

**Dynamics Working Group**

Procedure Manual

Revision 11

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# **Foreword**

This Procedure Manual is intended for use by the stakeholder members of the Electric Reliability Council of Texas (ERCOT) for the purpose of creating and maintaining the dynamics database and dynamics simulation cases which are used to evaluate the dynamic performance of the ERCOT system.

The majority of ERCOT members utilize Siemens Power Technologies Inc. (PTI) Power System Simulator (PSS/E) software. Consequently, the various activities in the procedure manual incorporate PSS/E procedures and nomenclature in describing these activities. Wherever possible, a description of the PSS/E activity is given so users of software other than PSS/E may implement similar actions.

# **Activities of the DWG**

1. DWG builds dynamic data sets and dynamic study cases for the ERCOT system from data supplied by equipment owners. ERCOT coordinates the compilation and publication of dynamics data and dynamics study cases. The dynamics data are published in the form of dynamics study cases (flat start cases) as described within this document.
2. DWG prepares the annual update of the Stability Book that documents data used in the flat start cases.
3. DWG provides a forum for discussing dynamic modeling and system dynamic performance issues and questions.
4. DWG performs other activities as directed by the Reliability and Operating Subcommittee (ROS).

# **Administrative Procedures**

## **Membership**

DWG membership is open to ERCOT, Transmission Service Providers (TSPs), and Texas Reliability Entity (TRE).

Each NERC Transmission Planner within the ERCOT footprint and each ERCOT TSP with an assigned area in the SSWG and DWG base cases, shall have at least one designated Dynamics Working Group (DWG) member. The designated DWG member(s) shall be an employee(s) of an ERCOT Registered TSP. A Designated Agent that is not a DWG member may represent a DWG member. All Designated Agents must follow data sharing rules as outlined in Section 2.5. Designated Agents are permitted on the DWG email exploder list at the discretion of the sponsoring DWG member under the stipulation that a Non-Disclosure Agreement (NDA) is in place with the sponsoring DWG member and proper notification has been provided to ERCOT. It is the responsibility of the sponsoring DWG member to inform ERCOT of Designated Agents acting on their behalf. It is also the responsibility of the sponsoring DWG member to inform ERCOT of Designated Agents that no longer represent them and to have them removed from the email exploder list. Participating Designated Agents shall be reviewed annually by DWG.

DWG members and any Designated Agents shall be identified in the DWG roster, and the roster will be updated as needed by DWG. DWG shall notify ROS (in the monthly report) of any TSPs that are required to have a designated DWG member but do not have a DWG representative identified on the DWG roster.

Each January, the DWG will nominate a Chair and Vice-Chair to be approved by the ROS.

## **Duties of Chair and Vice-Chair**

The Chair will coordinate the activities of the DWG and represent the DWG at the ROS meetings and other working group meetings as required.

The Vice Chair will support the Chair and fulfill the duties of the Chair in the absence of the Chair.

## **Meetings**

The DWG will meet at least quarterly. DWG meetings are closed meetings. DWG members and Designated Agents of DWG members may attend. If a Designated Agent is not on the DWG roster, the sponsoring DWG member will inform ERCOT and the DWG Chair and Vice Chair of the name of the Agent attending one week prior to the meeting.

The Chair may coordinate additional meetings as needed to facilitate the activities of the DWG. The Vice Chair will track attendance and document meeting minutes for in-person meetings.

Agendas and meeting schedules will be published at least two weeks prior to the meeting. The minutes of each meeting will be distributed to DWG members.

## **Reports to ROS**

Each month, the DWG Chair will provide a written report to the ROS if needed.

## **Dynamic Data Sharing Rules**

Dynamic data and dynamic study cases are considered confidential and protected. They shall be provided to DWG members only.

DWG members can provide dynamic data and dynamic study cases to a consultant for the DWG member’s own studies under the condition that a NDA is in place between the DWG member and the consultant.

# **Dynamic Data**

## **General**

### Software

DWG uses PSS/E version 33. During years where a PSS/E version change is being conducted, the previous PSS/E version user defined models shall also be provided until a full transition is completed.

### Dynamic Models – General

Dynamic models shall be submitted to both ERCOT and the connecting TSP and shall fulfill the following requirements:

* Each dynamic device requires a model with model parameters that represent the dynamics of the device.
* Dynamic models shall be compatible with the software and version listed in Section 3.1.1. Models should not interfere with the operation of other models.
* All associated dynamic models for a given generating unit shall be provided with the same MBASE in accordance with the machine characteristics where the MBASE is typically the generator MVA rating.
* No model shall restrict the DWG from using any integration time-step less than or equal to a ¼ cycle in simulations.
* No model in the DWG’s Unacceptable Model List shall be used. Refer to Section 3.1.8.

### Standard Dynamic Models

The use of PSS/E Standard dynamic models is preferred when they can accurately represent the dynamic performance of the device being modeled.

### User-Written Dynamic Models

A user written model is any model that is not a standard Siemens PSS/E library model. When no compatible PSS/E standard dynamic model(s) can be used to represent the dynamics of a device, accurate and appropriate user written models can be used, if accepted by ERCOT and the DWG after being tested for compatibility with the flat start cases.

User-written models for the dynamic equipment and associated data must be in Dynamic Linked Library (DLL) format.

* User-written source code, object code, and parameters must be updated for PSS/E version changes per Section 3.1.1 or as requested by the DWG and/or ERCOT. The preferred User-written model format for PSS/E version 33 or later is the DLL format.
* Models requiring allocation of bus numbers shall be compatible with the ERCOT bus numbering system, and shall allow the user to determine the allocation of the bus numbers.
* User-written models shall not require a specific sequence or directory structure in order to load them.

User-written model(s) must be accompanied by the following:

* Technical description of characteristics of the model,
* Block diagram for the model,
* Values and names for all model parameters,
* Text form of the model parameter values (PSS/E dyre file format),
* Description of all state variables and var variables
* A user’s guide for each model shall be provided and,
* Appropriate procedures and considerations for using the model in dynamic simulations and steady state modeling.

### Maintenance of Dynamic Models

Maintenance of the models is the responsibility of the device owner. Models shall be maintained in accordance with Section 3.2. Any user-written dynamic models shall also be maintained to fulfill the requirements in Section 3.1.4.

### Dynamic Data for Existing Equipment

“As-built” data is required for all completed facilities. Unit-specific data shall be reported for generator units installed after 1990. If permanent new equipment or temporary equipment in place for more than a year is added to the facility then the dynamic model data needs to be re-submitted. “As-Built” data shall be submitted in accordance with Section 3.2.

### Dynamic Data for Planned Equipment

The development of future year case data may require an entity to submit the best available information for the planned equipment prior to development of a detailed design. In such cases, estimated or typical manufacturer’s dynamic data, based on units of similar design and characteristics, may be submitted. However, the Resource Entity shall update the model information upon completion of the detailed design and again upon commissioning the equipment. Dynamic data for planned equipment shall be submitted in accordance with Section 3.2.

### Unacceptable Dynamic Models

A list of acceptable/unacceptable dynamic models was developed by the NERC System Analysis and Modeling Subcommittee (SAMS), a technical group with electric reliability organizations and power industry stakeholders members. The SAMS list contains dynamic models which have been deemed obsolete or depreciated by technical experts on power system modeling. The models highlighted in orange in the aforementioned list are to be considered unacceptable models and shall not be accepted for new generator interconnections nor for dynamic model updates. If a generation interconnection or dynamic model update has begun prior to a model being identified as unacceptable by the NERC SAMS, the model shall be allowed to be used in the dynamic flat start cases. Unacceptable models that already exist in the ERCOT dynamic dataset shall be phased out through dynamic model updates including updates received via the NERC MOD-026-1 and MOD-027-1 processes. The list of acceptable/unacceptable dynamic models are published on the NERC SAMS website below under “SAMS Reference Materials.”

<http://www.nerc.com/comm/PC/Pages/System-Analysis-and-Modeling-Subcommittee-(SAMS)-2013.aspx>

The DWG Unacceptable Model List is the NERC SAMS’ List of models noted as unacceptable/prohibited with exception of those models for which DWG has a technical justification not to adopt.



## **Dynamic Data for Equipment Owned by Resource Entities (REs)**

### Dynamic Data Requirements for New Equipment

*Note: This section addresses the requirements stated in R1 of NERC Standard MOD-032-1 (effective July 1, 2015).*

REs are responsible for providing models with model parameters resulting in a tuned model that represents the dynamic performance of the device. Final responsibility for the submission and the accuracy of the dynamic data lies on the RE. ERCOT and the DWG will provide voluntary assistance if requested by REs to complete parameter tuning and prepare PSS/E model records. The DWG member representing the TSP to which the RE is connected is responsible for working with ERCOT to incorporate the dynamic data received from the RE into the DWG Flat Start cases (dyre file) during annual updates.

The RE shall fulfill its interconnection data requirement by including acceptable dynamic models for their facilities along with a complete RARF. The RE may have additional model and data reporting obligations to ensure compliance with NERC reliability standards and/or other requirements.

The following two subsections describe data requirements for two distinct categories of generation facilities:

* 1. Conventional Generation Facilities Interconnecting More Than Ten MW of Generation Capacity:

1. The model data shall include, at minimum, a generator model, a governor model, an exciter model, and if applicable, a power system stabilizer model and an excitation limiter model.
2. Classical model data is not acceptable.
3. Estimated or typical model data is not acceptable for units after they have connected to the ERCOT system.
4. In accordance with the SSWG Procedure Manual, all non-self-serve generation connected to the transmission system at 60 kV and above with at least Ten MW aggregated at the Point of Interconnection (POI) must be explicitly modeled. This translates to (1) no lumping of generating units and (2) explicit modeling of each step-up transformer.
5. The SSWG manual states that station auxiliary load for generating plants should not be modeled explicitly at the generator bus. While explicit modeling of station auxiliary load may be necessary for certain dynamic simulations, DWG dynamic study cases shall not include it.
6. Explicit frequency protection relay models shall be provided for all generators where relays are set to trip the generating unit within the “no trip zone” of NERC Standard PRC-024 Attachment 1.
7. Explicit voltage protection relay models shall be provided for all generators where relays are set to trip the generating unit within the “no trip zone” of NERC Standard PRC-024 Attachment 2.
8. A governor model is not required for the steam turbine(s) of combined cycle plants.
   1. **Intermittent Renewable Resources (e.g. Wind and Solar) Facilities:**

The RE shall provide the following data as applicable to the generator technology:

1. Model, data and description of voltage control method.
2. Model, data and description of how they will meet ERCOT reactive requirements.
3. A one-line diagram of the proposed facility.
4. Data for all transformers. The data should include:
   * MVA rating.
   * High and low-side rated voltage.
   * Number of taps, and step size.
   * Impedance, including base values if different from rated values listed above.
5. Dynamic modeling data including:

* Wind generator or solar inverter manufacturer and type.
* Rated voltage.
* Rated MVA.
* Reactive capability, leading and lagging.
* Rated MW output.
* Net MW output.
* Transient or subtransient reactance, including base values, if applicable.
* Transient or subtransient time constant, if applicable.
* Total inertia constant, H, of generator, including the shaft and gearbox, if applicable.
* Number of machines by manufacturer types.

1. Reactive resource data such as capacitor banks, STATCOMS, etc. Provide the number of devices, location of the devices, step size, speed of switching, location where voltage is monitored and controlled, control strategy, and voltage limits. For dynamic reactive devices, provide the appropriate model and data.
2. Line data from the POI to each generator shall include:

* Line type (overhead or underground)
* Line length
* Line resistance in ohms/1000 ft
* Line reactance in ohms/1000 ft
* Line susceptance in mhos/1000 ft

1. Wind turbine models shall account for rotor mass, aerodynamic energy conversion, and pitch control.
2. Explicit frequency protection relay models shall be provided for all IRRs where relays are set to trip the resource within the “no trip zone” of NERC Standard PRC-024 Attachment 1.
3. Explicit voltage protection relay models shall be provided for all IRRs where relays are set to trip the resource within the “no trip zone” of NERC Standard PRC-024 Attachment 2.
4. Estimated or typical model data is not acceptable for units after they have connected to the ERCOT system.

### Updates to Existing Dynamic Data

The RE shall submit dynamic model updates to ERCOT and the TSP to which they are connected within 30 days of any facility change and/or test result that necessitates a model update to accurately reflect dynamic performance. The data requirements specified in section 3.2.1 for new equipment also apply to all submitted model updates. Obsolete data should be deleted as appropriate.

When only one component of a generating unit is updated, it may be acceptable to submit an updated model only for that component. However, the RE shall still ensure that all models associated with that generating unit utilize the same MBASE per section 3.1.2. For example, replacement of an old excitation system with a new excitation system requires an RE to provide an updated exciter model. The RE shall ensure that the model parameters for the updated exciter model use the same MBASE as the generator and governor models.

## **Data for Load Resource**

Load Resource under frequency trip relay models shall be prepared annually by ERCOT using a PSS/E standard model. Data for the Load Resource model shall be documented in the Stability Book.

## **Dynamic Data for Equipment Owned by Transmission Service Providers (TSPs)**

### Under Frequency Firm Load Shedding (UFLS) Relay Data

UFLS data shall be prepared annually in accordance with ERCOT and NERC standards. TSPs are responsible for preparing the UFLS relay model records for their respective loads. The TSP shall submit the UFLS relay data to ERCOT in the form of a PSS/E dyre file using an appropriate model. The models should contain the necessary information to properly represent the UFLS relay actions in a dynamic study, including:

1. Location (bus number and/or load ID) of load to be interrupted.
2. Fraction of load to be interrupted.
3. Corresponding frequency set points.
4. Overall scheme clearing times (including all time delays, breaker clearing times, etc.)

Also, the TSP should indicate any other schemes that are part of or impact the UFLS programs such as related generation protection, islanding schemes, automatic load restoration schemes, automatic capacitor/reactor switching, and Remedial Action Scheme (RAS).

All UFLS data will be documented in the annual Stability Book.

### Under Voltage Load Shedding Relay Data

An ERCOT TSP which has UVLS relays in its service area designed to mitigate under voltage conditions potentially impacting the system reliability is to establish and maintain a UVLS Program consistent with NERC Standards.

The TSP owning an UVLS Program will submit the corresponding relay model to ERCOT during the annual data update. The DWG member shall submit the UVLS relay data in the form of a PSSE dyre file using an appropriate model.

It is the responsibility of the TSP to ensure the UVLS program model submitted has been tested through an assessment as per NERC standards.

Also, the TSP shall indicate any other schemes that are part of or impact the UVLS programs such as related generation protection, islanding schemes, automatic load restoration schemes, automatic capacitor/reactor switching, and RASs.

The model shall contain the necessary information to properly represent the under voltage relay actions in a dynamic study, including:

1. Location (bus number and/or load ID) of load to be interrupted.
2. Fraction of load to be interrupted.
3. Corresponding voltage set points.
4. Overall scheme clearing times (including all time delays, breaker clearing times, etc.).

All UVLS data from the responsible entities will be documented in the annual Stability Book.

### Protective Relay Data

The operation of protection, control, and RAS systems can affect the dynamic performance of the ERCOT system during and following contingencies. Planning, documenting, maintaining, or other activities associated with these systems is outside the scope of the DWG. However, because they can affect dynamic performance, the DWG should, on an as needed basis, identify and document protection, control, and RAS systems for inclusion to its dynamic data sets. Identification of these protection systems will normally require the assistance of individuals or groups outside the DWG. The specific information to be considered for inclusion will depend on the type, purpose, and scope of study.

Protection, control, and RAS systems included in the DWG database should be in the form of a dynamic model and shall be compatible with the software listed in section 3.1.1. Protection, control, and RAS systems adequately modeled for dynamic purposes by other working groups only need to be referenced in the DWG study reports.

The DWG member, as part of the annual database update, shall review and update as necessary protection, control, and RAS systems already in the DWG database. This review should include evaluating the existing data for applicability and accuracy.

Protective relay data included in a DWG flat start case shall be documented in the Stability Book.

### Load Model Data

*Note: This section addresses the requirements stated in R1 of NERC Standard MOD 032-1 and R2.4.1 of NERC Standard TPL-001-4.*

Another key component of any dynamic study is the load model and its representation as a function of changing frequency or voltage. The load model can have a significant effect on results of dynamic analysis. For this reason, it is important to use an appropriate load model during the study.

DWG shall review and update static load models for each area, composed of a mix of constant impedance (Z), constant current (I), and constant power (P) representations, known as ZIP models. PSS/E CONL activity is used to incorporate the ZIP models into a PSS/E study.

Additional detailed data for dynamic load modeling (large motor MW, small motor MW, etc.) is provided in the Annual Load Data Request (ALDR). ALDR information can be used with generic motor model parameters for screening purposes.

DWG recommends the use of a composite load model to represent various typical dynamic load elements, and in particular, modeling of Air Conditioning load as needed for studies. These load dynamic models are not included in the DWG flat start cases.

Within 30 days of a written request from ERCOT, a TSP shall provide load dynamic models with documentation explaining the process to derive such models.

A standard load-frequency dependency model (LDFRAL) will also be documented in the Stability Book.

### Other Types of Dynamic Data

*Note: This section addresses requirements stated in R1 of NERC Standard MOD 032-1 (effective July 1, 2015).*

All elements with dynamic response capabilities (such as SVC, STATCOM, Superconducting Magnetic Energy Storage (SMES), DC tie, and Variable-Frequency Transformer) that are in service and/or modeled in the SSWG base cases shall be represented with an appropriate dynamic model. The DWG member of the TSP owning the equipment shall submit the model to ERCOT during the annual dynamic database update or as needed for studies.

### Missing or Problematic Dynamics Data

The DWG is responsible for reviewing the dynamic data on an annual basis and reporting to the ROS any missing data or unresolved issues relating to data submission requirements. DWG will report select data problems to the respective ERCOT working group per Section 4.2.3.

If the DWG and/or ERCOT identifies inappropriate or incomplete dynamic data, the appropriate DWG member and/or ERCOT shall request that the equipment owner resolves the discrepancies by following processes established by existing NERC Standards or ERCOT rules. The final responsibility for the submission and the accuracy of the data lies with the equipment owner. All of the data and the revisions requested by ERCOT shall be resolved by the entity owning the equipment within 30 days. Until valid data becomes available, ERCOT or the DWG member to whose system the equipment is connected shall recommend an interim solution to the missing or problematic data.

### Dynamic Data and Stability Book Storage

ERCOT shall make available to the DWG members in electronic format the dynamic data described in this document. ERCOT shall maintain a repository of dynamic data approved by the DWG and will maintain the submitted revisions.

# **Overview of DWG Activities**

## **Updating Dynamic Data and Flat Starts**

### Schedule for Dynamic Data Updates and Flat Start Cases

*Note: This section addresses requirements stated in R2 of NERC Standards TPL-001-4.*

Each June, the DWG shall prepare a detailed schedule for developing flat start cases and providing associated dynamic contingencies. The DWG shall begin the flat start case development process as soon as practicable after SSWG base cases are posted – normally July 1. The DWG shall prepare flat start cases for near term on-peak, near term off-peak and long-term on-peak conditions to facilitate planning assessments required by NERC Standard TPL-001-4. It is intended that the three dynamic data sets be developed concurrently to be utilized in planning assessments for the next year (YR+1). The following diagram presents a schedule as a reference for DWG flat start case development:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| YR (YR=Current Year) | | | | | | | | | YR + 1 | | |
| Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar |
| YR SSWG Build Process  July 1 - Cases Posted | | |  |  |  |  |  |  |  |  |  |
|  |  | Prepare DWG Flat Start Schedule | DWG Dynamic Flat Start Case Development  Near Term On-Peak Case  Near Term Off-Peak Case  Long Term On-Peak Case | | | | | | |
|  |  |  |  |  |  | Final DWG Data Sets Posted | |
|  | Submit Dynamic Contingency Files and Dynamic Load Models | |
| Stability Book Finalized and Posted | | |

The DWG flat start case development process adds detailed dynamic models to network elements represented in an SSWG base case that reflect behavior during and following system disturbances. The DWG shall normally prepare dynamic flat start cases based on the following SSWG steady state cases:

* Near-Term On-Peak Case: (Y+3) SUM1
* Near-Term Off-Peak Case: (Y+4) HWLL
* Long-Term On-Peak Case: (Y+7) SUM1

For example, the following flat start cases would be developed during the period from July 2017 through January 2018: 2020 SUM1, 2021 HWLL, and 2024 SUM1. These cases could then be used for planning assessments performed in 2018. The DWG may choose to develop dynamic flat start data sets for alternative cases that meet the same objectives with respect to facilitating the completion of NERC TPL planning assessments.

After January 1st, 2015, ERCOT shall serve as the flat start coordinator for all DWG cases.

### Dynamic Data Updates

Each DWG member shall review the dynamic data from the prior year for its portion of the ERCOT System and provide necessary updates according to the schedule established in section 4.1.1. The changes in the data must be identified and submitted with the updated data.

Data for mothballed units shall be retained. Obsolete data should be deleted.

Other revisions of data that should be submitted to the flat start coordinator include updates to the load model, Zsource corrections, generation netting, or any other modifications to the network necessary for dynamic studies.

### Dynamic Data Screening

DWG members should review the dynamic data for equipment connected to their system for completeness and applicability. The data should be appropriate for the model, and the model should be appropriate for the equipment. Before submitting data for inclusion in updated dynamic base cases, each DWG member should perform dynamic data screening.

### Flat Start Criteria

DWG Flat Start cases shall:

* Initialize with no errors;
* Demonstrate that simulation output channels for frequency, voltage and power do not deviate from an acceptable range for a ten-second run with no disturbance.
* The product of a successful flat start will be a PSS/E simulation-ready base case (the unconverted base case) with its associated dynamic data files including user models (.dyr, .obj, .lib, and .dll files), stability data change documentation, python (.py) files and response files (.idv) files. The product of a successful flat start also includes the steps taken to build the flat start case such as network model changes (i.e. changing the schedule of the North DC, tuning voltages, etc.).

## **Post Flat Start Activities**

### Distribution of Flat Start Results and the Dynamic Data Base

Upon completion of each flat start, all dynamic data and final data files shall be posted on the ERCOT MIS so that it is accessible to all DWG members and to ERCOT. This posting shall be within the schedule established by the DWG for the given flat start.

### Stability Book

The Stability Book is an annual document used to record dynamic data changes and/or corrections required during the flat start processes. The flat start coordinator shall prepare the annual stability book. Recommendations to revise load flow data are also included in the book. DWG Members are required to communicate these recommendations to other respective working groups, including Steady State Working Group, Operations Working Group, and Network Data Support Working Group, to eliminate recurring problems.

The following information is included in Stability Book:

* Deviation tables or plots of the flat start results are included to verify the successful completion of the flat start process.
* Dynamic data. This data is in the DOCU ALL PSS/E activity format.
* Under frequency and under voltage load shedding relay data submitted by each of the appropriate DWG members.
* Additional information identified for inclusion by Section 3.4

### DWG Coordination with the Steady State Working Group

To support coordination with the Steady State Working Group, Operations Working Group, and Network Data Support Working Group a list of changes made to the following steady-state power flow data shall be reported to the ERCOT Steady State Working Group representative:

* Unit MVA Base: this is also known as MBASE and is used as the base quantity for many dynamic model parameters associated with generating units.
* Zsource: reactive machine impedance that is required to match the subtransient reactance specified in the dynamic generator model for proper initialization of dynamic simulations.

ERCOT shall compile the list of data changes following finalization of the flat start DWG shall coordinate with SSWG to assure that conflicting data is corrected during future SSWG case building activities.

### DWG Dynamic Contingency Assumptions List

The DWG shall construct a dynamic contingency assumptions list detailing contingency assumptions for each TSP for the purpose of screening studies conducted by ERCOT and the DWG members. ERCOT and the DWG members shall annually review and update the dynamic contingency assumption list. Upon completion of the annual review, ERCOT shall collect the contingency assumptions and submit the finalized dynamic contingency assumptions list to the DWG.

The assumptions shall include:

* Breaker trip time for normal clearing,
* Breaker trip time for delayed clearing due to stuck breaker
* Breaker trip time for delayed clearing due to relay failure
* Relay characteristic assumptions to assess generic apparent impedance swings that can trip any transmission system elements
* Other assumptions deemed necessary by DWG as specified during the annual review

### DWG Dynamic Contingency Database

The DWG shall prepare a Dynamic Contingency Database according to a standard spreadsheet format. The spreadsheet format will be reviewed annually. The dynamic contingency database will be distributed to DWG members.

## **Other DWG Activities**

### Event Simulation

Note: This section addresses NERC MOD-033-1.

ERCOT will compare dynamic system model performance to that of actual system response data at least once every 24 calendar months.

If no significant dynamic event occurs within the 24 calendar months, the next dynamic event that occurs will be used to validate system performance.

- An event will be selected based on its impact to the network and availability of recorded data. ERCOT will request Market Participants affected by the event to supply the actual network performance data records in electronic format.

- ERCOT will create a reasonable replica of the system configuration and power flow conditions at the time the event occurred in a dynamic system model, with contingencies replicating the sequence of switching activities that occurred during the event.

- ERCOT will determine the acceptable fidelity of the dynamic system model by comparing system performance simulations to that of actual system performance.

A system validation simulation will be deemed not acceptable if:

* The simulation crashes or does not produce data output.
* The signals simulated do not trace actual system performance for the selected measured signals.
* The post-event steady-state power flow of selected 345 kV lines deviate more than 10% from their actual measured values.

A difference in performance will be resolved as follows:

* ERCOT will identify deficient models and suggest replacements or corrections to achieve acceptable fault performance.
* Faulty data or modeling information will be reported back to the data owner. When existing NERC standards are applicable (i.e.: MOD-026, MOD-027, MOD-032, TPL-001), data correction shall follow such process.
* Section 3.4.6 applies while data is being corrected. Section 4.2.2 applies to communicate these finding to other respective working groups.

The DWG will review recent significant events to determine their suitability for an event simulation. For a selected event, the affected TSP will provide actual system behavior data (or a written response that it does not have the requested data) to ERCOT within 30 calendar days of a written request.

### Procedure Manual Revision Guidelines

The DWG is responsible for maintaining and updating this Procedure Manual. Revisions, additions and/or deletions to this Procedure Manual may be undertaken at such times that the DWG feels it is necessary due to changes in PSS/E dynamic simulation software or to meet new and/or revised requirements of NERC, ERCOT, or any other organization having oversight or regulatory authority.

At least annually, the DWG Chair shall request a thorough review of the current Procedure Manual for any needed revisions. The notification will request that proposed revisions be submitted to the DWG Chair (or the Chair’s designate) for consolidation and distribution to all DWG members for comment and/or additional revision.

The DWG Chair may seek approval of any revision, addition, or deletion to the Procedure Manual by email vote, regular meeting, or called special meeting as deemed necessary or requested by DWG membership.

## **Recommended DWG Study Methodologies**

*Note: This section addresses, in part, requirements R4, R5 and R6 of NERC Standard TPL-001-4*

Voltage stability margin, transient voltage criteria, and damping criteria are described in the ERCOT Planning Guide Section 4.

### Voltage Instability Identification in Stability Studies

Voltage Instability is indicated by severely low bus voltage or bus voltage collapse.

Voltage Instability could cause:

* Motor stalling leading to significant amount of customer initiated motor tripping.
* Loss of generator(s) due to low voltage
* Voltage collapse of an area

### Cascading Identification in Stability Studies

Cascading Definition - Cascading is defined as the uncontrolled loss of any system facilities or load, whether because of thermal overload, voltage collapse, or loss of synchronism, except those occurring as a result of fault isolation. Cascading is indicated by one or more of the following conditions:

* Uncontrolled sequential loss of generators
* Uncontrolled sequential loss of load
* Uncontrolled sequential loss of branches.

Cascading could cause conditions like:

* Voltage collapse of an area
* Expanding number of buses with voltage instability
* System islanding, frequency instability due to power-load unbalance

NERC Definition: The uncontrolled successive loss of system elements triggered by an incident at any location. Cascading results in widespread electric service interruption that cannot be restrained from sequentially spreading beyond an area predetermined by studies.

### Uncontrolled Islanding Identification in Stability Studies

Uncontrolled islanding is the separation and loss of synchronism between a portion of the interconnection and the remaining interconnected system. Islanding originates with uncontrolled loss of branches, ending with the formation of sub-network islands.

Generators disconnected from the System by fault clearing action or by a RAS are not considered out of synchronism. Similarly, islands formed from being disconnected from the System by fault clearing action or by a RAS are not considered an uncontrolled island.

Sub-network islands have the following characteristics:

* The sub-network islands have both generation and load to support the continuation of the island.
* The sub-networks formed are not connected to each other.

Uncontrolled islanding in a screening study could cause:

* Out-of-step generators
* Off-nominal frequency disturbances
* Eventual collapse of an island due to frequency or voltage instabilities caused by the generation-load unbalance in the sub-network island.

### Generator Protection Assumptions

*Note: This section addresses, in part, requirements R3.3.1.1 and R4.3.1.2 of NERC Standard TPL-001-4 (effective January 1, 2016).*

If dynamic models are not provided for Generator protection schemes, generic generator protection may be assumed for screening purposes

1. For synchronous generators, a rotor angle swing greater than 180 degrees may be considered an unstable generator.
2. Generators may be assumed to be compliant with the minimum requirements of Section 2.9 Voltage Ride-Through Requirements for Generation Resources of the ERCOT Nodal Operating Guide.
3. Generators may be assumed to be compliant with the minimum requirements of Section 2.6 Requirements for Under/Over-Frequency Relaying of the ERCOT Nodal Operating Guide.