September 23, 2025 Virtual Meeting

IBR Plant Modeling Requirements and Best Practices (~225 attendees)

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

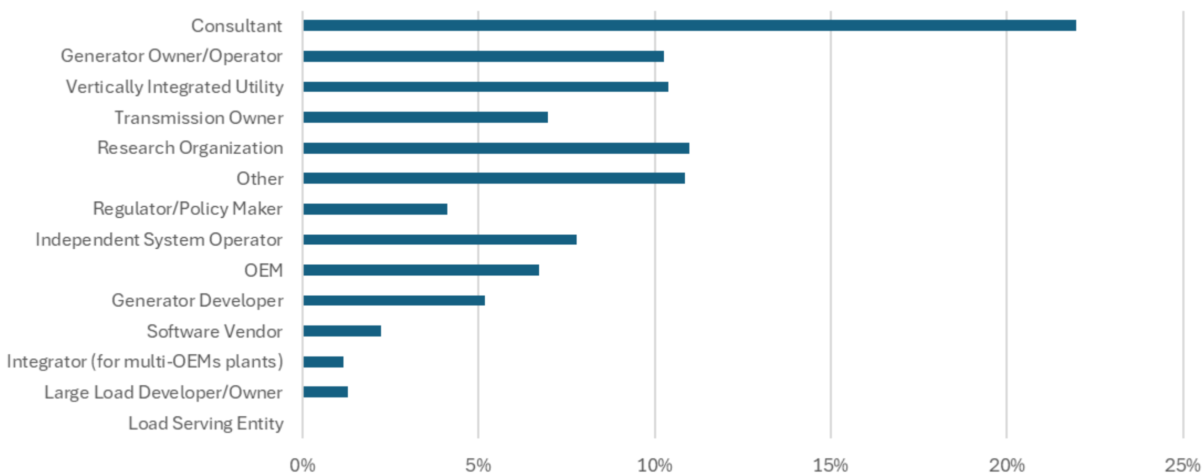

Figure 1: Meeting attendees by industry sector

This fifth meeting of Season 2 of the DOE i2X FIRST initiative focused on IBR plant modeling requirements and best practices, sharing experience from an ISO/RTO, developer/consultant, and perspectives looking forward in this area. Presentations included the following:

Bruno Leonardi, New York Independent System Operator (NYISO)

Bruno shared recent updates, initiatives, and perspectives from the NYISO. FERC Order 901 and New York State Reliability Council (NYSRC) Reliability Rule B5 (effective since February 9, 2024) have been some of the key drivers for NYISO to enhance their modeling requirements, and NYISO believes its IBR modeling requirements are in alignment with NERC's vision in this area (see Figure 2). While enhanced modeling and performance validation requirements can improve reliability and increase the accuracy and trust in models used for studies and decision making, these requirements can also affect timely commercial operation dates which can affect resource adequacy and reduction of security margins. In particular, Bruno mentioned that the NERC recommendations use the following statement (emphasis added):

> *"Performance testing processes should include sufficient tests necessary to show conformity with published performance expectations without adding undue study burden"*

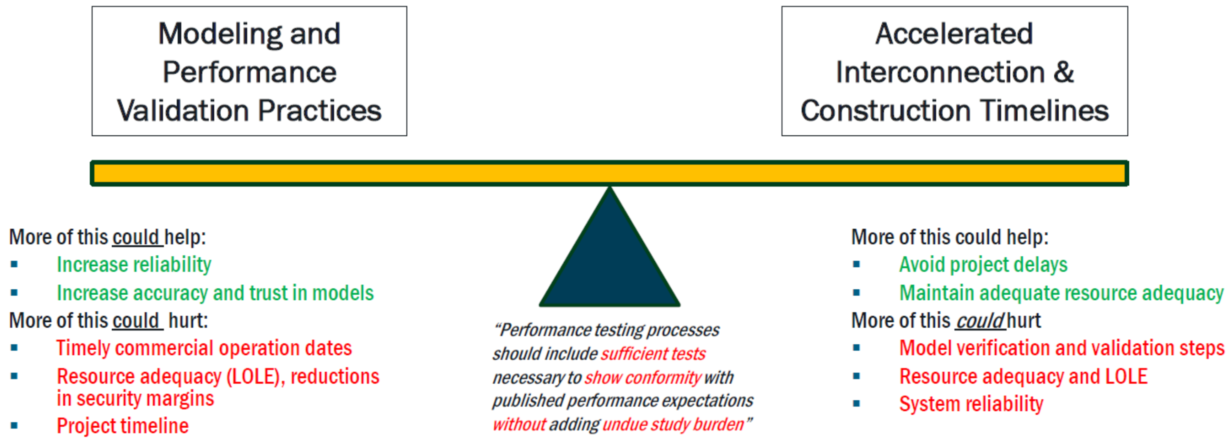

Figure 2: NYISO Perspectives on IBR Modeling Requirements and NERC Vision [Source: NYISO]

NYISO has established some core practices regarding IBR plant modeling, as shown in Figure 3. These include:

- Requiring models to accurately represent the as-planned and as-installed equipment.
- Clear equipment and model performance requirements
- Aggregate plant representation
- Benchmarked and aligned phasor domain transient (PDT) and EMT models
- Preference for standard library models but accepting all types of models
- Performing EMT studies later in the interconnection study process rather than earlier

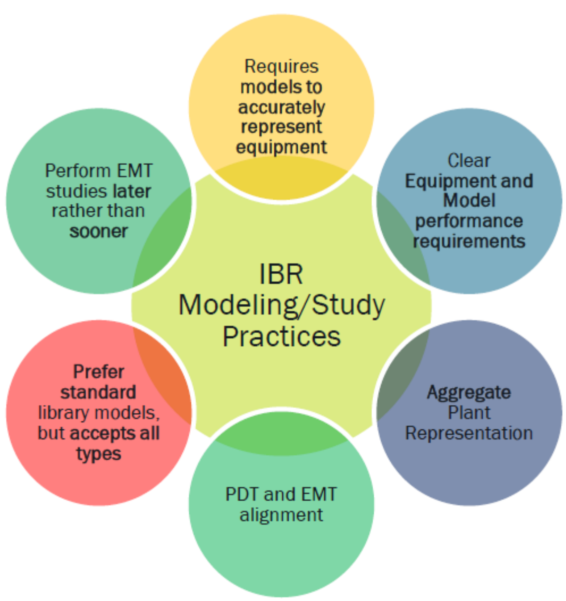

Figure 3: NYISO IBR Plant Modeling Practices [Source: NYISO]

Regarding EMT modeling and studies, Bruno shared some ongoing efforts and requirements that NYISO has implemented. EMT models are required for all IBR plants in the New York system including existing plants, plants under construction, and future IBR plants. Most EMT studies are only performed on a small area of the network, and NYISO is developing screening methods and processes to determine which IBRs must undergo more extensive EMT studies. NYISO is also thinking about the EMT study process as more of a "cycle" rather than a snapshot of the interconnection process, where EMT studies may be redone during plant construction or prior to COD once settings are confirmed/verified. The EMT study efforts have been moved later in the study process, once project details are solidified. This includes gathering EMT models *after* the cluster system impact studies prior to/during plant construction and then conducting studies as needed leading up to plant COD.

In terms of IBR modeling requirements, NYISO has established a set of tests that are similar to those specified in IEEE 2800-2022. NYISO opted not to specify quantitative pass/fail criteria; clear deviations off of baseline performance will generate questions during reviews. NYSRC Rule B5 adopted IEEE 2800 requirements (see Figure 4).

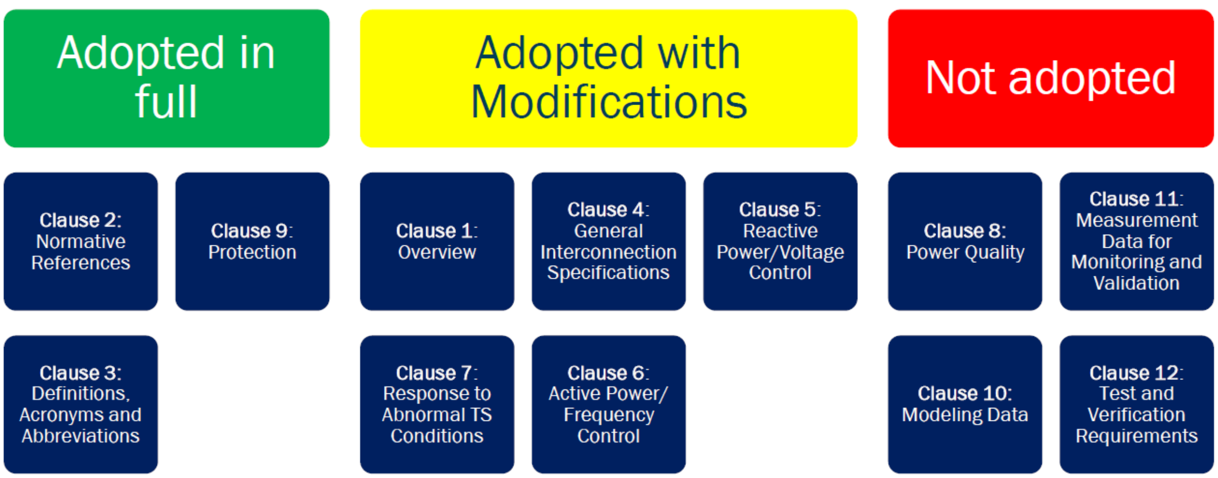

Figure 4: NYSRC Rule B5 Adoption of IEEE 2800-2022 [Source: NYISO]

Kasun Samarasekera, Elevate Energy Consulting

Kasun shared three recent case studies of IBR modeling and related those efforts to many of the IBR modeling and performance issues described in the i2X initiative. The first case involves a recent PSCAD model validation effort that revealed discrepancies between what was assumed to be a verified EMT model and actual behavior of the equipment in the field during an event. Somewhat abnormal response in the field was observed and the team attempted to recreate this performance in the model. To do so, the team needed to extract the inverter as-left settings, review the PSCAD model documentation, and review the actual PSCAD model. Inconsistencies in naming conventions across these three domains resulted in challenges interpreting what is installed in the field versus in the model (see Figure 5). Findings showed that the model performed very well to simulated disturbances and that model was used to pass ISO/RTO modeling tests whereas the actual equipment in the field had abnormal performance issues that needed further analysis. This highlighted the need for model verification (i.e., comparing "as-built" equipment and settings with the submitted model) during commissioning as well as ongoing model validation efforts to ensure the model matches the actual performance.

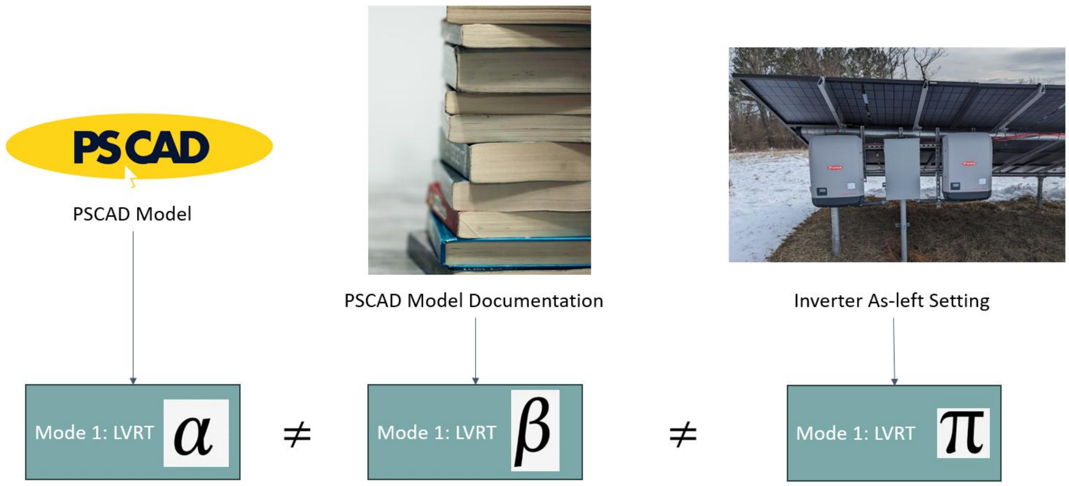

Figure 5: Discrepancies between Model, Documentation, and As-Left Settings [Source: Elevate Energy Consulting]

The next case study focused on a PPC OEM's generic model that may not meet the new ERCOT requirements related to PPC accuracy and validation as well as ongoing challenges interpreting what qualifies as "generic" versus actual control hardware in the loop (CHIL) testing and model validation. Generic PPC models based on, for example, the standard library "REPC" control block diagrams are no longer allowed in ERCOT. CHIL validation has become increasingly common for IBR units (i.e., turbines and inverters) but not necessarily for PPCs. Unrealistic PPC models (i.e., high gains, no communications delay, etc.) are rather common to achieve desired performance required by the system operator and these models are often used as defaults during the interconnection process.

Kasun highlighted the importance of accurate PPC model validation, which can include two options:

- .DLL "real code" wrapper where the actual control code is used and masked by a .DLL in the simulation models[1]
- PSCAD block model with CHIL validation to prove that the model matches actual performance

The last case study described working with an OEM PSCAD model in the HECO region where model updates by the OEM to pass certain tests resulted in failed results for other tests that

[1] CHIL testing is still recommended even when using these types of models to validate that the model matches the actual performance of the equipment.

previously passed, which highlights the need for comprehensive model testing approaches. In this situation, the OEM-specific models were provided with default parameter values and may not meet all grid code requirements under all necessary conditions. Thus, model tuning is necessary. This required close collaboration between the OEM, the project developer, and the consultants supporting the project to ensure inverter compliance with the applicable rules. The OEM made changes to the model based on a new version that enabled the plant to improve its ride-through capability; however, the plant then exhibited unacceptable damping following some disturbances. Conducting all required tests to ensure the model wholly passes all requirements prior to submission can help lead to a successful submission. Ensuring some degree of verification of the model against the field equipment/proposed settings helps ensure accuracy throughout the process.

Lastly, Kasun highlighted a recent concept and framework developed by Elevate to create more consistency and standardization between models and as-left settings across OEMs. Some OEMs have adopted a process where a mapping file can be used to extract as-left settings and port them to the models, and vice versa. However, these mapping files are not standard and require significant time to understand and refer to for project engineers. The exercise of extracting as-left settings and understanding how they map to the models should be a 5-minute exercise that can be quickly checked; however, this is not the case presently on a widespread basis. Thus, the concept of a ".IBR" file could be used to convert OEM mapping of their parameters (models and as-lefts) such that a standardized reporting tool could be used to extract parameters and settings when needed.

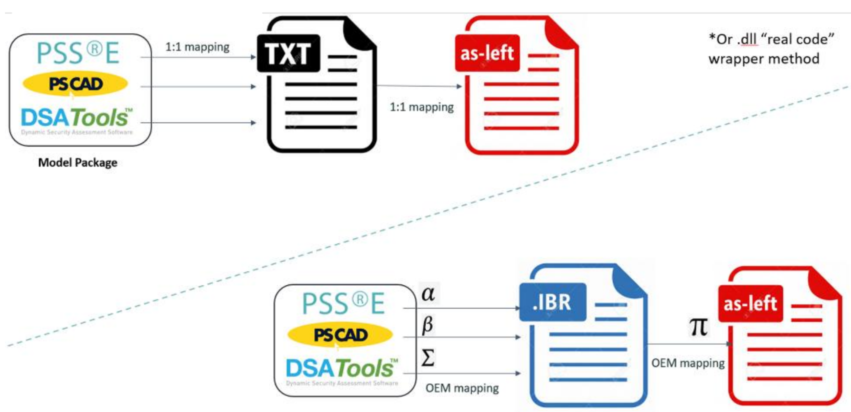

Figure 6: Concept of ".IBR" Standardized Mapping File between Model and As-Lefts [Source: Elevate Energy Consulting]

Andrew Isaacs and Lukas Unruh, Electranix

Andrew and Lukas highlighted that industry has made good progress in the area of IBR performance and modeling including publication of an IEEE standard that raises the performance bar, the prevalence of IBR modeling requirements, development of automations and processes to gather and review models, and understanding of GFM technology. These efforts have hopefully led to meaningful reliability benefits and the reduction of risks to the bulk power system. However, more work is needed moving forward to improve model accuracy such as:

- Requirements and guidance regarding unit-level model validation reporting and inclusion of type testing from IEEE P2800.2
- Improved IBR commissioning, testing, and verifications around COD
- As-built confirmations (i.e., verification) to ensure control firmware, parameters, etc.
- Adoption of .dll standards (i.e., real code models)
- Improved PPC modeling, modeling of plant communications delays, DC-side protections and controllers, etc.

OEMs may be providing a general purpose model that must be parameterized for specific projects and conditions yet the OEMs do not have sufficient resources to create and maintain as-left models that continually reflect the equipment in the field. OEMs are apprehensive to share "proprietary" information with project developers and consultants supporting the modeling efforts throughout the interconnection process. Some equipment protections may be disabled by default, leaving errors or omissions in the models if not carefully reviewed.

Data management is also becoming a challenge as more model iterations are required during the interconnection process as changes occur to the IBR plant design and equipment selection. Documentation and models need to reflect these changes and be reported accordingly. Code management, version control, etc., are all key to enabling this more effectively. Data repositories where models are "fetched" can play a key role here.

Improvements and maturity in screening tools and automations are also key for EMT studies. This includes screening for weak systems, SSO risks, etc., using high-quality, commercial-grade tools rather than one-off scripts. Clean and effective automation tools for building cases and conducting studies is needed so that the everyday study engineer does not need to be an expert in EMT modeling, similar to how PDT tools are used today.

Andrew and Lukas also highlighted that expanding study capabilities will also improve informed decision making, and this is applicable not only to IBRs but also to large load interconnection analysis as well.

<u>Q&A and Interactive Group Discussion</u>

What requirements, checks, verifications, etc., does NYISO have in place to ensure the models match the proposed equipment, particularly early in the interconnection process?

Some requirements exist for PDT models but no requirements around verification exist for EMT models yet. NYISO recently started their EMT implementation strategy and are working through when to request models, the level of detail in the models, and how those models will be used in studies. NYISO has not gotten to the point of requiring verification steps but did highlight that the NERC alert included recommendations regarding verification and validation of models.

Did NYISO send a request to all GOs for EMT model submissions from existing plants? Did it include model quality testing or benchmarking?

All existing IBR plants have been asked to submit an EMT model in accordance with the EMT modeling guidelines NYISO has published and were given six months to prepare and submit the model. There are several tests in the guideline to evaluate model performance and usability, and those tests are not pass/fail but rather are meant to be informational. If significant discrepancies from the "baseline response" are observed, additional discussions to understand why the models deviate may ensue. This should lead to better, usable models. Benchmarking between the PDT and EMT models is only requested for selected tests. NYISO recognizes that this is a fluid topic with IEEE 2800.2 and the recent NERC alert proposing test procedures to help facilitate conformity evaluation, so new processes to address that may emerge in the future.

Is Rule B5 applicable from Calendar Year 2023 onwards? What is the expectation from IBR projects submitted before that time? Does NYISO still expect an EMT model?

Correct, if you read Rule B5, it says it is applicable to projects in the interconnection studies process. Plants already in commercial operation are not asked to comply with it. The expectation for existing IBR plants remains unchanged and guided by the NYISO Tariff and manuals, local TO requirements, and applicable NERC, Northeast Power Coordinating Council (NPCC) and NYSRC rules and standards. The NYISO tariff grants NYISO the ability to request EMT models (or studies) from any market participant. EMT models were not requested until recently but given the significant volume of new IBR plants interconnecting to the system, having accurate EMT models of existing IBR plants is important. Those models are useful not only for system reliability studies, but also when there is a need to study new IBR plants connecting near existing ones.

Please elaborate on how NYISO enforces changes/upgrades to the IBR plant or network when the studies are occurring post-GIA? The developer has a signed GIA, so how do you enforce requiring changes at this late phase?

NYISO has requirements that every time a change occurs at the facility, a new model must be provided and additional studies may be needed. NYISO recognizes that settings changes do occur throughout the interconnection process. Things are likely to change, so it is hard to set a firm date on when changes can no longer occur. The requirements in the NYISO manuals and tariff require developers to report changes and a new study cycle may be initiated.

NYISO has not adopted IEEE 2800-2022, Clause 10 (Modeling Data). Does NYISO intend to adopt this clause in the future along with tests specified in IEEE P2800.2? If not, what

would need to change in IEEE 2800-2022 or IEEE P2800.2 for NYISO to be more inclined to adopt the 2800/.x framework and tests?

NYSRC Rule B5 adopts most of IEEE 2800-2022 and made modifications to clauses that NYSRC thought needed adjustment. Clause 10 has not been adopted as part of Rule B5. NYISO has started collecting EMT models so, to an extent, is already doing part of what Clause 10 asks. Complete adoption of Clause 10 remains a topic of discussion. Adoption of IEEE P2800.2 (or a slightly modified version of it) seems like a natural step for NYISO given that NYISO/NYSRC adopted most of IEEE 2800-2022 requirements through rule B5. Currently NYISO is not asking for model validation steps to be performed, and this is a critical step in ensuring models capture actual equipment behaviors. This remains a fluid topic of discussion. NYISO will issue public statements when more details can be shared.

There appears to be a lot of focus on "validation" but not nearly as much focus on "verification". What do the presenters think about this?

The state of the art IBR modeling is rather good, particularly model validation at the IBR unit level when done correctly (e.g., using DLL real code wrapper standards). It is useful to do validation both at the IBR unit and IBR plant level to identify issues, fix modeling or site errors, etc. However, the much larger gap is verification right now. There are many instances where the models simply do not match the as-left settings, configuration, controls, protections, etc., at the site. This completely invalidates the model and makes validation efforts meaningless and/or much more difficult. The process of verification is not straightforward and standardization in this area is needed. Verification should be a 5-minute exercise, but it presently is a spiderweb across settings, models, and documentation. Industry harmonization and ideally standardization would be very impactful for industry practitioners.

Regarding identifying weak system, what is the main advantage and features of the mentioned commercial software over various SCR-based methods?

Traditional SCR based metrics become unreliable in medium-to-high penetration IBR scenarios. SCR does not consider the impacts of nearby IBRs. Weighted SCR (WSCR) can consider nearby IBRs but 1) assumes they are all interacting in unison (overly conservative), and 2) requires discrete selection of which IBRs to include in the calculation which can arbitrarily skew the metric one way or another. New tools are a highly-scalable implementation of SCR with Injection Factors (SCRIF) (see Cigre WG B4.62 *Connection of wind farms to weak AC networks* (2016)), with the modification of setting device-dependent source impedances to distinguish between short-term voltage control ability of various resources. It accounts for nearby IBRs according to the voltage coupling between POIs, which can also be defined as off-diagonal impedance elements in the equivalent reduced impedance matrix.

Key Themes

- NYISO continues to evolve and enhance its IBR modeling requirements in response to FERC Order 901 and NYSRC Rule B5, emphasizing alignment with NERC's broader vision. The approach seeks to balance improved model fidelity and reliability benefits against potential delays in achieving commercial operation dates, which directly affect resource adequacy and system security margins.
- EMT modeling is becoming a core requirement for all new and existing IBR plants in New York, but NYISO is treating EMT studies as a cyclical process rather than a one-time step. Studies are being conducted later in the interconnection process, with screening tools developed to identify which IBRs require more detailed analysis and ongoing updates through construction and prior to COD.
- Case studies highlight gaps between verified EMT models and actual equipment behavior, underscoring the importance of commissioning-based model verification and ongoing validation. Challenges such as inconsistent naming conventions, unrealistic generic PPC models, and OEM tuning that resolves one test but breaks another all point to the need for more comprehensive and standardized validation frameworks.
- Verification of models against as-left settings remains a significant industry gap compared to validation. Without ensuring that models truly reflect installed equipment, protections, and settings, validation efforts become far less meaningful. Efforts like the conceptualized framework of the standardized ".IBR" mapping file aim to streamline and harmonize this process, making verification efficient and practical across OEMs.
- Industry progress includes adoption of IEEE 2800-2022, growing use of DLL "real code" wrappers, and increased reliance on CHIL validation, but OEMs face resourcing and proprietary-data barriers that limit the availability of accurate, project-specific models. Data management and version control are increasingly critical as models evolve through plant design changes, highlighting the need for structured repositories and automation.
- Looking forward, automation and improved screening tools are viewed as essential to making EMT studies more accessible and less expert-dependent. Enhancing PPC modeling, incorporating plant communication delays, and applying commercial-grade screening methods for weak systems and SSO risks will elevate study quality and help ensure that BPS decision-making reflects the real performance of IBRs under diverse operating conditions.