Platte River Power Authority

Ten-Year Transmission Plan

(2016-2025)

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I. Executive Summary

The Platte River Power Authority (PRPA) Ten-Year Transmission Plan (2016-2025) is developed to assure that an adequate transmission system is planned for the reliable delivery of electricity to its municipal owners in Estes Park, Fort Collins, Longmont, and Loveland, Colorado and to other PRPA transmission customers. The planning studies and reliability assessments for the near-term and longer-term planning horizons demonstrate that the PRPA transmission system meets the performance requirements of the Western Electricity Coordinating Council (WECC) and of the North American Electric Reliability Corporation (NERC) Standards TPL-001-4 and FAC-013-2. PRPA transmission projects planned for the next ten years are listed in the following **Table 1** in order of in-service date, and are illustrated on the 2015-2025 Transmission System Map and 2015-2025 Plan of Service Diagrams in **Exhibit 1**.

Table 1: PRPA Planned Transmission Projects

In-Service	Project Name	Description	Purpose
January 2016	Crossroads 115kV Substation Expansion	Add 115/12.47kV transformer T2 and a Ring Breaker.	New delivery point to serve growing load.
May 2016	Laporte 230kV Substation Expansion	Add a 230 kV breaker-and-a-half yard, convert the Laporte-Laporte Tap 115kV line section to 230 kV, connect four 230 kV lines (two to Rawhide, one to College Lake, and one to Timberline), and add a 230/115kV transformer T2 for a second source to the Laporte 115 kV.	Improve system reliability in the Fort Collins area.
May 2017	Boyd 230/115kV Substation Expansion	Add 230/115kV transformer T2 and reconfigure 230kV and 115kV yards to breaker-and-a-half arrangement.	Improve system reliability in the Loveland area.
May 2017	Avery 230kV Substation	Sectionalize Carey-Timberline 230kV Line with new substation.	New PSCo delivery point to serve growing load.
December 2017	Harmony 230kV Substation Terminals Upgrade	Modify CT tap and transformer relaying.	Remove conditional line ratings on the Portner and Timberline lines.
March 2018	Re-Configure Harvard Substation	Connect Harvard 115/12.47 kV transformers T1 & T2 to different bays at LongmontNW Substation.	Improve reliability to each transformer. Meet PRPA design criteria.
May 2018	Loveland Foothills 115/12.47kV Substation	Site is near water tank on W 43rd St and existing Loveland West-Horseshoe 115kV line to locate additional 115/12.47kV transformer(s).	New delivery point to serve growing load.
July 2019	Timberline 230/115kV T3 Replacement	Replace 230/115kV transformer T3 with new transformer.	Improve system reliability in the Fort Collins area. Existing transformer was installed 1976.
November 2019	Fordham 115kV Substation Expansion	Add 115/12.47kV transformer T3.	New delivery point to serve growing load.
May 2021	Rawhide Unit 1 GSU Replacement	Cycle through replacing Rawhide Unit 1 GSUs(3 + 1 spare) in coordination with major Rawhide plant outage.	Satisfy Maintenance Requirements.
May 2021	Loveland Boedecker 115/12.47kV Substation	Site near Southeast corner of Boedecker Lake adjacent to Loveland West Tap 3-terminal 115kV line structures to locate additional 12.47kV transformer(s).	New delivery point to serve growing load.
November 2021	Valley 115kV Substation Expansion	Add 115/12.47kV transformer T3.	New delivery point to serve growing load.

December 2021	Fort Collins Northeast 115/13.8kV Substation	Considering sites near Timnath or Cobb Lake 115kV Substations to locate additional 115/13.8kV transformer(s).	New delivery point to serve growing load.
May 2022	Loveland Southeast Substation	Considering sites near intersection of I-25 and Hwy 402 to locate additional 12.47kV transformer(s). Could be a 230kV or 115kV transmission interconnection depending on desired project route.	New delivery point to serve growing load.

II. Scope

The study area is the Foothills Area Transmission System (Foothills System) located in northern Colorado as shown in **Exhibit 2**. The PRPA transmission system is situated in the Foothills System and interconnected with Public Service Company of Colorado (PSCo), Tri-State Generation and Transmission Association, Inc. (TSGT), and Western Area Power Administration (WAPA). The near-term (years one through five) and longer-term (years six through ten) planning horizons were studied and the results documented herein over a range of forecasted system demands and subject to the various contingency conditions defined in the NERC Standards TPL-001-4 for Categories P0-P7 and EE.

III. Assumptions

1. Loads are represented at the high-voltage busses.
2. PRPA detailed representation with substation transformers and low-voltage bus loads are not used in this study. However, power factors have been adjusted for high-voltage bus representation.
3. Voltage criteria violations on the transmission system are of more concern at load busses than at non-load busses.

IV. Criteria

PRPA adheres to NERC Transmission Planning Standards and WECC Reliability Criteria, as well as internal company criteria for planning studies. PRPA's power flow and stability simulation criteria:

Category P0 –
"N-0" System Performance Under Normal (No Contingency) Conditions (Category P0) as referenced in Table 1 of NERC Standard TPL-001-4

Voltage:	0.95 to 1.05 per unit
Line Loading:	100 percent of continuous rating
Transformer Loading:	100% of highest 65 °C rating

Category P1-P2 Events –
"N-1" System Performance Following Loss of a Single Element (Category P1-P2) as referenced in Table 1 of NERC Standard TPL-001-4

Voltage:	0.92 to 1.07 per unit (PRPA) 0.90 to 1.10 per unit (all others)
Line Loading:	100 percent of continuous rating or emergency rating if applicable
Transformer Loading:	100% of highest 65 °C rating

Category P3-P7 Events –
"N-1-1 or N-2 or More" System Performance Following Loss of Two or More Elements (Category P3-P7) as referenced in Table 1 of NERC Standard TPL-001-4

Voltage and Thermal: Allowable short-term and/or emergency rating(s) will be considered for achieving acceptable system performance as determined by the affected parties along with any available emergency mitigation plans. System adjustments – including interruption of firm transmission service and non-consequential load shedding will be considered for achieving acceptable system performance, where allowed in Table 1 of TPL-001-4.

Category Extreme Events (EE) -
"N-1-1 or N-2 or More" System Performance Following Extreme Events (Category EE) as referenced in Table 1 of NERC Standard TPL-004-0

Voltage and Thermal: Evaluate for risk of widespread instability, cascading or uncontrolled islanding in the BES. Identify possible actions to reduce the likelihood of, or mitigate the adverse consequences of, any occurrence of cascading. Use all available system adjustments, emergency facility rating(s) and/or emergency voltage limits, to evaluate possible actions to mitigate consequences of the event.

A stability simulation will be deemed to exhibit positive damping if a line defined by the peaks of the machine relative rotor angle swing curves tends to intersect a second line connecting the valleys of the curves with the passing of time. Corresponding lines on bus voltage swing curves will likewise tend to intersect. A stability simulation which satisfies these conditions will be defined as stable. A case will be defined as marginally stable if it appears to have zero percent damping and voltage dips are within or at the WECC Reliability Criteria limits.

Transient stability criteria require that all generating machines remain in synchronism and all power swings should be well damped. Transient voltage and frequency performance should meet the following criteria:

- Following fault clearing for Category P1 events, voltage may not dip more than 25% of the pre-fault voltage at load buses, more than 30% at non-load buses, or more than 20% for more than 20 cycles at load buses. Frequency should not dip below 59.6 Hz for 6 cycles or more at a load bus.
- Following fault clearing for Category P2-P7 contingencies, voltage may not dip more than 30% of the pre-fault voltage at any bus or more than 20% for more than 40 cycles at load buses. Frequency should not dip below 59.0 Hz for 6 cycles or more at a load bus.

Note that load buses include generating unit auxiliary loads.

NERC Standards require that the system remain stable and no Cascading occurs for Category P1-P7 Events. Cascading is defined in the NERC Glossary as "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." A potential triggering event for Cascading will be investigated upon one of the following results:

- A generator pulls out of synchronism in transient stability simulations. Loss of synchronism occurs when a rotor angle swing is greater than 180 degrees. Rotor angle swings greater than 180 degrees may also be the result of a generator becoming disconnected from the BES; or
- A transmission element experiences thermal overload and its transmission relay loadability is exceeded.

V. Procedure

The studies were performed by PRPA System Planning using the Siemens-PTI PSS/E computer simulation software versions 33.5.0. The transmission system models were developed from models prepared by WECC. Previous planning and operational studies by PRPA, the Foothills Planning Group, and the Colorado Coordinated Planning Group (CCPG) have concluded the heavy summer loading scenarios cover the most critical system conditions over the range of forecasted system demand levels. Both heavy and light load scenarios were studied for the near-term planning horizons and heavy load scenarios for the longer-term planning horizons to conduct a thorough assessment for all seasons. Transmission topology and system demand were modified according to which season and year are studied. Light load scenarios apply to Spring and Fall system conditions and heavy load scenarios apply to Summer and Winter system conditions.

WECC Approved base cases were selected accordingly based on case availability where load, generation, and transmission topologies were updated as necessary with the most recent modeling representations of the planned PRPA and Foothills systems. The study cases include both existing and planned facilities, the expected system conditions, and the effects of any Bulk Electric System (BES) equipment planned to be out-of-service during the critical demand levels.[1] All normal operating procedures and the effects of all control devices and protection systems are modeled. Reactive power resources are included in the model to ensure adequate reactive resources are available to meet system performance.

[1] PRPA makes every effort to avoid removing a BES facility or equipment including protection systems from service for planned maintenance or construction during the summer peak demand levels or during other high-risk system conditions when PRPA may implement "No Touch" procedures. PRPA performs system studies when a BES facility is scheduled to be removed from service.

The PRPA 10-year Load Forecast by Substation is listed in **Exhibit 3**. PRPA uses its "high" load forecast for reliability margin to reflect uncertainties in projected BES conditions. The PRPA Load and Resource Allocations for each base case studied are provided in **Exhibit 4**. These exhibits represent the projected PRPA customer demands, firm transfers, and generation dispatch modeled in the bases cases. All projected firm transfers are modeled according to the data for loads, resources, obligations, and interchanges described in the "Associated Material" document provided with each approved WECC base case. The generation dispatch in each base case was modified to fully stress the PRPA system by setting the Rawhide Plant to its near maximum generation output of 700 MW (net). See **Exhibit 5** for the study procedure where the modified generation dispatch values are documented.

Contingencies selected for system performance evaluation are those Category P1-P7 and EE which are expected to produce the more severe system impacts in the study area. The rationale for selecting the more severe contingencies/disturbances is based on knowledge of the Foothills transmission system and engineering judgment. The selected steady-state contingencies and stability disturbances are based on consideration of the following factors in the rationale: large bulk power transfer paths, significant EHV stations, large generating stations, transmission circuits using common structure and/or common right-of-way, switchyard bus configuration, layout of breakered bay positions, primary and backup protection for transmission elements, etc. These contingencies are simulated using the Matrix routine written for contingency analysis on the PSS/E computer simulation software.

Computer simulation software solution methods are as follows:

	Pre-contingency	Post-Contingency
Area Interchange Control	Off	Off
Phase-Shifter	Lock	Lock
TFMR LTC	Adjust	Adjust
Switched Shunt Reactor/Capacitor	Adjust	Lock
DC Taps	Adjust	Adjust

All busses and branches in Zones 706 and 754 of the WECC base cases are monitored for criteria violations. A list of simulated forced outage contingencies is provided in **Exhibit 6**. The PRPA transmission system is fully contained within Zones 706 and 754 and completely studied by the list of contingencies.

Study results are reviewed and assessed for compliance with the WECC and NERC standards.

Planned upgrades, additions, or corrective actions needed to meet the performance requirements are identified and included in the transmission plan for Category P1-P7 and EE contingency conditions which cause a criteria violation. System performance problems associated with Category EE contingencies are evaluated for possible actions to reduce the likelihood or mitigate the consequences of the extreme event.