

IBR Interconnection Requirements, Latest Developments



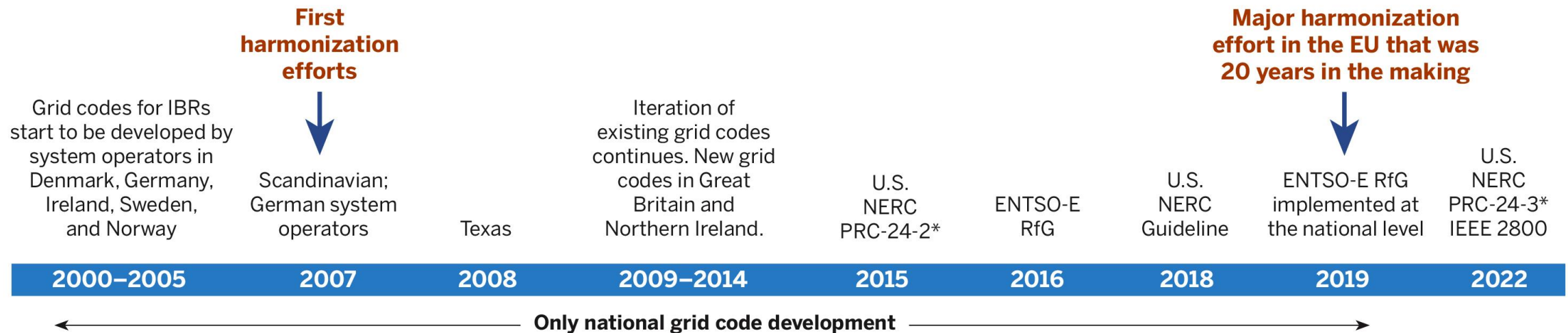
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03/26/2024

Timeline of Harmonization Efforts for IBR Grid Codes in Europe and the United States



- Grid codes specify the capabilities that IBRs must have in order to reliably interconnect to the grid.
- Diversity in grid codes requires multiple product designs and increase equipment costs.
- Comprehensive harmonized grid code for IBRs took 20 years to develop in Europe.
- The U.S. still has no harmonized grid code, some areas only apply minimal requirements as per FERC LGIA

NERC Disturbance Events – Catalyst for IBR Standard Improvements

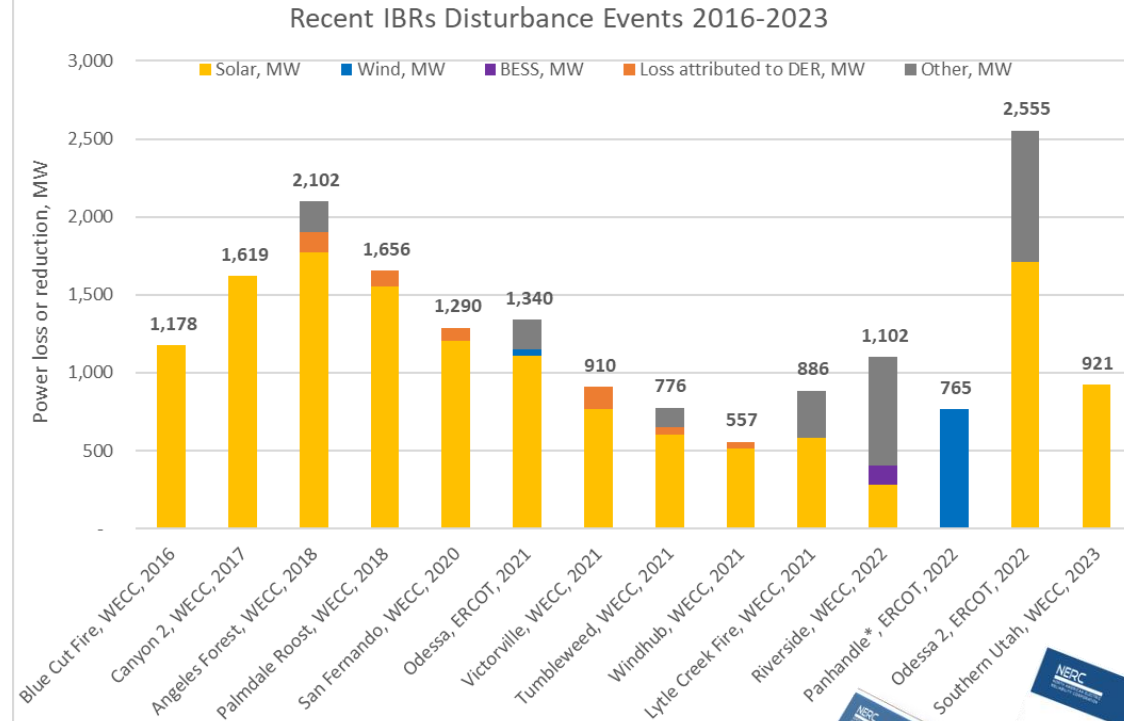


Table 1.1: Causes of Solar PV Active Power Reductions

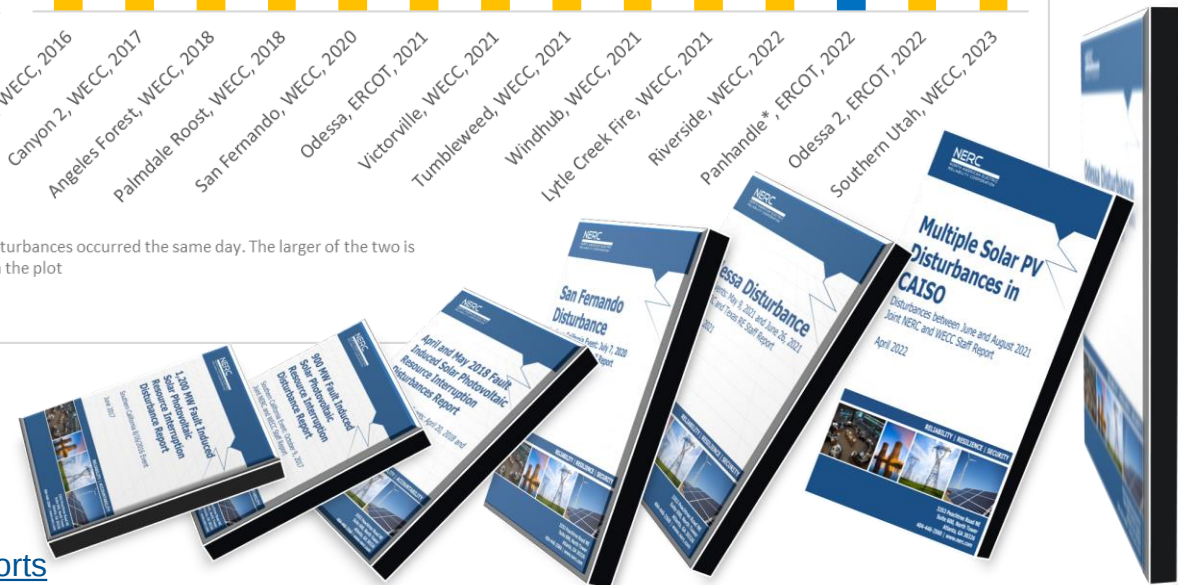
Cause of Reduction	Odessa 2021 Reduction [MW]	Odessa 2022 Reduction [MW]
Inverter Instantaneous AC Overcurrent	–	459
Passive Anti-Islanding (Phase Jump)	–	385
Inverter Instantaneous AC Overvoltage	269	295
Inverter DC Bus Voltage Unbalance	–	211
Feeder Underfrequency	21	148*
Unknown/Misc.	51	96
Incorrect Ride-Through Configuration	–	135
Plant Controller Interactions	–	146
Momentary Cessation	153	130**
Inverter Overfrequency	–	–
PLL Loss of Synchronism	389	–
Feeder AC Overvoltage	147	–
Inverter Underfrequency	48	–
Not Analyzed	34	–

* In addition to inverter-level tripping (not included in total tripping calculation.)

** Power supply failure



* Two disturbances occurred the same day. The larger of the two is shown on the plot



Source: [NERC Event Reports](#)

NERC Disturbance Events, Causes of Tripping



Causes of tripping in eight NERC Disturbance Events

Cause Code	2016 - Blue Cut Fire, CA	2017 - Canyon 2 Fire, CA	2018 - April May events, CA	2020 - San Fernando event, CA	2021 - Odessa 1, TX	2021 - June August events, CA	2022 - Panhandle event, TX	2022 - Odessa 2, TX
AC low voltage protection				x		x		
AC overcurrent protection				x		x		x
AC overvoltage protection					x	x	x	x
DC low voltage protection				x		x		x
DC overcurrent						x		
DC reverse current tripping		x	x					
Instant frequency tripping	x							
Instant overvoltage tripping		x	x					
Intra-plant interactions		x					x	x
Momentary cessation	x	x	x	x	x	x		x
Overfrequency protection						x		
PLL synchronization/phase jump		x			x			x
Slow active power recovery		x		x	x	x	x	
Underfrequency protection					x	x		x

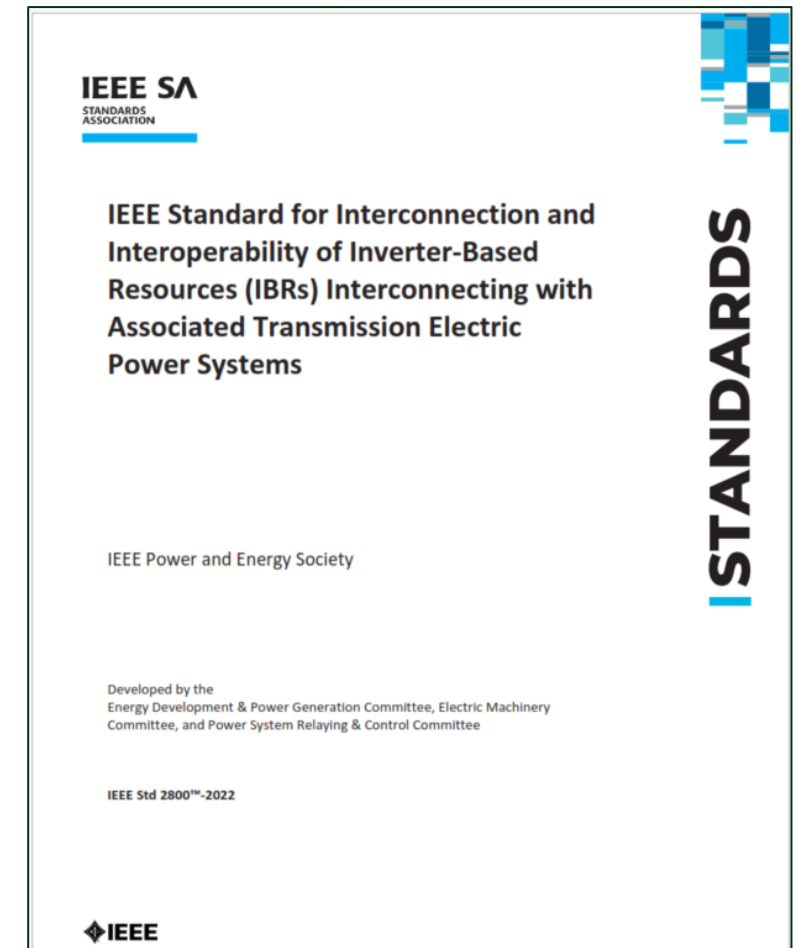
This matrix is MISO's summary of information contained in the reports.



IEEE 2800-2022 Standard

- ❑ The standard **harmonizes** Interconnection Requirements for Large Solar, Wind and Storage Plants
- ❑ It is a **consensus-based** standard developed by over ~175 Working Group participants from utilities, system operators, transmission planners, & OEMs over 2 years
- ❑ It has successfully passed the IEEE SA ballot among 466 SA balloters (**>94% approval**, >90% response rate)
- ❑ **Published on April 22, 2022 (Earth Day)**
- ❑ **Only when adopted by the appropriate authorities, IEEE standards become mandatory**

More Info at <https://sagroups.ieee.org/2800/>



Available from IEEE at <https://standards.ieee.org/project/2800.html>
and via IEEEExplore: <https://ieeexplore.ieee.org/document/9762253/>

IEEE 2800-2022 Adoption Efforts

Source, Jens Boemer, EPRI

'wholesale adoption'



General Reference



- Florida Power and Light
- Salt River Project (reference to IEEE2800 in the PPA)
- Southwest Power Pool



Detailed Reference



- Duke Energy
- ISO-NE
- MISO
- New York ISO
- Ameren ATXI (reference to adopted clauses in the GIA)
- Southern Company



Full Specification



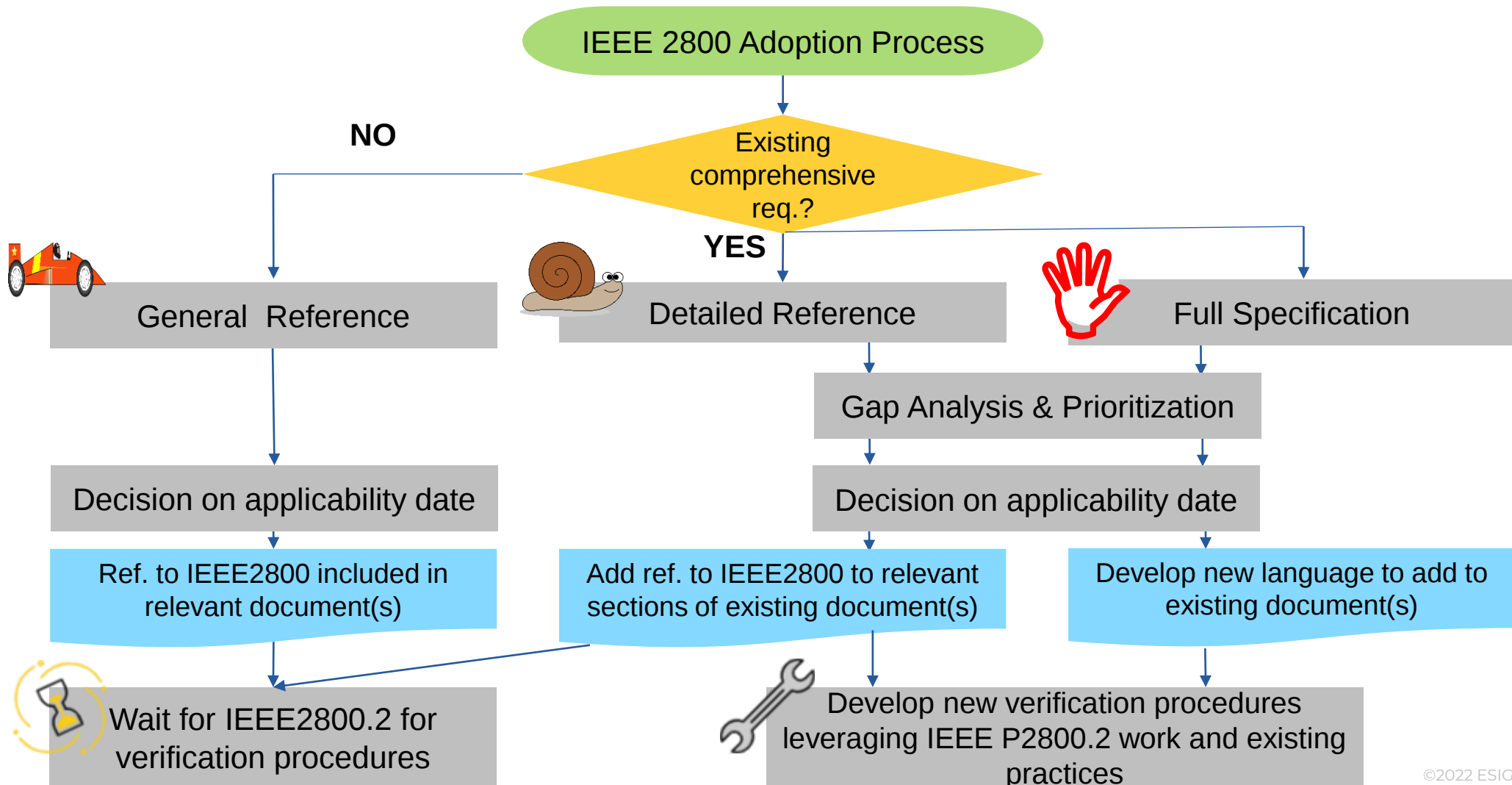
ERCOT

- Ameren IL

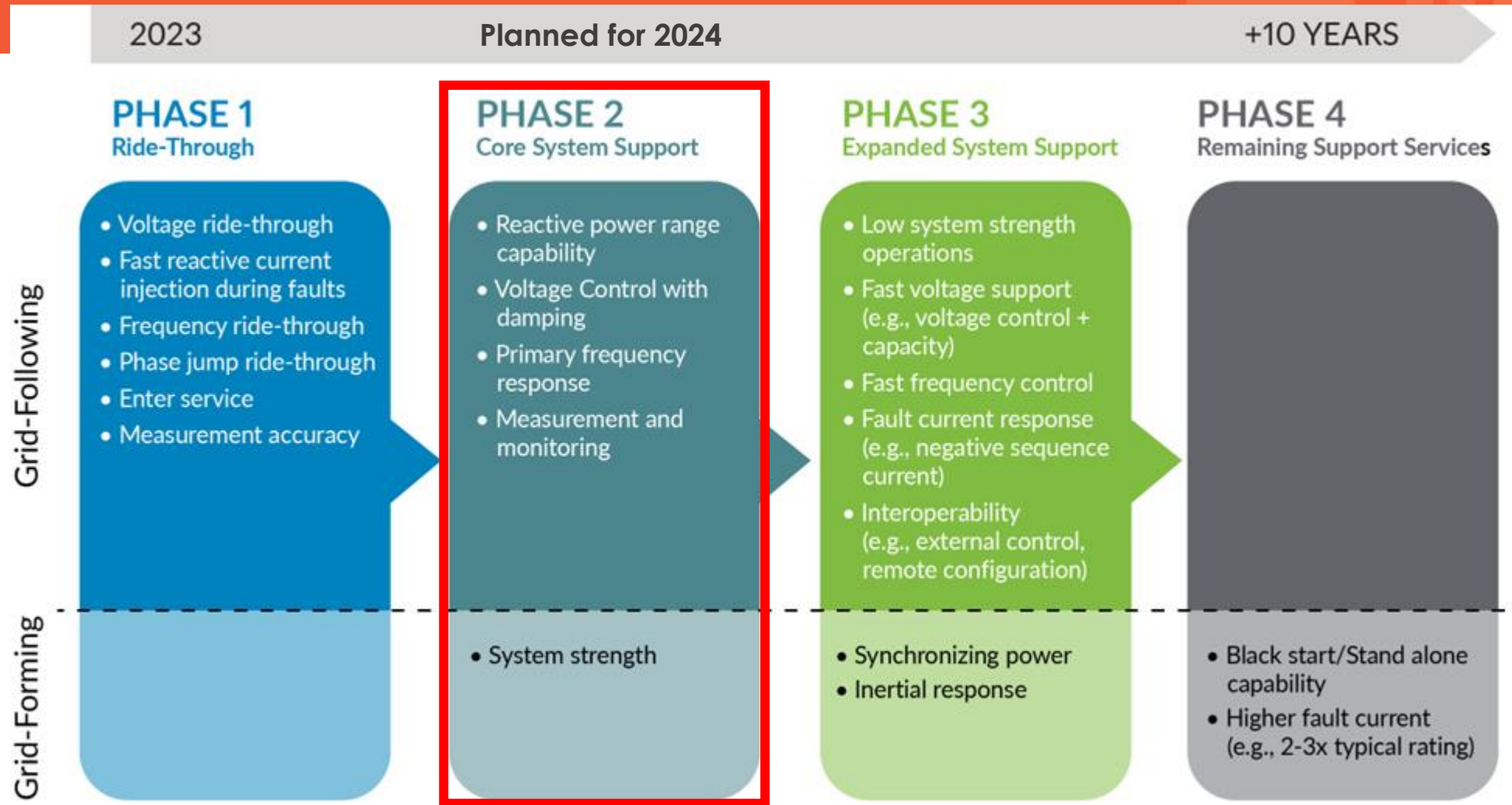


Other Utilities and ISOs Considering IEEE2800-2022 adoption: AESO, BPA, Long Island Power Authority, Great River Energy, Manitoba Hydro, TVA

Adoption Process, Based on Current Practice



Adoption Priorities – MISO



P2800.2 Summary

Title: Recommended Practice for Test and Verification Procedures for Inverter-Based Resources Interconnecting with Bulk Power Systems

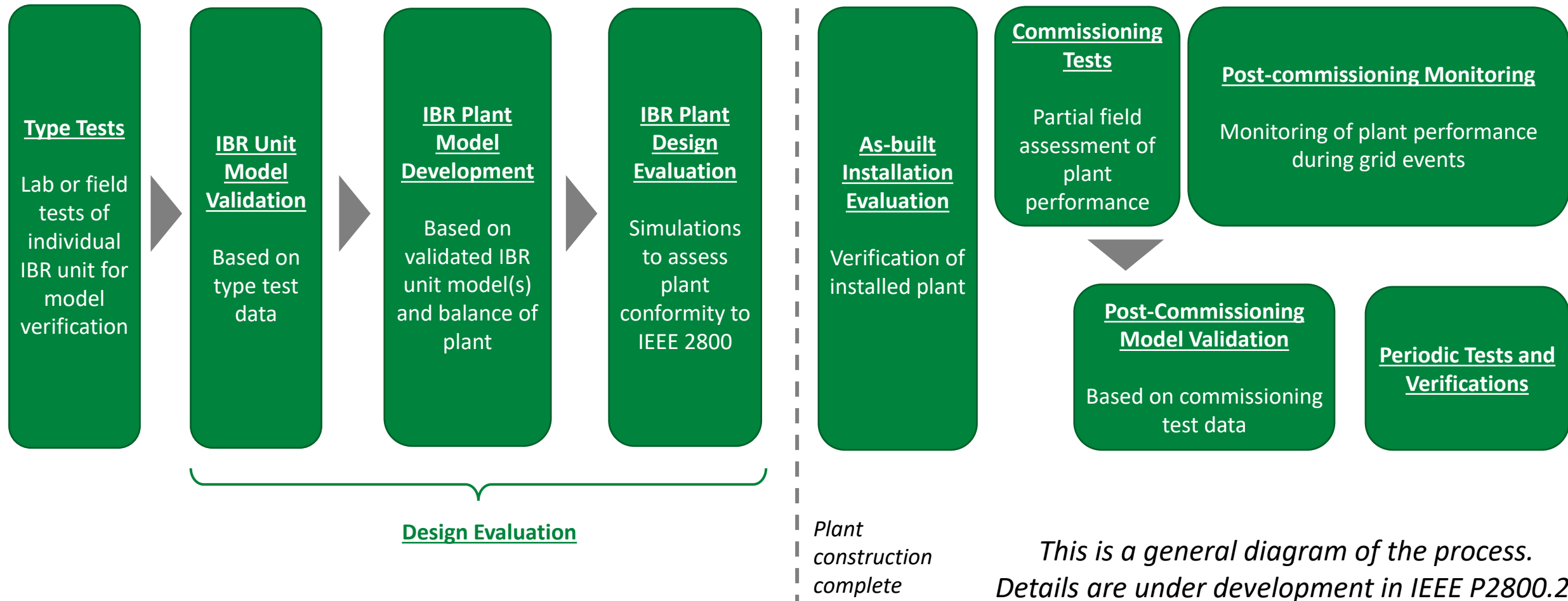
Scope:

- Defines recommended practices for test and verification procedures that should be used to confirm plant-level conformance of IBRs interconnecting with bulk power systems in compliance with IEEE Std 2800.
- Applies to IBRs interconnected to **transmission and sub-transmission** systems
- May also apply to isolated IBRs that are interconnected to an alternating current (AC) transmission system via dedicated voltage source converter high-voltage direct current (VSC-HVDC) transmission facilities, e.g., offshore wind farms
- Includes specifications for the equipment, conditions, tests, modeling methods, and other verification procedures that should be used to demonstrate conformance with IEEE 2800

Overview of conformity assessment steps in IEEE P2800.2

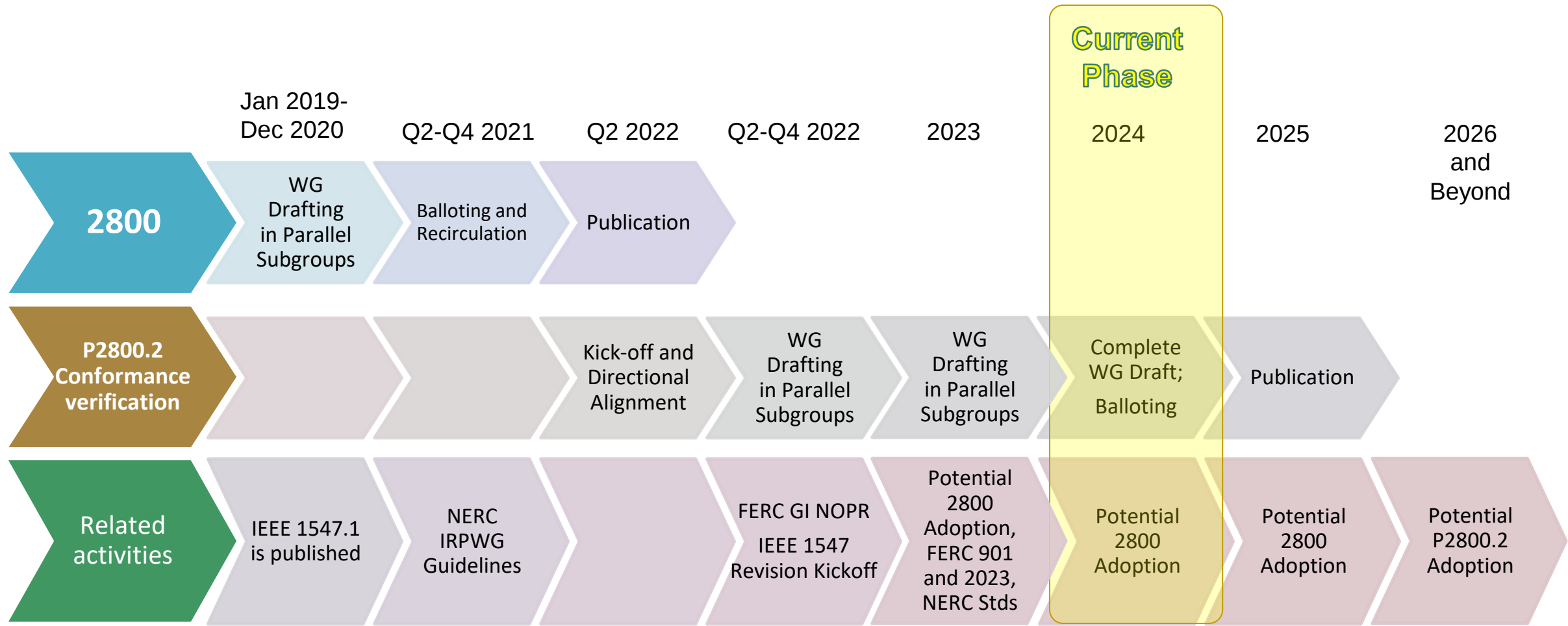
Recommended Practice for Test and Verification Procedures for IBRs

Interconnecting with Bulk Power Systems



*This is a general diagram of the process.
Details are under development in IEEE P2800.2.
Some variations permitted.*

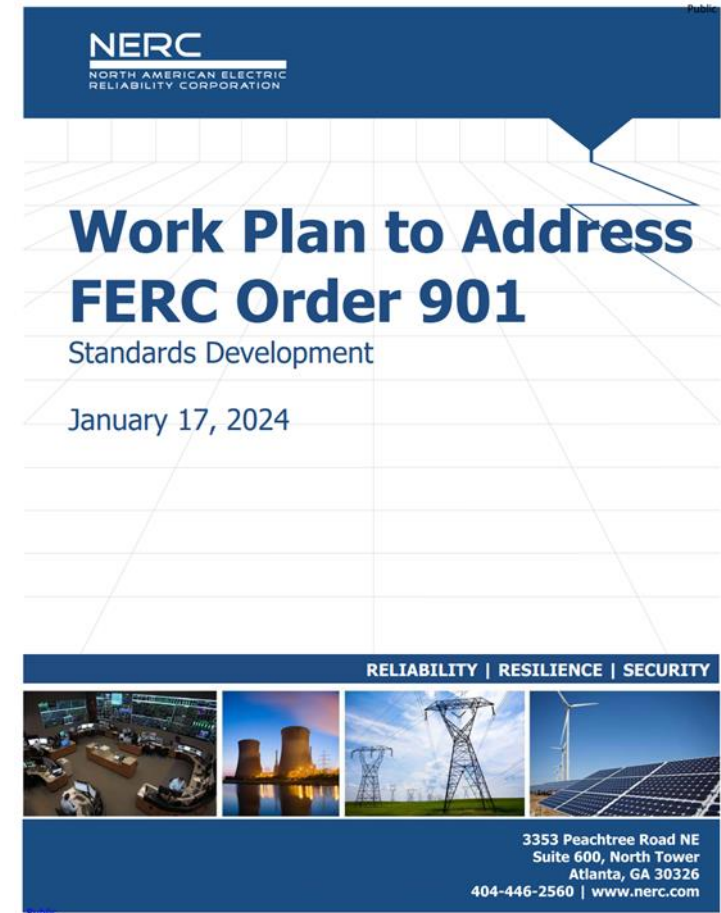
Potential Adoption Timeline



FERC Order 901 and NERC Work Plan



- FERC Order 901 issued on October 19, 2023
- Directs NERC to submit a detailed standards development plan to address IBR reliability gaps in four areas
 - Data sharing
 - Model validation
 - Planning and operational studies
 - Performance requirements
- Informational filing due by January 17, 2024
- New or modified standards to be submitted by November 2026



NERC Order 901 Response Milestones



- ✓ 1. Submission of Order No. 901 Work Plan – Completed: **01/17/2024**
 - 2. Development and filing of Reliability Standards to address
 - Disturbance Monitoring Data Sharing,
 - Performance Requirements, and
 - Post-Event Performance Validation for Registered IBR
 - 3. Development and filing of Reliability Standards to address
 - Data Sharing and Model Validation for all IBR – Proposed completion: **11/4/2025**
 - 4. Development and Filing of Reliability Standards to Address
 - Planning and Operational Studies Requirements for all IBR Proposed completion: **11/4/2026**
- Proposed completion: **11/4/2024**

NERC High Priority Projects



Completed by the End of 2024		
2020-02 Modifications to PRC-024 (generator ride-through)	2021-03 Modifications to CIP-002 (TOCC)	2021-07 Extreme Cold Weather
2021-04 Modifications to PRC-002 (data sharing)	2016-02 Virtualization	2023-07 TPL-001 Extreme Weather
2023-02 Performance of IBRs	2023-03 Internal Network Security	2022-03 Energy Assurance (Operations)
	2023-04 CIP-003 Low Impact Criteria	
	2023-06 Physical Security	

11 high priority projects after reprioritization

NERC Medium to Low Priority Projects



Completed by 2025 and Beyond		
2022-05 CIP-008	2020-06 Verification of Model and Data for Generators	2021-01 Verification and data reporting for active and reactive power
	2023-01 EOP-004 IBR Event Reporting	
2017-01 Modifications to BAL-003-1.1	2019-04 Modifications to PRC-005-6	2021-02 Modifications to VAR-002-4.1
2021-08 Modifications for FAC-008	2022-01 Reporting ACE Definition and Associated Terms	2022-02 MOD-032, TPL-001 Footnote 13d
2022-04 EMT Models in NERC MOD, TPL, FAC Standards	2023-05 FAC-001/FAC-002 DER	2023-08 MOD-031 Demand and Energy

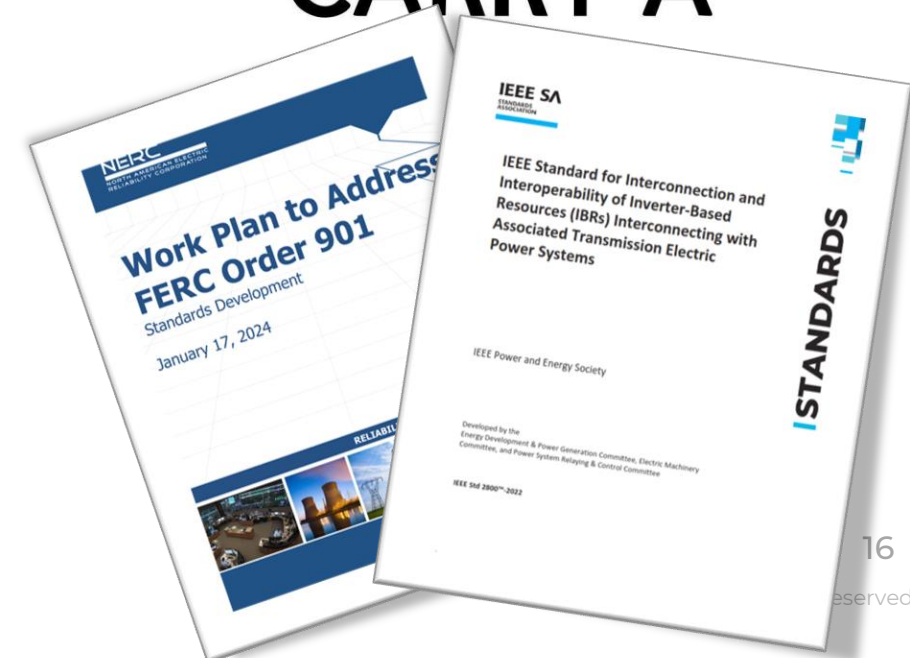
13 medium and low priority projects after reprioritization

Conclusions



**DON'T
PANIC
AND
CARRY A**

- Developers will build plants to existing minimum requirements.
- To maintain reliability with higher shares of IBRs comprehensive interconnection requirements are needed, incentivizing IBRs with state-of-the-art capabilities
- Adoption of IEEE2800 can provide harmonized set of interconnection requirements as well as uniformity and enhanced performance of the future IBR fleet.
- FERC Order 901 also recognizes this need for comprehensive IBR performance requirements and NERC Standards will follow.
- **Important to actively participate in industry forums:**
 - NERC Standard Drafting Teams
 - IEEE P2800.2,
 - NERC IRPS





THANK YOU

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