NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Standard Authorization Request (SAR)

Complete and submit this form, with attachment(s) to the NERC Help Desk. Upon entering the Captcha, please type in your contact information, and attach the SAR to your ticket. Once submitted, you will receive a confirmation number which you can use to track your request.

The North American Electric Reliability Corporation (NERC) welcomes suggestions to improve the reliability of the bulk power system through improved Reliability Standards.

Requested information			
SAR Title:	EMT Models in NERC MOD, TPL, and FAC Standards		
Date Submitted:	June 8, 2022		
SAR Requester			
Name:	Allen Schriver, NextEra Energy (NERC IRPS Chair) Julia Matevosyan, ESIG (NERC IRPS Vice Chair)		
Organization:	NERC Inverter-Based Resource Performance Subcommittee (IRPS)		
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SAR Type (Check as many as apply)			
☒ New Standard ☒ Revision to Existing Standard ☐ Add, Modify or Retire a Glossary Term ☐ Withdraw/retire an Existing Standard		☐ Imminent Action/ Confidential Issue (SPM Section 10) ☐ Variance development or revision ☐ Other (Please specify)	
Justification for this proposed standard development project (Check all that apply to help NERC prioritize development)			
☐ Regulatory Initiation ☐ Emerging Risk (Reliability Issues Steering Committee) Identified ☐ Reliability Standard Development Plan		☒ NERC Standing Committee Identified ☐ Enhanced Periodic Review Initiated ☒ Industry Stakeholder Identified	
Industry Need (What Bulk Electric System (BES) reliability benefit does the proposed project provide?):			
The bulk power system (BPS) in North America is undergoing a rapid transformation towards high penetrations of inverter-based resources. Transmission Planners (TP) and Planning Coordinators (PC) are concerned about the lack of accurate modeling data and the need to perform electromagnetic transient (EMT) studies during the interconnection process and long-term planning horizon. The growth of inverter technology has pushed conventional planning tools to their limits in many ways, and TPs and PCs are now faced with the need to conduct more detailed studies using EMT models for issues related to inverter-based resource integration issues. This SAR proposes including EMT models and studies in planning-related NERC Standards to ensure reliable operation of the BPS moving forward. See attached supporting paper for more details.			

Requested information
Purpose or Goal (How does this proposed project provide the reliability-related benefit described above?):
This project addresses the reliability-related need and benefit by ensuring TPs and PCs have accurate models necessary to adequately conduct reliability assessments under increasing levels of inverter-based resources. This requires the collection of EMT models by applicable entities and TPs and PCs to conduct EMT studies where needed. Furthermore, this proposed project addresses reliability issues identified in the NERC disturbance reports by accomplishing the following: • Ensuring that the interconnection study process is clear on the modeling and study requirements needed to ensure reliable operation of the BPS, inclusive of EMT modeling and studies (NERC FAC-002). • Ensuring that EMT models are available to TPs and PCs for the purposes of reliability studies – interconnection studies per FAC-002 and planning assessments per TPL-001 (using MOD-032 as the modeling data standard, or a new standard if deemed necessary) • Ensuring that model quality issues are addressed both during interconnection studies (FAC-002) and during annual case creation and planning assessments (MOD-032/TPL-001) • Ensuring that EMT studies are conducted by TPs and PCs during the interconnection study process (FAC-002) and during annual planning assessments (TPL-001) if the TP or PC identifies a reliability need to conduct these studies (i.e., on an as-needed basis with technical justification).
Project Scope (Define the parameters of the proposed project):
This project will modify three existing NERC Standards – FAC-002, MOD-032, and TPL-001. The scope of the project is to modify NERC standards to 1) include specific requirements for EMT modeling and EMT studies, where needed, and 2) ensure accurate models are provided by applicable entities and corrections to modeling errors are addressed in a timely manner.
-Detailed Description (Describe the proposed deliverable(s) with sufficient detail for a drafting team to execute the project. If you propose a new or substantially revised Reliability Standard or definition, provide: (1) a technical justification[1] which includes a discussion of the reliability-related benefits of developing a new or revised Reliability Standard or definition, and (2) a technical foundation document (*e.g.,* research paper) to guide development of the Standard or definition):
The proposed project will produce three deliverables – modifications to FAC-002, modifications to MOD-032 (or a new standard related to EMT model collection), and modifications to TPL-001. Modifications to each standard seek to (1) incorporate EMT modeling and studies, as applicable, and (2) include model quality checks for all models used in reliability studies. The proposed modifications for each standard include the following: • NERC FAC-002 Enhancements:

[1] The NERC Rules of Procedure require a technical justification for new or substantially revised Reliability Standards. Please attach pertinent information to this form before submittal to NERC.

Requested information

- **TP and PC Conduct EMT Studies Where Necessary:** Modify the standard to include studies involving EMT models, where necessary, as part of the interconnection study process. The drafting team may consider adding a statement in Requirement R1.3 to include EMT studies.
- **Ensure Accurate Models are Provided and Verified Prior to Commercial Operation:** Include a requirement that the TP and PC have a process to verify (i.e., sign off) that the models used in FAC-002 interconnection studies are a reasonable representation of the plant being commissioned prior to commercial operation. This verification should focus on, at a minimum, the following:
  - Converter-level[2] control modes, settings, and protections
  - Plant-level control modes and settings
  - Applicable facility protection systems

  This verification should be conducted at the time of plant commissioning or during trial operations. The requirement should state that corrective actions be implemented to ensure the models used in studies match the actual plant configuration, equipment, and settings. Proof of accuracy for EMT and positive sequence models should be provided for the type of phenomena these models will be used to assess, including large disturbances (faults), control behavior and interactions, etc. The GO shall provide sufficient documentation to ensure control modes, settings, and protections, and performance match between the model and the installed equipment. Discrepancies between models or validation results throughout the interconnection process may require re-studies by the TP to ensure reliable operation prior to commercial operation and may be subject to any operational constraints by the Transmission Operator (TOP) and Reliability Coordinator (RC) until the facility can be operated in a planned and studied operating state.
- **Clarify Requirements on Applicable Entities Providing Accurate Models:** Clarify existing requirements that use vague terms like "coordinate and cooperate" to more explicitly state that the applicable entities will provide accurate models meeting the TP and PC modeling requirements (including model quality specifications), and that any modifications to equipment or settings during the interconnection study process shall be communicated to the TP and PC for determination if any additional reliability studies are necessary.

- NERC MOD-032 Enhancements:
  - ***NOTE*:** The IRPS believes that these enhancements could be made either from modifications to MOD-032 or by introducing a new NERC Standard specifically focused on gathering EMT models and modeling data for the purposes of reliability studies. The team generally believes that concepts of Requirement R1 and Attachment 1 are applicable for EMT modeling/studies; however, the development of interconnection-

[2] Converter is used here rather than inverter to also include possible controls and protections in hybrid plants that may utilize dc/dc converters.

Requested information

wide cases to the MOD-032 Designee and annual case creation process may not be applicable for EMT studies.

- **Explicit Inclusion of EMT Models:** Modify standard requirements, where applicable, to replace "dynamics" and differentiate between EMT and RMS fundamental frequency positive sequence models. Modify Attachment 1 of the standard to explicitly include EMT modeling requirements, where necessary, and include specific details relevant for EMT studies. Include sufficient detail in the table such that TPs and PCs conducting EMT studies can ensure they are able to gather sufficient modeling information from applicable entities. BPS elements that the TP and PC need to gather modeling information for may include, at a minimum:
  - Transmission elements, including transmission-connected reactive devices (SVCs, STATCOMs, etc.)
  - Generating resources, both inverter-based (converter controls, plant-level controller controls, and any other applicable control systems) and synchronous
  - HVDC circuits
  - Other information requested by the PC or TP necessary for modeling purposes
- **Process for Collection of EMT Models and Modeling Data:** Ensure that the standard clearly states that the TP and PC should have a clearly documented process for determining when EMT models and modeling data shall be required from applicable entities. EMT models are not necessarily required in all instances from all entities. However, if and when the TP and PC require EMT models and data to conduct EMT studies, they shall have the authority to gather EMT models from applicable entities for the purposes of performing reliability studies. The TP and PC should use MOD-032 to gather data to create localized or regional models or base cases for reliability studies; the intent is not to create a requirement for interconnection-wide EMT models unless the TP and PC have a reliability need to do so (i.e., can be specified per Requirement R1 as part of the TP and PC modeling requirements and reporting procedures).
- **Model Quality Enhancements:** Modify standards requirements to more clearly and explicitly specify that all models, including EMT, are accurate and represent the equipment installed in the field. Any modeling deficiencies should be identified by the TP and PC and addressed by the applicable entity in a timely manner. Model quality should be assessed by the TP and PC during the annual case creation process to ensure models are accurate for use in reliability studies. Presently the standard provides an option for the TP and PC to consider, but does not require entities to ensure model quality as part of the process.

- NERC TPL-001 Enhancements:
  - **Differentiate Stability Portions:** Modify the stability portions of the standard (e.g., Requirements R2 and R4) to more clearly and accurately differentiate between studies using EMT models and studies using RMS fundamental frequency positive sequence models. Ensure that all standard requirements, Table 1, and Attachments are clear in this regard.

Requested information
○ **Process for Conducting EMT Studies:** Include a requirement that the TP and PC shall develop a process for determining when detailed studies using EMT models are requirements such that those studies are done in specific and limited scenarios where they are necessary. TPs and PCs shall then perform EMT studies for situations that meet the rationale. This will require gathering suitable models, per MOD-032 and determining appropriate study assumptions, contingency events, etc. Study requirements and assumptions should be specified in TPL-001, to the extent possible. ○ **Appropriate Stability Criteria:** Modify Requirements R5 and R6 to ensure that stability criteria for inverter-based resources is clear, consistent, and appropriate for both EMT and RMS fundamental frequency positive sequence simulations. If additional stability criteria should be specified for EMT studies, then the drafting team should ensure that the criteria is appropriate and applicable for the different studies. The requirements shall also be enhanced to clearly state that the TP and PC shall develop corrective action plans when the instabilities are identified, applicable and clear for inverter-based resources in addition to synchronous generation (both in EMT and RMS fundamental frequency positive sequence simulations). The standards revisions will apply to TPs and PCs as they conduct interconnection studies and planning assessments, TOs that may need to supply EMT models for the transmission network, and GOs as they provide accurate generator modeling information to the TP/PC for studies. FAC-002 presently applies implicitly to the developers of new facilities (since the TP/PC have a study process for studying new resources prior to interconnection); this SAR does not seek to change existing applicability of any standards, only strengthen and improve requirements to address known reliability gaps. The inclusion of EMT modeling requirements apply to generating resources (inverter-based and synchronous), synchronous condensers, transmission-connected dynamic reactive devices (e.g., STATCOMs, SVCs, etc.), transmission elements, and any other elements necessary for reliability study purposes. Models of all BPS elements in the areas for which an EMT study is required are needed to create an accurate network model to study possible reliability risks. See supporting paper for more details. The attached supporting paper provides a list of reference materials and documentation that serve as a strong technical basis for these changes to the NERC Standards. Most notably, the Odessa disturbance report (2021) and CA disturbance report (2022) strongly emphasize enhancements to the NERC Standards and specifically focus on inclusion of accurate and reliable EMT models (in addition to accurate and reliable positive sequence models) and updates to address model quality for reliability studies.
Cost Impact Assessment, if known (Provide a paragraph describing the potential cost impacts associated with the proposed project):
Exact costs for this project are unknown. Near-term costs are likely to increase as industry develops practices around development, collection, and use of EMT models for reliability studies; however, the team believes that long-term costs will likely be minor as industry is already expanding necessary skills and expertise in this area across many areas of the world. OEMs are developing real-code models,

Requested information
generator owners are gaining familiarity with existing EMT modeling requirements, and transmission planners are gaining experience conducting or managing EMT studies. Generation and transmission entities will likely experience up-front and ongoing costs in areas where EMT studies are becoming increasingly necessary from a grid reliability standpoint. These costs are recognized; however, the team has made a focused and concerted effort to minimize costs while achieving necessary reliability outcomes for this project. Outcomes from this project to ensure an adequate level of reliability for the BES significantly outweigh the incremental costs of implementation from this proposed project.
Please describe any unique characteristics of the BES facilities that may be impacted by this proposed standard development project (*e.g.*, Dispersed Generation Resources):
No BES facilities will be directly impacted by the proposed standard modifications. Asset owners of BES facilities (GOs, TOs) will be required to provide EMT models, where applicable, and ensure model quality of the models submitted to the TP and PC. The TP and PC will be required to verify model quality and perform EMT studies using these models, as needed for reliability purposes.
To assist the NERC Standards Committee in appointing a drafting team with the appropriate members, please indicate to which Functional Entities the proposed standard(s) should apply (*e.g.*, Transmission Operator, Reliability Coordinator, etc. See the most recent version of the NERC Functional Model for definitions):
Transmission Owners, Transmission Planners, Planning Coordinators, Generator Owners, equipment manufacturers, consultants conducting EMT studies, and any other EMT modeling and studies experts
Do you know of any consensus building activities[3] in connection with this SAR? If so, please provide any recommendations or findings resulting from the consensus building activity.
This SAR was developed by the NERC IRPS, a large group of industry experts focused specifically on ensuring reliable operation of the BPS under increasing penetrations of BPS-connected inverter-based resources. This SAR was also endorsed by the NERC RSTC.
Are there any related standards or SARs that should be assessed for impact as a result of this proposed project? If so, which standard(s) or project number(s)?
Project 2020-06 *Verification of Models and Data for Generators* is focused on validation of models, inclusive of positive sequence dynamic models and EMT models. This SAR is recommending that model verification and submittal by the GO (and model quality checks by the TP) occurs prior to commercial operation; whereas the existing MOD-026 and MOD-027 standards allow for a time period (e.g., 1 year) after commercial operation to correct model errors. However, this can lead to reliability issues not being identified during interconnection studies. Therefore, Project 2020-06 should consider the recommendations in this SAR and these efforts can be aligned for both projects. If that project is completed by the time a new SAR Drafting Team is stood up for this proposed project, then the new Standard Drafting Team could help ensure alignment. These efforts are in alignment and complement

[3] Consensus building activities are occasionally conducted by NERC and/or project review teams. They typically are conducted to obtain industry inputs prior to proposing any standard development project to revise, or develop a standard or definition.

Requested information
each other. This SAR is not seeking to change any NERC Glossary Terms and therefore will not affect any other standards in this manner.
Are there alternatives (e.g., guidelines, white paper, alerts, etc.) that have been considered or could meet the objectives? If so, please list the alternatives.
NERC has published a number of disturbance reports highlighting the need for these changes to be made to NERC Standards. NERC has also published modeling-related Alerts for inverter-based resources to raise industry awareness of ongoing modeling challenges. NERC IRPS has also published numerous guidelines, technical reports, white papers, etc. to help educate industry and recommend best practices. However, the recommendations are not sufficient to ensure accurate EMT studies are conducted for ensuring BES reliability with increasing levels of inverter-based resources.

Reliability Principles	
Does this proposed standard development project support at least one of the following Reliability Principles (Reliability Interface Principles)? Please check all those that apply.	
☒	1. Interconnected bulk power systems shall be planned and operated in a coordinated manner to perform reliably under normal and abnormal conditions as defined in the NERC Standards.
☐	2. The frequency and voltage of interconnected bulk power systems shall be controlled within defined limits through the balancing of real and reactive power supply and demand.
☒	3. Information necessary for the planning and operation of interconnected bulk power systems shall be made available to those entities responsible for planning and operating the systems reliably.
☐	4. Plans for emergency operation and system restoration of interconnected bulk power systems shall be developed, coordinated, maintained and implemented.
☐	5. Facilities for communication, monitoring and control shall be provided, used and maintained for the reliability of interconnected bulk power systems.
☐	6. Personnel responsible for planning and operating interconnected bulk power systems shall be trained, qualified, and have the responsibility and authority to implement actions.
☐	7. The security of the interconnected bulk power systems shall be assessed, monitored and maintained on a wide area basis.
☐	8. Bulk power systems shall be protected from malicious physical or cyber attacks.

Market Interface Principles	
Does the proposed standard development project comply with all of the following Market Interface Principles?	Enter (yes/no)
1. A reliability standard shall not give any market participant an unfair competitive advantage.	Yes
2. A reliability standard shall neither mandate nor prohibit any specific market structure.	Yes
3. A reliability standard shall not preclude market solutions to achieving compliance with that standard.	Yes

Market Interface Principles	
4. A reliability standard shall not require the public disclosure of commercially sensitive information. All market participants shall have equal opportunity to access commercially non-sensitive information that is required for compliance with reliability standards.	Yes

Identified Existing or Potential Regional or Interconnection Variances	
Region(s)/ Interconnection	Explanation
None	None

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SAR Status Tracking (Check off as appropriate).	
☐ Draft SAR reviewed by NERC Staff ☐ Draft SAR presented to SC for acceptance ☐ DRAFT SAR approved for posting by the SC	☐ Final SAR endorsed by the SC ☐ SAR assigned a Standards Project by NERC ☐ SAR denied or proposed as Guidance document

Version History

Version	Date	Owner	Change Tracking
1	June 3, 2013		Revised
1	August 29, 2014	Standards Information Staff	Updated template
2	January 18, 2017	Standards Information Staff	Revised
2	June 28, 2017	Standards Information Staff	Updated template
3	February 22, 2019	Standards Information Staff	Added instructions to submit via Help Desk
4	February 25, 2020	Standards Information Staff	Updated template footer