November 25, 2025 Virtual Meeting

Change of Management during IBR Plant Interconnection Process and Commissioning, How to Maintain Conformity (~175 attendees)

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

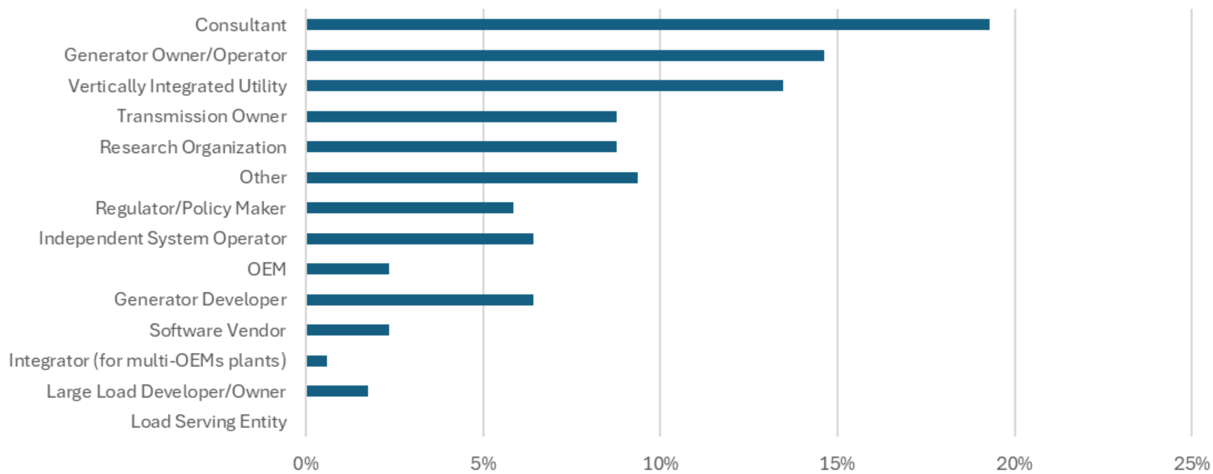

Figure 1: Meeting attendees by industry sector

This seventh meeting of Season 2 of the DOE i2X FIRST initiative focused on IBR plant change management during the interconnection process and commissioning and how to maintain conformity throughout that process. Presentations included the following:

<u>Katie Iversen, Joseph Parry, Andrew Lopez, AES</u>

The AES team shared their perspectives regarding the importance of verifying inverter and PPC settings, alignment of models and field implementation, and how standardized processes can reduce friction across OEMs, contractors, and internal teams. They highlighted that this effort supports grid reliability, helps IBR plant developers achieve project success for commercial operation, supports operational performance and regulatory compliance, and improves productivity and resource management.

The “as studied” models need to match the “as commissioned” configuration of the site for many reasons and this can be an overlooked area during commissioning activity; thus, focused attention during commissioning to ensure site parameterization matches the studied models, and that any discrepancies are addressed effectively, helps meet utility and regulatory obligations. Allowing these discrepancies to persist can be costly, lead to risks during commercial operations, and may undermine compliance efforts.

While standard library models are still widely used, they often deviate significantly from actual equipment behavior. They do not have a close correlation to actual equipment settings (controls and protection). On the other hand, EMT and UDMs more closely match the actual inverter/PPC settings and make verification efforts easier so long as those settings are made available to the user/IBR plant developer. It is important to have requirements for IBR plant performance and model/simulation requirements and reviews.

Inverter settings have a lifecycle (see Figure 2) that evolves from the early-stage equipment selection, equipment capabilities, and site-specific project needs. These settings may change to reflect the IBR plant performance requirements for a specific region. This involves working with the OEMs to iterate and tune the inverter settings. Those settings (model and actual) get approved by the utility/ISO and serve as the baseline for commissioning efforts. However, those settings may change during commissioning and also may change during commercial operations intentionally or unintentionally.

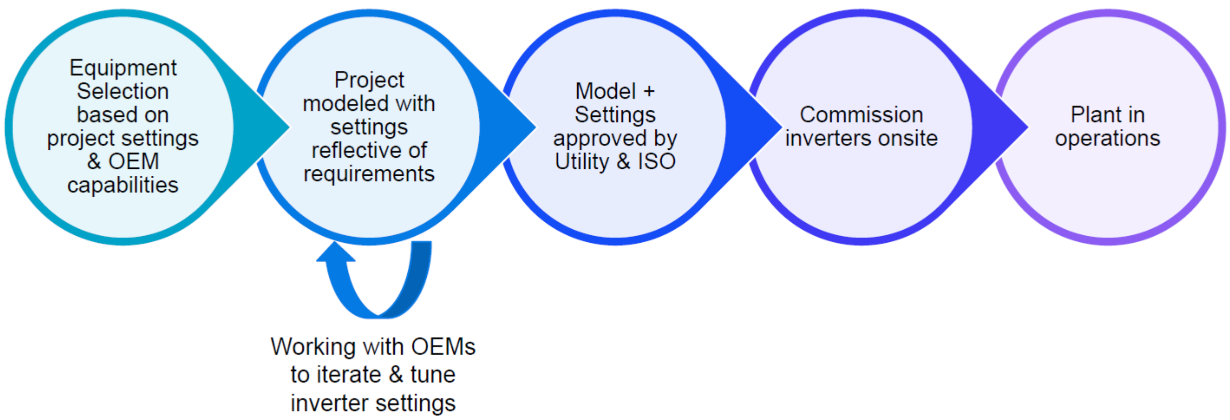

Figure 2: Inverter Setting Lifecycle (Source: AES)

The AES team recognized that the inverter setting lifecycle is not a linear process prior to equipment selection, which may include parts of the interconnection process. Prior to equipment selection, best efforts should be made to gather reasonable information about the project; however, this information may not exist, and more generic information is often used. Once equipment has been selected, settings should not deviate from the selected and approved values; otherwise, this may pose risks to project success.

To address variability across OEMs' models, platforms, file types, etc., AES requests deliverables from inverter OEMs that include documentation of, approval of, and visibility into inverter parameters (see Figure 3). This includes an inverter settings statement after the model is studied and approved which converts the model and inverter settings into a digestible list that is used for commissioning efforts. It also includes an on-site parameter verification process that verifies the approved parameters are uploaded on the actual equipment. Lastly, it includes SCADA integration to capture some of these settings into the SCADA alarming and historian for improved visibility, compliance support, and traceability of settings.

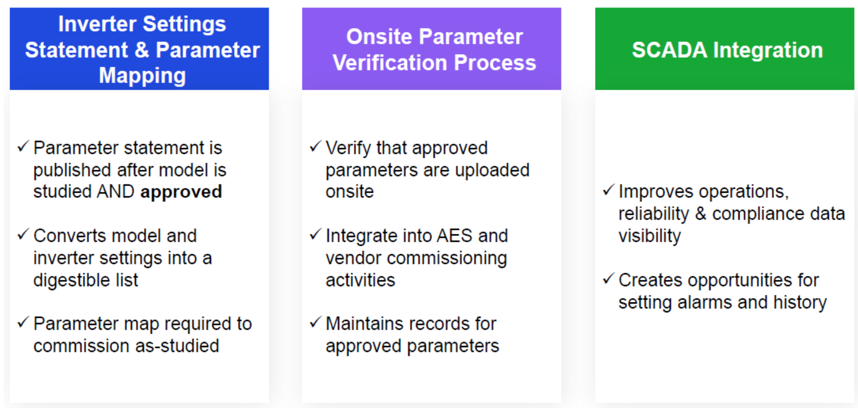

Figure 3: Deliverables for Inverter OEMs (Source: AES)

AES is focusing on ensuring modeling accuracy throughout the commissioning process and has developed a timeline to reduce commissioning friction by identifying critical checkpoints for parameter upload, verification, and onsite download (see Figure 4). This approach creates a division of responsibilities between the internal modeling team, OEM(s), commissioning engineers, and project engineers. The goal is to maintain alignment between the approved models and what gets implemented in the field. At the beginning of the process, the verified parameter list is uploaded to the equipment and then immediately downloaded for verification. Furthermore, at inverter hot commissioning[1] and IBR plant testing phases, the settings are again downloaded and re-verified.

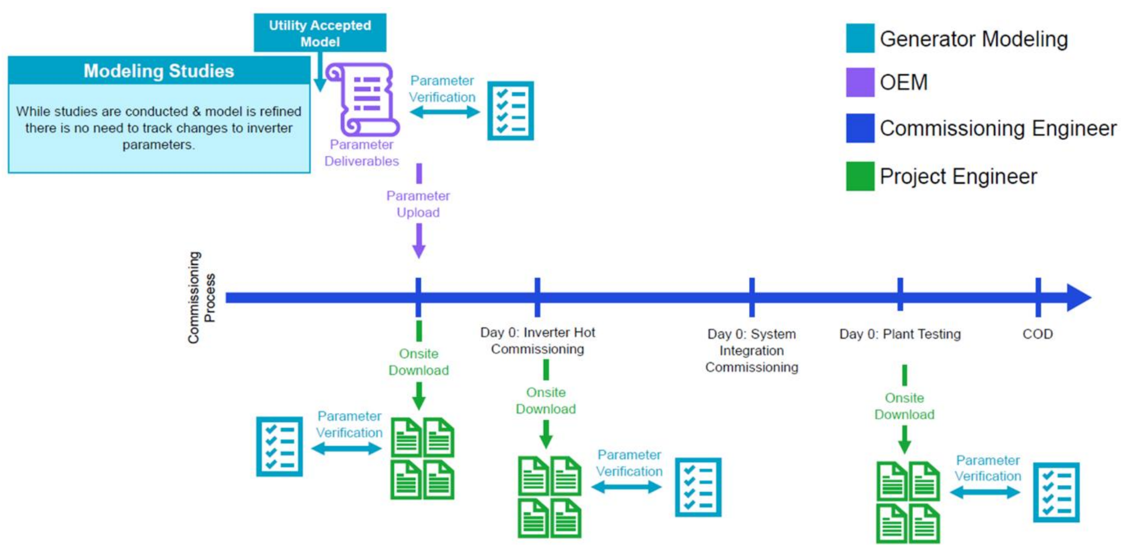

Figure 4: Key Milestones for Modeling and As-Left Setting Verification (Source: AES)

AES has had experience with this approach, identifying situations where parameters were inconsistently pushed to inverters at an IBR plant. Most inverters had the correct settings, but

[1] Phase of commissioning where an inverter is tested while energized and connected to its DC source or the grid.

one set of inverters was configured with different settings unexpectedly. Their IBR plant verification practices and systems were able to help them quickly identify and address this issue on-site.

The presentation concluded with key takeaways for IBR plant developers, owners, and operators:

- Standardize grid reliability settings such as ride-through parameters and voltage/frequency control settings, and file types (OEMs, industry groups, developers)
- Improve interconnection processes and IBR plant model reviews (transmission planners)
- Standardize access to inverter settings and settings change alerts (OEMs, industry groups)
- Focus on change management for inverter/PPC firmware and software updates (OEMs, developers/owners)

Miguel Cova Acosta, Vestas

Miguel shared OEM perspectives regarding change management during the IBR interconnection process. Changes in personnel, ownership, and project management during the interconnection and commissioning of IBR plants can jeopardize grid code conformity, which is not a single milestone. Rather, maintaining grid code compliance is a responsibility spanning early development, contracting, engineering, construction, commissioning, and commercial operation (see Figure 5). Each phase introduces players including sales teams, project developers, EPCs, OEM engineering groups, grid operators, and service teams. Handoffs create potential for misalignment or misinformation, yet a successful project maintains continuity through these transitions.

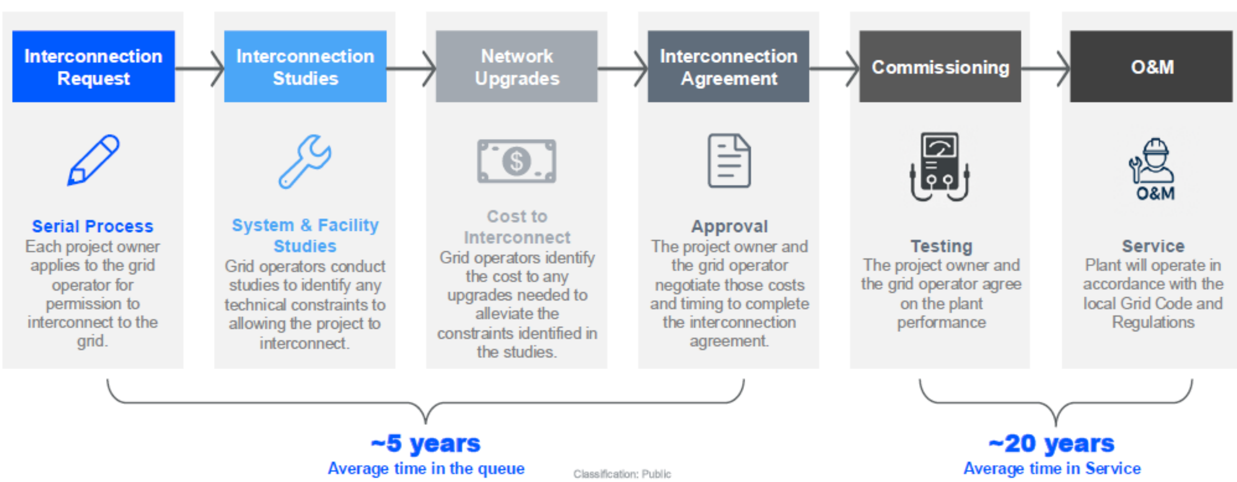

Figure 5: Interconnection Process Overview from OEM Perspective (Source: Vestas)

One challenge in maintaining grid code compliance is that the grid code often applies at the IBR plant POI rather than individual turbines/inverters and thus the OEM is generally not directly responsible for grid code compliance. Meeting requirements at the IBR unit-level does not guarantee compliance at the point of common coupling for the inverters because of the collector system and other design decisions. Long feeders, weak grid conditions, low system inertia, series compensation, control interactions, and other factors can significantly affect the electrical response at the POI and thus the IBR plant must be evaluated as an entire resource connecting to the grid.

There are several areas where change management can go wrong, as illustrated in Figure 6. Early-stage design decisions and specification misalignment can result in equipment selections and/or configurations that do not match the actual grid code requirements or grid needs. These may be based on commercial urgency rather than technical reality and have long-term consequences that resurface later in the process. Drift between the actual product decisions and the models used for grid code evaluation and reliability studies can also create conflicts or issues during commissioning or with the transmission provider. Deviations of as-sold or as-left settings from the approved models can result in noncompliance. Communication and handoff challenges exist between teams and entities. Lastly, human factors such as turnover, lack of training, misinterpretation or misunderstanding of equipment capabilities, and other factors all lead to areas of concern. Clear and effective OEM deliverables throughout the full IBR plant lifecycle help overcome these challenges.

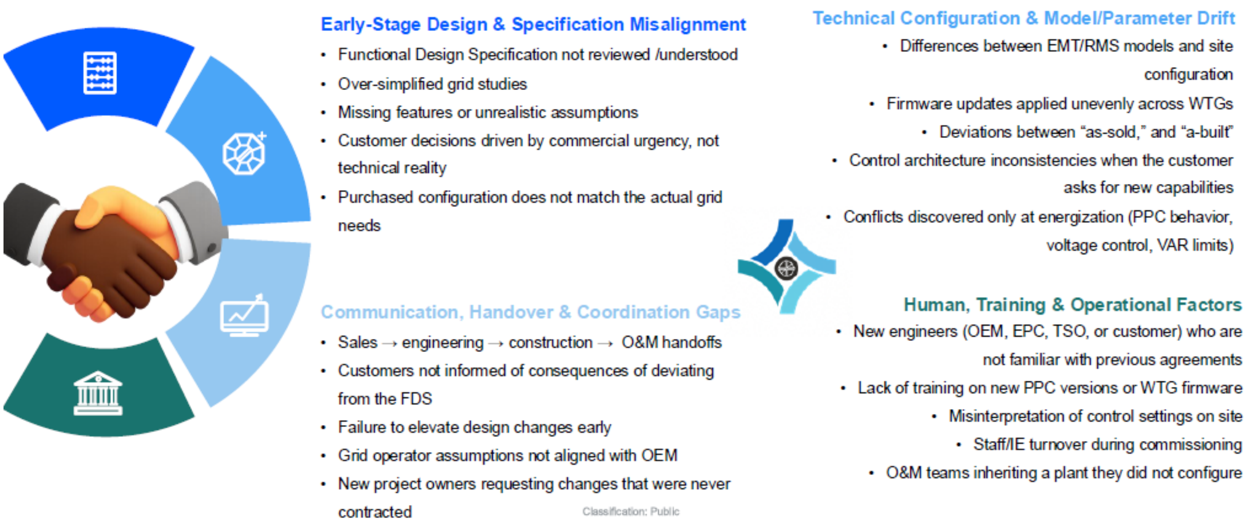

Figure 6: Areas Where Change Management Can Go Wrong (Source: Vestas)

Rigorous early-stage electrical design and well-developed foundational documents are critical because later-stage issues often stem from gaps or misunderstandings early in the process. Maintaining consistency between models and as-built plant configuration/settings is essential for grid code conformity as even small deviations in controls, parameters, or firmware can compromise commissioning. In practice, challenges arise from coordination breakdowns across EPCs, OEMs, owners, and grid operators. Continuity and competency across all involved teams have a major influence on project success. Strong OEM involvement across the entire lifecycle helps preserve design integrity and long-term grid compliance requires ongoing verification to keep documentation, models, and field settings aligned.

Patrick Hart, Mortenson

Patrick shared EPC perspectives on managing change during the interconnection and commissioning of IBR plants and emphasized that changes occurring throughout the process (before or after commercial operation) can affect compliance, performance, and long-term project viability. The EPC must play an active role in design, coordination, and compliance to ensure projects stay aligned with evolving grid code requirements. Prior to COD, transitions bring more work and higher timeline risk but offer greater flexibility to address early. For example, changes in IBR plant configuration, metering locations, communication protocols, settings, control modes, etc., can be reconsidered and ensure that the equipment is physically capable of such changes. After COD, however, changes are more challenging and may not be practical with the equipment installed. In either case, detailed documentation, knowledge of interconnection requirements, and understanding of exemptions or other practical design considerations are essential.

Post-COD owners should never assume a project is compliant; instead, they should independently review and verify commissioning test results, assess operational data, and verify whether warranties, service agreements, and OEM support are intact. Patrick shared recommended practices for maintaining compliance through transitions:

- **OEM Compliance:**
  - Verify NERC compliance such as ride-through capability and operation, reactive power capability, active power performance, recording capabilities, protective relays, and other features.
  - Ensure equipment capability and performance meets NERC and utility interconnection requirements.
- **Operational Compliance:**
  - Understand operation of the facility, particularly for hybrids, multi-phase projects, and co-located sites.
  - Verify critical documentation such as control narratives, commissioning test plans and results, operational manuals, maintenance manuals, and cybersecurity plans and protections.
- **Financial Performance:**
  - Verify ratings, degradation estimations, capacity factors; determine storage energy/power overbuild, expected derating conditions, augmentation options.

- Analyze operational data and equipment performance such as fault performance, serial defects, offending unit(s), etc.

From an IBR plant buyer perspective, conduct rigorous compliance gap analysis against NERC and IEEE standards to compare facility design with compliance obligations. Ensure stricter cybersecurity requirements are met. Ensure OEM and EPC engagement throughout the process. Plan for any necessary upgrades in situations where gaps may exist.

Q&A and Interactive Group Discussion

Equipment selection may come well after dynamic models are required by the utility/ISO. Can you elaborate on how this should be handled from an IBR developer perspective?

This is a complex issue, and a truly linear process only begins once the inverter selection is finalized, but the early design stage carries significant variability. Iterative reviews are unavoidable—early-stage iterations simply help ensure the IBR plant developer presents the strongest initial case while later iterations refine project settings and validate them through testing. When equipment selection is still open, the IBR plant developer coordinates closely with the development team to narrow options to IBR technologies that can pass interconnection model acceptance tests and other requirements. Once the equipment is locked in during execution, the IBR plant developer repeats those tests with actual design data.

A common misconception is that early-stage projects lack sufficient detail to justify meaningful analysis, so the effort seems premature. In practice, early analytical discipline sets the project up for success during execution by clarifying what questions must be answered and what model information is required across stakeholders. As noted, a linear approach cannot fully capture the interplay between equipment selection and settings validation. The reality is that iterative analysis is unavoidable as early design details mature. Above all, the execution team and the interconnection team must stay tightly aligned for the process to work.

What specific interoperability protocols and data formats are used to integrate inverter settings with the SCADA system? How is data being extracted out of the inverter and how is that communicated to SCADA? Is there opportunity to identify situations where firmware updates are causing inadvertent settings changes?

Secure File Transfer Protocol (SFTP) is being evaluated since it's already used for other functions like data reporting to the ISO. Inadvertent changes are exactly the type of situation the IBR owner is looking to identify proactively along with regular downloads of inverter settings and timely notifications from OEMs about updates. SCADA values can be verified before and after changes occur. Alarms can be programmed to flag setting changes without relying on OEM notifications, though those are still preferred.

When a firmware update requires inverter setting changes, the OEM must communicate those updates to the developer. Once a change is identified, the IBR owner confirms the changes meet the requirement, coordinates with the modeling team to update the model(s), revalidates performance to ensure it still passes applicable tests, and then communicates the changes back to the utility. Increasing on-site verification can improve visibility into errors, erroneous settings, etc., and corrections can be made before they lead to grid events.

Is there more convergence toward standardized parameters or standardized approaches to extracting information?

Standardizing actual parameter values is challenging because they depend on equipment capabilities, but standardizing *which* parameters must be exposed for grid reliability (without compromising OEM intellectual property) is essential. Protective relays use ANSI numbers to clearly identify specific settings; the IBR community should consider a similar approach to IBR control functions like ride-through, PFR, and voltage control. Even a manual but consistent, standardized method for extracting these parameters would be a meaningful step forward. Ultimately, visibility across all stakeholders is key.

When should the OEM provide dynamic models during the interconnection process?

The IBR developer is requesting dynamic models from OEMs once they know what IBR unit they are submitting to be used in the interconnection process. This establishes the latest and greatest validated unit model at that point in time to use for model quality tests as required by the utility, and it gets updated throughout the interconnection process as required and as known.

What specific studies are performed to obtain the inverter settings? Say, for instance, in ride-through settings, what specific study is done to get the setting after the model has been validated to work?

There are a few tests that are considered: 1) Model Quality Tests required by the utility for the IBR plant to meet, 2) NERC PRC-029 ride-through evaluation tests, and 3) upcoming IEEE P2800.2 conformity assessment practices. Some tests may not be a requirement to get through the interconnection process; however, they support commercial operations.

Requirements are defined at the POI but equipment components (PPC or inverter) need to support meeting these. How does this practically work together, especially for equipment bought earlier than new requirements? Who has the onus to solve the problem of taking nonconformant equipment and making it work? What can be done to solve this dilemma?

It depends heavily on the nature of the issue. Much of this comes back to how well the IBR developer structured the OEM contracts. If the requirements were clearly captured, the OEM may still be responsible for meeting them. Often, these details are overlooked, or the IBR developer references IEEE 2800-2022 when it does not apply to the OEM directly. If the issue is a firmware or parameter update, it can typically be handled through a change order that compensates the OEM for implementing the update. Some changes may be physically infeasible;

in those cases, the applicable requirements may include exemption or exception provisions that need to be invoked.

The OEMs generally stress that grid code compliance does not directly apply to them as many of the requirements are established at the IBR plant POI or POM; thus, an OEM cannot singularly state that their product complies with a specific requirement. IBR developers and utilities must ensure that the OEM product(s) used support compliance with the requirements, requiring additional design evaluation testing and verification.

How are PPC OEMs providing tuned parameters sufficient for utility model approval that will not change during commissioning? Specifically gain values for AVR or PFR.

Some OEMs emphasize that they do not make unilateral changes to PPC settings; updates are only implemented with explicit owner approval and follow a defined checks-and-balances process. From an EPC perspective, experiences vary—during commissioning, they often work closely with the controller vendor to tune the plant to meet required reaction and response times. This frequently results in setting adjustments that differ from the original study models due to real-world factors such as metering, filtering, and communication delays. Since communication delays are often not represented in models, the plant's actual performance can diverge from expectations, raising the question of why these delays are not routinely modeled. Developers and owners value detailed model reviews and as-left verification, but there is a clear need for greater standardization across the industry.

As an OEM, do you have a standardized settings file that seamlessly translates model and as-left settings?

Approaches have changed throughout the years. In the US, external companies often conduct model testing and studies and thus the OEM obfuscates many parameters out of fear of intellectual property risks. For PPCs, there is much more transparency to the customer because there is less IP concern in the PPC. But in the inverters, there are thousands of parameters, and it can be "overwhelming" to customers or third parties using the models. Tools have been developed by, for example Vestas, for correctly parameterizing an as-built/as-left model within hours. A model is generated that matches the site, and this is somewhat automatic. However, for legacy sites, this may not be possible since they tools have been focused on newer vintages of inverters/turbines only.

<u>Key Themes</u>

- **Maintaining Alignment Between Models and Field Implementation:** There is a mission-critical need to ensure that the "as-studied" models match the "as-commissioned" and "as-left" inverter and PPC configuration and settings. Deviations between model and field settings directly affect grid code compliance, regulatory compliance, operational performance, and grid reliability. Standardized processes, repeated parameter verification, and coordinated checks among developers, OEMs, and commissioning teams are essential to prevent costly discrepancies.

- **Change Management as a Continuous Lifecycle Responsibility:** Grid code conformity is not a single milestone; rather, it is a lifecycle obligation that spans development, engineering, construction, commissioning, and decades of operation. Changes in personnel, ownership, equipment selection, or design assumptions introduce risk, especially when documentation is incomplete or knowledge transfer is weak.
- **Early-Stage Design Quality Drives Downstream Success:** Many downstream issues trace back to early-stage design gaps, incomplete interconnection requirements or IBR developer specifications to OEMs, overly generic studies, or assumptions made before equipment selection. Iterative analysis helps IBR developers identify feasible technology options, understand model requirements, and avoid surprises during execution.
- **Standardization and Transparency Are Increasingly Necessary:** Across developers, OEMs, EPCs, and utilities, there is growing recognition that lack of standardization—whether in parameter naming, data formats, settings access, or model deliverables—creates friction and risk. Stakeholders called for clearer exposure of essential reliability parameters without compromising intellectual property, like the ANSI standardization approaches used in protective relays. Consistent, repeatable methods for extracting and verifying settings would improve visibility, reduce errors, and strengthen confidence in model accuracy.
- **Commissioning Requires Iteration and Collaboration:** Commissioning can be a valuable opportunity to identify grid code compliance risks that may not show up beforehand such as communication delays, filtering effects, metering locations, or hardware limitations. EPCs and IBR developers routinely work with controller vendors to tune response times and adjust parameters, often revealing gaps that models did not capture. Sustained OEM engagement, routine downloads and as-left verification, and strong coordination between interconnection and execution teams are crucial for ensuring that the plant performs as required and remains compliant over time.