NERC
NORTH AMERICAN ELECTRIC
RELIABILITY CORPORATION

2022 California Battery Energy Storage System Disturbances

California Events: March 9 and April 6, 2022
Joint NERC and WECC Staff Report

September 2023

RELIABILITY | RESILIENCE | SECURITY




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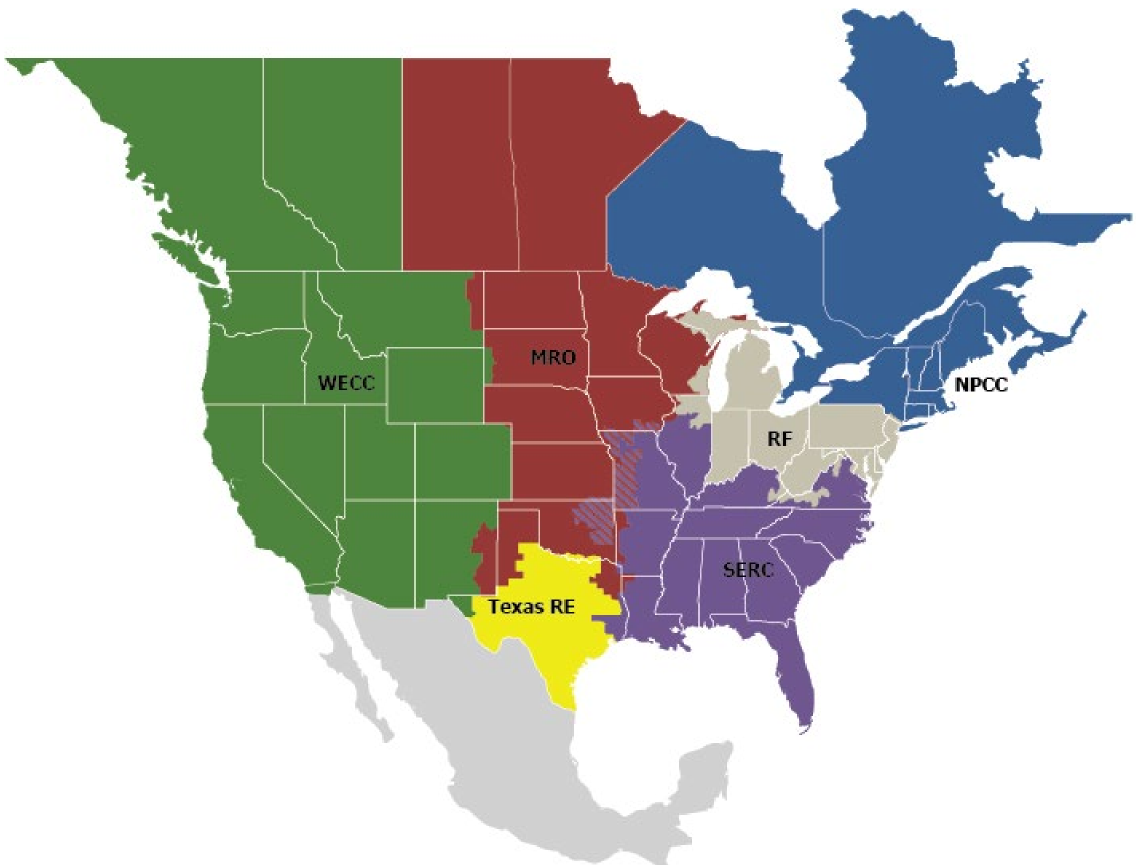
Preface

Electricity is a key component of the fabric of modern society and the Electric Reliability Organization (ERO) Enterprise serves to strengthen that fabric. The vision for the ERO Enterprise, which is comprised of the NERC and the six Regional Entities, is a highly reliable, resilient, and secure North American bulk power system (BPS). Our mission is to assure the effective and efficient reduction of risks to the reliability and security of the grid.

Reliability | Resilience | Security
Because nearly 400 million citizens in North America are counting on us

The North American BPS is made up of six Regional Entities as shown on the map and in the corresponding table below. The multicolored area denotes overlap as some load-serving entities participate in one Regional Entity while associated Transmission Owners/Operators participate in another.



MRO	Midwest Reliability Organization
NPCC	Northeast Power Coordinating Council
RF	ReliabilityFirst
SERC	SERC Reliability Corporation
Texas RE	Texas Reliability Entity
WECC	WECC

Executive Summary

NERC continues to analyze disturbances that involve the widespread reduction of inverter-based resources to identify systemic reliability issues, support affected facility owners, and share key findings and recommendations with industry for increased awareness and action. Refer to the NERC *Quick Reference Guide: Inverter-Based Resource Activities*[1] for more details on all aspects of work in this area. NERC continues to stress the need for industry action in multiple areas to address the systemic reliability risks posed by inverter-based resource performance issues. Multiple recent disturbances that involve the widespread reduction of solar photovoltaic (PV) resources have occurred in California, Utah, and Texas. This report assesses two widespread losses of battery energy storage systems (BESS) caused by normally cleared faults in the Western Interconnection that occurred on March 9, 2022, and April 6, 2022. These events are unique in that they are the first major events involving BESS facilities. These events highlight the need to consider BESS in the same light as any other inverter-based resource, such as solar PV for their systemic reliability risks. A majority of the inverters involved are made by the same manufacturers that also make solar PV inverters.

The events were each initially categorized as a Category 1a (3/9) and 1i[2] (4/6) events in the NERC Event Analysis Process due to the magnitude of generation loss and number of affected facilities.[3]

Key Findings and Recommendations

Based on the findings of this disturbance report and in the context of past disturbance reports for inverter performance issues, NERC recommends the following actions:

- **BESS may have the same systemic performance problems as solar PV resources.**
  - All BESS facilities experienced partial plant tripping caused by inverter protection, failing to ride through normally cleared single-line-to-ground grid faults. The affected inverters tripped on both new causes and causes previously reported associated with solar PV resources. Facilities also exhibited the previously identified plant control interaction that delays the return to pre-disturbance output levels. To minimize the proliferation of systemic risks in BESS resources as occurred in solar PV resources, industry should quickly eliminate these problems, especially since BESS resources are expected to play a key role in enhancing reliability in the changing resource mix.
- **BESS ride-through performance is not adequately assessed during the interconnection process.**
  - Transmission Owners (TOs) and Generator Owners (GOs) should identify unreliable ride-through performance issues prior to commercial operation. TOs should establish clear ride-through performance requirements in their interconnection requirements and enforce them throughout the interconnection process. NERC Project 2020-02[4] deliverables can provide minimum ride-through performance requirements. Prior to commercial operation, TOs should conduct comprehensive assessments to determine if their ride-through performance requirements are met. GOs should facilitate such assessments, including providing necessary detailed plant modeling in electromagnetic transient (EMT) domain. GOs should perform testing during the trial operation period prior to commercial operation to validate that the actual performance is reflective of the models used during the study phase.[5]

[1] https://www.nerc.com/pa/Documents/IBR_Quick%20Reference%20Guide.pdf

[2] The April event was initially categorized as a 1i event. However, after further review, the loss was determined to be just under 500 MW, and the event was declared a Category 0 event.

[3] NERC Event Analysis Program: https://www.nerc.com/pa/rrm/ea/Pages/EA-Program.aspx

[4] https://www.nerc.com/pa/Stand/Pages/Project_2020-02_Transmission-connected_Resources.aspx

[5] See Article 24 of the FERC pro-forma Large Generator Interconnection Agreement (LGIA)

- **Poor commissioning practices are a significant contributor to the unreliable performance of IBRs.**
  - The unreliable inverter ride-through performance, site metering issues, and meter misconfiguration should have been identified as part of commissioning checks. Transmissions Planners and Planning Coordinators should conduct ride-through performance assessments[6] as part of their interconnection studies and confirm that installed equipment, performance, and capabilities match those in the studied models. The NERC Inverter-Based Resource Performance Subcommittee (IRPS) is actively working on the whitepaper *BPS-Connected IBR Commissioning Best Practices* to highlight best practices for commissioning BPS-connected inverter-based resources to ensure that the appropriate protection, controls, and monitoring are configured; inverter performance is assessed and verified; and that actual installed operational capabilities match what were studied with the models. There is an increasing need for a commissioning standard to ensure installed facilities match what was modeled and studied during the interconnection process and that the facility was commissioned in a reliable manner.
- **NERC will be conducting a model quality assessment of this event and subsequently issue an alert as needed.**
  - NERC collected positive sequence and EMT models from the affected GOs and TOs as part of this disturbance analysis. In addition to this report, which focuses solely on unreliable performance, NERC will be conducting a detailed assessment of the models of the affected facilities.
- **Lack of adequate monitoring hinders performance and event analysis.**
  - In addition to not properly assessing the ride-through performance during interconnection study and configuring the inverters appropriately, all BESS involved did not have fast logging enabled and thus lacked the needed data to determine their transient dynamic performance, such as sufficient reactive current injection during the disturbance. They also did not meet California Independent System Operator's (CAISO) 10 ms recording data resolution requirements. NERC Project 2021-04[7] is underway to ensure adequate data is available across the entire ERO Enterprise footprint to allow for thorough analysis of abnormal performance of IBR to identify root causes and mitigations.
  - There were other significant data quality issues, including the lack of individual facility metering in CAISO's supervisory control and data acquisition and inconsistency between BESS facility data and CAISO data. Additionally, several facilities had their meter data "freeze" on the last value at the onset of the fault.

Recommendations for GOs

- All GOs should check with their inverter manufacturer to ensure that their inverters are not prone to tripping on the following causes, in addition to those previously reported, during normally cleared unbalanced grid faults:
  - Unexpected, unbalanced ac current
  - Unexpected dc bus overvoltage tripping
  - Unstable dc bus voltage
- All GOs should ensure both inverter and plant level recording functions are configured to meet the requirements in the interconnection agreements. Additionally, GOs should perform the following:
  - Ensure fast logging is enabled
  - Ensure that meter data does not freeze on the last value when subjected to system transients during grid faults

[6] Disaggregated plant EMT models are necessary to fully assess potential partial plant tripping and other performance issues.

[7] https://www.nerc.com/pa/Stand/Pages/Project-2021-04-Modifications-to-PRC-002-2.aspx

Chapter 1: Overview of Disturbances

This *2022 California Battery Energy Storage System Disturbances* report documents the key findings and recommendations from analyzing the abnormal loss of BESS resources that occurred in Southern California on March 9 and April 6, 2022. This chapter provides details regarding the initiating event, pre-disturbance conditions, overview of disturbances involving BESS, and additional relevant details. **Chapter 2** provides the key findings and establishes the basis for the recommendations. **Appendix A** provides a detailed analysis of the affected BESS facilities. **Appendix B** provides brief summaries of the affected facilities that are not BESS. This report focuses solely on the performance and causes of abnormal power reduction. NERC is working on a separate assessment of the models of the affected facilities.

Description of Analysis Process

CAISO identified the events on March 9, 2022, and April 6, 2022, by observing the reduction of power outputs across multiple BESS and solar PV facilities. The events met the criteria for Category 1a and 1i event, respectively, per the NERC Event Analysis Program based on the total MW losses and number of facilities outaged. NERC and WECC agreed to develop a disturbance report to share the key findings and recommendations from the analysis with industry. NERC and WECC decided to focus specifically on BESS due to the unique opportunity of visibility because the first disturbance occurred after sunset (exclusively BESS, no solar) and the same facilities participated in both disturbances. CAISO independently solicited requests for information to affected entities and also held follow-up calls with those entities to gain any additional information needed to perform root cause analysis. NERC and WECC collaborated with CAISO and prepared this report based on the information provided by CAISO.

Pre-disturbance Operating Conditions

The March disturbance occurred at 18:03:20 Pacific time after the sun had set. The April disturbance occurred at 15:06:05 Pacific time when the solar PV facilities were still producing power. Most of the affected BESS facilities were located in the vicinity of solar PV facilities. While solar PV facilities were involved in the April event, this report specifically focuses on the BESS facilities. **Table 1.1** shows the generation mix prior to the disturbances.

Table 1.1: Pre-disturbance Resource Mix

Resource Type	March 9	April 6
Internal Net Demand	26,067.0	24,360.0
Solar PV	55.5	12,589.0
Wind	2,567.2	531.7
BESS	769.4	212.1
Synchronous Generation	15,567.9	8,215.2

Overview of Disturbances involving BESS

This report covers the following two events that occurred in March and April of 2022:

- **March 9, 2022:** At 18:03:20 Pacific time, a generator bus was faulted when a generator circuit breaker had an internal failure at a natural-gas-fired, simple-cycle facility in Riverside County, California, causing a C-phase-to-ground fault on the 220 kV system. Generator units relayed, disconnecting the natural gas generators that were carrying 694 MW. The fault was cleared in approximately 4.5 cycles. In addition, inverter-based resources from many different facilities also unexpectedly reduced 408 MW, 124 MW of which is attributed to BESS. The fault therefore resulted in a total loss of 1,102 MW of generation, and system frequency dropped to 59.916 Hz. CAISO, the Balancing Authority, raised regulating unit output to assist in the recovery of the frequency and ACE. The time from the event start to the frequency nadir was measured at around 12 seconds. System frequency returned to normal in three minutes.

- **April 6, 2022:** At 15:06:05 Pacific time, a B-phase-to-ground fault occurred on a 220 kV bus at a new BESS plant that was undergoing testing. The fault was cleared in approximately four cycles. The normally cleared fault resulted in an unexpected reduction of 498 MW from multiple inverter-based resources. The loss of generation caused the system frequency to fall from around 60.014 Hz to 59.924 Hz. The time from the event start to the frequency nadir was around seven seconds. The CAISO Balancing Authority raised regulating unit output to assist in recovery of the frequency and ACE. System frequency returned to normal in one and half minutes.

In both events, the faults occurred in the Southern California area within the CAISO footprint. Multiple BESS and solar PV facilities were identified as exhibiting unreliable performance. All affected facilities are within or near the Southern California area (see **Figure 1.1** and **Figure 1.2)**.

Figure 1.3 and **Figure 1.4** show the reduction in solar PV and BESS resources reported by Southern California Edison (SCE) Operations for each disturbance. **Figure 1.5** shows the Western Interconnection frequency from PMU data at nearby 500 kV substation for both disturbances.

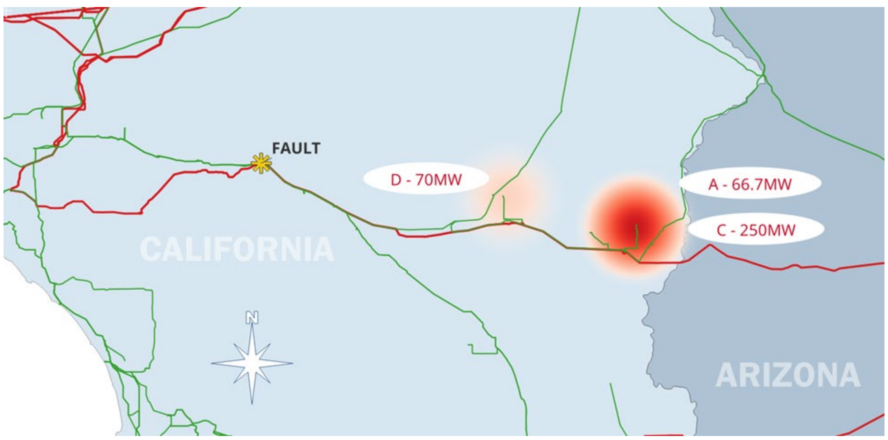


Figure 1.1: Map of the Fault Location and Affected IBR Facilities—March 9, 2022

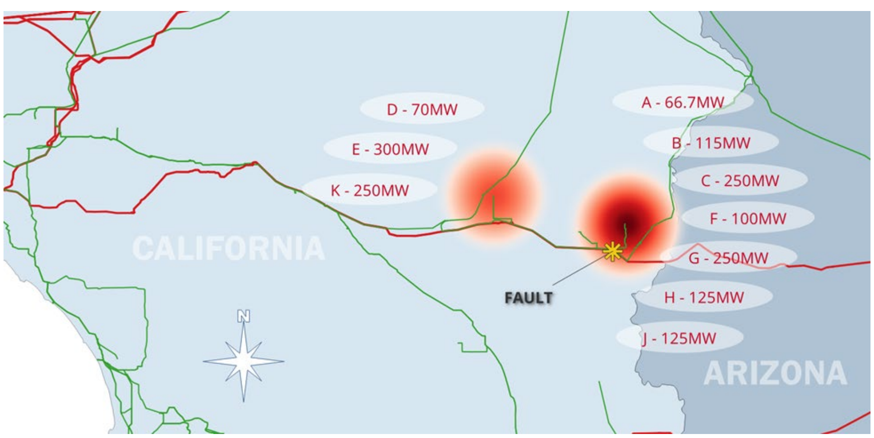


Figure 1.2: Map of the Fault Location and Affected IBR Facilities—April 6, 2022

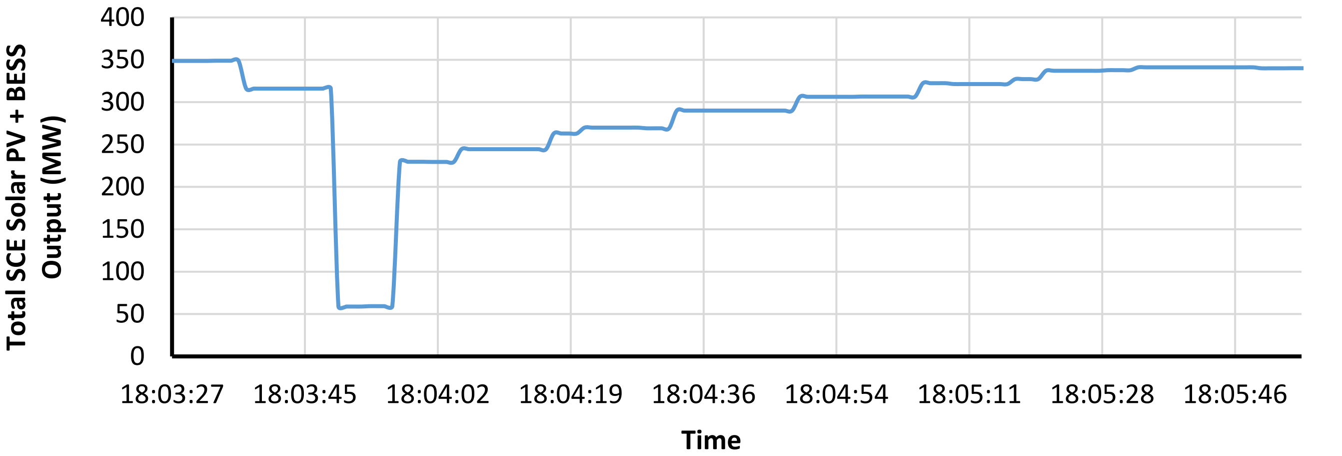


Figure 1.3: SCE BPS-Connected Solar PV + BESS during March 9 Disturbance [Source: SCE]

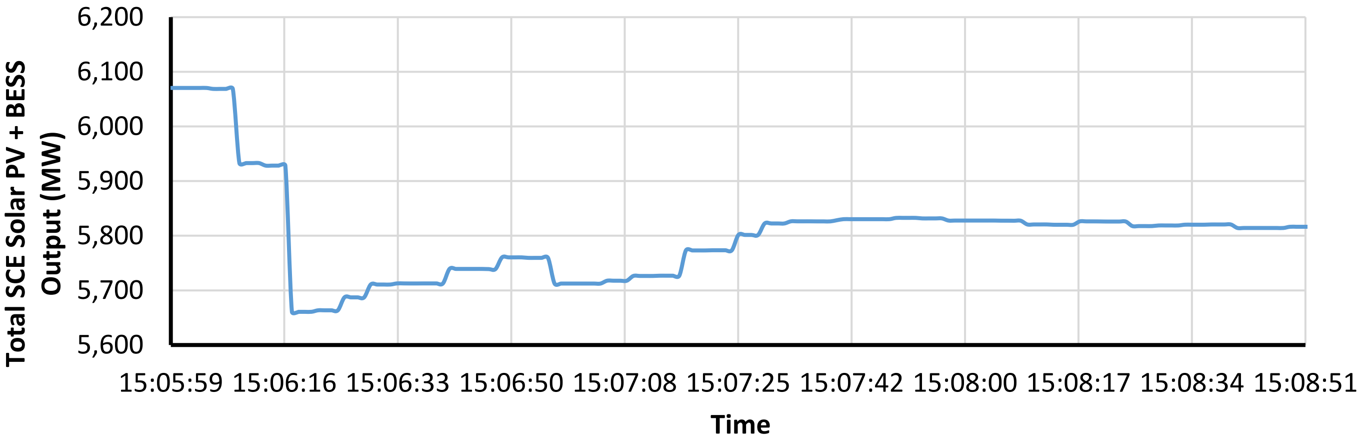


Figure 1.4: SCE BPS-Connected Solar PV + BESS during Disturbance on April 6 [Source: SCE]

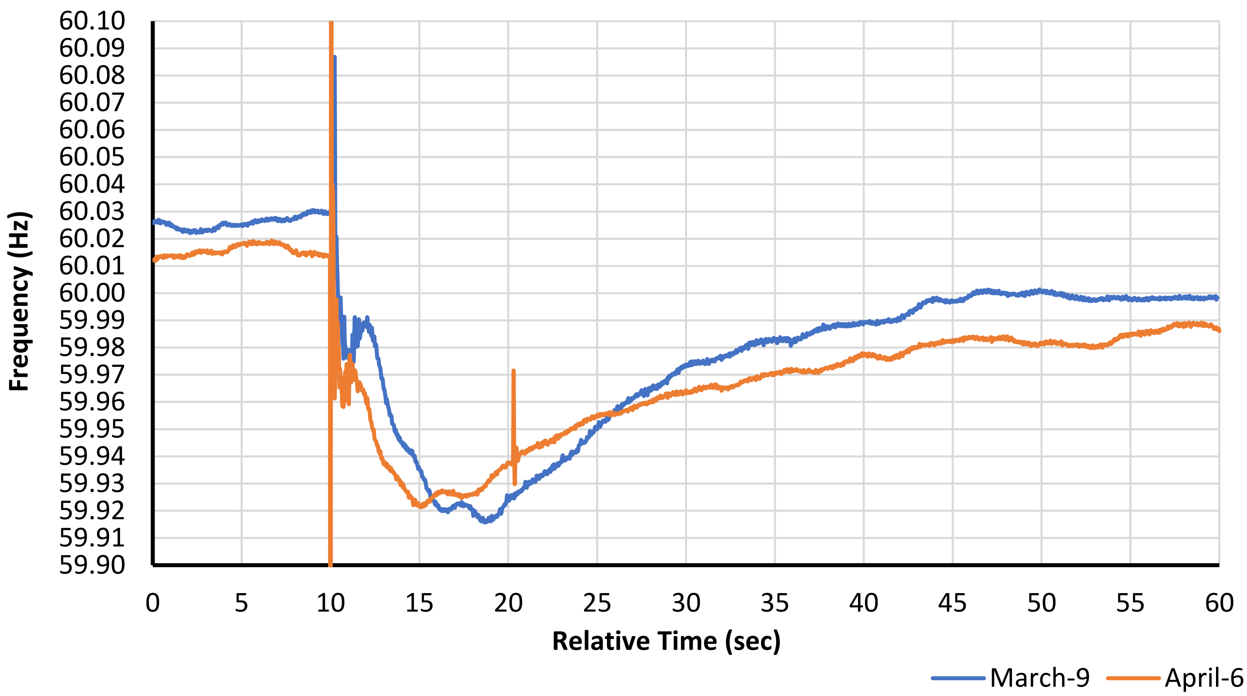


Figure 1.5: WECC System Frequency for Each Disturbance [CAISO]

Chapter 2: Detailed Findings from Disturbance Analysis

This chapter describes the key findings from this analysis, including corrective actions taken by CAISO and GOs. Refer to **Appendix A** for details regarding each affected facility.

Causes of BESS Abnormal Power Reduction

The causes of abnormal active power reduction for each BESS or hybrid facility are listed in **Table 2.1.** The facilities saw multiple inverters trip due to multiple causes, making it difficult to break down active power reductions by fault codes.

<table>
<tr><th colspan="9">Table 2.1: Causes of BESS Abnormal Power Reduction</th></tr>
<tr><th>Cause of Reduction</th><th colspan="2">Plant A</th><th colspan="2">Plant B</th><th colspan="2">Plant C</th><th colspan="2">Plant D</th></tr>
<tr><td>Original Equipment Manufacturer</td><td colspan="2">Power Electronics</td><td colspan="2">Power Electronics</td><td colspan="2">Power Electronics</td><td colspan="2">Power Electronics</td></tr>
<tr><td></td><td>March</td><td>April</td><td>March</td><td>April</td><td>March</td><td>April</td><td>March</td><td>April</td></tr>
<tr><td>Total MW Reduction</td><td>20</td><td>N/A*</td><td rowspan="8">Not Involved</td><td>26</td><td>73</td><td rowspan="8">Inconclusive due to poor metering data to support GOs claims</td><td>30</td><td>N/A*</td></tr>
<tr><td>AC Overcurrent</td><td>X</td><td>X</td><td></td><td>X</td><td></td><td></td></tr>
<tr><td>AC Overvoltage</td><td></td><td>X</td><td></td><td></td><td></td><td></td></tr>
<tr><td>DC Bus Voltage Unbalance</td><td></td><td>X</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Unbalanced AC Current</td><td>X</td><td>X</td><td>X</td><td>X</td><td></td><td></td></tr>
<tr><td>DC Overvoltage</td><td></td><td>X</td><td></td><td></td><td>X</td><td></td></tr>
<tr><td>Half Bus DC Vmax</td><td></td><td>X</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Unknown/Misc.</td><td></td><td></td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
</table>

* Not available due to data quality and availability issues detailed in **Appendix A**.

Previously Reported Causes of Tripping

Most affected facilities experienced the following causes of inverter tripping that have already been extensively covered in previous disturbance reports. Therefore, technical details regarding them are omitted in this report:

- Inverter instantaneous ac overcurrent
- Inverter instantaneous ac overvoltage tripping
- Inverter dc voltage unbalance tripping

Other causes of tripping not identified in previous disturbance reports are detailed in the following sections.

Inverter Unbalanced AC Current Tripping

This is the most common cause of tripping observed in both disturbances. The inverter module can trip when an unbalance has been detected in the module output currents that are above a programmed threshold and remains for longer than a programmed time delay.

All GOs should check with their inverter manufacturer to ensure that their inverters are not prone to unexpected unbalanced ac current tripping during normally cleared unbalanced grid faults.

Inverter DC Bus Overvoltage

Inverter dc bus overvoltage tripping was observed in two facilities: one while discharging and another while charging. All GOs should check with their inverter manufacturer to ensure that their inverters are not prone to unexpected dc bus overvoltage tripping during normally cleared unbalanced grid faults.

Inverter Half DC Bus Overvoltage

This protection is triggered when an inverter module continues to experience unstable dc bus voltage despite being stopped on dc bus overvoltage fault. All GOs should check with their inverter manufacturer to ensure that their inverters are not prone to tripping on unstable dc bus voltage during normally cleared unbalanced grid faults.

Data Quality

None of the facilities involved met CAISO's requirement of 10 ms data recording resolution. No inverter-level oscillography data was available from any of the facilities involved because they did not have the required fast logging enabled. CAISO reported that these deficiencies have been corrected.

Miscoding Inverter Faults

While one facility had legacy inverters that utilize momentary cessation, GOs of other affected facilities have mis-coded inverter tripping lasting tens of seconds as momentary cessation. Momentary cessation is a controlled behavior during certain grid conditions and is vastly different from an inverter tripping inadvertently and reconnecting after a short time.

One facility only reported high level inverter fault codes, which do not provide any useful insights. The inverters involved in these events are made up of multiple modules, and inverters can experience loss of all or some of the modules (partial trip). The actual trip mechanism, as part of self-protection design, occurs within the modules and thus the module fault codes are more meaningful. NERC recommends all GOs log and report module fault codes.

Mitigations through CAISO Enforcement of Interconnection Agreement

Based on the findings from the two BESS events, CAISO identified that the affected facilities did not meet the performance-related requirements of the Generator Interconnection Agreement (GIA).[8] Subsequently, CAISO issued notice of breach letters to affected GOs advising that the terms and conditions of Appendix H of the LGIA are not being met by their facilities. The notice highlighted the provisions related to the voltage ride-through and minimum transient data recording requirements. The letter required GOs of affected BESS facilities to develop and implement mitigation plans to eliminate the unexpected causes of tripping and make changes to recording capabilities to meet the interconnection agreement requirements. The following summarizes the corrective actions taken by CAISO and GOs:

- CAISO reported that all but one facility has been enhanced with inverter software upgrades. The software upgrades increased the threshold for dc bus unbalance tripping and implemented faster activation of stronger dc balancing and faster activation of low voltage ride-through mode. CAISO reviewed evidence of the effectiveness of the mitigation plans provided by the GOs working with the inverter manufacturer. Evidence includes the lab test results from the inverter manufacturer that showed the performance of the inverter before and after the software upgrade.
- These enhanced facilities performed better during an event in February 2023 that involved an unbalanced grid fault. This suggests some evidence of the efficacy of the changes implemented post 2022 events.
- CAISO updated technical requirements of their *pro forma* LGIA, requiring the plant controller to be coordinated with the inverters so that the plant controller will not restrict inverter reconnection following the clearance of a low voltage transient.

[8] https://www.caiso.com/planning/Pages/GeneratorInterconnection/InterconnectionAgreement/Default.aspx

Appendix A: Detailed Review of Affected BESS Facilities Tripping

This appendix describes the causes of abnormal performance at each affected BESS facility that reduced power output unexpectedly during the Cat 1a and 1i disturbances in 2022.

Table A.1 provides an overview of the BESS facilities involved in the March event followed by additional details for each specific facility.

Table A.1: Review of BESS Facilities Involved in 3-9-2022 Event

Facility ID	Capacity [MW]	Reduction [MW]	POI Voltage [kV]	In-Service Date	Cause of Reduction
Plant A	66.7	20	230	June 2021	Inverter ac overcurrent tripping; unbalanced ac current tripping.
Plant C	250	73	230	June 2021	Inverter ac overcurrent tripping; unbalanced ac current tripping.
Plant D	70 (35 MW BESS)	31	230	June 2021	DC bus voltage overvoltage; unknown for some.
TOTAL		**124**			

Plant A

Plant A is a 66 MW facility connected to the 230 kV network that went into commercial operation in June 2021. The plant reduced output from 57 MW to 37 MW during the event (see Figure A.1). The plant consists of a total of 29 inverters; 15 inverters experienced instantaneous ac overcurrent tripping, and 12 inverters experienced unbalanced ac current tripping.

To mitigate these issues, the GO worked with the inverter original equipment manufacturer to perform software and configuration updates not only at this facility but proactively at other facilities that use the same inverter make and model.

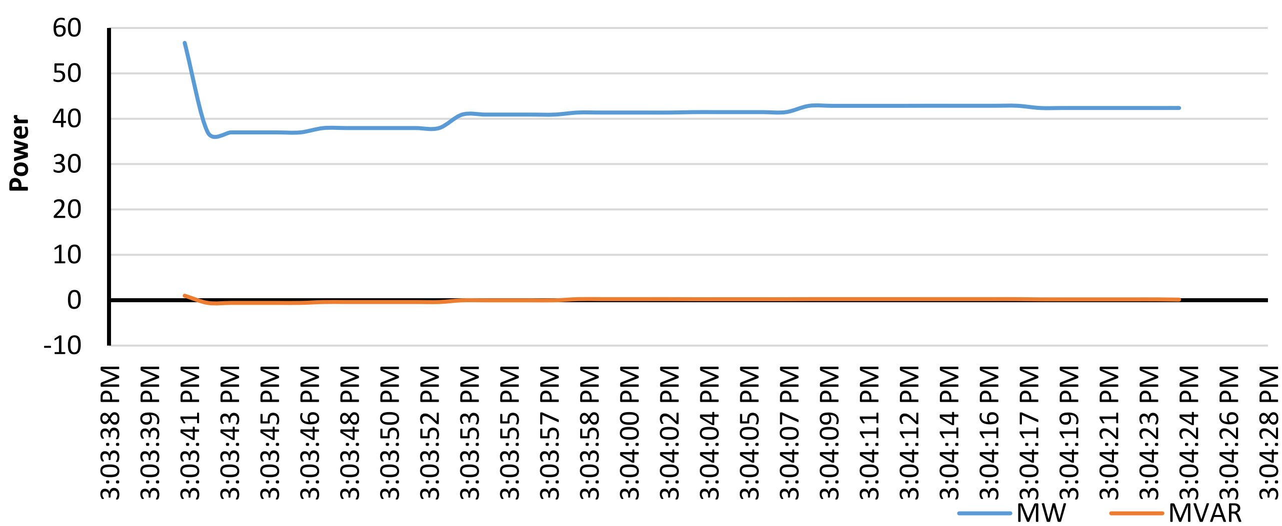


Figure A.1: Plant A Active and Reactive Power at POI on March 9

Plant C

Plant C is a 250 MW facility connected to the 230 kV network that went into commercial operation in June 2021. The plant reduced output by 73 MW during the event (see **Figure A.2**). The plant consists of a total of 88 inverters. Of these, 27 inverters experienced instantaneous ac overcurrent tripping, and 35 inverters experienced unbalanced ac current tripping. GO was unable to provide any useful information regarding the cause of tripping from 12 additional inverters that reduced power.

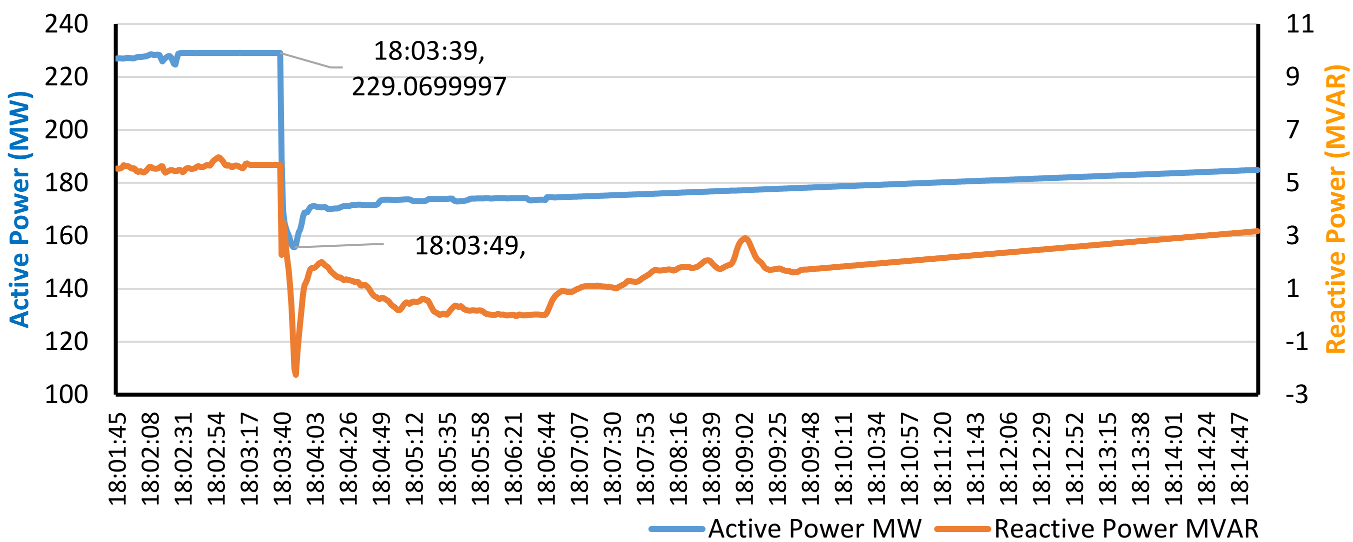


Figure A.2: Plant C Active and Reactive Power at POI on March 9

Plant D

Plant D is a 70 MW hybrid PV + BESS facility connected to the 230 kV network. It went into commercial operation in June 2021. The plant consists of 13 BESS inverters that are rated for 35 MW total. The plant reduced output from 30.7 MW to 0 MW during the event (see **Figure A.3**). Inverter logs show 12 inverters tripped and 1 inverter was already off-line before the event. Two inverters tripped on high dc voltage protection four seconds before another 11 inverters tripped for an unknown reason as their fault code merely indicated that all internal modules were off-line. The plant partially recovered after 48 minutes.

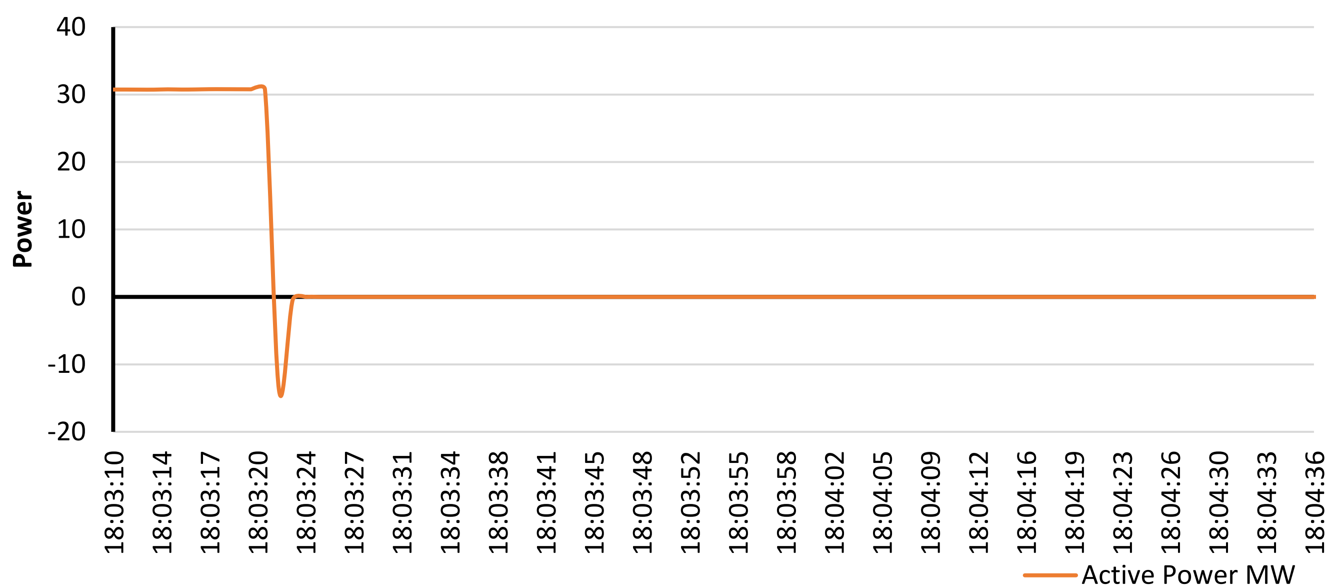


Figure A.3: Plant D Active Power at POI on March 9

Table A.2 provides an overview of the BESS facilities involved in the April event followed by additional details for each specific facility. Unlike the March event, this disturbance occurred during solar production, so the power output reduction can be attributed to unexpected inverter tripping in both the solar PV plants and BESS. The facilities involved in the March event also participated in the April event.

Table A.2: Review of BESS Facilities involved in 4-6-2022 Event					
Facility ID	**Capacity [MW]**	**Reduction [MW]**	**POI Voltage [kV]**	**In-Service Date**	**Cause of Reduction**
Plant A	66.7	Inconclusive	230	June 2021	Inverter ac overcurrent tripping; unbalanced ac current tripping; dc bus unbalance; half bus dc voltage max; dc bus overvoltage; high ac voltage
Plant B	115	26	230	April 2021	Unbalanced ac current tripping; Unknown for some
Plant C	250	Inconclusive	230	June 2021	Unknown
Plant D	70	Inconclusive	230	June 2021	Unknown

Plant A

The facility metering failed a few minutes before the event, so the data from the GO was inconclusive. CAISO data aggregates output from these facilities with several others, so the total facility output power reduction due to BESS inverter tripping could not be determined. However, inverter logs show that 14 out of 29 inverters tripped from a variety of different inverter protections: dc inverter ac overcurrent, unbalanced ac current, dc bus unbalance, half bus dc voltage max, dc bus overvoltage, and high ac voltage. All but one inverter remained off-line for an extended period of time.

The GO identified and implemented a process for collecting data from a secondary source as a mitigation for future events.

Plant B

Plant B is a 115 MW facility connected to the 230 kV network that went into commercial operation in April 2021. The plant output dropped by 26 MW during the event from the pre-disturbance level of 36 MW (see **Figure A.4**). The plant consists of a total of 45 inverters. GO reported that five inverters tripped (three tripped on unbalanced ac current protection; cause of trip unknown for the rest). However, the loss of five inverters does not add up to the total 26 MW lost, suggesting that there is a data quality issue.

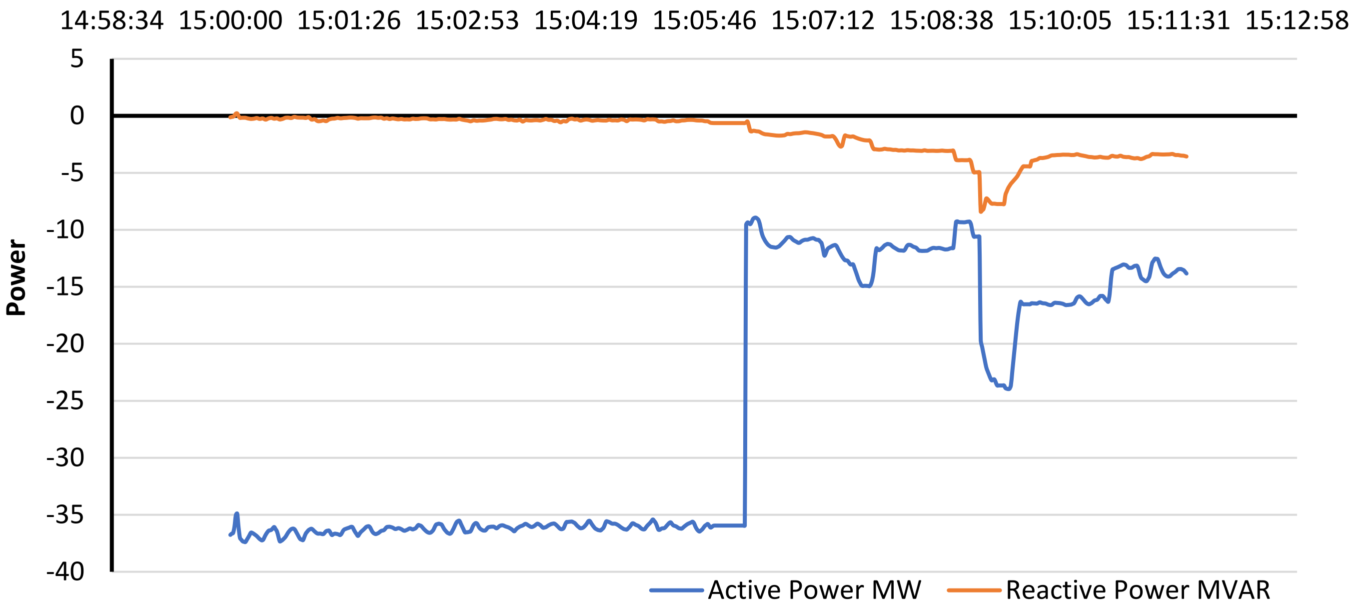


Figure A.4: Plant B Active and Reactive Power at POI on April 6

Plant C

The GO reported there was no inverter fault and attributed the abnormal power response to the facility charging at a lower power level than the set point to manage the battery nearing its full state of charge. However, data from GO (**Figure A.5**) indicated that the facility metering was interrupted right around the disturbance due to the log recording the same value for a few seconds. When the recording resumed, the plant charging power level dropped, and the reactive power consumption increased simultaneously, suggesting that a few inverters were lost. The results are inconclusive.

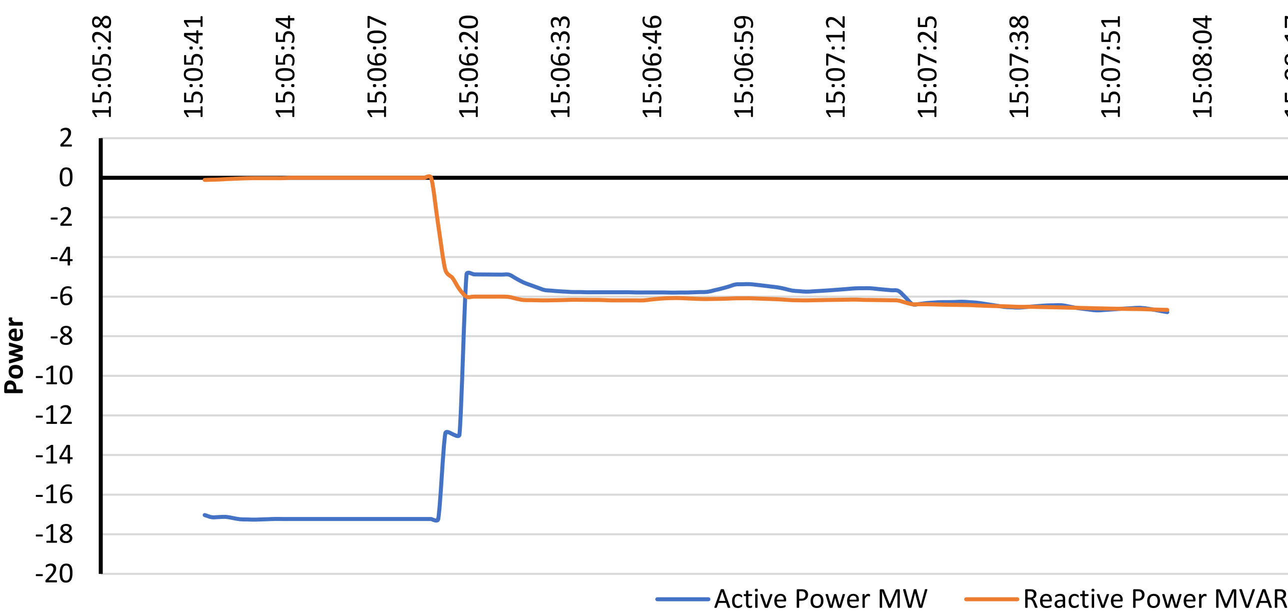


Figure A.5: Plant C Active and Reactive Power at POI on April 6

Plant D

This facility is part of a multi-phase project. Since CAISO's data is an aggregate for multiple phases, metering data for the individual facility was not available. Therefore, no power output plot can be produced. However, the GO-supplied logs indicate that 9 out of 13 inverters faulted for unknown reasons

Appendix B: Details on Non-BESS Generator Tripping

This section briefly describes the power reduction observed in facilities that are not BESS during the same events described above.

Synchronous Generation

On March 9, a generator breaker failed at a natural-gas-fired facility in Riverside County, causing a phase to ground fault on the generator 220 kV bus. Consequentially, the generator units relayed as expected, causing a loss of 694 MW. The fault was cleared in approximately 4.5 cycles.

On April 6, a steam unit and a natural gas unit tripped, causing a loss of 123 MW and 167 MW, respectively. The cause of the natural gas unit tripping was attributed to a transformer bank differential protection scheme current transformer being left shorted during past scheduled work.

The issue was corrected on April 11, 2022.

Solar PV Facilities

On March 9, since the event was after sunset, the solar PV facilities were not producing power. The following solar PV facilities experienced unexpected power reductions during the April 06 event.

Plant E is a 300 MW facility connected to the 230 kV network that went into commercial operation in 2014. The plant experienced a 104 MW power reduction due to momentary cessation. It is an older facility where momentary cessation could not be disabled. Its power recovery has improved since the last event it was involved in. One inverter tripped on dc overcurrent. See **Figure B.1**.

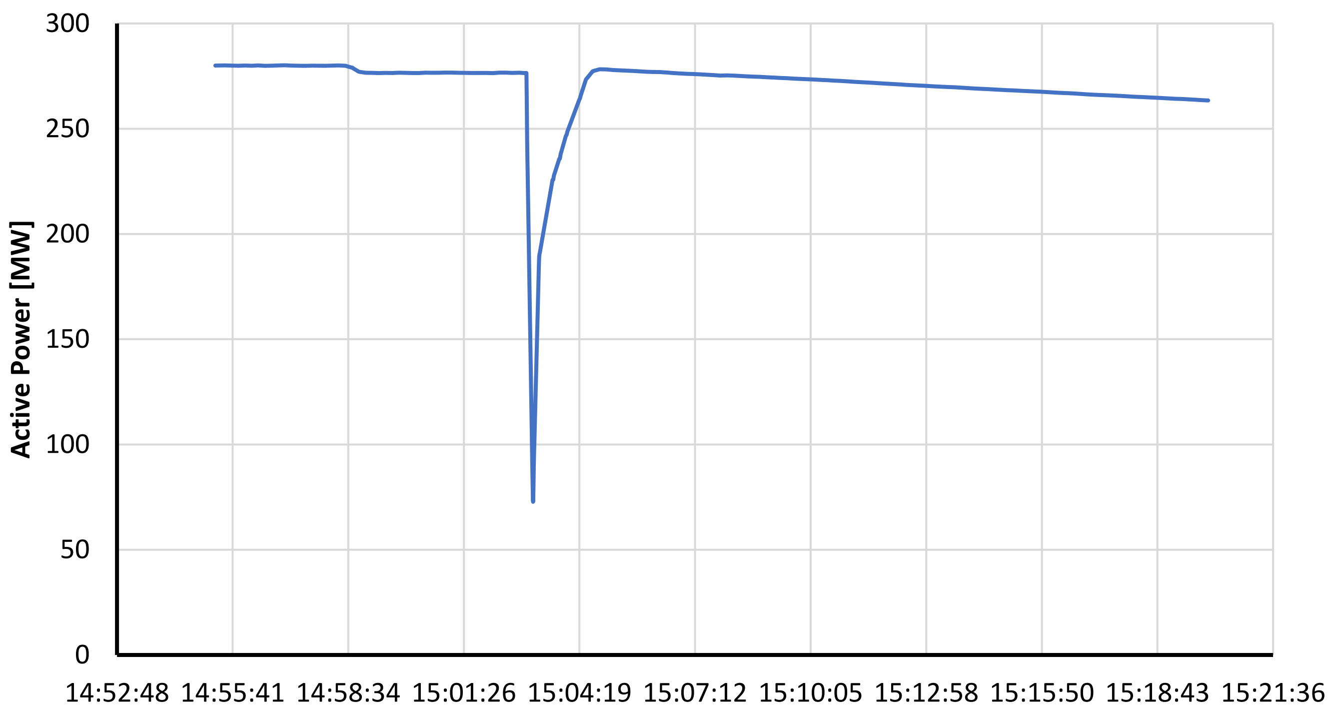


Figure B.1: Plant E Active Power at POI on April 6

Plant F is a 100 MW facility connected to the 230 kV network that went into commercial operation in 2022. During the event, the plant output dropped from 78 MW to 0 due to 26 inverters tripping on ac overcurrent. See **Figure B.2**.

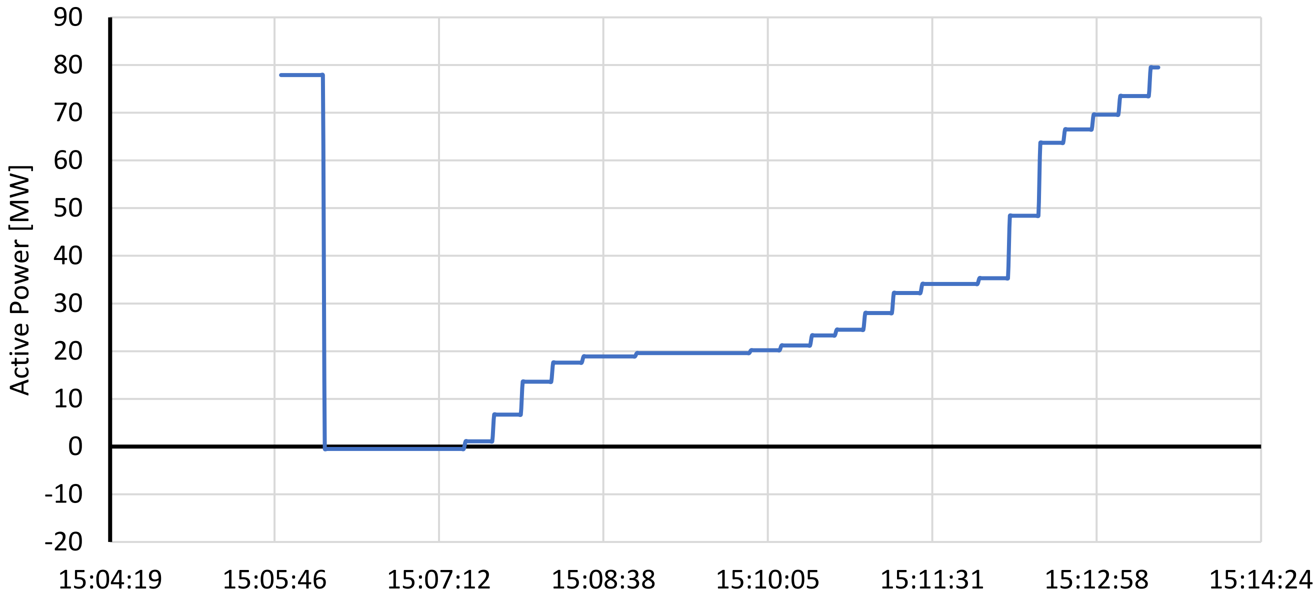


Figure B.2: Plant F Active Power at POI on April 6

Plant G is a 250 MW facility connected to the 230kV network that went into commercial operation in 2016. During the event, the plant output dropped from 239 MW to 60 MW due to 192 inverters tripping on low line-to-line voltage and 2 inverters of a different manufacturer tripping for unknown reasons as the inverters did not record fault codes. A few months prior to the event, the inverter trip settings had been revised from being set directly on PRC-024 no-trip boundaries, but the inverter still tripped. See **Figure B.3**.

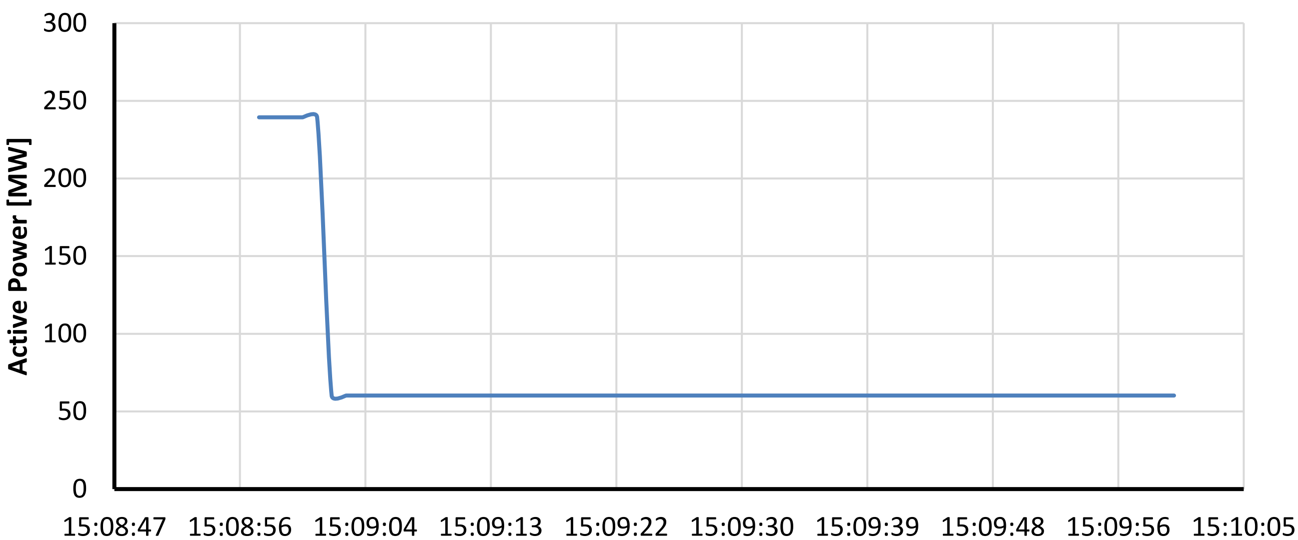


Figure B.3: Plant G Active Power at POI on April 6

Plant H is a 125 MW facility connected to the 230 kV network that went into commercial operation in 2020. During the event, the plant output dropped from 123 MW to 43 MW due to 23 inverters tripping and 3 inverters experiencing partial loss of modules. The causes of tripping included high voltage ac, unbalanced dc bus, and ac overcurrent. See **Figure B.4**.

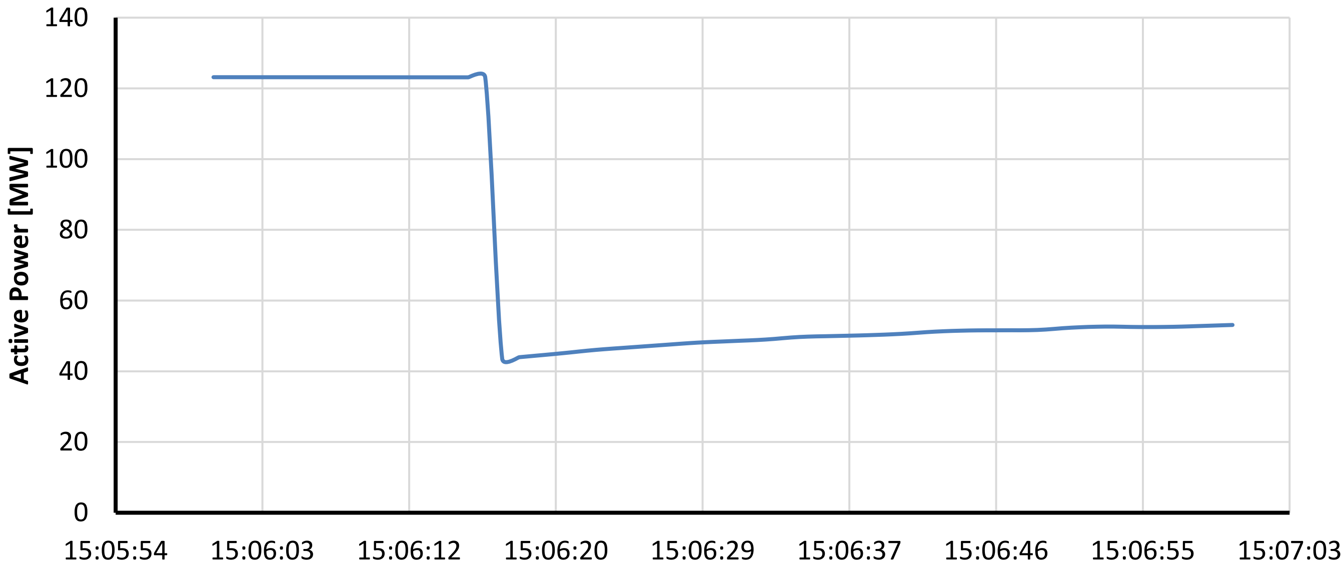


Figure B.4: Plant H Active Power at POI on April 6

Plant J is a 125 MW facility connected to the 230 kV network that went into commercial operation in 2020. During the event, the plant output dropped from 125 MW to 92 MW due to 26 inverters experiencing partial module loss and 1 inverter tripping completely. The causes of tripping included unbalanced dc bus and unknown. See **Figure B.5**.

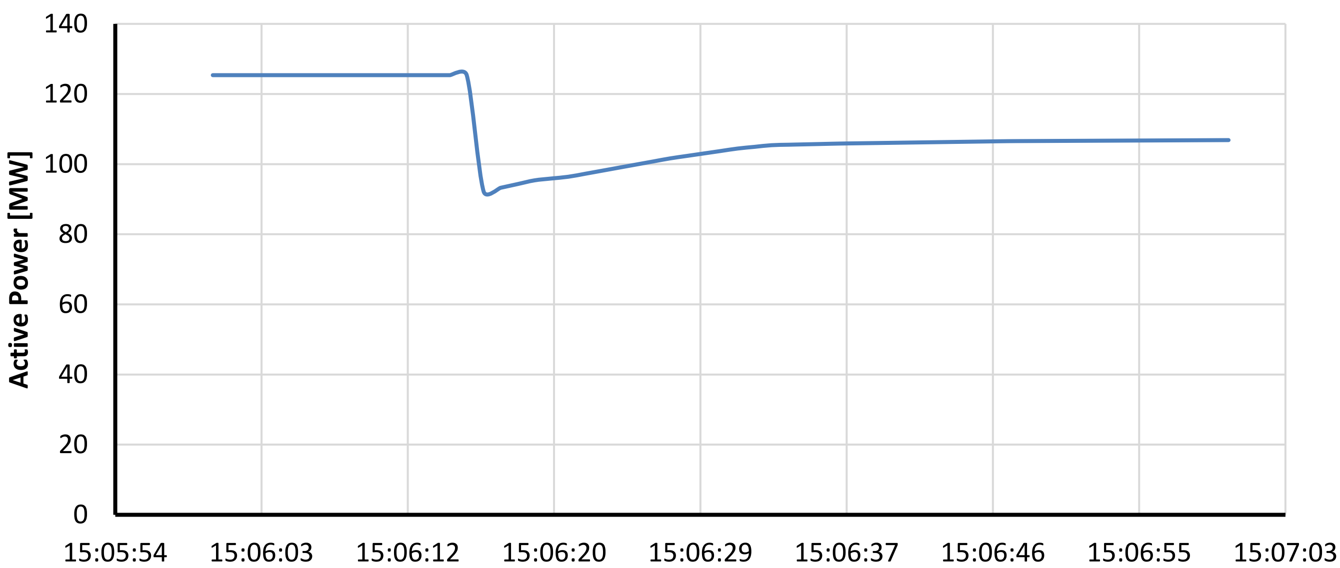


Figure B.5: Plant J Active Power at POI

Plant K is a 250 MW facility connected to the 230 kV network that went into commercial operation in 2014. During the event, the plant output dropped from 40 MW to 37 MW due to momentary cessation. No inverter tripping was reported. See **Figure B.6**.

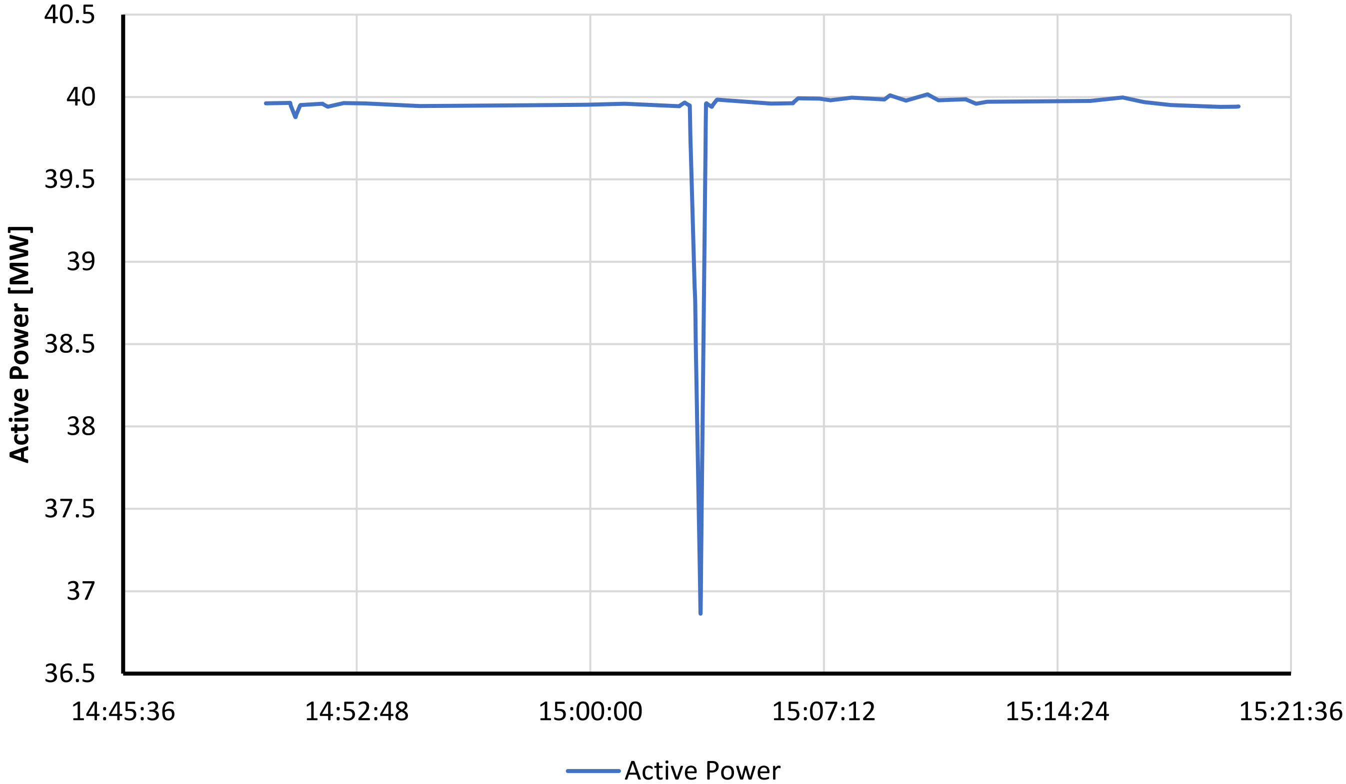


Figure B.6: Plant K Active Power at POI on April 6

Appendix C: List of Contributors

This disturbance report was published with the contributions of the following individuals. NERC gratefully acknowledges WECC, CAISO, and the affected GOs and GOPs. Coordination between all affected entities was crucial for the successful analysis of this disturbance and publication of this report. NERC would also like to acknowledge the continued engagement and support of the inverter manufacturers to ensure that the mitigating measures being developed are pragmatic and implemented in a timely manner. Lastly, members of the NERC IRPS continue to support NERC in its mission to ensure reliable operation of the BPS with rapidly increasing levels of inverter-based resources.

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