**IBRWG Meeting Minutes**

**April 2025**

**Chair: Julia Matevosyan, Vice-Chair: Miguel Cova Acosta**

**IBRWG met on April 18th (Webex, Open Meeting).**

The agenda and the presentation slides are available [here](https://www.ercot.com/calendar/04182025-IBRWG-Meeting-_-Webex)

110 people attended the meeting (at peak)

**IBRWG Main Meeting**

**NOGRR245 IBR Capability Maximization – Lessons Learned**

Ryan Quint & Kasun Samarasekera, Elevate Energy Consulting

* The presentation is of lessons learned and common themes across the board not compliance advice or guidance
* Provided some background of NOGRR245 on side 4: These changes came after large events that happened in Texas, most of the issues that happened mostly involved just software / firmware upgrade needs. There were only a few tripping issues during the Odessa event that were more related to hardware issues. The maximization concept was introduced to find a way to eliminate these risks and improve the ride through capability of IBRs.
* What is maximization? It’s sprinkled through NOGRR425 language and generally we understand what it is but as you start on implementation there are interpretation issues. Maximization is configuring an IBR plant protection (inside the facility and controls) and coordinating those protections within equipment ratings to maximize the ability of the IBR units (inverters) and supplemental devices to ride through faults.

Kasun walked through a generic example:

* Slide 6 blue curve is NOGRR245 frequency ride through requirements, now you need to ask the OEM what is inverters capability to ride through. In the example on slide 7 OEM’s capability is outside of the NOGRR245 requirements which his great, but next step is to check that “as left” of the inverter are also on or outside (better than) of the NOGR245 requirements. The example is showing that the capability is not maximized because it’s set not on inverter maximum capability provided by OEM and furthermore not conformant with NOGRR245 requirement. The next step is also to check that plant relays are not set such as to limit the ride through capability even further.
* Large coordination exercise looking at all different protection to make sure that they are set to maximum and to ride through. In the example it seems like it is coordinate with inverter “as left” capability but is not conformant with NOGRR245.
* Slide 10 shows an example of NOGRR245 compliant frequency ride through capability, with inverter capabilities and protections coordinated and capability maximized in compliance NOGRR245 requirements well aligned.
* Sucesses of the NOGRR listed on slide 12:
  + IBR ride-through maximization will likely ***dramatically improve*** the capabilities and operational performance of IBRs across the ERCOT system
  + **Maximization is a successful concept** – (Elevate found that) many instances of IBR facilities commissioned with settings meeting requirements at the time but below maximum equipment capabilities (as provided by inverter OEM).
  + **Expanded ride-through capabilities** at inverter level and balance of plant relaying, using software-based upgrades
  + **Disabling protections prone to tripping** (phase jump, ROCOF, anti-islanding, instantaneous protection, unfiltered quantities, etc.), where possible
  + **Upcoming improved IBR model quality** that aligns with as-left equipment in the field
  + **Resource Entities strongly leaning in to maximize ride-through capability and support the ERCOT system**, seeking information from OEMs persistently, directly, and clearly
* Imagine the car is an inverter, the generators are buying same cars from same dealership but one car owner’s car is limited to 30 mile/h and another car owner’s car is limited 60 mile/h and then they go back to the dealership and ask what’s the capability of this car model and it turns out the capability 100 mile/h so the speed analogy is of the IBR ride through capability.
* Found protection settings that were enabled that were not necessary to protect the inverter itself and susceptible to tipping (e.g. phase jump or anti-islanding protection) if removed allow to maximize capability up to the inverter capabilities.
* Also found that PSS/E and PSCAD models of some resources are not matching “as left” settings of the actual plant. This effort then creates an additional opportunity to review the models and carry out model quality tests (MQT)
* Another example on slides 13 showing already maximized capability of the VRT plant
* Slide 14 is again frequency ride through capability. But high voltage relay is set within capability of the IBR unit and within NOGRR245 requirements. The goal is to expand these settings on or outside of IBR unit capability and NOGRR245 requirement curves
* The las example on slide 15 shows where inverter capability was set beyond the capability provided by OEM. This needs to be adjusted too, to ensure that inverters themselves don’t get damaged.

Ryan continues with challenges and opportunities to improve

* The concept of maximization is a positive thing, but what are the areas that are challenging and need improvement. Based on Elevate’s lessons learned.
* What is maximization, we are using MQT simulations to see if the ride through expectation at the POI and if the equipment in the plant is riding through – standard practice. **Reflecting information provided by OEM in terms of inverter capability and trying to reflect it to the POI is not an easy task** but this is what was asked for during the maximization process, no guidance provided on how to reflect inverter capability up to the POI. Lack of guidance will lead to broad interpretation of the information that is being provided by plant owner.
* The list of considerations to think about is on slide 18.
  + Protection philosophies within each site and how those are documented vary widely;
  + Pre-disturbance operating point(s) – Qmax/Qmin, Pmax
  + Current injection assumptions during dynamics
  + Main power transformer online tap changer assumptions
  + Static or dynamic reactive devices
  + IBR plant network impedances
  + Models used, and model accuracy, if used. Type of model used also matters EMT/PSS/E aggregated vs detailed models
* All of these are playing into ride through performance.
* Going through this exercise is a non-trivial task and can get different answers depending on considerations.
* In section 2.9 of the Nodal Operating Guides there is something that was heavily debated during NOGRR245 process and subsequent workshops and this is Instantaneous Protection and Filtering (slide 19). The sub-requirement says any instantaneous overvoltage protection that could **disrupt power output** shall use at least one cycle (of fundamental frequency) measurement window to reduce such possibility. – this means anywhere, any protection, while IEEE2800-2022 original language says “**disrupt power output of the entire plant**” which means HV plant level protection. Slide 19 compares the language in two documents.
* Handful of legacy sites have instantaneous protection. Need to combine instantaneous protections, measurement quantities, filtering and calculation of RMS quantities, needed to understand how they all work together to get the right answers and whether or not the exemptions are needed.
* Inconsistencies in data and data sources listed on slide 20. Hard to get useful information for the REs on what’s is actually in the field, because RE doesn’t have access to extract the parameters from the inverters. Sometimes the settings are not that of actual equipment but of the equipment that was expected to go in the field but never got purchased. Technicians might need to be sent to the site and work with OEMs to access key parameters. There is a need to develop a standardized way to extract these key parameters that would be consistently used across the industry.
* Process complications on slide 21:
  + Resource Entity reads NOGRR 245 and needs to take action
  + May bring in consultants; companies align on approach; coordinate with ERCOT on questions
  + They combined reach out to the OEM to gather necessary information
  + OEM may pull in a sales engineering rep (not technical SMEs, necessarily)
  + Group sets up a call, which then grows to 15+ people, rather high sensitivity because of demands
  + Hours and resources wasted coordinating and holding meetings to educate and inform stakeholders
  + Weeks later, OEM shares information requested; not 1:1 match of needed information
  + Resource Entity and consultant quickly reviews data; realize gaps
  + Cycle repeats, often numerous times
  + Divergent answers being received by OEMs and Resource Entity
  + OEM goes radio silent 1-2 weeks before deadline
* To counter these issues, Elevate with GridStrong platform created their own RFI to be able to fill it NOGR245 correctly and consistently. This is one platform that all involved parties have worked on, no emails, no attachments, no diverging version of information. Some OEMs engaged on this very effectively.
* Coordination with OEMs on slide 23:
  + OEMs largely resource constrained under system-wide requests
    - Different people within same OEM provided different answers to Resource Entities
    - “Bird’s eye view” across OEMs helped align responses and get consistent data
    - Handful of responses didn’t arrive until days before deadline
  + Site-specific support not provided in some cases; generic letters fleet-wide by inverter type
  + More information needs documented by default when delivering or modifying equipment
    - Compare relay manuals (1500 pages long) and inverter/turbine narratives (30 pages long).
  + Verifying as-left parameters/settings is painful – rounds of clarifications and field checks
    - Why can’t this be like pulling .RDB files? Can we create .IBR files?
  + Many IBR owners (especially for legacy assets) do not have access to IBR unit parameters of equipment they own
    - Why is Resource Entity responsible for attesting compliance when they have no access?
  + Status quo needs to change globally; possible adverse effects on reliability
    - Aligns with key finding from recent [NERC Alert Report on IBR Model Quality Deficiencies](https://www.nerc.com/pa/rrm/bpsa/Alerts%20DL/Inverter-Based_Resource_Modeling_Deficiencies_Aggregated_Report.pdf)
* Standardized framework for an IBR file of parameters is needed, presented on slide 27. Inverter settings exported into standardized .IBR file, the format and data for the file are developed and agreed upon by the developers/OEMs/ISOs across the industry. Option to export relevant .RDB file date into .IBR file too. Same goes for relevant PPC data. The .IBR data can be read into OEM Auto-translator to populate dynamic models for PSCAD, PSS/E, DSA Tools and this will trigger MQT again, this can also be automated.
* Slide 28 lists the benefits of standardized framework and how it could have simplified a NOGRR245 process or other similar capability maximization efforts.
* High level recommendations on slide 30:
  + Develop best practices for tracking and retaining various data sources
  + Explore how a standardized framework for accessing IBR plant information, as described, could be implemented by (or required of) the OEMs
  + Spot check or validate that requested info is available from OEMs ahead of large comprehensive RFIs
  + Update NOGR Section 9 to address ambiguities and technical uncertainties • More flowcharts, timeline recaps, etc., can help stakeholders understand expectations and process
  + As recognized by all, DocuSign approach was painful – need more innovative software forward approaches that enable streamlined submittal, collaboration, updates, etc.
  + Think through RFI questions and goals of asking them. Don’t mix “nice to have” with mandatory compliance.
* Next Steps on slide 31:
  + Line up reported maximizations – IBR unit, BOP relays, settings changes, etc.
  + Coordinate with OEMs, gather updated IBR models
  + Update IBR plant models and follow PGRR 109 modeling process
    - Conduct MQTs for proposed changes (majority of resources)
    - Streamlined, efficient, and high-quality MQTs to minimize back-and-forth will be critical
  + Submit for ERCOT approval, then implement
  + Update ERCOT as changes made according to NOGRR 245 rules
    - Awaiting ERCOT reviews of extensions and exemptions
  + Be proactive; start early!
* Bob Wittmeyer complimented on the presentation and encouraged ERCOT to think about these lessons learned when developing Large Load ride through requirements.
* Julia, where you found that protection settings were set below inverter capability and not allowing to maximize plant ride through capability, were you able to figure out what led to those settings in the first place, i.e. what were the concerns/issues that led to those protection settings?
* Ryan: Yes, were having to check why is it set the way it is and may be it’s for a reason, e.g. to protect a piece of equipment and then the maximized capability has to be inclusive of that. But Elevate’s experience with that varied project to project. Documentation wasn’t available in some cases and people didn’t know why the protections are set the way they are. There were many protection settings that were just turned off at the end of the day, because they didn’t know why it is set the way it is. In some cases, it was not clear why protections set certain why originally but was possible to widen the settings to maximize the plant ride through capability up to the inverter settings. Back up protection considerations need to be layered here too. And then there were some examples like Volts/Hz which could have been dedicated Volts/Hz relay setting in Volts/Hz protection or layered Voltage assumptions and Frequency settings which may or may not be set in the inverter. E.g. some of the IBR unit frequency settings may be set extremely wide so if someone is worried about Volt/Hz on their transformers it’s very likely that Volts/Hz transformer protection can be more restrictive and it just needs to be considered but there was not sufficient time to discuss this before the April 1st deadline.
* Julia, have you seen where changes of these protections would jeopardize their maintenance agreements or insurance contracts?
* Ryan hadn’t seen this in their experience. One thing to share is that when you are going through this exercise of maximizing ride through capability then most often an IBR unit is the most limiting curve. We haven’t done protection coordination studies but agreed with some protection firms to work through that after April 1 deadline because they didn’t expect to limit the ride through capability further, but protection coordination is still needed (through can be done at a later stage).
* Amjad Al-Shakaji from my experience often times default settings are left from the vendor. Question if IBRs are providing ride through voltage support depending on the current they are providing this might trip the inverters within the plant.

Question regarding inverter controls and plant controls in real time operations various inverters will have various operating points while the models that been studied are aggregated and represent same operating point for all. Have you look into any modeling improvements needed to capture this?

* Ryan one thing that ERCOT could do for the new facilities that are being built is to make sure that the capability is maximized before the plant is commissioned. And documentation is provided that whatever goes in the fields is not a default. ERCOT has actually has this requirement already but other areas don’t. On the last piece more detailed models like EMT can capture more details of the plant but to model the issue that you are describing one will need a detailed plant model representing every inverter, which is not common practice today. Any type of the model will have inherent limitations we just have to know what they are so that when the models don’t match because of those limitations we know what is going on.
* Amjad meant communication delays that are in the field inhibiting speed of response of the IBR plant and those are not reflected in the model so inherently the model behaves better than what’s possible in reality.
* Amjad had another question on what if IBR plants are providing dynamic reactive support and can trip protections internally at the plant as a result.

Ryan: Resources ride through capability depends on inverter characteristics and PPC, making sure that you don’t see long duration current injection into high voltage conditions post-fault. Running some simulations checks helps.

* Amjad, on ride through capability, some of the utilities require analysis for an number of SCR levels. A similar concept is applicable to background harmonics, but those are hard to get what is your experience about this.
* Ryan: there was a recent DOE i2x webinar in February (the recording, siodes and synopsis is posted on ESIG webpage [here](https://www.esig.energy/i2x-first-forum/)) which provided excellent information on this topic and one of the key challenges that was brought up was where the background harmonics were already exceeds the requirements of the IEEE standards.
* Julia asked what group should pick up an assignment of developing Standardized framework for an IBR file of parameters, is it IEEE, NERC, any other?
* Ryan: the initial work shouldn’t be rigid like a standard, but more of development of conceptual grounds / general direction for future standard may be developed. This requires all stakeholder collaboration OEM developers. May be like NERC Reliability Guidelines for IBRs were later converter to IEEE Standards.
* Julia so may be start with NERC IRPS white paper and then move on to Reliability Guideline and standard eventually.

**NOGRR245 IBR Capability Maximization – Lessons Learned**

Mike Tabrizi & Piyush Warhad Pande, Zero-Emission Grid

* Their experience was also similar to what Elevate presented but also, they had to deal a lot with the plants where OEM went out of business. And they haven’t gone through the process of more recent PGRRs (as those were not grandfathered). And then there were other IBR plants that were newer and much more organized and the whole process was easier with them.
* The maximization is tricky, a lot that goes into it and there is a need for a lot of empiric type of assessment because cannot just rely on data sheets to understand the plant capability
* Some of REs that were tech savvy preferred to stick to minimum capability requirement and then commit to what “maximization” means for them by December 2025.

Piyush continued:

* Shared the process that they follow, insights they gathered, recommendations and next steps
* Slide 2-4 show the applicability of NOGRR245 and timelines
* Slide 5: what is the maximization definition and how to ascertain what the IBR plants can achieve. Need to be careful to understand what applies to you, when SGIA was executed and what is the performance floor that you are required to meet. Ride-trough doesn’t mean just stay connected, it means also not to reduce active power injection, unless you need to prioritize for reactive injection.
* Maximizing IBR ride through is done through maximization for FRT settings minimizing disconnection other settings are involved (not using RoCoF values, phase jump values, anti-islanding protection, instantaneous values)
* OEMs are very crucial in this exercise. Once OEM information is gathered you also need to understand overlaying capabilities and settings of the entire plant.
* Because of a lot of data coming from OEMs it can get overwhelming and REs are trying to limit themselves to the document. But Zero-Emissions Grid recommendation is to supplement this with modeling and simulations to fully understand plant capabilities (i.e. detailed PSCAD simulations).
* RFI procedure: the plant should not be confused with the inverter. Overall capability of the entire plant will be limited by the weakest element. Data gaps is another issue – in a lot of cases (depending on the project development stages) what are the project maximum ride through capabilities? Need to think very carefully about what is submitted before April 1st. Another issue is that QSA production settings do not correspond to field settings.
* Planning early helps
* Areas requiring clarity are pointed out on slide 7
  + What review/validation steps that ERCOT will follow after April 1st
  + How unanswered/incorrect responses are going to be handled?
  + If the resource in reality doesn’t meet the maximization plans what happens?
  + Etc. (see more on the slides)
* Key Takeaways and recommendations (on slide 8)
  + Ensure full plant capability assessment not just inverter specs – full plant analysis is needed
  + Ensure coordination with bulk of plant studies, TRV, TOV, ensure protection coordination of the plant
  + Align study models and field implementations
  + Start early coordination with OEMs
  + Recommended policy flexibility (what is the pass forward from extension to exemption?
  + What is the process after the April 1st submission, past December 31st, post Jan 2028?
  + Detailed engineering assessment is needed to decide how much you can maximize otherwise without clear guidance of how to do it and process, the REs will stick to minimum requirements rather than maximization.
* Amjad: Question regarding reactive at night support, IEEE2800 calls for capability throughout any power 0 to the site rating is that an expectation from NOGRR245 to provide reactive at night?
* Mike in the past ERCOT requirement that there is always a condition on the amount of dispatch early days requirement was triangular, now it’s a rectangle but down to 10% active power output but IEEE 2800-2022 requires reactive power capability down to zero active power output
* Amjad, the reactive power capability at 0 output is different compared to non-zero output and needs to be considered at the plant design stage.
* Julia responds in the chat that there’ll be DOE i2x webinar dedicated to this topic on 4/29, registration and agenda are here <https://www.esig.energy/i2x-first-forum/>
* Amjad another question regarding Section 11 of IEEE 2800-2022, requirement on data collection from IBR plants. OEMs being responsible for providing event records captured at certain rates. To my knowledge to get that data you need to ask OEMs to access, and interpret. Have you run into that barrier and is there any push in industry that REs should be able to pull those out but themselves and analyze the conditions?
* Mike: This is related to many issues. OEM is only responsible for their own equipment and so it becomes the challenge to isolate inverter capability and plant level capability. The models can help with this issue especially detailed PSCAD models. All models should be benchmarked to PSCAD. E.g. ERCOT asks for PSS/E model first and PSCAD model only when it comes to QSA. In our opinion it has to be the other way around. Because it’s PSS/E model that has to be benchmarked to PSCAD not the other way around.

It is always a challenge to translate OEM characteristics to the plant level characteristics.

* Julia comments in the chat: NOGRR255 in ERCOT was meant to adopt some of IEEE 2800-2022 Clause 11 requirements into ERCT Nodal Operation Guides.
* Amjad: You mentioned PSCAD as a good dynamic tool, but what is your view for different types of Hardware-in-the-loop systems? Some manufacturers are already using those. May be these can be used to improve PSCAD models
* Mike: I am not aware of such requirements, but it is being used by some OEM. I hope we go into that direction to ensure better model accuracy, there probably needs to be more enforcement around that, especially with lessons learned from the disturbance events in ERCOT
* Julia: IEEE P2800.2 produced an Annex recommending use of HIL for model validation. IEEE P2800.2, now reached the stage where this month the balloting pull is formed (until May 2nd) and then the draft will be out for review and commenting. Direct link to join ballot group: <https://development.standards.ieee.org/myproject-web/app#joinballot/10749/Y>

**Comparison of NERC PRC-028, IEEE2800, NOGRR255**

Eric Newmann, TRE

* The comparison is walking through the requirements in PRC-029 and compares with the other two documents
* The slides are self-explanatory and posted on the meeting page.
* Julia: Can you please provide an update on the status of PRC-028. I know it has been approved by NERC and is FERC for approval?
* Eric: There is an implementation timeline for existing IBR plants you need to be 50% compliant after 3 years from the effective date or PRC-028 and 100% complainant after the approval date by Jan 1st, 2030.
* The effective date is expected by July 1st, 2025. All the dates are listed in the PRC-028 implementation plan
* Julia: Can you confirm that based on your analysis there are no conflicts between PRC-028 and NOGRR255 and where there are differences NOGRR255 is more stringent, but not the other way around?
* On the couple of dates PRC-028 has higher requirements (those dates are on the slides) but for the most part NOGRR255 goes above and beyond PRC-028 requirements.
* Glen Bray: is asking what does it mean “ALL fault codes and alarms” for Sequence of Event Recording, what does it mean is there any guidance on what codes to record? There are hundreds of codes…
* Eric: I wouldn’t be able to speak to PRC-028 on this topic
* Glen Bray: is any guidance going to come out?
* Kevin Mahoney brough up an issue with fault recording data requirements on all the IBR units. He is not sure it made it to the final ERCOT requirements.
* Julia comments that the earlier version of PRC-028 had the requirement of the last 10% collector feeders, but it got pulled out.
* Kevin points out and Chase Smith confirms that this was later removed from NOGRR255 as well. Earlier version of PRC-028 had that language and ERCOT included it too to align with that, but then PRC-028 removed it and NOGRR255 did too. TRE updated the slides accordingly after the meeting.

**Other NERC Updates**

Mark Henry, TRE

* Milestone 2 – FERC has received 23 industry comments on PRC-029, the IBR Performance standard, closed on March 24, Docket RM25-3-000. No decision announced. (Other PRC standards approved by FERC earlier this year.)
* Milestone 3 – Standard drafting teams posted the following on April 17. Ballot pools open until April 28, voting period 10 days before comment closure:
  + [Project 2020-06](https://www.nerc.com/pa/Stand/Pages/Project-2020_06-Verifications-of-Models-and-Data-for-Generators.aspx) - Model Validation and Model Verification Definitions, **comment period open until May 12, 2025**.
  + [Project 2021-01](https://www.nerc.com/pa/Stand/Pages/Project_2021-01_Modifications_to_MOD-025_and_PRC-019.aspx) – System Model Validation with IBRs, **comment period open until May 21, 2025**
    - MOD-033-3 Steady-State and Dynamic System Model Validation
  + [Project 2022-02](https://www.nerc.com/pa/Stand/Pages/Project2022-02ModificationstoTPL-001-5-1andMOD-032-1.aspx) - Uniform Modeling Framework for IBR, **comment period open until May 16, 2025**
    - MOD-032-2 – Data for Power System Modeling and Analysis
    - IRO-010-6 – Reliability Coordinator Data and information Specification and Collection
    - TOP-003-8 – Transmission Operator and Balancing Authority Data & Information ​Specification & Collection
    - Implementation Plan
  + [Industry Engagement Technical Conference](ttps://www.nerc.com/pa/RAPA/Lists/RAPA/DispForm.aspx?ID=805&Source=https%3A%2F%2Fwww%2Enerc%2Ecom%2Fpa%2FRAPA%2FPages%2FCalendar%2Easpx) **June 3-5, 2025,** in Arlington, VA (first half webcast)
* NERC released its [public report](https://www.nerc.com/pa/rrm/bpsa/Alerts%20DL/Inverter-Based_Resource_Modeling_Deficiencies_Aggregated_Report.pdf) on the 2024 IBR Model Quality Deficiency Alert on April 1
  + Something that NERC does on regular basis when they are seeing some systemic issues.
  + This is not to write a standard but to for industry awareness and to provide recommendations
  + This is the third time that this was done for IBRs
  + A lot of difficulties that Elevate and Zero-Emissions Grid mentioned in their earlier presentations
  + Based on a lot of responses the capability of IBR plants is not maximized, and models are not representative of the plants as in the field.
  + Transmission planners need some improvement on what they are studying
  + Ride Through is not what they expected to see. Information for some was not even available
  + 20% of resources still use triangular reactive power capability not a rectangular as required and many resources are capable of achieving
  + There’ll be another NERC Alert pretty soon.
* Category 2 registration of IBR’s connected at >60kV transmission and nameplate >20 MVA begins in May 2025
* AJ Albaaj: Looking at the NERC Level 2 Alert report, it says that the next step is NERC Level 3 Alert with essential actions needed to address the deficiencies observed – what does it mean and what is the timeline for that?
* Mark: NERC staff is working on Milestone 3 material so probably sometimes in summer and there’ll probably be discussion in some NERC technical groups, was there any discussion in NERC IRPS? It’s the higher-level alert but will be similar to this one but then direct actions will follow (maybe a standard).
* Julia: At NERC IRPS, I believe, they mentioned June this year.
* Mark: probably after the tech conference on Milestone 3 standards.
* Julia: One question for PRC-029, in the implementation plan there was a process for applying for exemptions. Is there any guidance of what that process is going to involve, is this going to be something similar to what Ryan and Mike were showing for NOGRR245 or something more streamlined?
* Mark: There is nothing defined about it yet, first FERC will have to approve it, then they’ll need some reporting on how many plants are requesting exemptions. I’ll take a note to follow up.

**Other Industry Updates**

Julia Matevosyan, ESIG

* 2025 ESIG Spring Technical Workshop, March 17-2, Austin. [**Presentation and recording are posted here**](https://www.esig.energy/event/2025-spring-technical-workshop/). Topics relevant for IBRWG:
  + Oscillations and Stability
  + Grid Forming Inverters
  + FERC Order 901, NERC Milestone 3
  + Large Load Integration

Highlights from some select presentations are on the following slides.

* IESO has included the following **GFM capability requirement** **for all BESS** in the connection assessment applications. IESO has included the following GFM capability requirement for all BESS in the connection assessment applications.
* IESO has included the following GFM capability requirement for all BESS in the connection assessment applications. [Presentation by M. ElNozahy (IESO) is available here](https://www.esig.energy/download/session-1a-establishing-grid-forming-capability-requirements-at-ieso-mohamed-einozahy/?wpdmdl=12905&refresh=67e16d7fd4e2d1742826879)
* EPRI presented a study in ERCOT, ATC area, demonstrating benefits of
  + AGS from IBRs provides transient damping capability.
  + It also provides reactive power support both during and after the event to help stabilize the network
  + Location is important for better effectiveness
  + Off-the-shelf solution may not work, may need application-specific tuning
* RMS presented on Grid-Forming Inverter Applications for Improved Reliability and Power Quality in AI Data Centers. Showing that GFM BESS co-located with AI Data Center can provide voltage and frequency control at the POI, so that the Data Center may be able to ride through without switching over to the back-up gen, it can support black start and grid restoration (if designed to do so) and provide system inertia and other stability services.
* Presentation from EMTP on Integration of GFM IBRs in Chelian Grid. Large scale EMT model of the entire Chelian grid was developed and benefits of GFM IBR tested at different locations on the grid.
  + The results for the Chilian grid proved GFM IBRs can positively impact the dynamic behavior and stability of grids composed mostly of VRE resources.
  + System parameters and conditions, such as the penetration of GFL IBRs and their associated control strategies, the presence of SynCons, as well as the availability of dynamic compensation devices, play a pivotal role in the minimum amount of GFM required in large grids.
  + Additional research needed to test additional capabilities and attributes for this technology in large grids, such as short-term over current contribution, protection coordination, and black start capabilities
* Additionally, DOE i2X FIRST workshop March 17, 2025 (half-day hybrid event)
* Covered IBR plant conformity assessment process with applicable interconnection requirements after IBR plant commissioning, learning from the draft IEEE P2800.2 (SG5). [Presentation and recording are posted here](https://www.esig.energy/event/i2x-first-hybrid-workshop-interconnection-standards-workshop-spring-2025/)
* ESIG reposted the recordings, presentations and synopsis for the prior meetings to ESIG i2x FIRST page <https://www.esig.energy/i2x-first-forum/>
* If you have participated in i2x FIRST meetings before, please provide your feedback filling in a short survey here <https://t.e2ma.net/click/ckst2i/wrf4ivw/0mezvbb>
* Last meeting of season 1: **Tuesday, April 29** **from 11 a.m. – 1 p.m. ET,** will focus on reactive power and voltage control requirements, specifically “Vars at night,” Reactive at sunrise as well as a developer’s perspective on Reactive Power-Voltage Control Requirements. [REGISTER FOR THE MEETING](https://uvig.webex.com/weblink/register/ra24ec46df0f4e336c33da7941a95bc33)
  + **Nighttime Reactive Power Support from Solar Inverters:** Aminul Huque, EPRI
  + **Communication of Capability and Status of Online IBRs at 0 MW Output:**Alex Lee, ERCOT
  + **Reactive Power – Voltage Control Requirements, Developer’s Perspective:** Divya Kurthakoti Chandrashekhara, Orsted
* **i2x FIRST SEASON 2** will start in May focusing on implementation of IEEE2800, NERC Milestone 3 Standards and Grid Forming Specs. More info will be available @ <https://www.esig.energy/i2x-first-forum/>