**IBRWG Meeting Minutes**

**February 2025**

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

**IBRWG met on January 21th (Webex, Open Meeting).**

The agenda and the presentation slides are available [here](https://www.ercot.com/calendar/02212025-IBRWG-Meeting-_-Webex)

111 people attended the meeting (at peak)

**IBRWG Main Meeting**

A request was made by Kattie Rich (chair of ROS) not to discuss anything related to NOGRR272 and PGRR121.

After some discussion and confirmation from Caitlin Smith (chair of TAC), the WG agreed to move on with the meeting agenda, only focusing on technical issues.

**PE’s GFM Capabilities and Perspective on ERCOT’s Advanced Grid Support Requirements for ESR**

Stephen Giguere, Power Electronics

* Provided introduction about the company: inverter manufacturer, manufacturer of energy storage and EV charging solutions.
* 30 GW of annual production capacity
* Started with Australian definition of GFM, slide 6
* Comment about modeling work, that modeling requirements should be so stringent that it takes 12-18 month to move to the next stage of the project.
* PE is doing Virtual Synchronous Machine (VISMA) approach to GFM, this allows keeping voltage constant in sub-transient to transient timeframe after an event, injecting current into the grid as needed.
* PE is involved in GFM projects in Great Britain and Australia, there are lessons learned from these areas
* Chart from slide 9 is from European experience but may inform the US experience as well. Showing how the need for different services from IBRs is changing as shares of IBRs on the grid are increasing. At certain penetration level adding BESS is helpful as their can provide additional services but at as penetration levels are increasing, it makes sense to have BESS with voltage source behavior (GFM), to achieve additional stability benefits and this is what is observed in Australia for example.

****

* Power Electronics GEN 2 and GEN 3 PCSK/M Inverters prepared to be updated to operate in Grid Forming – Voltage Source Mode (VISMA)
* PE GEN 3 Inverter with overload capacity when operating in VISMA mode
* Skept through the slides related to NOGRR272 as was requested at the start of the meeting and moved on to ERCOT’s Testing Framework, sharing the table with seven tests identified by ERCOT
* None of the tests are surprising. PE worked with Electranix[[1]](#footnote-1) and they are very well respected in the industry. Suggested that it’s more valuable to carry out these tests with project specific plant models, not just inverter models.
* Summarized of GFM vs GFL, comparison of capability tables on slides 21-23. Start conditions listed in the first row, is what an IBR needs in order to start.

Power rating row shows 100% for GFL and 90% for GFM, which means that in GFL mode no overloading capability is allowed, while in GFM mode there’s 10% of additional overloading capability allowing inrush currents etc.

* GFM Reference projects on slides 25-26. Slide 27 shows confirmed GFM projects in different areas. APAC number actually all in Australia, that have all the challenges on HECO but on the continent. So, there are a lot of lessons learned from there on the modeling side and developer side and applied as GFM is being deployed in the U.S.
* PE also can provide modelling and studies support.
* Q&A
* Julia: Do you have your OEM specific models available under NDA if e.g. ERCOT or a developer would like to test?
* Stephen: Yes, we have PSS/E and PSCAD models available for both GFL and GFM inverters
* Fred: One of your slides is showing an inverter rating 100% for GFL and 90% for GFM. For GFL this 100% does that include the capability for reactive response?
* Stephen: I was thinking about this in terms of kVA rating, so this is a kVA rating that will give you a rated current.
* Mark Henry: The projects on side 27 are these from all manufacturers or just PE?
* Stephen: We only track our own projects
* Julia: ESIG is keeping track for all GFM projects around the world [here](https://www.esig.energy/working-users-groups/reliability/grid-forming/gfm-landscape/projects/). Will check if PE’s projects are already included.

**SUNGROW’s GFM Capabilities Perspective of ERCOT’s Advanced Grid Support Requirements**

Ling Chen, SUNGROW

* SUGROW is an OEM, manufacturing inverters for PV and BESS
* Will cover GFM technology and benefits, GFM model test results and GFM project references.
* GFM technology is developed around virtual synchronous generator concept
* It has the capability to respond automatically or spontaneously to the grid voltage or frequency events
* Slide 3 shows GFM response to voltage disturbance and a difference in response between GFM and GFL inverter. While GFL inverter is providing voltage support (as seen on the right-hand side zoomed out charts this support only starts after 100 ms), while GFM responds in subtangent timeframe. This is the main difference between GFL and GFM
* Slide 4 shows how GFM inverters can enhance the response to the frequency disturbance. There are two types of control, one is a droop control similar to PFR in a GFL inverter, on top of that there’s inertia control that can be provided in millisecond range. Additionally, inertia controls are adjustable, and inertia contribution can be increased as needed.
* Slide 5 demonstrates ride through capability under extremely weak grid conditions. Under extreme grid conditions it’s always a challenge for the inverter to ride through disturbance, in GFL IBRs oscillations are observed during the recovery period after the ride through. The figure shows that GFM is not susceptible to these oscillations.
* Slide 6 demonstrates damping capability that helps to enhance stability for inter-area oscillations as well as control interactions between several GFL IBRs.
* SUNGROW has developed OEM specific inverter models, those were provided to ERCOT and successfully passed the tests in ERCOT AGS ESR Testing Framework document. Slides 8-11 are showing the results. On the left-hand side of each slide is the response of SUNGROW GFM inverter model while on the right-hand side there are sample acceptance results provided by ERCOT for comparison.
* The next few slides provided samples of the projects. Ling referred to the ESIG’s list of grid forming projects as providing more comprehensive information, while the presentation is bringing up a few samples.
* SUNGROW also has local capability to support GFM model development and encouraged interested stakeholders to reach out.
* Q&A
* Julia: What were the main drivers for the projects that you’ve shown in these different countries? Are those driven by pilot projects, requirements, tenders or markets?
* Ling: I believe that in South Australia it was a utility requirement. But in another project in Finland and Saudi Arabia this is a reliability requirement
* Pablo Rocomora: How would the price differ between GFL project and project with GFM capabilities.
* Ling: This is something to be discussed on project-by-project basis but what I can say is that in all inverters that SUNGROW produces, it’s a software upgrade to make it grid forming, no hardware upgrade is required. There may be additional costs associated with the modeling efforts (tests) which are more comprehensive than for grid following.
* Julia: That was a good question, and we should ask PE the same.
* Stephen: Yes, it’s about $5000 extra cost for the filter, per inverter.
* Julia (clarifying question): Can you talk about the overall cost of GFL vs GFM of the same size?
* Stephen: We are actually using the same power modules. The only thing is just to upgrade the firmware functionality, but to meet GFM requirements you might need more beefy filters, so that’s really the only thing that’s needed to enable grid forming.

**Including HRL as an aggregated value of a defined IRR Group**

Ismael Moral Diaz, Acciona

* Slide 2 some information on Acciona, originally from Spain but now represented in 40+ countries. Over 14 GW globally including wind, solar, storage, biomass and hydro
* Slied 3 indicates discrepancies between interconnection studies and real time operation associated with primary resource variability and output variability between the units (where a plant consists of multiple units). SGIA is signed for a single plant of given MW output (not on a per-unit basis). The plant then operates with different HRLs per unit and generates an alert if a unit exceeds the limit. Control is also not limited at the POI level it considers individual unit operation.
* Slide 4 provides ERCOT’s definition of HRL and what it is used for and applicability to thermal generation vs IBRs.
* Slide 5-7 demonstrate the issue using the example plant with two units having 140 MW and 160 MW HRL respectively but using same PPC controlling the output to 300 MW (as per SGIA). On a bright sunny day both units can produce up to their HRL, while if there is a cloud cover over one unit it cannot produce maximum, the other unit has capability (overbuilt) to produce more but is limited by pre-set unit HRL that it cannot go above, and this results in loss of revenue for the plant.
* On slide 8 Acciona proposes to group HRL in aggregated units. Proposes to use existing definition for IRR Group. This will no effect planning phase and studies as during the planning phase different HRL per unit is not being accounted for. This proposal will also allow ERCOT to get more MW from existing power plants in operation.
* Slide 9 demonstrates how this proposal would work in the example.
* Two key aspects to consider is ERCOT reactive requirement and PPC functionality. Slide 11 explains reactive power requirements. And how PV can still provide maximum reactive support even during cloudy conditions/low output.
* Slide 12 explains PPC functionality and how the issue with individual unit HRL may prevent the PPC from controlling the plant to produce maximum from all of the units combined, based on available irradiance, while respecting SGIA limit.
* Slide 13 presents the recap for the proposal.
	+ HRL aggregation: When units are grouped, a single HRL value is assigned per plant instead of separate HRLs for each unit.
	+ Operational Benefits: Maintains compliance with ERCOT requirements, including reactive power.
	+ Allows for increased stabilization of generation injections in the ERCOT area helping to maintain a stable grid, for instance during Energy Emergency Level (EEA).
	+ Flexibility: This approach is optional - if units prefer to have different setpoints and participate with separate bids at different prices, they can retain individual HRLs.
* Ismael also asked if other project owners/developers have similar experiences and would like to share?
* Seth Maslowski (Ulteig): Would like to share this experience from the perspective of the plant systems integrator and advise plants to register as IRR Group Resources. And what Isamel is proposing is exactly the reason why you might want to have IRR Group Resource. IRR Group Resource was created at the time when it wasn’t possible to have a single PPC controlling both units. So, this discussion makes a lot of sense.
* Julia: What would the next steps be with the proposal?
* Isamel: We just wanted to bring it up to people’s awareness and see if other companies have similar experience and our ideas for solution and then formally propose this change to ERCOT.
* Julia: If there are other generator owners that see similar issues please follow up and we can work with ERCOT to formally propose the changes.

**PRC-029-1 & NOGRR245 Comparison and Category 2 Registration Practice Guide**

Mark Henry, ERCOT

* The request was to compare NERC PRC-029 standard and NOGRR25.
* PRC-029-1 is NERC’s new ride through standard for IBRs. IBRs are defined as Type 3&4 wind, PV solar and BESS inverters and fuel cell inverters. Type 1 & 2 wind is covered in PRC-024-4 which was a precursor to PRC-29.
* Both of these standards were sent to FERC after the exhaustive stakeholder process. NERC had exercised Rule 321 to extend the work on the standard but both standards are at FERC right now, they just issued a Notice of Proposed Rule Making RM 25-3-000, comments due till 3/24, after this time they’ll review the comments. TRE encourages to review and submit comments.
* Slide 2 compares requirement R1 (VRT/FRT) of PRC-029 with Section 2.9 and 2.9.1 in NOGRR245. There is a match there but lot more details in NOGRR245.
* Slide 3 compares requirement R2 (VRT) of PRC-029 to NOGRR245. The latter requires maximizing capability with regards to all scope of ride through requirements, which PRC-029 seems to only mention maximizing capability with regard to voltage support.
* Slides 4-5 compare Attachment 1 of PRC-029 and NOGRR245, ERCOT preserves a portion of legacy ride through curve, while PRC-029, but otherwise the same ride-through curve.
* Slide 6 shows the comparison for the ride through curve to understand the tables better.
* Slide 7 compares requirement R3 of PRC-029 and NOGRR245. The requirements are fairly similar. Except for section 2.6.2.2 of the NOGRR with regards to DGRs, which was out of scope for PRC-029
* Slide 8 compares Attachment 2 of PRC-029 (FRT Table) with NOGRR245 frequency ride through table. Illustrates additional steps in ERCOT’s FRT requirement.
* Slide 9 again illustrates FRT tables for DGRs and highlights that it was out of scope for PRC-029.
* Slide 10 showing FRT requirements compared in terms of curves with additional step as per ERCOT’s requirements.
* Slide 11 compares R4 of PRC-029 hardware limitations with NOGRR245. PRC-029 does not have the exemption process steps detailed in NOGRR245 Section 2.11 and 2.12, although R4 has a similar intent (details spelled out on the slide). ERCOT doesn’t decide whether or not grant an exemption from PRC-029, this will have to come from Texas RE, if your facility is in ERCOT region or other REs for other regions.
* Last slide presents Category 2 IBR Registration Practice Guide Release and webinar on Application of the Registration Criteria for Category 2 Generator Owner and Generator Operator Inverter-Based Resources March 3, 2025, | 2:00–3:30 p.m. Eastern. Registration link is available on the slide.
* Q&A
* Shawn Wang: Wanted to clarify PRC-029 requirement about maximum capability, it’s very different from NOGRR245. In PRC-029 capability maximization is about current limit. The requirement is to provide support up to the maximum current limit. So, it’s related but expressed differently that in NOGRR245

**Other Industry Updates**

Julia Matevosyan, ESIG

* Salt River Project (SRP), utility in AZ, recently released a Business Practice on Grid Forming Battery Energy Storage System Specification and Simulation Test Procedures, effective February 14, 2025.
* SRP is "adopting GFM technology for BESS on a case-by-case basis” and the Business Practice serves as the technical requirements for SRP to test performance against for applicable interconnections.
* The Business Practice applies to “to any standalone BESS or the BESS component of a co-located facility where SRP specifies that the BESS shall operate in GFM mode.”
* The functional specification mirrors NERC specification closely and the simulation test procedures are a simplified version of the NERC tests, using one test system and simulation test with pass/fail criteria defined.
* ESIG completed a study looking into the benefits of GFM BESS in realistic network. In collaboration with ATC (transmission owner in Wisconsin and part of Michigan), who under NDA provided their network model in EMT. The study also looked at if GFM BESS is a “do no harm” solution, in terms of any adverse interactions or under operation in strong grid conditions. The results are summarized on slide 3 and slide 4 lists out study recommendations. The [webinar](https://www.esig.energy/event/webinar-benefits-of-gfm-study-discussion/) was held recently presenting the study results and recommendations.
* The last slide is information on [ESIG Spring Technical Workshop](https://www.esig.energy/event/2025-spring-technical-workshop/) and sessions relevant for IBRWG scope.

**DWG and IBRWG Collaboration**

AGS ESR Model Quality Tests, Sun Wook and Scott Zuloaga

* Fred: this discussion item will be high level, to address if the detailed tests work, we will not discuss NOGRR272 and PGRR121 and keep it to technical content of the tests.
* Sun Wook: These changes to DWG Manual on AGS ESR Testing were presented last week at DWG meeting, so we should be ok to provide high level update here.
* Sun Wook: we will also cover responses to comments on testing (again not on PGRR and NOGRR).
* Scott went through DWG Manual redlines, just stepping through where the changes were made, the manual is posted on IBRWG meeting page
* The redlines are consistent with ERCOT’s AGS ESR Testing document (posted on September 2024 IBRWG meeting page).
* Got a few comments from DWG last week and will be updating the document accordingly but these changes are not yet included.
* Sun Wook: ERCOT has posted the FAQ document on the February 2025 IBRWG meeting page.
* Sun Wook stepped through the Questions during the meeting, the slides provide detailed responses. Focusing only on technical items (skipped Q1 as advised in the beginning of the meeting) and skipped some questions that were discussed in the previous meetings.
* Sun Wook also highlighted where questions resulted in changes in DWG Manual.
* Q&A
* Stephen Solis: Question on Q1 response. Is ERCOT going to be making assumptions in the planning studies and any studies determining limits, if you we have to maintain SOC to get the benefit of AGS ESR, are we assuming that it’s not going to be there to be conservative in the studies where you are making a decision if additional equipment or transmission is needed. There seems to be a disconnect between no headroom requirement and then needed headroom to get the benefit, can you please elaborate?
* Sun Wook: I was trying to avoid policy related questions around PGRR and NOGRR. But basically, ERCOT does not mandate any headroom. But I would like to separate this question from the MQT discussion here. The FAQ is only related to MQT (not planning studies).
* Stephen Solis comments (after the presentation completed): Coming back to the same question, would like to point out [NERC White Paper](Grid%20Forming%20Functional%20Specifications%20for%20BPS-Connected%20Battery%20Energy%20Storage%20Systems), chapter 2, page 16, there is a bullet that talks about that, this is something to consider from a technical perspective for the MQT.

1. Electranix is the consultant that work with ERCOT to develop the testing framework posted at the [September 2024 IBRWG meeting page](https://www.ercot.com/calendar/09162024-IBRWG-Meeting-_-Webex) [↑](#footnote-ref-1)