

NERC Inverter-Based Resource Webinar Series

Webinar 1 – Introduction to Inverter-Based Resources

| Frequently Asked Questions | |
|---|--|
| Question/Theme | Answer |
| Do Inverter-based resources have to meet the same requirements as synchronous generation? | Inverter-based resources should meet all NERC standards requirements necessary to ensure reliable operation of the bulk power system (BPS). Additionally, numerous standards enhancements are underway to bring clarity to how existing requirements should apply to IBR. Transmission Planners (TP) and Transmission Operators (TOP) have also begun implementing IBR specific requirements to help ensure reliability. |
| How will BPS reliability be maintained under a high penetration of IBR or in weak grid areas? | The strategies to strengthen weak grid areas are similar to the strategies for the BPS as a whole under high IBR penetration. The main strategies are ensuring there are enough grid-forming resources online (whether synchronous machine based or inverter-based), and reducing the impedance between locations, if possible (i.e., higher capacity connections between buses, or more connections). |
| Why are we not seeing IBRs with Grid Forming (GFM) capabilities connecting to the BPS? | GFM application in BPS is still relatively new with only a handful of IBRs currently operating with GFM capabilities world-wide. GFM is an important mechanism for increasing BPS reliability in the future and should be implemented once the effects of the technology have been sufficiently studied on the BPS. |
| Does the ERO anticipate a significant number of retrofit projects to ensure IBR meet future requirements? | Retrofit projects can be extremely costly and difficult to implement as older hardware and software may not be able to meet current requirements. The amount of retrofitting necessary to help ensure BPS reliability will depend on the needs of each region and the balance between cost, feasibility and BPS reliability. |
| Does NERC provide recommendations to the industry regarding IBR modeling and performance? | NERC provides guidance and recommendations through work items from various working groups, task forces, and subcommittees. Industry members may get involved in these groups in order to participate in the discussion |

| Frequently Asked Questions | |
|--|--|
| Question/Theme | Answer |
| | or to be aware industry direction and best practices. |
| Will NERC create requirements to replace positive sequence modeling with EMT modeling? | There is no plan to replace positive sequence modeling. Positive sequence modeling will likely continue to be a large part of the planning and interconnection process for some time. NERC is currently working on a standard project to introduce EMT modeling in relevant reliability standards. They are intended to supplement the existing study and modeling efforts underway throughout the industry. To support industry adoption of EMT modeling, NERC has recently formed the Electromagnetic Transient (EMT) Task Force (EMTTF) which, along with other NERC activities will provide guidance and best practices for EMT modeling. |

NERC Inverter-Based Resource Webinar Series

Webinar 2 – NERC Disturbance Reports and Lessons Learned

| Frequently Asked Questions | |
|--|--|
| Question/Theme | Answer |
| Do your data requests go to Reliability Coordinators, Balancing Authorities, or Generator Owners (GO)? | This depends on the nature of the request, but yes NERC engages with the affected asset owners (GOs) to gather data, working collaboratively with the Regional Entities as well as the RC/BA. |
| If a facility has a digital fault recorder (DFR) installed, will it be triggered for all events of interest? | DFR can record only for trigger events it has been programmed for. We do see that if a DFR/relay is capturing data, that data has historically been available, but that is often because a notable fault has occurred nearby meeting the recording trigger criteria. Some of the plants that are significantly further away from the fault may not trigger their DFR/relay records, which is why inverter-level and plant-level data is very useful for event analysis. |
| Is data recording mandatory? | Data recording requirements are available in NERC PRC-002 as well as local transmission service provider interconnection requirements or market operator rules. Detailed requirement information is located within the applicable requirement documents for each location. |
| Should a DFR be installed at each IBR facility? | DFR data is very useful to see overall plant response during and immediately following fault events. It is often the only high-speed source of data that can show the overall plant response during the fault. |
| Why have ride-through settings been installed that are too restrictive to ride through BPS disturbances? | NERC has observed numerous systemic deficiencies in the alignment between actual facility performance and the performance of the facility model throughout the interconnection process. These discrepancies can lead to instances where installed ride through (and other control functions) settings are not what has been verified to be reliable through the interconnection process. Additionally, settings that have been updated throughout the facility design and study process may not have been communicated to those who commissioning the facility, further driving discrepancies. |

NERC Inverter-Based Resource Webinar Series

Webinar 3 – Inverter-Based Resource Performance Issues

| Frequently Asked Questions | |
|---|---|
| Question/Theme | Answer |
| Are inverter-based resources required to provide frequency or voltage response with no resources available? (i.e., no wind or sunshine) | IBR are required to provide voltage and frequency response only within the capabilities of the technology. The amount of grid support available for any given amount of resource (wind or sunshine) will vary between manufacturers, technologies, and plant design. |
| What role can IEEE 2800-2022 and NERC guidance play in improving observed IBR performance issues? | IEEE 2800-2022 provides technical minimum requirements for IBR performance as a voluntary standard. NERC provides guidance on improving BPS reliability through outreach, Reliability Guidelines, White Papers, and other publications. Information from both of these sources can inform new mandatory requirements intended to improve IBR performance. |
| How important is event monitoring equipment (PMUs) to understanding IBR performance issues? | When investigating IBR performance issues, the investigation is only as good as the data available to study. For this reason, the higher fidelity and accurate event data that is available, the better the quality of the investigation. |

NERC Inverter-Based Resource Webinar Series

Webinar 4 – Establishing and Enhancing Interconnection Requirements

| Frequently Asked Questions | |
|---|---|
| Question/Theme | Answer |
| Will new requirements be applicable to <i>only</i> newly interconnected IBR facilities or to currently operating IBR facilities also? | Significant consideration regarding the retroactive applicability of any requirements is needed on a requirement-by-requirement basis. Some requirements cannot be met without significant hardware additions or improvements, while others may be simpler to implement. For each requirement, the reliability improvement must be weighed with the cost (time, resources, and financial cost) of performing the necessary retrofitting. |
| Does NERC have specific requirements for which electromagnetic transient (EMT) simulation software to use? | NERC does not have any requirements or suggestions as to which EMT (or positive sequence) simulation software to use. Transmission Planners (TP) or Planning Coordinators (PC) may specify which format models shall be in. |
| What active interconnection standards are best to use? | NERC Standard FAC-001-3 requires that TP and PC document and make available requirements so that entities seeking to interconnect will have the necessary information. For this reason, it is best to contact the TP or PC responsible for the area in which a project is intended to interconnect to receive specific interconnection requirement information. |
| How are changes to model parameters or site design captured throughout the interconnection process? | Changes to model parameters or to the design of the IBR should be confirmed through the study of those parameters. If a parameter change will change the performance of the IBR, sufficient studies should be performed or re-performed with the new IBR performance to ensure BPS stability. Changes to any inverter or plant controller parameters should also be verified by their manufacturers to ensure they are compatible with the products software and do not damage any equipment. |
| How can IEEE 2800 help inform future interconnection requirements? | The areas that do not have detailed interconnection requirements for IBRs today should strongly consider adopting IEEE2800 “wholesale”. The standard was developed with |

Frequently Asked Questions

| Question/Theme | Answer |
|----------------|---|
| | <p>state-of-the-art IBR capabilities in mind, by a large body of experts and had very high response and approval rated in IEEE SA ballot. It therefore provides a solid basis for future interconnection requirements. In areas where detailed interconnection requirements already exist, a gap analysis with IEE2800 and piecemeal adoption could be an easier route to take, since changing existing requirements may involve more complex stakeholder process (for example in ERCOT).</p> |

NERC Inverter-Based Resource Webinar Series

Webinar 5 – Modeling Part 1 – Modeling Requirements, Model Creation, Model Usability

| Frequently Asked Questions | |
|---|---|
| Question/Theme | Answer |
| How are equipment models supported by the manufacturer after the products are no longer being produced? | Support varies between manufacturers, but if the manufacturer is still active in the market, they may have the ability to support older equipment and models. If the manufacturer no longer exists, it is nearly impossible to get any information regarding the model or the products being modeled. In these cases, it may be appropriate to parameterize a standard library model as accurately as possible for use in studies. |
| Do modeling requirements vary across different Transmission Planners and Planning Coordinators? | It is up to each TP to create and post their own requirements. In some cases, while requirements are posted, they may not be overly detailed or prescriptive. However, there is movement to standardize, strengthen, and add more detail to requirements driven by broader adoption of new and emerging industry standards. |
| How do third party consultants get sufficient information on the usability, parameters, and control functions when working with manufacturer-specific models? | It is an iterative and highly technical process. In order get such information, consultants initially request all documentation surrounding the IBR controls and how this relates and is implemented into the EMT model, i.e., firmware based model or programmed model. Additionally, we request any HIL testing demonstrating the hardware response is aligned with the EMT model response. Consultants then proceed to conduct multiple meetings or email exchanges to ensure the model and the parameters selected are approved by the manufacturer and confirmed that these parameters will be installed in the field. |
| Why are default models used to perform interconnection studies? Which models should be used? | NERC has recently published an updated Dynamic Modeling Guidance document that includes NERC’s recommended practices for dynamic modeling and studies ¹ . |

¹ nerc.com/pa/RAPA/ModelAssessment/Documents/Dynamic_Modeling_Recommendations.pdf

Frequently Asked Questions

| Question/Theme | Answer |
|---|--|
| <p>When performing model validation, is the model performance validated against the individual inverters or the plant as a whole?</p> | <p>There are different types of model validation that provide different benefits. Models can be validated at the “unit” level (i.e. individual inverters) and also at the “plant” level (i.e. the entire IBR plant). Unit model validation is useful for matching a models performance against measurements taken in a controlled testing environment and is intended to show model accuracy compared to a predetermined and typically default parameter set. Plant level model validation should be performed in addition to the unit model validations and help ensure that the whole plant model is parameterized to match what is or has been installed on-site.</p> |

NERC Inverter-Based Resource Webinar Series

Webinar 6 – Modeling Part 2 – Model Quality, Model Benchmarking

| Frequently Asked Questions | |
|---|---|
| Question/Theme | Answer |
| How are inverter or plant controller software version changes handled? Do all software version changes trigger a re-study? | Changes to inverter or plant controller software versions should be reviewed for their effect on the performance of the facility. If the software version changes affect the performance of the facility, then a restudy should be performed. If the software changes do not alter the performance of the facility, a restudy may not be necessary. GOs are encouraged to provide detailed information around the changes for the reviewer (TPs/PCs/TOs) to carefully consider and make best engineering judgement. |
| How are manufacturer-specific models kept up to date and supported throughout the lifespan of a facility? | Manufacturer-specific model support varies between manufacturers. Consideration should be made by both Generator Owners and manufacturers to ensure that changes made throughout the lifecycle of the facility are reflected in the model, are documented, verified, and coordinated. |
| What is needed from industry stakeholders to help increase overall model quality? | Increased collaboration between all stakeholders, including generator owners and equipment manufacturers, is necessary to ensure sufficient match between what will be installed in the field and what was studied during the interconnection process. Further, additional modeling requirements will help ensure that the IBR equipment and plant models have sufficient level of detail and accuracy to help ensure BPS reliability. |
| Which models should be used for each step in the interconnection and planning study process? (Positive sequence manufacturer-specific, positive sequence standard library, EMT) | NERC has recently published an updated Dynamic Modeling Recommendations ² document that includes NERC’s recommended practices for dynamic modeling and studies. |

² nerc.com/pa/RAPA/ModelAssessment/Documents/Dynamic_Modeling_Recommendations.pdf

NERC Inverter-Based Resource Webinar Series

Webinar 7 – Studies – EMT, Special Studies, Interconnection Studies

| Frequently Asked Questions | |
|---|---|
| Question/Theme | Answer |
| How can industry learn more about EMT studies, special studies, and which simulation domain or model type to use? | NERC has recently published a Dynamic Modeling Recommendation ³ document which provides recommendations for which simulation domains and model types to use for various study types. Additionally, NERC is continuously doing outreach regarding modeling, IBR risks and potential solutions, and EMT modeling through the Inverter-Based Resource Performance Subcommittee (IRPS) and the EMT Task Force (EMTTF). |
| How should industry model existing sites in the EMT domain if the manufacturers of that technology are no longer in business, support a specific product, or if an EMT model was not provided at the time of the interconnection process? | There is a range of solutions depending on the regional requirements, but it may be a combination of requesting/requiring models, use of proxy models, or in some cases generic models. While this creates a model to be used in studies, using models that have not been verified by the manufacturer introduces significant inaccuracies in the modeling efforts. For this reason, NERC recommends that a standard library model, a user-written and manufacturer verified model, and an EMT model is submitted for all incoming IBRs before interconnection. |
| When should special studies (studies in addition to normal interconnection process studies) be performed? | The need for the performance of “special studies” will be determined by the TP or PC for the interconnecting facility. The need for special studies varies from area to area based on their regional reliability needs, but these studies should be performed in situations where the typical interconnection studies are insufficient for mitigating a BPS stability risk. The need for special studies It varies from area to area based on their regional reliability needs. |
| How are IBR facility parameters verified before performing special studies? How do you ensure changes made during these studies are put into operation? | Before or at commissioning, model parameters should be verified against the rating of facility equipment and parameters programed on-site in the inverter, plant controller and other control and protection devices. Studies should aim to |

³ nerc.com/pa/RAPA/ModelAssessment/Documents/Dynamic_Modeling_Recommendations.pdf

Frequently Asked Questions

| Question/Theme | Answer |
|---|---|
| | <p>minimize any on-site changes or tuning; there should be processes in place to ensure any such changes are reflected back in the models used by planning and/or operation.</p> |
| <p>Will EMT Modeling and study requirements become mandatory in the future?</p> | <p>It is likely that EMT modeling and study requirements will continue to become more widespread and commonplace. There are currently multiple TP and PC that enforce EMT modeling and study requirements. Additionally, there is a NERC Standards project currently underway which aims to update some existing NERC standards to include EMT specific requirement language.</p> |

NERC Inverter-Based Resource Webinar Series

Webinar 8 – Interconnection Process

| Frequently Asked Questions | |
|--|--|
| Question/Theme | Answer |
| Are there any current criteria to “filter out” speculative or exploratory projects earlier in the interconnection process to avoid spending resources on projects that will likely not reach commercial operation? | Different regions have different criteria to determine commercial viability, however regions typically include fees and study cost payments throughout the interconnection process in an effort to dissuade the continued study of projects with a low probability of reaching commercial operation. For reliability reasons, each project must be studied in the same manner sequentially, regardless of the probability that it will reach commercial operation. |
| Is there any resistance to the adoption of IEEE 2800-2022 within industry? | Generally, Industry is supportive of IEEE 2800-2022. However, there are concerns regarding implementation guidance as well as applicability to existing resources. |
| How are delays within the interconnection process due to study or re-study work mitigated? | Solutions vary by region, but in general some timelines can be flexible, to allow for extensions to perform necessary study work. It is essential to BPS reliability that interconnection studies are performed accurately and with high quality modeling inputs. |

NERC Inverter-Based Resource Webinar Series

Webinar 9 – Commissioning

| Frequently Asked Questions | |
|--|---|
| Question/Theme | Answer |
| Are the settings used and performance studied throughout the interconnection process typically validated against site measurements during the commissioning process? | The level of parameter verification varies between regions. NERC IRPS is working to publish a “Commissioning Best Practices” white paper in order to provide recommended best practices for commissioning testing and model validation. |
| How can parameters in the models and in the actual product be cross referenced and confirmed? | The process and overall feasibility of matching model parameters and product parameters depends heavily on the type of model used. Using a manufacturer-verified EMT or positive sequence user-written model should provide the best match between model and product parameters, but confirmation with the manufacturer is recommended. The use of standard library models, due inherently to their generic nature of, can have significant challenges when matching model parameters to actual installed products. For this reason, NERC recommends ⁴ using manufacturer-verified user-written positive sequence and EMT studies throughout the interconnection process and while modeling the study control area during local reliability studies. |
| How are discrepancies uncovered during the commissioning process mitigated? How is matching performance between study model and actual site confirmed? | Discrepancies between the modeled representation and what has been commissioned will need to be mitigated either through performing additional studies or matching the commissioned performance to the modeled performance. |
| Do Generator Owners or Generator Operators typically have remote access to site parameters? If so, which parameters are typically available? | Generator Owners/Operators typically have remote visibility into the operational parameters of the facility. Manufacturers also may have remote access and this access typically includes significantly more detail. |

⁴ nerc.com/pa/RAPA/ModelAssessment/Documents/Dynamic_Modeling_Recommendations.pdf

NERC Inverter-Based Resource Webinar Series

Webinar 10 – IBR Registration and Reliability Standards Enhancements

The Webinar 10 FAQ and recording pertain to modifications of the NERC Rules of Procedure (ROP) that would address owners and operators of inverter-based resources that are outside of the Bulk Electric System definition but connected to the bulk power system. As a result, Webinar 10 resources have been published in the draft [ROP revisions](#) that has been posted on the NERC website for 45-day public comment.

NERC Inverter-Based Resource Webinar Series

Webinar 11: Overview of IBR Risk Mitigations and Next Steps

No comments were received during Webinar 11.