NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

MOD-032 Case Improvement Tracking

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RELIABILITY | ACCOUNTABILITY




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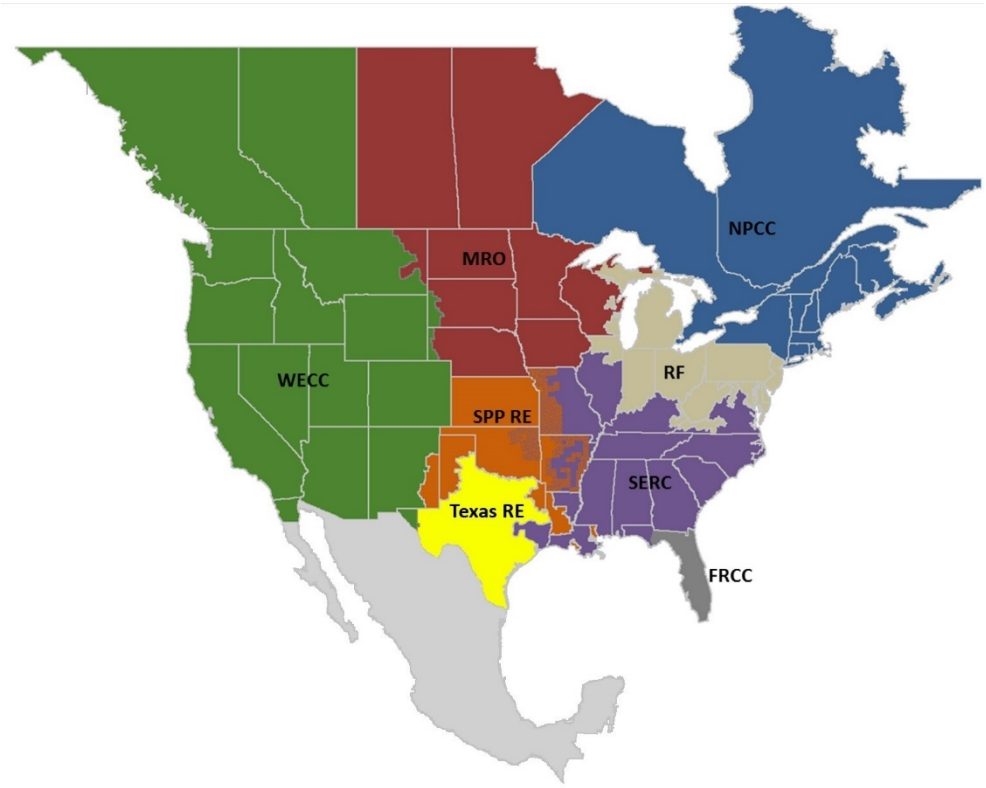
Table of Contents

Preface

The North American Electric Reliability Corporation (NERC) is a not-for-profit international regulatory authority whose mission is to assure the reliability and security of the bulk power system (BPS) in North America. NERC develops and enforces Reliability Standards; annually assesses seasonal and long-term reliability; monitors the BPS through system awareness; and educates, trains, and certifies industry personnel. NERC's area of responsibility spans the continental United States, Canada, and the northern portion of Baja California, Mexico. NERC is the Electric Reliability Organization (ERO) for North America, subject to oversight by the Federal Energy Regulatory Commission (FERC) and governmental authorities in Canada. NERC's jurisdiction includes users, owners, and operators of the BPS, which serves more than 334 million people.

The North American BPS is divided into eight Regional Entity (RE) boundaries as shown in the map and corresponding table below.



The North American BPS is divided into eight RE boundaries. The highlighted areas denote overlap as some load-serving entities participate in one Region while associated transmission owners/operators participate in another.

FRCC	Florida Reliability Coordinating Council
MRO	Midwest Reliability Organization
NPCC	Northeast Power Coordinating Council
RF	ReliabilityFirst
SERC	SERC Reliability Corporation
SPP RE	Southwest Power Pool Regional Entity
Texas RE	Texas Reliability Entity
WECC	Western Electricity Coordinating Council

Purpose and Introduction

Background

MOD-032-1 seeks to "establish consistent modeling data requirements and reporting procedures for development of planning horizon cases necessary to support analysis of the reliability of the interconnected transmission system." Requirement R4 of MOD-032-1 states:

"Each Planning Coordinator shall make available models for its planning area reflecting data provided to it under Requirement R2 to the Electric Reliability Organization (ERO) or its designee to support creation of the Interconnection-wide case(s) that includes the Planning Coordinator's planning area."

NERC, as the ERO, has designated the Regional Entities ("MOD-032 Designees") as the interconnection-wide, base model creators referred to in Requirement R4 of MOD-032-1. These entities include:

- **Eastern Interconnection:** Florida Reliability Coordinating Council (FRCC), Midwest Reliability Organization (MRO), Northeast Power Coordinating Council, Inc. (NPCC), ReliabilityFirst Corporation (RF), SERC Reliability Corporation (SERC), and Southwest Power Pool Regional Entity (SPP), acting collectively through the Eastern Interconnection Reliability Assessment Group (ERAG)
- **Texas Interconnection:** Texas Reliability Entity, Inc. (TRE)
- **Western Interconnection:** Western Electricity Coordinating Council (WECC)

The MOD-032 Designees support the creation of the interconnection-wide powerflow and dynamics cases, and the agreements put in place between the ERO and those listed above will continue so long as the MOD-032 Designees continue to demonstrate, to NERC's satisfaction, the Designee Functions and Attributes included in Attachment A of the MOD-032 Designee Agreements. In Attachment A, the following functions and attributes[1] are of specific interest for developing a feedback loop to improve the quality and fidelity of the interconnection-wide powerflow and dynamics cases:

1. Designees shall develop and maintain a case creation manual for their interconnection, including the process by which the designated cases will be assembled, tested for quality, and tested for case fidelity (in alignment with ERO Metrics).
2. Designees shall develop a feed-back process including the Planning Coordinators of the interconnection and their constituent equipment owners and operators to prevent recurring data or models problems found during case creation or quality and validation testing.
3. Designees shall direct the Planning Coordinators to use NERC standardized interconnection-wide dynamics models for equipment when made available through the NERC Standardized Powerflow Parameters and the NERC Standardized Dynamics Model List2. Temporary "unapproved" models may be allowed if an approved model is not yet available or is under development. Each Planning Coordinator may be more restrictive if they desire.
4. Designees shall have a process for correcting cases for current or future years, created in the latest case creation cycle, that are already in use. The process should include:
    a. Coordination with the involved Planning Coordinator(s) and equipment owner(s) to resolve and correct problems found.
    b. Timely posting of modifications made to cases to correct problems.

[1] Attribute numbers and exact verbiage may be different across MOD-032 Designee Agreements; however, the concepts are the same.

[2] This list is now called the *NERC List of Acceptable Models for Interconnection-wide Modeling* and can be found HERE.

c. Notification of problems and solutions to known case recipients.

This report provides:

1. Documentation of NERC findings through its case quality and fidelity assessments
2. Documentation of NERC approved dynamic model list
3. Recommendations to the MOD-032 Designees by the ERO on improving case quality and fidelity
4. Tracking of the MOD-032 Designees' implementation of the feedback loop to address the case quality and fidelity issues identified

MOD-032 Designee Contacts

Table 1.1 lists primary contacts related to MOD-032-1, the MOD-032 Designees, and interconnection-wide case quality improvements for each Designee.

Table 1.1: MOD-032-1 Designee Contacts

MOD-032 Entity	Entity	Primary Contacts	Email
ERO	NERC	Ryan Quint Ganesh Velummylum John Moura	ryan.quint@nerc.net ganesh.velummylum@nerc.net john.moura@nerc.net
Eastern Interconnection	ERAG	John Idzior (MMWG, RF) Jeff Mitchel (ERAG Chair) Gaurav Karandikar (SERC) Salva Andiappan (MRO)	john.idzior@rfirst.org jeff.mitchell@rfirst.org gkarandikar@serc1.org sr.andiappan@midwestreliability.org
Texas Interconnection	Texas RE	Brad Woods Mark Henry	brad.woods@texasre.org mark.henry@texasre.org
Western Interconnection	WECC	Kent Bolton Enoch Davies Donald Davies Branden Sudduth	kent@wecc.biz enoch@wecc.biz donald@wecc.biz branden@wecc.biz

Chapter 1: NERC Case Quality Findings and Recommendations

NERC performed three annual Case Quality Metrics (CQM) Assessments – Phase 1[3] in 2015, Phase 2[4] in 2016, and Phase 3[5] in 2017. These assessments review the powerflow (dynamics-ready) and dynamics data in the planning cases created by the MOD-032 Designees for modeling errors and suspect data. This section provides the results, key takeaways, and recommendations from those assessments. After each assessment, the results are provided to each MOD-032 Designee for further review and engagement with their members to correct these errors. The metrics scripts are publicly posted on the NERC SAMS webpage.

Appendices A, B, and C describe how the MOD-032 Designee is addressing modeling errors in future cases. Refer to the appendices for more information on specific modeling improvements. Table 2.1 classifies each metric in terms of whether it is identifying bad data, suspect data, or a case setup issue.

Case Quality Metrics:
The case quality metrics assessment is an assessment of the interconnection-wide models developed by the MOD-032 Designees. These metrics quantify the number of errors or suspect data in the cases in a number of different steady-state and dynamics areas. Identified discrepancies are labeled as "violations"; however, this is not to be confused in any way with compliance to any standards. The goal of identifying these potential "violations" in modeling is to work with the MOD-032 Designees to get them analyzed and corrected.

2015 Phase 1 Assessment

The 2015 CQM Assessment focused on a heavy summer case for each interconnection. The following observations and recommendations were made from the assessment:

- **Steady-State Metrics:** These metrics relate to the steady-state powerflow data or operating conditions of the case. All violations should be mitigated prior to the case being released for use by the Planning Coordinators. MOD-032 Designees should be putting processes in place to ensure these errors are mitigated[6] and corrected for each metric listed.
- **Dynamics Metrics:** These metrics related to generator netting, use of classical models, and errors with inconsistent reactances. All violations should be mitigated prior to the case being released for use by the Planning Coordinators. MOD-032 Designees should be putting processes in place to ensure these errors are mitigated[7] and corrected for each metric listed.

2016 Phase 2 Assessment

The 2016 CQM Assessment included three future year cases for each interconnection. The following observations and recommendations were made from the assessment:

- **Steady-State Metrics:** Metrics were added in Phase 2 to check reasonableness of data and case setup, rather than just explicit errors. The generator reactive limit, generator power factor, and load power factor metrics track setup of generation and load in the case. These may not constitute errors; however, this should be clearly documented in the Appendices of this report.

[3] Phase 1 Case Quality Metrics Assessment can be found HERE.
[4] Phase 2 Case Quality Metrics Assessment can be found HERE.
[5] Phase 3 Case Quality Metrics Assessment can be found HERE.
[6] The exception to this is size (e.g., MVA, kV, etc.) threshold levels the MOD-032 Designee uses for their data checking process as compared with the ERO assessment. These should be clearly documented by the MOD-032 Designee in their respective Appendix section of this report; otherwise, the metric values should be zero in future cases.
[7] The exception to this is size (e.g., MVA, kV, etc.) threshold levels the MOD-032 Designee uses for their data checking process as compared with the ERO assessment. These should be clearly documented by the MOD-032 Designee in their respective Appendix section of this report; otherwise, the metric values should be zero in future cases.

- **Dynamics Metrics:** Phase 2 involved a significant ramp-up of dynamics metrics. The following overall observations and recommendations are made (MOD-032 Designee corrections should be clearly documented in the Appendices of this report):
  - The inconsistent time constants, similar to inconsistent reactances, are simply errors in the generator models and should be corrected accordingly.
  - The modeling of saturation showed strange results with many units considered suspect. However, the "severe saturation factors" identified saturation factors outside a range of reasonability. These saturation factors should be corrected accordingly.
  - The inconsistent speed damping, lead-lag time constants, power development fractions, DC exciter self-excitation, and Type 3 wind modeling errors are also simply data errors that should be corrected accordingly.
  - The use of GAST models is being tracked since the GAST model is not considered an acceptable model as per the NERC List of Acceptable Models. The MOD-032 Designees should be putting processes in place to (1) disallow future use of these models for new units, (2) phase these models out for the existing fleet, and (3) validate test reports using these models for the existing fleet who have submitted MOD-026 records (in coordination with the Transmission Planners).

2017 Phase 3 Assessment

The 2017 CQM Assessment again included three future year cases for each interconnection. No new metrics were added to the assessment; however, some metrics were improved or modified either to address errors in the assessment scripts or to align with industry recommendations. The following observations and recommendations are made from the assessment.

- **Steady-State Metrics:** Electric Reliability Council of Texas (ERCOT) corrected a script error in their case dispatch tools that was identified in the 2015 CQM Assessment. This correction was made in 2016 and showed up as a significant improvement in performance in the 2017 CQM Assessment. Generators dispatched at their reactive limits is still an issue for all interconnections. Generators with reactive limits that have very low power factor (large reactive limits relative to active power limits) is still an issue for all interconnections.
- **Dynamics Metrics:** Unreasonable inertia constants and saturation factors are still an issue for all interconnections. Generator time constant inconsistencies continues to only be an issue in the WI. Inconsistent generator speed damping parameters are still an issue in the TI and WI, but not in the EI. DC exciter self-excitation errors are still an issue for all interconnections. Use of the GAST model is an issue in the EI and TI. However, it is a prominent and noteworthy issue in the EI that deserves attention by the MOD-032 Designee. NERC developed a Modeling Notification on this topic to support a transition away from this model. Poor load power factor in still an issue in the TI. A noticeable increase (although still below 5%) in netted generators in the WI was observed.

Table 2.1: Bad and Suspect Data Metrics				
Steady-State Metrics				
Phase	**Metric**	**Bad Data**[8]	**Suspect Data**[9]	**Case Setup Issue**[10]
Phase I	P_{max} Violations			X
	P_{min} Violations			X
	Scheduled Interchange Sum			X
	Voltage Schedule Conflicts			X
	Tap Step Violations		X	
	Tap Step Violations (Severe)		X	
	Low Emergency Rating		X	
	High Emergency Rating		X	
	Thermal Overloads			X
	Thermal Overloads (Severe)			X
Phase II	Gen Reactive at Limits			X
	Gen Reactive Limit Power Factor		X	
	Pos Seq TX Circulating Current		X	
	Poor Load Power Factor		X	
	Generator R_{source}:X_{source} Ratio	X		
Dynamics Metrics				
Phase	**Metric**	**Bad Data**	**Suspect Data**	**Case Setup Issue**
Phase I	Gens without Models		X	X
	Netted Gens with Models		X	X
	Netted Generators		X	
	Gens with Classical Models		X	
	Inconsistent Reactances	X		
Phase II	Inconsistent Time Constants	X		
	Unreasonable Inertia Constants		X	
	Unreasonable Saturation Factors		X	
	Severe Saturation Factors	X		
	PSS but no Excitation		X	
	Inconsistent Speed Damping	X		
	Inconsistent Lead-Lag Time Const	X		
	Erroneous Power Dev Fractions	X		
	GAST Models		X	
	DC Exciter Self-Excitation Errors	X		
	Inconsistent Type III Wind Speeds	X		

[8] "Bad data" are errors that are blatantly incorrect and should be corrected. For example, reactance or time constant inconsistencies that are not physically possible.

[9] "Suspect data" is data that looks abnormal and may or may not be in error. This should be reviewed by the MOD-032 Designees more closely, and addressed accordingly.

[10] "Case setup issues" are potential issues with how the individual elements are compiled (e.g., powerflow case or dynamics data file) and applied to create the initial operating state from which simulations would then be performed.

Chapter 2: NERC Case Fidelity Findings and Recommendations

NERC does not formally perform a case fidelity assessment for each interconnection-wide case due to the complexity, size of the interconnection-wide models, and breadth of data needed to perform such an assessment. NERC is relying on MOD-033-1 and the work performed by the Planning Coordinators to address potential case fidelity issues on a recurring basis. However, NERC does perform system analysis using the interconnection-wide planning models. These analyses include (see Figure 3.1):

- **Interconnection-Wide System Analysis:** NERC may identify issues while performing system analysis and studies using the interconnection-wide cases created by the MOD-032 Designees.
- **NERC Event Analysis:** As part of the NERC Event Analysis process, NERC may perform simulations to attempt to recreate the event and explore additional topics related to the causes and effects of the event. Any issues identified during these analyses may be identified for improvement.
- **NERC Technical Committee Activities:** The interconnection-wide powerflow and dynamics cases are commonly used as part of the NERC technical committee efforts, particularly the NERC Planning Committee. Any issues identified using the interconnection-wide models for these purposes will be documented.
- **Other Simulations and Modeling Efforts:** NERC, at its discretion from other events, analysis, and activities, may identify issues encountered while using the interconnection-wide cases.

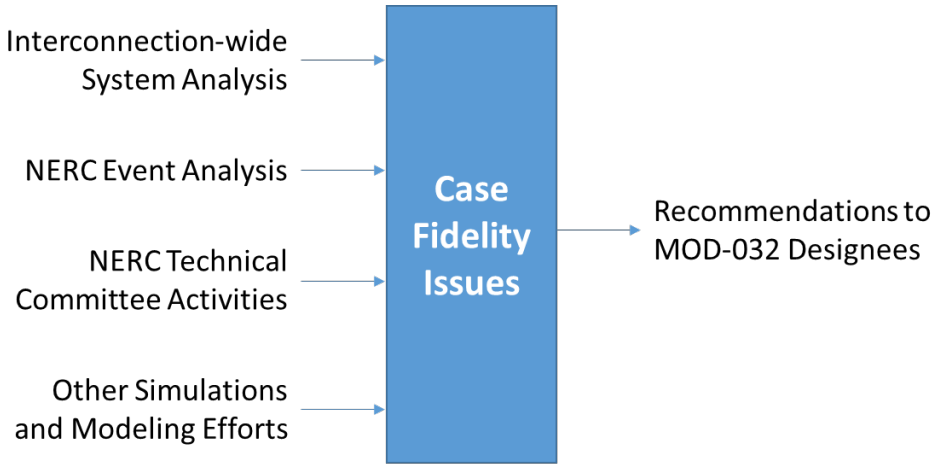


Figure 3.1: Flowchart of Case Fidelity Issues

As part of the analyses, NERC may encounter potential modeling issues related to case fidelity (or quality) that will be tracked in this section for each interconnection. These case fidelity (or quality) issues identified during any NERC system analyses should be addressed by the MOD-032 Designees in coordination with the ERO and the affected Planning Coordinators since these issues are generally larger modeling discrepancies that can affect most or all of the interconnection-wide model rather than only small modeling differences or issues.

The following subsections describe case fidelity (or quality) issues identified and an explanation or recommendation of future action for each interconnection.

Eastern Interconnection

The following case fidelity issues have been identified by NERC in its system analyses.

Frequency Response Modeling

Related Interconnection: Eastern Interconnection

NERC System Analysis performed frequency response assessment for the Eastern Interconnection and identified a number of modeling issues during this assessment. Those are listed below for reference and follow up:

- NERC could not obtain a reasonable initialization using the ERAG/MMWG provided files for the 2021 Light Load Base Case. Several parameter deviations exceeded a reasonable level for a 60 second no-disturbance simulation.
- Model data is not supplied to ERAG/MMWG by all entities in a consistent PSS/E version. Incompatible versions do not initialize as expected (e.g., models developed in PSS/E v32 mixed with models developed in PSS/E v33).
- Frequency responsiveness of generating resources is treated as an after-the-fact addition to the case. This makes the root dynamics case list an invalid representation of the dynamic performance of the Eastern Interconnection, not accurately capturing governor response from many generating resources, and therefore not accurately capturing changes in transfers resulting from this governor response.
- Deadband modeling in PSS/E is not included for most governor models. PSS/E is working on this but it needs to be expedited, driven by NERC and ERAG/MMWG. Deadband plays a significant role in governor response in the Eastern Interconnection relative to the other interconnections in North America due to its large size.
- Frequency response in the settling timeframe (beyond 30 seconds) is experiencing abnormal oscillatory behavior that should not be occurring in the simulation and is not experienced in reality.

Recommendation:
MMWG should include modeling of frequency response capability as part of the standard dynamics models at the absolute earliest possible time. The additional models added to generate a "frequency responsive dynamic case" are part of the unit's dynamic behavior and thus should be included in the standard list of dynamic models. MMWG should make this a high priority topic for case fidelity improvement.

- "Fully responsive" resources under governor control that provide and sustain frequency response should be modeled with an accurate governor model.
- "Squelched response" should be modeled using the appropriate dynamic models (e.g., GGOV1 or other governor models combined with the LCFB1 model). Plant-level controls that return the unit to a load set point should be modeled if they affect the performance of the resource within 60 seconds (typical maximum stability simulation length).
- "Non-responsive" resources should be modeled accordingly (e.g., governor response disabled). Siemens PTI is working on implementing a baseload flag, at the request of NERC and industry, to match other software vendor capabilities. MMWG should develop a plant to use this baseload flag once available in the software.

Nonsynchronous resources should also accurately be modeled. The second generation renewable models (e.g., REGC/REEC series) should be used rather than first generation renewable models. This will help alleviate which will help alleviate some of the initialization and numerical stability issues encountered during studies.

Update: MMWG has accepted the NERC recommendation beginning with the 2017 Series cases. All dynamic cases will include the additional frequency responsive modeling to accurately reflect conditions in the field.

Simulation Crashing for Large Historical Contingencies

Related Interconnection: Eastern Interconnection

When studying frequency response of historical events to benchmark the frequency responsiveness of the dynamics case, NERC System Analysis faced numerical issues and case divergence for these contingencies. A number of wind models had to be GNET'd to get a reasonable simulation, which is not an acceptable solution in the long term.

NERC System Analysis presented these findings and the simulations studied to MMWG. It was agreed that these large historical contingencies would be tested prior to releasing the cases to improve the robustness of the cases for contingencies more commonly studied for TPL-type studies.

Key Takeaway:
NERC Staff shared results of simulation issues under historical contingency conditions and MMWG has added these contingencies to the list of those to be tested prior to case creation and release to Planning Coordinators. Contingencies added include:

- May 25, 2014 at 07:01 Trip Millstone 2 (870 MW) and Millstone 3 (1,233 MW)
- EI 2015-04-07 Washington, D.C., (1981 MW) (Calvert Cliffs 1 & 2 tripped at 1779 MW net)
- EI 2007-08-04 EI Frequency Dist. (Rockport) (4457 MW)

Change Management Issues

Related Interconnection: Eastern Interconnection

HVDC Models

- The HVDC models did not have consistent steady-state modeling for each end of the DC connection. It is not possible to "GNET" the DC equivalent unit to resolve initialization issues. The required DLL models were not made available for the HVDC circuits in the base cases.
- The steady state modeling for the HVDC models was incorrect in the MMWG base cases. The appropriate PSS/E dynamic library models were not provided for the user model "PWRHL2".

Hydro Quebec DLLs

- Several Hydro Quebec (HQ) units did not initialize properly. It was determined that there were missing object codes or DLLs for models from Hydro Quebec. ISO-NE and Hydro Quebec were still transitioning to change/update their models to PSSE v33 whereas the rest of the EI had moved on to v33.

Manitoba Hydro Unit Modeling

- Manitoba Hydro Limestone and Kettle Unit 3 and Unit 4 would not initialize correctly. NERC requested and received dynamics modeling files to revise the modeling for these units. The version of the units provided in the MMWG dynamics case was not compatible with the DLLs supplied to MMWG.

Recommendation:
These issues discussed above are all related to change management of dynamic models that were not compatible in the original case released by MMWG. The HVDC modeling should have consistent steady-state modeling for each end of the circuit. Required DLLs should be provided with each release of the base case(s). Modeling data submitted by entities to ERAG/MMWG should be supplied in a consistent PSS/E version.

Update: The issues noted above have been corrected and will be implemented starting with the 2017 Series of cases.

Texas Interconnection

There are no case fidelity issues in the Texas Interconnection at this time.

Western Interconnection

There are no case fidelity issues in the Western Interconnection at this time.

Chapter 3: NERC Approved Dynamic Model List

The NERC Modeling Working Group (MWG) developed the *NERC Libraries of Standardized Powerflow Parameters and Standardized Dynamics Models*[11] in October 2015. NERC MWG was disbanded in 2016 and its efforts were consolidated into the NERC SAMS activities. NERC SAMS now develops and maintains the *NERC List of Acceptable Models for Interconnection-wide Modeling*[12], which is a simplified and more explicit version of the original model list. This list is developed by a group of stakeholders and subject matter experts in the area of powerflow and dynamics modeling, and is expected to be implemented by the MOD-032 Designees as per the Designee Agreement, Attachment A.

The following sub-sections describe how the approved model list is implemented by each of the MOD-032 Designees.

Eastern Interconnection

Section 9.2 "Dynamic Modeling Requirements" of the MMWG Procedural Manual Version 19, updated October 26, 2017, states:

> G. Standard PSS™E dynamic models, listed in the NERC Library of Standardized Dynamic Models, shall be used for the representation of all generating units and other dynamic devices unless both of the following conditions apply:
>
> 1. The specific performance features of the user-defined modeling are necessary for proper representation and simulation of inter-Data Submitting Entity dynamics, and
> 2. Standard PSS™E dynamic models cannot adequately approximate the specific performance features of the dynamic device being modeled.

NERC Recommendation:
NERC recommends that the text in the MMWG Procedural Manual be updated to reflect the updated NERC List of Acceptable Models posted on the NERC SAMS webpage, which supersedes the original NERC Library of Standardized Dynamic Models.

Update: The MMWG has revised its manual to state: "Standard PSS™E dynamic models should be used for the representation of all generating units and other dynamic devices unless both of the conditions below apply. The use of models listed as unacceptable, in the NERC List of Acceptable Models, should be avoided." Language to specify that only models listed in the NERC List of Acceptable Models should be used was removed in recognition that the use of new standard library models, which have not yet been added to the list, may be necessary. Use of models which are listed as unacceptable in NERC list are stated as "should be avoided" to allow entities sufficient time to phase them out and avoid compliance issues.

[11] The *NERC Libraries of Standardized Powerflow Parameters and Standardized Dynamics Models* can be found HERE.
[12] The *NERC List of Acceptable Models for Interconnection-wide Modeling* can be found HERE.

Texas Interconnection

The ERCOT Dynamic Working Group (DWG) focuses on dynamics model improvements. DWG revised its manual to include the NERC List of Acceptable Models, and the ERCOT Reliability and Operations Subcommittee (ROS) approved the revised manual on January 11, 2018.

NERC Recommendation:
NERC recommends that Texas RE continue monitoring the adoption and implementation of the NERC List of Acceptable Models is the DWG manual. Texas RE should report back progress and improvements in case quality to NERC SAMS for information sharing with other industry members.

Western Interconnection

The Western Interconnection powerflow and dynamics cases are compiled based on the requirements listed in the Data Preparation Manual (DPM). The DPM states that "All dynamic models contained in the master dynamics file (MDF) shall be those approved by the Modeling & Validation Work Group. (MVWG)". MVWG is responsible for providing an adequate set of dynamic models for planning and operating studies. This is accomplished through the WECC Approved Dynamic Model Library. Models not included within the approved list are not accepted during the base case compilation process. The Approved Dynamic Model Library is reviewed by the Modeling & Validation Work Group (MVWG) quarterly during each work group meeting and is updated as necessary. The latest version of the WECC Approved Dynamic Model Library was approved November 2016.

WECC has an established process for changing the WECC Approved Dynamic Model Library. Models that are included within the WECC Approved Dynamic Model Library must conform to the WECC Dynamic Modeling Procedure.

Currently, the WECC Approved Dynamic Model Library is more restrictive than the NERC List of Acceptable Models, and can suffice as an acceptable model list. However, this list should be enforced uniformly across the interconnection; exceptions should be documented for reference.

NERC Recommendation:
NERC recommends that WECC and the MVWG continue the WECC Approved Dynamic Model Library. Any discrepancies where the WECC Approved Dynamic Model Library becomes less restrictive than the NERC List of Acceptable Models should be reported to NERC immediately.

Chapter 4: Closing Remarks

This document serves as a tracking mechanisms for case quality and fidelity improvements across all MOD-032 Designees. The goal of this document is to ensure clear and coordinated identification of modeling issues, recommended corrections to those issues, and feedback from NERC on the implementation of those recommendations. Issues with use of the interconnection-wide models due to quality and fidelity issues has been a longstanding challenge for all interconnections, particularly those with multiple PCs. The modeling improvements initiative being driven by NERC and the Regions, in conjunction with the NERC Reliability Standards (e.g., MOD-026-1, MOD-027-1, MOD-032-1, MOD-033-1), is directly tackling these issues to provide higher quality, verified, and usable models for the purposes of planning and operating the BPS.

Table 5.1 provides a high-level overview of each of the efforts discussed in more detail in this tracking document.

Table 5.1: Modeling Improvements Overview

Topic	Eastern Interconnection	Texas Interconnection	Western Interconnection
Case Quality (Steady-State)	Satisfactory	Improving	Satisfactory
Case Quality (Dynamics)	Issues to be Addressed	Issues to be Addressed	Issues to be Addressed
Case Fidelity	Issues to be Addressed	Satisfactory	Satisfactory
Approved Model List	Satisfactory	Improving	Satisfactory

Appendix A: MOD-032 Designee Tracking – Eastern Interconnection

The implementation of case quality metrics, case fidelity improvements, and the NERC approved model list for the Eastern Interconnection is described in this section.

Case Quality

Table A.1 provides tracking of how the case quality metrics are being considered and implemented by the MOD-032 Designee in the Eastern Interconnection. The MMWG Process Manual for case creation can be found here: LINK (Version 18, last updated March 22, 2017).

Table A.1: EI Case Quality Modeling Improvements Tracking

Steady-State Metrics			
Phase	**Metric**	**Description of Addressing Metric**	**Acceptable to NERC?**
Phase I	P_{max} Violations	Currently included as a data check in the MMWG case creation process.	Yes
	P_{min} Violations	Currently included as a data check in the MMWG case creation process.	Yes
	Scheduled Interchange Sum	Currently included as a data check in the MMWG case creation process.	Yes
	Voltage Schedule Conflicts	Currently included as a data check in the MMWG case creation process.	Yes
	Tap Step Violations	MMWG currently uses criteria of VMA – VMI < 1.95 × Step Size	Yes
	Tap Step Violations (Severe)	MMWG currently uses criteria of VMA – VMI < 1.95 × Step Size	Yes
	Low Emergency Rating	MMWG currently uses criteria of: RATEB < RATEA, RATEA = 0, RATEB = 0, RATEB >= 3 X RATE A (only for 69kV+)	Yes
	High Emergency Rating	MMWG currently uses criteria of: RATEB < RATEA, RATEA = 0, RATEB = 0, RATEB >= 3 X RATE A (only for 69kV+)	Yes
	Thermal Overloads	MMWG currently screens all branches and transformers > 69 kV as well as all GSU's for any loading above RATE A.	Yes
	Thermal Overloads (Severe)	MMWG currently screens all branches and transformers > 69 kV as well as all GSU's for any loading above RATE A.	Yes
Phase II	Gen Reactive at Limits	This will be added as an informational check only starting with the 2018 series cases. It will not be required to change. Units are dispatched at point on the D curve. There is no desire among the membership to adjust the dispatch in an effort to reduce QGEN to a number below QMAX.	Yes, NERC to continue monitoring
	Gen Reactive Limit Power Factor	This check will be added starting with the 2018 series cases.	Yes

Table A.1: EI Case Quality Modeling Improvements Tracking			
	Pos Seq TX Circulating Current	This check will be added starting with the 2018 series cases.	Yes
	Poor Load Power Factor	This check will be added starting with the 2018 series cases.	Yes
	Generator R_{source}:X_{source} Ratio	This check will be added starting with the 2018 series cases.	Yes
Dynamics Metrics			
Phase	**Metric**	**Description of Addressing Metric**	**Acceptable to NERC?**
Phase I	Gens without Models	Currently included as a data check in the MMWG case creation process.	Yes
	Netted Gens with Models	Currently included as a data check in the MMWG case creation process.	Yes
	Netted Generators	Currently included as a data check in the MMWG case creation process.	Yes
	Gens with Classical Models	All classical models will be removed starting with the 2017 series cases. Some will still remain as they are an equivalent representative of the outside world.	Yes
	Inconsistent Reactances	Currently included as a data check in the MMWG case creation process.	Yes
Phase II	Inconsistent Time Constants	This check will be added starting with the 2018 series cases.	Yes
	Unreasonable Inertia Constants	Currently included as a data check in the MMWG case creation process.	Yes
	Unreasonable Saturation Factors	This check will be added starting with the 2018 series cases.	Yes
	Severe Saturation Factors	Currently included as a data check in the MMWG case creation process.	Yes
	PSS but no Excitation	All instances will be corrected starting with the 2017 series cases.	Yes
	Inconsistent Speed Damping	Currently included as a data check in the MMWG case creation process.	Yes
	Inconsistent Lead-Lag Time Const	This check will be added starting with the 2018 series cases.	Yes
	Erroneous Power Dev Fractions	Currently included as a data check in the MMWG case creation process.	Yes
	GAST Models	Use of the GAST model will be phased out starting with the 2017 series cases.	Yes
	DC Exciter Self-Excitation Errors	This check will be added starting with the 2018 series cases.	Yes
	Inconsistent Type III Wind Speeds	All instances will be corrected starting with the 2017 series cases.	Yes

NERC Recommendation:
ERAG (MMWG) should report back on the metrics requiring follow up once considered for inclusion by MMWG. Justification for each metrics should be clearly documented in this tracking report once completed. ERAG should coordinate with NERC to address those metrics not deemed acceptable to NERC.

Case Fidelity

MMWG will consider the listed issues and recommendations related to case fidelity and report back to NERC accordingly.

- At its October 2017 meeting, the MMWG decided to change the way frequency response was modeled in the set of dynamic cases. Separate frequency response cases will no longer be created and published. The mythology used to reflect frequency response will be applied to the entire set of dynamic cases.
- The issues noted with HVDC modeling, Hydro Quebec DLL's, and the Manitoba Hydro unit modeling have been corrected and will be implemented starting with the 2017 series of cases.
- The MMWG has revised its manual to state: "Standard PSSTME dynamic models should be used for the representation of all generating units and other dynamic devices unless both of the conditions below apply. The use of models listed as unacceptable, in the NERC List of Acceptable Models, should be avoided." Language to specify that only models listed in the NERC List of Acceptable Models should be used was removed in recognition that the use of new standard library models, which have not yet been added to the list, may be necessary. Use of models which are listed as unacceptable in NERC list are stated as "should be avoided" to allow entities sufficient time to phase them out and avoid compliance issues.

Appendix B: MOD-032 Designee Tracking – Texas Interconnection

The implementation of case quality metrics, case fidelity improvements, and the NERC approved model list for the Texas Interconnection is described in this section.

Case Quality

Table B.1 provides tracking of how the case quality metrics are being considered and implemented by the MOD-032 Designee in the Texas Interconnection. The ERCOT Dynamics Working Group (DWG) procedure manual can be found here: LINK (Revision 11, last updated March 2, 2017). It does not yet contain the case quality metrics.

Table B.1: TI Case Quality Modeling Improvements Tracking

Steady-State Metrics			
Phase	**Metric**	**Description of Addressing Metric**	**Acceptable to NERC?**
Phase I	P_{max} Violations	Combined cycle dispatch code error corrected; code applied during case creation process.	Yes
	P_{min} Violations	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	Scheduled Interchange Sum	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	Voltage Schedule Conflicts	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	Tap Step Violations	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	Tap Step Violations (Severe)	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	Low Emergency Rating	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	High Emergency Rating	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	Thermal Overloads	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	Thermal Overloads (Severe)	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
Phase II	Gen Reactive at Limits	Included as data check in ERCOT case creation process, starting in 2017 case preparation. Not considered data quality error by ERCOT.[13]	Yes, requires follow up
	Gen Reactive Limit Power Factor	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	Pos Seq TX Circulating Current	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	Poor Load Power Factor	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up

[13] ERCOT and Texas RE have stated that dispatching units at their reactive limit in the pre-contingency power flow base case is part of their planning practices. Generator Owners and the NERC Power Plant Modeling and Verification Task Force (PPMVTF) have stated they have significant concerns with this approach, as that initial operating condition is not considered a credible dispatch.

Table B.1: TI Case Quality Modeling Improvements Tracking			
	Generator R_{source}:X_{source} Ratio	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
Dynamics Metrics			
Phase	**Metric**	**Description of Addressing Metric**	**Acceptable to NERC?**
Phase I	Gens without Models	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	Netted Gens with Models	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	Netted Generators	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	Gens with Classical Models	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	Inconsistent Reactances	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
Phase II	Inconsistent Time Constants	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	Unreasonable Inertia Constants	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	Unreasonable Saturation Factors	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	Severe Saturation Factors	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	PSS but no Excitation	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	Inconsistent Speed Damping	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	Inconsistent Lead-Lag Time Constants	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	Erroneous Power Dev Fractions	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	GAST Models	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	DC Exciter Self-Excitation Errors	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up
	Inconsistent Type III Wind Speeds	Included as data check in ERCOT case creation process, starting in 2017 case preparation.	Yes, requires follow up

NERC Recommendation:
The data checks should be reviewed by ERCOT and included in the DWG procedure manual at the next available opportunity. Texas RE and ERCOT should follow up with NERC once implemented and the tracking table will be updated accordingly once proven in a case quality metric assessment.

Case Fidelity

There are currently no case fidelity issues with the Texas Interconnection base cases.

Appendix C: MOD-032 Designee Tracking – Western Interconnection

The implementation of case quality metrics, case fidelity improvements, and the NERC approved model list for the Western Interconnection is described in this section.

Case Quality

Table C.1 provides tracking of how the case quality metrics are being considered and implemented by the MOD-032 Designee in the Western Interconnection. The WECC Data Preparation Manual for case creation can be found here: LINK (last updated August 10, 2016).

Table C.1: WI Case Quality Modeling Improvements Tracking

Steady-State Metrics			
Phase	**Metric**	**Description of Addressing Metric**	**Acceptable to NERC?**
Phase I	P_{max} Violations	Reported for on-line units in data quality log of potential errors for data submitters' awareness and review. Not corrected by WECC since this field is "information only" (does not affect initialization).	No
	P_{min} Violations	Reported for on-line units in data quality log of potential errors for data submitters' awareness. Not corrected by WECC since this field is "information only" (does not affect initialization).	No
	Scheduled Interchange Sum	Included in WECC case building process.	Yes
	Voltage Schedule Conflicts	Not included in data quality log of potential errors. WECC is evaluating ways to incorporate this check into the data quality log of potential errors.	Yes, requires follow up
	Tap Step Violations	Not included in data quality log of potential errors. WECC is considering for inclusion in the latest revision of the data quality log of potential errors.	Yes, requires follow up
	Tap Step Violations (Severe)	Not included in data quality log of potential errors. WECC is considering for inclusion in the latest revision of the data quality log of potential errors.	Yes, requires follow up
	Low Emergency Rating	Not included in data quality log of potential errors. WECC is considering for inclusion in the latest revision of the data quality log of potential errors.	Yes, requires follow up
	High Emergency Rating	Not included in data quality log of potential errors. WECC is considering for inclusion in the latest revision of the data quality log of potential errors.	Yes, requires follow up
	Thermal Overloads	Reported in data quality log of potential errors for data submitters' awareness and review. Thermal overloads are corrected for branches and transformers > 100 kV in WECC operating cases except in cases where overloads are the correct representation as stated by the data submitter.	Yes

Table C.1: WI Case Quality Modeling Improvements Tracking			
	Thermal Overloads (Severe)	Reported in data quality log of potential errors for data submitters' awareness and review. Thermal overloads are corrected for branches and transformers over 100 kV in our operating cases except in cases where overloads are the correct representation as stated by the data submitter.	Yes
Phase II	Gen Reactive at Limits	Not included in data quality log of potential errors. WECC is considering for inclusion in the latest revision of the data quality log of potential errors.	Yes, requires follow up
	Gen Reactive Limit Power Factor	Not included in data quality log of potential errors. WECC is considering for inclusion in the latest revision of the data quality log of potential errors.	Yes, requires follow up
	Pos Seq TX Circulating Current	Not included in data quality log of potential errors. WECC committees are discussing this metric to determine the appropriate next steps.	Yes, requires follow up
	Poor Load Power Factor	Not included in data quality log of potential errors. WECC is considering for inclusion in the latest revision of the data quality log of potential errors.	Yes, requires follow up
	Generator R_{source}:X_{source} Ratio	Not included in data quality log of potential errors. WECC is considering for inclusion in the latest revision of the data quality log of potential errors.	Yes, requires follow up
Dynamics Metrics			
Phase	**Metric**	**Description of Addressing Metric**	**Acceptable to NERC?**
Phase I	Gens without Models	All on-line units are checked to verify that a model is included, excluding those units on the netting exempt list. This check is not included for off-line units.	Yes
	Netted Gens with Models	Generally, any generator with a model that is netted is reported to the data submitter because the model is causing issues with our standard stability runs. In WECC data quality log of potential errors, any netted generators are reported as missing a model and are being tracked. WECC maintains a list of equipment that are modeled as generators but that do not require a generator model (e.g., back-to-back HVDC) deemed a netting exempt list.	Yes, requires follow up
	Netted Generators	In WECC data quality log of potential errors, any netted generators are reported as missing a model and are being tracked. WECC maintains a list of equipment that are modeled as generators but that do not require a generator model (e.g., back-to-back HVDC) deemed a netting exempt list.	Yes
	Gens with Classical Models	Model not considered an acceptable model as per WECC approved model list, and will not be included in future cases. Currently no GENCLS models in WECC cases.	Yes

Table C.1: WI Case Quality Modeling Improvements Tracking			
	Inconsistent Reactances	Not included in data quality check. WECC will consider including this metric at future committee meetings.	Yes, requires follow up
Phase II	Inconsistent Time Constants	Included in WECC PPMVDTF data check routine.	Yes
	Unreasonable Inertia Constants	Not included in data quality check. WECC will consider including this metric at future committee meetings.	Yes, requires follow up
	Unreasonable Saturation Factors	Included in WECC PPMVDTF data check routine.	Yes
	Severe Saturation Factors	Included in WECC PPMVDTF data check routine.	Yes
	PSS but no Excitation	Not included in data quality check. WECC will consider including this metric at future committee meetings.	Yes, requires follow up
	Inconsistent Speed Damping	Included in WECC PPMVDTF data check routine.	Yes
	Inconsistent Lead-Lag Time Const	Not included in data quality check. WECC will consider including this metric at future committee meetings.	Yes, requires follow up
	Erroneous Power Dev Fractions	Not included in data quality check. WECC will consider including this metric at future committee meetings.	Yes, requires follow up
	GAST Models	The GAST model is currently on the WECC Approved Model list and has not been considered for removal. As more information is provided the removal of the model will be considered at future committee meetings.	Yes, requires follow up
	DC Exciter Self-Excitation Errors	Not included in data quality check. WECC will consider including this metric at future committee meetings.	Yes, requires follow up
	Inconsistent Type III Wind Speeds	Not included in data quality check. WECC will consider including this metric at future committee meetings.	Yes, requires follow up

NERC Recommendation:
WECC should report back on the metrics requiring follow up once considered for inclusion by WECC and/or its technical committees. Justification for each metrics should be clearly documented in this tracking report once completed. WECC should coordinate with NERC to address those metrics not deemed acceptable to NERC.

Case Fidelity

There are currently no case fidelity issues with the Western Interconnection base cases.