable goals efficiently and reliably.[21] Such design changes and any new market products would be intended to provide needed revenues for the types of operating characteristics needed over time.

For example, the ISO's 2007 report (see Box 1 above) pointed to the potential need for additional regulation services in certain hours, which would require changes to the current market procurement procedures for this product. That report also quantified increased ramping requirements needed on the system. The ISO has started to examine

[20] Both the locational marginal price and the deviations from the schedule are averaged over the month.
[21] These market design changes are listed in the Catalogue of Market Design Initiatives, currently under development for 2009-2010. See http://www.caiso.com/1fb1/1fb1856366d60.html.

changes to the market design that would serve to elicit additional ramp capability. Several types of technology solutions are discussed in the next section.

Some market enhancements that may impact renewable integration are already in the pipeline for 2010-2011. These include measures to administratively increase prices for ancillary services and energy during shortages of those products (called "scarcity pricing"), which could provide price signals for the market to provide additional capability to deliver these services. Such scarcity may occur because of renewable integration requirements (as well as in general to conditions of shortages in energy and capacity). The ISO will also introduce financial bids in the forward market that can improve convergence of day-ahead and real-time prices (called "convergence bidding"). These bidders would have the incentive to displace thermal generation that is scheduled when wind resources do not schedule day-ahead, potentially improving the efficiency of the ISO's scheduling and commitment processes.

Improved Operational Tools

The added variability introduced into the bulk power system by increased levels of renewable resources requires operational tools that improve the situational awareness and reactive capabilities of the ISO and transmission operators throughout the western interconnection. Some of these tools will likely build from the ongoing deployment of synchrophaser measurement tools. This technology provides for sub-second monitoring of grid conditions and thus enhances the ability of system operators to deliver interconnection-wide networking, event analysis, model validation and real-time controls on a wide-area basis. By improving detection and mitigation of power system vulnerabilities, synchrophaser technology can significantly increase the reliability of the interconnection, and allow for the release of latent transmission capacity at very low cost to foster a more robust west-wide market for renewable energy.

Other tools must be developed to forecast operational reliability problems associated with increased renewable variability. As noted above, the ISO's 2007 study has identified an increase in regulation and ramping requirements for renewable integration. Accordingly, in addition to improved forecasts and other measures to continuously improve market efficiency, the ISO is developing a tool to forecast the ability of resources in the day-ahead and the operational time-frames to meet expected load and variable generation ramp requirements. It does so by applying the most up-to-date load forecast, wind forecast, market data and related correlation of wind and load. The result will be recommendations to incorporate into market systems or used by operators to enhance reliability through greater situational awareness.

Box 3. International Comparisons of Renewable Integration

In its 2007 Integration of Renewable Resources report, the ISO provided a brief review of international experience with renewable integration. The ISO advanced this effort in 2008 through an evaluation of Spain's grid operators at Red Eléctrica de España (REE). With a system-wide peak load of 45,500 MW, REE depends heavily on flexible generation to back up its nearly 15,000 MW of installed wind, which supplies 10 percent of the country's total electric power. Currently, 19,838 MW of installed combined-cycle gas generation and 4,800 MW of pumped hydroelectric generation are used to meet REE's load ramps of up to 4,000MW/hr and wind ramps of up to 1,172 MW/hr upward and 785 MW/hr downward. In fact, Spain has a total capacity of over 80,000 MW, much built to accommodate the growth in wind. To facilitate the integration of wind into their operations, REE manages a centralized renewable generation control center, which collects all information about current wind generation and provides a centralized forecast. All wind production facilities with total installed capacity of 10 MW or greater must be controlled by a compliant control center, and be able to execute orders within 15 minutes at all times. Other measures used by REE include roughly 2,500 MW of load that is interruptible up to 10 times per year, as well as mandatory regulation service margins of 1.5 percent of installed capacity from all generators connected to the grid. REE typically has as much as 1,000 MW of regulation capacity available to meet swings in load and wind. Using these measures, REE reliably meets the demands that wind puts on their system. However, REE still faces significant challenges in managing congestion caused by wind, as well as reliability issues such as trips at wind generators caused by low-voltage conditions.

5) Technology Solutions To Facilitate Renewable Integration

New types of technologies and technical specifications are necessary to achieve renewable integration, especially given the variety of environmental policies being implemented within just a few years.

Interconnection Standards (Grid Codes)

There is a recognized interrelationship between the design standards of generation and other supply and delivery equipment and the standards related to the overall performance of the bulk power system as adopted by reliability entities, such as the North American Electricity Reliability Corporation, the Western Electricity Coordinating Council and the ISO. Individual components of the power system must be designed to contribute to or, at a minimum, not harm, the ability of the bulk power system to maintain its integrity during system emergency events and diverse operating conditions. It is, therefore, important that a set of interconnection performance standards be applied to variable generation and other innovative technologies, including storage devices, to avoid system reliability degradation. For instance, the Federal Energy Regulatory Commission in its Order No. 661 adopted low-voltage ride through standards for wind generation that prevent such resources from tripping off during specific voltage conditions. Other functions must also be addressed as the magnitude and diversity of renewable technologies increase and more variable generation interconnects at the distribution system level. These functions include:

- Voltage regulation and reactive power capability
- Low and high voltage ride-through
- Inertial-response
- Ramp rate and curtailment control
- Frequency control (governor action)

Modern wind turbine designs (Type 3 and 4 generators)[22] can be designed to provide many of these system performance functions. The expected performance of newly developed utility-scale photovoltaic and solar thermal generators is much less well understood.[23] However, solar thermal technologies are expected to exhibit characteristics more similar to conventional generators. Moving forward, it is necessary for system operators and generation developers to have consistent and well-defined expectations regarding the contribution of variable generators to maintaining system performance.

Energy Storage

A key characteristic of electric power production and the power market is the high cost of storage options. Most current storage takes place in hydro systems, whether through river dams (which store water for long periods of time before generating during the peak months) or pumped storage (which stores water at night when power is lower cost for release during the peak hours of the next day). Pumped storage is an ideal resource for renewable integration, but is difficult to site and can take an estimated 10-12 years to permit, license and construct. Other storage options, such as batteries and compressed air systems, are developing utility-scale capacity but are still expensive. These are discussed briefly in the box below. Nevertheless, the economics of storage generally should be improved by its ability to provide the operational needs created by renewable integration and the possible increase in off-peak to peak price spreads for energy, especially when greenhouse gas emissions are also assigned a cost. A large amount of storage on the system would greatly improve system operations at higher RPS.

Energy storage resources have a number of characteristics that are particularly suited for facilitating renewable integration. They can provide a fast response to control signals, frequency response and automated dispatch commands. They have high ramp rates and are easy to start and stop. They are thus well-suited providing the regulation services that the ISO has identified as potentially important to renewable integration. On a larger scale, such as pumped storage, storage can substantially shift loads and take advantage of the potential off-peak surplus in clean energy (due to excess wind production) and mitigating overgeneration conditions. Plug-in hybrid electric vehicles and fully electric vehicles are also, by definition, storage devices since they operate using batteries.

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[22] Type 3 wind turbines are double-fed induction (asynchronous) generators and Type 4 wind turbines are considered full-conversion generators in that the latter passes all turbine power output through an AC-DC-AC power electron converter system.

[23] Solar thermal generators focus direct normal irradiance to heat water or oil that is then used to produce steam to drive a large conventional electric generator. Photovoltaic technology converts energy in sunlight directly to direct current. (See, NERC “Accommodating High Levels of Variable Generation”, special report (April 2009) available at www.nerc.com

The ISO is currently working to establish viable rules for smaller-scale, energy limited storage resources, such as batteries and flywheels, to interconnect and participate in the ancillary services markets. The ISO also will review proposals for larger scale storage projects as well as transmission projects that can increase the capacity of existing pumped storage plants. The ISO anticipates stepping up these efforts to ensure that maximum support is available to meet RPS.

Box 4. Types of Energy Storage Technologies

Pumped hydro generates electricity by pumping water into upstream reservoirs when demand is low and running the water through turbines when demand is high. It is the most widespread energy storage system on power networks. Several new pump-hydro systems have been proposed for construction in California and may be on-line by as early as 2016. These new units can provide regulation services and operating reserves, while also shifting large amounts of energy from off-peak periods for delivery at peak load times.

High-Speed Flywheel systems utilize a massive rotating cylinder and can provide fast regulation services. New designs are based on clustering individual units to provide MW scale energy storage.

Battery Storage, which includes lithium Ion batteries and sodium sulfur batteries, can provide 15 to 60 minutes of energy storage and provide regulation services.

Compressed Air Storage can utilize abandoned gas and oil wells, or alternatively pipelines or above ground tanks, to store compressed air and recover it for use in a typical turbine generator.

Super capacitors, or electrochemical capacitors, possess swift charge and discharge capabilities. More powerful than batteries, they can be cycled tens of thousands of times. Those with energy densities under 20kWh/m3 have been successfully developed, and larger units are in development.

Flow batteries have low energy density, but they offer high capacity and independent power and energy ratings. Technologies in use include polysulfide bromide (PSB), vanadium redox (VRB), and zinc bromide (ZnBr).

Plug in Hybrid Vehicles (PHEVs) can in principle be used as battery storage resources for use on the grid -- a concept called Vehicle to Grid (V2G).

Demand Response

Increased price-responsiveness by power consumers will also facilitate renewable integration. As with storage, there is much interest in demand response, which as a resource can potentially follow the variability of renewable output, either through direct dispatch signals sent by the ISO to or through the direct actions of consumers to price signals. Demand response also provides capacity that can reduce load on peak days, in response, for example, to a decline in wind production during peak hours (see discussion of resource adequacy below). This demand response capacity could be offered to the ISO as ancillary services, including the possibility of providing regulation service from certain, appropriately configured demand response resources.

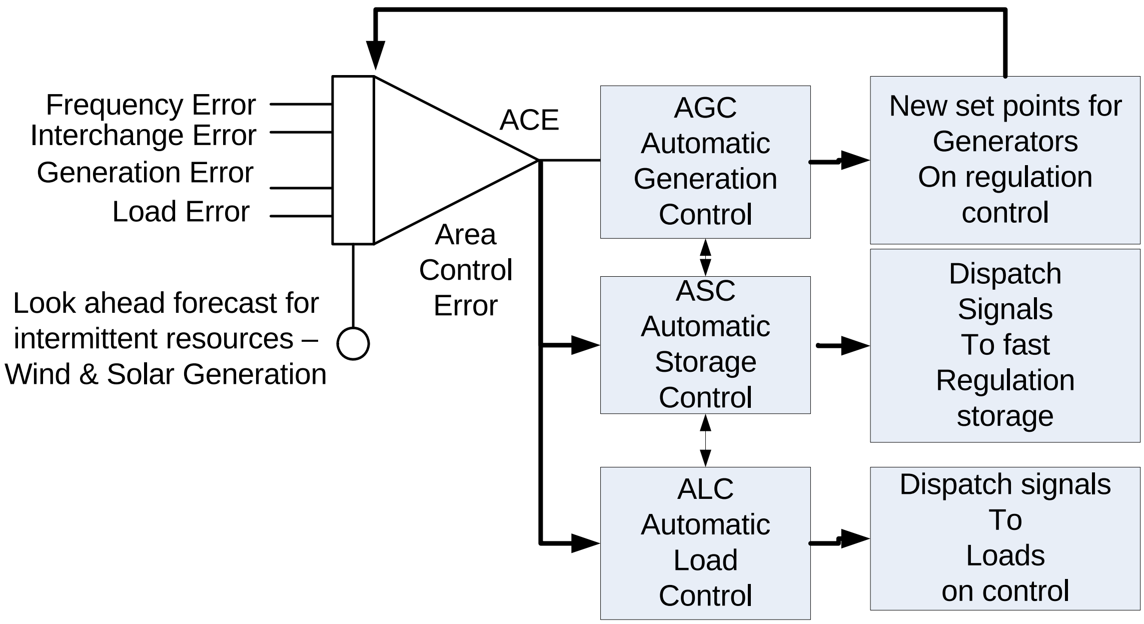
While there is substantial demand response potential, the ISO is currently unable to tap its full capability in an effective and integrated manner. As a result, the ISO has a number of initiatives underway in cooperation with California state agencies, utilities, large consumers and demand response aggregators to improve this capability.[24] For example the ISO is proposing to implement a new demand response product, the "proxy demand resource", in addition to its participating load program, by summer 2010. This product would initially enable about 500 MW of demand response. The ISO's vision is to eventually provide mechanisms for demand response to participate fully in the wholesale market 24 hours a day, seven days a week.

Smart Grid

The smart grid refers to the integration of digital communication technology into all segments of the power sector, including generation, delivery, and consumption. These upgrades promise to improve system capabilities, including support for environmental policy objectives. Among other benefits, a smart grid will support the deployment of distributed generation such as rooftop solar photovoltaic systems, demand response and storage technology. Using advanced applications and automated control technologies, smart grid may facilitate the provision of ancillary services by demand response and storage resources. These capabilities could be significant, especially with potential contributions from a future fleet of plug-in hybrid electric vehicles with smart grid-supported charge and discharge capability.

Though the smart grid is in its early stages of development, its potential to mitigate renewable generation variability is clear. The ISO views these developments as an important part of a long-term strategy for renewable energy integration. For example, the ISO is working on new concepts for optimum dispatch of energy storage and demand response resources to provide regulation service. One of the ideas is to provide forward forecasting from variable generation resources such as wind and solar and blend that with anticipated changes in system load. The result should be a control signal that moves energy storage resources for small changes in the system, then moves the hydro and thermal generation resources for larger changes and finally dispatches participating loads for large changes. The control concept might look like the following diagram:

[24] Materials on the ISO Demand Response initiatives can be found at http://www.caiso.com/1893/1893e350393b0.html.



The federal government recognizes the implementation of smart grid as a crucial step toward achieving energy policy goals. Two government agencies – the Federal Energy Regulatory Commission and the Department of Energy – are currently seeking to advance smart grid development.[25] The ISO has offered its comments to federal and state smart grid initiatives and is working toward clarifying its own role.

The smart grid, in addition to its role in renewable integration, will enhance grid reliability on a local and regional basis, decreasing the number of planned outages. It will also give consumers the ability to manage power costs by shifting their consumption from peak to off-peak hours. These developments will optimize statewide energy use, dampening load growth and reducing the need for investment in generation, transmission and distribution infrastructure.

[25] The Federal Energy Regulatory Commission's Proposed Policy Statement and Action Plan on Smart Grid Policy outlines its plan to adopt certain smart grid standards and set interim rate policy to cover related grid expenditures made before the Commission develops a complete policy. This kind of policy adjustment is necessary on the federal and state levels to craft appropriate incentives for smart grid research and deployment. The DOE's proposed web-based Smart Grid Information Clearinghouse will consolidate public technical, legislative and other information on smart grid development and practices. Its purpose would be to promote cooperation and coordination between all smart grid stakeholders.

6) Renewables and Infrastructure Development

Achieving a 33 percent RPS will affect all aspects of the California and regional power system infrastructure. Moreover, these changes will be amplified by those driven by greenhouse gas emissions reductions, other environmental policies and the introduction of new technologies available for market and system operations. Most fundamentally, current policies and initiatives to develop the most cost-effective renewable resources rely heavily on high voltage transmission expansion to access those resources, most of which are located in remote areas. Identifying the right transmission projects to develop the best mix of renewables for cost and operational reasons will be the central challenge for the ISO and the state.

Infrastructure development must also address the need for non-renewable resources – especially the existing and new gas plants that will continue to provide energy and much of the increased operational requirements created by variable generation renewables. These plants play a key role in maintaining supply adequacy and local reliability over time.

This section begins with discussion of the ISO's role in developing and shaping generation infrastructure, including the resource adequacy program, the planned restrictions on plants with once-through cooling, and generation interconnection programs. Transmission planning is then examined, with a focus on the ISO's role in translating the Renewable Energy Transmission Initiative into a viable plan to achieve the 33 percent RPS.

Resource Adequacy

In 2004, the State of California established a resource adequacy program to ensure that load-serving entities procure sufficient generation capacity to meet monthly peak loads plus a planning reserve margin.[26] Most resources within the ISO footprint that have a resource adequacy contract are obligated to make themselves available to the ISO, whether through a self-schedule or a bid into the ISO energy and ancillary services markets.[27] The ISO plays a role in the resource adequacy program by establishing capacity requirements for local capacity areas, primarily urban areas, which have a limit on the amount of power that can be imported during peak hours. The ISO also has the authority to "backstop" the program by procuring resource adequacy capacity in the event that load-serving entities fail to meet their obligations and also when conditions on the grid change – e.g., a significant transmission or generation outage – such that the ISO needs to position additional resource adequacy capacity in particular locations to ensure reliability. Resources that qualify to provide resource adequacy sell their capacity to load-serving entities through bilateral contracts, which sets the energy's value. The ISO

[26] The CPUC operates the resource adequacy program for its jurisdictional investor-owned utilities. The publicly owned utilities are subject to their own local reliability authority requirements.

[27] Limited energy resources, such as hydro, and renewable resources have special resource adequacy rules that exempt them from offering into the ISO day-ahead market.

recently implemented rules for a standard capacity product that can facilitate trade in resource adequacy contracts.

A significant challenge under higher RPS is to establish the capacity value of variable generation in a manner that preserves the objectives of the resource adequacy program and system reliability. The particular concern is the summer peak hours when wind is typically operating at low output, which requires other capacity resources to be available. The ISO is working with stakeholders and the CPUC to develop a new approach to determining capacity values for wind and solar resources during peak hours.

Once Through Cooling Regulations

Approximately 38 percent of California's in-state generation capacity (gas and nuclear power) uses water for "once through" cooling. Under a draft policy recently issued by the State Water Resources Control Board, these units will be required to reduce their impact on marine organisms. Depending on the provisions of the final rule, some plants may have to retire or repower in order to meet the new requirement.[28] Plants are located in local capacity areas and zonal areas, so the ISO needs to assess the reliability impacts (to the ISO controlled grid) from any such retirements. The ISO is currently working with representatives of the CPUC and CEC to develop a viable sequence for addressing once-through cooling requirements for particular units and local capacity areas. The ISO anticipates that future transmission studies reflecting the adoption of a water board policy will commence with the 2011 transmission planning process. The ISO also anticipates that the CPUC, as part of its Long-Term Procurement Plan proceeding will include measures to address any adopted water board policy to eliminate the impacts of once through cooling technology.

There are several linkages between once-through cooling policy and renewable integration. First, and most importantly, in addition to providing essential local reliability services in some cases, these plants also provide the ramping and regulation services needed for renewable integration. Thus, complying with once-through cooling regulations is yet another factor to consider in preparing the power system for higher levels of renewable resources.

Grid Interconnection Process Reform

The ISO's generation interconnection process is intended to ensure that new generation interconnects to the ISO grid in reliable manner. To accomplish this objective, the ISO assesses grid impacts of new generation using a newly revised interconnection process. This also addressed a backlog of projects in the ISO generation interconnection queue by:

- Abandoning the prior serial project-by-project study approach in favor of one that groups geographically related generation projects to enhance processing efficiency;

[28] See http://www.swrcb.ca.gov/water_issues/programs/npdes/docs/cwa316/draft_otcpolicy.pdf.

- Increasing the financial commitments and consequences throughout the interconnection process in an effort to realize more realistic outcomes that match system needs. In exchange, the new process establishes a "cap" on the interconnection customer's financial responsibility and, in doing so, addresses the cost uncertainty that inhibited investment under the under the prior serial study approach.

- Establishing an accelerated study process for those interconnection customers that are able to satisfy predefined criteria.

As a result of these reforms, 122 interconnection projects withdrew from the ISO queue. Nevertheless, the renewable capacity remaining in the interconnection queue for processing, as shown in the Table below, represents more than enough capacity to meet the 33 percent renewable goals. When the first set of grouped interconnection studies are completed later this year and companies' financial obligations significantly increase, the ISO expects additional projects to withdraw at that time. As these changes in the queue occur, it will be increasingly important for the ISO, state agencies, and stakeholders to understand the interaction between utility procurement, generation siting and the queue.

Generation Project - Fuel Type	# of Projects by Fuel Type	MW Capacity by Fuel Type
Biomass	4	85
Geothermal	10	502
Land Fill Gas	2	14
Natural Gas / Solar	1	150
Solar	88	30,291
Solar / Biomass	1	106
Wind	50	12,783
Water	2	540
Total	158	44,471

The ISO Transmission Planning Process

The ISO transmission planning process is a well-defined set of analyses and procedures outlined in the ISO Business Practice Manual for the Transmission Planning Process.[29] Over the past few years, transmission planning has been increasingly oriented towards access to renewables, as illustrated by the recently CPUC-approved Sunrise project. With the advent of the large scale, multi-transmission line planning envisioned under Renewable Energy Transmission Initiative, the ISO and stakeholders may need to consider some tariff amendments to ensure cost-effective development of California and west-wide transmission infrastructure and integration of renewables into the California grid. In addition, as described in subsequent sections, the ISO is committed to working jointly with publicly-owned utilities and the investor-owned utilities to plan the appropriate transmission lines.

[29] See https://bpm.caiso.com/bpm/bpm/version/000000000000013.

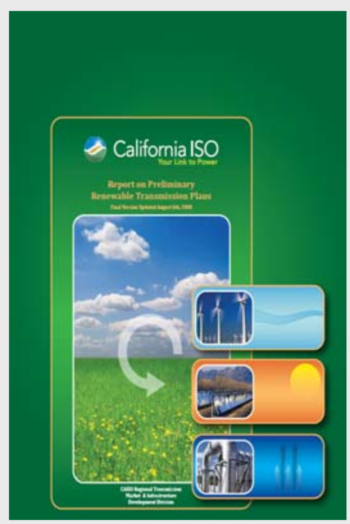
Renewable Energy Transmission Initiative

As noted above, meeting the 33 percent RPS goals will require a substantial amount of new transmission development, as most large scale renewable resources are located in remote areas. RETI is a statewide initiative designed to identify and quantify the renewable resources that can provide cost-effective energy to meet the RPS requirements, and also to identify the transmission investments necessary to ensure delivery of that energy to California consumers.[30]

The voluntary effort has brought together renewable transmission and generation stakeholders, regulators and ratepayers to identify, plan and establish a rigorous analytical basis for regulatory approvals of the next major renewable transmission projects. The Initiative's first phase produced a report outlining approximately 40 Competitive Renewable Energy Zones (CREZs) using a methodology including both economic and environmental protection factors. Phase 2 is ongoing, including a draft report issued June 3, 2009, that refined energy zones (now at 36, five of which are out of state) and also sketches out more than 100 conceptual transmission upgrades.

RETI plays a role of significant importance by helping the ISO balance the successful integration of the state's renewable initiatives with planning for a robust, reliable and cost-effective transmission infrastructure. The ISO believes this "balance" can be achieved by using the energy zones prioritization to inform the ISO's 2010 Transmission Study Plan. The objective is to identify the need for specific transmission upgrades that will enable load serving entities to meet the 33 percent RPS goals (see Box 5 for an initial conceptual assessment by the ISO).

Box 5. Conceptual Transmission Planning for Renewables up to 33% RPS



Transmission planning to support renewable development in California will be a multi-year effort. A first phase in conceptualizing the routes and cost of possible transmission projects was the Report on Preliminary Renewable Transmission Plans prepared by the ISO in August 2008 to inform the RETI process.

Significant additional transmission plans must be developed to achieve the state's 33 percent RPS goals. Based on preliminary assessment from various generation interconnection and transmission project plans, the report identifies six conceptual transmission projects that, if built and brought on-line by 2020, can help the state meet the 33 percent RPS and for several years beyond. These potential transmission projects, intended to connect and deliver renewable resources to the grid, are estimated to cost approximately $6.5 billion (+/- 50% accuracy) in 2008 dollars. The report is available at http://www.caiso.com/2007/2007d75567610.pdf.

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[30] RETI information can be found at http://www.energy.ca.gov/reti/index.html.

Options for Financing Renewable Transmission

The transmission infrastructure needed to facilitate the development of renewable resources may be identified through one of two interrelated ISO processes – the interconnection process and the transmission planning process, both of which are discussed above. The assignment of financial responsibility and the mechanisms for cost recovery for the added transmission facilities depend not only on the process in which it was identified, but also for the function the transmission facility serves. The Table above summarizes the financing options, including those specifically designed for renewable resource interconnection.[31]

As noted above and described in the Table below, in 2007, FERC approved a unique financial tool, the Location Constrained Resource Interconnection mechanism, developed by the ISO and market participants that breaks down barriers facing renewable power development. Renewable power is often located in remote areas without power lines to connect with the grid. Power plant owners are generally responsible for building radial interconnection facilities or "trunk lines" needed to connect to the high voltage transmission grid. Renewable power developers often found it difficult to secure the upfront financing necessary to construct such large interconnection facilities.

The financing mechanism removes this barrier by allowing the transmission owners to initially recover the costs of building a radial, renewable transmission facility from California ratepayers. The connected generators reimburse the cost based on their pro rata usage of the new facility. As more renewable generators are built and connected to the new facility, they will pay their share of the costs as well.

In May 2009, the ISO recently approved the first location constrained project. The Highwind-Windhub facility helps with the initial interconnection of approximately 759 MW in the Tehachapi area. The Highwind-Windhub project is scheduled to come on line December 31, 2010.

Other changes to the transmission planning and approval process may prove essential to facilitating the development of the transmission essential to meeting a 33 percent RPS. The ISO will continue to work with RETI, state agencies and stakeholders to address permitting challenges as well as other obstacles that become apparent.

[31] For more information, see CAISO Tariff Section 24 et al and Appendix Y and the Business Process Manual for Transmission Planning.

Interconnection Process		
Type of Facility	**Characteristics**	**Financing**
Interconnection Facility	• Radial – power flows one direction • Single Beneficiary • Between generator and point of interconnection to transmission	Generator developer pays with no reimbursement
Reliability Network Upgrade	• Transmission beyond point of interconnection • Triggered by generator • Remedy short circuit and stability issues	• Financing costs assigned to generator developers, unless paid by transmission owner • Full amount assigned to developer if studied individually • Amount assigned to generator developer if studied in a group pro rata based on MW capacity of plant • Upon commercial operation, Gen developer reimbursed either (1) though payments from transmission owner over 5 years or (2) through Merchant Congestion Revenue Rights
Delivery Network Upgrades	• Transmission beyond pt of interconnection • Triggered by generator • Remedy thermal overloads or congestion	• Financing costs assigned to generator developers, unless paid by transmission owner • Assigned only to developers requesting Full Capacity Delivery Status (qualify for resource adequacy) • Full amount assigned to generator developer if studied individually • Amount assigned to generator developer if studied in a group pro rata based on flow impact • Upon commercial operation, Gen developer reimbursed either (1) though payments from transmission owner over 5 years or (2) through Merchant Congestion Revenue Rights
Location Constrained Resource Interconnection Facility	• Radial – power flows one direction • Connects two or more unaffiliated locationally constrained generators to pt of interconnection with transmission • Locationally constrained generators located in Energy Resource Areas identified by the state • Demonstration of commercial interest equal to 60% of the line's capacity	• Financing costs assumed by the participating transmission owner • Participating transmission owner files a tariff rate to recover cost of line on a pro rata basis from generators as they come online • Any costs unrecovered after assignment to generators included in transmission owner's transmission revenue requirement and recovered through CAISO Transmission Access Charge
Transmission Planning Process		

Network Transmission Facilities	• Determined by the CAISO to be needed for:
	    • Reliability – specific NERC/WECC standard violation
	    • Economic Efficiency – value to CAISO ratepayers or Merchant Transmission Facility
	    • Preserve Long-term CRRs
		• Financing costs assumed by participating transmission owner (in whole or in part depending if joint project with non-PTO) with cost recovery through CAISO Transmission Access Charge
		
		• If Merchant Transmission Facility, financing from project developer with reimbursement solely based on revenue received by developer through receipt of Merchant CRRs Congestion Revenue Rights.

Location Constrained Resource Interconnection Facility	See above	See above

Joint Planning of Transmission

With several entities engaged in grid planning and transmission development to access renewables in California and out-of-state, it is increasingly important to work from a jointly defined set of needs in order to plan most efficient system possible. To that end, the ISO, municipal-owned utilities and investor-owned utilities have initiated a planning coordination effort, called the California Joint Transmission Planning Group. This group is working together to identify transmission system expansions to meet the reliability, economic and renewable access needs of the state.

7) Regional Dimension of Renewable Development

California, the neighboring western US and Canada region have substantial opportunities for cost-effective renewable development if existing transmission capacity is used more efficiently and if transmission expansion is planned through effective regional coordination and cooperation. Development will also depend on policies such as the option of tradable renewable energy credits, as discussed above.

To advance these goals, the ISO is exploring opportunities for a better strategic alignment between the national energy agenda[32] and western regional policies, including the identification of Western Renewable Energy Zones.[33] The ISO will work with other sub-regional planning groups, the California Joint Transmission Planning Group and other planning authorities throughout the West on important regional planning issues in the coming months.

In addition to these regional planning efforts and the federal policymakers' interest in assisting the west with transmission planning, siting and cost allocation challenges, the ISO believes that there is some benefit to studying the operational impact of the western renewable portfolio standard targets in the aggregate. This analysis should also consider the effect on operations of greenhouse gas goals, such as those being developed within the Western Climate Initiative. The evolving policy and regulatory framework – at state, regional and national levels – should be consistent with sustaining a liquid power trading

[32] FERC, DOE and Congress are all seeking to advance regional transmission planning, permitting and cost allocation. The American Recovery and Reinvestment Act of 2009 (ARRA) directs DOE to help facilitate interconnection-based transmission plans for the East, West and ERCOT. $60 million is set aside in the stimulus bill for funding related to preparation of these interconnection-wide plans, and DOE issued a "Funding Opportunity Announcement" (FOA) outlining criteria for awarding these funds on June 15, 2009. In the West, the Transmission Expansion Policy and Planning Committee (TEPPC) within the Western Electricity Coordinating Council (WECC) is likely to be the entity to coordinate development of an interconnection-wide plan.

[33] The Western Governors' Association and DOE initiated the Western Renewable Energy Zones) process in May 2008, which emulates the California RETI process on a west-wide basis. Phase 1 of the process, the identification of the renewable energy zones, was completed in June and accepted by the governors' association at its annual meeting June 15. See Western Renewable Energy Zones (WREZ) Phase 1 Report, June 2009. Available at http://www.westgov.org/wga/publicat/WREZ09.pdf. The background documents contemplate that the conceptual transmission plans that would be developed following the energy zones identification would take place through "existing WECC and sub-regional transmission planning groups."

market in the West. The ability to move power across the region becomes particularly important when considering the need to balance and firm variable generation. In general, policies and regulations to support renewable energy should retain sufficient flexibility for grid operators and market participants to engage in seasonal and geographic trades in the interest of optimizing power, costs and infrastructure.

Finally, the ISO believes that further development of the rules, procedures and products available in Western power markets can serve a key role in regional renewable integration. In particular, improved congestion management and rules for dynamic scheduling, pseudo tie arrangements, and intra-hour scheduling changes would promote renewable integration. Markets – including the ISO market – also expand the scope of available flexible resources for load-following and ancillary services to meet the integration requirements for regional renewable development.