NERC

NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

NERC Inverter-Based Resource (IBR) Webinar Series:

Session 3: Inverter-Based Resource Performance Issues

June 13, 2023

RELIABILITY | RESILIENCE | SECURITY




California ISO

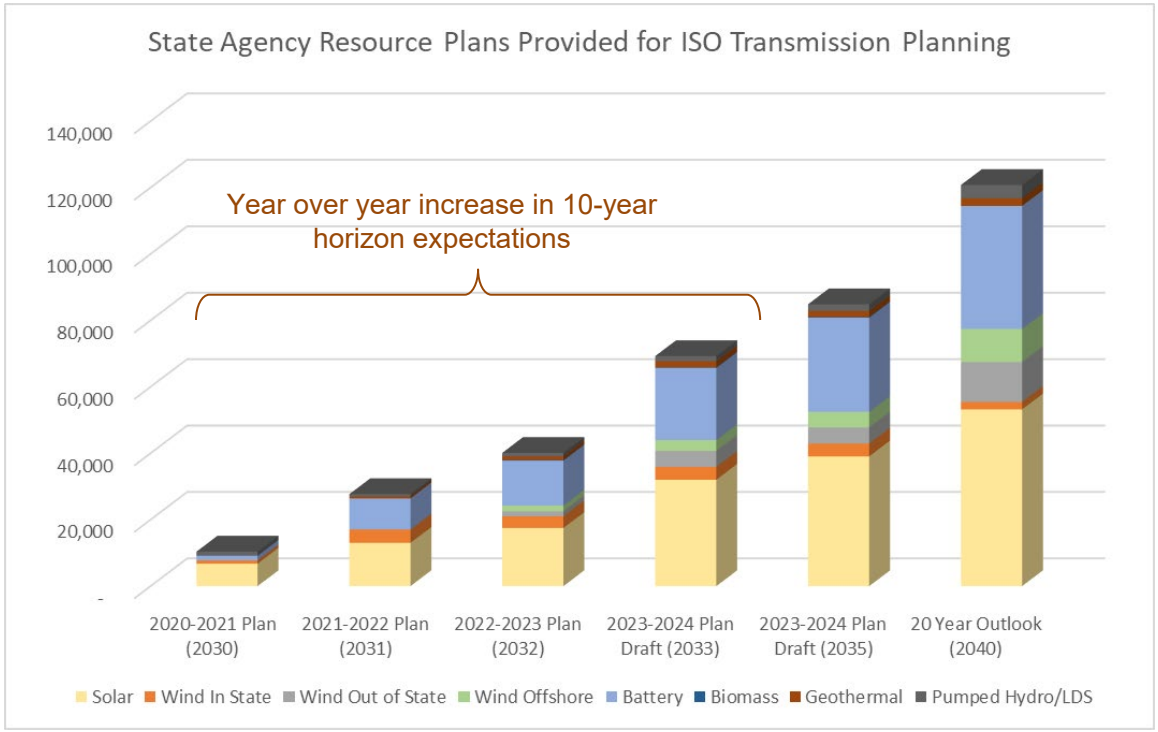
NERC Webinar 3

Managing the growth and monitoring of inverter-based resources

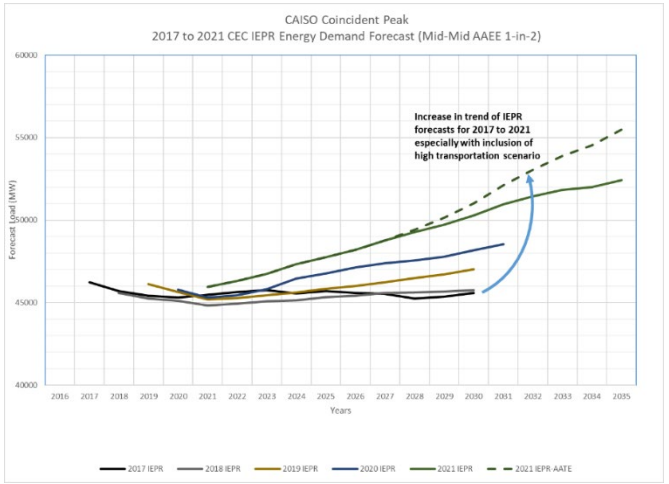
Dede Subakti
VP, System Operations

June 13, 2023

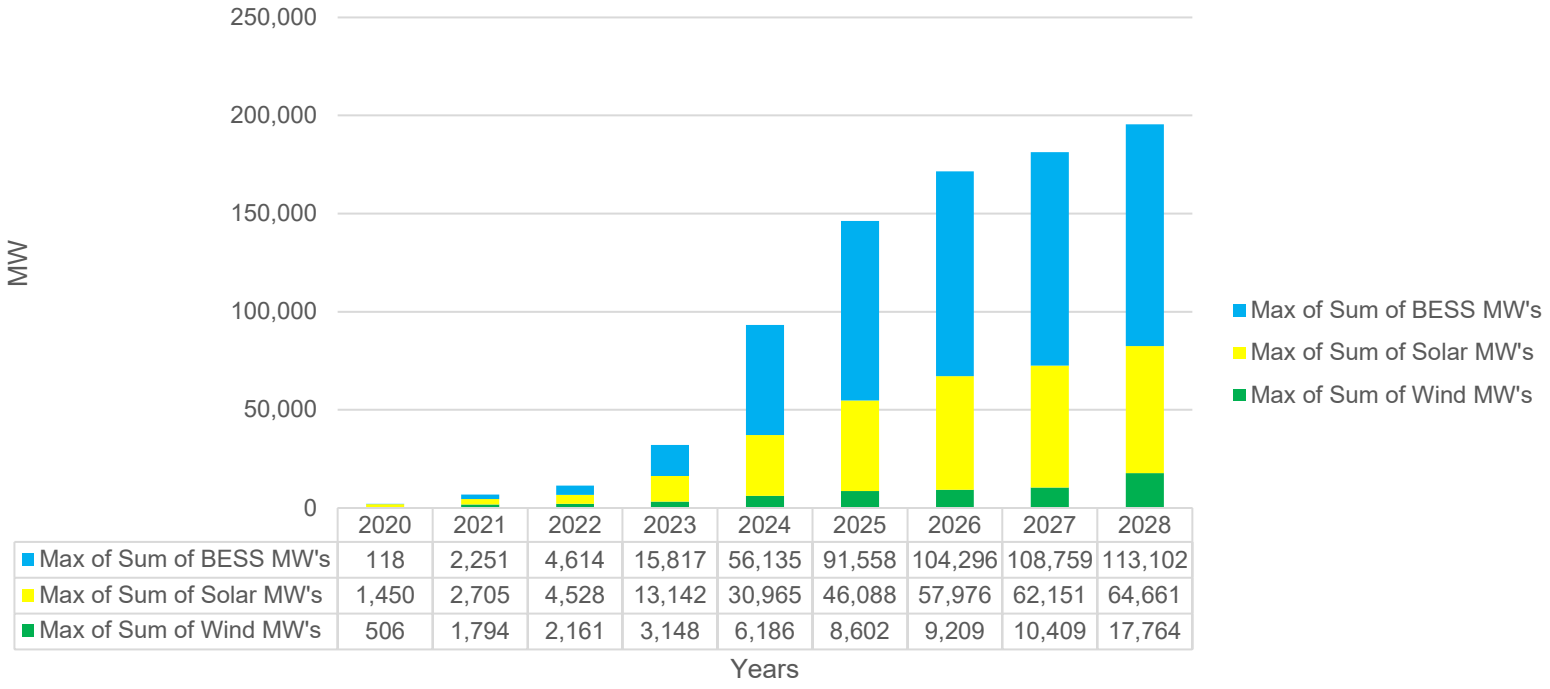
The need for new resources to meet California's long-term need has escalated quickly



We are accelerating infrastructure quickly due to escalating load growth, electrification, and de-carbonization



There is a large volume of renewable resources competing to be part of that supply, as shown in our interconnection queue



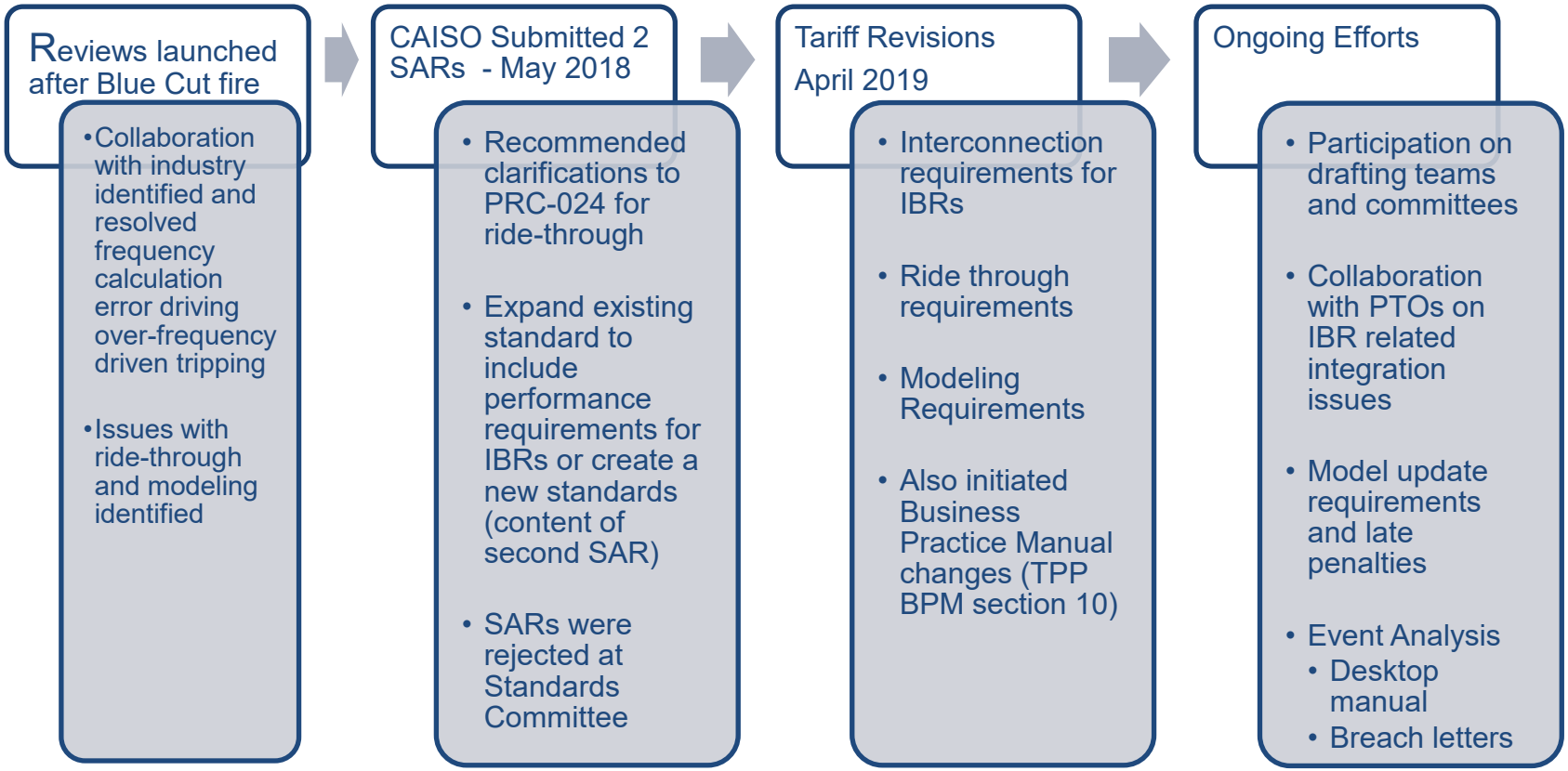
	2020	2021	2022	2023	2024	2025	2026	2027	2028
Max of Sum of BESS MW's	118	2,251	4,614	15,817	56,135	91,558	104,296	108,759	113,102
Max of Sum of Solar MW's	1,450	2,705	4,528	13,142	30,965	46,088	57,976	62,151	64,661
Max of Sum of Wind MW's	506	1,794	2,161	3,148	6,186	8,602	9,209	10,409	17,764

Years

Summary of Recent IBR (Primarily PV Solar) Loss Events

#	Event	Date	IBR Loss in Bulk Power System (MW)
1	Blue Cut Fire	8/16/2016	1,178
2	Canyon 2 Fire	10/9/2017	937
3	Angeles Forest	4/20/2018	877
4	Palmdale Roost	5/11/2018	711
5	San Fernando	7/7/2020	1000
6	Victorville	6/24/2021	765
7	Tumbleweed	7/4/2021	605
8	Windhub	7/28/2021	511
9	Little Creek Fire	8/24/2021	583

Timeline of ISO Actions responding to performance concerns

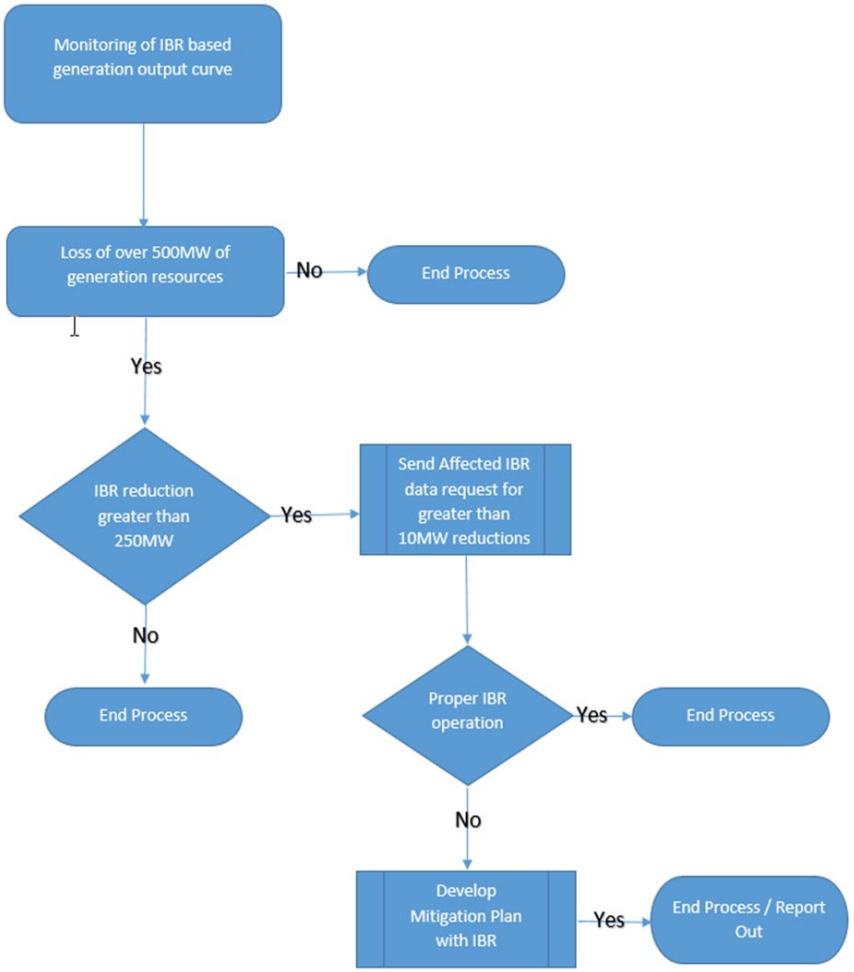


The ISO's comprehensive model data review has made significant progress and has been a daunting task for the industry

ALL									
Phase	# Gen in Phase	Pending Submission	Under Initial Review	Cure Submission Reviews	Conditionally Compliant, EMT Pending	Compliant	Voided	Totals	% compliance (incl. conditional)
New COD	119	14	19	41	4	41	0	119	14%
Phase 1	81	0	0	5	8	68	0	81	10%
Phase 2	86	0	0	7	12	63	4	86	10%
Phase 3	73	0	0	14	6	45	8	73	9%
Phase 4	112	0	0	54	3	51	4	112	14%
Phase 5	96	3	1	79	0	9	4	96	12%
Phase 6	89	15	8	61	0	3	2	89	11%
Phase 7	28	11	11	5	0	1	0	28	3%
Phase 8	32	31	1	0	0	0	0	32	4%
Phase 9	67	52	15	0	0	0	0	67	8%
Phase 10	9	9	0	0	0	0	0	9	1%
Phase 11	36	36	0	0	0	0	0	36	4%
Total	828	43	39	266	33	281	22	828	100%
%		5%	5%	32%	4%	34%	3%	83%	
# of rows	828								
					EMT: 31				
					Quality Deficiency: 2				

- Phases prioritized by potential impact – size and location
- Phase 9 is due July 1, 2023 have recently been sent to generators
- Some generators submit their data early
- $739,500 penalties to date and penalties have been effective at encouraging model submission

Current Monitoring Procedure Overview



Possible Areas for NERC's Assistance

- Develop reliability standards for IBRs – fast track where possible
  - Areas of concern in the FERC NOPR

- Prioritize efforts utilizing a risk based approach
  - Performance standard for IBRs
  - Model quality

- Modification to BES definition
  - Include IBR resources below the current 75 MVA threshold

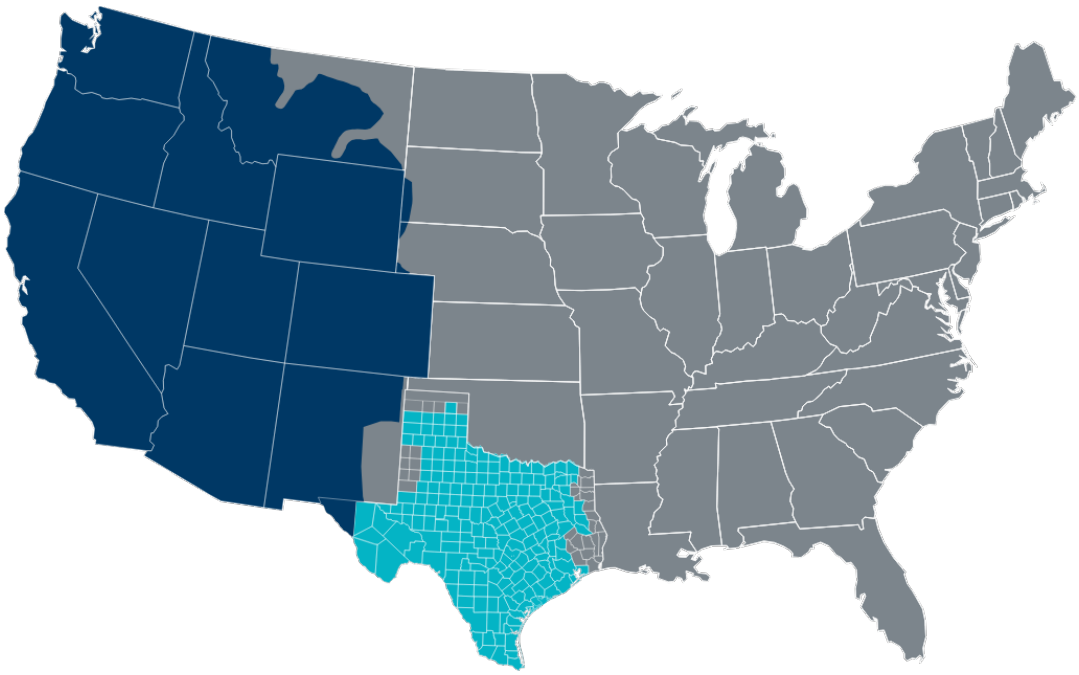
Questions and Answers After All Presentations

ERCOT Experience with Inverter-Based Resource (IBR) Performance Issues

NERC IBR Webinar Series
June 13, 2023

Jeff Billo
ERCOT Operations Planning

The ERCOT Region

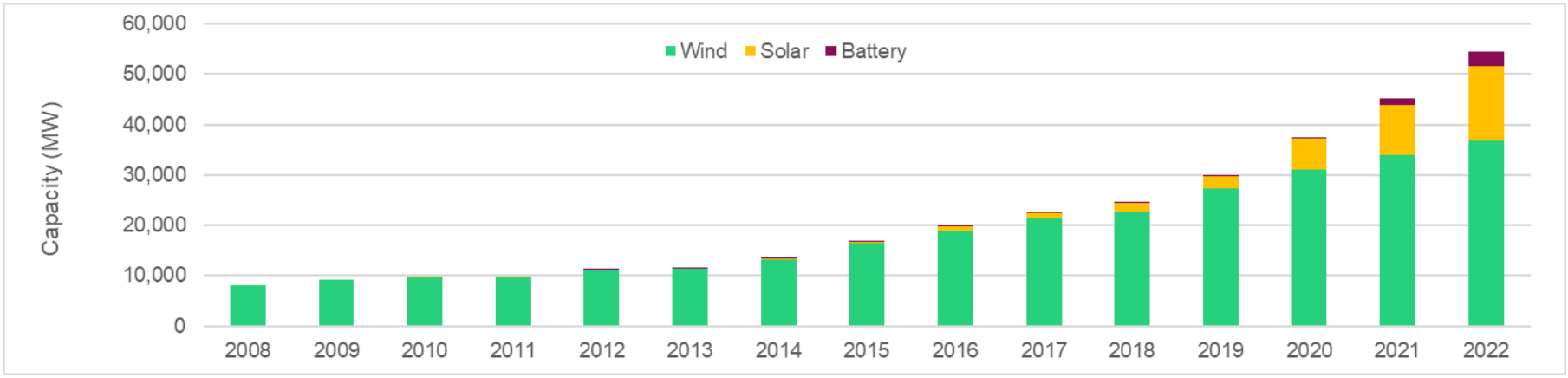


The interconnected electrical system serving most of Texas, with limited external connections

- 90% of Texas electric load; 75% of Texas land
- **80,148 MW** peak, July 20, 2022
- More than 52,700 miles of transmission lines
- 1,100+ generation units (including PUNs)

ERCOT connections to other grids are limited to ~1,220 MW of direct current (DC) ties, which allow control overflow of electricity

ERCOT's IBR History Book



2008: Competitive Renewable Energy Zone (CREZ) Transmission Optimization Study

2009: Wind Plant-Series Capacitor Subsynchronous Oscillation (SSO) event in South Texas

2010: CREZ Reactive Study

2013: All CREZ Transmission In Service

2016: Panhandle System Strength Study

2014: Panhandle REZ Study

2018: Alibates and Tule Canyon Synchronous Condensers In Service

2018: High Renewable Penetration Study

2008: IBR Voltage Ride-Through Requirements

2009: IBR Reactive Power Requirements

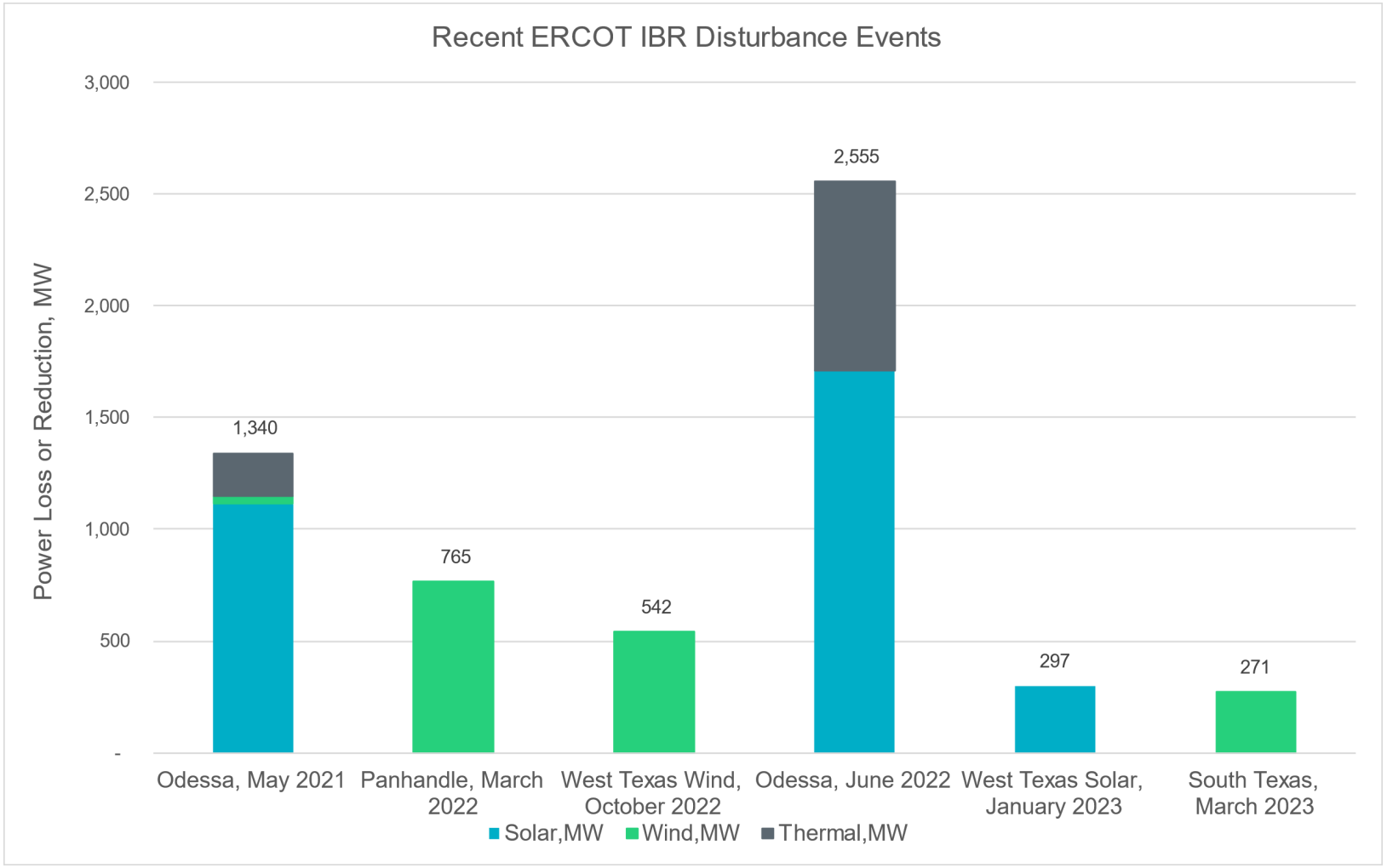
2010: IBR Primary Frequency Response Requirements

2014: IBR High Voltage Ride-Through Requirements

2017: Subsynchronous Resonance Requirements

2023: West Texas Grid Strength Study

Recent ERCOT IBR Disturbance Events



Current Improvement Activities

IBR ride-through capabilities need to be improved		
	Existing resources must meet current requirements	ERCOT created a focused task force and is working with manufacturers and generator owners to develop mitigation plans (IBRTF)
	Required ride-through standards need to be more robust	NOGRR 245 has been proposed to implement new industry-wide ride-through requirements in IEEE 2800 standard
Modeling capabilities need to be improved		
	Unit models provided to ERCOT need to reflect actual field settings	Improved requirements for updating parameters and perform model validation
	Simulations need to include detailed models for IBR controls and protection	ERCOT implemented the use of more-detailed simulation for all new generators in 2021 (PGRR 085) (Model Quality Guide)
Large load ride-through performance needs to be improved		
	Need to reduce lack of ride-through by large loads	ERCOT will be proposing large load interconnection process which will require improved dynamic modeling and ride-through requirements for large loads
West Texas system strength needs to be improved		
	Need to reduce system sensitivity to incorrect capabilities and tuning	ERCOT will be proposing project to add synchronous condensers to strengthen the system in West Texas

Questions and Answers After All Presentations

Operational Impacts of IBRs at TVA

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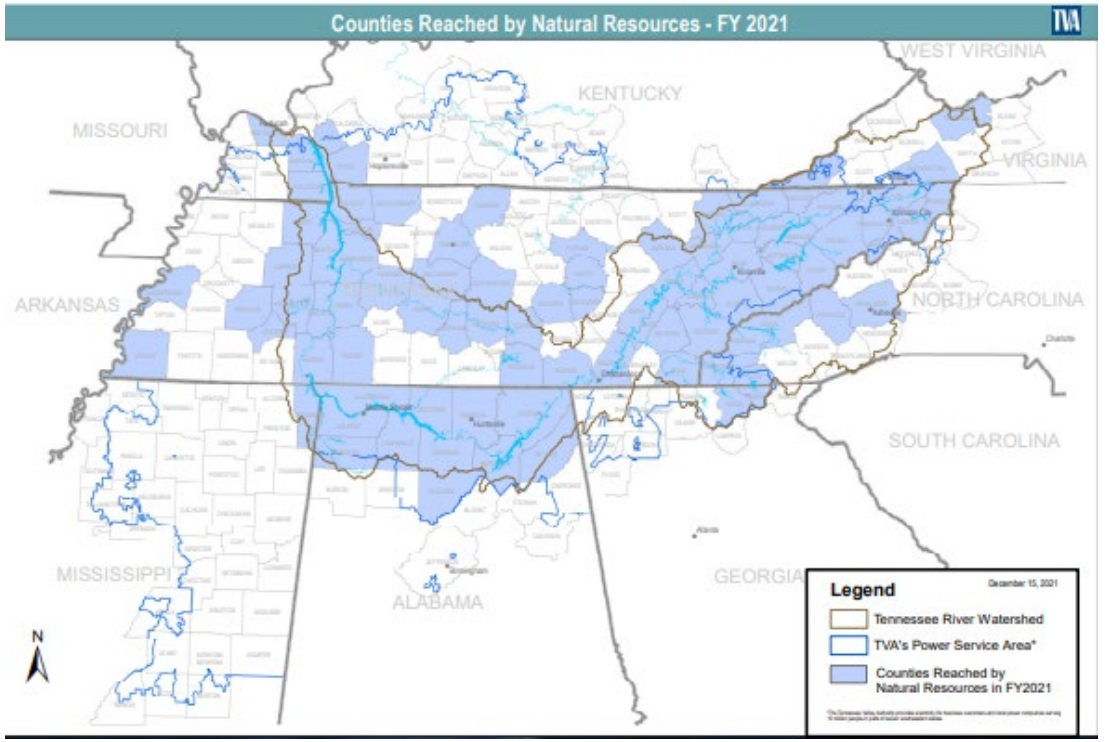
TVA Region

- Power Service Area
  - 80,000 Square Miles
  - 10 Million Residents
  - 198 Counties
- Watershed Area
  - 293,000 Acres of Public Land
  - 650,000 Acres of Reservoir Surface Water
  - 11,000 Miles of Public Shoreline
  - $12 Billion Economic Benefit from Recreational Opportunities



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Transmission System Details

One of the nation's **largest & most reliable**

99.999% reliable since 2000

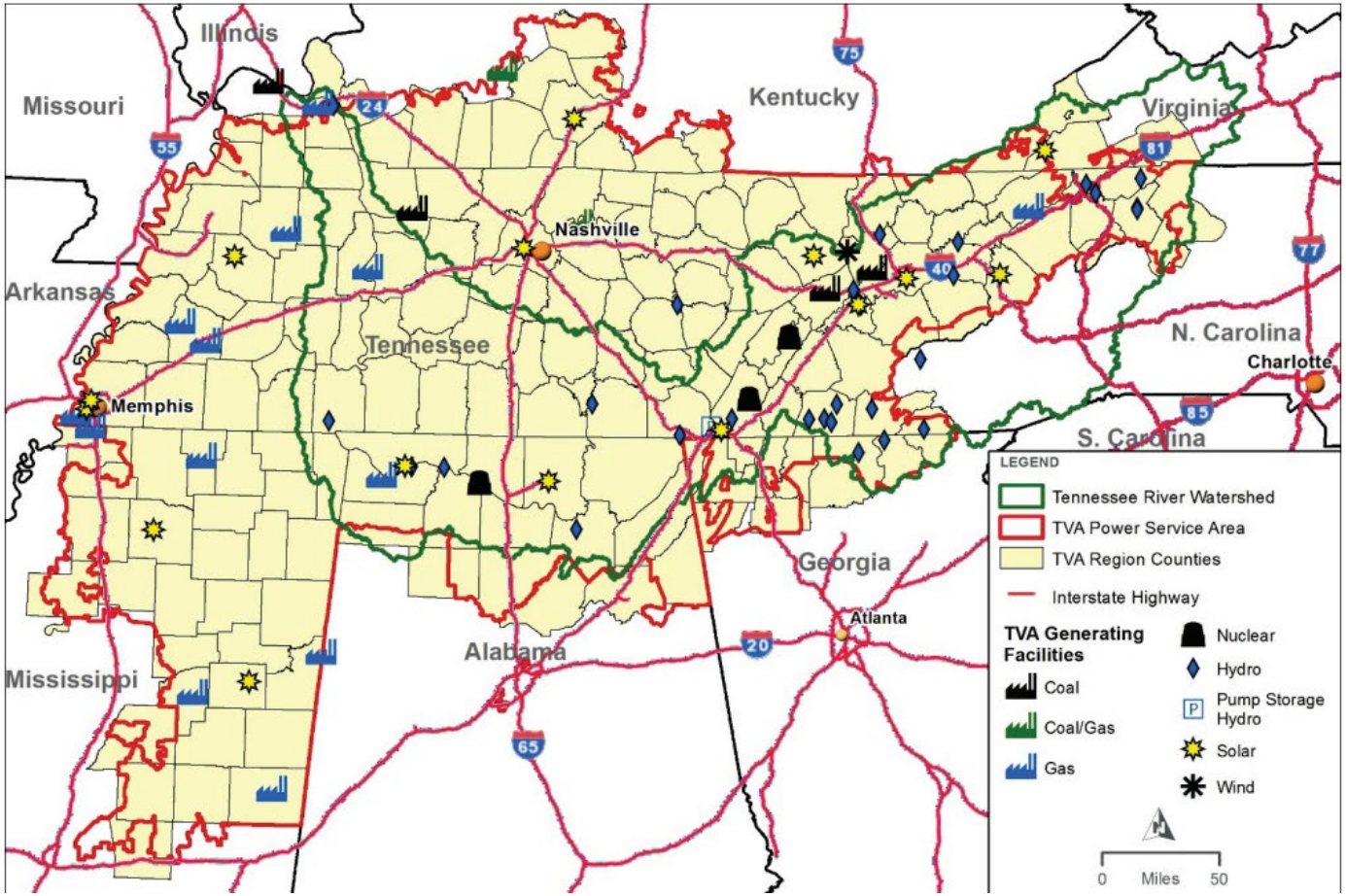
Interrelated demands

- Bulk system capacity
- Generation
- Asset performance
- Customer delivery
- Economic development

System assets

- 16,000+ circuit miles
- 104,000+ transmission structures
- 500+ substations
- 1,300+ customer connection points
- 293,000 acres of land
- 3,900 miles backbone telecommunications fiber

TVA's Integrated System



IBR Introduction

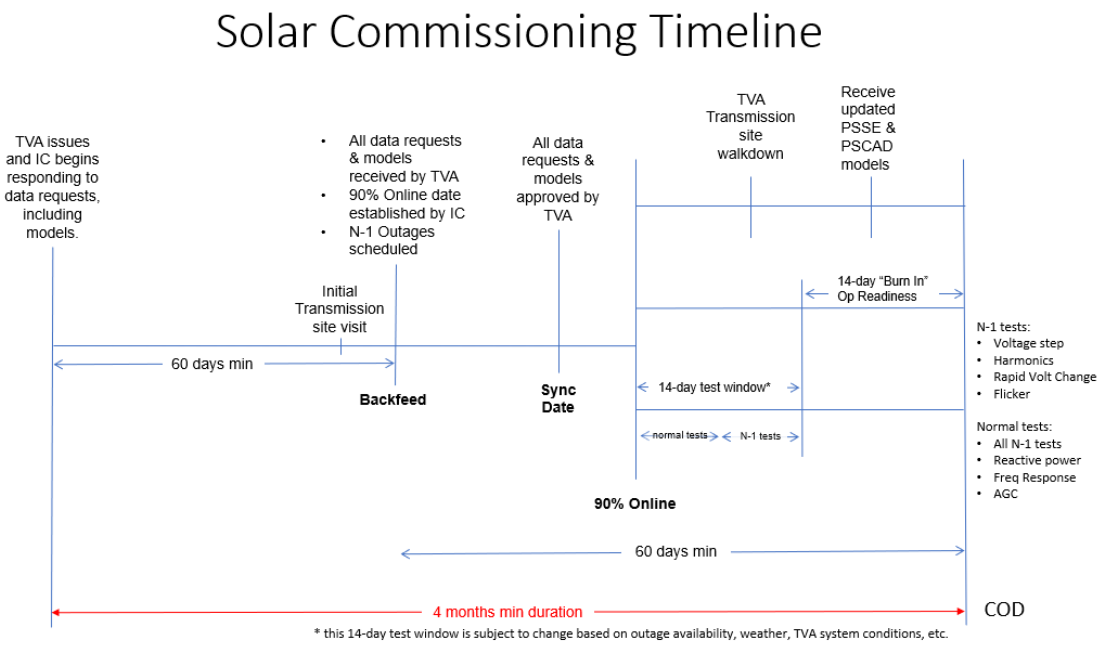
- 607 MW of transmission-connected IBRs consisting of 5 solar plants are operating on the TVA system today.
- Aggressive plans are in place to have 10,000 MW of solar by 2035
- Comprehensive commissioning process implemented in 2021, including:
  - EMT modeling requirements
  - Field testing and verification procedures
  - Real-time plant monitoring

Commissioning Experience

- Many issues successfully detected during commissioning:
  - Incorrect inverter, PPC, and protection settings
  - Real and reactive power oscillations
  - Incorrect bus for voltage control
  - Transformer tap position discrepancies
  - Cap bank control issues
  - Inverter start-up issues
- Most issues are noted during:
  - Model verification
  - Operational testing
  - 14-day burn-in period

Commissioning Experience

- Modeling Verification
  - Primary focus is on EMT model
  - Model quality and functionality checks
  - Selected performance tests (EMT)
  - Verification with field-installed equipment
  - “Best effort” validation during commissioning test period
- Field Testing
  - Voltage and frequency step tests
  - Reactive power capability
  - AGC (signal following accuracy)
  - Harmonics and transformer energization
  - 14-day burn in period



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Operational Experience

- Many issues are discovered post-commissioning:
  - Unexpected performance for large disturbances
  - Unintended impact of inverter firmware changes
  - Unintended impact of tweaks to plant controller
  - Network firewall changes at plant applied to wrong port, causing erratic controller operation
- Real-time monitoring:
  - Detect and correct issues before they can reoccur at an inopportune time
  - [equipment types – PMUs. etc]
  - [alarms – P and Q oscillations, harmonics, etc.]

Summary

- Commissioning process has been very successful.
- Gaps remain:
  - Configuration control post-commissioning
  - Large disturbances difficult to test and models are still lacking.
  - Qualified personnel to handle a reliable transition from 1 GW to 10 GW of IBRs by 2035

TVA Solar Ramp-down Events

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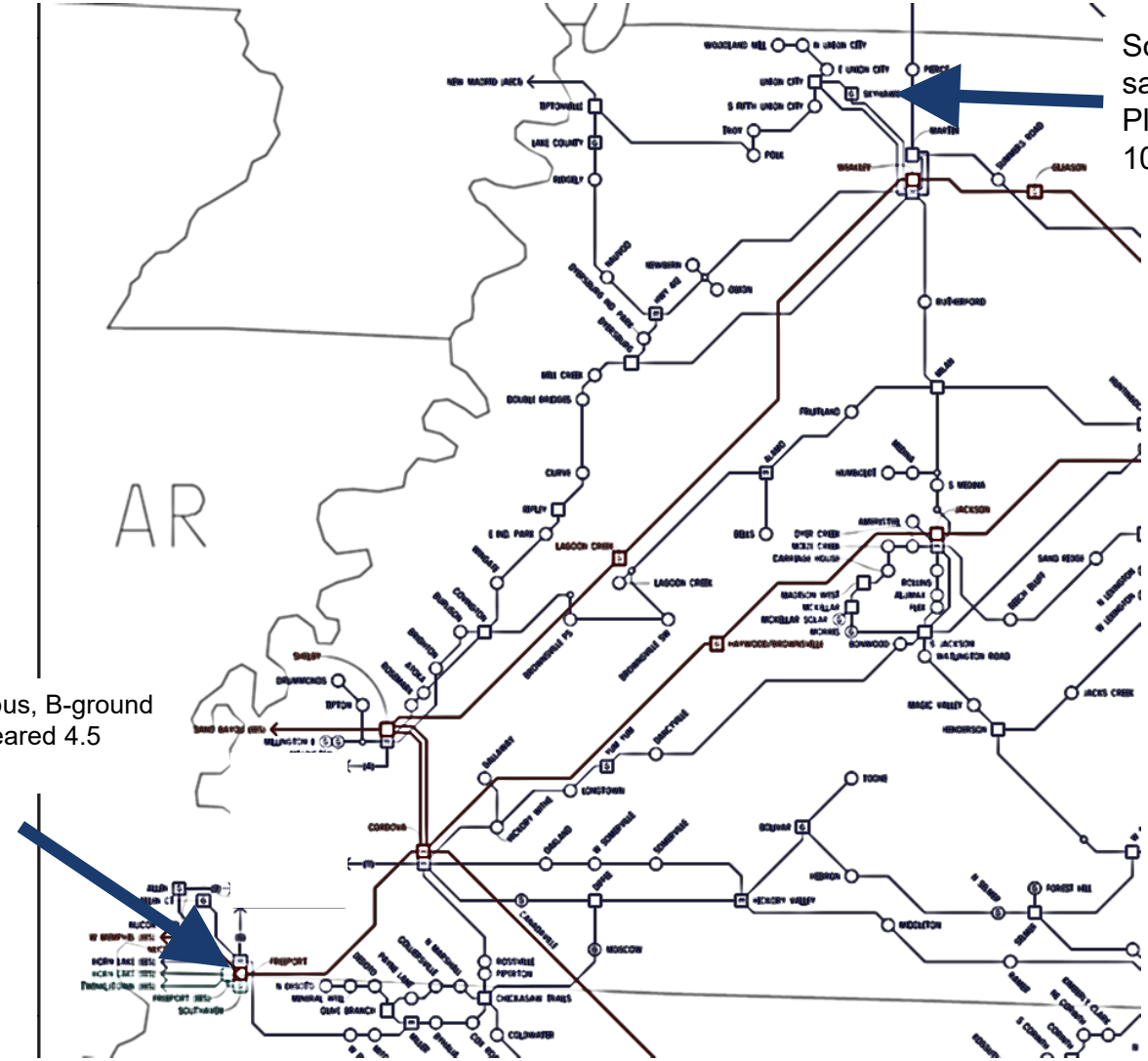

Solar Plant, pre-event generation 94MW, saw 82% sag for Freeport bus fault
Plant entered momentary cessation, 10MW/min recovery

500kV bus, B-ground fault, cleared 4.5 cycles

3/15/2023 500kV bus fault with Solar cessation

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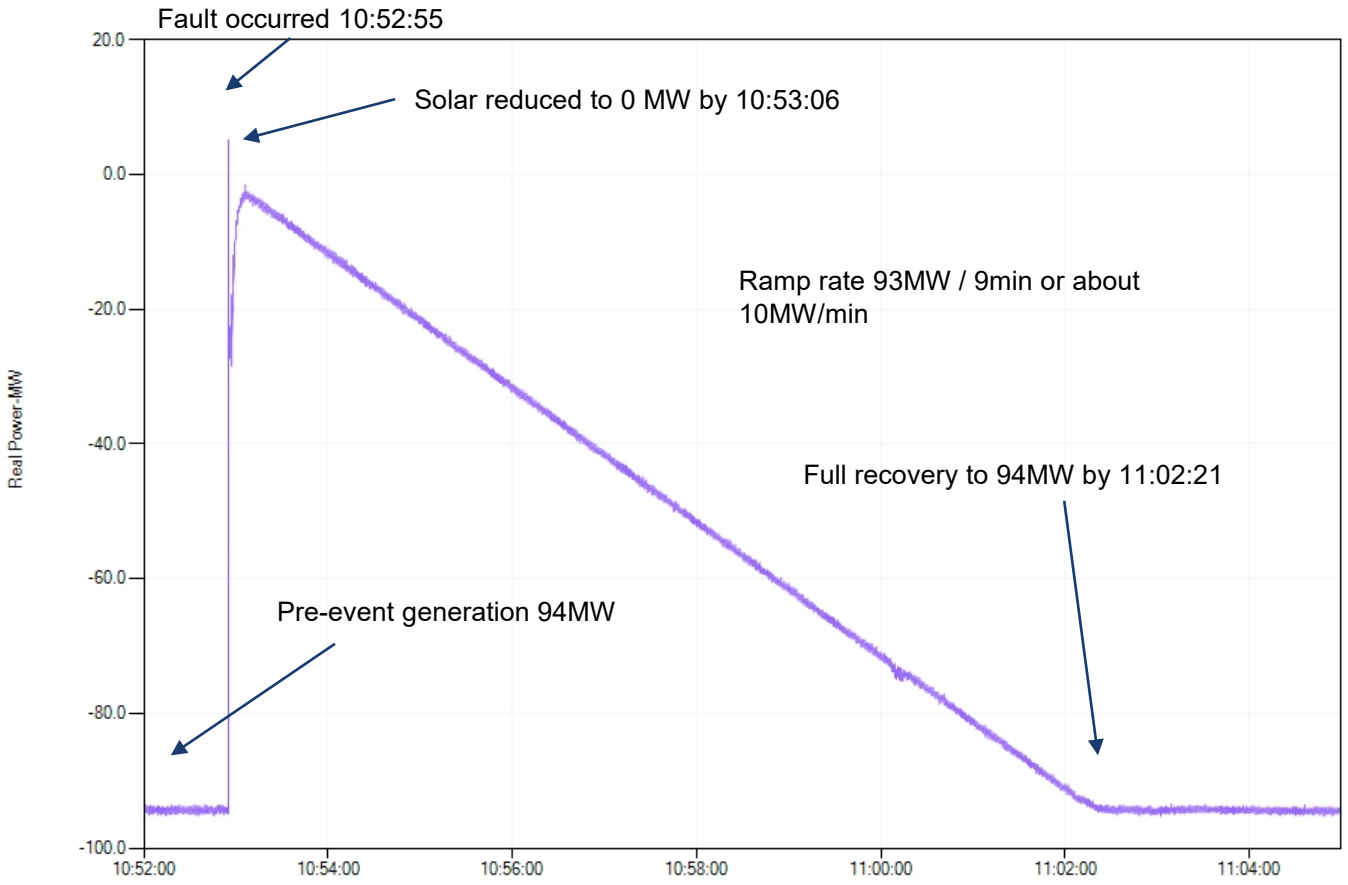

Start Time: 2023-03-15 10:51:58.201 End Time: 2023-03-15 11:04:59.739

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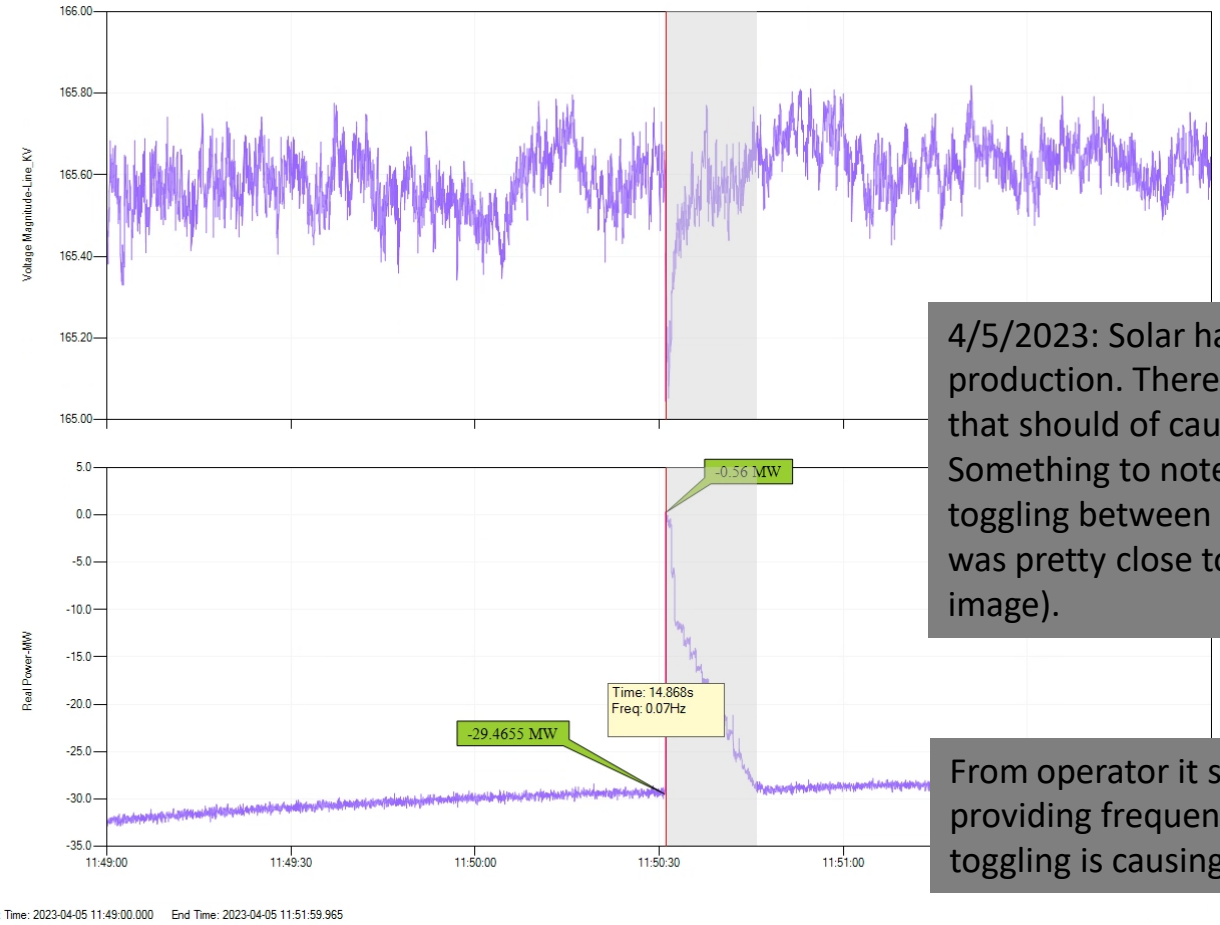

4/5/2023: Solar had an instantaneous 30MW drop in production. There doesn't appear to be any system events that should of caused such an instant reduction in output. Something to note is the plant frequency controller keeps toggling between "On" and "Off" and one of those toggles was pretty close to the same time as this event(see last image).

From operator it sounds like the PPC is not properly providing frequency control at all times, uncertain if that toggling is causing any power drops to inverters.

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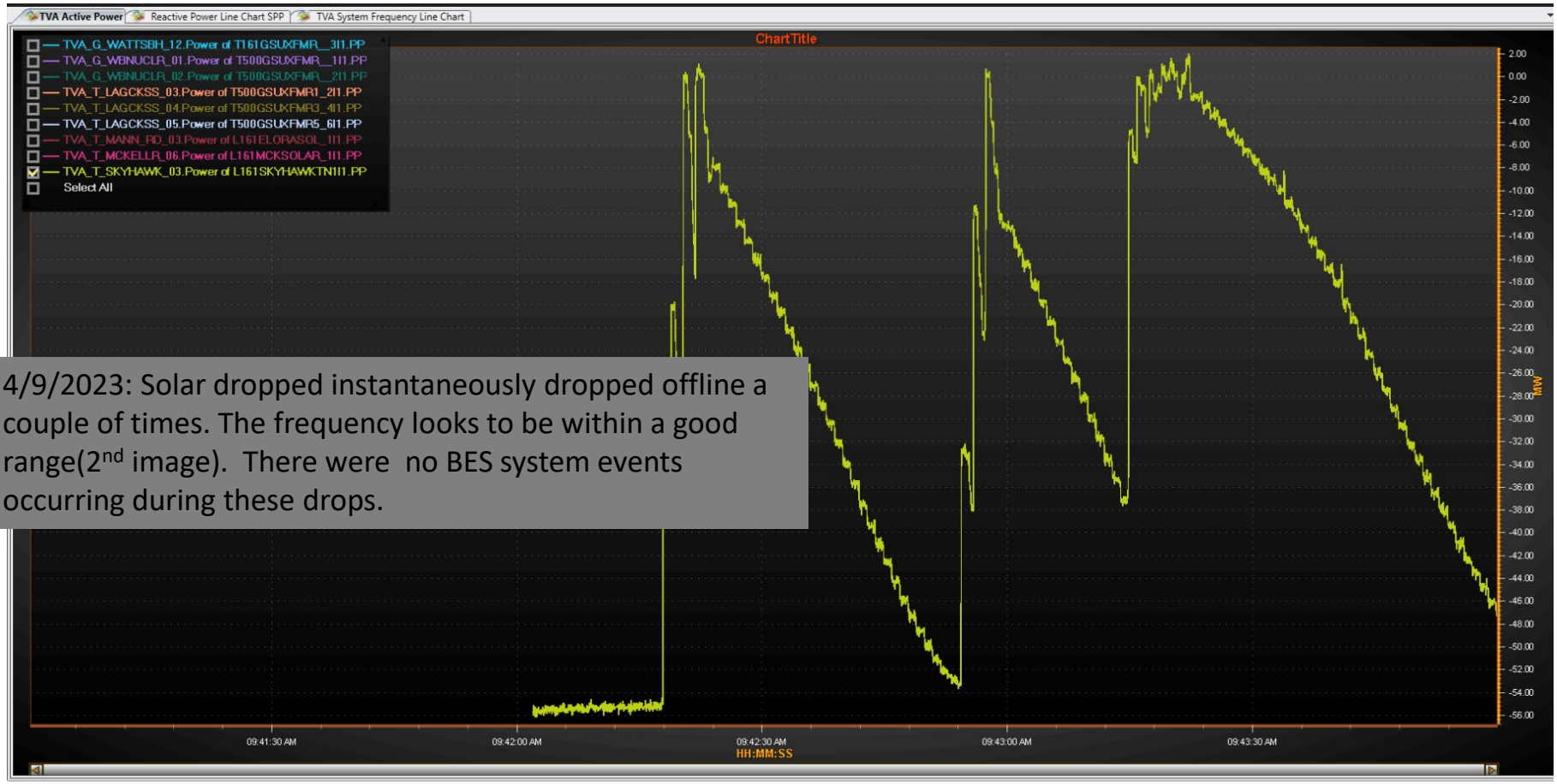

4/9/2023: Solar dropped instantaneously dropped offline a couple of times. The frequency looks to be within a good range(2nd image). There were no BES system events occurring during these drops.

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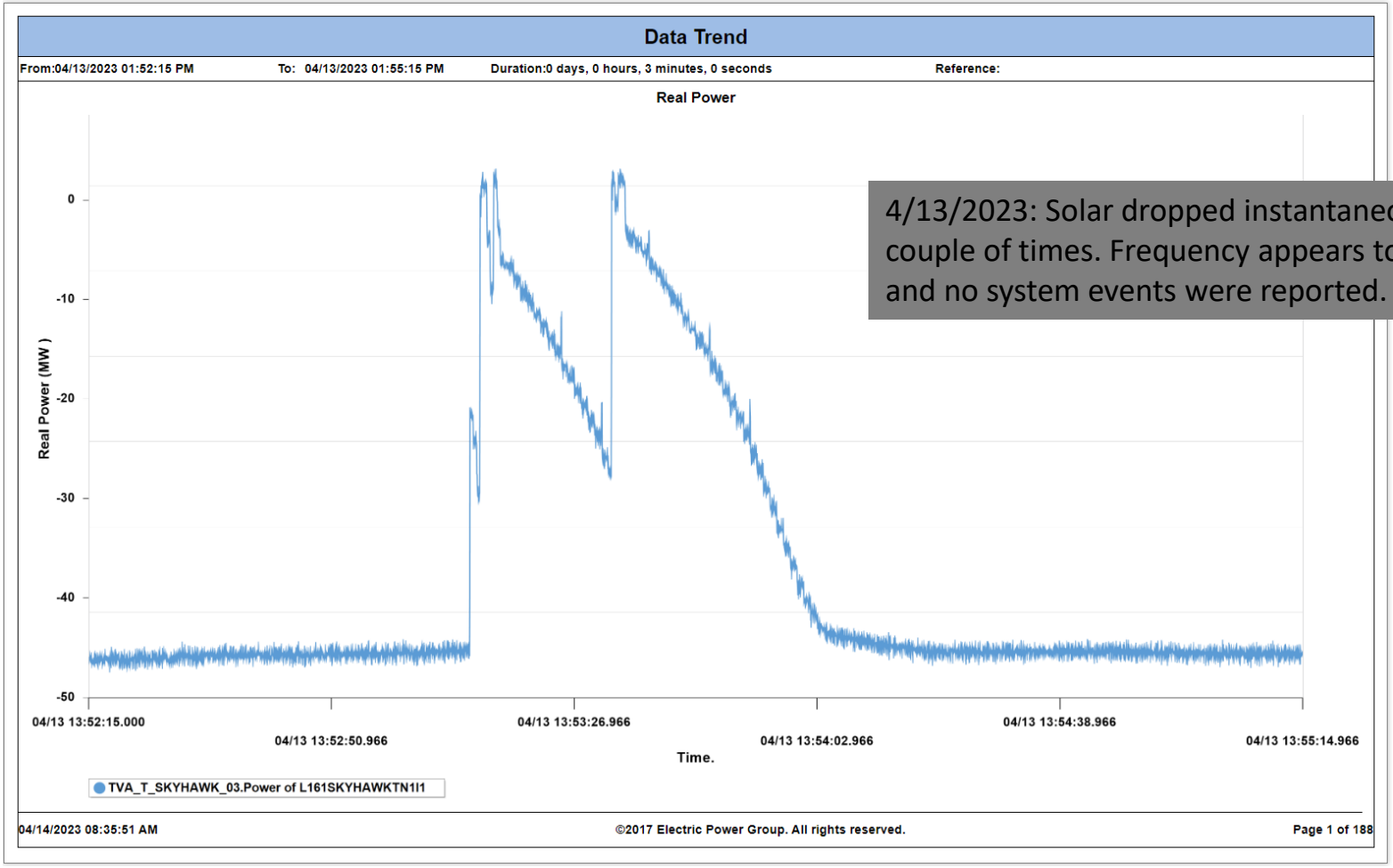

4/13/2023: Solar dropped instantaneously a couple of times. Frequency appears to be good, and no system events were reported.

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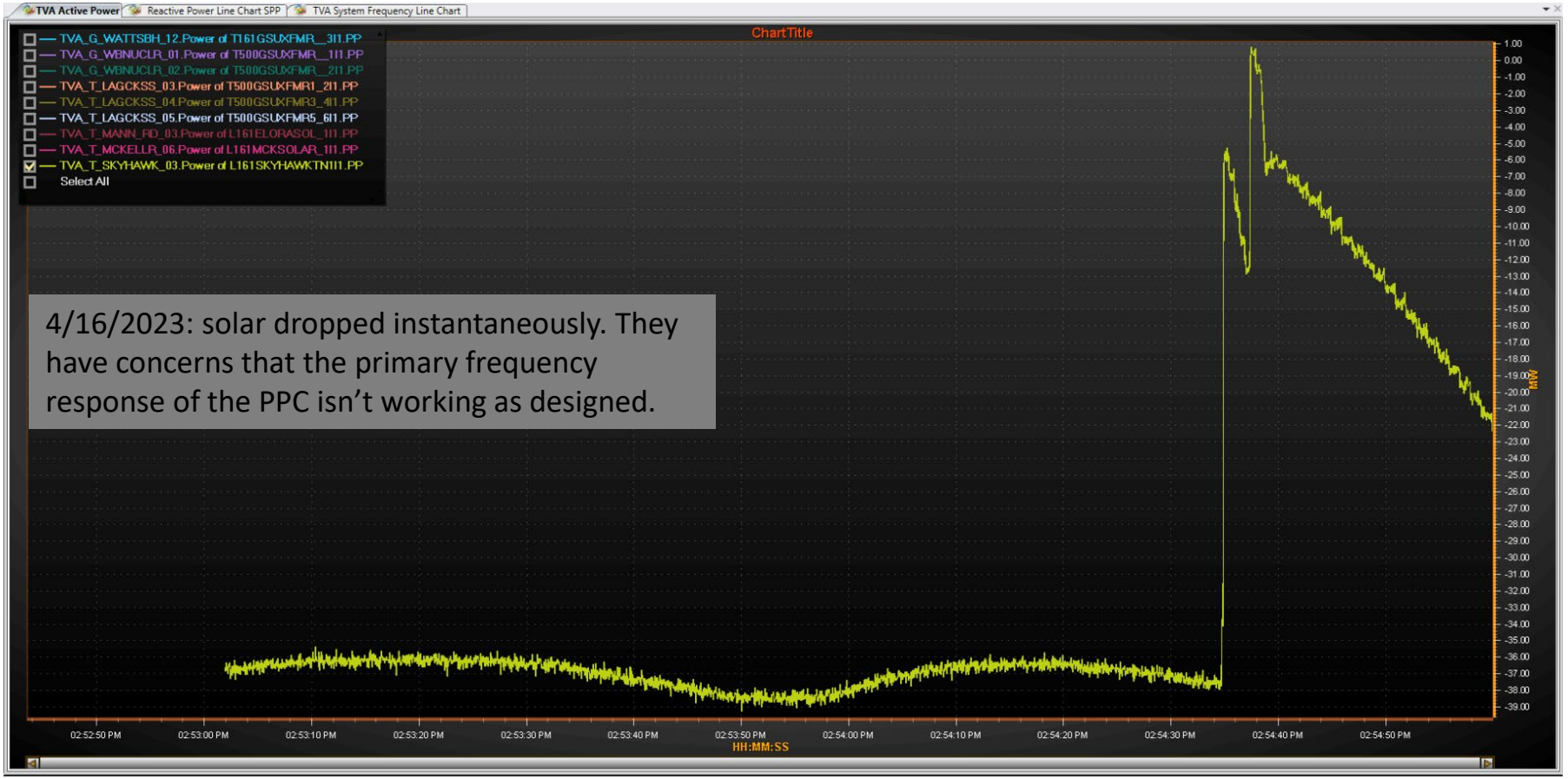

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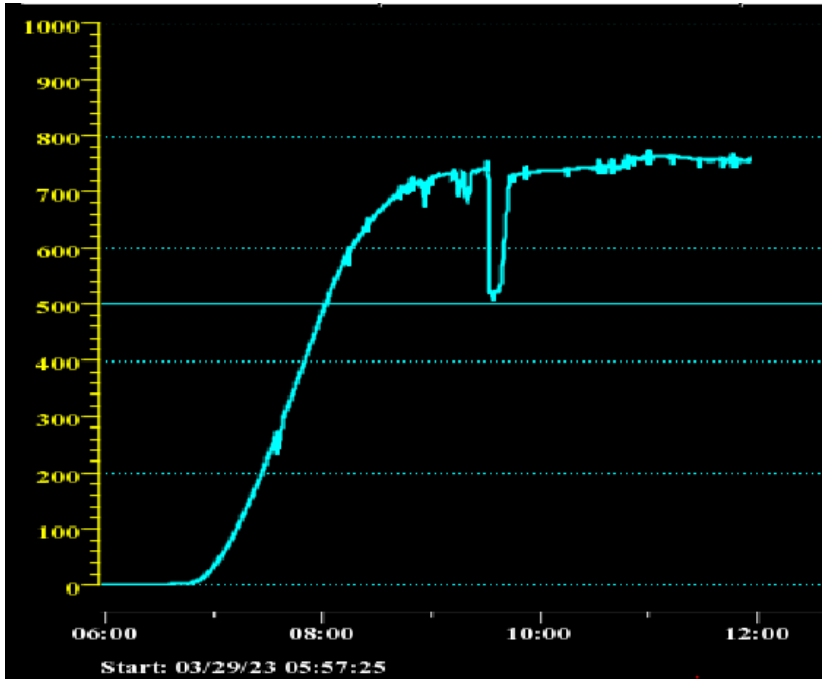
Solar Momentary Cessations

- TVA noticed significant (33%) unexpected drop in total solar generation the morning of 3/29/2023
- Cause determined to be a particular solar site dropped from 224MW (starting 09:31:57) to zero (by 09:32:56)
- Ramp up started 09:38:25
  - Back to 204MW at 09:44:17
- BA contacted plant – they were unaware, so had not notified TVA
- NOTE: There are no known switching events on the TVA system at any of these times



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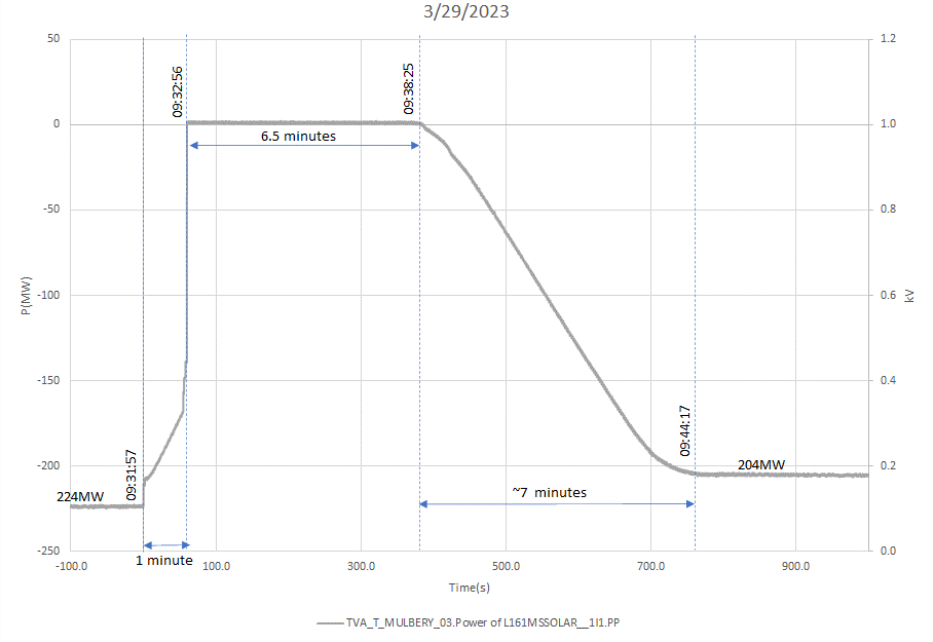
Summary

- 09:30 solar output 224MW
- 09:31:57 solar step change to 210MW, coincident with 0.3kV step increase in 161kV bus voltage (168.2 to 168.5kV)
  - 09:31:59 Additional solar step change to 207MW
  - 09:32:02 Another 0.2kV step increase from 168.4kV to 168.6kV resulted in no MW step change
- 09:31:59 solar began rampdown
  - 09:32:52.000 solar stepdown from 167MW to 158MW
  - 09:32:52.966 solar stepdown from 157MW to 149MW
  - 09:32:55.033 solar stepdown from 147MW to 140MW
  - 09:32:56.966 solar stepdown from 138MW to 0MW
  - NOTE: Plant continued to inject 17MVAR into TVA system until 09:33:06
- 09:38:25 solar began ramping back up
  - 09:44:17 solar at 204MW



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Questions and Answers

Feel free to reach out to us if interested in participating in the NERC IRPS or EMTTF!