Joint Generator Interconnection Workshop

Closing Remarks

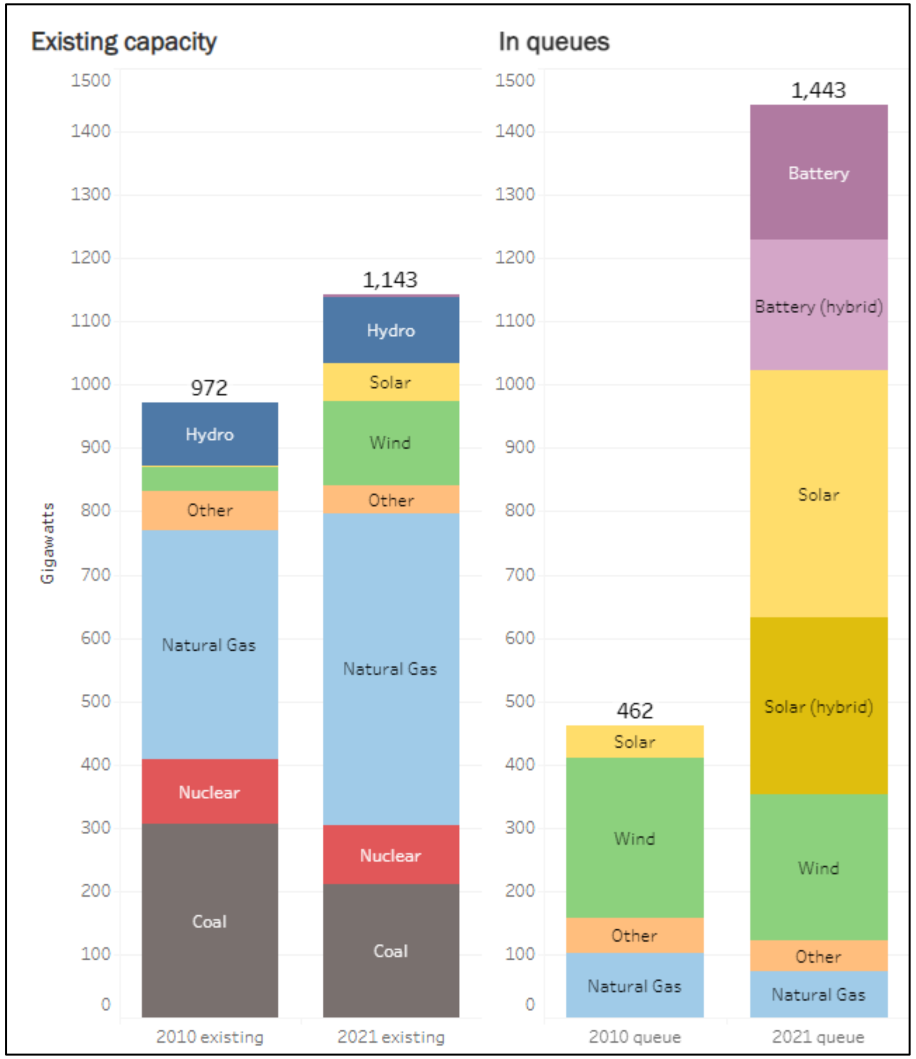
Julia Matevosyan

Chief Engineer

ESIG

8/11/2022

Motivation for this Joint Workshop



179 FERC ¶ 61,194
UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

[Docket No. RM22-14-000]

Improvements to Generator Interconnection Procedures and Agreements

(June 16, 2022)

IEEE Std 2800™-2022

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

Developed by the

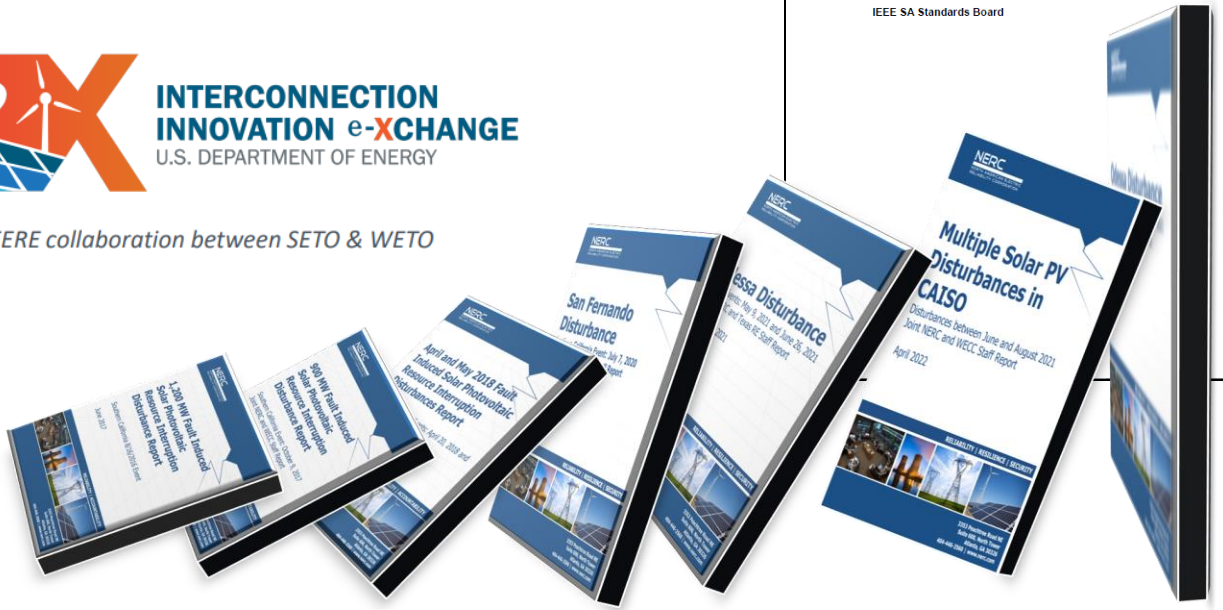
Energy Development & Power Generation Committee, Electric Machinery Committee, and Power System Relaying & Control Committee
of the
IEEE Power and Energy Society

Approved 9 February 2022

IEEE SA Standards Board

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

an EERE collaboration between SETO & WETO



https://emp.lbl.gov/generation-storage-and-hybrid-capacity

Day 1: Interconnection and Transmission Planning Process

ESIG

Today

Generator Interconnection

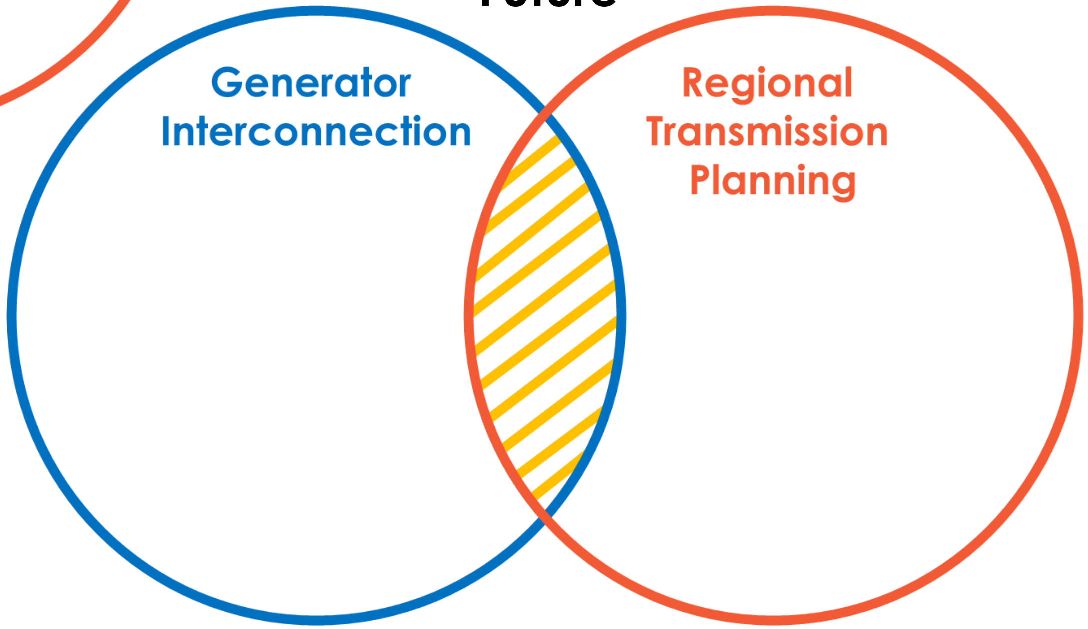
- Individual project or cluster analysis
- Local reliability analysis only
- Static "snap-shot" analysis
- Limited transmission upgrades for specific project(s)
- Reliability > Economic benefits
- Short-term horizon
- Generator pays for upgrades

Regional Transmission Planning

- Full system-wide analysis
- Economic, Reliability, and Adequacy
- Full-year or multi-year analysis across broad range of conditions
- Regional or interregional transfers
- Economic >= reliability
- Longer-term horizon
- Policy and environmental benefits
- Load pays

Limited overlap & coordination

Future



Integrated generator interconnection & regional transmission planning

- Multi-benefit planning
- Renewable Energy Zones
- Combined benefits of generator interconnection and system-wide benefits
- Longer time horizon
- Wider range of benefits

Source:
TELOS ENERGY

Day 1: Interconnection and Transmission Planning Process

ESIG

Source: Brattle

- Integrating generation interconnection (GI) into transmission planning processes offers more cost-effective, holistic solutions that can address the wide range of future needs, while reducing cost and time necessary to interconnect cheap, clean generation
- The benefits of integrated planning increase for planning processes that:
  - Consider generation needs over longer time frames
  - Reduce the scope of network upgrades triggered by GI through more integrated, proactive transmission planning that simultaneously considers multiple needs
  - Use proactive multi-value planning processes to address both near- and long-term needs
  - Look beyond regional seams to identify more cost-effective interregional solutions
  - Rely on advanced transmission technologies to address identified needs
  - Improve and standardize study criteria and dispatch assumptions
  - Utilize pragmatic cost allocations that are roughly commensurate with benefits received
- Cost allocation doesn't need to dictate the design of the process, nor be a barrier to the process improvements. If we find cost-effective integrated GI and transmission planning methodology, the cost allocation can be developed (CPPTF at SPP and Enel white paper offer possible solutions).

Day 1: Proactive Planning and Multiple Benefits

ESIG

Proactive Planning

- Proactive generation interconnection planning can help bridge the gap between short-term generation interconnection studies and long-term transmission planning studies while reducing the generation interconnection costs significantly
- A cost allocation mechanism that allows late-comers to pay their share would likely reduce the needs for restudies and allow for extending study windows.
- Expanding the scope of the current GI studies, or combining/overlapping its scope with transmission planning, could further reduce GI costs.

Source: Brattle

Multiple Benefits of Transmission

1. Production cost savings
2. Capital cost savings
3. Emissions benefits
4. Risk Mitigation
5. Resource Adequacy
6. Resilience

Source: TELOS ENERGY

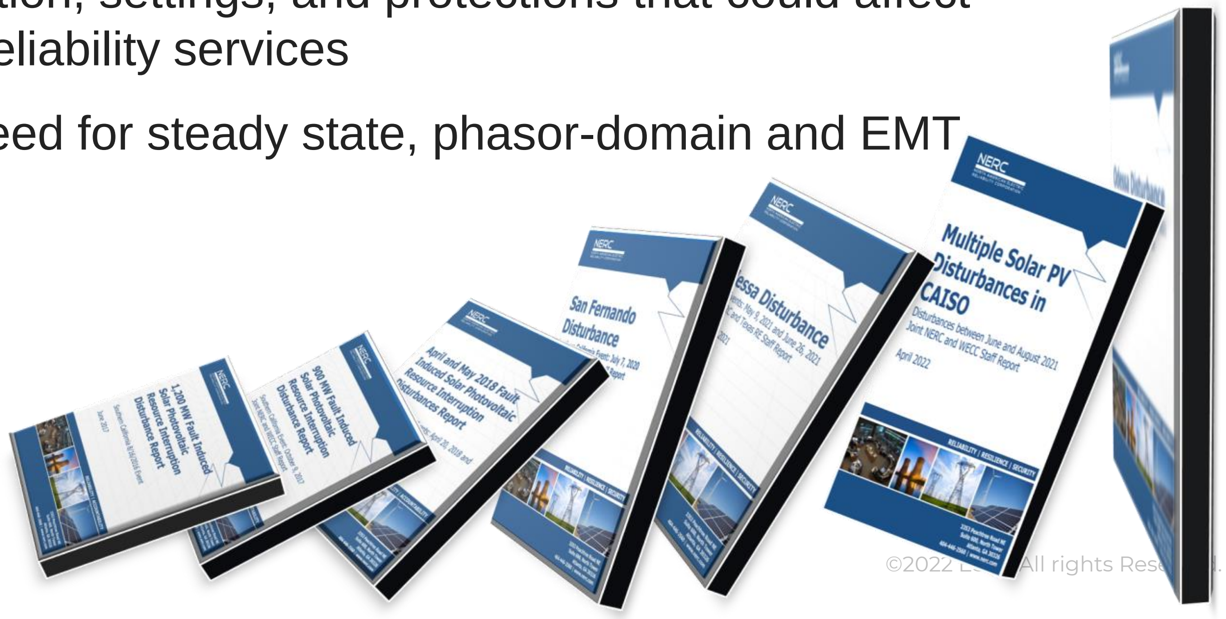
Day 1: Examples of Integration of GI and Transmission Planning

- MISO's and SPP's Joint Targeted Interconnection Queue (JTIQ) Study shows that proactively studying a larger set of generation interconnection requests offers substantial cost and time savings, identifies more optimized network upgrades as well as eliminates uncertainty for the developers
- MISO LTRA effort simultaneously evaluated 20-year reliability, economic, and public policy needs for a diverse set of future scenarios and identified "least regrets" portfolio of multi-value transmission projects ($10 billion portfolio supports 53 GW of GI, reduces costs by $37-70 billion)
- SPP's CPPTF recognizes interdependences between GI and transmission planning and seeks to integrate these processes for more cost-effective streamlined approach. This is achieved in tight collaboration with all involved stakeholders.
- PJM's recent Offshore Wind Transmission Study that proactively evaluated all existing state public policy needs identified $3.2 billion in onshore upgrades for >75GW of renewables compared to individual GI studies that identified $6.4 billion in onshore upgrades for 15.5 GW of renewables.
- ERCOT's GI process is probably the most effective in the U.S.. Upgrades are focused only on local GI needs; network constraints are managed through market dispatch and upgrades are assessed in transmission planning (not sufficiently proactive and doesn't consider multiple values of transmission)

Day 2: Studies and Modeling

Recent NERC disturbance event report identify need for:

- More detailed, clear, harmonized interconnection requirements
- Better alignment of interconnection studies with project development timelines
- Accurate modeling: models that reflect equipment and settings in the field and match actual equipment behavior
- Models need to include controls, modes of operation, settings, and protections that could affect ability to ride through and provision of essential reliability services
- Use of right models to study right phenomena (need for steady state, phasor-domain and EMT models)

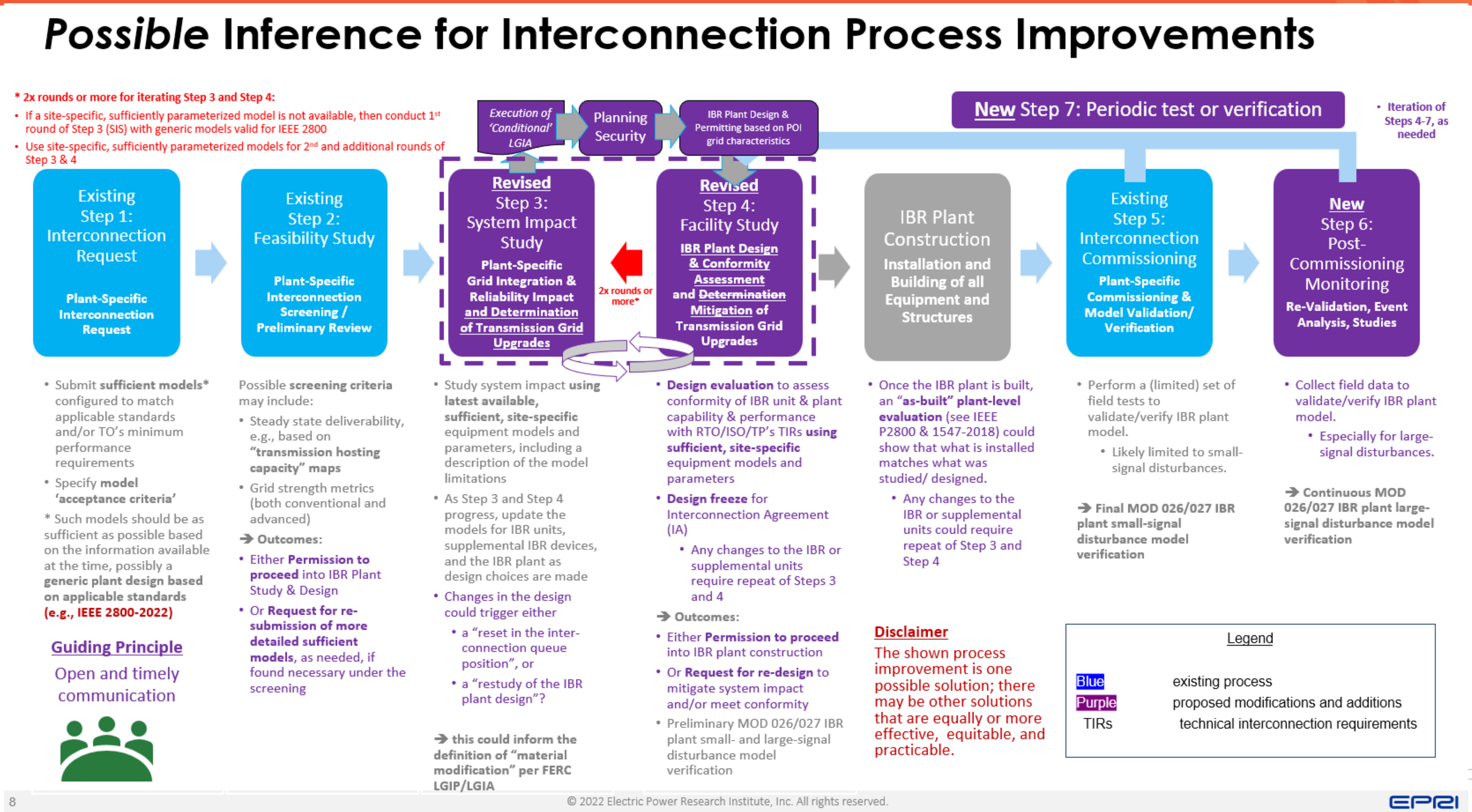


Day 2: Studies

- Project development, especially offshore, takes a long time and faces a lot of uncertainties
- Accurate transmission model/data early reduces project design iterations and minimizes risks of sub-optimal designs and reduces need for restudies
- For offshore projects better coordination between gird operator and developer needed to provide earlier indication on onshore equipment requirements and associated permitting and reduce project development timelines.
- Interconnection studies should be timed in a way that allows obtaining more accurate models representative of equipment to be installed in the field as this information becomes available. This will reduce need for re-studies and increase fidelity/usefulness of the study results.
- Stability impacts from the projects coming online around the same time should be assessed in concert, using accurately parametrized models that reflect equipment to be installed in the field.
- Where relevant (e.g. oscillatory behavior under weak grid conditions), in collaboration with OEMs and the developer, control parameter tuning of a plant under study should be considered as an alternative to costly transmission upgrades to reduce the costs.

Day 2: Studies

ESIG



Day 2: Modeling

- All models have their limitations generic models are not necessarily bad, EMT models are not necessarily more accurate
- Use appropriate type of models for appropriate studies (e.g. detailed UDM models are necessary for control tuning, while correctly parametrized, validated generic model may be used for planning studies; sub-cycle phenomena and unbalanced conditions are not captured in the positive sequence and EMT models/studies are needed)
- Control-loops and protective functions relevant for a studied phenomena should be included in the model
- Model validation and diligent parametrization is crucial for both positive sequence (UDM and generic) and EMT models
- Limited validation against field tests is possible at commissioning. Unit type-testing combined with careful plant design evaluation can be used to gain fidelity in the models. Then, post-commissioning disturbance monitoring should be used to validate the models for large signal disturbances.

Day 2: Modeling

- Present models (both positive sequence and EMT) have been unable to capture some of the causes of inverter tripping in the disturbance events analyzed by NERC.
- Limitation of a model should not be confused with limitation of the simulation domain itself. Improved future models, both in positive sequence and EMT, can help capture the behavior observed in the field.
- It is recommended to start collecting, quality testing and validating EMT models ahead of EMT studies being needed. For example, ISO-NE and ERCOT have been doing this for a number of years and over time improved their EMT skills, model quality/model validation requirements.

Day 3: Interconnection Requirements & IEEE2800

- Balanced and harmonized interconnection requirements play a critical role in the deployment of advanced technology capabilities to meet grid needs; provide certainty to OEMs and improve grid reliability
- For example, harmonized requirements have been approved in Europe in 2016 (ENTSO-E RfG)
- IEEE2800 has been developed with wide industry participation and has been approved in April 2022 with high approval rate
- IEEE2800 defines minimum capability requirements for IBRs connected to sub-transmission and transmission (includes modeling requirements)
- IEEE2800.2 Recommended Practice for Test and Verification Procedures for Inverter-based Resources (IBRs) is under development

Day 3: Interconnection Requirements & IEEE2800

- OEMs and developers welcome harmonization efforts and implementation of IEEE2800. If adopted in the regions it provides certainty and improves grid reliability.
- Majority of the capabilities required by IEEE2800 are already available in existing equipment.
- Several, more complex/demanding requirements will need to be implemented in new equipment. Transitional arrangements need to be developed in collaboration with grid operators.
- Plants that may get built in a near future may not be fully compliant with 2800. OEMs, developers, grid operators should work together to realize which IEEE 2800 requirements can be met for plants going in-service in a near future.
- Smaller developers, especially of solar and battery storage plants need additional education about interconnection requirements and performance expectations for IBRs.

Day 3: Interconnection Requirements & IEEE2800

- Grid operators need to be proactive to keep developers well informed on interconnection requirements, modeling requirements and performance expectations.
- Some grid operators already started a gap analysis of their existing requirements in comparison with 2800 with the goal of piecemeal implementation. Some of the IEEE2800 requirements, if implemented, will mitigate some of the IBR tripping causes observed in recent disturbance events.
- Voltage ride-through requirement proposed in the FERC NOPR likely needs revision to encourage IBR behavior that’s more helpful for the grid recovery. Harmonization with PRC-024 or IEEE2800 language is beneficial.

Day 3: DOE i2X Initiative

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

an EERE collaboration between SETO & WETO

Department of Energy funded Interconnection Innovation e-Xchange initiative (i2X) :

- Enable simper, faster, fairer interconnection of wind and solar resources while boosting reliability, resiliency and security of the grid
- Convene diverse stakeholders involved in the interconnection of solar, wind and energy storage resources (including distributed resources and T&D coordination)
- Facilitate peer learning, knowledge exchange and development of new interconnection ideas and capabilities
- Data collection and transparency, development of meaningful metrics (e.g. for LBNL analysis of the GI queues)
- Transmission Analysis (interconnection procedures, interconnection costs, criteria and dispatch, timing mismatch between availability of equipment and studies)
- Provide access to various interconnection technical assistance opportunities to support the partners in their implementation of developed reforms

What's next?

- All presentation materials will be posted on the Workshop page after the event
- This workshop was **recorded,** and recording will be made available on ESIG's YouTube channel shortly after the event
- Unanswered questions from each session will be addressed and Q&A file posted on the Workshop page shortly after the event
- ESIG will summarize the highlights of the three-day workshop in 3 blog posts (one for each day)
- An email with a link will go out to all workshop attendees once 3 blog posts have been posted at the end of September
- ESIG will continue with webinars related to interconnection process, studies, modeling, interconnection requirements to share best industry practices on these topics and inspire industry reforms

THANK YOU
&
STAY TUNED