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| **NOGRR Number** | [**245**](https://www.ercot.com/mktrules/issues/NOGRR245) | **NOGRR Title** | **Inverter-Based Resource (IBR) Ride-Through Requirements** |

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| **Date** | April 15, 2024 |

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| **Market Segment** | Not applicable |

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| **Comments** |

**INTRODUCTION**

My name is Dr. Ryan Quint, and I am the Founder and CEO of Elevate Energy Consulting (“Elevate”), which was started in January 2024 to help the electricity sector tackle grid reliability issues during the energy transition. Prior to starting Elevate, I was the Director of Engineering and Security Integration at the North American Electric Reliability Corporation (NERC) and was responsible for leading many of NERC’s emerging risk mitigation activities, particularly related to inverter-based resources (IBRs).[[1]](#footnote-2) I was deeply involved in the event analysis and was the primary author of nearly all the IBR-related NERC disturbance reports[[2]](#footnote-3) – including the 2021 Odessa report,[[3]](#footnote-4) 2022 Odessa report,[[4]](#footnote-5) and the Panhandle Wind report.[[5]](#footnote-6) I was also the coordinator of the NERC Inverter-Based Resource Performance Subcommittee (IRPS)[[6]](#footnote-7) and primary author of multiple foundational NERC Reliability Guidelines that have helped shape industry actions including the initial drafts of IEEE 2800-2022.[[7]](#footnote-8) I have a deep knowledge and understanding of IBR-related performance issues and the near-miss events that have occurred across multiple interconnections and around the world, and have had the chance to understand the perspectives from major equipment manufacturers, asset owner/operators, transmission providers, system operators, and regulatory bodies.

I want to acknowledge that I am currently working with Clearway Energy and supporting the Joint Commenters broadly on this topic. I am submitting these comments and perspectives independently and they do not represent the position of Clearway or the Joint Commenters. I also want to express my appreciation to the ERCOT Board of Directors (“ERCOT Board”) for consideration of these comments regarding Nodal Operating Guide Revision Request (NOGRR) 245. I am unable to travel to the April 2024 ERCOT Board meetings due to a prior commitment; however, I submit these comments to help aid all stakeholders with a clear understanding of the issues at hand. It is recognized that ride-through performance is a highly technical topic and should be given due diligence by all stakeholders involved.

**KEY TAKEAWAYS**

Here are the key points I would like to highlight, which will be further expounded upon in the subsequent sections:

1. ERCOT staff should be commended for their effective and efficient event analysis process following the large-scale IBR-related events, including their ability to bring together key stakeholders and develop meaningful risk mitigations.
2. The majority of IBRs involved in past large-scale disturbances, particularly solar PV, can correct their past performance issues with commercially reasonable, software-based upgrades. The level of risk associated with large-scale IBR tripping appears to be significantly reduced due to the work of ERCOT and its stakeholders.
3. The TAC-approved NOGRR 245 uses a June 2024 applicability date for new requirements, which is based on the well-established precedent of not imposing retroactive requirements to resources that already have a signed interconnection agreement. Changing requirements after-the-fact can cause complications, challenges, and future non-compliance since original equipment manufacturers (OEMs) use established requirements to specify and build equipment. This precedent seems appropriate here since no quantitative technical basis justifying an elevated level of risk of a prospective vs. retroactive implementation date has been presented.
4. The 20-30 GW described by ERCOT that would be subject to legacy requirements instead of the new preferred requirements if the implementation date were in June 2024 vs. June 2023 does not appear to present a significant ERCOT system-wide reliability risk. These resources are 95+% solar PV and batteries leveraging the newest technology and software upgrades (fixes) from OEMs to address these known ride-through deficiencies. Resource entities will be deploying IBRs with the latest equipment that address past deficiencies while meeting the legacy ride-through requirements. Further modeling and reliability studies would be needed to provide a technical basis for the claim that these newly connecting resources pose a serious instability risk to the ERCOT system.
5. The TAC-approved NOGRR 245 leverages a Commercial Reasonability concept where exemptions can be sought for ride-through capability issues that cannot be addressed with cost-effective fixes. Software-based updates to solve ride-through deficiencies are required, by default. This process gives due consideration to older legacy equipment that may uncover hardware limitations (e.g., turbine or converter issues, hard-coded inverter settings that cannot be changed, etc.). The exemptions are not intended to be a loophole. Ride-through failures are not acceptable and should be penalized accordingly, particularly if a resource trips for a reason not previously identified. But after deeper analysis than ever conducted before, the resource owner/operator may uncover an issue that cannot be addressed without complete tear-down of the resource, which is likely to be uneconomic. Forced early retirement of these resources is unlikely to be in the best interest of consumers across Texas.
6. If the TAC-approved version of NOGRR 245 is not approved in full, the Board should consider adopting the requirements specifically for newly connecting resources that would then be subject to applicable IEEE 2800-2022 clauses. All parties appear to agree on this matter, and it will bring certainty for OEMs and Resource Entities in the ERCOT market moving forward. Any qualms with legacy requirements should not hold up adoption of improved requirements for resources signing new interconnection agreements, effective as soon as possible.
7. With respect to resources signing interconnection agreements between June 2023 and June 2024, if decision makers are still uncertain regarding the level of risk, I propose a “defense in depth” approach where these resources specifically could be subject to a one-time requirement to maximize their ride-through capability to the greatest extent possible within commercial reasonability. This would de-risk the ERCOT system in terms of resource ride-through concerns and also provide a bridge to the long-term solution of IEEE 2800 requirements effectiveness starting in June 2024 (as proposed in the TAC-approved NOGRR). While this approach may not be necessary to secure reliability, in my view, it could represent a reasonable middle ground that would allow rules to be finalized and resolve this period of regulatory uncertainty.

**BACKGROUND**

The 2022 and 2021 Odessa events involved unexpected tripping and performance issues from over 1700 MW and 1100 MW of solar photovoltaic (PV) resources, respectively. The Panhandle Wind and the 540 MW wind event[[8]](#footnote-9) were both entirely wind-related issues. While the Western Interconnection has experienced large-scale IBR-related issues since 2016 (i.e., the Blue Cut Fire)[[9]](#footnote-10) – and continues to identify systemic IBR-related performance issues that are in some ways not being addressed[[10]](#footnote-11) – it is important to acknowledge the exceptional technical team at ERCOT that has been responsible for the event analysis conducted in close coordination with Texas RE and NERC after each event as well as ERCOT’s proactive convening of affected resource entities (and broader ERCOT stakeholder community) in the ERCOT Inverter-Based Resource Working Group (IBRWG)[[11]](#footnote-12) where technical discussions and further analyses have led to significant risk mitigation activities being implemented.[[12]](#footnote-13) ERCOT is industry-leading in terms of its robust event analysis process that results in effective and efficient reduction of risks, including engaging its key stakeholders in a meaningful and productive way.

Reviewing four of the largest IBR-related events in Texas – the 2022 Odessa, 2021 Odessa, Panhandle Wind Event, and 540 MW wind event – there are important learnings and factors that should be acknowledged. **The vast majority of solar PV issues in both Odessa events are fixable with software updates that are currently available and would generally be required under the TAC-approved NOGRR 245**. ERCOT and solar PV asset owners are working to get updates rolled out that should effectively eliminate these identified causes of tripping, to a great extent, moving forward. Software-related corrective actions should be mandated to the greatest extent feasible.[[13]](#footnote-14) There are also a small handful of solar PV-related tripping issues that are not easily fixable with basic software updates. For example, KACO inverters comprise a relatively small set of resources on the ERCOT system and may not be able to fix all (but maybe some) of their performance deficiencies since that OEM is now out of business. Lastly, several wind-related events involved some fixable software issues, some maintenance-related issues,[[14]](#footnote-15) consequential tripping (i.e., should not be considered ride-through failure), and corrective actions that could not be determined due to challenges getting responses from OEMs. Some wind issues may be fixable with minor hardware upgrades; however, the extent and cost of such upgrades is not well-understood by all parties and needs careful consideration moving forward.

**Nearly 90% of the affected resources can mitigate their past performance issues when commercially reasonable mitigations are deployed.** Assuming these mitigations had been previously addressed by OEMs, these events would have subsequently been on the order of 50-200 MW due to the remaining 10% of resources not mitigated, which does not meet the NERC Event Analysis Category 1i criteria[[15]](#footnote-16) and would likely never been analyzed by NERC or Texas RE in significant depth. ERCOT acknowledged that “software changes…will be good enough to hold off the…catastrophic type [instability, uncontrolled separation, and cascading] event” and stated that “software and parameterization changes as being deemed commercially reasonable by default gives [ERCOT] the most benefit in the short term for reliability.”[[16]](#footnote-17)

**APPLICABILITY DATE IN TAC-APPROVED NOGRR 245**

The TAC-approved NOGRR 245 draft uses a June 2024 date to differentiate between preferred (IEEE 2800) ride-through requirements and legacy ride-through requirements applicability. The justification for this date is it aligns with the expected and intended approval date of the NOGRR, avoiding the potential retroactivity of requirements applicability to resources that already have a signed interconnection agreement.

Never-ending arguments regarding the applicability date are not grounded in technical basis. The two parties will continue to disagree on this matter, and ERCOT should have a well-established protocol or policy on this matter that avoids this type of wasteful back-and-forth, to the extent possible.

**REMAINING LEVEL OF RISK**

ERCOT expressed concerns and subjective opinions regarding the residual level of risk that exists after the known IBR performance issues described above have been addressed. For example, at the March 2024 TAC meeting, ERCOT highlighted that they originally proposed having the new (IEEE 2800-2022) requirements apply to IBRs signing interconnection agreements after January 1, 2023 (retroactively). That proposal was changed by ERCOT to June 2023, and ERCOT stated that moving the enforcement date to the NOGRR approval date would likely exempt 20-30 GW of IBRs from the new requirements.[[17]](#footnote-18) They argued that the exclusion of 20-30 GW of IBRs from new requirements poses a significant risk to ERCOT reliability; however, there were no quantitative reliability studies shown to stakeholders to justify that position. Rather, a statement was made that ERCOT “can’t go and tell you it’s going to be reliable with any further concessions.”

The 20-30 GW of IBRs within this approximate 1-year window between 2023 and 2024 consists of 95+% solar PV resources and battery energy storage resources. As stated above, most *existing* resources have software fixes to address the ride-through performance issues to-date. Additionally, these new 95+% solar and battery resources connecting soon do not have known systemic ride-through deficiencies that would cause widespread instability. However, the Joint Commenters have highlighted that discussions with some OEMs have highlighted that there may still be challenges will meeting certain aspects of the preferred (IEEE 2800) ride-through requirements, particularly since the complementary test and verification standard (IEEE 2800.2)[[18]](#footnote-19) is still in active development.[[19]](#footnote-20)

While the past ride-through issues identified to date in ERCOT were concerning, ERCOT has addressed those issues very well with its stakeholders. Newly connecting resources that can roll off the production line with the latest firmware upgrades, control modes, settings, and protections are not likely to exhibit these same reliability issues in a *systemic* manner. There may still exist resources that are commissioned inappropriately or set incorrectly or tuned poorly; those resources should be held accountable for their failed performance and can address the issues with commercially reasonable updates. But the broad statements that the grid could experience widespread instability if the rigorous IEEE 2800 requirements are not adopted for these 2023-2024 resources is insufficiently backed with quantitative study results. ERCOT stakeholders, and industry at-large, would be open to reviewing any simulation results that could back that claim, but none have been produced.

**COMMERCIAL REASONABILITY – OLD LEGACY VERSUS RECENT LEGACY RESOURCES**

It is safe to say that the level of rigor of analyses conducted on newly interconnecting IBRs today is drastically different than it was 20+ years ago. Simulation models, tools, computational abilities, technological understanding, and many other factors continue to improve and evolve every day, even today. As Texas stakeholders continue exploring appropriate requirements, particularly for legacy resources, it is unrealistic to assume that an IBR from circa 2010 would have close to the same ride-through capabilities as an IBR from circa 2022. Technology continues to evolve at a rapid pace, as well as our ability to visualize, uncover, and understand potential ride-through issues with these resources.

The Joint Commenters proposed a concept of Commercial Reasonability that essentially ensures that existing resources are taken to their maximum ride-through capability within commercial reasonability through ongoing assessments of ride-through capability. With a deeper understanding of how to analyze this capability than previously applied at the time of interconnection (which could be 15+ years ago), resources may uncover issues not previously explored during past interconnection studies. However, fixing those issues may be problematic or commercially unreasonable to fix (even to the older legacy requirements, particularly for relatively older legacy assets). Hence why in the spirit of ensuring maximized ride-through performance and the continued reliable, cost-effective operation of the grid, there needs to be some degree of latitude granted for existing resources.

Newly interconnecting IBRs should have no issue meeting the legacy ride-through requirements and can even likely get close to or exceed many aspects of the preferred (IEEE 2800) requirements. However, older legacy resources such as wind farms or older solar plants may have hard-coded controls or equipment limitations that were previously unknown. Examples could include, for instance:

* A few legacy solar PV plants with momentary cessation that cannot be eliminated without complete change-out of all inverters.
* Some legacy wind turbines that cannot meet portions of the voltage ride-through curve (e.g., maybe upon more detailed EMT analysis).
* Legacy resources that are unclear as to their phase angle jump or rate-of-change-of-frequency (ROCOF) capabilities.[[20]](#footnote-21)

After deeper analysis than ever conducted before, the resource owner/operator may uncover an issue that cannot be addressed without complete tear-down of the resource, which is likely to be uneconomic and could force early retirement of these resources which is not in the best interest of Texas consumers.

It should be reiterated that ERCOT and its stakeholders necessarily have a common vision of ensuring reliability, resilience, security, and *affordability*. The Joint Commenters approach, approved by TAC and crafted from ongoing discussions with ERCOT, strikes a reasonable balance to this dichotomy of reliability and cost. Again, new resources should have relatively minimal issues complying with requirements and performing to exceptionally high levels of ride-through capability. But there may be older resources that need exemptions due to unexpected ride-through capability issues. Note that a ride-through capability exemption issue does not mean that the resource will inherently trip for any future grid event.

**ADOPT REQUIREMENTS FOR NEWLY CONNECTING RESOURCES NOW**

Should the Board not be comfortable advancing the full TAC-approved version of NOGRR 245, one prudent path forward would be to adopt the provisions for new resources so that OEMs can have certainty of regulatory requirements for new resources and solidify plans and design for resources to meet these requirements. OEMs need this certainty as a design criterion in terms of developing product cycles with relatively long lead times. Essentially all parties agree on the forward-looking requirements for new resources adopting the specific clauses in IEEE 2800-2022 outlined in the TAC-approved version. Regardless of the action taken at the Board meeting, the Board should consider adopting this aspect of the requirements as soon as possible considering the agreement among all parties.

**DEFENSE IN DEPTH APPROACH FOR RESOURCES WITH 2023-2024 GIAS**

The facts show that there should be a significantly reduced risk of large-scale systemic IBR tripping after the diligent work of ERCOT and its stakeholders. Persistent analysis of smaller events, proactive information sharing, and ongoing risk mitigation activities will be key to monitor this rapidly evolving landscape. The 20-30 GW of IBRs coming online are solar PV and batteries that have excellent ride-through capability when configured correctly; software fixes are available for many known reliability risk issues identified in the past.

However, if there is still doubt by the ERCOT Board or associated decision makers, a concession for both parties could involve a one-time requirement that the 20-30 GW of IBRs with signed interconnection agreements between 2023 and 2024 undergo a detailed ride-through capability assessment and be ***required*** to maximize their ride-through capability to the greatest extent possible within commercial reasonability and appropriate engineering judgment, taking their capability beyond minimum thresholds to the maximum equipment limits across the board. This is a well-established recommended best practice that should already be occurring; however, history and experience has shown that this is often not the case – equipment settings, protections, and controls are simply set right outside the mandatory requirements,[[21]](#footnote-22) which leaves room for possible misoperation and risk. ERCOT could require expanding capabilities to near limits within practicality to further de-risk the system from potential reliability issues. This would bridge concerns until IEEE 2800 requirements become enforceable (ideally in June 2024).

Furthermore, detailed assessments should be provided to ERCOT for review and for a more detailed understanding of resource ride-through capabilities. Models can subsequently be enhanced and verified to match these capabilities, with sufficient timelines for modeling updates. This would position the ERCOT system and its resources within this time window in as reliable a position as commercially reasonable and would improve ERCOT system reliability in terms of ride-through capability beyond any other market operator’s system as far as I know.

This concept is an option for consideration *only* in the instance where there are further doubts regarding the TAC-approved NOGRR. Without quantitative studies, it is unclear to stakeholders what the level of risk is on the ERCOT system between requirements. The systemic IBR risk issues are being addressed, and this proposed concept would only further add a layer of de-risking across the system.

**CONCLUSION**

The longer we delay on this matter, the further out we push starting to address other critical matters that require the exceptional brainpower, thought leadership, and technical expertise of ERCOT and its stakeholders. As the ERCOT system moves toward rapidly increasing levels of IBRs, it is imperative that ERCOT and its stakeholders proactively (rather than reactively) enhance interconnection requirements, processes, tools, and capabilities to handle this monumental shift in resource mix. We must collectively move forward with a sufficient ride-through standard and adequate level of ERCOT grid reliability; we must also safeguard investment confidence in the ERCOT system, respect the nature of contractual obligations and procurement considerations for resources with signed agreements, and let ERCOT and its stakeholders continue to set a positive precedent for other areas across North America and around the world.

I encourage ERCOT and its stakeholders to continue working collaboratively and professionally. There are bigger systems integration challenges on the horizon – weak grid and controller instability challenges, the need for more comprehensive EMT modeling and studies, deeper analytics and assessments of system stability, creation of grid forming (GFM) functional specifications and test procedures (especially in battery energy storage systems (BESS)), and other issues. This will require fostering a collaborative and cooperative environment at ERCOT moving forward.

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| Revised Cover Page Language |

None

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| Revised Proposed Guide Language |

None

1. [NERC IBR Risk Mitigation Strategy](https://www.nerc.com/comm/Documents/NERC_IBR_Strategy.pdf) [↑](#footnote-ref-2)
2. [NERC Major Event Reports](https://www.nerc.com/pa/rrm/ea/Pages/Major-Event-Reports.aspx) [↑](#footnote-ref-3)
3. [NERC 2021 Odessa Report](https://www.nerc.com/pa/rrm/ea/Documents/Odessa_Disturbance_Report.pdf) [↑](#footnote-ref-4)
4. [NERC 2022 Odessa Report](https://www.nerc.com/comm/RSTC_Reliability_Guidelines/NERC_2022_Odessa_Disturbance_Report%20(1).pdf) [↑](#footnote-ref-5)
5. [NERC Panhandle Wind Report](https://www.nerc.com/pa/rrm/ea/Pages/Panhandle-Wind-Disturbance-report.aspx) [↑](#footnote-ref-6)
6. [NERC IRPS](https://www.nerc.com/comm/RSTC/Pages/IRPS.aspx) [↑](#footnote-ref-7)
7. [IEEE 2800-2022](https://standards.ieee.org/ieee/2800/10453/) [↑](#footnote-ref-8)
8. [NERC 540 MW Wind Event Lessons Learned](file:///C:\Users\hannah.muller\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\31UCKMQ0\NERC%20540%20MW%20Wind%20Event%20Lessons%20Learned) [↑](#footnote-ref-9)
9. [NERC Blue Cut Fire Report](https://www.nerc.com/pa/rrm/ea/1200_MW_Fault_Induced_Solar_Photovoltaic_Resource_/1200_MW_Fault_Induced_Solar_Photovoltaic_Resource_Interruption_Final.pdf) [↑](#footnote-ref-10)
10. [NERC 2023 Southwest Utah Report](https://www.nerc.com/comm/RSTC_Reliability_Guidelines/NERC_2023_Southwest_UT_Disturbance_Report.pdf) [↑](#footnote-ref-11)
11. [ERCOT IBRWG](https://www.ercot.com/committees/ros/ibrwg) [↑](#footnote-ref-12)
12. [March 2024 IBRWG Meeting - Odessa Update Slides](file:///C:\Users\hannah.muller\AppData\Local\Microsoft\Windows\INetCache\Content.Outlook\31UCKMQ0\March%202024%20IBRWG%20Meeting%20-%20Odessa%20Update%20Slides) [↑](#footnote-ref-13)
13. There may be rare exceptions where the OEM may charge an extremely high price knowing that the update is mandatory, which could present some commercial reasonability considerations; however, these should be considered one-off instances. [↑](#footnote-ref-14)
14. Those resources can be held accountable for their ride-through failure; however, this does not pose a systemic risk and could be addressed in a future NOGRR. [↑](#footnote-ref-15)
15. [Electric Reliability Organization Event Analysis Process v5.0](https://www.nerc.com/pa/rrm/ea/ERO_EAP_Documents%20DL/ERO_EAP_v5.0.pdf) [↑](#footnote-ref-16)
16. ERCOT March 2024 TAC Meeting [↑](#footnote-ref-17)
17. [ERCOT March 2024 TAC Meeting - ERCOT NOGRR 245 Update](https://www.ercot.com/files/docs/2024/03/27/NOGRR%20245%20032724%20TAC.pptx) [↑](#footnote-ref-18)
18. <https://sagroups.ieee.org/2800-2/> [↑](#footnote-ref-19)
19. And even some requirements in IEEE 2800 are now being reconsidered and questioned through these deeper discussions. [↑](#footnote-ref-20)
20. ERCOT expressed that they do not intend to address phase angle jump or ROCOF requirements in this NOGRR. The new IEEE 2800 requirements explicitly address phase angle and ROCOF limits whereas the existing ERCOT legacy requirements could be interpreted to require riding through all phase jumps or ROCOF events since levels are not specified. ERCOT could simply add a disclaimer that they will not enforce any phase jump or ROCOF-related ride-through failures until addressed in a subsequent NOGRR. [↑](#footnote-ref-21)
21. This is a different approach than synchronous generation protection, and has been deemed a systemic practice for IBRs by NERC in the past. [↑](#footnote-ref-22)