



# **Bulk Electric System (BES) Planning Criteria**

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## 1.0 Introduction

The primary purpose of Evergy's bulk electric system (BES) is to supply our customers with economic and reliable electrical energy. To achieve this objective Transmission Planning has developed planning criteria that provides the basis for the minimum design and operating criteria of the BES. Evergy's Bulk Electric System (BES) Planning Criteria meets or exceeds all North American Electric Reliability Corporation (NERC) Reliability Standards and Southwest Power Pool (SPP) Transmission Planning Criteria.

## 2.0 Transmission Planning Studies

The interconnected transmission system should perform reliably under a wide variety of expected system conditions while continuing to operate within equipment and electric system thermal, voltage, and stability limits. Electric systems must be planned to withstand contingencies and maintenance outages. Extreme event contingencies, which measure the robustness of the electric systems, should be evaluated for risks and consequences. The NERC Reliability Standards define specific transmission planning requirements that provide reliability for the bulk interconnected electric system. SPP provides coordinated regional transmission planning requirements to promote reliability through its Planning Criteria Section 5, "Regional Transmission Planning", and related Attachment O, "Coordinated Planning Procedures", in the SPP Open Access Transmission Tariff (OATT).

Transmission planning criteria for the Evergy electric system shall at a minimum conform to the NERC Reliability Standards and SPP Transmission Planning Criteria Section 3 and meet the following:

- a) Excessive concentration of power being carried on any single transmission circuit, multi-circuit transmission line, or right-of-way, as well as through any one transmission station shall be avoided.
- b) Adequate transmission capability shall be maintained to provide for intra-regional, inter-regional and trans-regional power flows under normal and more probable contingency conditions as defined in Table 1 of the NERC Reliability Standards.
- c) Switching arrangements shall be utilized that permit effective maintenance of equipment without excessive risk to the electric system.
- d) Switching arrangements and associated protective relay systems shall be utilized that do not limit the capability of a transmission path to the extent of causing excessive risk to the electric system.
- e) Sufficient reactive capacity shall be planned within the Evergy electric system to maintain transmission system voltages within the criteria defined in Section 2.1. Some stations, such as those with combustion turbines connected to them, require higher voltage levels and thus may need additional reactive resources.

Transmission planning is performed for all planning horizons; operational (real time to 1 year in future), Near-term (1 to 5 years in future), and Long-term (5 to 10 years in future). It generally involves the analysis of the transmission system under various operating conditions, the identification of any potential violations, and the development of plans or actions to mitigate each violation.

Transmission planning must interface with the planning performed by the Distribution Provider and Resource Planner functions of the NERC Reliability Functional Model. The Distribution Provider provides input on the size and location of loads to the transmission planning process. The Resource Planner provides the size and locations of future resources through the SPP process. Long-term transmission planning is performed to develop an overall plan for expansion of the transmission system. This would include the approximate capacity and location of transmission assets required for future operations. Near-term transmission planning is performed to refine portions of the long-term transmission plan on localized areas and provide more definition of required transmission assets.

Another part of transmission expansion is driven by transmission service requests and generation interconnection requests made to SPP as the RTO. Evergy participates in SPP's transmission system planning process to assess the ability of the transmission system to provide these requested services. This includes development of plans or new transmission asset additions that will be required to meet reliability standards if the requested services are granted.

## **2.1 Transmission Contingency Analysis**

The Evergy transmission system shall be planned and constructed to meet the applicable NERC Reliability Standards for Table 1 of TPL-001-4, SPP Planning Criteria and their applicable requirements and measurements, and Evergy's own BES Planning Criteria.

Table 1 was developed to thoroughly search out the most severe, credible contingencies for study, creating the assurance that the many possible contingencies not studied are less severe. It lists the normal and contingency conditions under which the electric transmission system is to be analyzed. It also lists the limits or impacts that the transmission system can sustain and still meet an acceptable performance level.

### **2.1.1 Base Case Analysis**

Evergy will support and participate in the SPP Model Development Working group (MDWG) development and verification of base case transmission system models. Evergy base case models will maintain at least the following attributes:

- System facilities shall be modeled to reflect normal operating conditions and limits
- Line and equipment loading shall be within normal rating limits
- Voltage levels shall be maintained within plus or minus 5% of nominal voltage for all buses 69 kV and above
- Voltage levels at the Wolf Creek 345 kV substation shall be maintained between plus 3% and minus 1% of nominal voltage
- All customer electrical demands shall be supplied, and all contracted firm (non-recallable reserved) transfers shall be maintained
- Stability (dynamic and steady state) of the network shall be maintained
- Cascading outages shall not occur

### 2.1.2 Loss of Single Component Analysis

Eversource will perform single contingency studies under the following conditions:

- Initiating incident results in a single element out of service
- Line and equipment loadings shall be within emergency rating limits
- Voltage levels shall be maintained within plus 5% or minus 10% of nominal voltage for all busses within the Eversource Metro & Missouri West system
- Voltage levels shall be maintained within plus 5% and minus 7% of nominal voltage for load-serving busses from 69 – 200 kV and within plus 5% and minus 5% of nominal voltage on all busses above 200 kV within the Eversource Kansas Central System
- Voltage levels at the Wolf Creek 345 kV substation shall be maintained between plus 3% and minus 1% of nominal voltage
- No loss of customer electric demand (except as allowed through Attachment 1 of TPL-001-4)
- No curtailment of contracted firm (non-recallable reserved) transfers shall be required
- Stability (angular and voltage) of the network shall be maintained
- Cascading outages shall not occur

### 2.1.3 Loss of Two or More Transmission Components

Eversource will perform contingency studies under the following conditions:

- Initiating incident may result in two or more (multiple) components out of service including common right-of-way and common structure circuits
- Line and equipment loadings shall be within emergency thermal rating limits
- Voltage levels shall be maintained within plus 5% or minus 10% of nominal voltage for all busses within the Eversource Metro & Missouri West system
- Voltage levels shall be maintained within plus 5% and minus 7% of nominal voltage for load-serving busses from 69 – 200 kV and within plus 5% and minus 5% of nominal voltage on all busses above 200 kV within the Eversource Kansas Central System
- Voltage levels at the Wolf Creek 345 kV substation shall be maintained between plus 3% and minus 1% of nominal voltage
- Stability (angular and voltage) of the network shall be maintained
- Planned outages of customer demand or generation (as noted in Table 1 of TPL-001-4) may occur
- Contracted firm (non-recallable reserved) transfers may be curtailed
- Cascading outages shall not occur

### 2.1.4 Post-Contingency Voltage Deviation

Post-contingent voltage deviation is allowed unless the voltage falls outside applicable limits as outlined in Sections 2.1.1 through 2.1.3 above.

### 2.1.5 Extreme Contingency Events

Eversource will perform contingency studies where extreme contingency events could lead to uncontrolled cascading outages or system instability. Eversource shall document the measures and procedures to mitigate or eliminate the extent and effects of those events.

## 2.2 Short Circuit Analysis

After performing a short circuit analysis, the calculated fault current at any given transmission bus will be compared against the interrupt capability of all applicable breakers. If any applicable breakers are incapable of interrupting the fault duty, each potentially underrated breaker will be subjected to a fault under line-out conditions. Line out conditions are such that for the potentially underrated breaker, any transmission element protected by the breaker will be removed from service and a fault will be applied. When the results of the fault are received, the element will be placed back in service and the next applicable transmission element will be removed from service. This process is repeated for each applicable transmission element associated with the potentially underrated breaker. The worst-case line-out fault current will be compared against the interrupt duty of the breaker. If the worst-case line-out fault current exceeds the breaker interrupt rating, it should be flagged as underrated and a corrective action plan will be identified.

## 2.3 Dynamic Stability Analysis

To assess positive damping of power oscillations and transient voltage recovery during dynamic stability simulations, Evergy follows the SPP Disturbance Performance Criteria.

### 2.3.1 Power Oscillation Damping Requirements

The SPP Criteria uses Successive Positive Peak Ratios (SPPR) of machine rotor angles to determine if power oscillations are positively damped as seen in Figure 1. SPPR1 (first and second positive peak magnitudes) and SPPR5 (first and sixth positive peak magnitudes) are used to evaluate power oscillation damping if: 1) the statistical range of the machine rotor angle for the entire simulation is 16-degrees or greater, or 2) the machine rotor angle does not converge to a steady-state value by the end of the simulation (as seen in Figure 2). If the machine rotor angle channel does not converge or if SPPR1 is greater than or equal to 0.950 and SPPR5 is greater than or equal to 0.774, the power oscillation for the observed machine is unstable.

Any time after a disturbance is cleared bus voltages on the BES shall not swing outside of the bandwidth of 0.70 per unit to 1.20 per unit (shown in Figure ).

### 2.3.2 Transient Voltage Recovery Requirements

Per the SPP Disturbance Performance Criteria (as seen in Figure 3), bus voltages on the Bulk Electric System shall recover above 0.70 per unit, within 2.5 seconds after the fault is cleared. Bus voltages shall not swing above 1.20 per unit after the fault is cleared, unless affected transmission system elements are designed to handle such a rise.

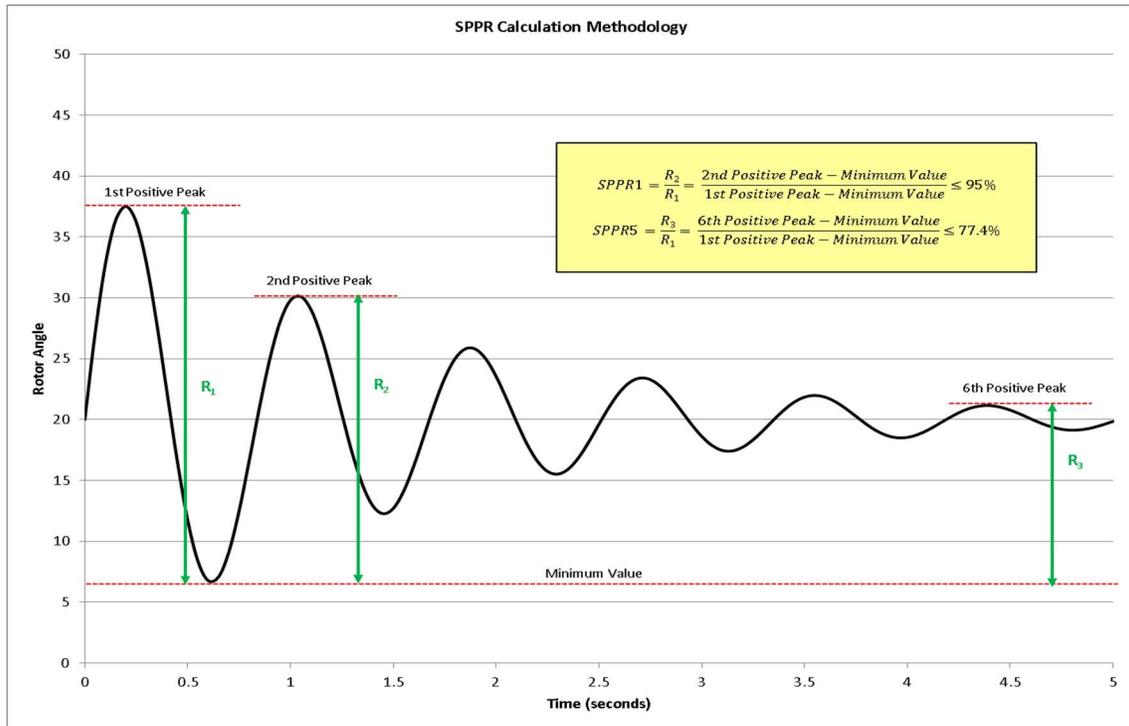


Figure 1: Successive Positive Peak Ratio (SPPR) Requirements

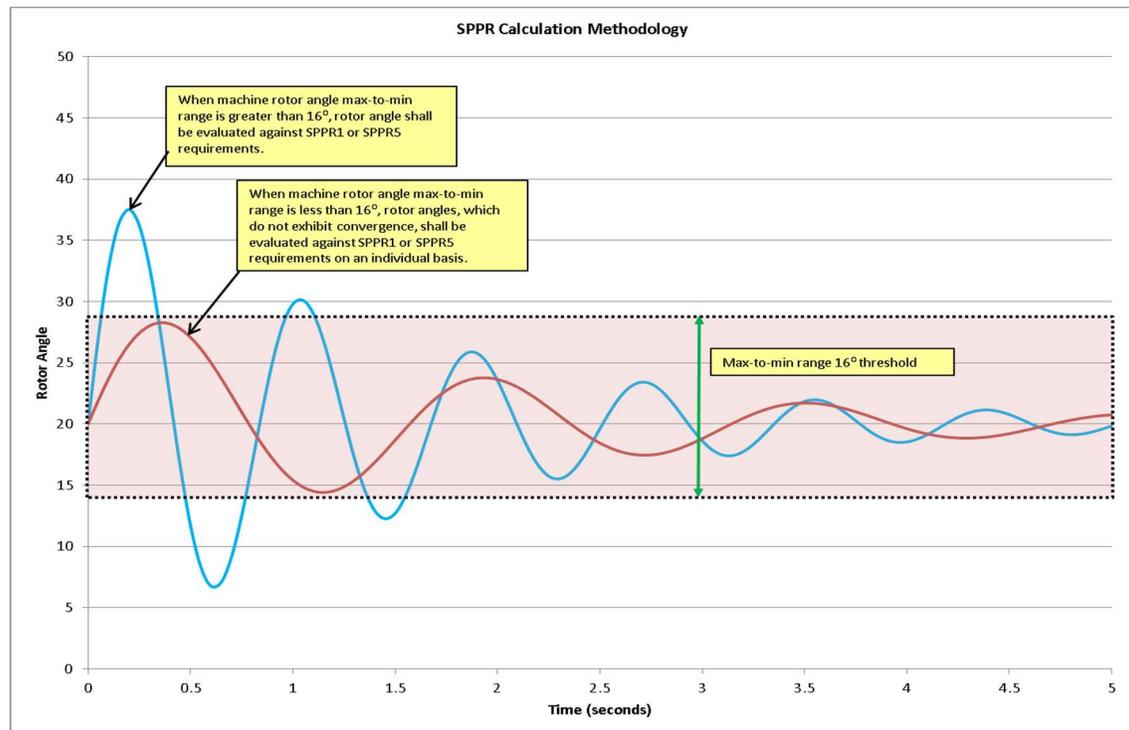


Figure 2: 16-Degree Minimum Rotor Angle Disturbance

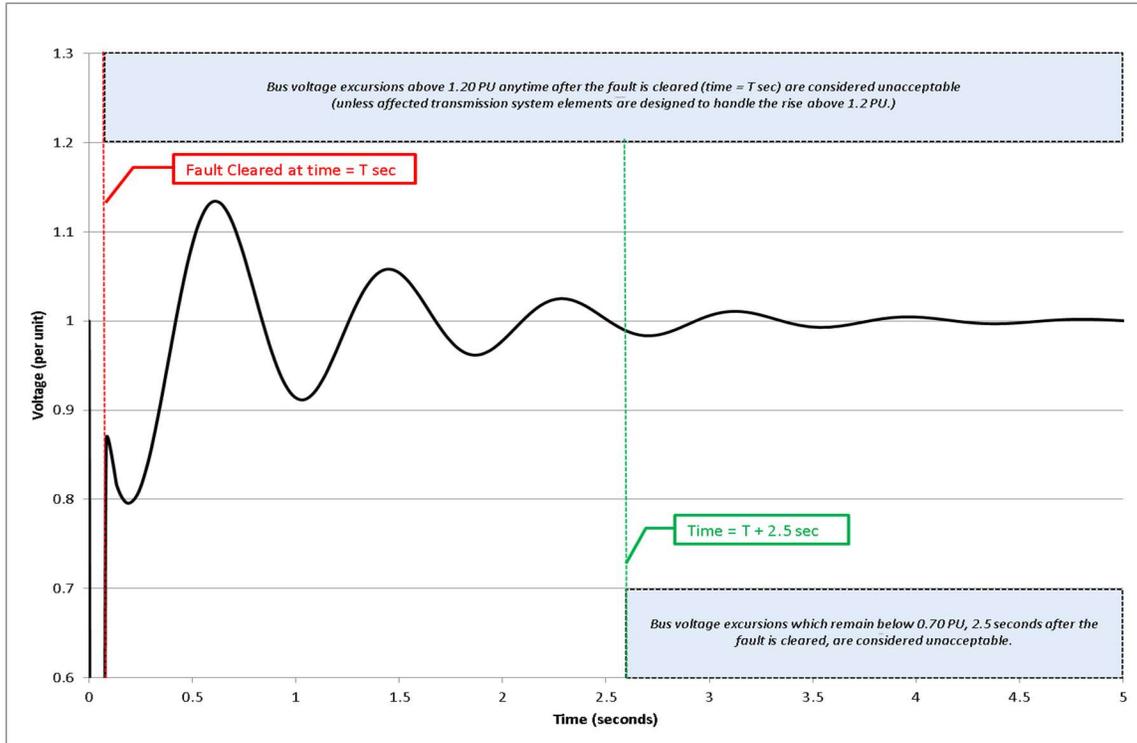


Figure 3: Transient Voltage Recovery Requirements

### 3.0 Transmission Planning for Serving New Customer Load

Distribution Planning Engineering has traditionally planned for serving existing and new load additions on the Evergy distribution systems (<69kV). This includes determining when new transmission sources are needed to meet increased demand on the distribution system due to, but not limited to, overloaded distribution facilities or inadequate distribution voltage profiles. These new substations are incorporated into Evergy’s transmission expansion plan by optimizing the existing transmission system network or expanding the system into these areas. Evergy will study load additions according to applicable NERC Standards, SPP Planning Criteria and OATT, and good utility practice.

### 4.0 Looping of Radial Facilities

The looping of radial facilities by the expansion of the transmission system will be considered when the product of the total radially served load and the length of the radial exceeds 400 MW-miles. Evergy will consider multiple factors when deciding whether an additional transmission feed is necessary.

## 5.0 Protective Relaying

Protective relaying, communications and instrumentation play an important role in maintaining the reliability of the BES. Protective Relay Systems (PRS) requirements shall be considered during the planning and design of generation, transmission and substation configurations. Protective system relays shall conform to NERC Protection and Control (PRC) Standards and accepted IEEE/ANSI practices.

- The bulk power protective relay system design shall have as its objective rapid clearing of all faults, with no fault permitted to remain uncleared despite the failure of any single protective system component. To accomplish this, transmission protection systems shall be installed as required to meet, at a minimum NERC PRC and Transmission Planning (TPL) Standards.
- Transmission Operators shall maintain communications systems to their generating stations, operation centers and to neighboring utilities, which shall provide adequate communication in the event of failure of any one element of the systems. In general, such communication systems should not be susceptible to failure during an interruption of the A.C. power supply in any part or all of their areas.
- Loading on the BES shall be monitored continually to ensure that operation is within safe limits.
- Suitable instrumentation, and/or other devices, shall be installed to measure appropriate quantities at key points in the electric system with appropriate automatic alarms.
- Underfrequency Load Shedding (UFLS) equipment shall be installed pursuant to the SPP Under-Frequency Load Shedding (UFLS) program, as detailed in the SPP UFLS Plan, for the purpose of maintaining a stable operating frequency.
- Automatic Restoration of Load schemes may be installed by Evergy to expedite load restoration. These systems shall be coordinated with all other schemes such as system protection, Underfrequency Load Shedding, Undervoltage Load Shedding, and Generation Control and Protection. These systems shall operate only after underfrequency and/or undervoltage events.
- Generation Control and Protection schemes shall be designed to conform to applicable NERC Standards and SPP Planning Criteria to provide a reasonable balance between the need for the generator to support the interconnected electric systems during abnormal conditions and the need to adequately protect generator equipment from damage.

## 6.0 Substation Bus Configuration

New substations or modifications to existing substations shall be designed using the bus configurations shown in Table 1, below, unless another arrangement is deemed appropriate, such as for predicted growth and expansion in the planning horizon. For the purposes of this table, terminals are considered transmission lines, BES transformers, and generator interconnections. Load-serving distribution and reactive device terminals may also be considered on a case by case basis.

*Table 1: Substation Bus Configurations by Voltage*

<b>Voltage (kV)</b>	<b>Number of Terminals</b>	<b>Substation arrangement</b>
100 - 200	1-2	Single Bus
	3-6	Ring Bus
	More than 6	Breaker-and-a-half
201-765	1-4	Ring Bus
	More than 4	Breaker-and-a-half

## 7.0 Power Quality Requirements

A project may be considered if harmonic distortion exceeds the recommended limits contained in IEEE Standard 519, which defines voltage waveform and harmonic content. Planning Level indices for voltage flicker will be governed by IEEE Standard 1453. Company criteria for voltage flicker and harmonic distortion at 161kV, 138kV, 115kV, or 69kV bus must meet the following criteria.

- Flicker level (short term)  $Pst_{95\%} \leq 0.8$
- Flicker level (long term)  $Plt_{95\%} \leq 0.6$
- Total harmonic voltage distortion  $THVD \leq 2.5 \%$
- Individual harmonic voltage level  $\leq 1.5 \%$
- Inductive power factor, monthly average  $\cos \phi \geq 0.98$
- Voltage fluctuation  $\Delta U \leq 1.0 \%$

## 8.0 Local Operational Reliability

Upgrades to the transmission system may be identified to improve local operational reliability. Criteria to be considered when identifying upgrades could include, but is not limited to, the following:

- Age and condition of equipment
- Reduction in customer outages
- Reduction of safety hazards
- Improvement to the protection and control schemes
- Increased transmission and distribution system flexibility
- Compliance with FERC, NERC and NESC requirements

## Document Version History

The following table documents changes to this document and its predecessors.

<b>Date</b>	<b>Document</b>	<b>Description</b>
9/2/20	Evergy Bulk Electric System Planning Criteria.pdf	Updated Section 5.0 to reflect changes to SPP Planning Criteria.
3/12/20	Evergy Bulk Electric System Planning Criteria.pdf	Updated logo and names of affiliate companies.
3/1/19	Evergy Bulk Electric System Planning Criteria.pdf	Document created.