UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Reliability Standards to Address Inverter-Based Resources	**Docket No. RM22-12**

COMMENTS OF THE CALIFORNIA INDEPENDENT SYSTEM OPERATOR CORPORATION

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The California Independent System Operator Corporation (CAISO) submits comments in response to the Commission's Notice of Proposed Rulemaking (NOPR) to direct the North American Electric Reliability Corporation (NERC) to develop new or modified reliability standards in three stages: (1) directives regarding registered inverter-based resources (IBR) failure to ride through frequency and voltage variations during normally cleared Bulk-Power System faults; (2) directives regarding data sharing and model validation for registered IBRs, unregistered IBRs, and IBRs connected as Distributed Energy Resources (DERs) and corresponding directives regarding planning and operational studies; and (3) directives for post disturbance ramp rates and phase lock loop synchronization.[1] The CAISO supports the Commission's proposal and offers comments on the proposed staggered development and three-stage prioritization. In addition, the CAISO shares lessons-learned from the tariff changes it implemented to impose IBR performance, data sharing, and data and model validation requirements; which today serve as the means for the CAISO to require IBRs participating in the

[1] *See Reliability Standards to Address Inverter-Based Resources*, Notice of Proposed Rulemaking, 181 FERC ¶ 61,125, P 8 (2022) ("NOPR").

CAISO's markets or interconnecting to the CAISO's system to ride through frequency and voltage variations, return to normal operations following a disturbance, and avoid unnecessary tripping due to phase lock loop synchronization issues.[2] The CAISO also offers comments on the Commission's proposed directives regarding data sharing and model validation as well as planning and operational studies. The tariff solutions deployed by the CAISO can continue to serve as the foundation for national reliability standards applicable to all IBRs that can have a material impact on the Bulk-Power System.[3]

I. Background

Electric grids across the nation are responding to rapid changes in the generation resource mix, including the rapid addition of many resources that employ inverters and converters to conform their direct current (DC) electricity to a form suitable for interconnection with alternating current (AC) electrical systems at both the transmission and distribution levels.[4] The Department of Energy previously estimated that as much as 80% of electricity could flow through power electronics, including inverters and converters, by 2030.[5] If appropriate reliability standards are in place, power electronics

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[2] *See Cal. Indep. Sys. Operator Corp.*, 168 FERC ¶ 61,003 (2019) (accepting the CAISO's tariff revisions to mitigate reliability issues caused by IBRs and to establish a platform to collect information to better inform the CAISO and stakeholders on the operation of IBRs).

[3] *See* NOPR at P 75 ("We seek comments from NERC and other interested entities on this staggered approach, including the 90-day timeframe to submit a compliance filing with a development and implementation plan, and on all other proposals in this NOPR.").

[4] *See, e.g.,* NOPR, 181 FERC ¶ 61,125 ("The reliability consequences that attend the rapid deployment of an unprecedented number of IBRs are, at this point, unarguable.") (Danly, Comm'r, concurring).

[5] *See, e.g., Power Electronics for Distributed Energy Systems and Transmission and Distribution Applications: Assessing the Technical Needs for Utility Applications*, Technical Report (Dec. 2015), *available at*: https://www.osti.gov/biblio/885985.

and the functionality they enable will play a pivotal role in maintaining the reliability and security of the nation's electric grid.

The CAISO has experienced the most rapid growth of IBRs in the United States. These resources have provided significant reliability contributions, but also have presented integration challenges. As the CAISO explained in response to the Commission's 2018 request for information on system resilience, given the rapid change of pace, the CAISO saw it necessary to take proactive steps to identify anticipated changes on the system and to mitigate any risks where possible.[6] To that end, the CAISO has conducted numerous studies to identify potential operational risks associated with the expected, extensive change in resource mix on the system.[7] These studies identified several emerging conditions requiring specific resource operational capabilities to address, including intra-hour upward and downward ramps, steep inter-hour ramps, oversupply risk, and decreased frequency response. The studies also validated the capability of IBRs to provide such services.[8] The CAISO first worked with partners at the National Renewable Energy Laboratory (NREL) and First Solar to assess a solar PV plant's capability to provide essential reliability services and published the results in early 2017.[9] As documented therein, hardware components

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[6] *See* Comments of the California ISO, Docket No. AD18-7 (Mar. 9, 2018).

[7] *See, e.g.,* CAISO FAST FACTS, *available at:* http://www.caiso.com/informed/Pages/CleanGrid/default.aspx.

[8] *See, e.g., Using Renewables to Operate a Low Carbon Grid* (Jan. 2017) ("First Solar Study"); *Wind Power Plant Test Results* (Mar. 2020) ("Avangrid Renewables Study"), *available at*: http://www.caiso.com/informed/Pages/CleanGrid/default.aspx.

[9] *See* First Solar Study at 5 ("This data showed how the development of advanced power controls can leverage PV's value from being simply an intermittent energy resource to providing services that range from spinning reserves, load following, voltage support, ramping, frequency response, variability smoothing and frequency regulation to power quality.").

enabling solar PV plants to provide a full suite of grid-friendly controls are already in existence; it is mainly a matter of activating these controls and/or implementing communications upgrades to enable the functionality fully. More recently, the CAISO has worked with its partners NREL and Avangrid Renewables in documenting a wind plant's capability to provide essential reliability services.[10] The 2020 report documents that such plants can (1) ramp up/down at specified ramp rates; (2) respond to 4-second control signals from the CAISO's energy management system; (3) control scheduled voltage when the plant's output varies from near zero to full output; (4) provide fast frequency control within the inertia response time frame; (5) provide frequency regulation similar to the governor actions of a conventional resource on governor control; (6) respond to frequency response deviations for low- as well as high-frequency events, and; (7) provide voltage support even when the wind is not blowing.[11]

As the Commission recounts in the NOPR, unanticipated inverter actions have had a material impact on the Bulk-Power System.[12] The source of these impacts principally was resources that are not otherwise required to register and comply with the reliability regime established by NERC.[13] The tariff solutions implemented by the CAISO require additional IBRs to meet identified performance, data sharing, and data and model validation requirements. The CAISO strongly supports the Commission's

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[10] *See* Avangrid Renewables Study at §§ 6-8 (documenting advanced grid-friendly capabilities of wind farms and the characteristics that can enhance system reliability).

[11] *Id* at § 11 (documenting the testing results).

[12] *See* NOPR at PP 25-26.

[13] *Id.* at P 26 ("[T]he continuing events across the Bulk-Power System and the risks that they pose to its reliable operation underscore the need for mandatory Reliability Standards to address these issues on a nationwide basis.").

action to impose national standards that ensure all IBRs that materially impact the Bulk-Power System comply with critical requirements.[14]

II. The CAISO Supports Developing and Implementing IBR Performance Requirements as Priority 1

The Commission proposes to require NERC to establish minimum performance requirements to ensure IBRs "continue to produce power and perform frequency support during system disturbances."[15] The CAISO supports this proposal. IBRs are not bound to the same inertial properties of turbine-based generation resources. A uniform set of national standards will ensure manufacturers, resource owners, and grid operators are working from a common set of expectations to ensure IBRs that can potentially have a material impact on the Bulk-Power System are calibrated to ensure the resulting waveforms are produced and maintained in a manner that matches those of the grid in voltage, frequency, phase, and phase sequence.

The CAISO supports the Commission's proposal to utilize a staggered approach to develop reliability standards for IBR resources, but encourages the Commission to elevate the proposed-priority 3 performance requirements to priority 1 performance requirements. In the NOPR, the Commission acknowledged that "[t]he risks to Bulk-Power System reliability posed by momentary cessation are greater than any of the IBR disturbances."[16] The CAISO agrees that it is essential to address this priority item, but it is equally important to establish a post-disturbance ramp rate standard to ensure such

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[14] Generation projects executing interconnection agreements or replacing their inverters or generating units on or after April 30, 2019 must comply with these enhanced IBR performance requirements and all Participating Generators must comply with the data sharing and data and model validation requirements set forth in Section 10 of the CAISO's Transmission Planning Process BPM.

[15] NOPR at P 93.

[16] *See* NOPR at P 15.

resources return to normal operations.[17] Developing the resulting IBR performance requirements for frequency and voltage ride through, post-disturbance ramp rate, and phase lock loop synchronization will require the attention and effort of numerous subject matter experts from a diverse set of organizations. Directing NERC to consider *all* performance requirements as priority 1 will promote efficient and effective standard-setting. Segregating performance requirements into priority 1 (frequency and voltage ride through) and priority 3 (post-disturbance ramp rate and phase lock loop synchronization) is inefficient, as the interplay of priority 1 performance requirements may be considered in isolation, resulting in unnecessary challenges and difficulties when attempting to establish the priority 3 performance requirements. Considering all performance requirements on a single priority 1 agenda will provide stakeholders an efficient forum to develop a set of harmonized performance requirements that will enable the efficient and effective operation of IBRs. Addressing all performance standards as priority 1 is an achievable task. The CAISO's existing IBR performance standards for all four performance requirements can serve as a base for NERC as it begins its standard setting process.

[17] *See* NOPR at P 64.

A. The CAISO's experience in developing and implementing IBR performance requirements for frequency ride through, voltage ride through, post-disturbance ramp rate, and phase lock loop synchronization.

Lacking nationwide reliability standards, the CAISO initiated a stakeholder process to impose on IBRs the performance requirements that the Commission discusses in the NOPR.[18] A stakeholder effort allowed the CAISO the opportunity to work with numerous parties, including inverter manufacturers, resource owners, transmission owners, and other interested parties.[19] This process ultimately resulted in changes to both the CAISO tariff and the BPMs such that IBRs seeking to interconnect or participate in the CAISO markets today must comply with both enhanced performance requirements as well as data sharing and data and model validation requirements.[20] The standards in the CAISO tariff are consistent with NERC's recommendations and experience has shown that modern inverters can meet these standards easily and without substantial costs or hardships.[21]

Using the CAISO's standards as a baseline to develop broadly-applicable IBR performance standards will allow NERC to set standards efficiently and effectively and

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[18] The historical record documenting the stakeholder process deployed to complete the 2018 Interconnection Process Enhancements Initiative is available at: https://stakeholdercenter.caiso.com/RecurringStakeholderProcesses/Interconnection-process-enhancements.

[19] *See e.g.,* Draft Final Proposal § 6.4 (Sept. 4, 2018) ("The CAISO proposed these new requirements to address incorrect and undesired tripping or cessation of inverter based generation which occurred during the routine high speed clearing of bulk electric transmission lines.")

[20] *See Cal. Indep. Sys. Operator Corp.*, 168 FERC ¶ 61,003, P 18 (2019) (accepting changes to the CAISO tariff); *see also* Business Practice Manual for Transmission Planning Process, § 10 (documenting the changes of PRC 0167 that resulted in additional IBR modeling requirements in Section 10), *available at*: https://bpmcm.caiso.com/Pages/BPMDetails.aspx?BPM=Transmission%20Planning%20Process.

[21] *See, e.g., Cal. Indep. Sys. Operator Corp.*, 168 FERC at n.23 ("CAISO notes that based on input from generation developers and inverter manufacturers that participated in a NERC task force and the CAISO's stakeholder initiative, the CAISO believes that the cost of meeting these requirements will be *de minimis*.")

(1) eliminate unnecessary momentary cessation for inverters during the clearing of a transmission line fault; (2) eliminate inverter tripping for momentary losses of synchronism; (3) require coordination of the central plant controller with the individual inverter control systems to facilitate reconnection of the inverters post-disturbance; and (4) address phase lock loop synchronization challenges. Below, the CAISO provides an overview of its existing IBR performance requirements, together with observations and lessons learned, to aid the industry in developing national performance standards for IBR resources.

1. Frequency Ride Through

Inverters that trip instantaneously based on near instantaneous frequency measurements are susceptible to erroneous tripping during transients generated by faults on the power system.[22] Following the Blue Cut Fire, the CAISO worked with Southern California Edison to engage directly with the inverter manufacturer associated with the projects that tripped during the Blue Cut Fire to develop a corrective action plan for implementing changes to inverter parameters to allow IBRs to ride-through frequency disturbance. The Blue Cut Fire Report documents how changes to inverter settings can mitigate erroneous tripping. To achieve this effect, inverter settings are adjusted to impose a momentary time delay that allows the inverter to "ride through" the distorted waveform period without tripping.[23]

Following investigation and development work with its stakeholders and partners, the CAISO revised its tariff to ensure IBRs operating under the CAISO interconnection

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[22] *See* NOPR at P 58 (citing the Blue Cut Fire Event Report at v, 15).
[23] Blue Cut Fire Event Report at 9, 15-16.

agreements configure and program their inverters to ride through frequency disturbances.[24] Specifically, the CAISO interconnection agreements require that IBRs "comply with the off nominal frequency requirements set forth in the NERC Reliability Standard for Generator Frequency and Voltage Protective Relay Settings, or successor requirements as they should be amended from time to time."[25] This requirement applies both to IBRs that would otherwise register with NERC and, because the performance requirement is a condition of interconnection, this requirement also captures IBRs that are not currently required to register with NERC.

In addition to requiring compliance with NERC's reliability standard for frequency control, the CAISO also developed an incremental IBR performance requirement for frequency ride through to close the gap identified in the Blue Cut Fire Event Report.[26] Through Order No. 842, the Commission stablished certain minimum requirements for IBRs, including the requirement to provide active power primary frequency response capability with a 5% droop for both under- and over-frequency conditions and a maximum deadband of ±36 mHz.[27] The CAISO's incremental requirement that binds all newly-interconnecting generators requires that IBRs adjust inverter settings to institute a time-delay for trip functions. In practice, the generator owner normally will commission

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[24] *See Cal. Indep. Sys. Operator Corp.*, 168 FERC 61,003 (2019) (approving the CAISO's tariff changes).

[25] *See* CAISO Tariff, Appendix EE (Large Generator Interconnection Agreement) at Appendix H § A.ii; *see also* CAISO Tariff, Appendix FF (Small Generator Interconnection Agreement) at Attachment 7 § A.ii

[26] *See* NERC, *1,200 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance* Report (June 2017), *available at*: https://www.nerc.com/pa/rrm/ea/1200_MW_Fault_Induced_Solar_Photovoltaic_Resource_/1200_MW_Fault_Induced_Solar_Photovoltaic_Resource_Interruption_Final.pdf ("Blue Cut Fire Event Report").

[27] *Essential Reliability Servs. & the Evolving Bulk-Power Sys.—Primary Frequency Response*, Order No. 842, 162 FERC ¶ 61,128 (2018).

an independent engineer to review all the control and protection equipment and develop settings (including relay settings) prior to equipment commissioning to comply with NERC's PRC-024 standard even if the generator is not otherwise required to register with NERC or abide by PRC-024. During the course of this work, the owner is able to confirm the programmed frequency settings include a momentary time delay to allow the IBR to ride-through frequency disturbances, as the CAISO requires. Some national inverter manufacturers even have established default settings to comply with the CAISO's more stringent requirements, with such default settings enabled by the manufacturer for both California and non-California installations.

The April 2022 NERC Report did not identify any notable frequency excursions by IBR resources in the CAISO during the 2021 events.[28] NERC, however, identified two legacy IBRs that exhibited frequency-related tripping during the 2021 events.[29] Upon further investigation, NERC determined that the two plants in question did not properly configure their settings to match the equipment capabilities and both employed a near-instantaneous trip timer.[30] Instantaneous trip settings based on instantaneously calculated frequency measurement are not permissible under PRC-024,[31] yet as NERC notes "these disturbances in 2021 involve different inverter manufacturers [than the Blue Cut Fire], illustrating that the issue is still not widely understood or addressed

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[28] *See* NERC and WECC, *Multiple Solar PV Disturbances in CAISO* at 15-16 (April 2022), *available at*: https://www.nerc.com/pa/rrm/ea/Documents/NERC_2021_California_Solar_PV_Disturbances_Report.pdf ("April 2022 NERC Report").

[29] *Id.*

[30] *Id.*

[31] *See* NERC Reliability Standard PRC-024-3, Attachment 1, n.9 ("Instantaneous trip setting based on instantaneously calculated frequency measurement is not permissible.")

across all manufacturers and plant owner/operators."[32] With a near-instantaneous trip timer programmed into the settings, rather than a time-delay trip timer, these legacy IBRs falsely tripped just as IBRs had done during the Blue Cut Fire.[33] The inverter manufacturer associated with such disturbances during the Blue Cut Fire confirmed that the issue is limited to older projects. As NERC explained, since CAISO implemented its tariff solution in 2019, the inverter manufacturer established default protection settings that utilize "a wide frequency window with a minimum of 1-second timer for any trip functions."[34] The CAISO encourages the Commission to move forward in directing NERC to establish a minimum standard to require all IBRs to ride-through frequency disturbances.

2. Voltage Ride Through

Most faults on the transmission grid are "transient," meaning they occur momentarily and often can be remedied in less than one second by "clearing" the fault by disconnecting and restoring power on the impacted line.[35] Modern inverters are sophisticated in detecting and responding to faults. In general, they are designed to "ride-through" most fault conditions so that the generators do not disconnect from the grid. The ride-through function is critical because grid operators must balance generation and load equally at all times to maintain voltage and support the interconnection-wide frequency to ensure reliability. NERC, IEEE, and others have instituted a number of rules, recommendations, and guidelines regarding when and how

[32] *See* April 2022 NERC Report at 16.
[33] *Id.* at 15-16.
[34] *Id.* at 16.
[35] *See, e.g.,* Blue Cut Fire Event Report at Chapter 3.

inverters should ride-through or respond to changes in voltage conditions. Nevertheless, in the course of investigating inverter response to grid conditions, the CAISO discovered that these rules, recommendations, and guidelines were insufficient to prevent some of the reliability issues experienced.

The Blue Cut Fire investigation revealed that the second largest significant contributor to reliability challenges was "inverter momentary cessation due to system voltage reaching the low voltage ride-through setting of the inverters."[36] Under ride-through requirements, IBRs must, among other things, (1) remain online for the voltage disturbance caused by any fault less than the normal three-phase fault clearing time (4-9 cycles) or one-hundred fifty (150) milliseconds; (2) remain online for any voltage disturbance caused by a single-phase fault on the transmission grid; and (3) provide SCADA capability to transmit data and receive instructions from the grid operator to protect system reliability. The scope of broadly applicable ride-through requirements does not, however, address situations where the inverter remains connected to the grid but temporarily suspends current injection (so-called "momentary cessation"). Momentary cessation is fundamentally different from the conventional understanding of the term "ride through." When momentary cessation occurs, the inverter control ceases to inject current into the grid while the voltage is outside the continuous operating voltage range of the inverter. The inverter remains connected to the grid, but it temporarily suspends current injection as it "rides through" the disturbance. When the system voltage returns within the continuous operating range, the inverter will resume

[36] *See* Blue Cut Fire Event Report at 4.

current injection after a short delay (typically 50 milliseconds to one second) and at a defined ramp rate.

When an inverter is in momentary cessation while in the no-trip area, the resource is not producing or absorbing reactive current, and manufacturers may not consider this a "trip." This is a reliability concern. As NERC explained, "[s]ome inverter manufacturers and Generator Owners have interpreted the no-trip area of the PRC-024-2 curves to allow momentary cessation."[37] The CAISO's updated interconnection requirements make clear that momentary cessation in the no-trip zone is impermissible.[38] These interconnection requirements, together with voluntary action by some inverter manufacturers, have helped ensure that newly-interconnected IBRs can both ride-through voltage disturbances and prevent momentary cessation when in the no-trip zone. This has abated the magnitude and frequency of reliability impacts attributable to momentary cessation. The risk, however, will remain in grids across the country until all IBRs that can have a material impact, individually or in the aggregate, are required to abide by NERC reliability standards for voltage ride-through and to prevent momentary cessation when in the no-trip zone. The CAISO strongly supports the Commission's proposal to direct NERC to establish reliability standards preventing IBRs from entering momentary cessation when in the no-trip zone if such IBRs could have a material impact on the Bulk-Power System.

Under the CAISO's tariff, newly-interconnected IBRs, together with legacy IBRs that materially modify their equipment, must comply with NERC's voltage ride-through

[37] *See* Blue Cut Fire Event Report at 5.

[38] *See* CAISO Tariff, Appendix EE at Attachment H, § A.i.3.; *see also* CAISO Tariff, Appendix FF at Attachment 7, § A.i.3.

requirements, and must also prevent momentary cessation. Specifically, IBRs must produce full rating reactive current when the AC voltage at the inverter terminals drops to a level of 0.50 per unit and must continue to operate and attempt to maintain voltage for transient voltage conditions between zero and 1.20 per unit in order to "ride through" voltage disturbances consistent with NERC's PRC-024-2 voltage ride through requirements.[39] By imposing this obligation through interconnection agreements, the CAISO was able to ensure compliance by IBRs that were not currently registered with NERC together with IBRs that are required to comply with PRC-024-2. In addition, to address the identified problem of momentary cessation, IBRs are required to calibrate their settings and control algorithms to eliminate the use of momentary cessation during certain transient voltage conditions.[40] Under this framework, "[m]omentary cessation (namely, ceasing to inject current into the transmission grid during a fault without mechanical isolation) is prohibited unless transient high voltage conditions rise to 1.20 per unit or more."[41] During transient high voltage conditions, an IBR must return from momentary cessation, if used, in one second or less. During transient low voltage conditions, IBRs are required to inject reactive current if operating within the no-trip zone and the "level of this reactive current must be directionally proportional to the

[39] CAISO Tariff, Appendix EE at Attachment H, § A.i.3.; *see also* CAISO Tariff, Appendix FF at Attachment 7, § A.i.3.

[40] CAISO Tariff, Appendix EE at Attachment H, § A.i.3.; *see also* CAISO Tariff, Appendix FF at Attachment 7, § A.i.3.

[41] CAISO Tariff, Appendix EE at Attachment H, § A.i.3.; *see also* CAISO Tariff, Appendix FF at Attachment 7, § A.i.3.

decrease in per unit voltage at the inverter AC terminals."[42] Upon cessation of transient voltage conditions and the return of the grid to normal operating voltage, the IBR

> automatically must transition to normal active (real power) current injection," and the individual inverters "must ramp up to inject active (real power) current with a minimum ramping rate of at least 100% per second (from no output to full available output). The total time to complete the transition from reactive current injection or absorption to normal active (real power) current injection must be one second or less.[43]

In developing these requirements, the CAISO worked closely with inverter manufacturers and resource owners to ensure the requirements could easily be met. To the best of the CAISO's knowledge, newly-interconnected IBRs subject to these requirements have not faced challenges in obtaining and programming inverters to meet the CAISO's requirement to prevent momentary cessation when in the no-trip zone.[44]

The April 2022 NERC Report documents the challenges arising from legacy IBRs that continue to have momentary-cessation enabled. Such resources are not obligated to comply with the CAISO's standards until the point at which equipment is replaced through a material modification or the individual interconnection agreement is otherwise amended. Broadly applicable NERC reliability standards should extend to these resources and require them to take the programming steps necessary to prevent their inverters from unnecessarily tripping or entering momentary cessation due to transient voltages. The April 2022 NERC Report documents the reliability challenges arising due

[42] CAISO Tariff, Appendix EE at Attachment H, § A.i.3.; *see also* CAISO Tariff, Appendix FF at Attachment 7, § A.i.3.

[43] CAISO Tariff, Appendix EE at Attachment H, § A.i.3.; *see also* CAISO Tariff, Appendix FF at Attachment 7, § A.i.3.

[44] As the April 2022 NERC Report explains, some legacy resources continue to enable momentary cessation. *See* April 2022 NERC Report at Table B.2.

to legacy resources that continue to operate with momentary cessation enabled.[45] NERC and WECC have worked closely with the owners of the legacy resources to ensure that momentary cessation settings are set as wide as possible to avoid any unnecessary adverse impacts to reliability.[46] However, as NERC reports, "these facilities will continue to reduce power output for an extended period of time since their settings often cannot be changed."[47] NERC continues to explore mitigation measures to reduce the impact of such legacy resources; including identifying and eliminating plant-level controller interactions that otherwise exacerbate the negative effect on the overall stability and reliability of the Bulk-Power System.[48]

The Commission requested input on potential "mitigation measures that may be needed to address any reliability impact to the Bulk-Power System caused by these existing facilities."[49] First, the CAISO encourages the Commission to require the development and adoption of enforceable NERC standards to specify inverter performance requirements as soon as possible. If the CAISO had not acted in 2018 to begin the process of amending its tariff, the thousands of IBRs deployed or ready for near-term deployment would not be prepared to meet the performance requirements that are incremental to existing NERC standards. Other regions of the country are experiencing an influx of IBRs, similar to what California experienced five or more years ago. The CAISO supports prompt action to ensure the new wave of resources can

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[45] April 2022 NERC Report at 14, 18-19 (documenting the plant-level controller interactions that exacerbate the challenge of legacy resources that have momentary cessation enabled).
[46] *Id.* at 14.
[47] *Id*.
[48] *Id*. at 14, 18-19, Table B.2.
[49] NOPR at P 95.

meet performance requirements, including preventing momentary cessation. Second, the Commission should support NERC in its continued identification of alternative technical changes or equipment modifications that can be made if legacy resources utilize inverters that are incapable of disabling momentary cessation. For example, the April 2022 NERC Report discusses how momentary cessation cannot be eliminated in certain legacy facilities but "eliminating plant-level controller interactions may be possible."[50] The Commission should support NERC in (1) determining whether additional technical or equipment mitigations can be deployed for legacy facilities that cannot otherwise eliminate momentary cessation and (2) establishing the resulting IBR standards necessary to further the continued reliable operation of the Bulk-Power System.

3. Post-Disturbance Ramp Rate

The CAISO supports elevating the prioritization of the proposed performance requirement so that IBRs must, as a priority 1 item, ensure the "post-disturbance ramp rate not to be restricted or to artificially interfere with the resource returning to pre-disturbance output level in a quick and stable manner."[51] Post-disturbance ramp rates are closely related to frequency and voltage ride through. Directing NERC to include post-disturbance ramp rate standard setting as a priority 1 item will support efficient and focused use of staff and expert time and attention. When the CAISO undertook its tariff solutions to implement requirements for post-disturbance ramp rates, this issue was included part and parcel with frequency and voltage ride-through requirements. For

[50] April 2022 NERC Report at 14.
[51] NOPR at P 96.

example, during the stakeholder process it became apparent that momentary cessation had to be defined as an action distinct from the action of "tripping."[52] Once the two concepts were distinguished, it was necessary to establish a standard by which an IBR must return to full service following momentary cessation due to transient voltage conditions and also establish a standard by which an IBR must attempt to resynchronize if a trip occurs. Considering post-disturbance ramp rate as a priority 1 item together with frequency and voltage ride-through requirements will allow the parties to achieve substantial efficiencies in the standard setting process.

With respect to post-disturbance ramp rates, the CAISO requires IBRs that have tripped to "make at least one attempt to resynchronize and connect back to the grid unless the trip resulted from a fatal fault code, as defined by the inverter manufacturer. This attempt must take place within 2.5 minutes from the inverter trip."[53] An attempt to resynchronize and connect back to the grid is not required if the trip was initiated due to a fatal fault code, as determined by the original equipment manufacturer.[54] If an IBR enters momentary cessation (in contrast with an IBR that has tripped), then upon return to normal grid voltage (.90 < V < 1.19 per unit), each inverter within the facility must automatically transition to normal active (real power) current injection and "ramp up to inject active (real power) current with a minimum ramping rate of at least 100% per

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[52] Momentary cessation was determined to encompass situations in which an IBR ceased to "inject current during a fault without mechanical isolation," whereas an IBR is considered to have tripped "where its AC circuit breaker is open or otherwise has electrically isolated the inverter from the grid. *See, e.g.,* CAISO Tariff, Appendix EE at Attachment H, § A.i.3.

[53] CAISO Tariff, Appendix EE at Attachment H, § A.i.3; CAISO Tariff, Appendix FF at Attachment 7, § A.i.3.

[54] CAISO Tariff, Appendix EE at Attachment H, § A.i.3; CAISO Tariff, Appendix FF at Attachment 7, § A.i.3.

second (from no output to full available output)."[55] The total time to complete the transition from reactive current injection or absorption to normal active (real power) current injection must be one second or less."[56] Further, resource owners must ensure that plant level controllers do not impede inverter restoration following transient voltage conditions, and they are required to program the plant controller in a manner that allows the inverters to "automatically re-synchronize rapidly and ramp up to active current injection (without delayed ramping) following transient voltage recovery, before resuming overall control of the individual plant inverters."[57] To the best of the CAISO's knowledge, newly-interconnected IBRs are generally able to obtain and program inverters and plant controllers to meet the CAISO's enhanced performance requirement for post-disturbance ramp rates.[58]

The CAISO supports the Commission directing NERC to establish IBR reliability standards to govern post-disturbance ramp rates for all IBRs that could have a material impact on the Bulk-Power System and it encourages the Commission to elevate this to a priority 1 issue. If the Commission moves forward expeditiously to promote the creation and adoption of all IBR performance requirements as a single priority item, then parties may begin the work necessary to validate models to ensure the results are

[55] CAISO Tariff, Appendix EE at Attachment H, § A.i.3; CAISO Tariff, Appendix FF at Attachment 7, § A.i.3.

[56] CAISO Tariff, Appendix EE at Attachment H, § A.i.3; CAISO Tariff, Appendix FF at Attachment 7, § A.i.3.

[57] CAISO Tariff, Appendix EE at Attachment H, § A.i.10; CAISO Tariff, Appendix FF at Attachment 7, § A.i.10.

[58] As noted *supra*, legacy resources post-disturbance ramp rate can pose challenges as detailed in the April 2022 NERC Report. *See* April 2022 NERC Report at 14, 18-19 (documenting the plant-level controller interactions that exacerbate the challenge of legacy resources that have momentary cessation enabled).

based on the actual expected performance of resources that are returning to full operation following a disturbance.

4. Phase Lock Loop Synchronization

The CAISO supports elevating the prioritization of the proposed performance requirement to require IBRs "maintain voltage phase angle synchronization with the Bulk-Power System grid voltage during a system disturbance."[59] The methods to address the challenge of phase lock loop synchronization were addressed by the CAISO in the same stakeholder initiative that produced the tariff revisions discussed above. Under the revisions approved by the Commission, IBRs interconnecting to the CAISO system "may not trip or cease to inject current for momentary loss of synchronism."[60] IBR controls "may lock the phase lock loop to the last synchronized point and continue to inject current into the grid at that last calculated phase prior to the loss of synchronism until the phase lock loop can regain synchronism." An IBR may trip only "if the phase lock loop is unable to regain synchronism 150 milliseconds after loss of synchronism."[61] This language matches how inverter controls are programmed. Inverter manufacturers provided comments in the CAISO's stakeholder process on the importance of retaining the option for a trip following failure to regain synchronization. Removing the option to trip "will dramatically limit the control the inverter has and we

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[59] NOPR at P 97.

[60] CAISO Tariff, Appendix EE at Attachment H, § A.i.9; CAISO Tariff, Appendix FF at Attachment 7, § A.i.9.

[61] CAISO Tariff, Appendix EE at Attachment H, § A.i.10; CAISO Tariff, Appendix FF at Attachment 7, § A.i.10.

believe that having control and getting offline when there is no 3phase system anymore is important."[62]

The April 2022 NERC Report documents how reliability impacts due to phase lock loop synchronization were limited to legacy units that are not currently required to comply with CAISO's enhanced reliability requirements for IBRs.[63] The phase-lock loop synchronization standard developed by the CAISO offers a starting point for NERC to develop the applicable IBR reliability. The CAISO supports moving this to performance requirement to priority 1, allowing all parties to complete standard setting for the full set of performance requirements in advance of deploying testing and model validation requirements.

B. Additional Considerations for IBR Performance Requirements.

In addition to considering all performance requirements as a priority 1 item, the CAISO encourages the Commission to provide guidance to stakeholders regarding the classification of IBRs that can have a material impact on the Bulk-Power System. If the Commission and NERC do not extend performance requirements to all IBRs, inclusive of IBR-DERs, then the Commission should provide guidance to NERC on the mitigation measures to support registered entities that may otherwise be responsible for capturing the functions or behaviors of unregistered IBRs. Specifically, NERC should address the means by which a registered entity would obtain the necessary information from the

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[62] *See* TMEIC Comments on CAISO Interconnection Process Enhancements, *available at*: http://www.caiso.com/InitiativeDocuments/TMEICComments-InterconnectionProcessEnhancements2018-RevisedStrawProposal.pdf

[63] *See* April 2022 NERC Report at 14.

unregistered IBR and the consequences for the unregistered IBR if it fails to provide the registered entity with all necessary information.

III. The CAISO Supports Developing and Implementing IBR standards for Data Sharing and Data and Model Validation as Priority 2

The past decades have revealed that the ideal size range for IBRs varies depending on several factors, including the cost of financing, the efficiency of solar panels, and the availability of land. These resources play an important role in California's efforts to decarbonize its electricity sector and increase the use of renewable energy sources, but not all such resources are bound by NERC's reliability standards. In general, resources that are connected to the Bulk Electric System and that exceed the 75 MW/MVA threshold for registration with NERC are required to comply with the applicable reliability standards. In contrast, resources that either are not connected to the Bulk Electric System or generate with less than 75 MW/MVA of capacity are often exempted from compliance with NERC reliability standards.

The following charts demonstrate that a number of IBRs connected to the CAISO system and/or operating in the CAISO markets may otherwise fall below the threshold for NERC's registration requirements. The resources represented below include only those resources registered in the CAISO's Master File, meaning that resources not participating in the CAISO's markets (*e.g.,* rooftop solar) are not included. At this juncture, approximately 60% of wind plants, 80% of solar plants, and 55% of storage plants registered in the CAISO Master File would fall below NERC's 75 MW/MVA threshold. This is shown in Figures 1-3.

Figure 1: Wind Units

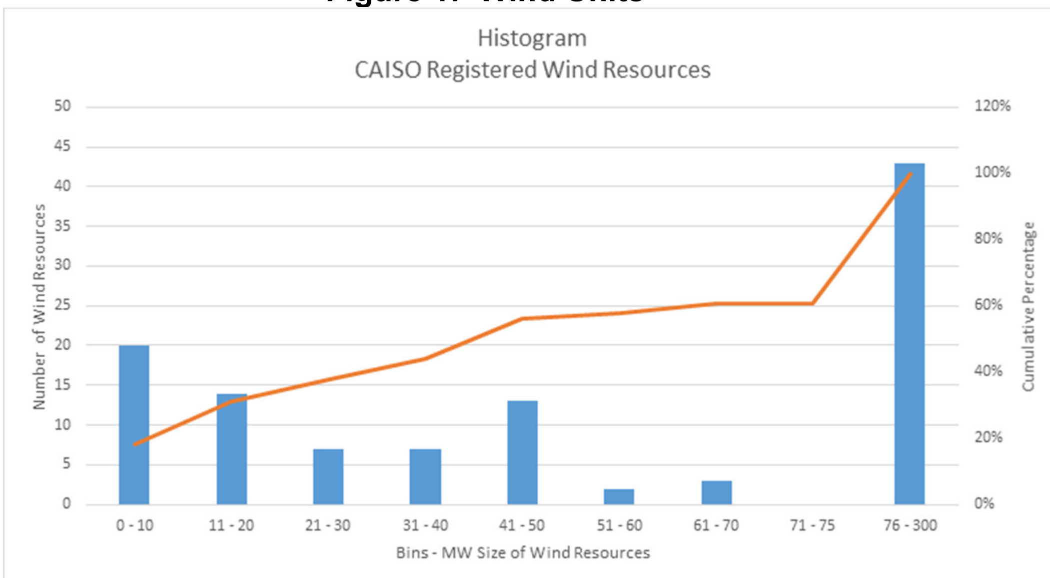


Figure 2: Solar Units

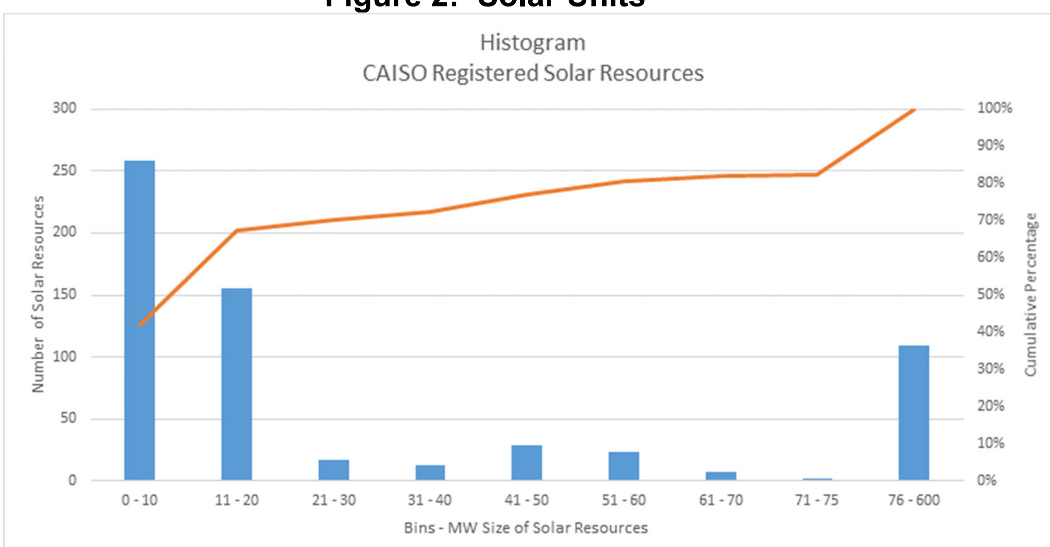
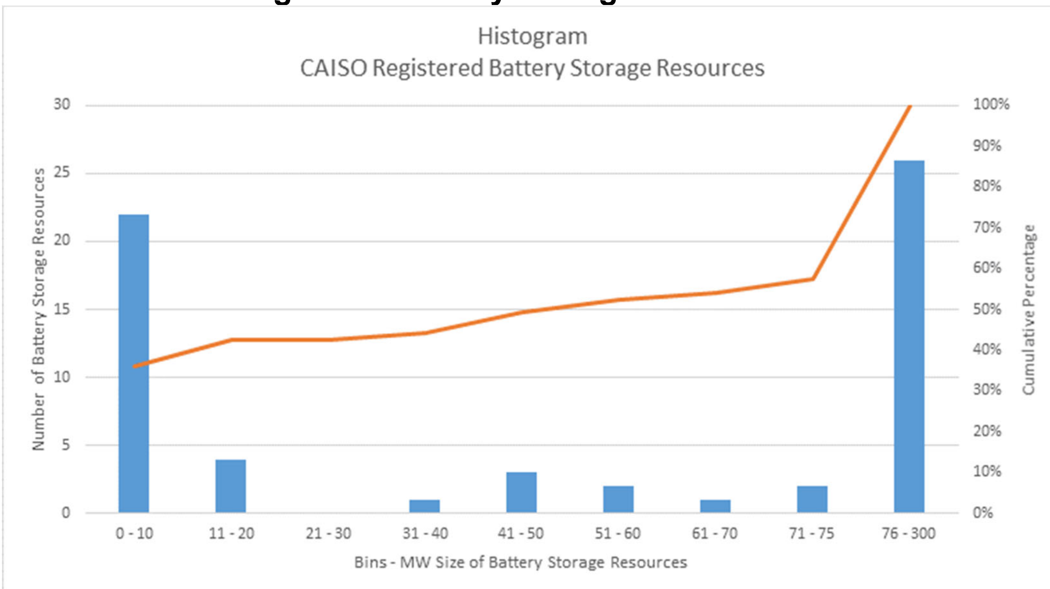


Figure 3: Battery Storage Units



A. The CAISO's experience in developing and implementing IBR standards for data sharing and model validation.

The CAISO agrees with the Commission that NERC's current standards are not sufficient to ensure all planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities receive accurate and complete data on the location, capacity, telemetry, steady-state, dynamic and short circuit modeling information, control settings, ramp rates, equipment status, disturbance analysis data, and other information about all IBRs that materially impact the Bulk-Power System (the "IBR Data").[64] Recognizing that accurate and up-to date generator modeling data is essential to maintain the reliability of the CAISO grid, in 2018 the CAISO revised its Business Practice Manual for Transmission Planning to set forth additional generator modeling requirements applicable to all generators operating under

[64] NOPR at P 27.

a Participating Generator Agreement.[65] As set forth therein, the CAISO utilizes these standard generator templates to solicit data and modeling information from all IBR resources participating in its markets, including IBR resources that do not currently register with NERC.[66] The BPM provides that category 1 templates are used to collect necessary information from Participating Generators collected to the Bulk Electric System and operating an individual resource with a nameplate capacity greater than 20 MVA or an aggregation greater than 75 MVA.[67] Category 2 templates collect information from Participating Generators connected at 60 kV and above and operating an individual resource with a nameplate capacity greater than 10 MVA or an aggregation greater than 20 MVA.[68] Category 3 templates collect information from Participating Generators connected to the Bulk Electric System or facilities above 60 kV with generation output lower than the Category 1 or 2 thresholds.[69] Category 4 templates are used for non-net energy metered (NEM) Participating Generators connected to non-Bulk Electric System facilities below 60V and explicitly modeled as an

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[65] Participating Generator means "A Generator or other seller of Energy or Ancillary Services through a Scheduling Coordinator over the CAISO Controlled Grid (1) from a Generating Unit with a rated capacity of 1 MW or greater, (2) from a Generating Unit with a rated capacity of from 500 kW up to 1 MW for which the Generator elects to be a Participating Generator, or (3) from a Generating Unit providing Ancillary Services or submitting Energy Bids through an aggregation arrangement approved by the CAISO, which has undertaken to be bound by the terms of the CAISO Tariff, in the case of a Generator through a Participating Generator Agreement, Net Scheduled PGA, or Pseudo-Tie Participating Generator Agreement." *See* CAISO Tariff, Appendix A (definitions). Participating Generators with multiple generating units mapped to a single Resource ID (*e.g.,* co-located IBRs) are considered aggregate resources and are required to report data on an individual generating unit basis

[66] *See* Transmission Planning Process BPM, § 10, *available at*: https://bpmcm.caiso.com/Pages/BPMDetails.aspx?BPM=Transmission%20Planning%20Process.

[67] *Id.* The category 1 and 2 templates are available at http://www.caiso.com/Documents/DataTemplateforGeneratorsinCategory1and2.xlsx .

[68] *See* Transmission Planning Process BPM, § 10.

[69] *Id.* The category 3 and 4 templates are available at http://www.caiso.com/Documents/DataTemplateforGeneratorsinCategory3and4.xlsx.

individual generating unit in the transmission planning power flow and stability studies.[70] Category 5 templates are for similarly-situated non-NEM resources modeled as aggregate resources.[71]

All resources in Categories 1 – 4 must provide the CAISO with steady state and dynamic models together with control and protection settings and short circuit data. Specifically, category 1 and 2 resources must provide the CAISO with test reports documenting completion of the dynamic data requirements set forth in the "WECC Generation Facility Data, Testing, and Model Validation Requirements" publication as well as test reports documenting real and reactive power capabilities.[72] These Participating Generators must also report any frequency and voltage relay protective settings (if applicable) and must document any relay settings that prevent the Participating Generator from meeting the applicable relay setting requirements included within NERC standard PRC-024-002.[73] Additionally, the CAISO requires an Electromagnetic Transient Model (EMT) for all IBRs in Category 1 and 2 resources and also collections geomagnetic disturbance data from such resources.[74] Category 3 and 4 resources are subject to less data collection, but they are still required to provide dynamic models from the manufacturer using the latest WECC-approved dynamic models and to demonstrate compliance with the frequency and voltage ride-through requirements set forth by the applicable transmission owner.[75] Distribution-connected

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[70] *See* Transmission Planning Process BPM, § 10.
[71] *Id.* The data template for category 5 resources is available at http://www.caiso.com/Documents/DataTemplate-Generators-Category5.xlsx.
[72] *See* Transmission Planning Process BPM, § 10.
[73] *Id.*
[74] *Id.*
[75] *Id.*

resources in categories 3 and 4 are further required to demonstrate compliance with IEEE 1547 and California's state interconnection rule 21.[76] Resources in categories 1-4 are deemed to have completed their data submissions upon the timely provision of all required and any requested information, including a demonstration that the model files (.epc and .dyd) initialize in the PSLF program. The CAISO does not collect modeling information from category 5 resources, but such resources do submit a data template to report information such as the generation type, net MW at the point of interconnection, point of delivery to the CAISO-controlled grid, and on-site load for cogeneration.

In 2021, the CAISO published a whitepaper documenting the work conducted with its partners to promote good practice of model development by interconnection customers, facilitate consistent model reviews by the transmission planners, and ensure the IBRs meet various interconnection requirements.[77] The whitepaper explains how modeling techniques evolve with technology, but the concepts and principles of the whitepaper are suitable to any IBR configuration, including hybrid resources such as solar + storage.[78] For example, a 30 MW solar plant connected to the transmission system would assemble a power flow model to include (1) an explicit representation of the interconnection transmission line; (2) an explicit representation of all station transformers; (3) an equivalent representation of the collector system; (4) an equivalent representation of the pad-mounted transformers, including the scaled MVA rating; (5) an

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[76] *Id.*

[77] *See Dynamic Model Review Guideline for Inverter Based Interconnection Requests*, Whitepaper (June 2021), *available at*: http://www.caiso.com/Documents/InverterBasedInterconnectionRequestsIBRDynamicModelReviewGuideline.pdf.

[78] *Id.* at 1.

equivalent representation of generators scaled to match the total capacity of the plant; and (6) an explicit representation of all plant-level reactive devices.[79] This component approach facilitates broadly applicable power flow modeling for IBRs, as demonstrated by the following figures included in the whitepaper:[80]

Figure 1: Single-Generator Equivalent Power Flow Representation for a Solar PV Power Plant

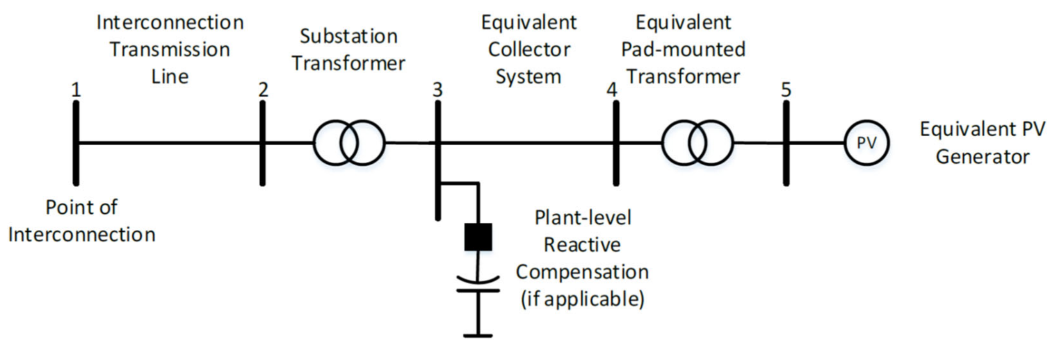
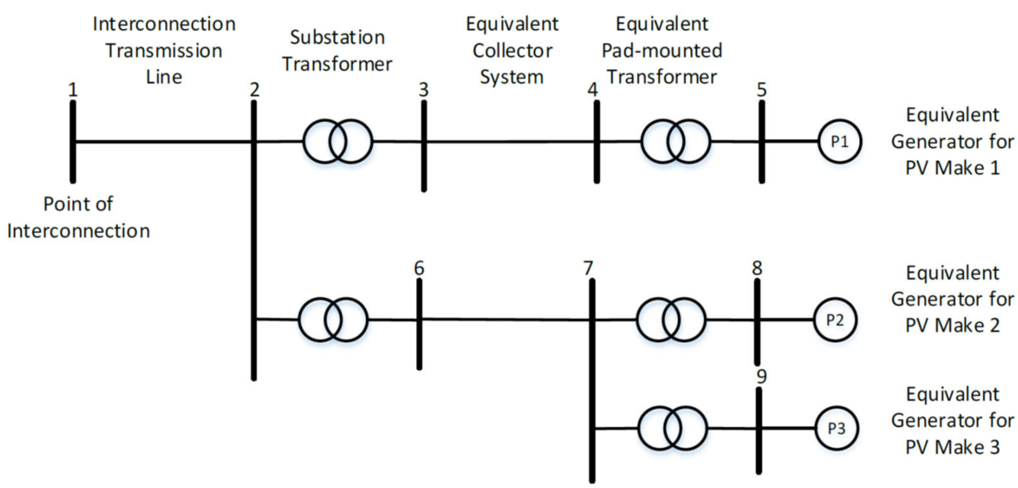


Figure 2: Multiple-Generator Equivalent Power Flow Representation for a Solar PV Power Plant



Through collaborative stakeholder efforts, WECC has made substantial inroads in developing and validating the component parts of dynamic models that are being

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[79] *Id.* at 1-4.
[80] *Id.* at 3.

used to accurately capture the performance of IBR plant.[81] The key components of the WECC-maintained list of approved dynamic models includes components for an IBR plant's converter/inverter, an electrical control to translate real and reactive power references into current commands,[82] a plant-level controller that sends real and reactive power references to local controllers,[83] and frequency and voltage protection models to capture inverter protection settings under abnormal frequency and voltage conditions.[84] WECC staff, in conjunction with members of WECC working groups, have devoted substantial time and attention to developing and completing the steps of a successful model validation procedure. In addition, WECC's models have been the subject of numerous research projects undertaken for the purpose of validating various components of the WECC IBR models. This work has included the collection of substantial data from commissioning tests, field tests, and grid disturbances, clearly defined the mode of operation (control mode) of the IBR and collaboration with manufacturers of solar inverters and wind turbines together with plant operators. NERC and its stakeholders may be able to leverage this experience when developing national standards for model development and validation

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[81] *See, e.g.,* WECC Generating Unit Model Validation Guideline (Apr. 2020), *available at*: https://www.wecc.org/Reliability/WECC%20Generator%20Unit%20Model%20Validation%20Guideline.pdf . *See also* WECC Generating Facility Data, Testing, and Model Validation Requirements (Apr. 2020), *available at*: https://www.wecc.org/Reliability/WECC%20Gen%20Fac%20Testing%20and%20Model%20Validation%20Rqmts%20v%204-23-2020.pdf.

[82] The WECC model includes the appropriate parameters to model the voltage control for IBR plants within the RECC model and the REPC model.

[83] The plant controller executes commands at the facility for functions including active power primary frequency response. The WECC model includes the appropriate parameters to model the primary frequency response for IBR plants within the REPG component.

[84] Protection settings may vary by manufacturer. The CAISO supports modeling to reflect the plant's actual capabilities.

B. The CAISO supports minimum standards for IBR data sharing and data and model validation to enhance the ability to predict, and plan for, system changes.

The CAISO strongly supports the Commission moving forward with a priority 2 action item "to ensure that the registered entities responsible for planning and operating the Bulk-Power System can validate both the individual registered IBR and unregistered IBR data as well as IBR-DER data in the aggregate by comparing the provided data and resulting models with actual performance and behavior."[85] As discussed above, a significant number of IBR resources participating in the CAISO's markets are not bound by NERC's reliability standards. Likewise, CAISO's standards do not bind across the WECC. In developing national reliability standards to address data sharing and data and model validation, NERC will support all grid operators in efficiently and effectively accessing the types of data that needed by planners and operators of the Bulk-Power System. If the Commission does not direct NERC to ensure all IBRs that can materially impact the reliable operation of the Bulk-Power System share data and provide validated modeling information, then the Commission should direct NERC to ensure its resulting standards allow the Transmission Owners and Distribution Provider a means to obtain any necessary data or test results from IBRs not otherwise subject to NERC's data sharing and data and model validation requirements. Proceeding on a patchwork approach where each planning and operating authority establishes its own data sharing and data and model validation guidelines is inefficient and unnecessary. As the CAISO's experience demonstrates, leading a stakeholder process to define and create the data collection templates, construct and valid IBR models and test reports, and

[85] NOPR at P 33.

develop binding contractual commitments requires a significant investment by staff and stakeholders.

National standards will incentivize entities to invest additional resources in research and development of data collection and technical tools that will aid grid operators in performing their essential reliability functions. Grid operators need to predict, and plan for, changing grid conditions. If the Commission directs NERC to establish data collection and model validation standards for IBRs that materially impact the Bulk-Power System, then the CAISO anticipates a significant increase in collaboration opportunities as industry players increase investment and achieve resulting gains in processing and validating the expected and actual performance of IBRs. The CAISO performs short-term demand, renewable, and weather forecasting to thirty-two (32) separate geographical areas, including both for the CAISO and the members of the CAISO's Western Energy Imbalance Market. CAISO's precision-intensive team helps provide the foundation for real-time decisions that are being made by the CAISO, WEIM Entities, and market participants throughout the West. National reliability standards that require the collection and reporting of IBR Data will aid the CAISO, and others, in shaping accurate planning assumptions, incorporating expected operating characteristics, and ensuring continued reliable operation across the Western Interconnection.

C. Additional considerations for IBR data sharing and model validation.

CAISO supports the Commission's proposal for data sharing and data and model coordination but is mindful of the technical, administrative, and compliance burdens associated with the imposition of additional IBR reliability standards. This initiative will provide NERC and all impacted stakeholders a forum to consider appropriate communication and coordination protocols to allow the efficient and effective exchange of information amongst all NERC-registered entities, including IBR resource owners, Distribution Providers, Transmission Owners, and Reliability Coordinators. The CAISO encourages NERC to use this effort to bolster its reliability standards to ensure IBRs can support reliability of the Bulk-Power System rather than shifting compliance obligations to Distribution Providers and Transmission Owners. The CAISO strongly supports the Commission, as well as NERC, in ensuring that Transmission Owners and Distribution Providers have a reliable and effective means of obtaining the necessary information if unregistered IBRs are connected to their systems.

If NERC establishes reliability requirements that require Distribution Providers or Transmission Owners to provide information on unregistered IBRs then, then it is essential that such entities have an accessible pathway to obtain necessary data from IBR owners and operators. Providing the means for such entities to access data from unregistered IBRs would, in turn, enhance the ability of system planners and operators to prepare for and manage the integration of such IBRs. For example, such work would ensure that any reliability standards ultimately established by NERC are appropriately synced with applicable technical (*e.g.,* IEEE 1547) and state-specific (*e.g.,* California Rule 21) interconnection standards. The CAISO supports NERC in undertaking the necessary work to ensure that planning and operational authorities are provided with information that is sufficient to account for the impact of IBRs on the Bulk-Power System.

IV. CAISO Supports Developing and Implementing Standards for Incorporating IBR Data Within Planning and Operation Processes as Priority 3.

The CAISO supports the Commission's proposal to direct NERC to establish standards that ensure planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities receive registered IBR modeling data from registered IBR generator owners and operators, as well as unregistered IBR modeling data and parameters and IBR-DER aggregate modeling data and parameters to ensure reliability.[86] The CAISO agrees with the Commission that system planners and operators need accurate planning and operational information to ensure that their own models, together with the interconnection-wide models, appropriately reflect IBRs to ensure reliable operation of the system.[87] Without such information, planners and operators cannot adequately predict resources' behaviors and the resulting impact to the reliability of the Bulk-Power System.

The CAISO supports the Commission's efforts to ensure transmission planners and planning coordinators work with generator owners and operators of IBRs connected to their system so the dynamic models correctly represent the large disturbance behavior of the actual installed equipment.[88] Planning entities will complete this task in the course developing and implementing IBR standards for data sharing and data and model development (priority 2 item, discussed above). As a practical matter, the CAISO and other grid operators must be able to evaluate the accuracy of the data and models in the context of their own dynamic models for planning and operations. Through the

[86] NOPR at P 33.
[87] NOPR at P 34.
[88] NOPR at P 39.

iterative process of developing the priority 2 standards, the CAISO anticipates that NERC will convene forums that will bring together both the IBRs connected to the system and the transmission planning and planning coordinators entities. This process will allow NERC to develop IBR data and model validation standards that, once completed, produce a usable and efficient framework so that planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities can rely on such data and models within their own study and evaluation processes.

After this priority 2 process is complete, it would be appropriate, as a priority 3 item, to document the ways in which planning coordinators, transmission planners, reliability coordinators, transmission operators, and balancing authorities use such information. In the NOPR, the Commission identified certain gaps, the first being "the use of incorrect and unvalidated registered IBR, unregistered IBR, and IBR-DER models (discussed above) that do not accurately represent performance and behavior of both individual and aggregate registered IBRs and unregistered IBRs, as well as IBR-DERs in the aggregate."[89] The second gap identified involves insufficient coordination among entities that is otherwise necessary "to build interconnection-wide cases that reflect the large disturbance behavior of both individual and aggregate registered IBRs and unregistered IBRs, as well as IBR-DERs in the aggregate (*i.e.*, tripping offline or momentary cessation individually or in the aggregate in response to a single fault on a transmission or sub-transmission system)."[90] Finally, the Commission identified a gap

[89] NOPR at P 44.
[90] NOPR at P 45.

in planning and operational studies and proposed the developing Reliability Standards to ensure planning and operational studies "account for the actual behavior of registered IBRs, unregistered IBRs, and IBR-DERs in the aggregate."[91]

The CAISO supports the Commission acting to close the identified gaps, but it recommends establishing this as a priority 3 item to be completed only after the development of standards concerning the collection and reporting of data and models for registered IBRs, unregistered IBRs, and IBR-DERs that materially impact the Bulk-Power System. In the CAISO's experience, planning and operational authorities incorporate all potential sources of reliable data within their assumptions and resulting models. The Commission recognized that some reliability issues identified in real-time have not been captured by planning studies because planners may not have access to a standard set of verified and reliable data concerning the real-time expected performance of all unregistered IBRs, registered IBRs, and IBR-DERs that could possibly have a material impact the Bulk-Power System. In the course of the priority 2 action item, the CAISO anticipates that entities will resolve the problems such as those identified in the Odessa and Panhandle disturbance reports, including identifying and understanding the "abnormally responding" IBRs and accounting for IBRs that "significantly reduce active power for depressed voltages."[92] In addition, in the course of the priority 2 effort, stakeholders will tackle the challenge of increasing visibility and locational granularity of IBR-DERs so such resources can be modeled "in an aggregate

[91] NOPR at P 47.
[92] NOPR at P 49 (citing the Odessa Disturbance Report, the Panhandle Report, and the April 2022 NERC Report).

and/or equivalent way to reflect their dynamic characteristics and steady-state output."[93] As verified and reliable data and models are made available, the CAISO would incorporate these models to identify potential system operating limits and interconnection reliability operating limit exceedances and to identify any potential reliability risks related to instability, cascading, or uncontrolled separation would be updated to account for additional data and modeling inputs.[94]

The CAISO supports the Commission's proposal to direct NERC to establish an action item to review the Reliability Standards and undertake necessary modification and addition to require planning authorities include data within their planning and assessments to reflect expected actions of individual and aggregate registered IBRs and unregistered IBRs, as well as IBR-DERs in the aggregate, under normal and contingency system conditions.[95] When such data is available, it is appropriate for planning assessments to include the study and evaluation of the ride through performance (*e.g.*, tripping and momentary cessation conditions) of such IBRs on a comparable basis to synchronous generation resources.[96] If such data is determined to be accurate and reliable, then it would then appropriate to require planning coordinators and transmission planners incorporate such information within their studies.[97] It is possible the existing reliability standards will be sufficient to require such actions once

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[93] NOPR at P 50 (citing the NERC DER Report).
[94] NOPR at P 52.
[95] NOPR at P 88.
[96] NOPR at P 88.
[97] NOPR at P 88 (proposing that such entities consider the individual and aggregate behavior of registered IBRs and unregistered IBRs, as well as IBR-DERs in the aggregate, using planning models of their area, and, using interconnection-wide area planning models, IBR behavior in adjacent and other planning areas that adversely impacts a planning coordinator's or transmission planner's area during a disturbance event).

planning coordinators and transmission planners have access to validated modeling and operational data for individual registered IBRs and unregistered IBRs, as well as IBR-DERs in the aggregate. If revisions are required, they can be considered as a priority 3 action item.

The CAISO also supports the Commission's proposal to direct NERC to establish an action item to review the Reliability Standards and undertake necessary modification and addition to require operational authorities include data within their operational studies to reflect expected actions of individual and aggregate registered IBRs and unregistered IBRs, as well as IBR-DERs in the aggregate, under normal and contingency system conditions.[98] Under the status quo, operators may not have confidence that their results are valid if the analysis lack appropriate data to support the inputs and assumptions concerning unregistered IBRs, registered IBRs, or IBR-DERs in the aggregate.[99] Completing priority 2 action items will reduce, if not eliminate, these concerns. It is likely that existing standards can be used to "require balancing authorities to include the performance and behavior of both individual and aggregate registered IBRs and unregistered IBRs, as well as IBR-DERs in the aggregate (*e.g.*, resources tripping or entering momentary cessation individually or in the aggregate) in their operational analysis functions and real-time monitoring."[100]

A. Ensuring compliance responsibilities are assigned to the appropriate registered entity.

[98] NOPR at P 89 (proposing that such entities include such data within "the various operational studies (including operational planning analyses, real-time monitoring, real-time assessments and other analysis functions)" used to assess the performance of the Bulk-Power System for normal and contingency conditions).

[99] *Id.*

[100] *Id.*

The CAISO encourages the Commission to direct NERC to address the potential "compliance trap" that arises for planning and operational authorities when such authorities rely on data submissions collected from third-parties (*e.g.,* resource owners, distribution providers, and transmission owners). The resulting reliability standards should make clear that the responsibility of ensuring accurate and complete data submissions rests with the entity providing such material (*e.g.,* resource owner). If the Commission directs NERC to establish uniformly applicable IBR data sharing and data and model validation standards, then entities like CAISO may have a process to collect and rely on third-party submissions of IBR Data. Shifting compliance responsibilities from the entity that owns and maintains the necessary data and models (*e.g.*, the resource owner) to a planning or operational authority is not appropriate. The resulting standards should establish sufficient guideposts so that planning and operational authorities, as well as Distribution Providers and Transmission Owners, can rely on data collected from IBR owners and operators.

Furthermore, the CAISO encourages the Commission to direct NERC to ensure that planning and operational authorities are not placed into a compliance trap or otherwise shouldering inappropriate or burdensome compliance and monitoring responsibilities. Specifically, the priority 3 initiative should establish standards that address the process and timeline by which planning and operational authorities must reflect data corrections if the responsible entity discovers and reports inaccuracies or errors in the data it receives from others. If planning and operational authorities discover insufficiencies in the models or inaccuracies in the data, such authorities should be authorized to undertake necessary corrections while still remaining compliant with all applicable Reliability Standards. This will ensure the resulting analyses accurately reflect the expected system performance when such analyses incorporate data and models for individual and aggregate registered IBRs and unregistered IBRs, as well as IBR-DERs in the aggregate.

B. Additional development of communication protocols and visibility tools.

As an enhancement to the priority 3 initiative, the CAISO encourages the Commission, NERC, and stakeholders to work collaboratively on developing additional communication protocols and visibility tools to allow planners and operators access to additional IBR data to mitigate certain real-time operational challenges that emerge when grid operators transition to managing a high penetration of IBRs. For example, the CAISO has experienced intra-hour ramps that are greater than 6,000 MW in some hours and has experienced 3-hour evening ramps that exceed 15,000 MW. In the CAISO's experience, this has presented unique control performance challenges during sunrise, sunset, and even during weekend days. If the electric grid will support additional industry transitions (*e.g.,* electric vehicles), then it is essential that planning and operational authorities are provided tools in which to manage the increased demands and complexities. In addition, the CAISO encourages NERC to consider whether new or modified reliability standards for IBR resources can help reduce the compliance burdens currently placed on operational and planning entities while still maintaining or exceeding current reliability thresholds.

The CAISO also encourages the Commission, NERC, and stakeholders to consider supporting the continued development and deployment of visibility tools to support planning and operation functions. The Commission's proposal to require IBR owners and operators provide models that accurately represent the planned performance of IBR resources is a step in the right direction. Whether through telemetry collections or other automated platform integrations, the CAISO encourages the Commission to direct NERC to consider requiring IBRs to provide additional data to enhance real-time visibility of Bulk-Power System operations. Providing a forum for planning and operational authorities to identify additional data points or performance capabilities and obtain additional visibility into IBR resources would further the goals of the NOPR.

V. Conclusion

The Commission should act on the NOPR in a manner consistent with the CAISO's comments.

Respectfully submitted,

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February 6, 2023

CERTIFICATE OF SERVICE

I certify that I have served the foregoing document upon the parties listed on the official service list in the above-referenced proceeding; in accordance with the requirements of Rule 2010 of the Commission's Rules of Practice and Procedure (18 C.F.R. § 385.2010).

Dated at Folsom, California this 6th day of February 2023.

/s/ Anna Pascuzzo
Anna Pascuzzo