Bonneville
POWER ADMINISTRATION

Reliability Criteria for System Planning
STD-N-000010 REVISION 02

Standard/Technical Content Owner: TPPA

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1. INTENT

The purpose of the Bonneville Power Administration's (BPA) *Reliability Criteria for System Planning* is to provide guidance to supplement the North American Electric Reliability Corporation's (NERC) *Transmission System Planning Performance Requirements*. This document also provides a guideline for making assumptions when planning the transmission system and where sensitivity studies are specified within the NERC planning standards. These criteria are intended to provide firm guidance but not absolute standards for transmission planning.

The NERC *Reliability Standards* for the Bulk Electric Systems (BES) of North America are mandatory standards that applicable entities must apply when planning, operating, and maintaining interconnected power systems across North America. Within those standards, the *Transmission System Planning Performance Requirements* (TPL) are applicable to Transmission Planning. In addition, the Western Electricity Coordinating Council (WECC) adopts Regional Criteria that establishes performance requirements for impacts that disturbances in one Transmission Planner's system can have on other systems external to that Transmission Planner's area. BPA follows the most current NERC *Transmission System Planning Performance Requirements* and WECC's *WECC Criterion, Transmission System Planning Performance* where applicable to plan the transmission system and meet mandatory compliance.

BPA facilities include system elements with nominal base voltages of 500kV, 345kV, 287kV, 230kV, 115kV, 69kV and lower voltage classes. These facilities are divided into three planning classifications: Main Grid, Secondary Grid, and Lower Voltage Network.

1.1 Applicability

This document is applicable to that portion of the Bulk Electric System (BES) where BPA is the Transmission Planner.

2. REVISION HISTORY

- Revision 02 (Current Revision), 09/21/2018: Updated this document (BPAs *Reliability Criteria for System Planning*) per input provided by BPAs Transmission Reliability Planning group, in order to align with the latest TPL-001-WECC-CRT-3.1, 09/21/2016, *WECC Criterion, Transmission System Planning Performance*. Also, document placed into the latest standards template format for improvement.
- Revision 01, 8/5/2013: Re-write of BPA's Reliability Criteria for System Planning to align the criteria with the latest NERC Transmission System Planning Performance Requirements and the WECC Criterion.
- Revision 00, 9/15/1989: Previous/original version of BPA's Reliability Criteria for System Planning.

3. DEFINITIONS

Lower Voltage Network: The Lower Voltage Network consists of any remaining Bulk Electric System (BES) or non-BES facilities not included in the Secondary Grid classification.

Main Grid: The Main Grid consists of Bulk Electric System facilities greater than 300 kV including all 500 kV and 345 kV transmission lines, and 500/230 kV and 345/230 kV transformers.

Secondary Grid: The Secondary Grid consists of Bulk Electric System facilities 300 kV and below including all transmission lines 100 kV through 300 kV, and transformers 500/115 kV, 230/115 kV, 230/161 kV, and 300/230 kV.

4. BACKGROUND

Historically, BPA's reliability criteria set the performance requirements for planning the Bonneville system, while the Western Systems Coordinating Council (WSCC) criteria set limits for impacts if disturbances in one Transmission Planner's system affected other systems external to that Transmission Planner's area. Applicable NERC planning standards were not developed until after 1997.

The original intent of BPA's reliability criteria was to provide firm guidance but not absolute standards for planning the system, tempered by engineering judgment and specific circumstances. In general, BPA's reliability criteria provided guidance on the following:

- Load and generation assumptions

- Assumptions for equipment ratings and associated ambient temperatures
- Guidance for bus arrangement and layout
- Steady-state voltage requirements
- Minimum system performance following a Contingency

Since their development in 1997, the NERC *Standards for System Performance*, TPL-001 through TPL-004, have evolved and they became mandatory in 2007. Those four Standards were consolidated into one Standard and were superseded by NERC Standard TPL-001-4 in 2016. Many of the performance requirements in BPA's reliability criteria have been superseded by the NERC Standards. In addition, the WSCC *Reliability Criteria for Transmission Planning* have evolved into the *WECC Criterion, Transmission System Planning Performance standard* to supplement the NERC Standards when assessing impacts on neighboring systems in the Western Interconnection. BPA's reliability criteria was subsequently re-written in 2013 to better align with and supplement the applicable NERC Standards and WECC Criterion, and to provide better planning guidance when factoring in assumptions.

5. POLICY AND APPLICATION

5.1 ASSUMPTIONS

5.1.1 *Loads*

The following are assumed default load levels to apply for planning the transmission system. Other load levels may be applied for performing sensitivity studies.

- **Peak Winter** - The peak winter load level expected at annual minimum temperatures that have a 50% probability of exceedance.
- **Peak Summer** - The peak summer load level expected at annual maximum temperatures that have a 50% probability of exceedance.
- **Off-Peak** - The average seasonal minimum off-peak load level. Light load level can range between 30% and 70% of peak load depending on the timeframe of study.

5.1.2 *Generation*

Resource assumptions should represent expected operation for the timeframe of the study for hydro, thermal, and variable generation sources. Other plausible variations in generation patterns that produce stresses in the transmission system should also be examined.

5.1.3 *Facility Ratings*

Applicable facility ratings used for transmission planning studies are established using applicable design standards either applied by BPA or otherwise established by BPA in accordance with STD-D-000011, *Bulk Electric System Facility Ratings Methodology*.

5.1.3.1 Transmission Lines

Transmission line ratings are calculated based on the methodology referenced in STD-D-000011, *Bulk Electric System Facility Ratings Methodology*. The transmission

system is planned assuming applicable facility ratings for transmission lines based on the ambient temperatures in Table 1.

Table 1.—Line Rating Temperatures

Load Period	East of Cascades	West of Cascades
Peak Winter	-15°C	-5°C
Normal Spring	20°C	20°C
Peak Summer	30°C	30°C

5.1.3.2 Transformers

Power transformer ratings are maintained in the *BPA Transformer Loading Guide* as referenced in STD-D-000011, *Bulk Electric System Facility Ratings Methodology*. When planning the transmission system, ambient temperatures assumed for transformer ratings will be consistent with those assumed for the season being studied. Site specific temperature data can be used when available.

Thermal Ratings applied for continuous loading are the rating at the assumed ambient temperature that causes a 24-hour average hot spot temperature of 110°C for transformers with thermally upgraded paper and 95°C for all others. The thermal ratings applied for continuous loading are assumed for normal system conditions.

Emergency Ratings applied are ratings assumed for cyclical loading above the thermal rating, at the assumed ambient temperature, that causes any of the following:

- An additional loss of life of 0.5% per week over the normal loss of life per week without causing maximum hot spot temperature to exceed 130°C for the weekly load factor calculated for the season being studied, or
- Loading to exceed 150% of maximum nameplate rating for transmission level transformers, or
- Loading to exceed 200% of maximum nameplate rating for customer service transformers.

Emergency Ratings are assumed for outage conditions.

5.1.3.3 Switchgear and Terminal Equipment

Switchgear ratings are established based on the methodology referenced in STD-D-000011, *Bulk Electric System Facility Ratings Methodology*. Switchgear is designed for normal applications where the ambient temperature does not exceed 40°C. When planning the transmission system, load-ability of switchgear can be adjusted for lower ambient temperatures consistent with the temperature assumed for the load level being studied.

5.1.4 *Substation Breaker Arrangements*

Guidance on substation breaker arrangements beyond what is needed to meet applicable system performance standards and criteria for bus outages and breaker failures is established in BPAs STD-N-000003, *Breaker Arrangement Application* policy.

5.1.5 *Remedial Action Schemes (RAS)*

Remedial Action Schemes (RAS), also known as special protection systems, are controlled protective measures planned in advance which are initiated following a power system disturbance to provide for acceptable system performance. Remedial actions, the individual protective measures that make up a remedial action scheme, are automatic supplementary controls that perform functions other than the isolation of electrical faults. Examples of remedial actions which are used on the BPA system include, but are not limited to:

- Generator Dropping - High speed disconnection of selected generators.
- Dynamic Braking Resistor - A special resistive load applied to decelerate rapidly accelerating generators.
- Shunt or Series Reactive Power Device Switching - High speed insertion or removal of shunt or series capacitors, or shunt reactors.
- Load Tripping - Disconnection of selected loads
- System Sectionalizing - Opening of select transmission circuits to alter network impedance to divert power flows.

5.2 System Performance Requirements

The BPA transmission system is planned to meet required performance for peak winter, peak summer and off-peak load levels. System tests and required performance for those tests are established in Table 1 of TPL-001-4, *NERC Transmission System Planning Performance Requirements* (or its successor). To meet required performance for system normal and contingency events, BPA plans the transmission system consistent with the planning events and required performance established in Table 1 of TPL-001-4, *NERC Transmission System Planning Performance Requirements* (or its successor). In addition, BPA applies TPL-001-WECC-CRT-3.1, 09/21/2016, *WECC Criterion, Transmission System Planning Performance* (or its successor) to define acceptable transient voltage response, voltage stability margin, and the potential for cascading or uncontrolled islanding, when disturbances have an impact on other transmission system(s) external to BPA's Transmission Planner area.

5.2.1 *Applicable Facility Ratings*

All facilities will not be loaded beyond their applicable facility rating established for the appropriate season and time duration for both system normal and contingency performance. For those contingency events where non-consequential load loss is allowed by TPL-001-4, *NERC Transmission System Planning Performance Requirements*, applicable facility ratings apply after assumed non-consequential load loss occurs.

5.2.1.1 Steady-State Voltage Performance

To meet steady-state voltage criteria, all Northwest regulating equipment, including generators, must be operated within limits. Coordinated operation of reactive power and voltage control facilities will be assumed.

5.2.1.2 Steady State Voltage limits

Steady-state voltage limits apply after automatic and manual adjustments of voltage control equipment are completed following a contingency.

The BPA transmission system is planned to meet the minimum applicable voltages in Table 2 for peak winter, peak summer, and off-peak load levels as defined in Section 5.1.1.

Shunt capacitors or reactors may be added to hold voltage schedules if necessary. Reactive additions should be considered if voltage schedules cannot be held for normal peak or off-peak conditions.

Table 2.—Allowable Voltage Ranges (per unit (p.u.)

Voltage Class	System Normal	Post Contingency
Main Grid 500 kV[2]	1.05-1.1 (525 kV-550 kV)	1.0 – 1.1 (500 kV- 550 kV)
Main Grid <500 kV[2]	1.0-1.05	0.95- 1.05
Secondary Grid[1,2]	1.0 -1.05	0.95 -1.05
Lower Voltage Network[1,2]	1.0 -1.05	0.95 -1.05

[1] Areas at the electrical fringes of the BPA transmission system, such as radial systems, local networks, or weakly connected systems, are allowed to be as low as 0.95 p.u. for system normal and 0.90 p.u. post-contingency where it is determined that customers will not be adversely impacted.

[2] All substation buses are allowed to exceed maximum voltage on a case-by-case basis where it is determined chronic over-voltages will not cause unacceptable equipment loss-of-life.

5.2.1.3 Pre and Post Contingency Voltage Deviation

Steady-state voltage deviation caused by a single shunt capacitor or reactor device switching event shall normally be limited to 3 percent of nominal voltage with all lines in service.

With any line or transformer out of service, voltage changes caused by reactive device switching should normally be limited to 8 percent. Exceptions to the 3 and 8 percent voltage change guidelines are allowed on an individual basis where either smaller voltage change is required for reliable operation of the system, or investigation shows larger voltage change is not detrimental to end use customers. Percent voltage change guidelines apply in the steady-state to any load bus and/or any bus with control systems that respond to voltage.

5.2.2 *Voltage Stability Performance*

Transmission system performance to maintain voltage stability is planned in accordance with established TPL-001-WECC-CRT-3.1, 09/21/2016, WECC Criterion, Transmission System Planning Performance as follows:

- All P0-P1 events shall demonstrate a positive reactive margin at a minimum of 105% of forecasted peak load or transfer path flow

- All P2-P7 events shall demonstrate a positive reactive margin at a minimum of 102.5 % of forecasted peak load or transfer path flow.

Voltage support and control equipment will be assumed to operate as expected within the timeframe being studied.

NOTE: P0 through P7 refers to the categories of contingencies identified in Table 1 of TPL-001-4, *NERC Transmission System Planning Performance Requirements*.

5.2.3 *Transient Voltage Response*

To meet required performance for transient voltage response after a contingency event, BPA plans the transmission system consistent with performance requirements established in TPL-001-WECC-CRT-3.1, 09/21/2016, *WECC Criterion, Transmission System Planning Performance* as follows:

- For all applicable buses serving load, voltages shall recover to 80% of the pre-contingency voltage within 20 seconds after fault clearing.
- For all applicable buses serving load, following initial voltage recovery to 80% of pre-contingency voltage, voltages shall not dip below 70% of pre-contingency voltage for more than 30 cycles or remain below 80% for more than 2 seconds.
- Oscillations that do not show positive damping within 30 seconds after the event shall be deemed unstable.

In addition, maximum acceptable voltage-swing on the BPA 500 kV system is 650 kV for 2.0 per unit designed transmission lines and 600 kV for 1.7 per unit designed transmission lines.

5.2.4 *Cascading and Uncontrolled Islanding*

To identify potential instability due to cascading or uncontrolled islanding, BPA uses the following minimum thresholds established in the TPL-001-WECC-CRT-3.1, 09/21/2016, *WECC Criterion, Transmission System Planning Performance* as follows:

- When post-contingency loading of a facility exceeds the known trip setting or 125% of the highest seasonal rating.
- When the transient voltage response for all applicable load bus voltage does not recover to 80% of the pre-contingency voltage within 20 seconds after fault clearing.
- When successive uncontrolled load loss occurs or successive generation loss occurs.

6. REFERENCES

Bonneville Power Administration (BPA), U.S. Dept. of Energy. STD-D-000011, Bulk Electric System Facility Ratings Methodology, Portland, Oregon.

Bonneville Power Administration (BPA), U.S. Dept. of Energy. STD-N-000003, Breaker Arrangement Application, Portland, Oregon.

Bonneville Power Administration (BPA), U.S. Dept. of Energy. Transformer Loading Guide, Portland, Oregon.

North American Electric Reliability Corporation's (NERC), TPL-001-4, NERC Transmission System Planning Performance Requirements.

Western Electricity Coordinating Council (WECC), TPL-001-WECC-CRT-3.1, 09/21/2016, WECC Criterion, Transmission System Planning Performance.