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| PGRR Number | [121](https://www.ercot.com/mktrules/issues/PGRR121) | PGRR Title | Related to NOGRR272, Advanced Grid Support Requirements for Inverter-Based ESRs |
| Date Posted | | October 31, 2024 | |
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| Requested Resolution | | Normal | |
| Planning Guide Sections Requiring Revision | | 6.2, Dynamic Model Development | |
| Related Documents Requiring Revision/Related Revision Requests | | Nodal Operating Guide Revision Request (NOGRR) 272, Advanced Grid Support Requirements for Inverter-Based ESRs | |
| Revision Description | | This Planning Guide Revision Request (PGRR) establishes model quality test and unit model validation requirements for inverter-based Energy Storage Resources (ESRs) with a Standard Generation Interconnection Agreement (SGIA) executed on or after April 1, 2025. | |
| Reason for Revision | | [Strategic Plan](https://www.ercot.com/files/docs/2023/08/25/ERCOT-Strategic-Plan-2024-2028.pdf) Objective 1 – Be an industry leader for grid reliability and resilience  [Strategic Plan](https://www.ercot.com/files/docs/2023/08/25/ERCOT-Strategic-Plan-2024-2028.pdf) Objective 2 - Enhance the ERCOT region’s economic competitiveness with respect to trends in wholesale power rates and retail electricity prices to consumers  [Strategic Plan](https://www.ercot.com/files/docs/2023/08/25/ERCOT-Strategic-Plan-2024-2028.pdf) Objective 3 - Advance ERCOT, Inc. as an independent leading industry expert and an employer of choice by fostering innovation, investing in our people, and emphasizing the importance of our mission  General system and/or process improvement(s)  Regulatory requirements  ERCOT Board/PUCT Directive  *(please select ONLY ONE – if more than one apply, please select the ONE that is most relevant)* | |
| Justification of Reason for Revision and Market Impacts | | ERCOT submits this NOGRR to provide greater support for system resilience and to maintain stable operation for an Inverter-Based Resource (IBR)-dominated ERCOT System. The IBRs currently connect to the ERCOT System are wind and solar Generation Resources and ESRs. More than 20 Generic Transmission Constraints (GTCs) have been created and enforced in Real-Time operation to ensure reliable operation. Most GTCs created in the last 10 years were related to IBRs and several of those GTCs are among the top 10 constraints on the ERCOT System. According to the ERCOT monthly Generator Interconnection Status Report, more than 100 GW of IBRs could connect to the ERCOT Transmission Grid by 2026. The continuous growth of IBRs requires ERCOT to explore options and system needs to continuously maintain the desired system stability and resilience.  In 2021 and 2023, the North American Electric Reliability Corporation (NERC) published two white papers related to grid forming for Bulk Power System (BPS)-connected battery energy storage systems. In these white papers, NERC stated that grid forming ESRs are needed to maintain stable operation for grids dominated by IBRs. Globally, electric system operators with a high penetration of IBRs, such as the United Kingdom’s Electric System Operator (ESO) and Australia’s Energy Market Operator (AEMO), not only have developed specifications but also implemented several grid-forming ESRs. These industrial efforts have led to the development of new capabilities that are commercially available today.  ERCOT has assessed the impact of such advanced grid support capability provided by the ESRs and presented the preliminary results to the Inverter-Based Working Group (IBRWG) in July 2024 (see presentation [ERCOT Advanced Grid Support Inverter-based Energy Storage System Assessment and Adoption Discussion](https://www.ercot.com/files/docs/2024/07/09/2024_07_ERCOT_IBRWG_ERCOT%20Advanced%20Grid%20Support%20Inverter-based%20ESRs%20Assessment%20and%20Adoption%20Discussion_v1_.pdf)). ERCOT believes the proposed requirements will help improve grid stability and resilience to maintain stable operation of the ERCOT Transmission Grid in this context in which IBRs are predominant. The potential benefits observed in the ERCOT assessment include: (1) improvement of voltage and frequency response during events, which would reduce events’ impact to the ERCOT Transmission Grid, (2) reduction in the risk of IBRs tripping or unstable operations, and (3) increase in GTC limits which could reduce generation curtailment due to stability constraints.  For those ESRs not required to comply with these advanced grid support requirements, ERCOT plans to consider ways to encourage existing ESRs to provide advanced grid support service when practical and feasible in future Revision Requests. ERCOT also plans to explore whether such advanced grid support services can be provided by other types of IBRs such as wind and solar Generation Resources. | |

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| Proposed Guide Language Revision |

6.2 Dynamics Model Development

(1) To adequately simulate dynamic and transient events in the ERCOT System, it is necessary to establish and maintain dynamics data and simulation-ready study cases representing the dynamic capability and frequency characteristics of machines and equipment connected to the ERCOT System.

(2) Dynamics data is the network data and mathematical models required in accordance with the Reliability and Operations Subcommittee (ROS)-approved Dynamics Working Group Procedure Manual for simulation of dynamic and transient events in the ERCOT System.

(3) For Resource Entities, dynamics data includes the data needed to represent the dynamic and transient response of Resource Entity-owned devices and/or Loads including but not limited to generating units, plants, and other equipment when connected to the ERCOT System including the data for any privately owned transmission system or collection system used to connect the Resource to the ERCOT System.

(4) For Transmission Service Providers (TSPs), dynamics data needed to represent the dynamic and transient capability of TSP-owned devices including but not limited to Load shedding relays, protective relays, FACTS devices (e.g., SVC, STATCOMs), Direct Current Ties (DC Ties), variable-frequency transformers, automatically switched shunts, and transformers with automatic load tap changers.

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| [PGRR101: Replace paragraph (4) above with the following upon system implementation of NPRR1133:]  (4) For Transmission Service Providers (TSPs) and owners of Direct Current Ties (DC Ties), dynamics data includes the data needed to represent the dynamic and transient capability of dynamic devices including but not limited to Load shedding relays, protective relays, FACTS devices (e.g., SVC, STATCOMs), DC Ties, variable-frequency transformers, automatically switched shunts, and transformers with automatic load tap changers. |

(5) The owner of a generator Facility or any dynamic device shall provide appropriate dynamics data to ERCOT, including the data for a planned Facility, in accordance with the Dynamics Working Group Procedure Manual. The dynamic data shall include the following:

(a) A model with parameters that accurately represent the dynamics of the device and that is compatible with the current version of the planning and operations model software as described in the Dynamics Working Group Procedure Manual. If a user written model is provided:

(i) A model manual containing a technical description of the model characteristics, including descriptions for all model parameters and variables, a list of which parameters are commonly tuned for site-specific settings, and a description of procedures and considerations for using the model in dynamic simulations, including steady state representation and limitations for model adequacy and usability in the planning and operations model software; and

(ii) The user-written model shall allow the user to determine the allocation of machine identifiers (bus numbers, bus names, machine IDs etc.) without restriction.

(b) Verification reports that support the model data based on documented field settings shall be provided as specified in the Dynamics Working Group Procedure Manual for Generation Resources, Energy Storage Resources (ESRs), and for Transmission Elements represented by a dynamic model. The reports shall demonstrate that the model parameters which are commonly tuned match site-specific settings implemented in the field. For new Generation Resources and ESRs, these reports shall be provided as required in paragraph (5) of Section 5.5, Generator Commissioning and Continuing Operations. For existing Generation Resources and ESRs, these reports shall be provided as required in paragraph (6) of Section 5.5. For Transmission Elements represented by a dynamic model, these reports shall be provided no later than two years following energization of new equipment and updated a minimum of every ten years.

(c) Results of model quality tests and associated simulation files that demonstrate acceptable performance of the models in the planning model and operations software as described in the Dynamics Working Group Procedure Manual. The Facility owner shall provide updated information whenever it provides a new or updated dynamic model to ERCOT representing a Generation Resource, ESR, or Transmission Element. These tests ensure the quality of the provided dynamic data and models for use in numerous system studies and consistency across planning and operations software platforms. Therefore, the Facility owner shall also assess sufficient sensitivities, including but not limited to Voltage Set Point at the Point of Interconnection (POI), real power output, and Reactive Power output to ensure acceptable model performance over the entire range of operating conditions. The Facility owner shall provide an explanation if model responses do not match.

(i) Facility owners shall include all site-specific dynamic models representing the Facility in the model quality tests. Facility owners can perform the tests in a simple test system without requiring ERCOT System information.

(ii) For Intermittent Renewable Resource (IRR) equipment aggregated together to form an IRR in accordance with paragraph (13) of Protocol Section 3.10.7.2, Modeling of Resources and Transmission Loads, the dynamic model shall represent the aggregated IRR.

(iii) Results for the following model quality tests shall be provided for Generation Resources, ESRs, or Transmission Elements that are not required to comply with Nodal Operating Guide Section 2.14, Advanced Grid Support Requirements for Inverter-Based ESRs, to demonstrate acceptable model performance. Additional details about each test, including the set up and description of desirable response, are included in the Dynamics Working Group Procedure Manual.

(A) Flat start test: A no-disturbance test shall be performed to demonstrate appropriate model initialization and the Facility’s dynamic response under a no-disturbance condition.

(B) Small voltage disturbance test: A voltage step increase and decrease shall be applied to the POI to demonstrate the Facility’s dynamic response.

(C) Large voltage disturbance test:

(1) For IRRs, ESRs, and inverter-based transmission equipment, the high and low voltage ride-through profiles as described in Nodal Operating Guide Section 2.9.1, Voltage Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs), Type 1 Wind-powered Generation Resources (WGRs), Type 2 WGRs, and Type 3 WGRs, shall be applied to the POI to demonstrate the Facility’s dynamic response.

(2) For Resources other than IRRs, ESRs, and inverter-based equipment, a fault shall be applied to the POI to demonstrate the Facility’s dynamic response.

(D) Small frequency disturbance test: A frequency step increase and decrease shall be applied to the POI to demonstrate the Facility’s dynamic response.

(E) System strength test: The model for IRRs and inverter-based Resources shall be tested under a few equivalent short circuit ratios, as described in the Dynamics Working Group Procedure Manual. This tests the robustness of the model to varying system conditions.

(iv) For inverter-based Energy Storage Resources (ESRs) required to comply with Nodal Operating Guide Section 2.14, results for the following model quality tests shall be provided to demonstrate acceptable model performance. Additional details about each test, including the set up and description of desirable response, are included in the Dynamics Working Group Procedure Manual.

(A) Flat start test: A no-disturbance test shall be performed to demonstrate appropriate model initialization and the Facility’s dynamic response under a no-disturbance condition.

(B) Small voltage disturbance test: A voltage step increase and decrease shall be applied to the POI to demonstrate the Facility’s dynamic response.

(C) Large voltage disturbance test: The high and low voltage ride-through profiles as described in Nodal Operating Guide Section 2.9.1, shall be applied to the POI to demonstrate the Facility’s dynamic response.

(D) Frequency change and inertia response test: A frequency change increase and decrease shall be applied to the POI to demonstrate the Facility’s dynamic response. The performance of this test will be assessed when operating within the inverter current limit.

(E) System strength test: The Facility shall be tested under multiple equivalent short circuit ratios, as described in the Dynamics Working Group Procedure Manual. This tests the robustness of the model to varying system conditions.

(F) Phase angle jump test: A step change is applied to the phase angle. This tests the capability to maintain the voltage phasor and resistance to angle change. The performance of this test will be assessed when operating within the inverter current limit.

(G) Loss of synchronous machine test: This test confirms the performance of the Facility to maintain synchronism and voltage phasor after changes occur on the ERCOT System. This test is not intended to require the Facility to operate reliably without connecting to the ERCOT Transmission Grid.

(d) Inverter-Based Resources (IBRs) shall provide results of the unit model validation to demonstrate that the PSCAD model, as described in the Dynamics Working Group Procedure Manual, accurately represents the dynamic responses of all inverter-based dynamic devices within the Facility. This validation is not intended to be site-specific; rather it is intended to be a hardware type test, where models representing different inverter hardware are benchmarked for accuracy. Validation results for a specific model of inverter can be submitted for multiple uses of that model of inverter.

(i) The validation results shall be included when submitting a PSCAD model to ERCOT.

(ii) Results for the following unit model validation tests shall be provided to demonstrate model accuracy. Additional details about each test are included in the Dynamics Working Group Procedure Manual.

(A) Step change in voltage;

(B) Large voltage disturbance (voltage ride-through tests);

(C) System strength test;

(D) Phase angle jump test; and

(E) Subsynchronous test.

(6) Dynamics data for a planned Facility will be updated by the Facility owner upon completion of the design for the Facility.

(7) Updated dynamics data for an existing Facility shall be provided to ERCOT when field tests, inspections, or other information demonstrates that the dynamics data should be changed to accurately represent the dynamic characteristics of the Facility.

(8) Dynamics Data is considered Protected Information pursuant to Protocol Section 1.3, Confidentiality.

(9) Dynamics data shall be provided with the legal authority to provide the information to all TSPs. If any of the information is considered Protected Information, the Facility owner shall indicate as such.