



System Operating Limit Methodology for Planning Horizon

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1. Purpose

NERC standard FAC-010-2.1 requires that each Planning Authority “shall have a documented System Operating Limits (SOLs) Methodology for use in developing SOL’s within its Planning Authority Area” for the planning horizon. This document describes the methodology for determining the SOLs, and the subset of SOLs classified as Interconnection Reliability Operating Limits (IROLs), for the planning horizon within the ERCOT Region [FAC-010-2.1 R1.1]. This methodology also documents the communications required by NERC FAC-014-2 [FAC-014-2 R5.3, R6].

2. Definitions

The NERC Glossary of Terms Used in Reliability Standards provides the following definitions:

Bulk Electric System (BES):

As defined by the Regional Reliability Organization, the electrical generation resources, transmission lines, interconnections with neighboring systems, and associated equipment, generally operated at voltages of 100 kV or higher. Radial transmission facilities serving only load with one transmission source are generally not included in this definition

System Operating Limit (SOL):

The value (such as MW, MVar, Amperes, Frequency or Volts) that satisfies the most limiting of the prescribed operating criteria for a specified system configuration to ensure operation within acceptable reliability criteria. System Operating Limits are based upon certain operating criteria. These include, but are not limited to:

- ***Facility Ratings*** (Applicable pre- and post-Contingency equipment or facility ratings)
- ***Transient Stability Ratings*** (Applicable pre- and post-Contingency Stability Limits)
- ***Voltage Stability Ratings*** (Applicable pre- and post-Contingency Voltage Stability)
- ***System Voltage Limits*** (Applicable pre- and post-Contingency Voltage Limits)

Interconnection Reliability Operating Limit (IROL):

A System Operating Limit that, if violated, could lead to instability, uncontrolled separation, or Cascading Outages that adversely impact the reliability of the Bulk Electric System.

Interconnection Reliability Operating Limit T_v (IROL T_v):

The maximum time that an Interconnection Reliability Operating Limit can be violated before the risk to the interconnection or other Reliability Coordinator Area(s) becomes greater than acceptable. Each Interconnection Reliability Operating Limit’s T_v shall be less than or equal to 30 minutes.

Facility Rating:

The maximum or minimum voltage, current, frequency, or real or reactive power flow through a facility that does not violate the applicable equipment rating of any equipment comprising the facility.

Normal Rating:

The rating as defined by the equipment owner that specifies the level of electrical loading, usually expressed in megawatts (MW) or other appropriate units that a system, facility, or element can support or withstand through the daily demand cycles without loss of equipment life.

Emergency Rating:

The rating as defined by the equipment owner that specifies the level of electrical loading or output, usually expressed in megawatts (MW) or Mvar or other appropriate units, that a system, facility, or

element can support, produce, or withstand for a finite period. The rating assumes acceptable loss of equipment life or other physical or safety limitations for the equipment involved.

SOLs in the planning horizon are described as the most limiting Facility Rating and its designed thermal or voltage rating together with the system conditions at which the limit is reached or exceeded when applying the NERC Transmission Planning (TPL) standards. Facility Ratings determine the fundamental limits of transmission system equipment. An SOL shall not exceed the associated Facility Rating [FAC-010-2.1 R1.2].

The IROLs for the planning horizon relate to specific system configurations or defined system conditions (demand level, generation pattern, transfer amount, and facility contingency conditions) for which instability, uncontrolled separation, or Cascading Outages are projected to occur as described in Section 3 of this methodology.

3. SOL/IROL Determination Methodology

This methodology is applicable for determining SOLs/IROLs used in the planning horizon by the assessment of the reliability of the currently planned ERCOT transmission system. The assessment is accomplished through steady-state power flow, voltage stability, and transient stability analysis.

3.1. Transmission Planner SOLs

Transmission Planners (TPs) provide System Operating Limits to ERCOT ISO as the Planning Authority. The TPs provide SOLs as Facility Ratings, any special transfer limits, and any stability limits that the TP has derived, to ERCOT ISO. In accordance with this methodology, the Transmission Planners will also identify any SOLs that qualify as IROLs based on the criteria identified in section 3.3 of this methodology. These limits will be used in the analysis described in sections 3.2 of this methodology to determine if any additional SOLs are identified.

3.2. System Assessment and General Performance Criteria

As required with NERC Reliability Standard TPL-001, in the pre-contingency state and with all facilities in service, the BES shall demonstrate transient, dynamic and voltage stability; all Facilities shall be within their Facility Ratings and within their thermal, voltage, and stability limits. In the determination of SOLs, the BES condition used shall reflect expected system conditions and shall reflect changes to system topology such as facility outages [FAC-010-2.1 R2.1].

As required with NERC Reliability Standard TPL-002, starting with all Facilities in service and following any of the contingencies identified for NERC Reliability Standard TPL-002, the system shall demonstrate transient, dynamic and voltage stability; all facilities shall be operating within their facility ratings and within their thermal, voltage and stability limits; and cascading or uncontrolled separation shall not occur. This would also include shunt devices and bipolar high voltage direct current systems not specifically included in TPL-002 Category B contingencies. [FAC-010-2.2, R2.2.1, R2.2.2, R2.2.3]. Starting with all Facilities in service, the system's response may include any of the following [FAC-010-2.1 R2.3]:

- Planned or controlled interruption of electric supply to radial customers or some local network customers connected to or supplied by the faulted facility or by the affected area [FAC-010-2.1 R2.3.1].
- System reconfiguration through manual or automatic control or protection actions [FAC-010-2.1 R2.3.2].

To prepare for the next contingency, system adjustments may be made, including changes to generation, uses of the transmission system, and the transmission system topology [FAC-010-2.1 R2.4]. As required with NERC Reliability Standard TPL-003, starting with all Facilities in service and following any of the contingencies identified in NERC Reliability Standard TPL-003, the system shall demonstrate transient, dynamic and voltage stability; all facilities shall be operating within their Facility Ratings and within their thermal, voltage and stability limits; and cascading or uncontrolled separation shall not occur [FAC-010-2.1 R2.5]. The system's response may include any of the following [FAC-010-2.1 R2.6]:

- Planned or controlled interruption of electric supply to radial customers or some local network customers connected to or supplied by the faulted facility or by the affected area [FAC-010-2.1 R2.3.1].
- System reconfiguration through manual or automatic control or protection actions [FAC-010-2.1 R2.3.2]
- Planned or controlled interruption of electric supply to customers (load shedding), the planned removal from service of certain generators, and/or the curtailment of contracted firm (non-recallable reserved) electric power transfers [FAC-010-2.1 R2.6.1]

Study cases published by ERCOT Steady State Working Group (SSWG), ERCOT Dynamics Working Group (DWG) or ERCOT Five-Year Transmission Plan are used for the assessments [FAC-010-2.1 R3.1]. This case will contain the best estimate of any planned transmission line maintenance outages, system configuration, anticipated generation dispatch, and load levels. Additional system conditions, including a winter off-peak case or high wind low load case, may also be studied if needed. [FAC-010-2.1 R3.5].

The models used in the analysis represent the entire ERCOT Transmission system including all Facilities 60 kV and above. The ERCOT Transmission system has a limited amount of flow capability between ERCOT and other Interconnections over DC-ties, so these interconnections are modeled in the base case data sets as generation or load using historical flow information. The level of detail in the system models used in the analysis is consistent with the SSWG and DWG manuals and processes [FAC-010-2.1 R3.1 R3.3].

The contingencies selected for this analysis are based on NERC TPL Standards. [FAC-010-2.1 R3.2]

Where appropriate, simulations of SPS actions are allowed and included in the studies. This would be determined by the impact the SPS would have on facilities in the studies. If an SPS is not in the area and does not impact a facility in the area, it would not be included. If the impact of the SPS does not affect the type of limit being determined, it would not be included [FAC-010-2.1 R3.4].

3.3. Determination Criteria

Based on the assessment results in section 3.2, additional SOLs are identified if the system performance cannot meet any of the following:

- Transient, dynamic, and voltage stability;
- No Cascading or uncontrolled separation;
- Voltage stability margin is greater than or equal to 5% for Category B and 2.5% for Category C;
- Post disturbance frequency within the range from 59.4 Hz to 60.4 Hz; or

- Manual system adjustments, such as system reconfiguration between contingencies in an N-1-1 Category C event, or load shedding are needed in order to prevent Cascading or transient, dynamic, or voltage instability.

An SOL is an IROL if the system performance response results in:

- Loss of load in the Cascading or voltage collapse, either through manual action or as a consequence of the event, is greater than a threshold as defined in section 3.4 of this methodology.
- Tripped generation greater than two largest units' capacity.
- Observable inter-area oscillation with damping ratio less than 3%.

The IROL T_v is the lower of the relay trip setting time delay, where applicable, or 30 minutes [FAC-010-2.1 R1.3, R3.6]. The IROL T_v may be set lower using engineering judgment, by considering factors such as the risk of the event and history of equipment operation in the area.

3.4. Load Loss Threshold Guidelines

The value of the load loss threshold will be four times 1% of the ERCOT Interconnection load level used in the study. Since frequency response bias used for the ERCOT Interconnection is typically set at 1% of peak load, by multiplying by a conservative value of 4 (to represent a .4Hz frequency response) results in a MW value that should result close to a .4Hz frequency deviation. In ERCOT, generator protection is set greater than 60.6 Hz, based on ERCOT regional rules, so a reliability margin is built in to the threshold [FAC-010-2.1 R3, R3.6]. ERCOT ISO or the TP may choose to deviate from this guideline as necessary but should justify the reasoning for such deviation and which should not negatively affect reliability.

4. Distribution

This methodology is posted on the ERCOT Planning and Operations Information website. Notifications related to revisions of the SOL Methodology for the planning horizon will be made prior to the effectiveness of the change. When the methodology is revised a notification of update is sent to each Transmission Operator and Transmission Planner in the ERCOT Region [FAC-010-2.1 R4.2, R4.3]. Notification of revisions to the Reliability Coordinator is within ERCOT ISO as ERCOT ISO is the single Planning Authority and Reliability Coordinator in the ERCOT Interconnection. Any other Planning Authority that indicates that it has a reliability-related need for the methodology will be provided the current copy of the SOL Methodology for the planning horizon as well as have a notification of update sent to that Planning Authority for any future revisions [FAC-010-2.1 R4, R4.1, R4.2,]. If a recipient of the SOL Methodology for the planning horizon provides documented technical comments on the methodology, ERCOT will provide a documented response to that recipient within 45 calendar days of receipt of those comments. The response will indicate whether a change will be made to the SOL Methodology for the planning horizon or, if no change will be made, the reason why [FAC-010-2.1 R5].

ERCOT as the PA sends the assessment results annually to each NERC Transmission Operator and Transmission Planner in the ERCOT Region through either email distribution list or ERCOT Market Notice. The results will be shared within ERCOT ISO, as appropriate. Internal communications will include the list of multiple contingencies and the associated stability limits, or notification that results did not identify any stability-related multiple contingencies.[FAC-014-2 R5.3, R6.1, R6.2].

A list of transmission Facilities that are identified to be critical to the derivation of an IROL and the station or substation location that are associated with the initiating contingencies that lead to the identification of an IROL, will be sent to the appropriate NERC Transmission Owners and NERC Transmission Operators to assist

those entities in identifying transmission Facilities that are Critical Assets per CIP-002-4, Attachment 1 Criteria 1.8. Additionally, Flexible AC Transmission Systems (FACTS) identified through analysis to be critical to the derivation of an IROL, a list of such systems and their associated contingencies will be sent to the appropriate NERC Transmission Owner and NERC Transmission Operator to assist those entities in identifying transmission Facilities that are Critical Assets per CIP-002-4, Attachment 1 Criteria 1.9

5. Document Revisions

Version	Description	Revision Date	Author(s)
0	Draft – for initial review	19-AUG-2008	
1	Approved by ERCOT Planning. Posted for review. No process changes.	31-DEC-2008	JESchmall
2	Director Approval	30-SEP-2009	DWoodfin
3	Modified for changes due to TOP JRO/CFR, other updates/corrections	28-MAY-2010	DWoodfin
4	Update methodology	26-NOV-2012	JBillo, YZhang, JConto, AZhou, GGnanam, SHuang