

October 21, 2025 Virtual Meeting

Challenges with IEEE2800-2022, Planned Revisions (~215 attendees)

Presentation recording and slides are available to download [here](#). Figure 1 shows the makeup of meeting attendees by industry sector:

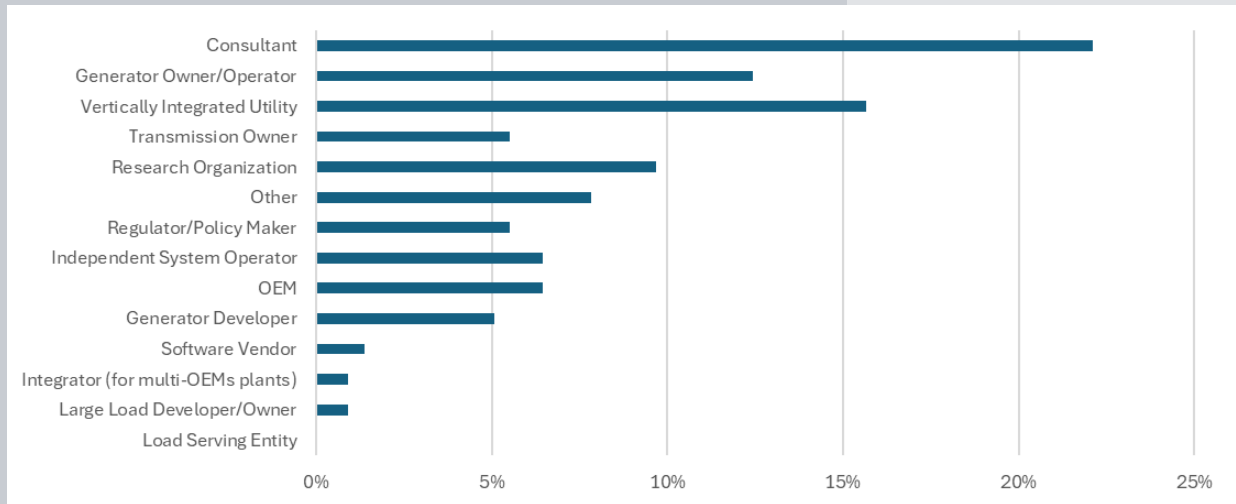


Figure 1: Meeting attendees by industry sector

This sixth meeting of Season 2 of the DOE i2X FIRST initiative focused on challenges with IEEE 2800-2022, ongoing IEEE P2800.2 recommended practice developments, and new efforts starting to revise IEEE 2800-2022 and initiate new projects related to grid forming (GFM) inverter technology as it relates to the standard. Presentations included the following:

Andy Hoke, National Renewable Energy Laboratory (NREL)

Andy provided an overview of the evolution, technical content, and implementation status of IEEE P2800.2, which provides recommended practices for test and verification procedures for **inverter-based resources (IBRs)** connecting to the transmission and sub-transmission system. The draft set of practices are closely tied to the foundational standard **IEEE 2800-2022**, which defines the minimum performance and capability requirements for applicable IBRs.

IEEE P2800.2 is current in the IEEE Standards Association (SA) ballot process and is expected to finish in late 2025 with publication in early 2026. The P2800.2 working group has over 170 voting members and over 50 non-voting members, with all major stakeholder groups represented (see Figure 2). The ballot group represents all key stakeholder groups and is not dominated by any one group. Initial ballot results back in June had an 87% approval rate, which exceeds the 75% threshold to pass. However, the working group continues to refine and improve the standard based on the comments received.

For more information, visit: energy.gov/i2X

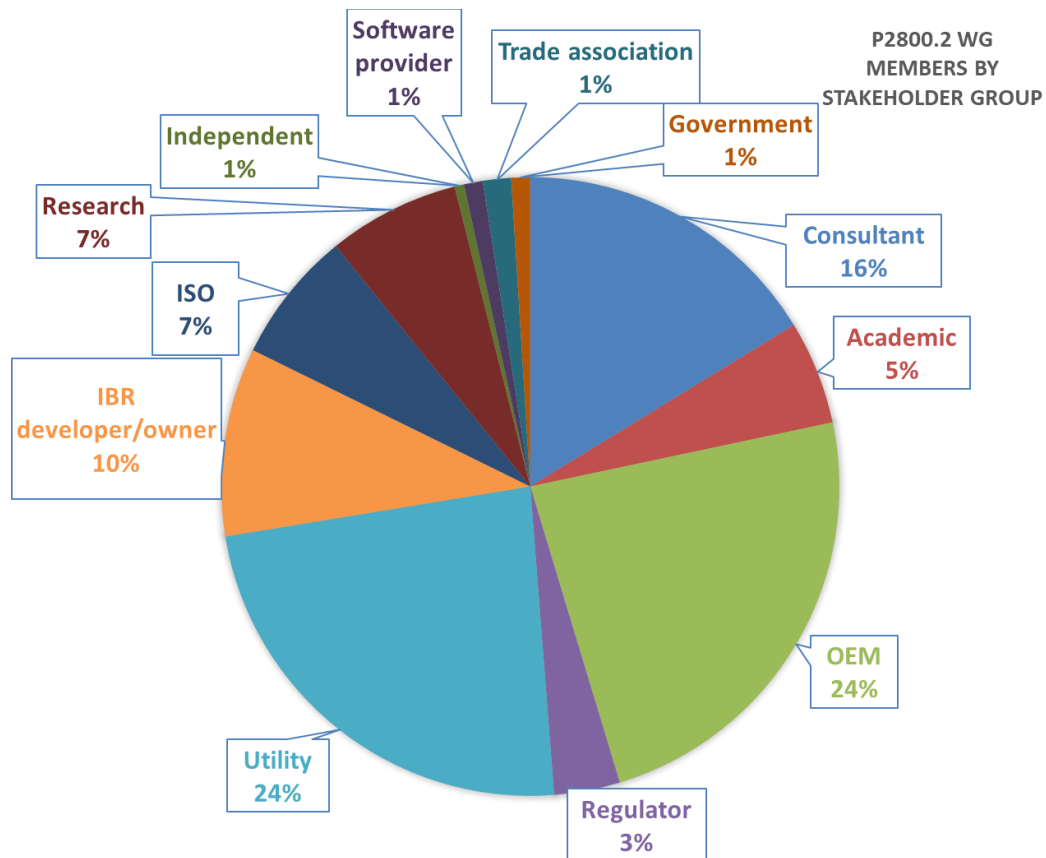


Figure 2: IEEE P2800.2 Working Group Members by Stakeholder Group (Source: IEEE)

The working group received 778 comments during the initial ballot and the Comment Resolution Group (CRG) of the working group – a group of 33 industry experts (the IEEE P2800.2 leadership team plus 13 additional invited subject matter experts) – has completed their review to address those comments. Most comments focused on type testing and IBR plant design evaluations, with a few notable themes:

- Prescriptiveness vs. Flexibility:** The working group debated whether type tests and IBR plant design evaluation tests should be prescriptive for uniformity and efficiency or flexible for user interpretation; Draft 4.0 of the standard is now somewhat more prescriptive than the prior draft following comment resolution.
- Type Tests:** Expanded detail and clarity with new tables, figures, and more rigorous frequency and ROCOF ride-through testing, while retaining general flexibility.
- Design Evaluation:** Slightly lowered model validation rigor, and removed the partial framework for quantitative IBR unit model validation – model validation is only qualitative in Draft 4.0 now. The guidance regarding non-aggregated models was moved to an annex and the draft retained the option to use either a simple test system or detailed real-grid test system.

- **Commissioning Tests:** Broadened scope with added voltage feedback, reactive power control, and power factor control tests, but maintained adaptability and declined alignment with specific regulatory frameworks.

The working group is expecting the timeline to publication as shown in Figure 3.



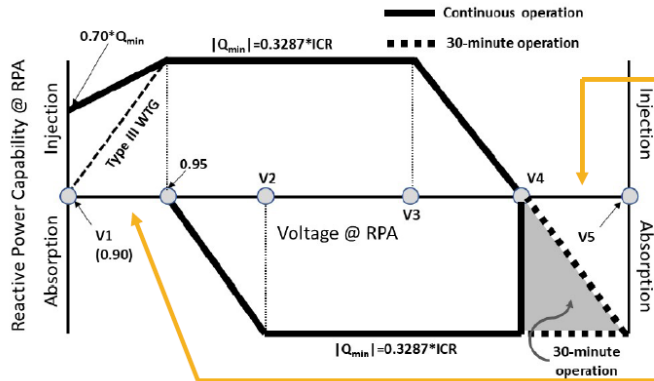
Figure 3: IEEE P2800.2 Working Group Timeline to Publication (Source: IEEE)

Manish Patel, Silicon Ranch

Manish provided a detailed review of potential areas of concern and issues to consider for a future revision of IEEE 2800-2022, including:

- Reactive power capability requirements (Clause 5.1)
- Voltage and reactive power control mode (Clause 5.2)
- Voltage ride-through capability requirements (Clause 7.2.2.1)
- Transient overvoltage ride-through requirements (Clause 7.2.3)
- Consecutive voltage deviation ride-through capability requirements (Clause 7.2.2.4)

Regarding reactive power capability (Clause 5.1), the clause states that the IBR units shall have the capability to provide reactive power support when the primary energy source is available and not available. It is recognized that this should likely be a requirement on the IBR plant, and not the IBR units directly (as the standard language currently seems to suggest). Further, the IBR plant is not required to operate at zero reactive power when voltage is greater than V_4 ; however, the IBR plant is required to operate at zero reactive power when voltage is less than 0.95 pu (see Figure 4). Thus, additional considerations and adjustments may be needed to the capability curve.



Plant is not required to operate at zero reactive power when voltage is greater than V4.

Is there a reason to require plant to operate at zero reactive power when voltage is less than 0.95 per unit?

Table 4—RPA voltage range^a

TS nominal voltage at the RPA	V1 (p.u.)	V2 (p.u.)	V3 (p.u.)	V4 (p.u.)	V5 (p.u.)
< 200 kV	0.90	0.99	1.03	1.05	1.10
≥ 200 kV except 500 kV and 735 kV as below	0.90	1.00	1.04	1.05	1.10
500 kV	0.90	1.02	1.06	1.10	1.10
735 kV ^b	0.90	1.02	1.06	1.088	1.10

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Figure 4: Annotated IEEE 2800-2022 Clause 5.1 Reactive Power Capability Curve (Source: IEEE)

Regarding voltage and reactive power control modes, Clause 5.2.2 includes confusing use of “reference value” and “RPA voltage set point” that may lead to the inability to meet the requirements depending on voltage droop and pre-event reactive power output. Additionally, the clause also uses the term “reactive power droop” whereas some Transmission Planners require voltage droop control and the standard may want to consider allowing this. Lastly, Table 5 of IEEE 2800-2022 includes a reaction time requirement and some individuals have argued that this time may need further clarification regarding if the measurement time is included or not in the reaction time requirement.

In Clause 7.2.2.1 regarding voltage disturbance ride-through requirements, the voltage versus cumulative time curve and table may be misunderstood by some and may need additional clarification. It is the intent of the working group that this requirement be interpreted as a voltage versus time curve wherein for a given voltage, the IBR plant shall not trip until the duration at this voltage exceeds the ride-through curve capability. Based on this understanding, one interpretation of the voltage ride-through requirement is that a wind plant, for example, must withstand a single voltage disturbance event where the voltage drops to zero at time t=0 and then gradually recovers following the curve steps. Additionally, there are some differences between IEEE 2800-2022 Clause 7.2.2.1 and NERC PRC-029 Attachment 1 Item #7. For a voltage that remains below 0.7 pu for 2.0 seconds and below 0.9 pu for 3.5 seconds, the IBR plant is allowed to trip per IEEE 2800-2022 but not allowed to trip per NERC PRC-029-1 based on the interpretation of the requirements. This may cause inconsistencies and difficulties meeting both distinct standards in situations where both apply.

Regarding transient AC overvoltage (TOV) requirements in Clause 7.2.3, the requirement applies at the point of measurement (POM); however, TOV protection is not applied at the POM and is usually included in IBR units (at the point of connection (POC)) to protect their power electronics. Hence, it is important to understand how TOV at the POM is reflected down to the POC. It is unclear whether an aggregate model is sufficient to study this or if a detailed non-aggregated model would be needed. Regardless, the IBR plant is allowed to trip if TOV is above the specified threshold for a duration longer than specified even if the fundamental frequency phasor component of the applicable voltage is within the mandatory or continuous operation region. One of the key challenges to this requirement is how to demonstrate conformance with the TOV ride-through requirements.

Some individuals have articulated that the consecutive voltage deviation ride-through capability requirement in Clause 7.2.2.4 is too complicated and impractical to test so many different scenarios. Furthermore, the consideration of energy displacement during faults and post-fault active power recovery is key for certain technologies. There are challenges with voltage source converter (VSC) high voltage DC (HVDC) connected IBRs typically used for offshore wind plants and certain Type 4 wind turbine generators (WTGs). IEEE 2800-2022 includes an exception only for IBRs connected via VSC HVDC due to limitations of the DC chopper to absorb energy, which can affect ride-through behavior, the balance of active/reactive current during the fault, and post-fault active power recovery.

All these issues are being documented in various ways and are planned to be included in the subsequent revision of IEEE 2800-2022.

Jens Boemer, Electric Power Research Institute (EPRI)

Jens shared forthcoming revisions to IEEE 2800-2022 and the development of a new IBR recommended practice for GFM equipment. The IEEE Power and Energy Society (PES) Wind and Solar Power Plant Interconnection and Design Subcommittee (WSPPID-SC), under the Energy Development and Power Generation (EDPG) Committee, is the parent subcommittee of the Inverter-Based Resources Interconnection Working Group (IBRI-WG), which houses the IEEE 2800-2022 standard efforts and IEEE P2800.2 recommended practice developments. As the IBRI-WG begins to embark on revisions to IEEE 2800-2022, they are encouraging anyone interested in participating to sign up if they are not currently part of the IEEE P2800.2 effort (those individuals part of IEEE P2800.2 efforts will automatically be included in the subsequent efforts). A direct link to express interest in the IBRI-WG in IEEE myProject is [here](#).

Stakeholders have asked for a revision cycle in the following areas:

- IEEE P2800a: IEEE 2800-2022 will be modified to reduce potential barriers to GFM technology adoption through an amendment process, and this topic has been identified as the most urgent.

- IEEE P2800.1: Specifications for optional GFM equipment capability and standardized performance will be established in a Recommended Practice document,¹ which will be deemed the IEEE P2800.1.
- IEEE P2800: A full revision effort to IEEE 2800-2022 will commence based on industry learnings during adoption thus far.

The IEEE P2800.1 project on GFM IBR equipment will also need to align with the other IEEE 2800/.x series of documents and thus the main standard will also need to be revised so as not to preclude the technology from being unable to meet the requirements applicable to all IBRs. This effort will need to evaluate the grid services provided by varying types of GFM technology as the future GFM recommended practices are developed. Additionally, a list of various clauses have been identified as a starting point for alignment between the IEEE P2800a, IEEE P2800.1 and IEEE P2800 efforts. There are also some plans to align with the IEC (International Electrotechnical Commission) and its efforts, where possible.

For the time being, adoption of IEEE 2800-2022 is still strongly encouraged as it establishes a solid baseline of IBR plant capability and performance requirements. After the forthcoming revisions are complete, industry may need to update their requirements to reflect the new version(s) of the standard. It is expected that the IEEE 2800 series of standards will undergo continuous learning and improvements, which should not deter any transmission provider or other authority governing interconnection requirements (AGIR) from adopting the latest version of the standard.

Q&A and Interactive Group Discussion

In addition to type testing of IBR units, is type testing of PPCs included in IEEE 2800.2? How do the considerations/type tests differ in that case?

IEEE P2800.2 includes type tests for IBR units (i.e., turbines/inverters) and PPCs. The same general concepts apply to validate these models.

ERCOT now requires type test results (control hardware in the loop (CHIL)) of PPCs or real code models of PPCs. What does IEEE P2800.2 say about this? And how should industry think about this for legacy and new projects?

CHIL testing and/or real code models are recommended. IEEE 2800-2022 is designed as a forward-looking standard and not intended to be applied retroactively to existing facilities. Industry may be adopting portions of the standard differently, which may result in challenges and obstacles.

¹ IEEE Standards are documents that specify mandatory requirements (i.e., “shall”) whereas Recommended Practices are documents in which procedures and position preferred by the IEEE are presented (i.e., “should”).

How many individuals submitted comments to the IEEE P2800.2 initial ballot?

About 40 people submitted comments (most people voted without commenting). As the working group moves into recirculation ballot, the group will look for ways to wrap up the work and try to avoid making major changes.

The original IEEE P2800.1 was the entity-based test and verification effort. Did that effort get replaced with this new effort? What are the processes/procedures?

Yes, the original IEEE P2800.1 entity-based project expired and no progress was made. Thus the .1 came available again, and the working group decided to use the opportunity to apply the .1 for the forthcoming GFM recommended practice effort.

ERCOT, MISO, and others already published GFM requirements. How does the working group envision the new IEEE requirements aligning with existing ones?

The idea is that the GFM task force under the IBRI-WG will review all requirements in North America and some internationally and to the extent that the group agrees on equipment-level requirements or recommended practices, they can be published as such. However, note that what will be published are recommended practices and entities can adopt as they see fit.

Please explain the benefits of harmonization between IEEE and IEC standards.

This is an aspirational goal by the IBRI-WG to coordinate with IEC. One of main drivers is that IBRs are a global market and OEMs design products for all markets and build in capabilities to design for regional configurations. These IBR often use the same hardware platform with different software versions. So, to the extent possible, such interconnection requirements should be globally coordinated and enable a more streamlined set of product offerings across markets.

Other regions around the world have already developed significant experience with GFM and how the technology can be utilized. Breaking down requirements for capability and performance and sorting out what are capability versus utilization requirements is essential.

When will the recirculation ballot for IEEE P2800.2 start and for how long will it be open?

The recirculation is expected to start the last week of October 2025 and will last 21 days.

How is the IBRI-WG deciding to make changes to IEEE 2800-2022?

The group has an informal list of potential items to change or fix in IEEE 2800-2022 based on feedback from industry thus far, including feedback from the i2X FIRST forum. Ultimately, what gets changed will be decided by the working group.

What is the rationale for different reactive power requirements for Type 3 and Type 4 wind turbines? There are type 4 wind turbines without any reactive power capability below cut-in wind speed.

The presenters noted that the justification was that Type 4 wind can easily be designed to provide reactive power at zero active power, just like a solar PV or BESS. In contrast, it is more difficult to design a Type 3 WTG to provide reactive power at very low active power. However, this is one of the requirements that some want to change in the revision to IEEE 2800-2022. Some of the currently available Type 4 wind turbines do not offer any reactive capability at zero wind.

Describe the term “utilization requirement” (in the context of GFM).

IEEE 2800-2022 front matter has informative notes describing differences between capability requirement, performance requirement, and utilization. Utilization is outside the scope of IEEE 2800-2022. However, it can relate to GFM performance and capabilities; for example, a GFM-capable inverter that provides response to voltage phase angle jump may require the inverter to adjust active power instantaneously. Inverter may be capable of this design, but it may not be able to deliver this active power if it is already operating at its maximum active power level. So, it is hard to differentiate what is about design of equipment and what is about utilization of equipment to deliver specific services. Utilization is outside scope of the IEEE 2800 series but may need further clarification in the context of GFM.

How can we better educate Utility Regulators on evolving IBR technology capabilities, requirements developments, and how changes are being made to address these?

The presenters talked about alignment, education, information sharing, etc. ESIG serves as a forum to provide such education, and there may be opportunities to coordinate with the National Association of Regulatory Utility Commissioners (NARUC).

Key Themes

- **IEEE P2800.2 Toward Publication:** The IEEE P2800.2 Working Group is nearing completion of recommended practice for testing and verification of applicable IBRs. The initial draft received 87% ballot approval and nearly 800 comments—most centered on type testing and design evaluation. The group continues refining the document, targeting publication in early 2026 following recirculation.
- **Balancing Prescriptiveness and Flexibility in Testing and Design:** A central theme throughout the P2800.2 development is the balance between standardized, prescriptive testing for uniformity and flexible approaches that accommodate diverse technologies. The latest draft (D4.0) modestly increases prescriptiveness for type testing while keeping space for user interpretation in design and commissioning evaluations.

- **Emerging Lessons and Gaps in IEEE 2800-2022 Implementation:** Experience with IEEE 2800-2022 has surfaced areas needing clarification—particularly in reactive power capability, voltage and reactive control modes, and ride-through requirement definitions. Misinterpretations of key clauses, complexity of other clauses, and alignment issues with NERC PRC-029 have revealed inconsistencies that can complicate compliance. These insights are shaping the next revision cycle to make the standard more practical and consistent with system operator expectations.
- **Upcoming Revisions and New Efforts on GFM Technology:** Parallel to the P2800.2 ballot, IEEE is launching three new efforts that will continue to refine and reshape the IEEE 2800 series of standards: P2800a to reduce barriers for GFM adoption, P2800.1 to define equipment-level requirements for GFM equipment, and a full revision of IEEE 2800-2022 to align all related standards.
- **Importance of Global Harmonization and Regulatory Education:** IEEE and IEC are attempting to coordinate efforts, although noted as “aspirational.” IBR technology and manufacturing are global efforts. Thus, aligning international standards reduces cost, complexity, and regional divergence in product design. Participants also emphasized the need to better educate regulators and policymakers about evolving technical standards.
- **Industry Participation and Continuous Improvement:** The IEEE IBRI-WG is encouraging broad participation in ongoing and future projects. Stakeholders were reminded that adoption of IEEE 2800-2022 should continue even as revisions are underway, since each iteration builds on lessons learned. The evolving IEEE 2800 series is intended to be a “living framework,” continuously refined to reflect advancements in technology, modeling, and system reliability practices.