California ISO

System Operating Limits (SOL)

Methodology

for the Planning Horizon

Version 3.4

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1 Purpose

The purpose of this document is to provide the methodology required under NERC Standards FAC-010-3 and FAC-014-2 for developing System Operating Limits (SOLs) and Interconnection Reliability Operating Limits (IROLs) used in the planning horizon within the California ISO Planning Authority Area.

2 Definitions

The following terms are defined in the *Glossary of Terms Used in NERC Reliability Standards* and are included below for reference:

- 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 Tv shall be less than or equal to 30 minutes.

- Cascading

  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.

Unless specifically indicated otherwise, the terms SOL, IROL and IROL T_v throughout this document should be read to mean SOL, IROL, and IROL T_v, used in the planning horizon, respectively.

3 Applicability

California ISO (ISO) has registered with NERC as a Planning Authority (PA)[1]. The California ISO Planning Authority Area covers the CAISO Controlled Grid as defined in the ISO Tariff. This SOL Methodology is applicable for developing System Operating Limits and Interconnection Reliability Operating Limits used in the planning horizon within the ISO's Planning Authority Area. (FAC-010-3 R1.1)

In general, a SOL for the planning horizon should be established for a facility or a group of facilities in accordance with this Methodology if the following conditions are met:

- In the case of a facility, if (1) planning studies indicate that applicable normal or post contingency system performance requirements (thermal, voltage, or stability) limit the facility below its facility rating in the pre-contingency state, and (2) the limit so identified is found to be appropriate for use in the reliable planning of the BES.
- In the case of a group of facilities, if the group of facilities has been defined as a monitored transmission path for use in the reliable planning of the BES.

For clarity, this SOL Methodology is not applicable for determining SOLs and IROLs used in the operations horizon. Refer to the RC West System Operating Limits Methodology for the Operations Horizon for the methodology applicable to the operations horizon within the California ISO Planning Authority Area[2].

This methodology is not applicable for determining facility ratings. If a SOL is not identified for a facility in accordance with this methodology, the rating of the facility will be used in planning the Bulk Electric System. SOLs shall not exceed associated facility ratings. (FAC-010-3 R1.2)

4 Applicable Performance Requirements

In the pre-contingency state with all facilities in service, and following single and multiple contingencies, SOLs shall provide BES performance consistent with Requirement R2 (R2.1

[1] The term "Planning Authority" was replaced with "Planning Coordinator" as of NERC Reliability Functional Model, v. 3, 2/13/2007. However, since NERC Standard FAC-010-3 has not been revised to reflect the change in terminology, this document continues to use the term "Planning Authority" for the sake of consistency with its governing standard.

[2] The RC West SOL Methodology for the Operations Horizon can be found at the following link: https://rc.caiso.com/DocLibs/RCOperatingProcedures/CAISO/RC0610.pdf.

through R2.6) and Regional Difference E1 (E1.1 through E1.3) of NERC Standard FAC-10-3 as detailed in the following sections. (FAC-010-3 R2)

4.1 Performance Under Normal Conditions

In the pre-contingency state 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 known Facility outages. (FAC-010-3 R2.1)

4.2 Performance Following Single Contingencies

4.2.1 Required Performance

Following the single contingencies identified in paragraphs 4.2.1(a) through 4.2.1(d) below (here after "Single Contingencies"), 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-010-3 R2.2)

a) Single line to ground or three-phase Fault (whichever is more severe), with Normal Clearing, on any Faulted generator, line, transformer, or shunt device. (FAC-010-3 R2.2.1)

b) Loss of any generator, line, transformer, or shunt device without a Fault. (FAC-010-3 R2.2.2)

c) Single pole block, with Normal Clearing, in a monopolar or bipolar high voltage direct current system. (FAC-010-3 R2.2.3)

d) Other contingencies that are considered single contingencies by California ISO in accordance with the ISO Planning Standards, such as a combined line and generator unit (G-1/L-1) outage, and the loss of a combined cycle power plant module as a single generator outage.

4.2.2 Allowable Response

Starting with all Facilities in service, the system's response to a Single Contingency may include any of the following:

a) 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-010-3 R2.3.1)

b) System reconfiguration through manual or automatic control or protection actions. (FAC-010-3 R2.3.2)

c) 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-010-3 R2.4)

d) The use of Special Protection Systems or Remedial Action Plans consistent with 4.2.2(a) to (c) and applicable California ISO Planning Standard guidelines. (FAC-010-3 R3.4)

4.3 Performance Following Multiple Contingencies

4.3.1 Required Performance

When establishing SOLs, starting with all Facilities in service, evaluation of the following "Multiple Contingencies" is required:

a) The following Multiple Contingencies, which are identified in Reliability Standard TPL-003[3]. (FAC-010-3 R2.5):

i. SLG Fault on a Bus Section with Normal Clearing.

ii. SLG Fault on a Breaker (failure or internal fault) with Normal Clearing.

iii. SLG or 3Ø Fault with Normal Clearing on a generator, transmission circuit, transformer or dc line (single pole block) followed, after manual system adjustments, by another SLG or 3Ø Fault with Normal Clearing on a generator, transmission circuit, transformer or dc line (single pole block).

iv. Bipolar (dc) line Fault (non 3Ø) with Normal Clearing.

v. Any two circuits of a multiple circuit towerline[4].

vi. SLG Fault, with Delayed Clearing (stuck breaker or protection system failure) on a generator, transformer, transmission circuit or bus section.

b) The following Multiple Contingencies identified in Regional Difference E1.1.1 through E1.1.5 of Reliability Standard FAC-010-3:

i. Simultaneous permanent phase to ground Faults on different phases of each of two adjacent transmission circuits on a multiple circuit tower, with Normal Clearing. If multiple circuit towers are used only for station entrance and exit

[3] NERC TPL-001 through TPL-004 Standards have been replaced by TPL-001-4 effective 12/31/2015, which will be replaced by TPL-001-5 effective 7/1/2023. However, since NERC Standard FAC-010-3 has not been revised to reflect the change, this document will continue to refer to the former TPL Standards where the reference is related to a requirement in FAC-010-3 until FAC-010-3 is updated.

[4] System assessments may exclude these events where multiple circuit towers are used over short distances (e.g., station entrance, river crossings) in accordance with Regional exemption criteria.

purposes, and if they do not exceed five towers at each station, then this condition is an acceptable risk and therefore can be excluded.

ii. A permanent phase to ground Fault on any generator, transmission circuit, transformer, or bus section with Delayed Fault Clearing except for bus sectionalizing breakers or bus-tie breakers addressed in E1.1.7.

iii. Simultaneous permanent loss of both poles of a direct current bipolar Facility without an alternating current Fault.

iv. The failure of a circuit breaker associated with a Special Protection System to operate when required following: the loss of any element without a Fault; or a permanent phase to ground Fault, with Normal Clearing, on any transmission circuit, transformer or bus section.

v. A non-three phase Fault with Normal Clearing on common mode Contingency of two adjacent circuits on separate towers unless the event frequency is determined to be less than one in thirty years.

c) The following Multiple Contingencies identified in Regional Difference E1.1.6 through E1.1.7 of Reliability Standard FAC-010-3:

i. A common mode outage of two generating units connected to the same switchyard, not otherwise addressed by FAC-010-3.

ii. The loss of multiple bus sections as a result of failure or delayed clearing of a bus tie or bus sectionalizing breaker to clear a permanent Phase to Ground Fault.

Starting with all Facilities in service and following any of the Multiple Contingencies identified in 4.3.1(a) and (b) above, 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-010-3 R2.5, E1.2.1 to E1.2.4)

SOLs shall be established such that for multiple Facility Contingencies identified in 4.3.1(c) above, operation within the SOL does not result in Cascading. (FAC-010-3 E1.3)

4.3.2 Allowable Response

In determining the system's response to Multiple Contingencies the following shall be acceptable:

- In addition to the responses allowed for Single Contingencies under 4.2.2 (a) and (b) above, 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 subject to the ISO Planning Standards. (FAC-010-3 R2.6, E1.2.5, E1.2.7)

- The interruption of firm transfer, load or system reconfiguration through manual actions or by means of automatic control or protection actions such as Remedial Action Schemes or Special Protection Systems, consistent with applicable California ISO Planning Standard guidelines. (FAC-010-3 R3.4, E1.2.6)

4.4 Reliability Margin Requirements

Consistent with current WECC Criteria, SOLs shall meet the following reliability margin requirements with respect to voltage stability (FAC-010-3 R3):

- A reliability margin of five percent for SOLs associated with normal conditions and Single Contingencies
- A reliability margin of two-and-half percent for SOLs associated with Multiple Contingencies identified in 4.3.1 (a) and (b).

5 Study Methodology

5.1 Methodology for Determining SOLs

In accordance with the requirements of NERC FAC 010-3, evaluation of system performance under normal conditions with all facilities in service, following Single and Multiple Contingencies is required when establishing SOLs. Steady state power flow, post-transient governor power flow and transient stability studies are used to evaluate system performance. SOLs should be established based on one or more scenarios within the planning horizon as appropriate.

All transmission facilities have physical facility ratings. A facility may be further constrained by a SOL when studies indicate the applicable normal or post contingency system performance requirements (thermal, voltage, stability) limit the operation of the facility below its facility rating in the pre-contingency state. Where a group of facilities are monitored as a transmission path, the SOL for the path must be established based on the applicable system performance requirements.

The SOL for a facility or path is generally determined by increasing or decreasing the relevant pre-contingency system variable associated with the facility or the path, most commonly power flow on a line or path, until the maximum safe operating point that results in acceptable performance for all applicable contingencies is reached. The SOL could be, among other things, a limit of power flowing on a line or path, a total generation limit in an area, or a limit on the total export of power from or to an area.

In cases where a facility or a path is desired to have a target SOL, SOL studies are conducted with the facility or path modeled at the desired SOL level, and the system enhancements or operational measures, if any, that are necessary to achieve the desired SOL are identified.

Post transient or voltage stability analysis is also performed to ensure the SOL meets voltage stability margin requirements.

Applicable facility normal ratings shall be applied in the pre-contingency state, and emergency ratings shall be applied following Contingencies. Applicable emergency ratings are those that are valid for a duration of at least 30 minutes. Facility voltages and voltage deviation limits shall be applied in accordance with the California ISO Planning Standards and WECC regional criteria.

The following sections provide general requirements and guidelines to be considered when performing studies to determine SOLs.

5.1.1 Study Models and Assumptions

Study Models used in the determination of SOLs must include at least the entire ISO Planning Authority Area as well as the critical modeling details from other Planning Authority Areas that would impact the facility or facilities under study. In general, study models should be based on recent WECC base cases which include the entire Western Interconnection. (FAC-010-3 R3.1)

Study models must be based on a full loop representation of the system and should be updated as appropriate to reflect the most accurate representation of transmission system configuration and ratings, generation and load in the study area for the study time period. (FAC-010-3 R3.3)

Study assumptions including load levels, generation dispatch and transfer flows should reflect expected system operating conditions and should be appropriate for the study. All relevant facilities should be within their normal thermal ratings and voltage limits and within applicable System Operating Limits. Relevant assumptions included in the study cases should be documented.

5.1.2 Power Flow Analysis

Power flow analysis is used to evaluate system performance under normal and applicable Single and Multiple Contingency conditions to identify facilities, if any, whose thermal or voltage (including voltage stability) limits may be violated. Power flow analysis may also be used to further evaluate the risk and impact of Cascading associated with excessive thermal overloading, in particular when evaluating SOLs that may qualify as IROLs. Contingencies that result in divergence or excessive voltage deviation should be further evaluated using post transient and transient analysis tools as appropriate.

- Selection of Applicable Contingencies

  All Single and Multiple Contingencies associated with or that could limit the operation of the facility or facilities under study, including those outside the ISO Planning Authority Area, should be studied. Applicable contingencies may be selected based on previous studies, established knowledge of the system in the study area and contingency screening studies. A description of the contingencies studied along with the rationale for selecting the contingencies should be documented. (FAC-010-3 R3.2)

- Selection of Monitored Facilities

  All facilities in the study area that could be impacted by the SOL of the facility or facilities under study, including those that are outside the ISO Planning Authority Area, should be monitored. A description of the monitored facilities along with the rationale for selection should be documented.

Available SPS or automatic remedial measures which affect steady state system response may be applied. These remedial measures may include generation and load dropping and automatic series and shunt capacitor switching. Manual remedial measures may not be applied except following the initial outage when simulating overlapping Single Contingencies for the purpose of establishing SOLs.

5.1.3 Post-Transient Analysis

Post-transient governor power flow analysis is used as required to evaluate system performance under normal and following critical Single and Multiple contingencies to identify facilities, if any, whose thermal, voltage, or voltage stability limits may be violated. Post-transient analysis in particular is utilized to further evaluate a limited number of critical contingencies where the results may benefit from the more detailed representation of the contingencies or a more accurate system response. Post transient analysis may also be used to further evaluate the risk and impact of Cascading associated with excessive thermal overloading, in particular when evaluating SOLs that may qualify as IROLs.

Either a standard power flow or post-transient analysis with the SOL quantity under study increased by the applicable margins or P-V analysis should be performed as required to ensure SOLs meet applicable voltage stability margin requirements. For contingencies that cause simulations to diverge — which signals voltage instability — post-transient voltage stability analysis may be performed using the P-V method to determine the SOL.

- Selection of Applicable Contingencies

The contingency list for post-transient analysis should include all critical contingencies, including those outside the ISO Planning Authority Area, for which further evaluation is required. This may include contingencies for which power flow simulation did not solve or post transient analysis is considered more appropriate. Applicable contingencies may also be selected based on previous studies or established knowledge of the system in the study area. A description of the contingencies studied along with the rationale for selecting the contingencies should be documented. (FAC-010-3 R3.2)

- Selection of Monitored Facilities

All facilities in the study area that could be affected by the SOL of the facility or facilities under study should be monitored, including those that are outside the ISO Planning Authority Area. A description of the monitored facilities along with the rationale for the selection should be documented. Currently, the tool used for post-transient analysis at California ISO monitors loading and voltage deviation of all BES facilities in the ISO Planning Authority Area and adjacent areas.

Available SPS or automatic remedial measures which affect post-transient system response may be applied. These remedial measures may include automatic series and shunt capacitor switching, generation and load dropping. Manual remedial measures should not be applied except following the initial outage when simulating overlapping Single Contingencies for the purpose of establishing SOLs. Transmission voltage regulating transformers, shunt capacitors and reactors, and phase shifting transformers should be fixed at their pre-contingency state except where there is specific information to do otherwise. Area interchange control should be disabled.

5.1.4 Transient Stability Analysis

Transient stability studies should be performed as needed to identify transient stability-related System Operating Limits and to further evaluate the impact of instability, in particular, when evaluating SOLs that may qualify as IROLs. A simulation result demonstrates stability if the system remains in synchronism and post disturbance oscillations exhibit positive damping. Duration of a stability simulation run should be ten seconds unless a longer time is required to ascertain stability.

- Selection of Applicable Contingencies

  The contingency list for transient stability analysis should include all critical Single and Multiple Contingencies, including those outside the ISO Planning Authority Area. Applicable contingencies may be selected based on the results of the power flow and post-transient analyses, previous studies and established knowledge of the system in the study area. A description of the contingencies studied along with the rationale for selecting the contingencies should be documented. (FAC-010-3 R3.2)

- Selection of Monitored Facilities

  Such variables as relative machine angles, frequency and voltages associated with selected facilities should be monitored to evaluate transient stability performance. A description of the monitored facilities along with the rationale for the selection should be provided. The action of under frequency and under voltage load shedding schemes and protection systems should also be monitored during the simulation.

System disturbance for stability studies should be simulated at locations that result in maximum stress on the system. Relay action and fault clearing time should be represented in simulations according to the expected operation of the system. Available SPS or automatic remedial measures which affect transient response should be modeled. These remedial measures may include high speed series and shunt capacitor switching, generation and load dropping. Manual remedial measures should not be applied except following the initial outage when simulating overlapping Single Contingencies for the purpose of establishing SOLs.

5.2 Methodology for Determining SOLs that Qualify as IROLs

This section includes criteria and guidelines to identify the subset of SOLs that qualify as IROLs and criteria for developing any associated IROL T_v. (FAC-010-3 R1.3, R3.6)

5.2.1 General IROL Criteria

By definition, any 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 shall be designated as an IROL. In general, instability, uncontrolled separation and cascading outages could lead to a widespread impact on the reliability of the BES and affect service to a large number of customers. Therefore, a SOL that could cause such adverse impacts if the limiting Single or Multiple Contingency occurs while the SOL is exceeded or, in the case of overlapping Single Contingencies, if the system is not adjusted quickly enough after the initial contingency should be identified as an IROL.

5.2.2 Excessive Overloading

Excessive overloading can cause cascading, instability or uncontrolled separation if the excessively overloaded facility is removed from service due to relay action, equipment failure, faults caused by excessive sagging or forced immediate manual disconnection (for example, due to public safety concerns). Each of these factors have contributed to one or more major past cascading outages in North America from the 1977 New York City Blackout to the 2011 Arizona-Southern California Outages. Conductor contact with trees and relay action that result from facility overloading are two of the common contributing factors for cascading outages[5].

Given some of these factors cannot be modeled in simulations, a facility should be flagged for further evaluation if the facility loading exceeds the lesser of:

- The facility's protection relay trip setting, and

[5] See Final Report on the August 14, 2003 Blackout (pages 103-110) and September 2011 Arizona-Southern California Outage Report.

- 125 percent of the facility's highest rating defined for a duration of 30 minutes or more[6].

Simulation steps for evaluating the impact of the loss of facilities that are flagged as excessively overloaded are described in Section 5.2.7.

5.2.3 Load Impact Threshold

There may be cases where the impact of instability, uncontrolled separation or cascading outages associated with a SOL violation is limited to a single facility or a local area. In such cases, the SOL may not qualify as an IROL provided the uncontrolled loss of load associated with its violation is demonstrated to be less than 1000 MW.

The load impact threshold represents an upper bound for load loss regardless of demonstrated containment, but excludes the loss of load due to the intended action of RAS/SPS. The threshold is intended to restrict the applicability of IROLs to large-area impacts rather than small-load areas. However, this requirement is not intended to limit the ability of the ISO or Transmission Planners in its Planning Authority Area from designating a SOL as IROL when doing so is considered prudent.

5.2.4 IROL T_V

The IROL T_V within the California ISO Planning Authority Area shall be:

- 30 minutes for all IROLs that are established for the pre-contingency state to satisfy post-contingency system performance requirements.
- Zero minutes for IROLs that are not contingency related unless, for example, the IROL is related to the action of a protection system with a built-in time delay, in which case the length of the time delay or 30 minutes, whichever is lower, shall be the IROL $T_{V.}$

5.2.5 Overlapping Single Contingencies

The methodology for determining SOLs that is described in Section 4 allows making manual system adjustments after the initial contingency when simulating the impact of overlapping Single Contingencies. However, when evaluating whether a SOL qualifies as IROL, the impact of not making required manual system adjustments quickly enough after the initial contingency, i.e. within an IROL Tv of 30 minutes, should be simulated. If results of simulation of an overlapping Single Contingency without manual system adjustment are consistent with that of an IROL violation, the SOL should be designated an IROL for the planning horizon. Corrective control capabilities and resources should be available to enable

[6] The 125% threshold is based on the WECC Transmission System Planning Performance Criterion TPL-001-WECC-CRT-3.2. The use of facility ratings defined for a duration of at least 30 minutes is to align the applicable rating with the definition of IROL T_V.

the system to return to a secure N-1 state as soon as possible, but no longer than 30 minutes following the critical Single Contingencies.

The application of this test is limited to SOLs associated with major facilities or paths that are considered to have the potential to qualify as IROLs. Such SOLs include, but may not be limited to SOLs that are associated with:

- transmission paths comprised of one or more transmission facilities operated at 500 kV or higher, or
- transmission paths comprised of three or more transmission facilities operated between 200 kV and 499 kV and have an "aggregated weighted value" exceeding 3000 according to the following table from NERC CIP-002-5.1a.

Voltage Value of a Line	Weight Value per Line
Less than 200 kV (not applicable)	(not applicable)
200 kV to 299 kV	700
300 kV to 499 kV	1300
500 kV and above	0

5.2.6 Identification of Facilities Critical to the Derivation of IROLs

NERC Standards such as CIP-014 and CIP-002 require identification of generation and transmission facilities that are critical to the derivation of IROLs. Generation and transmission facilities in California ISO Planning Authority Area that should be identified as critical to the derivation of an IROL in the planning horizon should include, but may not be limited to, each:

- facility that is a critical contingency for the IROL; or
- limiting element that is critical to the onset of instability, Cascading, or uncontrolled separation associated with the IROL

An SPS/RAS or other automated switching system should be identified as critical in the derivation of IROLs if its unavailability or failure to operate as designed would cause

- one or more SOLs to qualify as IROLs; or
- reduction in the value of one or more IROLs

5.2.7 Simulation Procedures for Determining IROLs

This section describes the simulation procedures for determining whether a SOL qualifies as an IROL assuming the SOL is already established in accordance with the SOL methodology. The main application of the procedure is to SOLs associated with major transmission facilities or paths that are considered to have the potential to qualify as IROLs, such as those that meet the criteria defined in Section 5.2.5. The procedure consists of the following two parts.

The first part of the process involves simulating the impact of Single and Multiple Contingencies other than overlapping Single Contingencies while the SOL of the facility or path under study is violated. This is done by simulating the impact of critical contingencies with the SOL exceeded by 5 percent or 2.5 percent depending on whether the contingency is a Single Contingency or a Multiple Contingency, respectively. The SOL exceedance percentages are based on the margin applied for voltage stability in the WECC region.

The second part of the process involves simulating the impact of overlapping Single Contingencies assuming the facility or path is not adjusted from its operation at its SOL to a secure N-1 state quickly enough after the initial Single Contingency, i.e. within an IROL T_V of 30 minutes. This is accomplished by simulating critical overlapping Single Contingencies with the system in steady state after the first contingency but without manual adjustment between the first and second contingencies. Steady state in this context is the state of the system after all automatic system responses have taken place and represents the state of the system 30 minutes after the initial contingency if operators do not make manual system adjustments.

Simulation results are considered to be consistent with IROL violation if transient instability, voltage instability, cascading or uncontrolled separation are observed. The potential for Cascading and uncontrolled separation due to excessive overloading — that is overloading in excess of the lower of the facilities trip setting or 125% of the facility's short-term rating — is evaluated assuming the affected facility would be removed from service. Simulations are repeated with excessively overloaded facilities removed from service until the SOL is confirmed to qualify as an IROL or no facility is excessively overloaded. If the excessively overloaded facility is a series capacitor on a transmission line, the series capacitor should be short-circuited (bypassed) rather than opened-circuited unless specific information is available.

During the simulations, the amount of load disconnected by protective action, safety net, UVLS and UFLS schemes or by manual action should be monitored. Disconnection of a total firm load exceeding the load impact threshold of 1000 MW should qualify the SOL as an IROL even if the simulation results do not indicate instability, cascading or uncontrolled separation.

The ISO will collaborate with affected Transmission Planners and Planning Authorities, as appropriate, in the determination of IROLs in the planning horizon.

6 Applicable Study Processes

This section describes the various study processes that may be used in the California ISO Planning Authority Area for developing and validating SOLs and IROLs. These processes include:

- The WECC Path Rating Process
- Annual ISO Transmission Planning Process (TPP)
- Other qualified studies that are consistent with NERC Standard FAC-010-3 and this SOL Methodology.

6.1 WECC Path Rating Process

The determination of Path Ratings for WECC paths follows the rigorous and collaborative WECC Path Rating Process detailed in the WECC guideline entitled Project Coordination, Path Rating and Progress Report Processes. The process requires members of the Western Interconnection to perform path rating studies in a way that conforms to the requirements, methodology, and processes contained therein including adherence to the NERC Reliability Standards and WECC Criteria. Facilities are granted an "Accepted Rating" by WECC at the conclusion of the review process. Transmission paths are subject to the WECC Path Rating Process if any of the following criteria apply:

- The limiting condition (e.g., thermal limit, stability, or voltage) in determining the Total Transfer Capability of the path or the System Operating Limit for transmission facilities that affect the path is on another system and the affected member system requests the path be rated.
- The study criteria that was required for establishing Accepted or Existing Rating has been changed and a path owner(s) or Project Sponsor(s) in at least Phase 2b of the Path Rating Process have requested a new path rating.
- The path must be operated within the constraints of a nomogram to meet NERC Reliability Standards and WECC Criteria, the elements of the nomogram (e.g., path flows or generation levels) are in different systems, and one of those systems or a neighboring member system requests the path be rated.
- The path owners or operators have requested a seasonal or operational Total Transfer Capability for a new path, or the path owners or operators have requested a seasonal or operational Total Transfer Capability that is in excess of an existing path's rating (Accepted, Existing, or Other).
- A facility (generator, series, or shunt reactive equipment; Remedial Action Scheme (RAS); etc.) that an Existing or Accepted Rating depends on is modified[9] or retired

from service, without regard to whether the facility is owned by the same system as the rated path.

- When a project seeks a path rating under the WECC Path Rating Process on a voluntary basis.

Ratings of WECC Transfer Paths are officially documented in the WECC Path Rating Catalog which is updated annually. For each Path, the Catalog includes a map of the Path, description of the Path, its Transfer Limit or Rating, and check boxes to identify whether the rating is an "Accepted Rating", "Existing Rating" or "Other Rating", as these terms are explained in the Catalog.

It is California ISO's assessment that Accepted Ratings for WECC Paths associated with the California ISO Planning Authority Area meet the intent and requirements of NERC FAC-010-3 and this SOL Methodology with respect to the determination of SOLs. Exceptions are new Accepted Ratings that are developed without considering the FAC-010-3 requirements applicable to the WECC region that are still included in the Regional Differences section but have recently been removed from the WECC Path Rating criteria. Therefore, WECC Accepted Ratings for facilities relevant to the California ISO Planning Authority Area are deemed to be the SOLs for those facilities for the planning horizon subject to the above exception and the conditions outlined in the Applicability section above. The ISO will continue to participate in the rating process for WECC transfer paths relevant to its Planning Authority Area to ensure proposed ratings are consistent with this SOL Methodology.

Path Ratings are subject to a review process based on the criteria specified above. When the Rating for an applicable WECC Path changes as a result of such a review, the new Accepted Rating becomes the SOL for the Path. In addition, the ISO may use its annual Transmission Planning Process to further ensure path ratings continue to be appropriate for use as SOLs in the planning horizon.

Since the WECC Path Rating Process does not include identifying IROLs, California ISO will collaborate with affected Transmission Planners and Planning Authorities to identify which of the Path Ratings relevant to the ISO Planning Authority Area qualify as IROLs in the planning horizon, consistent with this Methodology.

6.2 Annual ISO Transmission Planning Process

California ISO may use annual reliability assessment studies that are performed as part of the ISO Transmission Planning Process (TPP) in conjunction with supplemental SOL studies, as required, to identify or validate SOLs and IROLs for the planning horizon. Typically, the ISO uses the annual reliability assessment studies to identify reliability constraints that limit the operation of BES facilities or paths below their rating under normal conditions, and then performs supplemental studies, as needed, in accordance with this methodology to establish the SOL if the SOL is considered appropriate for use in the reliable planning of the BES.

The annual reliability assessment process which is developed in accordance with the requirements of the NERC TPL-001 Standard, the WECC Regional Criteria, and the ISO Planning Standards is consistent with NERC Standard FAC 10-3 and this SOL Methodology. Following is a high level overview of the Reliability Assessment process.

Reliability Assessment is a component of the annual ISO Transmission Planning Process (TPP), which culminates in a Transmission Plan report that provides a comprehensive assessment of the ISO system. The ISO has developed a Business Practice Manual (BPM) for the Transmission Planning Process which describes how transmission planning studies are to be conducted. The BPM requires the ISO to conduct power flow, post-transient voltage stability, and transient stability studies to demonstrate that the ISO system meets or exceeds the requirements of the NERC TPL-001 standard, the WECC regional criteria, and the ISO Planning Standards.

Following the BPM, the ISO prepares and publishes the annual transmission plan report. The Reliability Assessment component of the report, in particular, provides detailed information on the types of studies performed, years of study, base case modeling assumptions, load forecasts, generation dispatch, seasons studied, transfer levels on major WECC paths, and contingencies evaluated. Appropriate mitigations are proposed for any system performance issues identified. The mitigations generally include transmission upgrades, application of special protection systems (SPS) and operational solutions. As mentioned above, the operational solutions that involve limiting the operation of facilities below their rating in the pre-contingency state identify the facilities subject to SOLs. Supplemental studies may then be performed in accordance with this methodology to determine the SOL values and to identify which of the SOLs qualify as IROLs.

6.3 Other Qualified Studies

California ISO and Transmission Planners within its Planning Authority Area may establish SOLs and IROLs based on other studies provided the studies are consistent with NERC Standard FAC-010-3 and this SOL Methodology. Such studies may include SOL and path rating studies performed by the Transmission Planners and the Transmission Planners' annual reliability assessment or transmission planning studies performed pursuant to the NERC TPL-001-4 Standard, the WECC Regional Criteria, and the ISO Planning Standards.

7 Communication Requirements

The ISO shall issue this SOL Methodology, and any change to this methodology, to all of the following prior to the effectiveness of the change: (FAC-010-3 R4)

- Each adjacent Planning Authority and each Planning Authority that indicated it has a reliability-related need for the methodology. (FAC-010-3 R4.1)
- Each Reliability Coordinator and Transmission Operator that operates any portion of the ISO's Planning Authority Area. (FAC-010-3 R4.2)
- Each Transmission Planner that works in the ISO's Planning Authority Area. (FAC-010-3 R4.3)

8 Supporting Information

8.1 Document Owner

California ISO – TIP	California ISO Transmission Infrastructure Planning (TIP)

8.2 References

NERC Reliability Standards	**FAC-010-3** - System Operating Limits Methodology for the Planning Horizon
	FAC-014-2 – Establish and Communicate System Operating Limits
	TPL-003 - System Performance following loss of two or more Bulk Electric System elements (Category C)
	TPL-001-4 - Transmission System Planning Performance Requirements
	PRC-023-4 - Transmission Relay Loadability
	PRC-024-2 - Generator Frequency and Voltage Protective Relay Settings
WECC	WECC Project Coordination, Path Rating and Progress Report Processes Guideline
	WECC Path Rating Catalog
	WECC Transmission System Planning Performance Criterion TPL-001-WECC-CRT-3.2
RC West	System Operating Limits Methodology for the Operations Horizon
California ISO	Business Practice Manual (BPM) for the Transmission Planning Process
	California ISO Planning Standards
Major System Outage Reports	Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations (U.S.-Canada Power System Outage Task Force)
	Arizona-Southern California Outages on September 8, 2011: Causes and Recommendations (FERC and NERC Staff)

8.3 Version History

Version	Change	By	Date
1.0	1st Draft	Nan Liu	6/25/07
2.0	Updated for NERC Standard compliance	Nisar Shah	2/18/09
2.1	Updated to comply with the revised NERC Standard FAC-010-2.1 and to be consistent with the change in Functional Entity from the Planning Authority to the Planning Coordinator, as defined in the NERC Reliability Functional Model-Version 5.	Nisar Shah	8/3/10
3.0	Major document revision including addition of criteria for determining IROLs.	Nebiyu Yimer	1/29/13
3.1	Incorporated additional IROL methodology details and other miscellaneous document updates.	Nebiyu Yimer	5/27/15
3.2	Minor document update	Nebiyu Yimer	4/12/18
3.3	Removed footnote referencing the Peak RC SOL methodology for the 1000 MW load impact threshold for establishing cascading.	Nebiyu Yimer, Ebrahim Rahimi	5/24/18
3.4	Miscellaneous document updates	Nebiyu Yimer, Ebrahim Rahimi	6/13/2022

9 Technical Review

Reviewed By	Name	Signature	Date
Manager, Regional Transmission – South	Robert Sparks		June 13, 2022
Manager, Regional Transmission – North	Binaya Shrestha		June 13, 2022
Manager, Infrastructure Compliance	Jamie Johnson		June 14, 2022

10 Approval

Approved By	Name	Signature	Date
Director, Transmission Infrastructure Planning	Jeffrey Billinton		June 15, 2022