February 24, 2026 Virtual Meeting

IBR Standards – How to Make Sense of it All? (204 attendees)

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

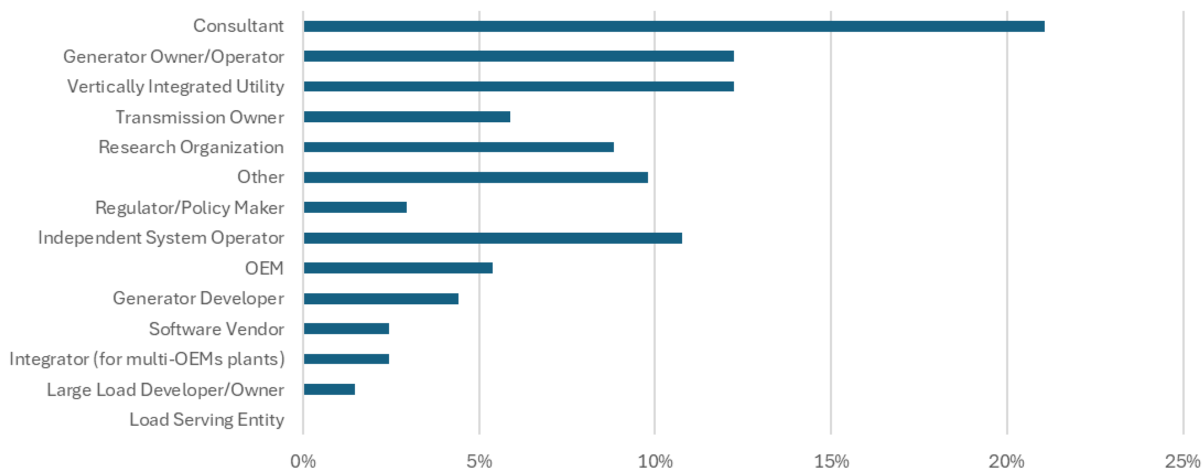


Figure 1: Meeting attendees by industry sector

The tenth meeting of Season 2 of the DOE i2X FIRST initiative focused on lessons learned developing IBR requirements, integration into existing processes, experience bringing new IBRs online, and ensuring they conform with applicable standards and requirements. The session focused on adoption of IEEE 2800-2022, recently approved NERC standards from FERC Order 901, the upcoming publication of IEEE P2800.2, and future updates to these standards.

<u>Jens Boemer, EPRI</u>

Jens Boemer presented on the evolving landscape of IBR standards and their implications for BPS reliability. He provided historical context regarding past NERC disturbance report findings, noting that unexpected IBR tripping, misapplication of IEEE 1547 standard to transmission-connected IBRs, lack of standardized IBR performance, modeling, and verification are all key contributors to reliability risks. He emphasized the importance of not just trusting IBR plant designs but also verifying that they are implemented correctly through as-built verification.

Jens outlined the relationship between voluntary and mandatory standards, particularly in the U.S., highlighting FERC Order 901 as a key driver for developing NERC Reliability Standards applicable to IBRs (see Figure 2). While NERC standards have been inspired by IEEE standards, IEEE standards have not been directly adopted by NERC. Thus, implementation of IEEE 2800-2022 relies heavily on ISO/RTOs, transmission providers, and other authorities governing interconnection requirements as well as IBR plant developers, OEMs, and other stakeholders to adopt the principles within the standard.

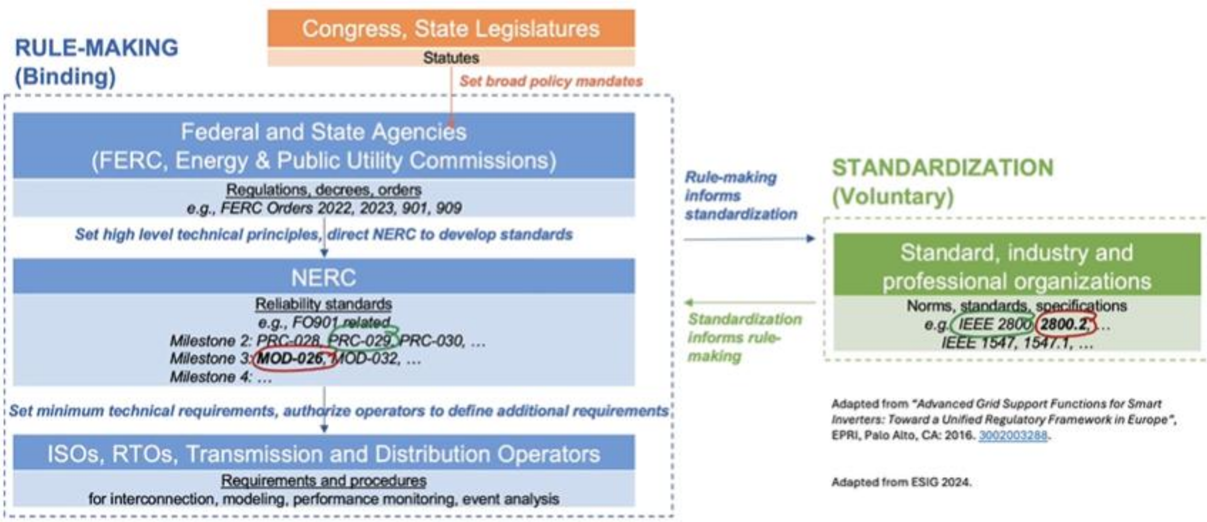


Figure 2: Relationships between voluntary and mandatory IBR standards in the United States [Source: EPRI]

Many Category 2 IBRs (i.e., between 20 MVA and 75 MVA connected at 60 kV and above) that have not been subject to mandatory NERC Reliability Standards will soon be through NERC IBR registration initiatives. Over 650 Category 2 IBRs have been identified by NERC, with expectations this number could rise to 700 or 800. These IBRs will now be required to meet standards like NERC PRC-029-1 for ride-through capability and performance, which is a significant shift for many existing facilities that previously had no mandatory reliability requirements.

Jens highlighted the difference between capability and utilization, advocating for early incorporation of capabilities into designs, even if they are not immediately required and utilized (see Figure 3). This is one way to mitigate grid reliability risks as the prevalence of IBRs grows.

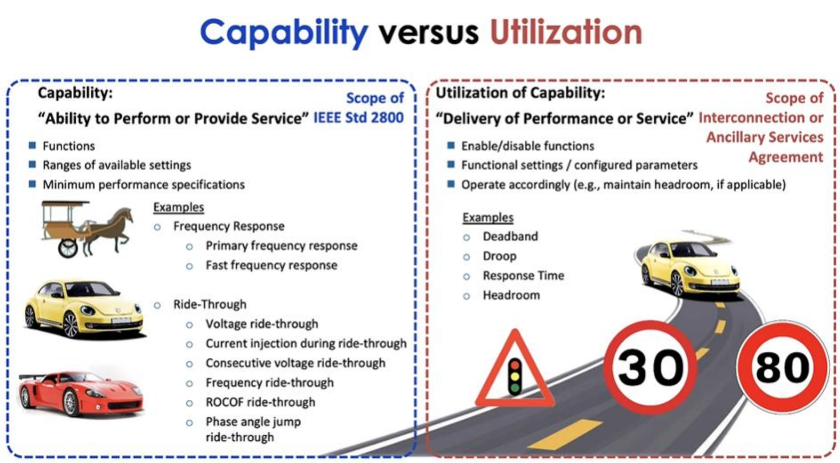


Figure 3: Relationships Between Capability and Utilization [Source: EPRI]

He also discussed the upcoming publication of IEEE P2800.2, which is expected to be published in April 2026 and aims to provide a coherent framework for verifying IBR capabilities and assessing conformity with IEEE 2800-2022. While modeling is a critical tool for assessing conformity, it is not the only method; evaluating design documentation is equally important.

Industry collaboration to update existing IBR modeling and performance requirements is critical to address known and future reliability risks, given the evolving nature of the grid. Many procedures in IEEE P2800.2 are not new and are being adopted by various entities already. However, these procedures were developed in a short timeframe and leave opportunities for improvement through industry engagement. Passing down knowledge and engaging the future workforce in standards development is also key to ensure ongoing improvements in IBR performance and reliability. Through industry collaboration, IEEE 2800 standards will move from a "hybrid integration" adoption approach to a "general reference" approach as the standard and its implementation continue to mature.

Scott Anderson, Salt River Project

Scott Anderson provided a detailed look at the Operational Readiness (OpR) program at Salt River Project (SRP) and how the utility is adapting to increasing levels of IBRs. SRP is one of the largest public power utilities in the U.S., based in Phoenix, AZ, with a historical focus on thermal generation, and a more recent focus on IBRs, particularly large-scale solar PV and BESS – most of these assets are under a power purchase agreement arrangement. SRP OpR initiative reflects SRP's commitment to operate future grids safely, reliably, and cost-effectively, emphasizing a strategic approach to managing a grid with higher IBR penetration.

The development of SRP's OpR strategy involved extensive data collection, surveys, and stakeholder engagement, including a "think tank" with over a hundred participants across the organization as well as external subject matter experts. This process led to a gap analysis that highlighted key areas for improvement across generation, tools, and people—specifically, understanding solar variability and battery storage technology, updating forecasting and situational awareness systems, and enhancing training and expertise in IBR technology. To address these gaps, SRP initiated 30+ projects across six thematic areas, with completed projects summarized and shared across relevant departments to ensure alignment and knowledge transfer. They are now in the fourth year of implementing the OpR strategy and have added nine new IBRs totaling 2.6 GW (1500 MW of solar and 1100 MW of BESS).

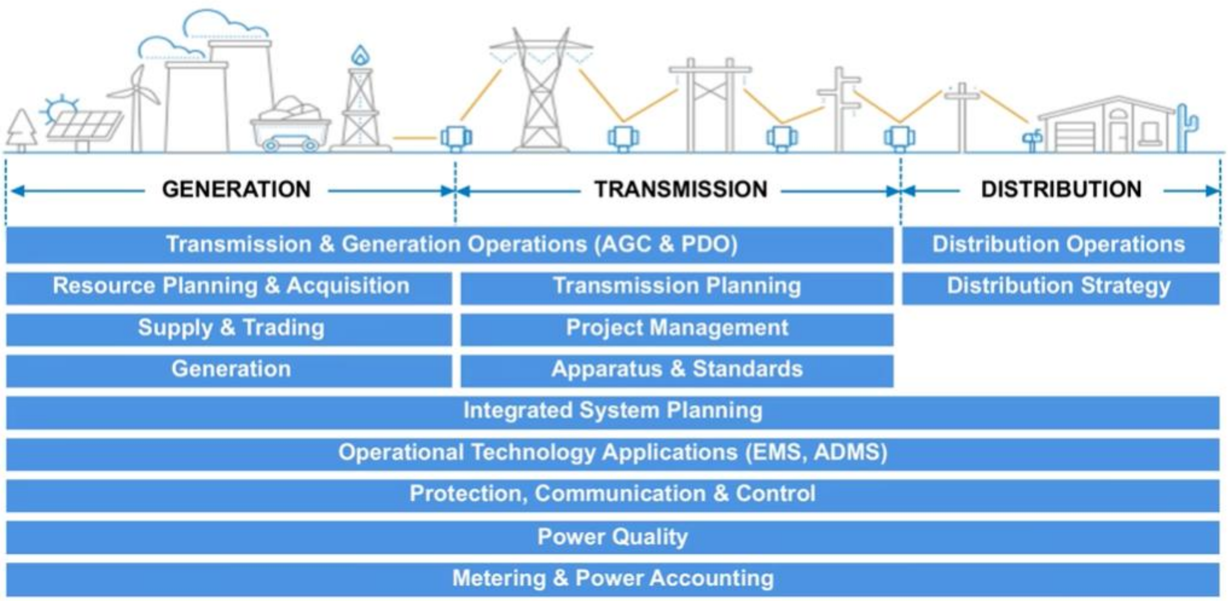


Figure 4: SRP OpR Enterprise Stakeholders [Source: SRP]

Collaboration is a central theme of the OpR program, which engages multiple departments across transmission, generation, and distribution to ensure a coordinated approach to integrating IBRs (see Figure 4). SRP has evolved its technical requirements for IBRs, informed by IEEE 2800-2022, NERC Order 901 standards efforts, and other industry reports. These requirements were structured around power purchase agreements (PPAs) and then moved to SRP's Facility Connection Requirements, with improvements including provisions for plant dispatch, data and telemetry responsibilities, forecasting obligations, and refined modeling and performance requirements. SRP leveraged the "hybrid integration" approach for IEEE 2800-2022 adoption (see Figure 5).

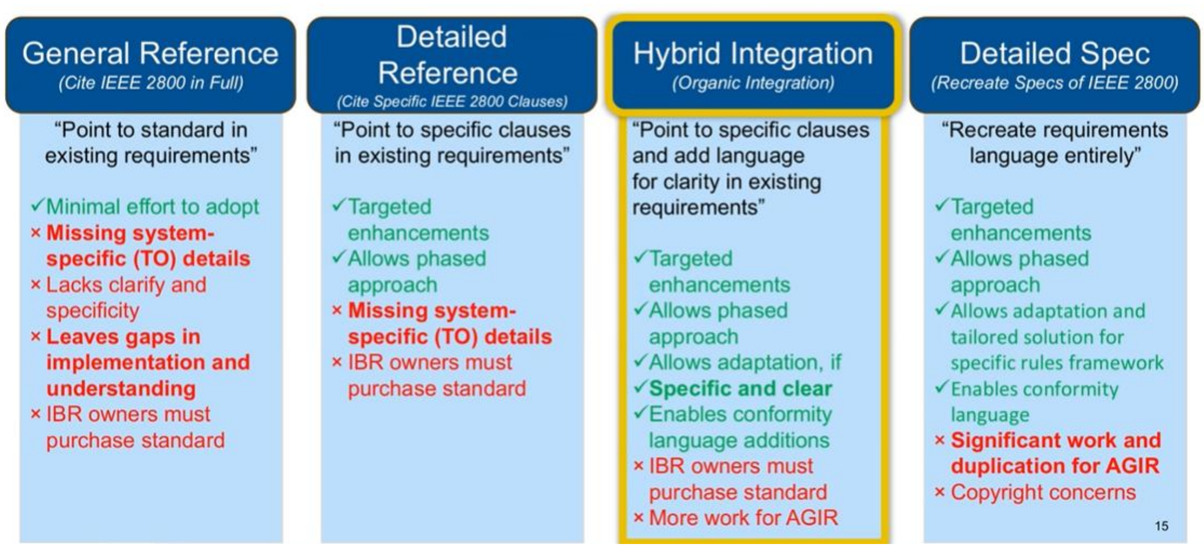


Figure 5: SRPs "Hybrid Integration" Approach to IEEE 2800-2022 [Source: SRP, adapted from ESIG]

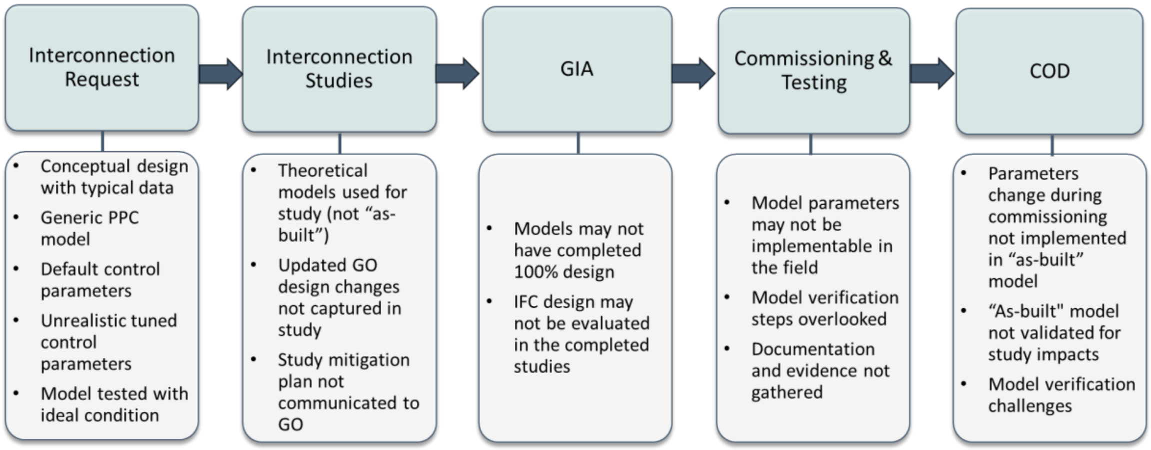
Scott shared real-world examples including sharing data from IBR sites that demonstrated SRP's success in integrating solar and BESS projects, highlighting measurable gains in cost effectiveness, reliability, and operational efficiency. Looking ahead, SRP recognizes the importance of proactively preparing for continued IBR growth and maintaining a focus on continuous improvement and strategic planning. SRP's collaborative, forward-looking approach to facing IBR-related challenges has proved an effective tool for the organization and a model for other industry stakeholders.

Ryan Quint, Elevate Energy Consulting

Ryan focused on the need to establish clear, harmonized interconnection performance and modeling requirements for IBRs as a foundational step toward improving grid reliability and streamlining the interconnection process. He also highlighted the numerous reliability events reported by NERC involving IBRs, noting these incidents point to broader, systemic challenges rather than isolated failures, which can be overcome with improvements to IBR plant conformity assessments during the interconnection process. The 2022 Odessa disturbance report was a tipping point that underscored this need, and stressed at the federal level the need for action both in the NERC Reliability Standards and in the FERC Generator Interconnection Procedures (GIP).

Ryan highlighted the importance of defining performance expectations early in the process. The first step is establishing clear, consistent performance requirements for newly connecting IBRs before projects move too far into development. Harmonizing these requirements based on learnings domestically and internationally can help avoid costly retrofits and redesigns later. By setting expectations upfront, utilities and developers can reduce uncertainty and ensure new IBRs are designed and operationally perform to meet performance expectations and requirements.

Ensuring accuracy and alignment between IBR plant model, IBR plant design, and performance requirements is central to achieving reliability objectives. IBR plants must be designed to meet established performance standards, and the models used in reliability studies must accurately reflect the actual project configuration. When models diverge from as-built designs, the integrity of planning studies and operational decision-making can be significantly compromised. This can be the result of the constant changes occurring to IBR plant designs throughout the interconnection process and IBR plant lifecycle (see Figure 6). Default model parameters, early-stage designs used in cluster studies, IBR plant equipment changes later in the process, and gaps in IBR plant commissioning all create opportunities for misalignment and systemic risks to be introduced.



* IFC = Issued for Construction; GIA = Generator Interconnection Agreement; COD = Commercial Operation Date

Figure 6: Potential Challenges with Current Interconnection Process [Source: Elevate Energy Consulting]

Without national-level requirements in place, industry has developed somewhat harmonized but notably different implementation of IEEE 2800-2022, IBR modeling requirements, performance conformity assessment processes, etc. Ryan stressed that harmonization can enhance reliability but also enable faster and more predictable interconnections by minimizing errors and rework. This requires sequential alignment throughout the interconnection lifecycle, with clear checkpoints to ensure that projects remain consistent with established requirements at each stage. Without such checks and balances, misalignment between study assumptions and actual plant capabilities can introduce reliability risks and delay project timelines.

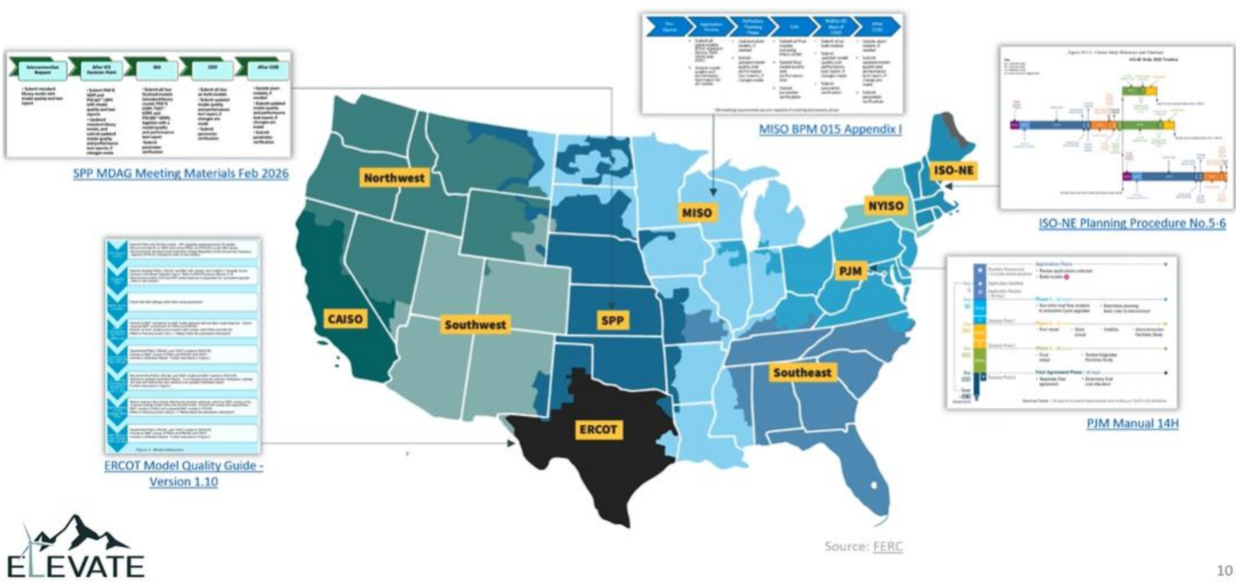


Figure 7: Regional IEEE 2800 Implementation Varies [Source: Elevate Energy Consulting]

Looking ahead, Ryan pointed to the implementation of the upcoming IEEE P2800.2 standard as a key opportunity to strengthen and modernize the interconnection process overall. He encouraged ongoing collaboration among utilities, IBR developers, OEMs, and regulators to ensure that performance requirements are consistently applied and effectively integrated in practice. He also emphasized that portions of IEEE P2800.2 need to be codified and put into action for effective change to occur. Industry is experiencing some implementation changes and improvements across regions (see Figure 7), but there are still key differences across the U.S. that need to be harmonized. He specifically cited MISO and ERCOT as adding in more model quality and performance testing requirements that are more in line with IEEE P2800.2. However, the challenge is that the current process is set up to fit these checks into a relatively short period of time between the cluster study and the final agreements. Overall, harmonized, clearly defined performance standards with checks at more frequent milestones and transmission provider involvement in the IBR plant commissioning and testing process are a strategic necessity for addressing the known IBR systemic risks.

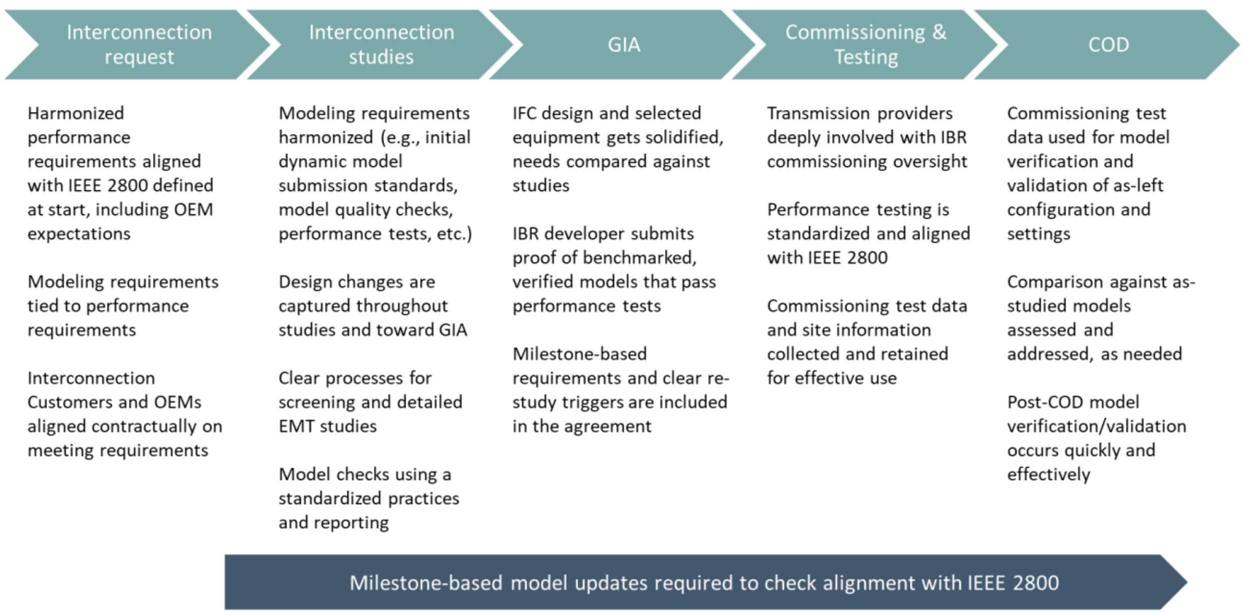


Figure 8: Recommended path forward to improve the IBR lifecycle [Source: Elevate Energy Consulting]

Q&A and Interactive Group Discussion

Is it beneficial for the grid to have IBRs injecting short-circuit current larger than nominal for five or more seconds?

Jens responded that there is no simple or generic answer to this question. Whether sustained fault current injection is beneficial depends on multiple factors, including grid conditions, the number and type of IBRs in the study area and beyond, and the protection systems in place, including legacy protection. In some cases, higher short circuit current contribution may be helpful; in others, it may introduce risk. IEEE 2800-2022 includes concepts related to overrating, though these are primarily focused on power rather than sustained current injection. He also indicated that EPRI has conducted research in this area and that further study is needed before drawing firm conclusions.

Ryan added that on the BPS, five seconds is already a very long fault duration. In his experience, even extreme cases tend to be significantly shorter, reinforcing that system context is critical when evaluating such scenarios.

Scott emphasized the importance of understanding both current system assumptions and future conditions, including how resource mix may evolve over the next decade. He noted that modeling assumptions and study expectations play a significant role in determining whether additional fault current is necessary or beneficial. Ryan further observed that traditional utility practices such as assuming all resources are online in short circuit analyses may create unrealistic assumptions that lead to costly upgrades.

Is a standalone STATCOM considered an IBR? If so, does this make sense considering the fundamental differences between generation and transmission assets?

Under IEEE 2800-2022, a standalone STATCOM does not meet the definition of an IBR because it is not "capable of exporting active power" as required by the standard's definition, (see Clause 3.1). However, STATCOMs may be used as "supplemental IBR devices" within an IBR plant to help the plant meet IEEE 2800-2022 performance requirements. In that context, the STATCOM becomes part of the overall IBR plant design. This distinction does not apply to transmission-connected STATCOMs operating independently of generation resources. The NERC construct is similar in that an IBR is defined as a generating asset whereas a standalone STATCOM is considered a dynamic reactive power resource.

What is a phasor model? Is it the same as a positive-sequence model?

Phasor models are based on fundamental frequency representations of the grid and the controls of IBR plants. While many phasor-domain models used in typical U.S. transmission planning practice are positive-sequence models, not all phasor models are strictly limited to positive-sequence representation. Positive-sequence models are a subset of phasor-domain models and depending on configuration, phasor models may produce negative- or zero-sequence components.

What does it mean for a regulatory body to adopt or enforce IEEE P2800.2 when it is written as a recommended practice (largely "should" and "may" language) rather than mandatory "shall" requirements?

IEEE 2800-2022 primarily uses "shall" language in the requirements but must be enforced by a regulatory body or other entity. The language in the requirements is written in a manner intended for use in enforceable requirements. IEEE P2800.2 is a voluntary set of recommended practices and thus intentionally leverages mostly "should" language.

Enforcement mechanisms are important for utilities and system operators to understand as they adopt both IEEE 2800-2022 and IEEE P2800.2. The adopting authority could choose to convert "should" statements to "shall" requirements. Jens suggested that during adoption, stakeholders should review each "should" statement and determine whether it is appropriate to make it mandatory.

Ryan added that IEEE 2800-2022 was developed through strong industry consensus, with extensive debate behind each requirement. Because IEEE P2800.2 is written entirely as a recommended practice, effective implementation may require a structured effort to review and potentially replace "should" language with enforceable "shall" requirements where appropriate. Jens also noted that initial adoption as guidance, without immediately introducing legal enforcement, may facilitate collaboration and smoother implementation.

It was mentioned that IEEE P2800.2 does not fully verify the model. What are some things that might get missed?

IEEE P2800.2 Clause 7.3 addresses procedures for IBR plant capability and performance assessment and specifies that "for each equipment model within a plant (for example, aggregated IBR unit model, power plant controller models, and supplemental IBR device models), controls and their parameter values should be configured such that they represent the overall IBR plant configuration and represent the utilization of capability as specified by the TS owner/TS operator."

In SRP's Iberian Peninsula workshop, one of the top concerns was difficulties coordinating with IBR plant developers, owners, and operators. Can you elaborate on that and any changes being implemented?

Scott explained that as the volume of new IBR projects increases, SRP has recognized the need for highly specific internal procedures that clearly define roles and responsibilities and how staff engage with IBR developers and owner/operators. This includes clarifying who is responsible for obtaining accurate IBR plant information and models and establishing enforcement mechanisms if requirements are not met. The coordination challenge stems in part from the pace of development now that they are adding numerous resources each year.

What is meant by "harmonized" requirements? Does harmonization refer to alignment across IBR technologies, across deployment stages, or something else?

Harmonization refers to establishing consistent, forward-looking technical minimum functional and performance requirements for IBR plants across entities. By defining clear baseline capabilities, system operators can better manage risk and decide when and how to utilize those capabilities to manage risk.

Key Themes

- **Voluntary Guidance and Mandatory IBR Reliability Standards:** The transition from largely voluntary guidance to mandatory NERC Reliability Standards and IEEE 2800-2022 adoption for IBRs is occurring rapidly, in an attempt to address known systemic risks that may stem from the interconnection process. Significant work is focused on effective implementation efforts to comply with these standards including meeting NERC standards, adopting requirements from IEEE 2800-2022, and incorporating recommended practices from IEEE P2800.2. IEEE P2800.2 implementation will require careful coordination among ISOs/RTOs, utilities, IBR developers, OEMs, third parties, and regulatory bodies.

- **Operational Readiness as an Organizational Initiative:** Utility operational readiness programs that bring together diverse stakeholders can help accelerate utility and system operator preparedness for rapidly rising IBR levels. Data gathering, internal surveys, cross-departmental engagement, and proactive risk mitigation have helped SRP accelerate solutions to manage higher IBR penetrations today and ahead. The utility has launched more than 30 projects across multiple themes to strengthen forecasting, situational awareness, training, modeling practices, IBR performance requirements, and interdepartmental coordination.
- **Challenges with current interconnection lifecycle:** There remain challenges throughout the interconnection process regarding model verification and accuracy, and IBR plant conformity assessments. Default or generic models, generalized assumptions, early-stage design used for cluster system impact studies, and lack of milestones later in the interconnection process are all contributors to these challenges. Final as-built designs may not be adequately checked and lack of oversight during IBR plant commissioning may underutilize the data available for model verification and validation. This introduces risks that can be fixed with improvements to the process and may lead to systemic risks persisting unless addressed.
- **National Harmonization of Technical Requirements to Reduce Reliability Risk:** The discussion continued to emphasize greater national consistency in how interconnection processes, IBR plant performance requirements, and IBR modeling requirements are defined and implemented. ISOs and utilities are developing somewhat similar yet notably different processes and requirements that create significant complications for IBR developers operating in different regions. The web of rules, requirements, milestones, etc., creates room for error and slowdown of the process. A more unified approach would reduce regional fragmentation, lower retrofit risk, and increase confidence that IBRs are designed to meet necessary technical minimum requirements.
- **Accountability Throughout the Interconnection Lifecycle:** Structured, milestone-based implementation of IEEE P2800.2, IBR modeling requirements, IBR plant performance conformity assessments, and commissioning practices can help address many of the challenges outlined. Alignment with IEEE P2800.2 between the authority governing interconnection requirements, the IBR developer, OEMs, and third parties can help streamline the process and reduce risk. More closely tracking design changes

throughout the interconnection process and conducting IBR plant design evaluations (including checking as-studied and as-built configurations) are key. Commissioning test data should be systematically collected and used to validate final plant settings, with transmission providers actively involved in oversight and model verification.