INTERCONNECTION INNOVATION e-XCHANGE
U.S. DEPARTMENT OF ENERGY

Forum for the Implementation of Reliability Standards for Transmission (i2X FIRST) | 9/24/24

An initiative spearheaded by the Solar Energy Technologies Office and the Wind Energy Technologies Office

BERKELEY LAB

EPRI

ESIG

The first half of this meeting call is being recorded and may be posted on DOE's website or used internally. If you do not wish to have your voice recorded, please do not speak during the call. If you do not wish to have your image recorded, please turn off your camera or participate by phone. If you speak during the call or use a video connection, you are presumed consent to recording and use of your voice or image.

Polling Question 1

What industry sector are you representing?

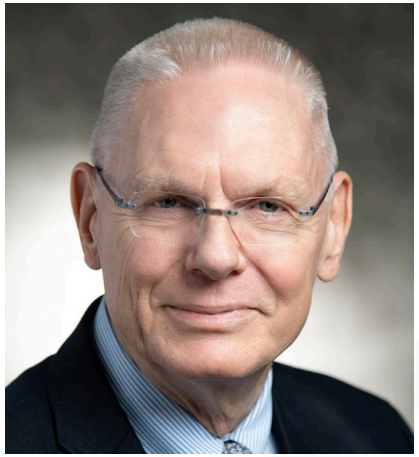
[Go to **slido.com** and enter event code **FIRST5**, then go to **Polls** tab]

Key Goals and Outcomes from i2X FIRST

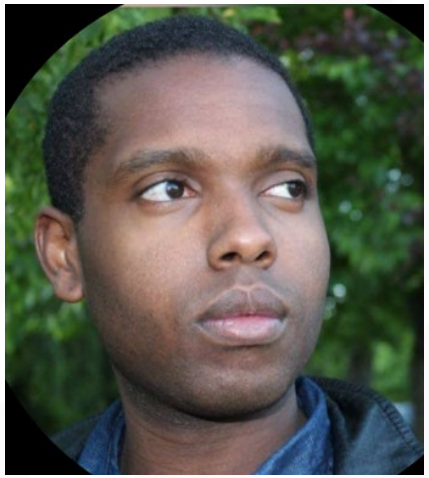
- To facilitate understanding and adoption of new and recently updated standards relevant for existing and newly interconnecting wind, solar and battery storage plants
- The Forum will convene the industry stakeholders to enable practical and more harmonized implementation of these interconnection standards.
- The presentation portion of the meeting will be recorded and posted, and presentation slides will be shared.
- Additionally, the leadership team will produce **a summary of each meeting** capturing:
  - Recommended best practices
  - Challenges
  - Gaps that require future work

Leadership Team

Cynthia Bothwell,
DOE's Wind Energy
Technologies Office



Robert Reedy
DOE's Solar Energy
Technologies Office



Dexter Hendricks
DOE's Solar Energy
Technologies Office

Jens Boemer, Electric
Power Research
Institute

Julia Matevosyan, Energy
Systems Integration Group

Ryan Quint, Elevate
Energy Consulting

Will Gorman, Lawrence
Berkley National Laboratory

Summary of the last meeting – Ride-Through Requirements, OEM Readiness

- IEEE 2800-2022, Clause 7, GE Vernova Perspective – Dustin Howard and Mariana Binda Pereira, GE Vernova
- NERC Milestone 2 Project Update – Jamie Calderon, NERC
- IEEE 2800-2022, Clause 7, Sungrow Perspective – Henry Aribisala, Sungrow
- Concept of "Maximizing" Ride-Through (20 min) – Ryan Quint, Elevate Energy Consulting
- Q&A and Interactive Group Discussion
  - Conformity of IBR plants with new Ride Through Requirements
  - Backward-Compatibility of IBR Plants with New Ride Through Requirements

Meeting summary, recording & presentations are posted here (click on Past Events at the bottom of the page)

Key Themes from the Last Meeting

- OEMs readiness for IEEE 2800-2022 requirements appears to be advancing significantly, although there are unique considerations for Type 3 wind turbines and newer technology like grid forming inverters.
- OEMs continue to prepare for widespread adoption and implementation of IEEE 2800-2022 across North America.
- OEMs are concerned with blanket application of IEEE 2800-2022 or other related standards (e.g., the draft NERC PRC-029) to existing assets. Reasonable exemptions based on technology limitations are required.
- A potential solution to this challenge is the concept of "IBR ride-through maximization," specifically focused on maximizing the ride-through performance of IBRs using software/firmware related updates. This may be a viable solution to minimize risk on the BPS while also avoiding costly retrofits.
- NERC standards developments related to FERC Order 901 continue to evolve, with some standards receiving successful ballot (e.g., PRC-028 and PRC-030) and other failing ballot, which invoked Section 321 of the NERC Rules of Procedures and led to an industry technical conference on IBR ride-through performance and issues with the draft PRC-029 standard.

Upcoming i2X FIRST Meetings

1. May 28th, 2024, 11 a.m.- 1 p.m. ET: Introduction of Evolving Standards Landscape
2. June 25th, 2024, 11 a.m.- 1 p.m. ET: IEEE2800 Ride Through Requirements
3. July 30th, 2024, 11 a.m.- 1 p.m. ET: IEEE2800 Ride Through Requirements, OEM Readiness
4. August 20th, 2024, 11 a.m.- 1 p.m. ET: IEEE2800 Ride Through Requirements, OEM Readiness, cont.
5. September 24th, 2024, 11 a.m.- 1 p.m. ET: Measurement Data for Performance Monitoring and Model Validation
6. October 24th, 2024 hybrid, full day, during ESIG Fall Workshop, Providence, RI: Conformity Assessment
7. November 26th, 2024, 11 a.m.- 1 p.m. ET:
8. December 17th, 2024, 11 a.m.- 1 p.m. ET:
9. January 28th 2025, 11 a.m.- 1 p.m. ET:
10. February 25th 2025
11. March 20th, 2025 hybrid full day event during ESIG Spring Workshop, Austin, Texas

Sign up for all future i2X FIRST Meetings here: https://www.zoomgov.com/meeting/register/vJItceuorTsiErIC-HInpPbWuTUtrYQAuoM#/registration

Follow DOE i2X FIRST website: https://www.energy.gov/eere/i2x/i2x-forum-implementation-reliability-standards-transmission-first for meeting materials & recordings and for future meeting details & agendas

i2X FIRST One-Day Workshop, Providence, RI | In-person and Online

- Interconnection Standards Workshop with the Focus on Conformity Assessment, **Thursday, October 24, 2024**
- The i2X FIRST workshop will cover **IBR plant design evaluation process, "as-built" evaluation and commissioning testing**, learning from the draft IEEE P2800.2.
- The agenda is available here
- **In-person** and **Free Online** participation options are available
- Held after the ESIG Fall Technical Workshop (10/21-10/23) in Providence, RI

Click Here for In-person i2X FIRST Workshop Registration

Click Here for FREE Online i2X FIRST Workshop Registration

Measurement Data for Performance Monitoring and Model Validation – Agenda

- I2x FIRST Intro (10 mins) – Will Gorman, LBNL
- NERC Technical Conference Update (15 mins) – Kyle Thomas, Elevate Energy Consulting
- Need for Disturbance Monitoring (15 mins) – Alex Shattuck, NERC
- IEEE 2800-2022 Clause 11 *Measurement data for performance monitoring and validation* and NERC PRC-028 *Reporting Requirements for Inverter-Based Resources* (20 mins) – Manish Patel, EPRI
- Q&A and Structured Discussion (40 mins) – led by Ryan Quint, Elevate Energy Consulting
  - Measurement and Monitoring Requirements
  - Differences between PRC-028 and IEEE 2800-2022, Clause 11

Virtual Meetings Code of Conduct

1. *Assume good faith and respect differences*
2. *Listen actively and respectfully*
3. *Use "Yes and" to build on others' ideas*
4. *Please self-edit and encourage others to speak up*
5. *Seek to learn from others*

Mutual Respect . Collaboration . Openness

Stakeholder Presentations

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Mutual Respect . Collaboration . Openness

Q & A Session

Interactive Group Discussion Topics

Topic #1: New Measurement and Monitoring Requirements

- Please go to slido to make comments and add questions of your own: **slido.com** and enter event code **FIRST5**
- For verbal commentary, please use the raise hand feature and we will call on you
- Additional related / associated questions:
  - What do you see as a main benefit of new measurement and monitoring requirements
  - What do you see as a main challenge with new measurement and monitoring requirements
  - Do you see a need to place monitoring equipment in multiple locations within an IBR plant, what should these locations be

Topic #2: Differences between PRC-028 and IEEE 2800-2022, Clause 11

- Please go to slido to make comments and add questions of your own: **slido.com** and enter event code **FIRST5**
- For verbal commentary, please use the raise hand feature and we will call on you
- Additional related / associated questions:
  - Do you see need in alignment between PRC-028 and IEEE 2800-2022?
  - Do you see need for capturing event data with higher resolution?
  - Do you see any issues with PRC-028 implementation timelines?

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NERC PRC-029 Technical Conference Update

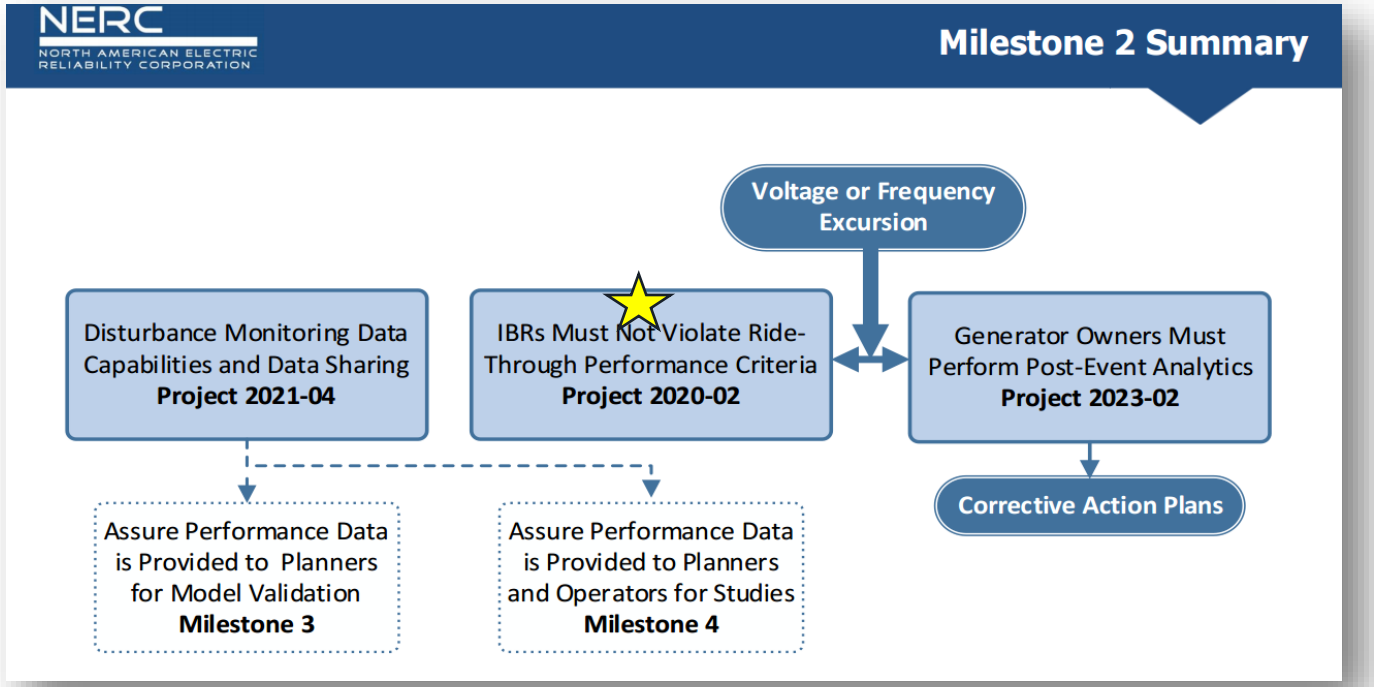
i2x Forum for the Implementation of Reliability Standards for Transmission (i2x FIRST)

Kyle Thomas, PE
VP of Engineering & Compliance Services

September 24, 2024

Background of the NERC PRC-029 Standard

- New Standard: PRC-029-1 – Frequency and Voltage Ride-through Requirements for Inverter-Based Resources (IBRs)
- Establishes capability-based ride-through criteria
- Establishes performance-based ride-through criteria
- Must be filed with FERC by November 4, 2024 for the FERC Order 901 deadline



NERC Standards Committee & NERC PRC-029 Webinar 9/19/2024

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History of the NERC PRC-029 Standard

- 1st draft: comment period and initial ballot from 3/27/2024 – 4/27/2024
  - ~200 pages of comments received, failed initial ballot
- 2nd draft: comment period and second ballot from 6/18/2024 – 7/8/2024
  - Failed second ballot
- 3rd draft: comment period and third ballot from 7/22/2024 – 8/12/2024
  - Failed third ballot
- 8/15/2024 – NERC Board of Trustees invoked Rule 321, leading to the Ride-Through Technical Conference on September 4-5, 2024

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NERC PRC-029 Technical Conference Presentations

Standards Committee & NERC Ride-through Technical Conference: Overview

- In-person in Washington DC, plus virtual attendance options
- Participation from utilities, developers, regulators, and IBR OEMs
- Agenda included presentations and panel sessions on:
  - Review of Voltage & Frequency Ride-through Criteria in draft PRC-029-1
  - OEM Perspectives on Voltage & Frequency Ride-through Criteria
  - Discussions on Frequency Ride-through Exemptions in PRC-029-1
  - Objectives of a Ride-through definition
  - Review of Milestone 2 implementation plans
  - Gathering stakeholder feedback through live online polling for all conference attendees (in-person and virtual)

NERC Technical Conference Materials:

Agenda, Panelist Bios, Presentations
Day 1 Recording | Transcript
Day 2 Recording | Transcript

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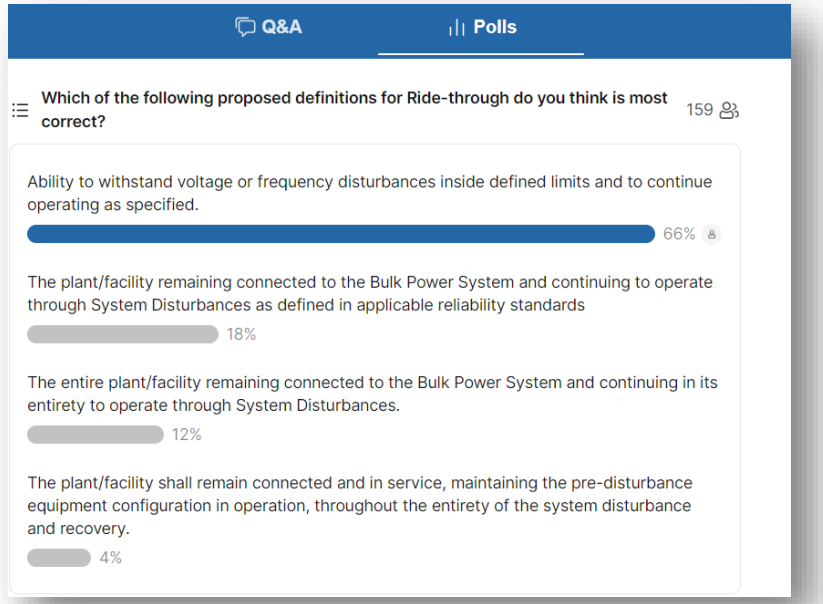
Standards Committee & NERC Ride-through Technical Conference: Key Takeaways

- A lot of discussions centered around the Frequency Ride-through criteria and the lack of Frequency Ride-through hardware exemptions for legacy IBRs in draft 3 of PRC-029-1
- Industry polling was valuable to get real time feedback from the industry attendees
- Incredibly helpful having everyone – utilities, developers, OEMs, regulators – in the room together working on these technical challenges
- Real-world feedback on IBR equipment and legacy IBR facilities' capabilities from OEMs and IBR Developers was insightful, heard that this real-world information is very valuable information



Example of an industry live poll during the conference

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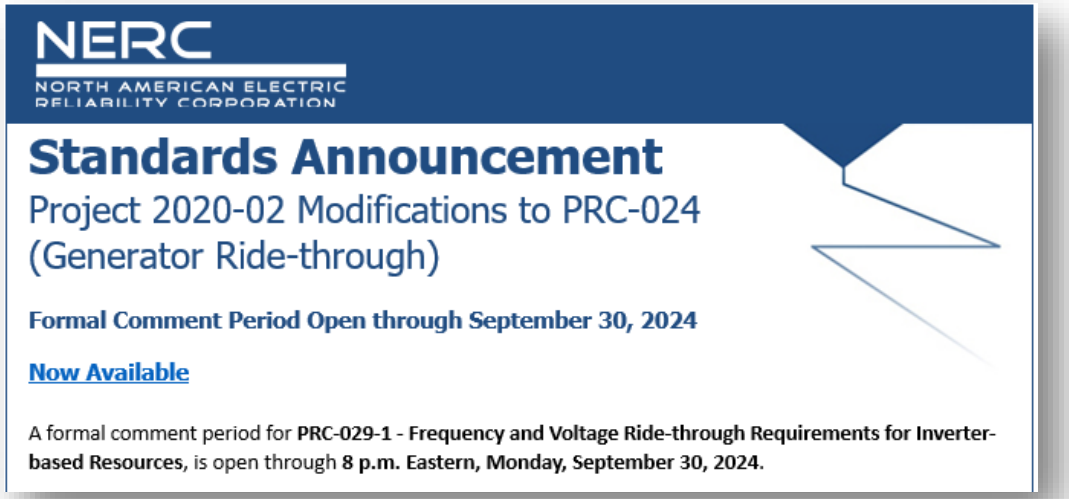
Standards Committee & NERC Ride-through Technical Conference: Next Steps

Draft 4 of PRC-029 released for comments on 9/17 (comments close on 9/30)

- Major updates in draft 4 of PRC-029-1:
  - Updated definition of Ride-through to remove ambiguity of words “entire” and “In its entirety”, and also added “voltage and frequency” words to system disturbances
  - Updated the Frequency Ride-through criteria to match the IEEE 2800-2022 Frequency Ride-through criteria
  - For legacy IBRs/equipment, added Frequency Ride-through exemptions if able to demonstrate hardware-based limitations
  - Updated hardware limitation evidence to include damage curves by OEMs
- Various minor grammar revisions

Next steps: Standards Committee & NERC drafting memo to NERC Board, and final industry ballot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Standards Announcement

Project 2020-02 Modifications to PRC-024 (Generator Ride-through)

Formal Comment Period Open through September 30, 2024

Now Available

A formal comment period for **PRC-029-1 - Frequency and Voltage Ride-through Requirements for Inverter-based Resources**, is open through **8 p.m. Eastern, Monday, September 30, 2024.**

NERC Project 2020-02 Website

References

- NERC Project 2020-02 Website
- NERC Technical Conference Materials:
  - Agenda, Panelist Bios, Presentations
  - Day 1 Recording | Transcript
  - Day 2 Recording | Transcript
- Draft 4 PRC-029-1 clean
- Draft 4 PRC-029-1 redline
- PRC-029-1 Implementation Plan
- Standard Authorization Request (SAR)

kyle.thomas@elevate.energy

Disturbance Monitoring Requirements in IEEE 2800-2022 and NERC Reliability Std PRC-028

i2X Forum for the Implementation of Reliability Standards for Transmission (i2X FIRST)

Manish Patel
ManPatel@epri.com

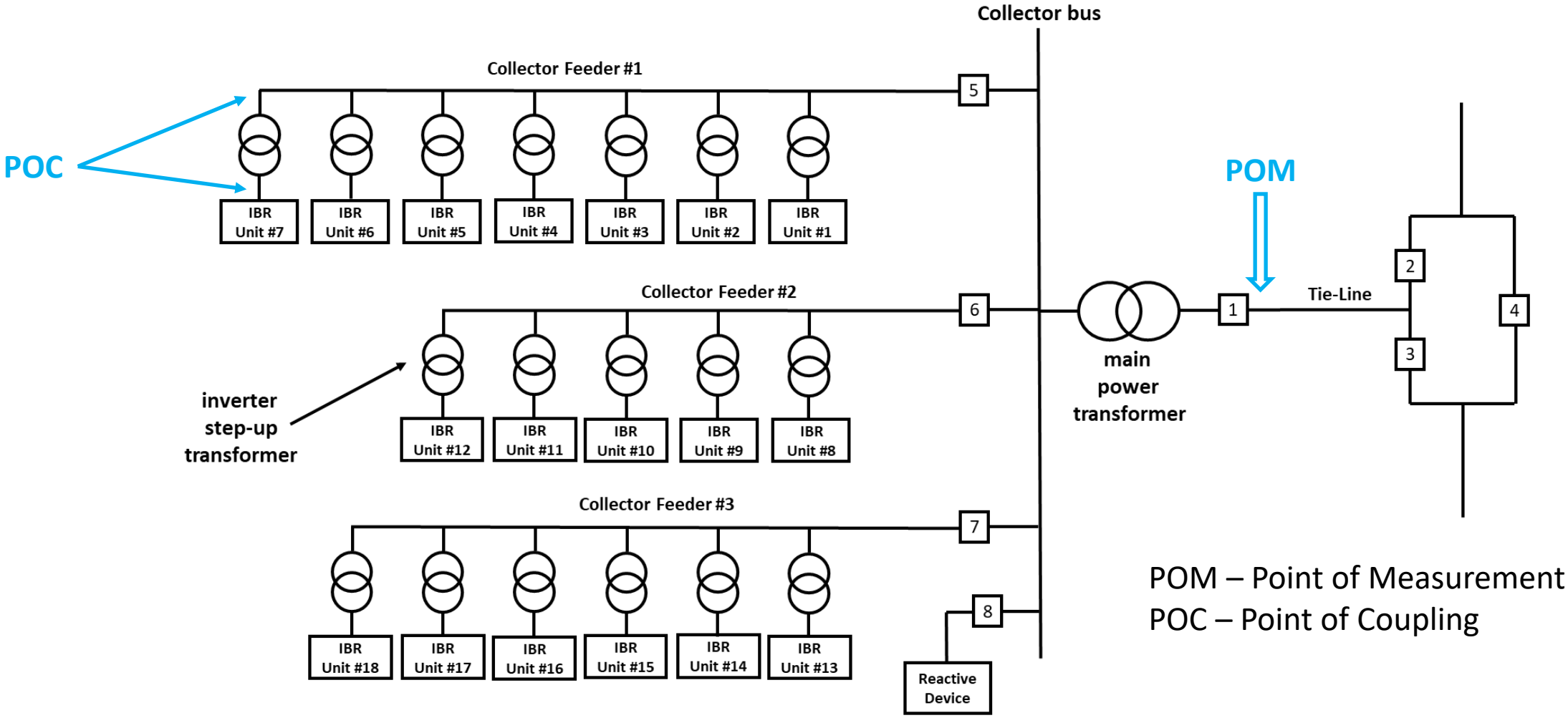
September 24, 2024

Classification: Public

IEEE 2800 versus PRC-028

	IEEE 2800-2022 Clause 11 (Measurement Data for Performance Monitoring and Validation)	PRC-028 Disturbance Monitoring and Reporting Requirements for IBRs	Comments
	Forward looking standard	Applicable to existing and new IBRs (BES and non-BES)	
SCADA Data	Yes	No	
Plant Level SER Data	Yes	Yes	Requirements in PRC-028 may be brief but serves purpose
Unit Level SER Data	Yes	Yes	
Plant Level DFR & DDR Data	Yes	Yes	
Unit Level DFR Data	Yes	No	In PRC-028, FR data from collector feeder breaker is required instead
Unit Level DDR Data	No	No	
Measurement Accuracy	Yes, except for unit level data	No	

Unit Level Versus Plant Level



POC (unit level monitoring) Versus POM (plant level monitoring)

IEEE 2800 versus PRC-028 SCADA Data

Provision data type	Measurement/data points (as applicable)	Recording rate	Retention	Duration	Measurement (as applicable)
Plant SCADA data (CSV file)	The plant SCADA system is often a lower resolution repository of information that, at minimum, shall include the following data points: Measurements — *Point of measurement* voltage and medium-voltage *collector system* voltages — *Point of measurement* frequency — *IBR plant* active and reactive power output — *IBR units* active and reactive power output of individual[147] — Shunt dynamic device reactive power output Signals — External control signals from the *TS operator* (BA, RTO, RC, etc.) — External automatic generation control signals — Active and reactive power commands sent to *IBR units*	One record per s	1 year	One year	Subclause 4.4, Table 1

Not included in PRC-028

IEEE 2800 versus PRC-028
Plant Equipment Status - Sequence of Event Recording Data

Provision data type	Measurement/data points (as applicable)	Recording rate	Retention	Duration	Measurement (as applicable)
Plant equipment status (tabular log file)	— All breaker statuses, including change of status log — Shunt (dynamic or static) reactive compensation device statuses — Substation transformer status (main step-up and *collector system*) — Status of on load tap changer — Medium-voltage *collector system* statuses — Status of individual *IBR units* — Time stamp — Time synchronization (e.g., GPS status word) or status of the GPS clock signal	Static, as changed	1 year **20 calendar days**	NA	Not applicable

PRC-028: Status of breakers associated with MPT, collector bus, reactive device(s), AC-DC & DC-AC converters in case of VSC-HVDC system with a dedicated connection to IBR, are included.

IEEE 2800 versus PRC-028
Digital Fault Recording Data

Provision data type	Measurement/data points (as applicable)	Recording rate	Retention	Duration	Measurement (as applicable)
Digital fault recording (DFR) data (COMTRADE format and tabular log file)	This data shall be captured for at least the plant-level (e.g., at the *point of measurement*) response to BPS events. It is typically high resolution (kHz) point-on-wave data (transient) and triggered based on configured settings. Data points shall include: — Time stamp — Phase-to-ground voltage for each phase — Bus frequency (as measured/calculated by the recording device) — Each phase current and residual or neutral current — Calculated active and reactive power output — If applicable, dynamic reactive device voltage, frequency, current, and power output — Applicable binary status	≥ 128 samples per cycle, triggered **≥ 64 samples per cycle, triggered**	90 days **20 calendar days**	5 s COMTRADE data, (split between pre-fault and post-fault data needs to be mutually agreed upon with the *TS owner/TS operator*) **2 second**	Subclause 4.4, Table 2

PRC-028 includes measurement/data points with noted differences

IEEE 2800 versus PRC-028
Dynamic Disturbance Recording Data

Provision data type	Measurement/data points (as applicable)	Recording rate	Retention	Duration	Measurement (as applicable)
Dynamic disturbance recorder (DDR) data (COMTRADE format and tabular log file)	A DDR shall capture the specified plant-level data continuously at the *point of measurement*. This data can be used for multiple purposes including event analysis and disturbance-based model verification. Data points shall include: — Time stamp — Bus voltage phasor (phase quantities and positive-sequence) — Bus frequency — Current phasor (phase quantities and positive-sequence) — Calculated active and reactive power output	Input: ≥ 960 samples per s output: ≥ 60 times (records) per s, continuous[149] **Same in PRC-028**	1 year **20 calendar days**	NA[149]	Subclause 4.4, Table 2

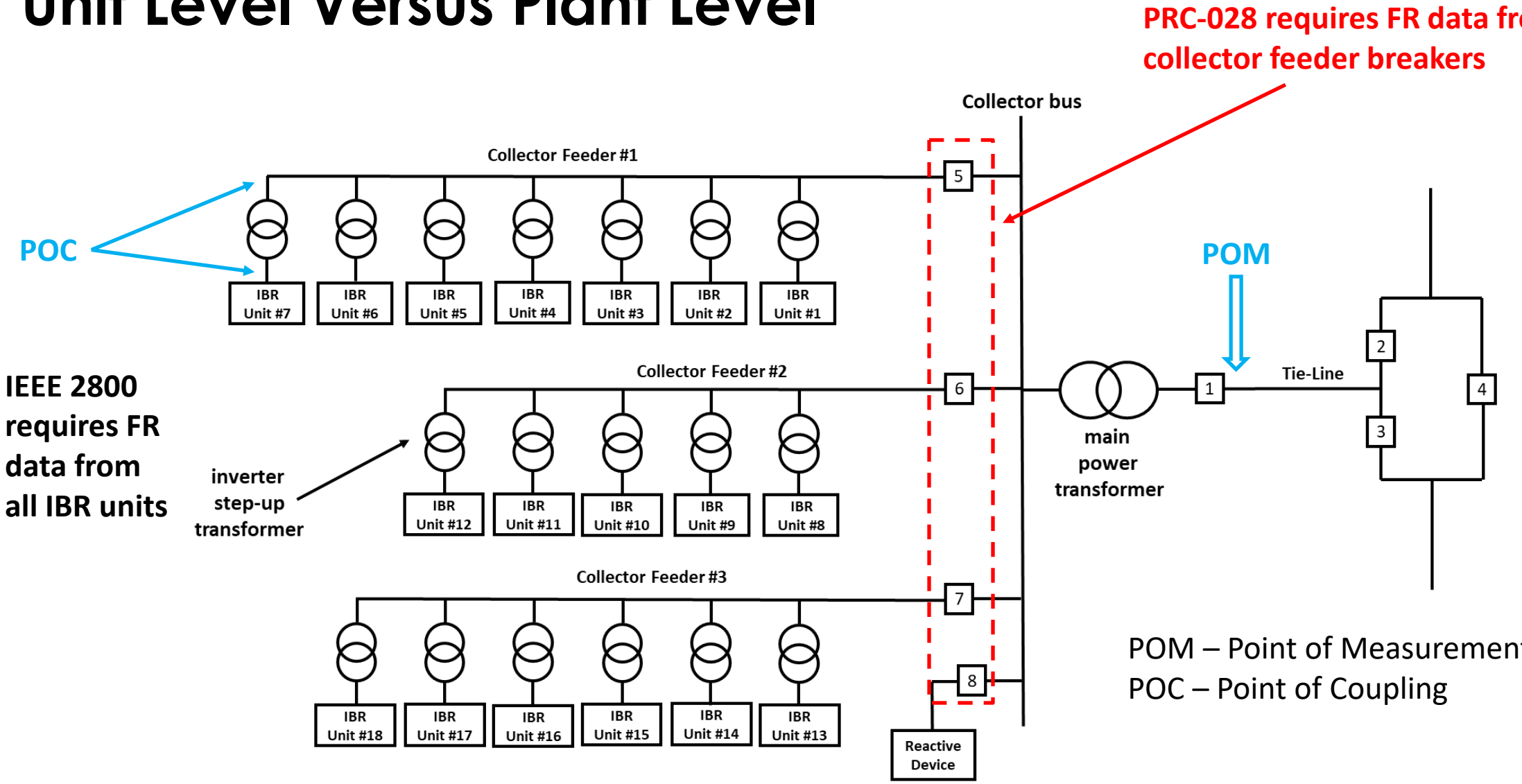
PRC-028 includes measurement/data points with noted differences

IEEE 2800 versus PRC-028
Inverter Fault Codes & Dynamic Recordings

Provision data type	Measurement/data points (as applicable)	Recording rate	Retention	Duration	Measurement (as applicable)
Inverter fault codes and dynamic recordings (CSV file and tabular log file)	For grid BPS faults/events which trigger ride-through operation of an *IBR unit* or cause it to trip, the following information shall be recorded at *IBR units* for analysis: — All major and minor fault codes — All fault and alarm status words — Change of operating mode — High- and low-voltage ride-through — High- and low-frequency ride-through — PLL loss of synchronism — DC current and voltage — AC phase currents and voltage — Pulse width modulation index (if applicable) — Control system command values, reference values, and feedback signals	Many kHz, triggered	90 days **20 calendar days**	5-s data, (split between pre-fault and post-fault data needs to be mutually agreed upon with the *TS owner/TS operator*) **Not Applicable**	Stated by *IBR owner*

- Inverter Fault Codes: Required by PRC-028. Standard provides flexibility for IBR units in-service before the effective date of this standard.
- Dynamic Recordings: Not required by PRC-028.

Unit Level Versus Plant Level



POC (unit level monitoring) Versus POM (plant level monitoring)

IEEE 2800 versus PRC-028
Time Synchronization

	IEEE 2800-2022 shall be synchronized to UTC with	PRC-028 shall be synchronized to UTC with
IBR Plant Level Monitoring	± 1 µs time accuracy	± 1 ms time accuracy
IBR Unit Level Monitoring	± 100 µs time accuracy	± 100 ms time accuracy

PRC-028 recognizes challenges of transmitting clock signal within the plant

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The Need for Disturbance Monitoring

Alex Shattuck, Senior Engineer, NERC

i2X Forum for the Implementation of Reliability Standards for Transmission

September 24, 2024

RELIABILITY | ACCOUNTABILITY

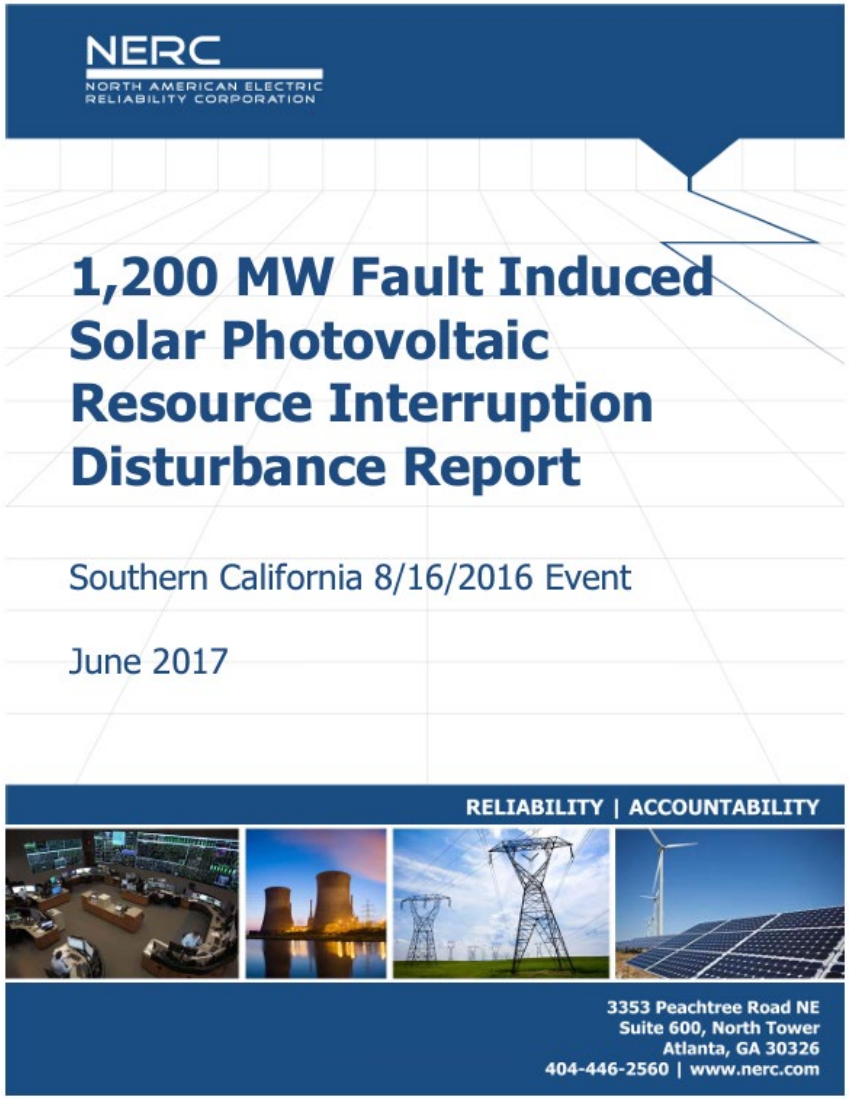



NERC Disturbance Reports

https://www.nerc.com/pa/rrm/ea/Pages/Major-Event-Reports.aspx

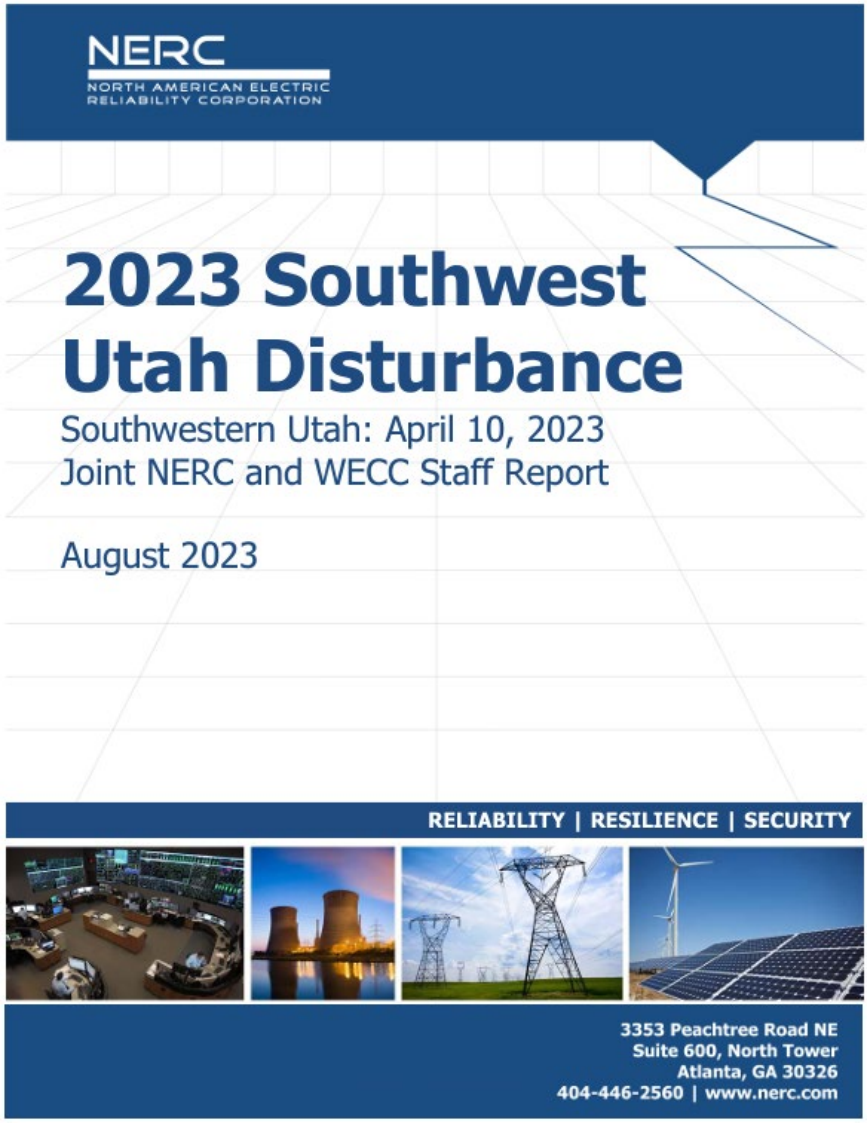
NERC Disturbance Reports

It all started with…

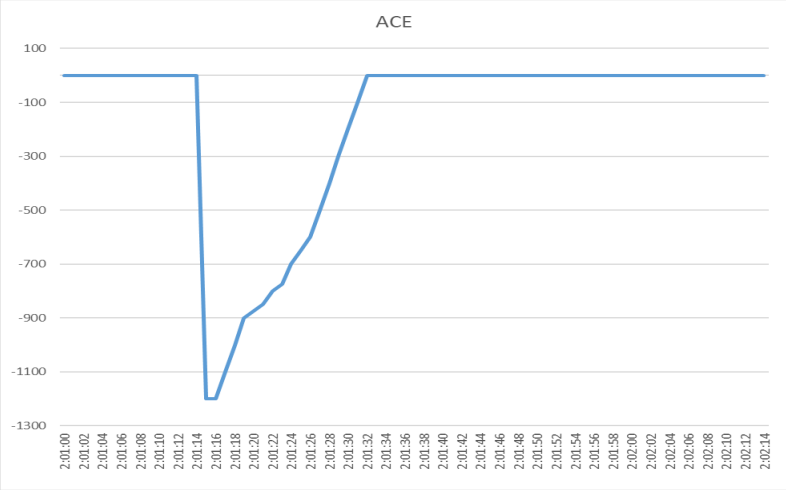


NERC Disturbance Reports

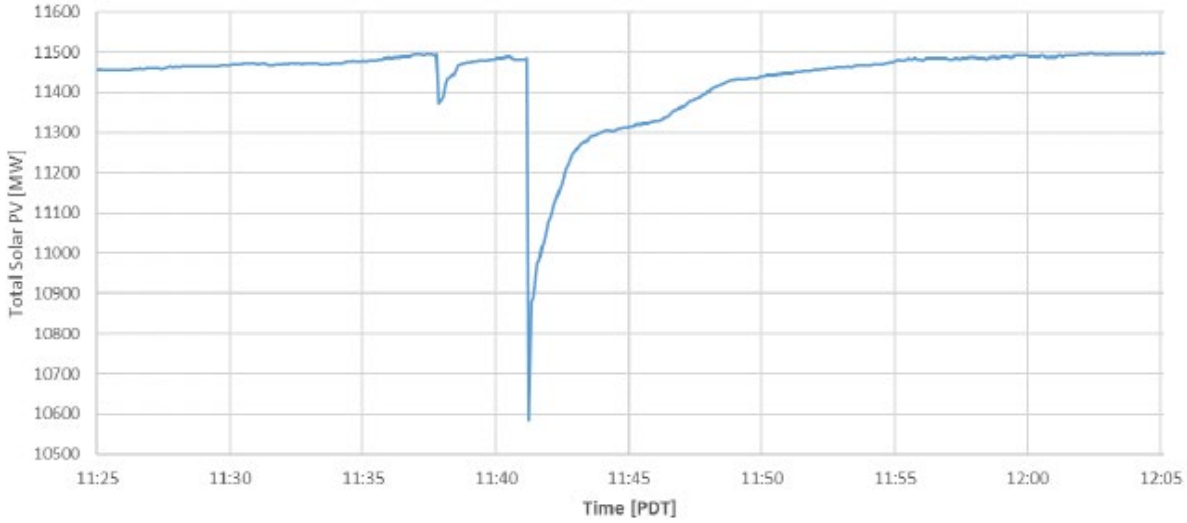
And the most recent…



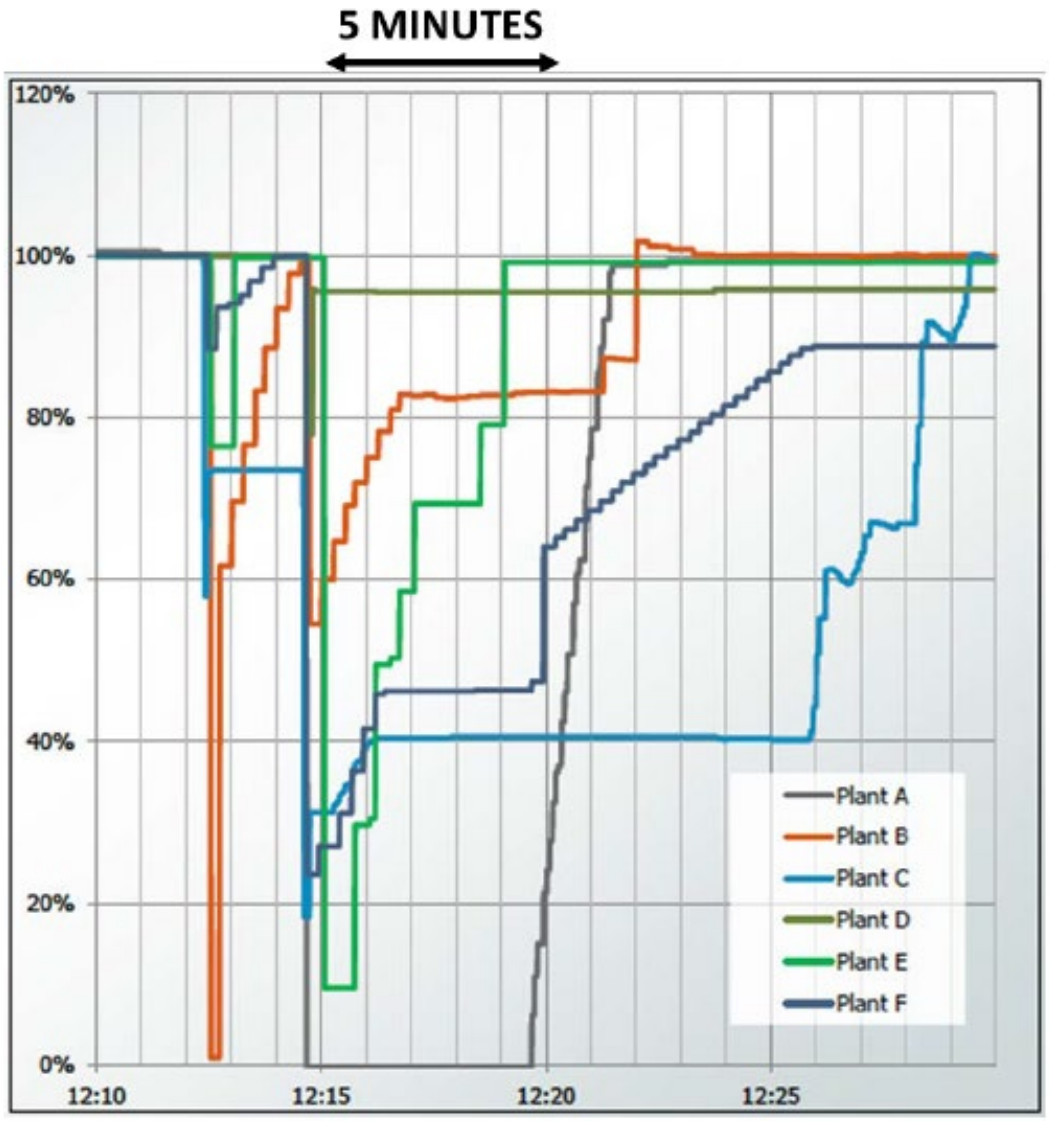
Solar PV Response



- Change in ACE
- Change in Total Solar Output



Individual Solar PV Response

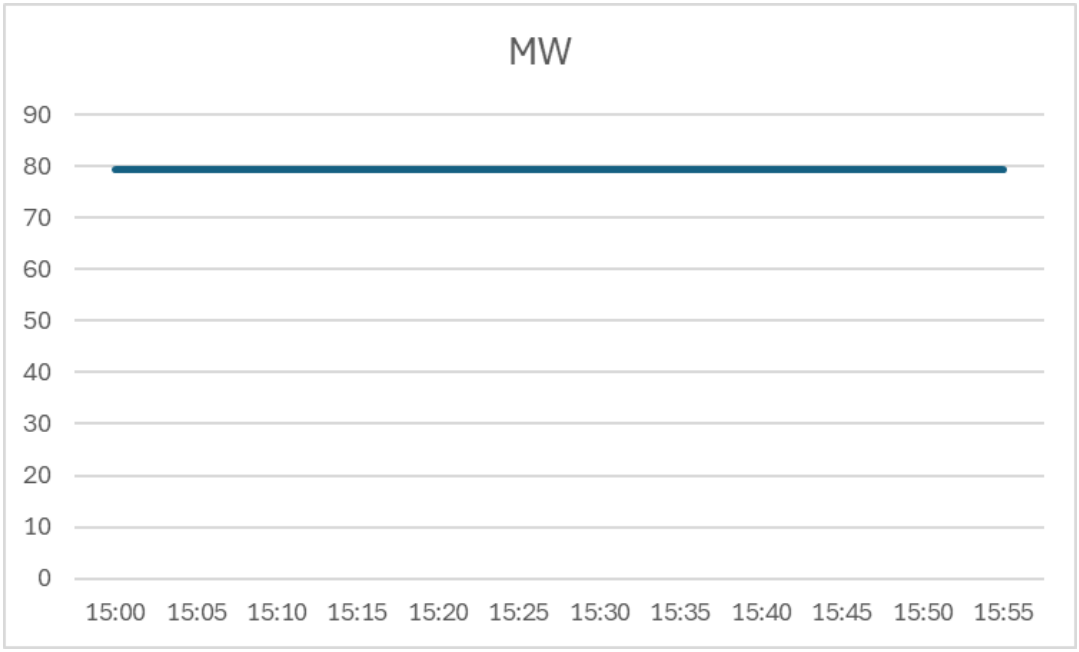


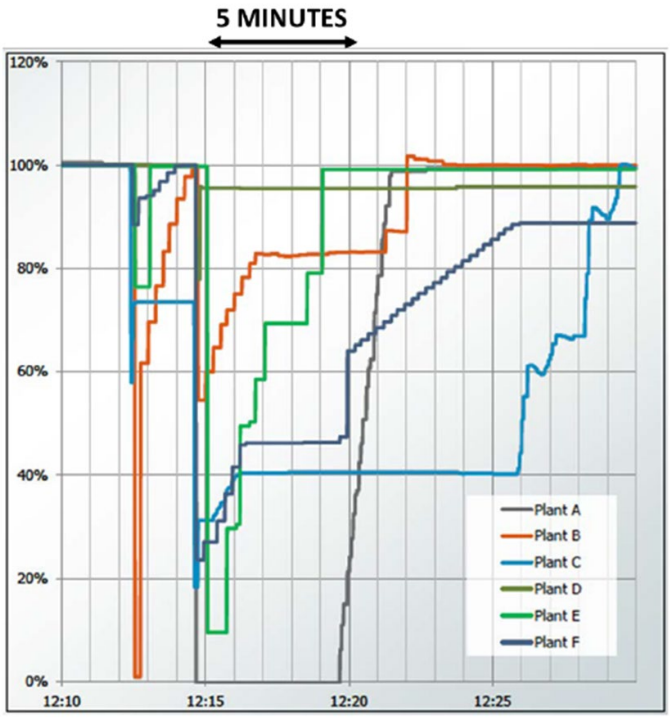
Data Requests

- Data recording for facility output during disturbance
  - Highest resolution data available
- Causes of reductions
- Settings for protection that operated during disturbance

Data Requests

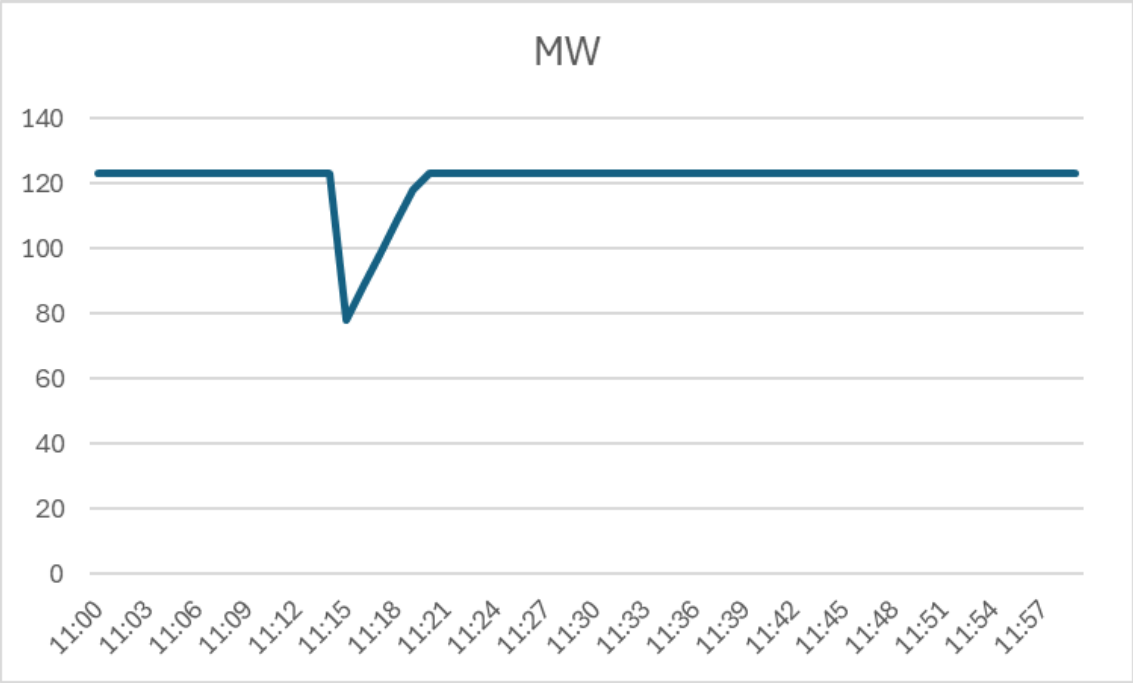
In the beginning…

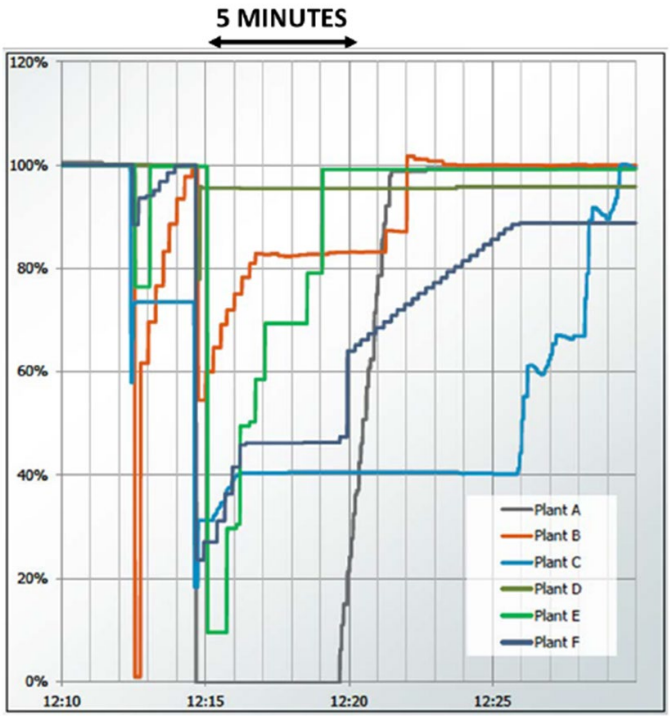




Data Requests

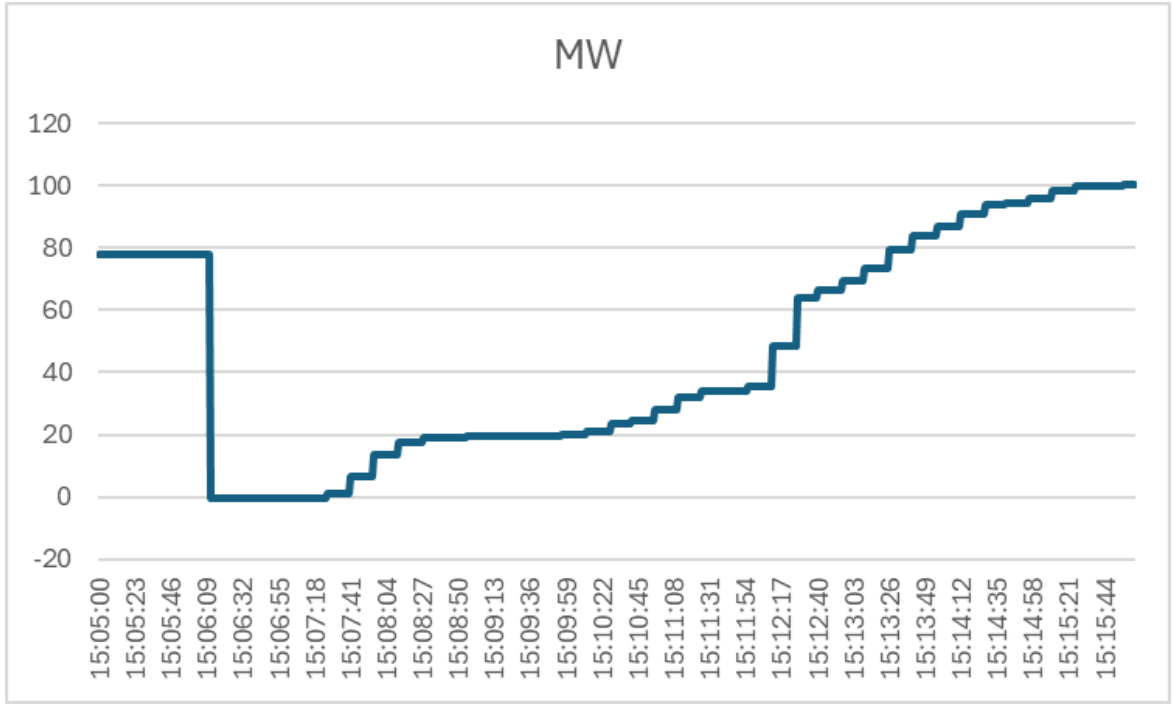
Then…

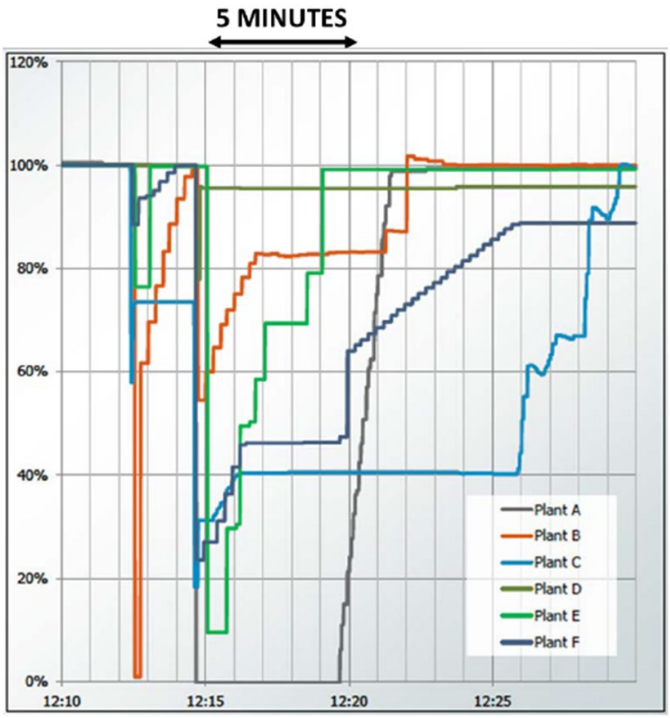




Data Requests

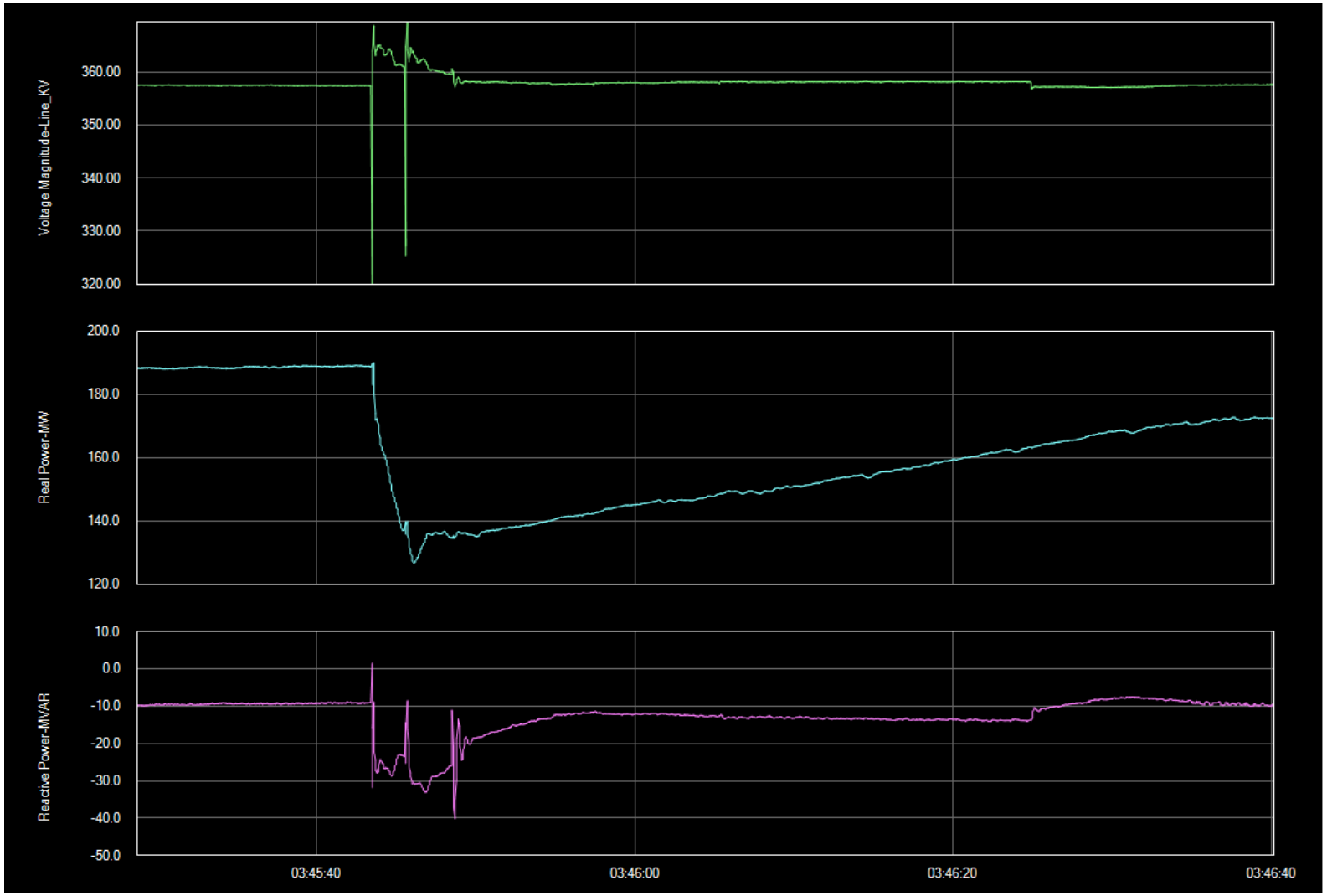
A little better…





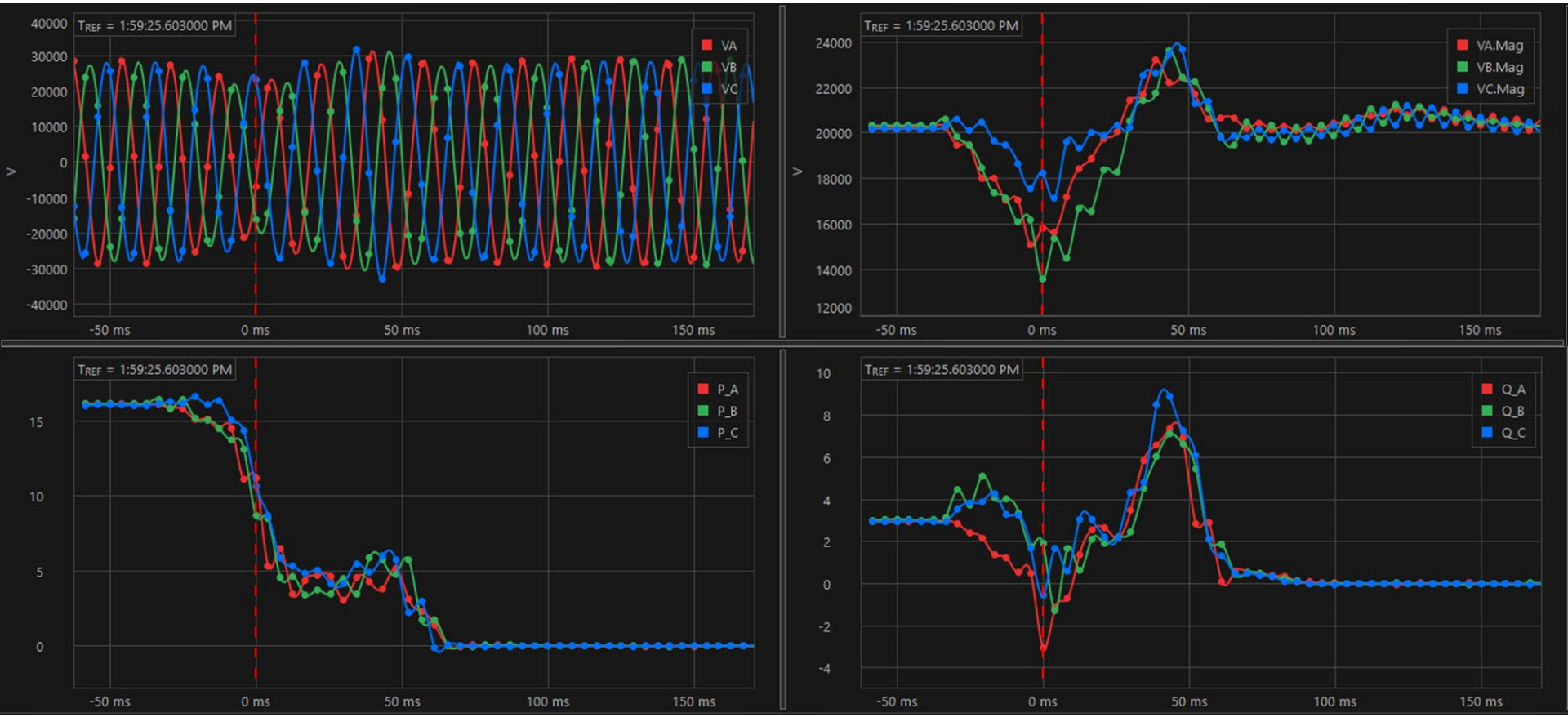
Data Requests

Now we're talking!



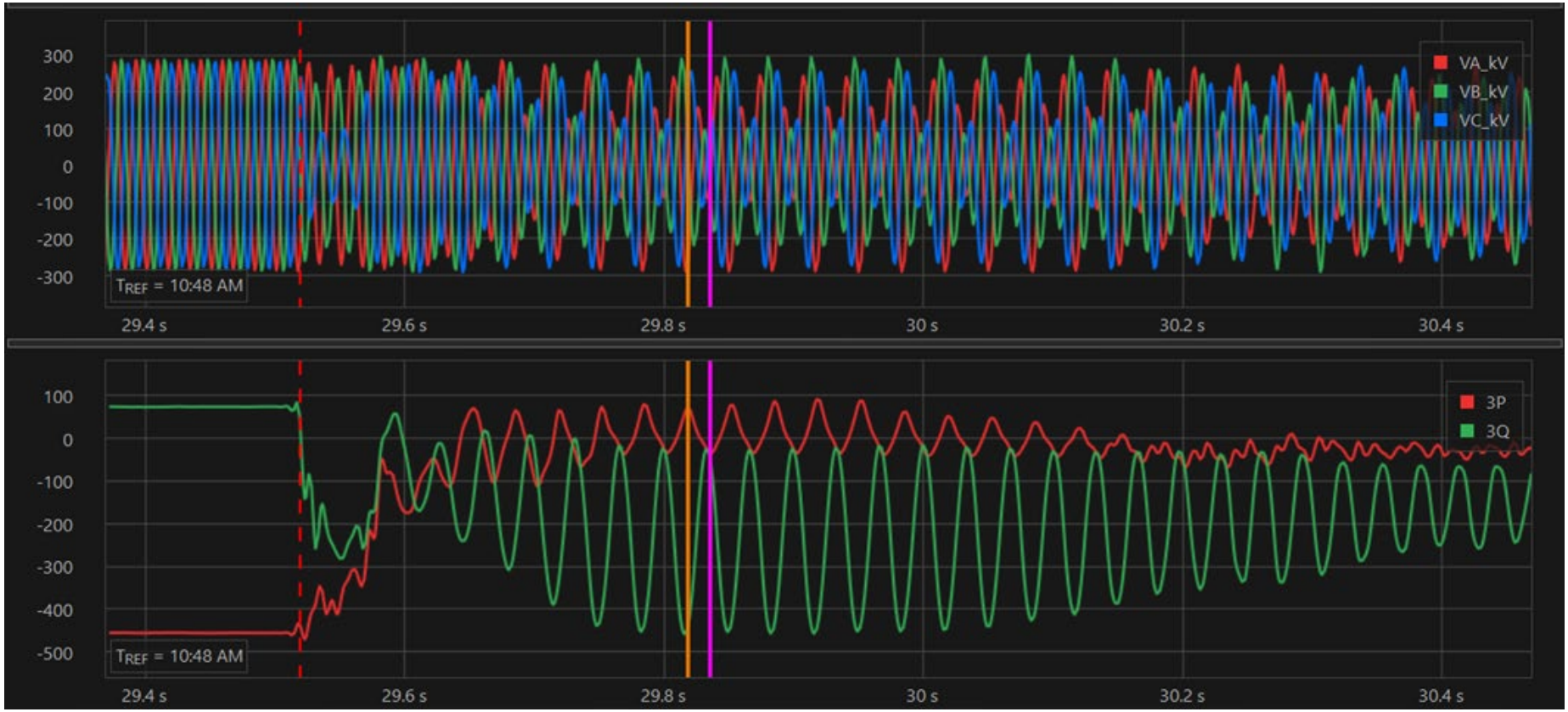
Data Requests

Wow!



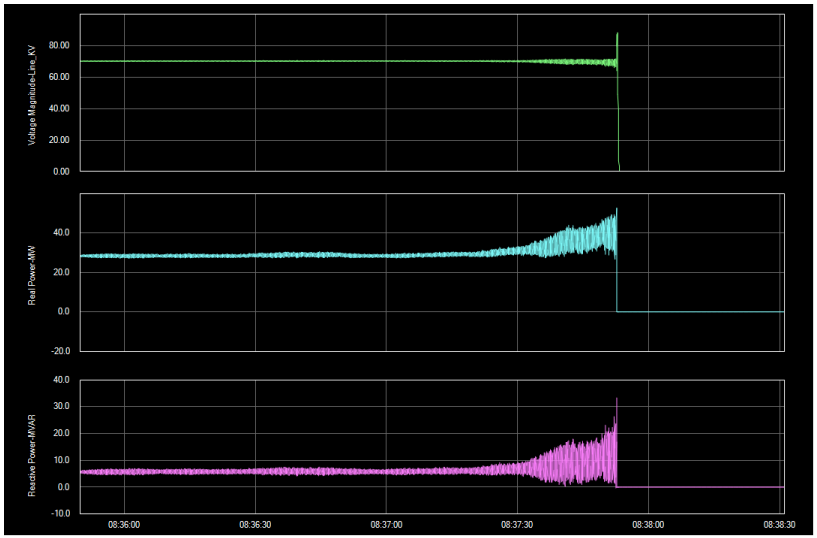
Data Requests

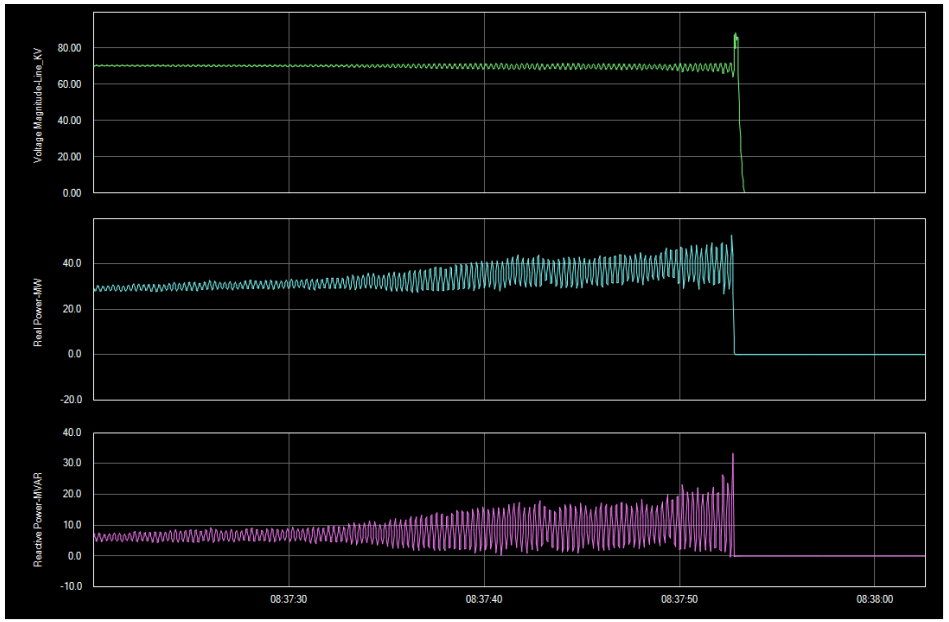
More Wow!



Data Requests

And finally…





NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Standards Announcement

Project 2021-04 Modifications to PRC-002 – Phase II | PRC-028-1

Additional Ballots and Non-binding Poll Results

Now Available

Additional ballots and non-binding poll of the associated Violation Risk Factors and Violation Severity Levels for **Project 2021-04 Modifications to PRC-002 - Phase II** concluded at **8 p.m. Eastern, August 12, 2024.**

The voting statistics are listed below, and the details can be accessed on the Ballot Results page.

	Ballot	Non-binding Poll
Standard	Quorum / Approval	Quorum / Supportive Opinions
PRC-028-1	87.04% / 80.70%	86.59% / 77.51%
Implementation Plan	85.04% / 84.55%	N/A

- **8/12/2024**

PRC-028-1 – Disturbance Monitoring and Reporting Requirements for Inverter-Based Resources

R4. Each Generator Owner shall have continuous dynamic disturbance recording (DDR) data and storage to determine the following electrical quantities for each main power transformer(s) it owns: *[Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]*

4.1. One phase-to-neutral or positive sequence voltage on high-side of the main power transformer(s).

4.2. The phase current for the same phase at the same voltage corresponding to the voltage in Requirement R4, Part 4.1, or the positive sequence current.

4.3. Real Power and Reactive Power flows expressed on a three-phase basis corresponding to each main power transformer(s) where current measurements are required.

4.4. Frequency of any one of the voltage(s) in Requirement R4, Part 4.1.

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R5. Each Generator Owner responsible for DDR data for the electrical quantities identified in Requirement R4 shall have DDR data that meet the following: *[Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]*

5.1. Input sampling rate of at least 960 samples per second.

5.2. Output recording rate of electrical quantities of at least 60 times per second.

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R6. Each Generator Owner shall time synchronize all SER, FR, and DDR data to meet the following: *[Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]*

6.1. Synchronization to Coordinated Universal Time (UTC) with or without a local time offset.

6.2. Synchronized device clock accuracy within ± 1 milliseconds of UTC. The IBR units shall have synchronized device clock accuracy within ± 100 milliseconds of UTC.

Questions