168 FERC ¶ 61,003
UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Before Commissioners: Neil Chatterjee, Chairman;
Cheryl A. LaFleur, Richard Glick,
and Bernard L. McNamee.

California Independent System Operator Corporation Docket Nos. ER19-1153-000
ER19-1153-001

ORDER ACCEPTING TARIFF REVISIONS

(Issued July 2, 2019)

1. On February 28, 2019, the California Independent System Operator Corporation (CAISO) filed tariff revisions to mitigate reliability issues caused by temporary losses of inverter-based generators.[1] The proposed tariff revisions also establish a platform to collect information to better inform CAISO and stakeholders on the operation of inverter-based generators. In this order, we accept CAISO's tariff revisions, effective April 30, 2019, as requested.

I. Background

2. CAISO asserts that the volume of inverter-based generators interconnecting within its Balancing Authority Area has increased dramatically in recent years and that its resource fleet includes over 18,000 MW of inverter-based generators.[2] CAISO explains that the basic function of inverters is to change direct current or variable frequency alternating current to 60 Hz alternating current for the transmission and delivery of electricity that generators produce. In addition, CAISO states that inverters monitor grid conditions and provide controls to ensure electricity from the generator is deliverable. Specifically, CAISO explains that inverters monitor the voltage and frequency of the grid and synchronize the generator's production to inject more or less current as needed. If the inverter detects grid conditions that could harm the generator, known as "faults," the

[1] CAISO states that inverter-based generators include solar photovoltaic and wind resources. CAISO Transmittal at 1.

[2] *Id.* at 2.

inverters are programmed to disconnect from the grid or otherwise cease injecting current.[3]

3. However, CAISO explains that these generators trip (disconnect from the grid) or enter momentary cessation (when a generator ceases to inject current during a fault but does not disconnect from the grid) at times when there is no risk of harm to them, resulting in the sudden loss of hundreds of megawatts of generation that can cause immediate reliability issues. CAISO also states that, once they are back online, these generators frequently take time to start injecting current into the system again, causing grid operators to re-dispatch other generation in the interim in order to balance load.[4]

4. CAISO states that, in fact, it has experienced numerous reliability events when inverter-based generators either tripped or ceased injecting current even though the faults that triggered those trips were cleared almost instantaneously. CAISO explains that many generator owners have reconfigured their inverters and protective relays to avoid the unnecessary trips and momentary cessation that caused previous reliability events. However, CAISO maintains that the risk of future events will remain until all inverter-based generators are required to program their inverter internal protection and protective relays consistently.[5]

II. CAISO Filing

5. CAISO states that, in consultation with its stakeholders, it has developed revisions to its *pro forma* generator interconnection agreement (GIA) to mitigate the risk of future reliability events caused by inverter-based generators. Specifically, CAISO proposes revisions to clarify that momentary cessation for inverters during transient transmission line faults violates the existing requirement in CAISO's *pro forma* GIA to remain online under certain specified conditions. Under the proposed revisions, momentary cessation will be prohibited unless transient high voltage conditions rise to 1.20 per unit or more, which it notes is consistent with the Commission's current ride-through requirement.[6] For transient low voltage conditions, CAISO proposes to require the generator to inject reactive current at a rate that is directly proportional to the decrease in voltage measured

[3] *Id.* at 4.

[4] *Id.* at 2.

[5] *Id.* at 13.

[6] *Id.* at 17 (citing *Standardization of Generator Interconnection Agreements and Procedures*, Order No. 2003, 104 FERC ¶ 61,103, at P 562 (2003); *Requirements for Frequency and Voltage Ride Through Capability of Small Generating Facilities*, Order No. 828, 156 FERC ¶ 61,062 (2016)).

at the inverter terminal. The inverter would be required to produce full rating reactive current when the alternating current (AC) voltage at the inverter terminals drops to a level of 0.50 per unit, and continue to operate and attempt to maintain voltage for transient voltage conditions between 1.10 and 1.20 per unit. CAISO states that the proposed requirements are different for transient high and low voltage events because, during low voltage events, prioritizing the injection of reactive power provides voltage support to the system – whereas, for high voltage conditions, it is preferable for the inverter to enter into momentary cessation (rather than tripping offline). CAISO notes that inverters would be permitted, but not required, to inject current during a transient low voltage event.[7]

6. CAISO also proposes several measures to mitigate concerns identified in its studies, North American Electric Reliability Corporation (NERC) reliability standard PRC-024-2, and associated NERC recommendations. First, CAISO proposes to clarify that asynchronous generating facility inverters may not trip or cease to inject current for momentary loss of synchrony within the no-trip zone specified in NERC reliability standard PRC-024-2. CAISO asserts that this prohibition is just and reasonable because it will ensure that generators remain online for faults that will be cleared almost instantaneously. Second, CAISO proposes to clarify that its existing power factor design criteria should be measured at the high-voltage side of the generating facility transformer, rather than "at the point of interconnection" under the current provisions. CAISO asserts that this revision is consistent with existing practices and the Commission's existing *pro forma* Large Generator Interconnection Agreement provisions regarding voltage measurement,[8] and will also increase transparency and eliminate ambiguity. Third, CAISO proposes to require that when generators trip or cease to inject current, they attempt to resynchronize promptly and consistently, going from no output to full output in one second or less. CAISO contends that this proposed requirement is consistent with NERC recommendations,[9] and can be met with available inverter technology without additional expense or burden. Fourth, CAISO proposes to update an anachronistic reference in the *pro forma* GIA to a document that is no longer published by the Western

[7] *Id.* at 16-18, 22.

[8] *Id.* at 27 (citing CAISO Tariff, §§ A(i)(1) and (2) of Appendix H to Appendix EE; §§ A(i)(1) and (2) of Attachment 7 to Appendix FF).

[9] *Id.* (citing NERC, *Industry Recommendation: Loss of Solar Resources during Transmission Disturbances due to Inverter Settings- II*, Alert ID R-2018-05-01-01, at 2-3 (2018)). https://www.nerc.com/pa/rrm/bpsa/Alerts%20DL/NERC%20Alert%20Loss%20of%20Solar%20Resources%20during%20Transmission%20Disturbance.pdf.

Electricity Coordinating Council, and to replace it with a reference to the relevant NERC reliability standard, PRC-024-2, as it may be amended from time to time.[10]

7. Finally, CAISO proposes to require asynchronous generating facilities larger than 20 MW to "monitor and record data for all frequency or voltage ride-through events, momentary cessation for transient high voltage events, and inverter trips."[11] CAISO proposes to require asynchronous generators to store the data for a minimum of 30 days and provide all data within 10 days of request from CAISO or the participating transmission owner. CAISO asserts that applying these requirements to large generators is a prudent and non-burdensome step at this time because, based on information from the stakeholder process, CAISO believes that large generators already have the plant controllers and analytics to comply with this requirement. CAISO asserts that having reliable access to these data will help ensure that CAISO and the relevant transmission owners investigating an event can obtain data promptly after the event occurs.[12]

8. CAISO asserts that, consistent with the Commission's similar directive in Order No. 842,[13] its revisions will apply to generators executing GIAs going forward. CAISO maintains that generators that are online or have already executed GIAs would be subject to the proposed tariff requirements only if they request to make modifications that replace their generating units or their inverters.[14] CAISO also asserts that generators subject to the proposed tariff requirements should not face any challenge in obtaining and

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[10] *Id.* at 26-28.

[11] *Id.* at 29 (citing CAISO Tariff, Proposed § A(vi) of Appendix H to Appendix EE).

[12] *Id.* at 29-30.

[13] *Essential Reliability Services and the Evolving Bulk-Power System—Primary Frequency Response*, Order No. 842, 83 Fed. Reg. 9,636 (Mar. 6, 2018), 162 FERC ¶ 61,128 (2018). Order No. 842 modified the *pro forma* Large Generator Interconnection Agreement and the *pro forma* Small Generator Interconnection Agreement to require newly interconnecting facilities, as well as existing large and small generating facilities (synchronous and non-synchronous) that submit new interconnection requests that result in an executed or unexecuted interconnection agreements, to install, maintain, and operate equipment capable of providing primary frequency response as a condition of interconnection.

[14] CAISO Transmittal at 17.

programming inverters to follow them and that the cost of meeting these requirements will be *de minimis*.[15]

III. Notice of Filing

9. Notice of CAISO's filing was published in the *Federal Register*, 84 Fed. Reg. 8902 (2019), with interventions or protests due on or before March 21, 2019. Timely motions to intervene were filed by Pacific Gas and Electric Company, Modesto Irrigation District, the City of Santa Clara, California, and Northern California Power Agency. Timely motions to intervene and comments were filed by Southern California Edison Company (SoCal Edison), First Solar, Inc. (First Solar), and NextEra Energy Resources, LLC (NextEra). On April 2, 2019, CAISO filed an answer in response to NextEra's comments.

10. On April 18, 2019, Commission staff issued a Deficiency Letter that requested additional clarification regarding CAISO's proposed revisions pertaining to low-voltage events. On May 3, 2019 CAISO filed its response to the Deficiency Letter (Deficiency Response) in Docket No. ER19-1153-001. Notice of the Deficiency Response was published in the *Federal Register*, 84 Fed. Reg. 20,873 (2019), with comments due on or before May 24, 2019. None was filed.

IV. Comments and CAISO Answer

11. SoCal Edison and First Solar support CAISO's proposed revisions as measures that will help CAISO maintain grid reliability and resilience given the rapidly changing resource mix and operating conditions on its system.[16]

12. NextEra states that it generally supports CAISO's proposed revisions, but requests that the Commission condition acceptance of CAISO's proposal on two modifications. First, NextEra asks the Commission to find that there must be a phase-in of CAISO's proposal to install equipment capable of recording data at the individual inverter level. NextEra states that such data cannot currently be captured by the inverters that are commercially available in today's market. NextEra suggests that this application could be limited to new or modified inverter-based generators with an in-service date of 2023 or later to allow inverter manufacturers time to incorporate the necessary diagnostic technology.[17] Second, NextEra requests that the Commission require CAISO to clarify that the instant revisions would not apply to new or modified interconnection agreements

[15] *Id.* at 17.

[16] SoCal Edison Comments at 2; First Solar Comments at 3-7.

[17] NextEra Comments at 3.

entered into after the April 30, 2019 effective date where the developer can show that its inverters were purchased before that date.[18]

13. In its Answer, CAISO asserts that NextEra's requested modifications are neither necessary nor prudent. CAISO contends that NextEra's requested phase-in and exemption for inverters purchased before the effective date of these revisions would impede efforts to mitigate the reliability issues identified in CAISO's filing. CAISO suggests that, if NextEra or any other developer has a good cause for seeking a limited waiver from any interconnection requirement, it does not need a pre-established waiver in the CAISO tariff. Further, CAISO notes that if CAISO, the participating transmission owner, and interconnection customer cannot agree on waivers from the *pro forma* GIA provisions, the interconnection customer has the option of requesting that its agreement be filed unexecuted to put the issue before the Commission. CAISO asserts that either of these available options are more appropriate solutions to the challenges alleged by NextEra. CAISO also notes that the modifications requested by NextEra were not developed through the stakeholder process, and argues that its proposal is just and reasonable without further modification.[19]

V. Deficiency Letter and Response

14. In the Deficiency Letter, staff noted that, while the relevant NERC reliability standard -- PRC-024-2 -- references voltage measurement at a generator's point of interconnection with the transmission grid, CAISO's proposed tariff language would require inverters to inject reactive current based on the voltage measured at the inverter terminal. Thus, staff requested further information on how the proposed tariff revision would ensure compliance with NERC reliability standard PRC-024-2. In the Deficiency Response, CAISO explains that NERC reliability standard PRC-024-2 specifies voltage regions in which it is not permissible for a generator to trip, but is silent on whether it is permissible for a generator to enter momentary cessation. CAISO states that its proposed revision to require the injection of reactive current is intended to prohibit momentary cessation within the no-trip zone. CAISO asserts that there is no conflict between its proposed tariff language and the NERC reliability standard PRC-024-2 because, although inverters will normally measure voltage at the inverter terminals, the inverters can be brought into compliance with the NERC standard by programming voltage set points adjusted to the point of interconnection.[20]

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[18] *Id.*

[19] CAISO Answer at 2-3.

[20] CAISO Deficiency Response at 2-3. CAISO notes that NERC has issued guidance on establishing compliant voltage set points. *Id.* at 3.

15. Staff also asked CAISO to clarify any expectations or requirements for inverters to inject active current during low voltage conditions. In its Deficiency Response, CAISO states that its proposal does not require active current injection during the specified low voltage events. CAISO states that, because reactive current control is a function of voltage, a quantitative control requirement can be specified. However, CAISO asserts that active current control depends on the pre-disturbance operating condition and a number of other factors, such as available fuel, and therefore cannot be specified based simply on the voltage condition.[21]

VI. Discussion

A. Procedural Matters

16. Pursuant to Rule 214 of the Commission's Rules of Practice and Procedure, 18 C.F.R. § 385.214 (2018), the timely, unopposed motions to intervene serve to make the entities that filed them parties to this proceeding.

17. Rule 213(a)(2) of the Commission's Rules of Practice and Procedure, 18 C.F.R. § 385.213(a)(2)(2018), prohibits an answer to a protest unless otherwise ordered by the decisional authority. We accept the answer filed by CAISO because it has provided information that assisted us in our decision-making process.

B. Substantive Matters

18. We accept CAISO's proposed tariff revisions, effective April 30, 2019, as requested. We find that the revisions are just and reasonable because the revisions will help mitigate adverse reliability impacts caused by inverter-based generators. Based on CAISO's study results that it included with its filing, as well as the NERC recommendations on this issue,[22] we find that the proposed revisions will enhance the reliability and resilience of the CAISO-operated grid by eliminating unnecessary momentary cessation for inverters during the clearing of a transmission line fault, eliminating inverter tripping for momentary losses of synchrony, and requiring prompt reconnection of the inverters following a trip. In particular, we find that CAISO's proposed requirement for generator interconnection customers to program their inverters to provide reactive support during transient low voltage conditions within the "no trip zone," by choosing voltage set points adjusted to the point of interconnection, is consistent with NERC reliability standard PRC-024-2 that requires generators respond to

[21] *Id.* at 4.

[22] NERC, *Industry Recommendation: Loss of Solar Resources during Transmission Disturbances due to Inverter Settings- II*, Alert ID R-2018-05-01-01 (2018).

the voltage as measured at the point of interconnection, and should help to prevent the adverse reliability impact of momentary cessation. Thus, we find that the proposed revisions are just and reasonable improvements over the existing tariff, will help eliminate any ambiguity in the current requirements, and can be implemented on a prospective basis without imposing any undue burden on generators.[23]

19. Further, CAISO's proposal to require the monitoring and recording of data for ride-through events, momentary cessation, and inverter trips is a just and reasonable measure for ensuring that CAISO and investigating transmission owners have timely access to data to diagnose the cause of an event. We expect that this data collection will help educate CAISO and stakeholders on the operation of inverter-based generators, and will help inform and support additional steps that CAISO may pursue to further mitigate the identified reliability challenges.

20. We are not persuaded by NextEra's contention that a phase-in of, or exemption from, these revisions is necessary. In its transmittal, CAISO explains that, based on its work in certain initiatives and through its stakeholder process, it appears most large generators have the capability to collect and store these data.[24] Moreover, we find that establishing a phase-in requirement or exempting certain inverter-based generators from the data collection requirements could impede efforts to mitigate the reliability issues identified by CAISO. Further, as noted by CAISO, the interconnection customer has the option of requesting that an unexecuted interconnection agreement is filed with the Commission. We find that this approach is a more appropriate solution for addressing generator-specific issues, rather than requiring a pre-established exemption in the CAISO tariff.

21. We acknowledge CAISO's recognition that these issues may require further mitigation in the future, and its stated intention to continue to work with stakeholders and regulators to identify further steps that may be warranted based on future grid topology and technology advancement.[25] We encourage CAISO to continue to assess whether these revisions are sufficiently addressing the issues CAISO identified and to explore with stakeholders further improvements that may become necessary.

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[23] CAISO Transmittal at 17. CAISO notes that based on input from generation developers and inverter manufacturers that participated in a NERC task force and CAISO's stakeholder initiative, CAISO believes that the cost of meeting these requirements will be *de minimis*.

[24] *Id.* at 29-30.

[25] *Id.* at 31.

The Commission orders:

CAISO's proposed tariff revisions are hereby accepted, effective April 30, 2019, as requested, as discussed in the body of this order.

By the Commission.

(S E A L)

Nathaniel J. Davis, Sr.,
Deputy Secretary.