

NERC

NORTH AMERICAN ELECTRIC
RELIABILITY CORPORATION

ERO Approved Criteria for Acceptable Models

Project 2022-02 Uniform Modeling Framework
for IBR

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RELIABILITY | RESILIENCE | SECURITY



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Executive Summary

The Criteria for Acceptable Models defines criteria for model submissions under the MOD-032, TOP-003, and IRO-010 Reliability Standards. Models that are submitted for development of planning horizon cases necessary to support analysis of the reliability of the interconnected transmission system shall meet requirements in this document.

Disclaimers

Interconnection-wide modeling requirements may differ from the requirements of specialized studies dedicated to a particular technical objective. NERC's Criteria for Acceptable Models applies to the models where NERC Reliability Standards require its use (generally for planning and operation models where multiple entities share information beyond their portion of the electric System, which includes interconnection-wide models).

Operations models shall meet the requirements in this document, provided that models for operations shall not reduce the ability of a Registered Entity to perform their Operational Planning Analyses and Real-Time Assessments (RTAs) in a timely manner. Thus, models deemed acceptable for planning purposes may be deemed unacceptable by a receiving entity for certain operations applications.

Chapter 1: Process

Updates to the Criteria for Acceptable Models

This section describes the process by which changes may be made to the Criteria for Acceptable Models or the revision processes in this document, excluding changes to the Unacceptable Models List which will be addressed in the following section.

- 1) Any person or entity may submit a request to the ERO to revise the Criteria for Acceptable Models. This request shall include, at a minimum:
 - a. Description of the suggested revision;
 - b. Technical justification for the suggested revision;
 - c. Supporting documentation; and
 - d. Identification of any Confidential Information as defined in Section 1500 of the NERC Rules of Procedure.
- 2) ERO staff shall review and evaluate the Criteria for Acceptable Models revision request, along with any group or subcommittee of the NERC Reliability and Security Technical Committee (RSTC) or its successor charged with assisting in such reviews. If no such group or subcommittee has been identified, ERO staff may work with other industry subject matter experts as needed to review and evaluate the request.
- 3) As part of the review process, ERO staff shall conduct a 45-day public comment period on the proposed revision request.
- 4) The proposed revision request, along with the results of the review, the comments received, a summary consideration of comments, and the recommended action, shall be presented to the NERC RSTC or its successor in a duly noticed public meeting.
- 5) The NERC RSTC may recommend the NERC Board of Trustees approve the revision request, reject the revision request, or remand the revision request for further work. If the NERC RSTC recommends approving the revision request, the NERC RSTC shall also recommend an effective date for the revision.
- 6) The NERC Board of Trustees, considering the recommendation of the NERC RSTC, shall approve the revision request, reject the revision request, or approve the revision request with modifications. If approved, the NERC Board of Trustees shall also approve an effective date for the revision.
- 7) The ERO shall provide public notice of a revision to the Criteria for Acceptable Models along with the effective date of the revision. The revised Criteria for Acceptable Models shall be posted to the NERC website and filed with FERC for informational purposes.

Updates to the Unacceptable Models List

This section describes the process by which changes may be made to the Unacceptable Models List. The following steps shall be taken to add, remove, or modify a model to the Unacceptable Models List:

- 1) Any person or entity may submit a request to the ERO to add or remove a model from the Unacceptable Models List. This request shall include, at a minimum:
 - a. The model name;

- b. Alternative model name(s), if any;
 - c. Organization(s) the submitting entity represents;
 - d. Description of the model's stated intent;
 - e. Request to add model as an "unacceptable" model or remove model as an "unacceptable" model;
 - f. Technical supporting documentation that includes the ability of the model to meet or not meet small and large disturbance behavior;
 - g. Identification of any Confidential Information as defined in Section 1500 of the NERC Rules of Procedure; and
 - h. An explanation, if any of the above technical support items are unavailable to the supporting entity.
- 2) ERO staff shall review and evaluate the information in the Unacceptable Models List change request, along with any group or subcommittee of the NERC RSTC or its successor charged with assisting in such reviews. If no such group or subcommittee has been identified, ERO staff may work with other industry subject matter experts as needed to review and evaluate the request.
 - 3) If the request is seeking to add a model to the Unacceptable Models List, ERO staff shall provide public notice that identifies the model being considered for addition to the list, includes a non-confidential summary of the rationale offered for its inclusion, and provides at least 30 days to submit comments.
 - 4) The results of this review and the recommended action shall be presented to the NERC RSTC or its successor in a duly noticed public meeting.
 - 5) The NERC RSTC may recommend the NERC Vice President of Engineering and Standards¹ approve the change request, reject the change request, or remand the application back to the ERO to work with the submitting entity. If the NERC RSTC recommends approving the change request, the NERC RSTC shall also recommend an effective date for the change.
 - 6) The NERC Vice President of Engineering and Standards, considering the recommendation of the NERC RSTC, shall approve the change request, reject the change request, or remand the application back to ERO staff to work with the submitting entity. If approved, the NERC Vice President of Engineering and Standards shall also determine the effective date for the change.
 - 7) The ERO shall provide public notice of a change to the Unacceptable Models List included in this Approved Criteria for Acceptable Models along with the effective date of the change. The revised document shall be posted to the NERC website and filed with FERC for informational purposes.
 - 8) Technical Rationale for each model added to the Unacceptable Models List shall be retained by the ERO for as long as practicable, but no fewer than five (5) years from the date a model is added to the list.

¹ This may include an equivalent NERC officer if by a different title, or their designee.

Chapter 2: ERO Approved Criteria

Planning Models

Models that are submitted for development of planning horizon cases necessary to support analysis of the reliability of the interconnected transmission system shall qualify with the following:

- 1) All models shall be representative of expected or as-built facilities.
- 2) All models shall be usable (see usability requirements below).
- 3) All standard library models are deemed acceptable until demonstrated to not meet usability requirements and/or demonstrated to be unable to represent the expected or as-built facilities.²
- 4) Models listed on the Unacceptable Model List shall not be used unless it is demonstrated that such a model represents the expected or as-built facilities with negligible error(s) in both small signal and large disturbance behavior and does not introduce numerical instability in the software used by TPs or PCs. In these cases, the model submitting entity may submit a request to update the Unacceptable Model List. A model may be used pending the disposition of the request.

Operational Models

Models that are submitted for development of operation cases necessary to support analysis of the reliability of the interconnected transmission system shall qualify with the following:

- 1) All models shall be representative of expected or as-built facilities.
- 2) All models shall be usable (see usability requirements below).
- 3) All standard library models are deemed acceptable until demonstrated to not meet usability requirements and/or demonstrated to be unable to represent the expected or as-built facilities.³
- 4) Models listed on the Unacceptable Model List shall not be used unless it is demonstrated that such a model represents the expected or as-built facilities with negligible error(s) in both small signal and large disturbance behavior and does not introduce numerical instability in the software used by TPs or PCs. In these cases, the model submitting entity may submit a request to update the Unacceptable Model List. A model may be used pending the disposition of the request.
- 5) Models shall not reduce the viability of a Registered Entity's ability to perform their OPAs and RTAs in a timely manner.

Usability Requirements

Models that are used for representation of generation and system components shall have sufficient documentation for the user of the model to understand its parameters, states, and outputs into the simulation software. Usable models are those models that include, at a minimum, the following:

- 1) A model manual, or other documentation, with a description of all model parameters, variables, and states. The manual or other documentation shall also describe the range of validity of the model and valid use cases or studies for which the model has sufficient fidelity.
- 2) A procedure to use and initialize the model in dynamic simulations, including alterations to the steady-state representation.

² Poor model quality may stem from poor parameterization and/or poor implementation of a model from code. Poor parameterization or poor implementation of a particular model shall not be used to generalize a model's designation in the Unacceptable Model List.

³ Poor model quality may stem from poor parameterization and/or poor implementation of a model from code. Poor parameterization or poor implementation of a particular model shall not be used to generalize a model's designation in the Unacceptable Model List.

- 3) Disclaimer(s) on the usability of the model for known model software or simulation domains.
- 4) An explanation of the model's adequacy to represent small and large disturbance behavior.
- 5) A list of commonly tuned parameters to align the model to site-specific settings as well as allowable tuning ranges for these parameters.

Chapter 3: Unacceptable Models List

Models that have been identified as unacceptable as list in Table 1 below. Revisions to this list may be made in accordance with the process described in “Updates to the Unacceptable Models List” above.

Table 1: Unacceptable Model List	
Known Unacceptable Model Name	Model Description
Renewable Energy Models	
WT3G1, WT3G2, wt3g	Generic Type 3 WTG Generator/Converter Model - Doubly-fed induction generator
WT4G1, WT4G2, wt4g	Generic Type 4 WTG Generator/Converter Model - Variable speed generator with full converter
WT3E1, wt3e	Generic Type 3 WTG Electrical Control Model
WT4E1, WT4E2, wt4e	Generic Type 4 WTG Electrical Control Model
WT3T1, wt3t	Generic Type 3 WTG Turbine Model
WT3P1, wt3p	Generic Type 3 WTG Pitch Control Model
WT12A1, wt1p, wt2p	Generic Type 1 and 2 WTG Pitch Control Model
WT4E1, wt4t	Generic Type 4 WTG Power Converter Model
wt4p	Generic Type 4 Pitch Control Model
REECB1, REECBU1, reec_b	Generic Phase 2 PV Electrical Controls Model
Machine Models	
GENSAL, gensal	Salient Pole Generator Model (IEEE Std 1110 §5.3.1 Model 2.1)
GENCLS, gencls	Classical Generator Model (IEEE Std 1110 §5.4.2)
GENTRA	Transient Level Generator Model
Excitation System Models	
texs	General Purpose Transformer Fed Excitation System
SEXS, seks	Simplified Excitation System
EX2000	GE EX2000 Excitation System
Turbine-Governor Models	
lm2500	LM 2500 Aero-Derivative Gas Turbine Governor Model
lm6000	LM 6000 Aero-Derivative Gas Turbine Governor Model
URGS3T, gast	WECC Gas Turbine Governor Model
GAST	Gas Turbine-Governor Model
GAST2A	Gas Turbine-Governor Model
GASTWD	Gas turbine-governor
IEEEG2	1981 IEEE Type 2 General Approx. Linear Ideal Hydro Model
WESGOV	Westinghouse Digital Governor Model for Gas Turbines
Load Models	
motorc	Phasor Model of Single-Phase Air-Conditioner Compressor Motor

Chapter 4: Form Revisions

This form is a sample to explain what is deemed a full application to change a model designation in the NERC Approved Model Criteria for Acceptable Models List.

Name of Person submitting			
Organization(s):			
Sector (if known)			
Telephone		Email	

Model Name	
Alternative Model Name(s) as implemented in software	
Equipment Model is stated to represent	
Indicate desired Action	☐ Add “model to the Unacceptable Models List, Section X of the Approved Model Criteria for Acceptable Models ☐ Remove model from the Unacceptable Models List, Section X of the Approved Model Criteria for Acceptable Models

Description of model ability to meet small signal Disturbances	
Description of model ability to meet large signal Disturbances	
Please cite and link any industry approved documentation regarding this model’s small and large signal disturbances	
Describe the technical document attachments that support the above questions	
Please identify any information in this application that may meet the criteria for Confidential Information, as defined in Section 1500 of the NERC Rules of Procedure.	

Section 4: Process Tracking	
Date Submitted to ERO	
Model Status	☐ Submitted to the ERO ☐ Assigned ERO Review team ☐ Investigation and review by ERO and submitting entity ☐ Remanded by NERC RSTC (or its successor) ☐ Approved by the NERC RSTC (or its successor)
Date of Approval	
Date of Model Notice to Industry	

Attachments:

If available, please include at least one report that demonstrates the ability or inability of the model to meet its stated purpose using Hardware-in-the-Loop, Software-in-the-Loop, or actual System response (e.g., in a commissioning test) that demonstrates the ability or inability to meet the model's stated purpose. At least one attachment should detail the model's error boundaries to represent its stated equipment with the test description and procedure outlined in that report. Entities shall label any attachment that may meet the criteria for Confidential Information under NERC Rules of Procedure Section 1500, along with the basis for the designation (e.g., Confidential Business and Market Information, Critical Electric Infrastructure Information, etc.). If any of this information is not available to the supporting entity, please provide an explanation.

Chapter 5: Technical Rationale

FERC Order No. 901

This document addresses directives within Federal Energy Regulatory Commission (FERC) Order No. 901 outlining the need to use industry approved models. Pre-defining a limited set of models (i.e., a library of models) that could be used to represent generation and system components is potentially at odds with objectives to also have accurate models, especially as technology rapidly progresses. Thus, instead of specifying a limited model library, this document provides acceptability criteria for models representing generation and system components. This document is based on the *NERC Dynamic Modeling Recommendations*⁴ but is standalone. Entities are encouraged to review the *NERC Dynamic Modeling Recommendations* for further consideration and technical background for this Criteria for Acceptable Models.

Operational Models

Transmission Operators (TOPs), Reliability Coordinators (RCs), and Balancing Authorities (BAs) are required to have a “documented specification for the data necessary” to perform Operational Planning Analysis (OPA), Real-Time Assessment (RTA), and Real-time Monitoring. This data specification is then distributed by the TOP, RC, and BA to entities to fulfil the data requirements and such entities provide the data in mutually agreeable format, security protocol, and process for resolving data conflicts. FERC Order No. 901 has identified that the transient dynamic performance of Inverter-based Resources (IBRs) is underrepresented in these models. However, many OPAs and RTAs do not perform a transient dynamic simulation for all credible Contingencies due to computational time constraints. As such, models for operations shall meet the same criteria for models for planning. Thus, models deemed acceptable for planning purposes may be deemed unacceptable by a receiving entity for certain operations applications.

Unacceptable Model List

As models have evolved and been implemented in software, some models have been proven to contain modeling errors, numerical issues, insufficient technical documentation, or have been phased out of use by the owners of the equipment due to the availability of better models. The unacceptable list of models shown in Table 1 below is categorized by the type of model, and as of publication, includes only PSPD models. Revisions to this list may be made in accordance with the process described in the “Updates to the Unacceptable Models List” above.

Usability Requirements

In current planning model software, most standard library models come with a list of parameters, their description, initial values, and the appropriate disclaimers. In these cases, references to the program’s application manual suffices for usability requirements 1 through 3.

In addition to the content usability requirements above, any identified inability of a model to function properly within a System Model may cause a model to be deemed unacceptable until the issue is addressed and eliminated. Such software usability issues include, but are not limited to:

- 1) Models that restrict user selection of the machine unique identifiers (e.g., number, name, ID) beyond the inherent software limitations.
- 2) Models that fail to robustly initialize under reasonable initial conditions.
- 3) Models that cause simulation crashes or conflict with other models in a system simulation, including other instances of the same model.
- 4) Models that require unique folder structures that are incompatible with System Model development.
- 5) Models that cause numerical instability or simulation solution challenges.

⁴ Available here: <https://www.nerc.com/pa/RAPA/ModelAssessment/Documents/Dynamic%20Modeling%20Recommendations.pdf>

Criteria Checklist Guideline

If all the checkboxes below can be attested to with evidence that the model meets these criteria, then the model at the date of delivery is deemed acceptable in accordance with this ERO Approved Criteria for Acceptable Models.

- ☐ The model name and description is not listed in the Unacceptable Model portion of the ERO Approved Criteria for Acceptable Models.
- ☐ The model is accompanied by a manual with descriptions of all model parameters, variables, and states.
- ☐ The model manual describes the range of validity of the model and valid use cases or studies for which the model has sufficient fidelity.
- ☐ The model is accompanied by a list of commonly tuned parameters for site-specific settings.
- ☐ The model is accompanied by a procedure to use and initialize the model in dynamic simulation.
- ☐ The model accompanied by an explanation of the model's adequacy to meet small and large disturbance behavior.
- ☐ The model does not place restrictions on unique identifiers (e.g., number, name, ID) used in simulation software.
- ☐ The model initializes robustly for all reasonable initial conditions and does not cause simulation crashes.
- ☐ The model does not require unique and burdensome folder structures that are incompatible with System Model development.
- ☐ The model does not cause numerical instability or simulation solution challenges.

Chapter 6: Version History

Version	Date	Action	Change Tracking
1	April 2025	Draft 1 Posting for Project 2022-02	Initial Draft