

Interconnection Study Process, Reliability Implications, and Possible Improvements

Preliminary thoughts regarding FERC's NOPR on Improvements to Generator Interconnection Procedures and Agreements

Jens Boemer, Technical Executive

Joint ESIG-NAGF-NERC-EPRI Generator Interconnection Workshop
Session 3: Interconnection Studies

August 10, 2022



Acknowledgements and Disclaimers

- EPRI conducts research and development relating to the generation, delivery, and use of electricity for the benefit of the public. **EPRI does not provide recommendations or regulatory advice related to the contents of this presentation.**
- **EPRI reserves the right to submit comments to ongoing and future FERC solicitations** related to the contents of this presentation and these comments may or may not be identical to the content presented here.
- **All comments provided reflect only the view of the EPRI technical experts** performing the review and do not necessarily reflect the opinions of those supporting and working with EPRI to conduct collaborative research and development.
- Part of this work was **supported in part by the National Renewable Energy Laboratory**, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Solar Energy Technologies Office and Wind Energy Technologies Office.
- Part of this work is **supported by the U.S. Department of Energy, Solar Energy Technologies Office** under Award Number DE-EE0009019 Adaptive Protection and Validated MODels to Enable Deployment of High Penetrations of Solar PV (PV-MOD).
- The views expressed in the presentation do **not necessarily represent the views of the DOE or the U.S. Government.**

Why We Are Here: Today's Interconnection Process

Generation Interconnection Queue Process

Technical Update

Project Manager
M. Bello

Product ID: 3002020483

September 2021

www.epri.com

- Backlog and long process
- Lack of technical standards
- Diversity of processes
- Different level of technical detail for models & studies
- Often not automated

ISOs/RTOs Interconnection Process Scope & Durations

FERC LGIP	CAISO	ISO-NE	NYISO	PJM	MISO	ERCOT	SPP	Ranges of Duration
Interconnection Request	Request Initiated							
Feasibility Study	Phase 1 Study (6 months)	Feasibility Study (3 months)	Optional Feasibility Study (3 months)	Feasibility Study (3 months)	Defining Planning Phase (DPP) Phase I Preliminary System Impact (4 ½ months)	ERCOT Screening Study (6 months)	Definitive Interconnection System Impact Study (DSIS) Phase 1 (3 months)	3 to 6 months
System Impact Study	Phase 2 Study (7 months)	System impact Study (9 months)	System Reliability Impact Study (3 months)	System Impact Study (4 months)	DPP Phase II Revised System Impact Study (2 ½ months)	Full Interconnection Study (FIS) (10 months)	DSIS Phase 2 (4 months)	2 ½ to 9 months
Facilities Study	System Impact and Facilities Study (4 months)	Facilities Study (3 to 6 months)	Class Year Interconnection Facilities Study (12 months)	Facilities Study (6 months)	DPP Phase III Final System Impact Study (3 ½ months)	Facility Study (3 months)	Facilities Study (4 ½ months)	3 to 12 months

Generation Interconnection Queue Process. EPRI. Palo Alto, CA: 2021. 3002020483. [Online] <https://www.epri.com/research/products/000000003002020483>

www.epri.com

© 2021 Electric Power Research Institute, Inc. All rights reserved.

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Generation Interconnection Queue Process. EPRI. Palo Alto, CA: 2021. 3002020483. [Online] <https://www.epri.com/research/products/000000003002020483>

Why We Are (Also) Here: Reliability Issues with IBR

Observed Solar PV Reliability Issues Are Rooted in Insufficient Unit Performance and Plant Design:

Inverter related causes

- PLL Loss of Synchronism
- AC Under- or Overvoltage
- Under- or Overfrequency
- Momentary Cessation
- Inverter AC Overcurrent
- Inverter DC Voltage

Plant controller related causes

- Slow Active Power Recovery

Collector system related causes

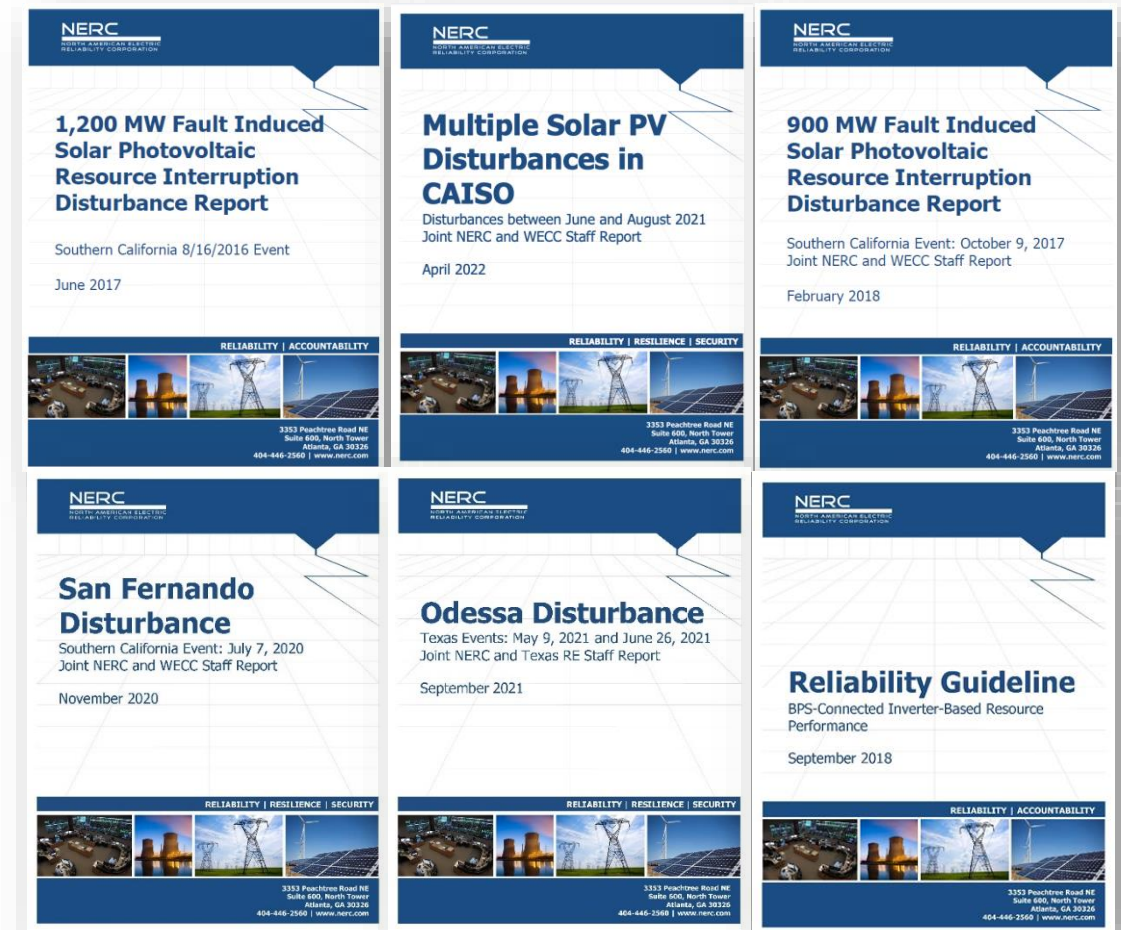
- Feeder AC Overvoltage
- Feeder Underfrequency

NERC recommendations call for more than just guidelines:

➤ Improvements to NERC Reliability Standards

- Improvements to Performance-Based Requirements
- Performance Assessment and Mitigation
- Ride-Through Standard In Lieu Of PRC-024-3
- Analysis and Reporting of Inverter-Based Resource Reductions
- Electromagnetic Transient Modeling and Studies for All Newly Interconnecting Inverter-Based Resources

➤ Significant Updates and Improvements to the FERC Generator Interconnection Agreements

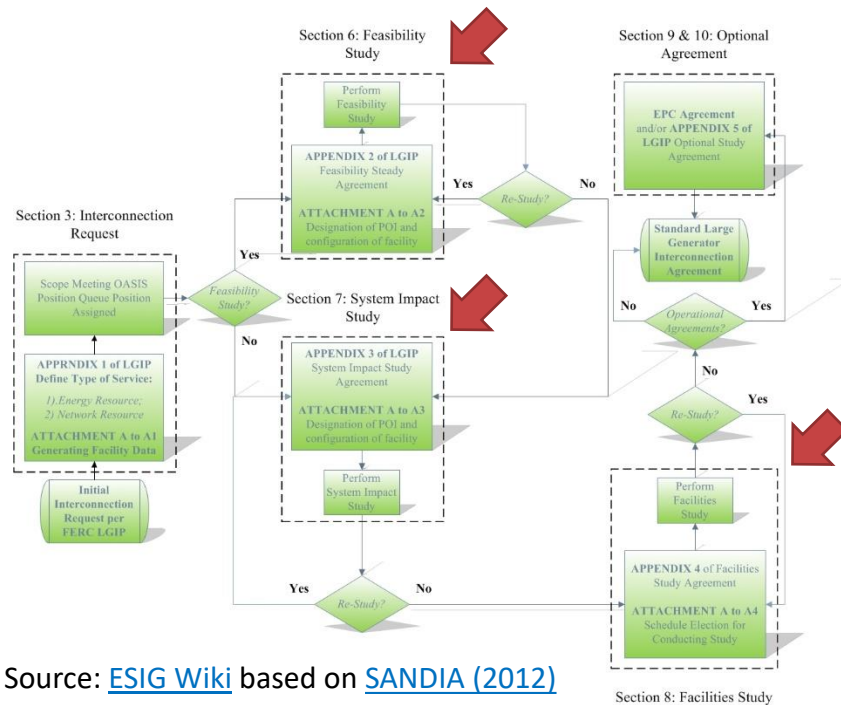


NERC Quick Reference Guide: Inverter-Based Resource Activities

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

North American Interconnection Procedures

FERC pro forma Large Generator Interconnection Procedures (LGIP)



Source: [ESIG Wiki](#) based on [SANDIA \(2012\)](#)

Feasibility Study

- Input: Designated/alternative POIs
- Purpose: identify thermal/voltage limit violations & estimate grid upgrade costs
- Scope: power flow and short circuit analysis (steady state)

System Impact Study

- Input: as above
- Purpose: evaluate reliability impact on transmission grid
- Scope: short-circuit, stability, power flow analysis

Facilities Study

- Purpose: estimate cost of the equipment, engineering, and construction work; identify electrical configurations of the transformer(s), switchgear, meters, and other station equipment; identify the nature and estimated cost of any transmission network upgrades

How to Improve Process Efficiency and Maintain Reliability?

FERC NOPR on Improvements to Generator Interconnection Procedures and Agreements (RM22-14)

- Press release available [here](#).
- Key areas of reforms:
 - Implement a first-ready, first-served cluster study process
 - Improve interconnection queue processing speed
 - **Incorporate technological advancements into the interconnection process**
 - **Update modeling and performance requirements for system reliability**

The screenshot shows the FERC website's news release page for 'FERC Proposes Interconnection Reforms to Address Queue Backlogs'. The page includes a navigation menu on the left with categories like 'Industries & Data', 'Public Participation', 'Enforcement & Legal', 'News & Events', 'About', and 'FERC Online'. The main content area features the title, date (June 16, 2022), and social media sharing options. Below the title, it states 'Docket No. RM22-14' and 'Items E-1 | Staff Presentation'. The text of the release describes the proposed rule aimed at expediting the interconnection process for new electric generation facilities. A quote from FERC Chairman Rich Glick is included, along with a note that the proposed rule includes several key areas of reforms. On the right side, there is a 'Contact Information' box for Mary O'Driscoll and a 'Latest News' section with a headline about environmental impact statements.

Focus of this presentation

Comments are due 130 days from publication in Federal Register : October 13, 2022

NERC IRPS Work Item #8: Summary of Recommendations¹

Recommendation 1

Paradigm shift towards IBRs as the “Good Citizen” – *Integrating a unified minimum set of IBR capability prior to its potential future utilization*

- ***Adoption of IEEE 2800-2022 as soon as possible (with additional guidance before P2800.2 is available)***

Recommendation 2

Interconnection Process Improvements – *Pre-commissioning and post-commissioning plant-level performance conformity assessment and verification*

- ***Revise FERC LGIP and associated ISOs/RTOs/TOs interconnection processes***

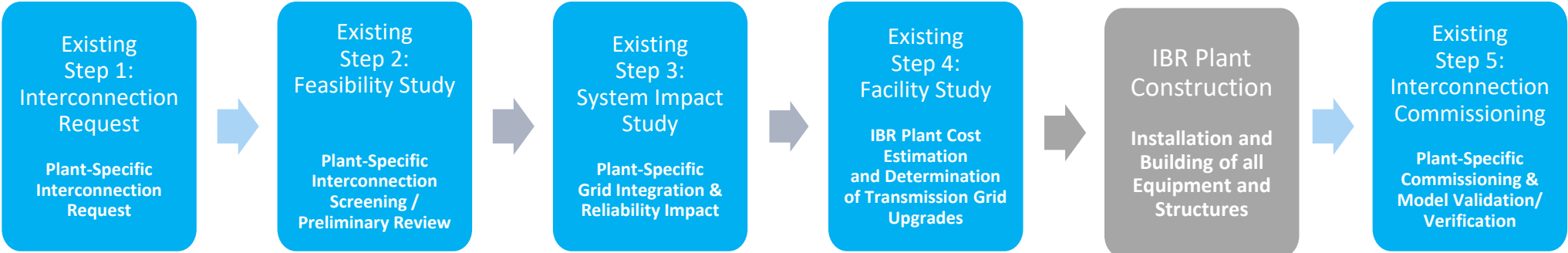
Recommendation 3

▪ Education and Collaboration – *Continuous and Iterative Improvement of IBR Performance Requirements, Plant-Level Modeling, and Model Validation*

- ***Engage in IEEE P2800.2 (Recommended Practice for IEEE 2800 Test and Verification Procedures)***

¹ The views presented on this slide reflect the personal views of the individuals presenting it and shall not be considered the official position of the **North American Electric Reliability Corporation** or any of its committees. The slide aims to outline the perceived consensus lines of the stakeholders involved in the applicable NERC IRPS Subgroup but may not be supported by all of its participants.

Review of Challenges and Opportunities for North America Interconnection Process



- **Insufficient**, diverse, or vague RTO/ISO/TP's technical interconnection requirements (**TIRs**)



- Submission of **any available models**, often **inappropriately configured**

- **Vague model 'acceptance criteria'**

Limited screening for:

- Grid strength metrics (neither conventional nor advanced)

that could help determine **whether at all, and what type of models and system impact studies** would be needed to reliably connect the IBR.

- System impact studies often use **insufficient and invalid models** that may **not** be **site-specific** and **may be configured with generic** parameters
- May **not represent** IBR units, supplemental IBR devices, and **the IBR plant design** ultimately commissioned in the field

- **No common assessment of IBR plant-level conformity** with regard to RTO/ISO/TP's technical interconnection requirements (TIRs)
- Detailed **IBR plant design may change** after Interconnection Agreement (IA) is executed

- What is built in the field does often not match what had been previously studied/modeled
- **No "as-built" plant-level evaluation**

- Only a (limited) set of field tests are performed to validate/verify IBR plant model.
 - Limited to small-signal disturbances.
 - Often **no verification of** large-signal disturbances such as **ride-through**

- **Limited collection of field data** to validate/verify IBR plant model.
 - Often not for large-signal disturbances.



IEEE 2800-2022
IEEE Standard for Interconnection and Interoperability of Inverter-Based Resources (IBRs) Interconnecting with Associated Transmission Electric Power Systems



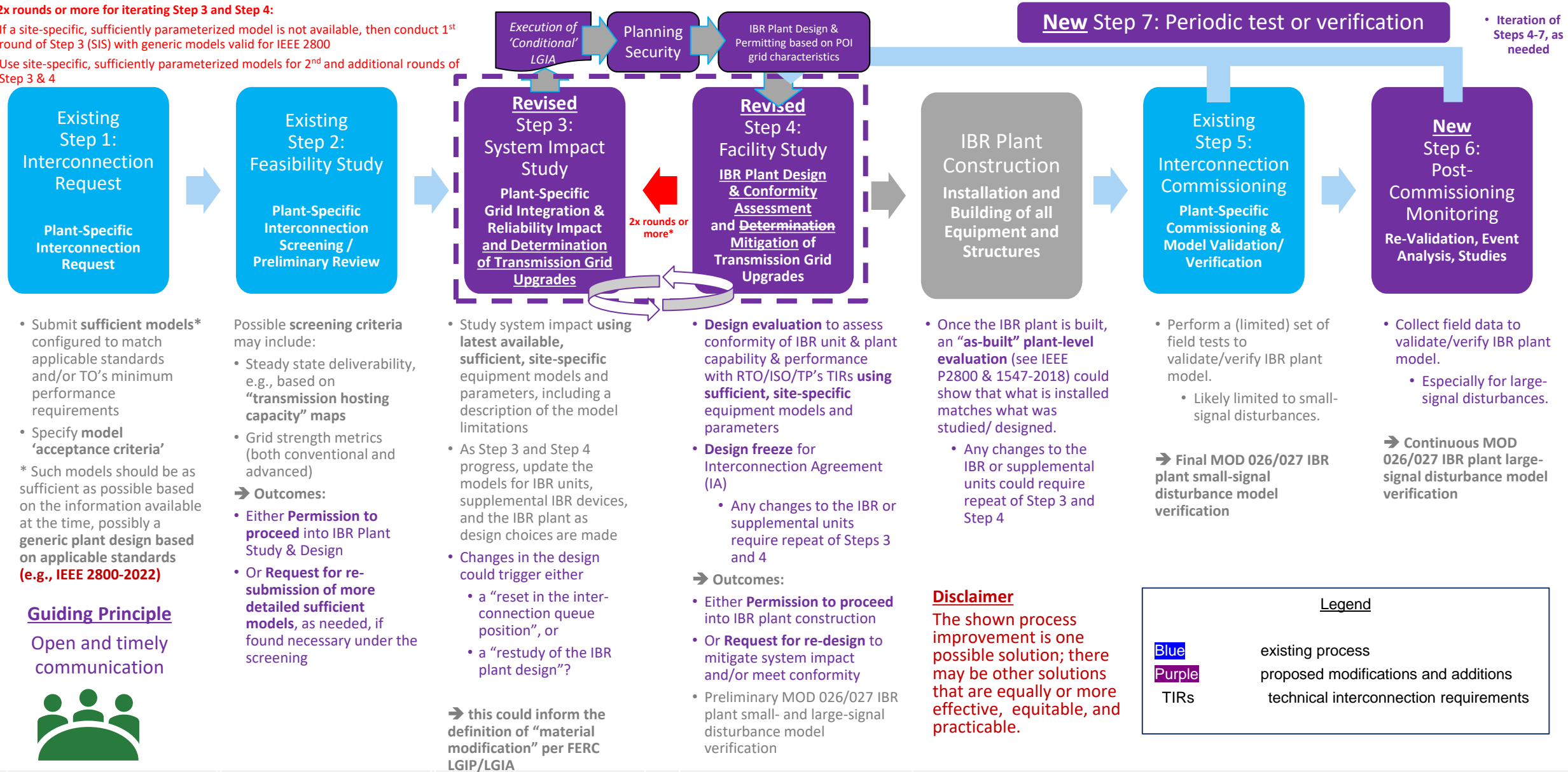
P2800.2
Recommended Practice for Test and Verification Procedures for Inverter-based Resources (IBRs) Interconnecting with Bulk Power Systems

IEEE SA: <https://standards.ieee.org/ieee/2800.2/10616/>
 P2800.2 WG: <https://sagroups.ieee.org/2800-2/>

Possible Inference for Interconnection Process Improvements

* 2x rounds or more for iterating Step 3 and Step 4:

- If a site-specific, sufficiently parameterized model is not available, then conduct 1st round of Step 3 (SIS) with generic models valid for IEEE 2800
- Use site-specific, sufficiently parameterized models for 2nd and additional rounds of Step 3 & 4



Support Reforms by Education and Collaboration

Get involved...!

ESIG Reliability Working Group

- Scope: modeling, grid codes and interconnection requirements, weak grids, grid forming converters, etc.
- Contact: [Jason MacDowell](#), GE Power | Web: <https://www.esig.energy/reliability-working-group/>
- Deliverables: technical reports, webinars | meets 3-4x times per year

NERC IRPS Subgroup Work Item #8

- Scope: interconnection process and studies
- Contact: [Ryan Quint](#), NERC | Web: <https://www.nerc.com/comm/RSTC/Pages/IRPWG.aspx>
- Deliverables: NERC reliability guideline | meets every other week

IEEE P2800.2 Working Group

- Scope: recommended practices for test and verification procedures for plant-level conformance
- Contact: [Andy Hoke](#), NREL | Web: <https://sagroups.ieee.org/2800-2/>
- Deliverables: IEEE recommended practice | WG meets 3-6x times per year; subgroups meet every other week

NERC Reliability Standards Drafting Teams

- MOD 026/027 Revision: [Brad Marszalkowski](#) | Web: https://www.nerc.com/pa/Stand/Pages/Project-2020_06-Verifications-of-Models-and-Data-for-Generators.aspx
- TPL-001-5.1 and MOD-032-1 Modifications: [Ben Wu](#) | Web: <https://www.nerc.com/pa/Stand/Pages/Project2022-02ModificationstoTPL-001-5-1andMOD-032-1.aspx>
- Modifications to FAC-001 and FAC-002: | Web: <https://www.nerc.com/pa/Stand/Pages/Project-2020-05-Modifications-to-FAC-001-and-FAC-002.aspx>

Open or Future FERC Dockets

- Scope based on Federal Power Act
 - Section 205 and 206: Office of Energy Markets and Regulations (OEMR) – transmission generation interconnection process
 - Section 215: Office of Electric Reliability – reliability standards
- [FERC NOPR on Improvements to Generator Interconnection Procedures and Agreements \(RM22-14\)](#) – comments due October 13, 2022

Preliminary Considerations for FERC's NOPR on Improvements to Generator Interconnection Procedures and Agreements¹ (1/2)

Update modeling and performance requirements for system reliability

- *For performance **requirements**, could FERC refer to existing IEEE standards 2800-2022 and 1547-2018/1547a-2020?*
 - IEEE standards are available to anyone (for purchase) and have been developed in a standards development process that is rooted in consensus, due process, openness, right to appeal and balance.
 - There is precedence in FERC orders, NERC reliability standards, and State PUCs' regulations for references to IEEE standards. Similar frameworks exist in other countries.
 - Referring to technical standards like IEEE can increase specificity and configurability of performance requirements.
 - Need for a set of criteria to determine when IEEE 2800 or 1547 be used for certain sub-transmission connected IBR plants.
- *For performance **verification**, could FERC refer to the evolving IEEE P2800.2 recommended practices? It may include:*
 - Requirements for type testing to ensure IBR unit conformity and availability of measurement data for model validation.
 - New procedures for plant-level conformity assessment prior to construction during "design evaluation".
 - Mandatory "as-built evaluation" after construction to compare against the previously evaluated plant design.
 - Continuous monitoring after commissioning for continuous performance conformity assessment and model validation.
- *How can **validated** models be submitted with an interconnection request at a time when plant equipment is not yet selected?*
 - Plant equipment like IBR units (inverters) and supplemental IBR devices (like plant controller, reactive devices, etc.) may not be firmly selected until a (conditional?) LGIA has been executed.
- ...

¹ EPRI reserves the right to submit comments to ongoing and future FERC solicitations related to the contents of this slide and these comments may or may not be identical to the content presented here.

Preliminary Considerations for FERC's NOPR on Improvements to Generator Interconnection Procedures and Agreements¹ (2/2)

Incorporate technological advancements into the interconnection process

- *Would **changes** in plant design, e.g., IBR units, be considered a “material modification”? If not, would such changes still require a re-submission of validated models? If so, how could that impact the timeline of the studies/process?*
- ...

Other issues

- *What about existing plants that do not perform as desired?*
- *What about plants that are currently in the interconnection queue?*
- ...

¹ EPRI reserves the right to submit comments to ongoing and future FERC solicitations related to the contents of this slide and these comments may or may not be identical to the content presented here.

Summary & Conclusions

- **Inverter unit conformity** with technical interconnection requirements / grid codes **does not guarantee plant-level conformity.**
- **Plant-level conformity assessment *prior to construction* requires validated equipment information** for use in IBR *design evaluation*.
 - Conformity assessment could range from the use of **check lists** to detailed equipment and plant **modeling**
 - If IEEE 2800-2022 is widely adopted, a “**common and sufficient**” **IBR plant design** may evolve that could allow for a **simplified design evaluation** and inform the **configuration of generic IBR plant models**
 - ***Transmission planners could develop new practices and contribute to IEEE P2800.2 (Recommended Practice for IEEE 2800 Test and Verification Procedures)***
- **North American interconnection practices/studies** for large IBRs could be improved.
 - Could **leverage international learnings** in IEC¹, ENTSO-e, German VDE and FGW², AEMO, et al.
 - ***FERC could fill some important gaps that have not been identified in the recent NOPR***

¹ IEC TS 63102:2021 Grid Code Compliance Assessment Methods For Grid Connection Of Wind And PV Power Plants

² VDE-AR-N 41xx, FGW Technical Guidelines TG3 (Measurements), TG4 (Modeling & Validation), and TG8 (Certification)

Jens Boemer

Technical Executive

Grid Operations & Planning | DER Integration

+1 (206) 471-1180

jboemer@epri.com

Mahdi Hajian

Senior Technical Leader

Grid Operations & Planning

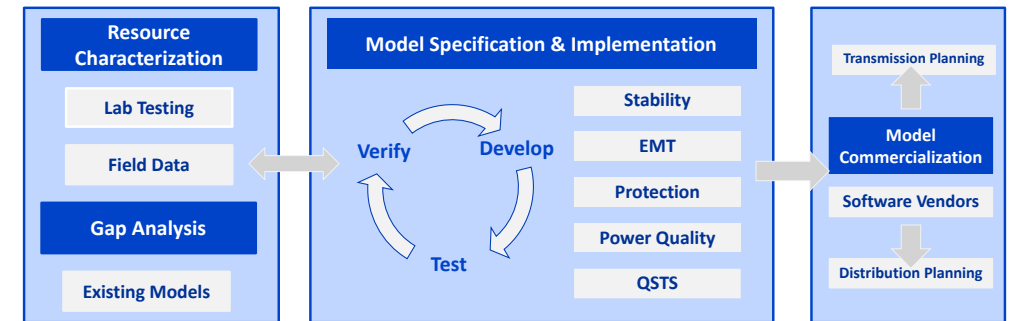
+1 (650) 855-1005

MHajian@epri.com

Thank you!

- More info available at:

<https://www.epri.com/pvmod>



Validated; publicly available models for various types of studies, reports detailing the research, close collaboration with industry stakeholders (NERC, WECC, IEEE, etc.)

A blue-tinted photograph of four people, two men and two women, standing in a row. They are dressed in professional attire, including lab coats and a hard hat. The text 'Together...Shaping the Future of Energy™' is overlaid in white on the image.

Together...Shaping the Future of Energy™