**IBRWG Meeting Minutes**

**November 2024**

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

**IBRWG met on November 15th (Webex, Open Meeting).**

The agenda and the presentation slides are available [here](https://www.ercot.com/calendar/11152024-IBRWG-Meeting-_-Webex)

108 people attended the meeting (at peak)

**IBRWG Main Meeting**

**PFR from IBRs under “Deep” Curtailment**

Evelyn Hernandez and Martin de Paz (Nordex)

* Frequency narrow band

Similarly to Vestas’s presentation in October, Nordex is showing that narrow frequency deadband and “chatter” around the deadband is making a lot of frequency adjustments (in the example on slide 3 almost 250 PFR events in a an hour, in another example 31 events in just 4 minutes) in a wind turbine, causing wear.

* Tech minimum of wind turbine production

Nordex defined technical minimum (TM) as the lowest power output at which a wind turbine control can operate efficiently and stably. This also then translates into TM of an entire wind generation plant.

Each NX WT has a technical minimum of 10% of its rated power.

Providing Primary Frequency Response (PFR) becomes especially crucial during low power production.

In these scenarios, the control response output can fall below this technical minimum, potentially leading to turbine switching off.

* Scenario 1: Underfrequency events at zero power production or curtailment down to 0 MW

During curtailment down to 0 MW, if an underfrequency event happens the expectation from ERCOT is that the plant will increase its production according to the droop function.

* In reality wind turbine needs: rotor acceleration, device supervision, synchronization with the grid, dc-link charged, blades pitched correctly, controllers engaged. Depending on the state of the turbine at the start of the event it may take a different amount of time before the turbine start responding.
* Scenario 2:Frequency event at curtailment around or below wind turbine technical minimum

Slide 8 shows a similar behavior/concern during an event where a wind turbine is curtailed to a low setpoint around TM. Shows there the turbine needs to be disconnected and reconnected again to respond to PFR command, when operating under TM.

* Scenario 3: Over frequency event at available power below wind turbine technical minimum

During over frequency events when available power is low, similar thing is happening. Provision on PFR can send the turbine to operate below its TM and result in disconnecting the turbines.

* Number of frequency events using ERCOT equivalent measurements.

Nordex also presented a number of ideas/solutions to these issues:

*For too many frequency response instances around narrow frequency deadband*, one solution could be incorporating a dead time for frequency events could slightly reduce the number of frequency events that WTs are responding, thereby minimizing the toggling of wind turbine (WT) connections during operations around the technical minimum (T.M.).

Additionally, validating frequency measurements between ERCOT and Nordex is crucial. By utilizing frequency measurements with the same quality, resolution, and treatment as ERCOT, OEMs can ensure the detection of an equivalent number of events within the narrow deadband. This approach allows WTs to respond to frequency events that are representative for the grid, thereby preventing unnecessary disconnection of WT T.M.

*For all the Scenarios that were presented*: a possible solution could be introducing a TM for the frequency control, excluding the contribution below this minimum all the operating scenarios (discussed above) can be addressed. This concept is implemented in EirGrid (Ireland) and some other European countries.

* Luis Hinojosa: the presentation helps ERCOT to understand the issues better. Question on slide 13, help to us understand what the technical minimum could be is it constant is it variable or depends on grid/wind continuous.
* Nordex: can be limited at 10% of wind turbine for Nordex
* Luis: with 10% for a WT, what does it mean for say 100 MW site
* Martin: 10 MW, but if less turbines are in operation you can discount that by a number of unavailable WTs.
* Luis: If the site is not at full output due to low wind conditions is it fair to assume that some number of WTs are already off?
* Martin: below cut-in speed the WTs will not be on, if not under curtailment it’s hard to predict how many turbines are on, it depends on wind conditions.
* Luis: Just to get to the bottom of this, does the turbine need to disconnect between 0-10% operation, always?
* Martin/Evelin: at a turbine level, yes
* Luis: How is the plant controller determining which turbine it sends the signal to? Is it every turbine that is online that gets a signal to respond or is PPC looking which turbines have more capability to provide response.
* Martin: PPC sends signal to all turbines that are connected.
* Luis: Can PPC optimize between available turbines, and distribute the signal to turbines that have more “legroom” such that response to an overfrequency event will not send them to TM?
* Martin: Will need to double check that with Nordex control design team.
* Luis: I heard that coming back online after WT being turned off can take 1-5 minutes, what causes this variation in start-up time?
* Martin: 1 minute could be quiet optimistic. It’s rather 2-5 minutes may be. Various safety checks that is what causing the range.
* Luis: Outside of frequency, if you are relieved from curtailment there may be an issue coming back for WGRs (apart from frequency events), i.e. in the next 5 minutes after release from curtailment a WGR may not be able to ramp as fast as ERCOT expects. May be we apart from looking at WT capabilities and limitations we also need to be looking at those of PPCs.
* Julia: Maybe we need to be looking at PPC control capability to optimize between turbines to provide PFR without sending them into below T.M. operation (and turning them off).

**Physical basics of low power operation of wind turbines**

Nicholas Miller (HickoryLedge)

* Providing perspective of system planner and modeler of frequency dynamics (among other things).
* Explaining the basics of wind turbine operation, particularly rotor dynamics, aerodynamic lift, and their interplay in maintaining stability at low power outputs.
* Some of the insights can be gained going back to wind turbine model development where aerodynamic behavior is included as a part of the model
* The concept of technical minimum was known even 20 years ago when PFR from wind was being developed. Within GE it was 20% of rated output.
* Slides 16-19 specifically, are showing how a WT can reach TM, under curtailment and lose ability to stay online / provide PFR in expected time.
* When blades are turned out of wind (for curtailment), turning it back in for provision of PFR is difficult (blades are heavy) and takes time.
* The challenges of reducing rotor speed while avoiding aerodynamic stall, when providing PFR during low speed conditions.
* The need for precise control of blade pitch, rotational torque, and generator response to manage stability under low wind conditions.
* **In Conclusion:** Active power control from low power levels whether due to deep curtailment of low wind speed is extremely challenging and subject to multiple physical stability constraints.
* Julia: How does this translate to plant level, do you know if overall PPC strategy is to take some turbines out and curtail remaining turbines less to ensure that they can continue operating above TM.
* Nick: yes, this strategy would make sense. Also, as the last speaker said, it’s not easy (not fast) to start at turbine back up once it’s been disconnected.
* Julia: Question to Luis, have you looked at how the number of online turbines is reflective of what’s happening at the plant under deep curtailment
* Luis: We have made some efforts at the past to look at this information but it’s really inconsistent.
* Luis: Question to Nick, how long does it take between a turbine reaching it’s TM, e.g. due to curtailment and turbine being disconnected? If a frequency event happens exactly at the time when WT reached it’s TM, will that turbine respond? There are examples at ERCOT where wind plants did provide response even from 0 curtailed state, is there some kind of control logic at those plants that doesn’t let WTs disconnect at (or below) their TM?
* Nick: The WT doesn’t want to be going on and off unnecessarily, and even as wind speed is constantly moving they don’t turn in and out, they got some inertia and it takes time. The answer how long time it takes is probably relatively complicated, but beyond Nick’s expertise to say what time delays are involved.
* Nitika: We understand that the answer is not straight forward. But we are seeing resources where curtailment is at 0, but they are providing response. Does it have to do with how long they have been in the curtailed state and what happened before they went there
* Nick: Yes, this goes back to WT not wanting to go in and out. So, if the turbines are still online and are not turned off, they might as well respond.
* Nitika: What we are measuring right now for PFR performances is 20 to 52 seconds after the event starts. How does that interplay with the time it takes for the resource to come back online and start responding. Does that help to give the equipment time to respond?
* Nick: Directly it helps, but it’s a question of equipment suppliers. Devil is in the detail here.
* Luis: With all the information that we got today we’ll take back it and discuss some options and ideas internally.

**Review and Discussion of NOGRR272 and PGRR121 related to Advanced Grid Support Requirements for Inverter-Based ESRs**

Sun Wook Kang (ERCOT)

* Reviewed recent updates to NOGRR272 and PGRR121, focusing on adoption of advanced grid support (AGS) capabilities for inverter-based energy storage systems (ESRs) as presented at August and September IBRWG meetings.
* The goal is to improve stability and resiliency of ERCOT grid with higher shares of IBRs.
* ERCOT also posted AGS ESR testing requirements on September IBRWG meeting page. Presented details of the testing requirements at October IBRWG and shared the drafts of the above PGRR and NOGRR.
* NOGRR272 and PGRR121 are officially posted for stakeholder comments on October 31st.
* This will be discussed at the December ROS meeting. ROS will direct IBRWG and DWG to review the NOGR272 and PGRR121.
* Sun Wook went through the draft NOGRR and PGRR:
	+ Added section 2.14 to existing Nodal Operating Guides to require all future ESR (with SGIA after April 1st 2025) to have advance grid support requirements.
	+ In the Planning Guide, Section 6.2, Paragraph 5c, where ERCOT used to have discussion on MQT, now includes AGS ESR MQT requirements as well. To verify new ESRs, we can provide AGS. Seven different tests are included as detailed in ERCOT report posted on September IBRWG website.
* Jason Yedinak: What if SGIA was executed before 4/1/2025 but then resource got amended, would it then require having AGS? [Jason than detailed a couple of examples, where quantity of battery modules got added after SGIA but prior to COD or another example is where augmentation of existing site was made by adding BESS units, does that trigger AGS requirement for the entire site, including existing units or just new additions? – ERCOT needs to take it back and think about it]
* Sun Wook: It will depend how significant update was and if it takes the resource into GINR. Something that needs to be considered and discussed further, possibly changes can be made to NOGRR272.
* Sun Wook comments that hopefully this will go through stakeholder process promptly as this really is essential for stability constraint improvement
* Julia: Will DWG manual also need updating? What’s the timeline for drafting and approving that language? Will this be brought up to IBRWG?
* Sun Wook: Yes there’ll be updating to DWG manual, with regard to MQT, to implement the tests from ERCOT report (posted on September IBRWG) into DWG. So far haven’t heard any major feedback so far. Possibly will bring it to IBRWG/DWG coordination.

**SPWG / IBRWG Coordination on Multiple-Ride Through and Next Steps Discussion**

**Mark McChesney (Oncor, SPWG chair)**

* This is following up on the discussion from August SPWG/IBRWG coordination discussion item (during August IBWG)
* Action item from ROS was around developing guidance and recommendations for transmission auto reclosing and sectionalizing schemes to improve IBR ride though probability.
* Mark provided an overview of IEEE 2800 requirements relevant here, i.e. consecutive ride-through capability and voltage phase angel change ride through (25 electrical degrees)
* One issue is when there’s a fault on the line of IBR plant, those will have a delayed reclose. But the mode significant concern is around lines that are adjacent to the IBR and how those will auto-reclose, the number of times and the phase angles that may be experienced by IBR plants for those events.
* Important parameters here are voltage level, angle difference, slip frequency, number of automatic recloses and time delay between automatic recloses.
* The request from August IBRWG meeting was to survey TDSPs for the typical range of settings for the above parameters in ERCOT region.
* Ran a survey for about a month, only got five responses from TDSPs, so these are not statistically significant, even though representing some of the larger TDSPs
* Most of them do apply reclosing. They reclose on all three fault times (single phase to ground, phase-to-phase and three phase to ground).
* Reclosing intervals varied from 25 cycles to 300 cycles.
* The number of reclosing instances varies by voltage level by mostly 1
* Open interval times for reclosing very between the voltage levels.
* Half of the responders apply voltage supervision before reclosing action, and they use single phase to ground voltage calculation for voltage supervision.
* Most of the responders replied that they applied synch check at reclosing.
* One of the major concerns to be discussed is synch check angle that they do apply when they synch check close, it’s 15-20 degrees, but one responded verbally that it was 40 degrees.
* Few of the system conditions are taken into consideration when deciding to apply auto reclosing and also deciding on synch check capabilities, such as switching surges, system stability, breaker duty, generator size.
* Reclosing is always blocked for breaker failure, the responders listed conditions under which this happens.
* Half of the responders consider if it’s a strong or weak source when they consider which line end terminal breaker is used to test the line.
* The survey will be posted on IBRWG meeting page for further review.
* Overall settings applied are very dependent on the location of IBRs and those lines. So the conclusion that could be made is that there needs to be a dialogue between IBR developer/owner and their TDSP to understand auto-reclose practices that are applied not only on the interconnecting line but also on the lines adjacent to that IBR plant. Things like number of recloses and phase angle jump are going to depend on the system conditions that the plant is in. There is a lot of variability there.
* Julia: It is important to bring this to IBR plant owner/developer and TDSP attention during plant development stage. This could be included in TDSP’s guides and documents. Or into ERCOT any relevant documents? Otherwise this need for coordination can easily fall through the cracks.
* Mark: Yes with this high variations seen from TDSP to TDSP these are questions that need to be discussed during interconnection process/agreement. May be looked at in conjunction with dynamic studies. This is not something where general guidance can be created.
* John Schmall: It looks like this evaluation is site-specific and not clear if it should be a part of interconnection process or on TDSP discretion.
* Mark: one of the comments that came up during the last SPWG meeting was that TDSPs are trying to be very transparent about their auto reclosing strategies during interconnection process.
* Julia: I know that during the interconnection process there is a meeting between ERCOT, TDSPs and IE to discuss the full interconnection study scope. May be this is when this coordination item on auto-reclosing can be captured as well. And in that case may be it can be captured in ERCOT’s Resource Integration Handbook?
* Mark: The question also is whose scope is this really in to verify what the phase jump conditions can be? Is this something that’s determined in the interconnection studies? Sharing the settings and agreeing what’s cases need to be looked at.
* John: Caution on phase angle jump. It may be a different issue than reclosing. Typically from reclosing perspective we are talking about fault conditions, and during this time phase jump ride-through doesn’t factor in.
* Julia: If you do auto-reclosing and cause a phase jump that IBRs are required to ride through it may result in IBR trip and if you could adjust the auto reclose settings to avoid that phase jump then may be it’s something coordination can help with.
* John: Phase-jump in the NOGRR245 and IEEE2800 is not for fault conditions but line switching (at no fault).
* John: Regarding the idea of bringing this up to the scoping meeting, it would be good to coordinate with the ERCOT Resource Integration Team.
* Julia: Yes, will take it to that Team
* Mark, trying to dynamically adjust what phase angle jump to synch check may be more nebulous to try to address. Just wanted to bring up.

**NERC and Other Industry Updates**

Julia Matevosyan (ESIG)

* MISO [presented](https://cdn.misoenergy.org/20241016%20PAC%20Item%2006d%20Battery%20Energy%20Storage%20System%20Grid%20Forming%20Controls%20%28PAC-2024-2%29653147.pdf) the latest draft of the proposed performance requirements for GFM BESS at October Planning Advisory Committee (PAC) meeting.
* The proposal was **to require GFM control capabilities from all BESS, starting with the DPP 2023 Cycle**\* (i.e. next gen interconnection cycle). DPP – Definitive Planning Phase
* The requirements and process are outlined in [Business Practice Manual (BPM-015) redlines](https://cdn.misoenergy.org/20241016%20PAC%20Item%2006d%20BPM-015-r29%20GI_GFM%20BESS%20REDLINE%20%28PAC-2024-2%29653141.docx) (Section 5.3.7 on Page 52).
* PAC stakeholders were invited to review and submit feedback to MISO’s proposal. MISO responded to stakeholder feedback submitted by 2 parties and shared requested clarifications in the responses and [November PAC meeting materials](https://www.misoenergy.org/events/2024/planning-advisory-committee-pac---november-13-2024/).
* **Next Steps: Finalize BPM-015 redlines to implement proposed requirements**
* GFM Progress Globally: 5 system operators have developed and approved grid forming specifications for IBRs (or just battery energy storage); 2 more are in draft
* Nine manufacturers have commercial offerings of GFM inverters.
* G-PST/ESIG Webinar: GFM Technology Adoption in ERCOT – Status Update, by Fred Huang (ERCOT) on November 12th. [Download Presentation](https://www.esig.energy/download/g-pst-esig-webinar-gfm-technology-adoption-in-ercot-status-update/?wpdmdl=12349&refresh=67348ca11a6111731497121) or [View Webinar Recording](https://youtu.be/kMiTP_85WVg)
* ESIG summarized the current status of efforts to improve interconnection standards for IBRs, [here](https://www.esig.energy/generation-interconnection-project-team/)
* ESIG summarized the IEEE PES GM 2024 Panel on IBR Integration. The panel included SMEs from Vestas, MISO, EPE, Elevate Energy and Dominion Energy. The keypoints of the discussion were on reliability challenges with IBRs, modeling issues and development of improved standards. The summary is available [here](https://www.esig.energy/generation-interconnection-project-team/)
* NERC addressed Milestone 2 of FERC Order 901 through filing the following standards PRC-028, PRC-29, PRC-30. Links to filings and other information are on slide 7.
* Work is ongoing on Milestone 3, focused on modeling. NERC is holding a [Technical Workshop](https://nerc.webex.com/webappng/sites/nerc/webinar/webinarSeries/register/669456158ed648bba90fdd46a52493f3) on January 15-16, 2025 to get industry’s feedback.
* DOE i2x Forum for the Implementation of Reliability Standards for Transmission held a [October 24th, 2024 hybrid, full day,](https://www.esig.energy/event/i2x-first-hybrid-workshop-interconnection-standards-workshop/) during ESIG Fall Workshop, Providence, RI, focusing on Conformity Assessment of IBR plants with applicable interconnection requirements (going through portions of IEEE P2800.2 draft)
* In October ESIG held a Fall Workshop, Providence, RI. Four sessions relevant for IBRWG scope, focused on EMT, high share of IBRs, Grid Forming and Large Load ineterconnection (see slides 12-13). Recordings of workshop sessions are [now available on the ESIG YouTube Channel](https://youtube.com/playlist?list=PL4JBq4uH3yMJAp-pmwuCsGqgz_q2PGcRB&si=FQmGPA70EiimMmh3).