

**Greenwood to Denver Terminal 230 kV  
Transmission Project  
System Impact Study Report  
for the  
Colorado Energy Plan Portfolio**

**Transmission Planning  
Public Service Company of Colorado**

**February 2020**

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## I. Executive Summary

This report summarizes the analyses performed to evaluate potential impacts to the Public Service Company of Colorado (PSCo, or the Company) transmission system for the delivery of generation associated with the Colorado Energy Plan (CEP). In August 2018, the Colorado Public Utilities Commission (PUC) approved Company's preferred CEP portfolio (CEPP) of generation, which included the retirement of Comanche units 1 and 2, the addition of approximately 970 MW of wind generation and approximately 735 MW of solar generation.

The results of this study indicate network upgrades to the transmission system are required in the Denver-Metro area to accommodate the portfolio of generation resources approved as part of the CEP. The recommended project is a new Greenwood – Denver Terminal 230 kV transmission line, or "GDT Project." The GDT Project is estimated to cost approximately \$50.1 million, plus or minus 20 percent, and is expected to be in service by December 2022. The transmission facilities identified in this study report are separate from the need for voltage control devices the Company has otherwise identified as necessary to accommodate the CEPP in Proceeding No. 19A-0728E.

In addition to the GDT Project network upgrade, the following minor upgrades to existing transmission lines within the Denver-Metro area must also be completed:

1. Upgrade the Greenwood-Monaco 230 kV line;
2. Upgrade the Leetsdale-Sullivan-Monaco 230 kV line; and
3. Upgrade the Daniels Park-Prairie-Greenwood 230 kV line.

These upgrades have a combined estimated cost of approximately \$1.8 million and are expected to be in service by December 2020. Therefore, the total costs associated with the Network Upgrades is estimated to be approximately \$51.9 million.

## II. Background

At least every four years, PSCo, an Xcel Energy company, files an Electric Resource Plan (ERP) with the PUC to evaluate future customer electric demand and determine the generation resources best suited to meet demand. The 2016 ERP was filed with the PUC on May 27, 2016 in Proceeding No. 16A-0396E. During proceedings for the 2016 ERP, the Company presented the PUC with its CEP proposal, which included the early retirement of coal-fired generating units and the addition of hundreds of MWs of renewable resources as a cost-effective means to meet the needs of the ERP. The Preferred CEPP includes accelerating the retirement of Comanche 1 (2023) and Comanche 2 (2025), adding approximately 970 MW of new wind generation, and adding approximately 735 MW of new solar generation.<sup>1</sup>

The PUC approved the Company's Preferred CEPP in Decision No. C18-0761 (mailed September 10, 2018). However, a single developer that successfully bid two projects into the Company's ERP competitive solicitation and which were included in the CEPP approved by the Commission, was unable to deliver the solar only and solar with storage projects as bid. As a result, the Company

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<sup>1</sup> Public statements indicate over 1,100 MW of wind. That figure includes an existing 162 MW wind farm.

issued a targeted request for proposals (“2019 Solar RFP”) to potentially replace approximately 200 MW of solar or solar with storage generation. The Company has proposed and the Commission is currently considering an amendment to the 2016 ERP in Proceeding No. 19A-0530E.

### **III. Objective**

The objective of this study was to evaluate the impacts to the Public Service transmission system due to the retirement of Comanche 1 and Comanche 2 and additions of approximately 970 MW of wind and 735 MW of solar generation. Specifically, this study identifies upgrades to the Denver-Metro transmission system to accommodate the CEPP. The CEPP includes significant renewable generation in the northeast plains as well as in the southern Pueblo area. The addition of approximately 1700 MW of renewable generation may cause potential overload conditions on transmission lines in the metro area. The key objective of the transmission plan is to eliminate potential overload conditions and therefore allow full dispatch of the low-cost renewable energy resources of the CEPP.

### **IV. Stakeholder Process**

The study utilized the Colorado Energy Plan Task Force (CEPTF) of the Colorado Coordinated Planning Group (CCPG) as a forum to inform interested stakeholders of the studies and to gather comments and alternatives for evaluation. The CCPG is a joint, high voltage transmission system planning forum. The purpose of the group is to assure a high degree of reliability in the planning, development and operation of the high voltage transmission system in the Rocky Mountain Region. PSCo kicked off the CEPTF in November 2017, with the objective of informing other utility planners and stakeholders of potential impacts to the Colorado transmission system and planning efforts by PSCo, in addition to recommended transmission upgrades. Several meetings were held that included participation from a wide variety of stakeholders, including:

- Basin Electric Power Cooperative
- Black Hills Energy
- Bright Energy Storage
- Buckyball Systems
- Colorado Public Utilities Commission
- Colorado Springs Utilities
- Dietze & Davis Law Firm
- Intermountain Rural Electric Association
- Lucky Corridor, LLC
- The Colorado Office of Consumer Counsel
- Tormoen Hickey LLC
- TradeWind Energy
- Tri-State Generation & Transmission Association
- Western Area Power Administration
- Western Resource Advocates

## V. Methodology

### A. Studies

This study consisted of steady state (power flow) analysis. Facility loadings and voltages were monitored within the study area consistent with North American Electric Reliability Corporation (NERC) and Western Electricity Coordinating Council (WECC) standards. A benchmark analysis was performed to compare alternative benchmark conditions. Once the benchmark case was developed, a steady state power flow and voltage comparison analysis was conducted for various transmission system alternatives. From this analysis the Company developed recommended transmission improvements necessary to satisfy the objectives.

### B. Modeling

#### 1. Cases

The technical analysis consisted of steady state (powerflow) using conventional transmission planning models. Studies utilized a five-year transmission system planning model that originated from the WECC 25HS2 model.

#### 2. Generation and Transmission Modeling

All existing generation and resources planned for the study horizon are included in the benchmark study case. The models reflect transmission facilities that are presently in-service and transmission facilities that are expected to be in-service during the study horizon. The significant transmission projects modeled in the benchmark case are shown in Table 1.

**Table 1: Significant Transmission Projects Included in the Study Models**

	<b>Project</b>	<b>ISD</b>
1	Pawnee – Daniels Park 345 kV Project	2019
2	PSCo Voltage Control Facilities	2020
3	Shortgrass - Cheyenne Ridge 345 kV	2020
4	Waterton – Martin 115kV line uprate	2021
5	Upgrade the Cherokee 115 kV bus	2021
6	Monument – Flying Horse 115kV series reactor project <sup>2</sup>	2022

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<sup>2</sup> PSCo presently utilizes an operating procedure that provides acceptable performance until the series reactor project is implemented.

### 3. Existing Generation

All existing generation and resources planned for the study horizon are included in the benchmark study case. Lists of the generation modeled in the benchmark case are provided in Appendix A.

#### C. CEPP Generation

The planned generation that the Company included in the study case includes:

**Table 2: Planned Generation Included in the Study Case**

Generation Resource	Bid #	Capacity (MW)	Point of Interconnection	ISD
Cheyenne Ridge Wind Farm	W192	499	Missile Site 345 kV Substation	2021
Bronco Plains Wind Farm	W602	300	Missile Site 345 kV Substation	2021
Mountain Breeze	W090	169	Keenesburg 230 kV Substation	2021
Total Wind Generation		968		
Hartsel Solar Facility	S085	72	Hartsel-Tarryall 230 kV	2023
Neptune Solar w/ Storage Facility	X645	250	Comanche – Daniels Park 345 kV	2023
Thunder Wolf Solar w/ Storage Facility	X647	200	Badger Hills (Mirasol) 230 kV Substation	2023
Solar Facility	35	113	Southern Front Range Area	2023
Solar w/ Storage Facility	56	100	Southern Front Range Area	2023
Total Solar Generation		735		

Generation resources in Table 2 were modeled at 100% of nameplate capacity.

Other Generation Assumptions:

- Comanche 3 Coal Generation @ Pmin
- Pawnee Coal Generation @ Pmin
- PSCo Wind Generation = 75% of rated capacity
- PSCo Solar Generation = 80% rated capacity

A detailed list of the generation in Area 70 and Area 73 in the benchmark case model can be found in Appendix A.

## VI. Criteria

The study adhered to the WECC and NERC Reliability Criteria. Pertinent criteria for this study include:

### 1. Steady State Voltage Limit Violation Criteria

Voltage violations requiring corrective actions are identified in steady-state simulations when steady-state voltages at PSCo (EHV and HV) BES buses are outside the following acceptable voltage limits:

- Normal (no contingency) conditions:  $V_{min} = 0.95$  pu,  $V_{max} = 1.05$  pu
- Post-contingency conditions:  $V_{min} = 0.90$  pu,  $V_{max} = 1.10$  pu

The screening criterion for generator voltage ride through capability is 0.90 pu to 1.10 pu for all planning event (P1 to P7) contingencies. If the initial screening simulation indicates that the generator bus voltage is outside this range, follow up simulations are performed as necessary based on a review of the generator's actual voltage ride through capability.

### 2. Element Loading

a) System-intact and Prior-Outage Conditions:

- Line loading monitored for 100% of the established summer normal lowest-rated equipment rating, as well as the conductor rating.
- Transformer loading monitored to 100% of the highest name plate rating or owner-provided rating.

b) Contingency (Forced-Outage) Conditions

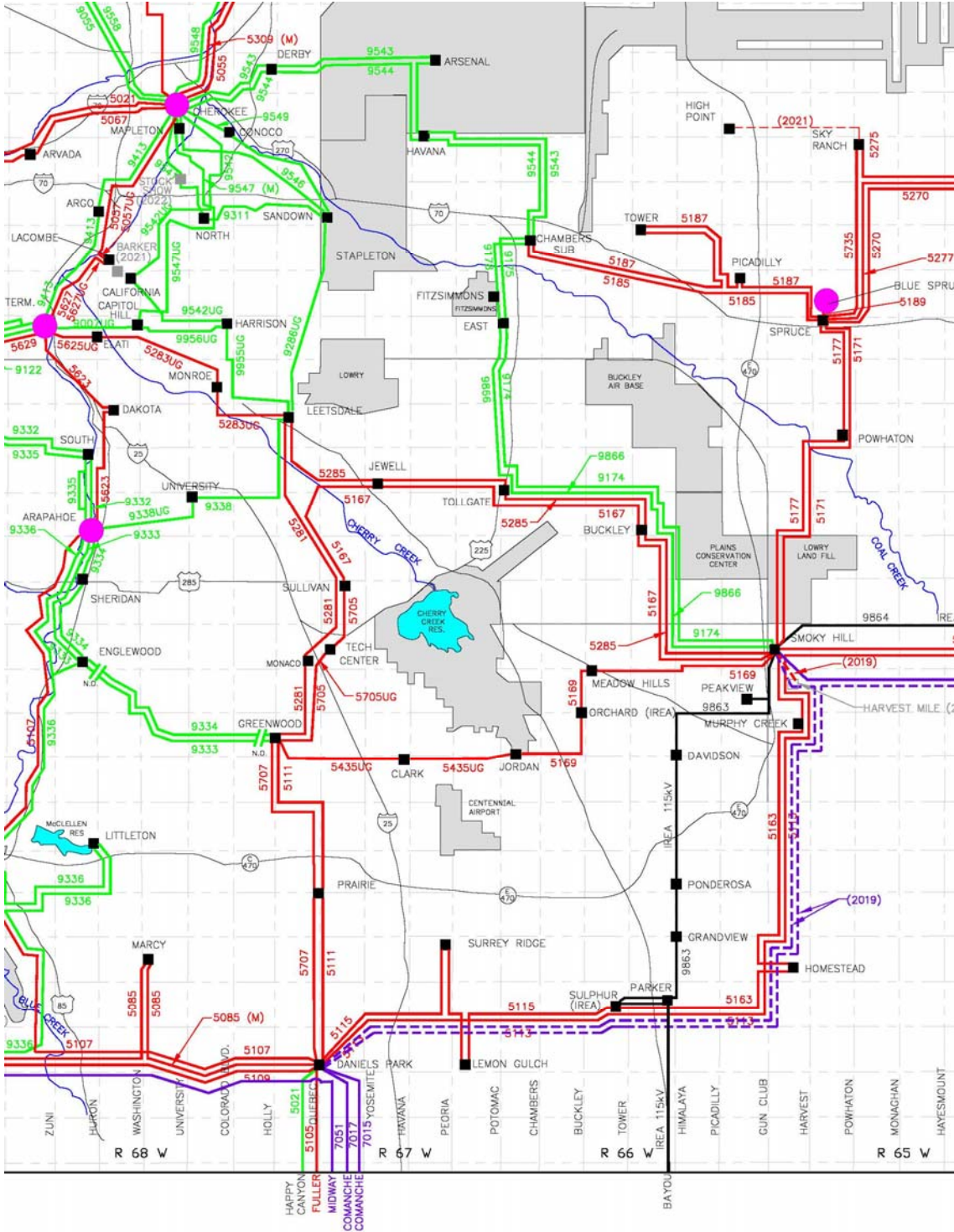
- Line loading monitored for 100% of the established summer normal lowest-rated equipment rating, as well as the conductor rating.
- Transformer loading monitored to 100% of the summer emergency rating or appropriate owner's top rating.
- Voltages flagged if outside 0.90 – 1.05 per unit, and/or if the change in voltage exceeded 0.05 per unit.

## VII. Benchmark Results

Most of the CEPP generation projects will be directly or indirectly interconnected to the Company's 345 kV "backbone" transmission system that runs from Pawnee Station near Brush, Colorado, to the Comanche Station, near Pueblo, Colorado. The majority of the PSCo load lies within the Denver-Metro area. The new CEPP generation will tend to move from the high voltage backbone to the customer loads through substations located at Daniels Park and Smoky Hill. Power then tends to travel through the Smoky Hill Substation located on the east side of the system, and through the Daniels Park Substation, located on the south side of the system. Power then moves through the 230 kV and 115 kV networks toward the Denver Terminal and Cherokee substations.

Figure 1 shows the 115 kV and 230 kV transmission system in the Denver-Metro area that can be affected by power delivered from the northeast and southern transmission networks. The purple lines depict 345 kV, the red lines depict 230 kV, and the green lines depict 115 kV transmission.

**Figure 1: Southeastern Denver-Metro Transmission System**





As the amount of electric energy from renewable generation connected to the high voltage 345 kV backbone increases and electric energy on the transmission system produced from fossil generation in the Denver Metro area decreases, there is a potential to overload some of the transmission elements between the Smoky Hill and Daniels Park substations, and the Denver Terminal Substation. Table 3 below shows the significant contingency results in the base case and the benchmark with the CEPP generation added.

**Table 3: Denver-Metro Benchmark Contingency Loading**

Loaded Element	Contingency	Rating	% Load Pre-CEPP	% Load CEPP
Greenwood – Monaco 230 kV	Smoky Hill – Buckley 230 kV	405	115%	146%
Monaco – Sullivan 230 kV	Smoky Hill – Buckley 230 kV	398	108%	139%
Sullivan – Leetsdale 230 kV	Smoky Hill – Buckley 230 kV	398	105%	136%
Leetsdale – Monroe 230 kV	Daniels Park – Santa Fe 230 kV	398	83%	115%
Monroe – Elati 230 kV	Daniels Park – Santa Fe 230 kV	398	65%	96%
Daniels Park – Prairie 230 kV #1	Daniels Park – Prairie 230 kV #2	478	90%	111%
Prairie – Greenwood 230 kV #1	Daniels Park – Prairie 230 kV #2	478	74%	95%
Leetsdale – Harrison 115 kV	Leetsdale – Monroe	141	72%	109%
Smoky Hill – Buckley 230 kV	Greenwood – Monaco 230 kV	506	89%	105%
Buckley – Tollgate 230 kV	Greenwood – Monaco 230 kV	484	93%	110%

Some of the overloads can be mitigated or reduced by minor, low cost transmission uprates that involve replacing termination equipment within the substations at each end of the lines (e.g., switches, jumpers, and relay equipment). These minor uprates include:

**1. Greenwood-Monaco 230 kV Uprate**

The rating of the Greenwood – Monaco 230 kV line can be uprated from 405 MVA to its full conductor rating of 503 MVA at a cost of approximately \$0.13 million.

**2. Leetsdale – Sullivan – Monaco 230 kV Uprate**

The rating of the Leetsdale – Sullivan 230 kV line can be uprated from 396 to 503 MVA and the Sullivan – Monaco 230 kV line can be uprated from 396 to 470 MVA at a cost of approximately \$1.4 million.

**3. Daniels Park – Prairie - Greenwood 230 kV Uprate**

The rating of the Daniels Park – Prairie – Greenwood 230 kV line can be uprated from 478 MVA to its full conductor rating of 576 MVA at a cost of approximately \$0.24 million.

The combined cost for the uprate projects described above are estimated to be approximately \$1.8 million.

Table 4 shows the remaining contingency loadings with the addition of the above uprates.

**Table 4: Contingency Loading of CEPP After the Minor Upgrades**

Loaded Element	Contingency	Rating	% Load CEPP
Greenwood – Monaco 230 kV	Smoky Hill – Buckley 230 kV	503	117%
Monaco – Sullivan 230 kV	Smoky Hill – Buckley 230 kV	470	118%
Sullivan – Leetsdale 230 kV	Smoky Hill – Buckley 230 kV	503	108%
Leetsdale – Monroe 230 kV	Daniels Park – Santa Fe 230 kV	398	115%
Monroe – Elati 230 kV	Daniels Park – Santa Fe 230 kV	398	96%
Daniels Park – Prairie 230 kV #1	Daniels Park – Prairie 230 kV #2	576	92%
Prairie – Greenwood 230 kV #1	Daniels Park – Prairie 230 kV #2	576	79%
Leetsdale – Harrison 115 kV	Leetsdale – Monroe	141	109%
Smoky Hill – Buckley 230 kV	Greenwood – Monaco 230 kV	506	105%
Buckley – Tollgate 230 kV	Greenwood – Monaco 230 kV	484	110%

**VIII. Alternatives**

In addition to the minor updates identified above, this study identified several potential transmission projects to address the potential overload conditions:

**A. Alternative 1: Greenwood – Denver Terminal 230 kV Line (Preferred Alternative)**

The potential overloads can be mitigated by adding a new 230 kV transmission circuit between the Greenwood and Denver Terminal Substations and the three minor line update projects listed above. The Greenwood – Denver Terminal line will provide an additional 230 kV path into the heart of Denver from the renewable generation injection areas. Table 5 shows the contingency performance before and after the project is implemented.

**Table 5: Contingency Loading of Alternative 1**

Loaded Element	Contingency	Rating	% Load CEPP
Greenwood – Monaco 230 kV	Smoky Hill – Buckley 230 kV	503	95%
Monaco – Sullivan 230 kV	Smoky Hill – Buckley 230 kV	470	94%
Sullivan – Leetsdale 230 kV	Smoky Hill – Buckley 230 kV	503	85%
Leetsdale – Monroe 230 kV	Daniels Park – Santa Fe 230 kV	398	73%
Monroe – Elati 230 kV	Daniels Park – Santa Fe 230 kV	398	55%
Daniels Park – Prairie 230 kV #1	Daniels Park – Prairie 230 kV #2	576	99%
Prairie – Greenwood 230 kV #1	Daniels Park – Prairie 230 kV #2	576	86%
Leetsdale – Harrison 115 kV	Leetsdale – Monroe	141	89%
Smoky Hill – Buckley 230 kV	Greenwood – Monaco 230 kV	506	90%
Buckley – Tollgate 230 kV	Greenwood – Monaco 230 kV	484	94%

The GDT Project involves constructing a new 230 kV transmission circuit along approximately 15.4 miles of existing transmission corridor. The Project involves rebuilding, re-conductoring, and/or re-energizing existing transmission facilities from the Greenwood Substation to the Denver Terminal Substation within existing rights-of-way (ROW). The new 230 kV circuit will interconnect at the Greenwood, Arapahoe, and Denver Terminal Substations to which new circuit breakers and buss work will be added to accommodate the new 230 kV circuit (the Project will bypass the Englewood and South Substations). Table 6 below describes the existing and proposed transmission infrastructure associated with the GDT Project.

**Table 6: Preferred Alternative Project Description (GDT Project)**

Project Segment (miles)	Existing Transmission Infrastructure	Proposed Transmission Infrastructure
1 (5.6)	Double circuit 115 kV de-energized transmission line on steel lattice structures.	Replace existing structures with single circuit 230 kV monopole structures.
2 (0.5)	Double circuit 115 kV transmission line on steel lattice structures, one circuit de-energized.	Replace existing structures with double circuit 115/230 kV monopole structures.
3 (3.4)	Double circuit 115/230 kV transmission line on steel lattice structures.	Re-conductor 115 kV circuit to 230 kV on existing structures.
4 (2.0)	Double circuit 230 kV transmission line on monopole structures. One circuit is currently energized at 115 kV.	Energize the 115 kV circuit to 230 kV on existing structures. New structures and conductor will be required near Arapahoe and South Substation to energize the circuit at 230 kV. No changes to the currently energized 230 kV circuit will occur.
5 (3.9)	Single circuit 230 kV transmission line on monopole structures.	Replace existing structures with double circuit 230 kV monopole structures.

**B. Alternative 2: Upgrade Existing Lines**

This alternative consists of upgrading each of the existing transmission lines that have the potential to overload. This alternative would consist of completing all of the following upgrades:

**1. Greenwood – Monaco – Sullivan – Leetsdale Transmission Line**

Replace the Greenwood – Monaco – Leetsdale 230 kV overhead/underground line with a new line capable of achieving a minimum continuous rating of 576 MVA. Replace all termination equipment at Greenwood, Monaco, and Leetsdale Substations to allow full use of the new line rating. The estimated cost of this portion of the project is approximately \$35.1 million.

**2. Leetsdale – Monroe 230 kV Underground Transmission Line**

Replace the existing Leetsdale – Monroe 230 kV underground line with a new line capable of achieving a minimum continuous rating of 576 MVA. Replace all termination equipment at Leetsdale and Monroe Substations to allow full use of the new line rating. The estimated cost of this portion of the project is approximately \$22.5 million.

**3. Monroe – Elati 230 kV Underground Transmission Line**

Replace the existing Elati – Monroe 230 kV underground line with a new line capable of achieving a minimum continuous rating of 576 MVA. Replace all termination equipment at Elati and Monroe Substations to allow full use of the new line rating. The estimated cost of this portion of the project is approximately \$37.5 million.

**4. Smoky Hill – Tollgate 230 kV Transmission Line**

Replace the existing Smoky Hill – Buckley – Tollgate 230 kV overhead line section with a new line capable of achieving a minimum continuous rating of 576 MVA. Replace all

termination equipment at Smoky Hill, Buckley, and Tollgate Substations to allow full use of the new line rating. The estimated cost of this portion of the project is approximately \$3.6 million.

**5. Leetsdale-Harrison 115kV Underground Transmission Line**

Replace the existing the Leetsdale – Harrison 115 kV underground line with a new line capable of achieving a minimum continuous rating of 240 MVA. Replace all termination equipment at Leetsdale and Harrison Substations to allow full use of the new line rating. The estimated cost of this portion of the project is approximately \$31.8 million.

This alternative mitigated unacceptable loading conditions by upgrading the overloaded lines to increase their power carrying capabilities. However, the alternative was rejected due to the cost, the number of elements involved, and potential issues with upgrades to underground lines. The total cost could be up to approximately \$130.5 million. Although this alternative is not recommended, future generation resource additions could drive the need to upgrade some or all of these lines.

**C. Alternative 3: Smoky Hill – Cherokee 230 kV Upgrade**

This alternative contemplates replacing the 115 kV double-circuit transmission between Smoky Hill and Cherokee substations with 230 kV transmission. It would consist of approximately 30 miles of replacement transmission. In addition, the conversion would impact four other 115 kV substations, including East, Fitzsimmons, Havana, and Derby. Those substations would have to be modified to accommodate 230 kV transmission terminations as well as replacing distribution transformers used to serve customer loads.

Although this alternative appeared to mitigate most of the loading issues, it was rejected due to the anticipated costs and concerns with constructability. Preliminary estimates indicated that this alternative could cost approximately \$200 million.

**Table 7: Contingency Loading of Alternative 3**

Loaded Element	Contingency	Rating	% Load Minor Upgrades	% Load Alt 3
Greenwood – Monaco 230 kV	Smoky Hill – Buckley 230 kV	503	117%	97%
Monaco – Sullivan 230 kV	Smoky Hill – Buckley 230 kV	470	118%	96%
Sullivan – Leetsdale 230 kV	Smoky Hill – Buckley 230 kV	503	108%	88%
Leetsdale – Monroe 230 kV	Daniels Park – Santa Fe 230 kV	398	115%	83%
Monroe – Elati 230 kV	Daniels Park – Santa Fe 230 kV	398	96%	65%
Daniels Park – Prairie 230 kV #1	Daniels Park – Prairie 230 kV #2	576	92%	93%
Prairie – Greenwood 230 kV #1	Daniels Park – Prairie 230 kV #2	576	79%	80%
Leetsdale – Harrison 115 kV	Leetsdale – Monroe	141	109%	85%
Smoky Hill – Buckley 230 kV	Greenwood – Monaco 230 kV	506	105%	87%
Buckley – Tollgate 230 kV	Greenwood – Monaco 230 kV	484	110%	91%

**D. Alternative 4: Cherokee – Denver Terminal 230 kV #2**

This alternative was considered based on feedback received from a CEPTF participant. The alternative contemplates converting the Cherokee – Argo – Denver Terminal 115 kV line to 230 kV operation. The existing 115 kV line shares transmission structures with the Cherokee – Denver Terminal 230 kV line and is therefore built 230 kV capable. In addition, the conversion would impact the Argo 115 kV substation. Studies indicated that this alternative was not effective in reducing overloads. Therefore, this alternative was rejected.

**Table 8: Contingency Loading of Alternative 4**

Loaded Element	Contingency	Rating	% Load Minor Upgrades	% Load Alt 4
Greenwood – Monaco 230 kV	Smoky Hill – Buckley 230 kV	503	117%	117%
Monaco – Sullivan 230 kV	Smoky Hill – Buckley 230 kV	470	118%	118%
Sullivan – Leetsdale 230 kV	Smoky Hill – Buckley 230 kV	503	108%	108%
Leetsdale – Monroe 230 kV	Daniels Park – Santa Fe 230 kV	398	115%	117%
Monroe – Elati 230 kV	Daniels Park – Santa Fe 230 kV	398	96%	98%
Daniels Park – Prairie 230 kV #1	Daniels Park – Prairie 230 kV #2	576	92%	92%
Prairie – Greenwood 230 kV #1	Daniels Park – Prairie 230 kV #2	576	79%	79%
Leetsdale – Harrison 115 kV	Leetsdale – Monroe	141	109%	112%
Smoky Hill – Buckley 230 kV	Greenwood – Monaco 230 kV	506	105%	105%
Buckley – Tollgate 230 kV	Greenwood – Monaco 230 kV	484	110%	110%

**E. Alternative 5A: Leetsdale – Sandown – Cherokee 115 to 230 kV Conversion**

This alternative was considered based on feedback received from a CEPTF participant. The alternative contemplates converting the Leetsdale – Sandown – Cherokee 115 kV line to 230 kV operation. The Leetsdale – Sandown section is an underground cable that is built 230 kV capable while the rest of the overhead line sections are built for 115 kV operation. This alternative would require adding a new 230 kV substation yard at Sandown. In addition, the conversion would impact the Conoco South 115 kV substation. While the alternative did alleviate one overload, studies indicated that this alternative was not effective in reducing the remaining overloads. Therefore, this alternative was rejected.

**Table 9: Contingency Loading of Alternative 5A**

Loaded Element	Contingency	Rating	% Load Minor Upgrades	% Load Alt 5A
Greenwood – Monaco 230 kV	Smoky Hill – Buckley 230 kV	503	117%	118%
Monaco – Sullivan 230 kV	Smoky Hill – Buckley 230 kV	470	118%	118%
Sullivan – Leetsdale 230 kV	Smoky Hill – Buckley 230 kV	503	108%	108%
Leetsdale – Monroe 230 kV	Daniels Park – Santa Fe 230 kV	398	115%	109%
Monroe – Elati 230 kV	Daniels Park – Santa Fe 230 kV	398	96%	90%
Daniels Park – Prairie 230 kV #1	Daniels Park – Prairie 230 kV #2	576	92%	93%
Prairie – Greenwood 230 kV #1	Daniels Park – Prairie 230 kV #2	576	79%	79%
Leetsdale – Harrison 115 kV	Leetsdale – Monroe	141	109%	94%
Smoky Hill – Buckley 230 kV	Greenwood – Monaco 230 kV	506	105%	106%
Buckley – Tollgate 230 kV	Greenwood – Monaco 230 kV	484	110%	11%

**F. Alternative 5B: Alternative 5A and a new Sandown – Chambers 230 kV Line**

This alternative was considered based on feedback received from a CEPTF participant. The alternative contemplates expanding on Alternative 5A: Leetsdale – Sandown – Cherokee 115 to 230 kV Conversion by adding a new Sandown – Chambers 230 kV line. The studies indicated that this alternative was not effective in reducing the remaining overloads from Alternative 5A. Therefore, this alternative was rejected.

**Table 10: Contingency Loading of Alternative 5B**

Loaded Element	Contingency	Rating	% Load Minor Upgrades	% Load Alt 5B
Greenwood – Monaco 230 kV	Smoky Hill – Buckley 230 kV	503	117%	119%
Monaco – Sullivan 230 kV	Smoky Hill – Buckley 230 kV	470	118%	120%
Sullivan – Leetsdale 230 kV	Smoky Hill – Buckley 230 kV	503	108%	109%
Leetsdale – Monroe 230 kV	Daniels Park – Santa Fe 230 kV	398	115%	101%
Monroe – Elati 230 kV	Daniels Park – Santa Fe 230 kV	398	96%	83%
Daniels Park – Prairie 230 kV #1	Daniels Park – Prairie 230 kV #2	576	92%	92%
Prairie – Greenwood 230 kV #1	Daniels Park – Prairie 230 kV #2	576	79%	79%
Leetsdale – Harrison 115 kV	Leetsdale – Monroe	141	109%	92%
Smoky Hill – Buckley 230 kV	Greenwood – Monaco 230 kV	506	105%	106%
Buckley – Tollgate 230 kV	Greenwood – Monaco 230 kV	484	110%	111%

**G. Alternative 6: Waterton – Arapahoe – Denver Terminal 115 kV to 230 kV Conversion**

This alternative was considered based on feedback received from a CEPTF participant. The alternative contemplates converting the Waterton – Arapahoe 115 kV line to 230 kV operation and building a new Arapahoe – Denver Terminal 230 kV line in existing corridors similar to a portion of the Proposed Alternative 1 project. The existing Waterton – Arapahoe 115 kV line shares transmission structures with a 230 kV line and is therefore built 230 kV capable. In addition, the conversion would impact the Littleton 115 kV substation. While studies indicated that this alternative reduces loading levels on overloaded lines, it was not effective in eliminating the overloads. Therefore, this alternative was rejected.

**Table 11: Contingency Loading of Alternative 6**

Loaded Element	Contingency	Rating	% Load Minor Upgrades	% Load Alt 6
Greenwood – Monaco 230 kV	Smoky Hill – Buckley 230 kV	503	117%	112%
Monaco – Sullivan 230 kV	Smoky Hill – Buckley 230 kV	470	118%	112%
Sullivan – Leetsdale 230 kV	Smoky Hill – Buckley 230 kV	503	108%	103%
Leetsdale – Monroe 230 kV	Daniels Park – Santa Fe 230 kV	398	115%	102%
Monroe – Elati 230 kV	Daniels Park – Santa Fe 230 kV	398	96%	84%
Daniels Park – Prairie 230 kV #1	Daniels Park – Prairie 230 kV #2	576	92%	89%
Prairie – Greenwood 230 kV #1	Daniels Park – Prairie 230 kV #2	576	79%	76%
Leetsdale – Harrison 115 kV	Leetsdale – Monroe	141	109%	102%
Smoky Hill – Buckley 230 kV	Greenwood – Monaco 230 kV	506	105%	101%
Buckley – Tollgate 230 kV	Greenwood – Monaco 230 kV	484	110%	106%



**H. Alternative 7: Pawnee – Green Valley 345 kV line**

This alternative contemplates building a new 345 kV single-circuit transmission line between Pawnee and Green Valley substations. It would consist of approximately 65 miles of new transmission. In addition, the alternative includes a new 345 kV substation yard at Green Valley. Studies indicated that this alternative was not effective in reducing overloads. Therefore, this alternative was rejected.

**Table 12: Contingency Loading of Alternative 7**

Loaded Element	Contingency	Rating	% Load Minor Upgrades	% Load Alt 7
Greenwood – Monaco 230 kV	Smoky Hill – Buckley 230 kV	503	117%	115%
Monaco – Sullivan 230 kV	Smoky Hill – Buckley 230 kV	470	118%	115%
Sullivan – Leetsdale 230 kV	Smoky Hill – Buckley 230 kV	503	108%	105%
Leetsdale – Monroe 230 kV	Daniels Park – Santa Fe 230 kV	398	115%	112%
Monroe – Elati 230 kV	Daniels Park – Santa Fe 230 kV	398	96%	93%
Daniels Park – Prairie 230 kV #1	Daniels Park – Prairie 230 kV #2	576	92%	89%
Prairie – Greenwood 230 kV #1	Daniels Park – Prairie 230 kV #2	576	79%	76%
Leetsdale – Harrison 115 kV	Leetsdale – Monroe	141	109%	106%
Smoky Hill – Buckley 230 kV	Greenwood – Monaco 230 kV	506	105%	104%
Buckley – Tollgate 230 kV	Greenwood – Monaco 230 kV	484	110%	109%

**I. Alternative 8: Missile Site – Spruce 345 kV**

This alternative contemplates building a new 345 kV double-circuit transmission line between Missile Site and Spruce substations. It would consist of approximately 40 miles of new transmission. In addition, the alternative includes a new 345 kV substation yard at the Spruce 230 kV substation. Studies indicated that this alternative was not effective in reducing overloads. Therefore, this alternative was rejected.

**Table 13: Contingency Loading of Alternative 8**

Loaded Element	Contingency	Rating	% Load Minor Upgrades	% Load Alt 8
Greenwood – Monaco 230 kV	Smoky Hill – Buckley 230 kV	503	117%	114%
Monaco – Sullivan 230 kV	Smoky Hill – Buckley 230 kV	470	118%	114%
Sullivan – Leetsdale 230 kV	Smoky Hill – Buckley 230 kV	503	108%	105%
Leetsdale – Monroe 230 kV	Daniels Park – Santa Fe 230 kV	398	115%	112%
Monroe – Elati 230 kV	Daniels Park – Santa Fe 230 kV	398	96%	94%
Daniels Park – Prairie 230 kV #1	Daniels Park – Prairie 230 kV #2	576	92%	81%
Prairie – Greenwood 230 kV #1	Daniels Park – Prairie 230 kV #2	576	79%	68%
Leetsdale – Harrison 115 kV	Leetsdale – Monroe	141	109%	105%
Smoky Hill – Buckley 230 kV	Greenwood – Monaco 230 kV	506	105%	106%
Buckley – Tollgate 230 kV	Greenwood – Monaco 230 kV	484	110%	111%

**J. Alternative 9: Energy Storage**

Energy storage (batteries) was considered, but current technology does not allow for continuous operation to alleviate reliability concerns. Energy storage devices do not presently have the ability to maintain adequate charge to mitigate potential unacceptable loading conditions that could occur. At this point in time, there aren't any proven, commercially available energy storage technologies that PSCo could effectively deploy to address the overloading issues presented by the CEPP. The Company will be integrating over 1800 MW of new generation onto its system, much of which is intended to replace existing generation facilities that will be retired. This is a significant amount of generation that would be difficult to accommodate by storage, particularly where much of the new generation is not intended to address load growth but will be replacing facilities that already serve existing load. Further, more study will be necessary to understand whether and how large-scale energy storage deployment could effectively address transmission reliability issues.

## **IX. General Conclusions**

The results of this study indicate network upgrades to the transmission system are required in the Denver-Metro area to accommodate the generation resources approved as part of the CEPP. The Preferred Alternative is a new Greenwood – Denver Terminal 230 kV transmission line (GDT Project). The estimated cost is approximately \$50.1 million and the expected in-service date is December 2022. The transmission facilities identified in this study report are separate from the need for voltage control devices the Company has otherwise identified as necessary to accommodate the CEPP.

In addition to the GDT Project, the following minor upgrades to existing transmission lines within the Denver-Metro area must also be completed with an estimated total cost of approximately \$1.8 million:

1. Upgrade the Greenwood-Monaco 230 kV line;
2. Upgrade the Leetsdale-Sullivan-Monaco 230 kV line; and
3. Upgrade the Daniels Park-Prairie-Greenwood 230 kV line.

## Appendix A

### Benchmark Generation Tables

Bus Number	Bus Name		Id	Area Num	Area Name	In Service	PGen (MW)	PMax (MW)
70010	TBII_GEN 0.6900		W	70	PSCOLORADO	1	58.5	78
70017	SI_GEN 0.6000		1	70	PSCOLORADO	1	30	30
70069	CABCRKA 13.800		HA	70	PSCOLORADO	1	135	156
70070	CABCRKB 13.800		HB	70	PSCOLORADO	0	135	162
70104	CHEROK2 15.500		SC	70	PSCOLORADO	1	0	0
70106	CHEROK4 22.000		G4	70	PSCOLORADO	1	200	335
70119	COMAN_1 24.000		C1	70	PSCOLORADO	1	200	360
70120	COMAN_2 24.000		C2	70	PSCOLORADO	1	215.5	357.6
70145	CHEROKEE5 18.000		G5	70	PSCOLORADO	1	150	184.6
70146	CHEROKEE6 18.000		G6	70	PSCOLORADO	1	150	185.4
70147	CHEROKEE7 18.000		ST	70	PSCOLORADO	1	200	228
70160	E_CANON 69.000		G1	70	PSCOLORADO	0	0	8
70180	FRUITA 13.800		G1	70	PSCOLORADO	0	0	19.7
70188	FTLUP1-2 13.800		G1	70	PSCOLORADO	0	35	44
70188	FTLUP1-2 13.800		G2	70	PSCOLORADO	0	35	49.6
70306	PP_MINE 69.000		G1	70	PSCOLORADO	0	0	3
70310	PAWNEE 22.000		C1	70	PSCOLORADO	1	500	535
70314	MANCHEF1 16.000		G1	70	PSCOLORADO	1	126	140
70315	MANCHEF2 16.000		G2	70	PSCOLORADO	0	126	140
70334	PUB_DSLS 4.1600		G1	70	PSCOLORADO	0	0	10
70344	R.F.DSLS 4.1600		G1	70	PSCOLORADO	0	0	10
70350	RAWHIDE 24.000		C1	70	PSCOLORADO	1	300	304
70351	RAWHIDEA 13.800		GA	70	PSCOLORADO	0	0	70
70406	ST.VR_2 18.000		G2	70	PSCOLORADO	1	125	133.9
70407	ST.VR_3 18.000		G3	70	PSCOLORADO	1	125	124.3
70408	ST.VR_4 18.000		G4	70	PSCOLORADO	1	125	145.4
70409	ST.VRAIN 22.000		ST	70	PSCOLORADO	1	300	318.3
70448	VALMONT6 13.800		G6	70	PSCOLORADO	1	43	57
70485	ALMSACT1 13.800		G1	70	PSCOLORADO	0	0	19.4
70486	ALMSACT2 13.800		G2	70	PSCOLORADO	0	0	18.5
70487	JMSHAFR4 13.800		G4	70	PSCOLORADO	1	23	34.8
70487	JMSHAFR4 13.800		G5	70	PSCOLORADO	1	23	33
70490	JMSHAFR3 13.800		G3	70	PSCOLORADO	1	35.5	36.1
70490	JMSHAFR3 13.800		ST	70	PSCOLORADO	1	29	50
70493	JMSHAFR2 13.800		ST	70	PSCOLORADO	1	24	50.7
70495	JMSHAFR1 13.800		G1	70	PSCOLORADO	1	35.8	35.8

Bus Number	Bus Name		Id	Area Num	Area Name	In Service	PGen (MW)	PMax (MW)
70495	JMSHAFR1	13.800	G2	70	PSCOLORADO	1	35	35
70498	QF_BCP2T	13.800	G3	70	PSCOLORADO	0	0	34.1
70498	QF_BCP2T	13.800	ST	70	PSCOLORADO	0	0	36
70499	QF_B4-4T	13.800	G4	70	PSCOLORADO	1	20	24
70499	QF_B4-4T	13.800	G5	70	PSCOLORADO	0	20	25
70500	QF_CPP1T	13.800	G1	70	PSCOLORADO	1	20	24
70500	QF_CPP1T	13.800	G2	70	PSCOLORADO	1	20	24
70501	QF_CPP3T	13.800	ST	70	PSCOLORADO	1	20	27
70502	PIONEER_IR_S34.500		S1	70	PSCOLORADO	1	52	80
70548	APT_DSLS	4.1600	G1	70	PSCOLORADO	0	0	10
70553	ARAP5&6	13.800	G5	70	PSCOLORADO	1	35	39
70553	ARAP5&6	13.800	G6	70	PSCOLORADO	1	35	39.5
70554	ARAP7	13.800	ST	70	PSCOLORADO	1	40	45
70556	QF_B4D4T	12.500	ST	70	PSCOLORADO	1	40	70
70557	VALMNT7	13.800	G7	70	PSCOLORADO	0	30	41.7
70558	VALMNT8	13.800	G8	70	PSCOLORADO	0	30	41.7
70560	LAMAR_DC	230.00	DC	70	PSCOLORADO	1	0	210
70561	RAWHIDEF	18.000	GF	70	PSCOLORADO	1	125	138
70562	SPRUCE1	18.000	G1	70	PSCOLORADO	1	130	145.1
70563	SPRUCE2	18.000	G2	70	PSCOLORADO	0	130	140.5
70564	RH_PV_GEN	0.6000	PV	70	PSCOLORADO	1	19	32.4
70565	KNUTSON1	13.800	G1	70	PSCOLORADO	1	40	67.5
70566	KNUTSON2	13.800	G2	70	PSCOLORADO	1	40	67.5
70567	RAWHIDED	13.800	GD	70	PSCOLORADO	1	53	70
70568	RAWHIDEB	13.800	GB	70	PSCOLORADO	1	53	70
70569	RAWHIDEC	13.800	GC	70	PSCOLORADO	1	53	70
70572	CEP_4	34.500	S1	70	PSCOLORADO	0	110	110
70577	FTNVL1&2	13.800	G1	70	PSCOLORADO	1	36	40
70577	FTNVL1&2	13.800	G2	70	PSCOLORADO	1	36	40
70578	FTNVL3&4	13.800	G3	70	PSCOLORADO	1	36	40
70578	FTNVL3&4	13.800	G4	70	PSCOLORADO	1	36	40
70579	FTNVL5&6	13.800	G5	70	PSCOLORADO	0	36	40
70579	FTNVL5&6	13.800	G6	70	PSCOLORADO	0	36	40
70580	PLNENDG1_1	13.800	G0	70	PSCOLORADO	1	4.8	5.5
70580	PLNENDG1_1	13.800	G1	70	PSCOLORADO	1	4.8	5.5
70580	PLNENDG1_1	13.800	G2	70	PSCOLORADO	1	4.8	5.5
70580	PLNENDG1_1	13.800	G3	70	PSCOLORADO	1	4.8	5.5
70580	PLNENDG1_1	13.800	G4	70	PSCOLORADO	1	4.8	5.5
70580	PLNENDG1_1	13.800	G5	70	PSCOLORADO	1	4.8	5.5
70580	PLNENDG1_1	13.800	G6	70	PSCOLORADO	1	4.8	5.5

Bus Number	Bus Name	Id	Area Num	Area Name	In Service	PGen (MW)	PMax (MW)
70580	PLNENDG1_1 13.800	G7	70	PSCOLORADO	1	4.8	5.5
70580	PLNENDG1_1 13.800	G8	70	PSCOLORADO	1	4.8	5.5
70580	PLNENDG1_1 13.800	G9	70	PSCOLORADO	1	4.8	5.5
70585	PLNENDG2_1 13.800	G1	70	PSCOLORADO	1	7.2	8.1
70585	PLNENDG2_1 13.800	G2	70	PSCOLORADO	1	7.2	8.1
70585	PLNENDG2_1 13.800	G3	70	PSCOLORADO	1	7.2	8.1
70585	PLNENDG2_1 13.800	G4	70	PSCOLORADO	1	7.2	8.1
70585	PLNENDG2_1 13.800	G5	70	PSCOLORADO	1	7.2	8.1
70585	PLNENDG2_1 13.800	G6	70	PSCOLORADO	1	7.2	8.1
70585	PLNENDG2_1 13.800	G7	70	PSCOLORADO	1	7.2	8.1
70586	PLNENDG2_2 13.800	G1	70	PSCOLORADO	1	7.2	8.1
70586	PLNENDG2_2 13.800	G2	70	PSCOLORADO	1	7.2	8.1
70586	PLNENDG2_2 13.800	G3	70	PSCOLORADO	1	7.2	8.1
70586	PLNENDG2_2 13.800	G4	70	PSCOLORADO	1	7.2	8.1
70586	PLNENDG2_2 13.800	G5	70	PSCOLORADO	1	7.2	8.1
70586	PLNENDG2_2 13.800	G6	70	PSCOLORADO	1	7.2	8.1
70586	PLNENDG2_2 13.800	G7	70	PSCOLORADO	1	7.2	8.1
70587	PLNENDG1_2 13.800	G0	70	PSCOLORADO	1	4.8	5.5
70587	PLNENDG1_2 13.800	G1	70	PSCOLORADO	1	4.8	5.5
70587	PLNENDG1_2 13.800	G2	70	PSCOLORADO	1	4.8	5.5
70587	PLNENDG1_2 13.800	G3	70	PSCOLORADO	1	4.8	5.5
70587	PLNENDG1_2 13.800	G4	70	PSCOLORADO	1	4.8	5.5
70587	PLNENDG1_2 13.800	G5	70	PSCOLORADO	1	4.8	5.5
70587	PLNENDG1_2 13.800	G6	70	PSCOLORADO	1	4.8	5.5
70587	PLNENDG1_2 13.800	G7	70	PSCOLORADO	1	4.8	5.5
70587	PLNENDG1_2 13.800	G8	70	PSCOLORADO	1	4.8	5.5
70587	PLNENDG1_2 13.800	G9	70	PSCOLORADO	1	4.8	5.5
70588	RMEC1 15.000	G1	70	PSCOLORADO	1	125	142.2
70589	RMEC2 15.000	G2	70	PSCOLORADO	1	125	150.5
70591	RMEC3 23.000	ST	70	PSCOLORADO	1	250	313
70593	SPNDLE1 18.000	G1	70	PSCOLORADO	1	120	143.07
70594	SPNDLE2 18.000	G2	70	PSCOLORADO	1	100	140.59
70616	TITAN_S1 0.6300	S1	70	PSCOLORADO	1	40	50
70629	RUSHCK_W1 34.500	W1	70	PSCOLORADO	1	285	380
70631	RUSHCK_W2 34.500	W2	70	PSCOLORADO	1	165	220
70632	CEP_1 34.500	W1	70	PSCOLORADO	0	500	500
70633	CEP_2 34.500	W1	70	PSCOLORADO	0	300	300
70635	LIMON1_W 34.500	W1	70	PSCOLORADO	1	151	201
70636	LIMON2_W 34.500	W2	70	PSCOLORADO	1	151	201
70637	LIMON3_W 34.500	W3	70	PSCOLORADO	1	151	201

Bus Number	Bus Name		Id	Area Num	Area Name	In Service	PGen (MW)	PMax (MW)
70651	CEP_8 34.500		S1	70	PSCOLORADO	0	75	75
70653	CEP_5 34.500		S1	70	PSCOLORADO	0	200	200
70665	JKFUL_W1 0.7000		W1	70	PSCOLORADO	1	93.1	124.1
70666	JKFUL_W2 0.7000		W2	70	PSCOLORADO	1	93.75	125
70670	CEDARPT_W1 0.6900		W1	70	PSCOLORADO	1	93.15	124.2
70671	CEDARPT_W2 0.6900		W2	70	PSCOLORADO	1	94.5	126
70701	CO_GRN_E 34.500		W1	70	PSCOLORADO	1	60.75	81
70702	CO_GRN_W 34.500		W2	70	PSCOLORADO	1	60.75	81
70703	TWNBUTTE 34.500		W1	70	PSCOLORADO	1	56.25	75
70710	PTZLOGN1 34.500		W1	70	PSCOLORADO	1	151	201
70712	PTZLOGN2 34.500		W2	70	PSCOLORADO	1	90	120
70713	PTZLOGN3 34.500		W3	70	PSCOLORADO	1	59.63	79.5
70714	PTZLOGN4 34.500		W4	70	PSCOLORADO	1	131.25	175
70721	SPRNGCAN 0.5700		W1	70	PSCOLORADO	1	48.6	64.8
70723	RDGCREST 34.500		W1	70	PSCOLORADO	1	22	29.7
70777	COMAN_3 27.000		C3	70	PSCOLORADO	1	550	780
70778	CEP_6 34.500		S1	70	PSCOLORADO	0	250	250
70819	CEP_3 34.500		W1	70	PSCOLORADO	0	169	169
70823	CEDARCK_1A 34.500		W1	70	PSCOLORADO	1	165	220
70824	CEDARCK_1B 34.500		W2	70	PSCOLORADO	1	60	80
70825	CEDAR2_W1 0.6600		W1	70	PSCOLORADO	1	93.75	125
70826	CEDAR2_W2 0.6900		W2	70	PSCOLORADO	1	75	100.8
70827	CEDAR2_W3 0.6600		W3	70	PSCOLORADO	1	18.75	25
70928	CEP_7 34.500		S1	70	PSCOLORADO	0	72	72
70931	GSANDHIL_PV 34.500		S1	70	PSCOLORADO	1	12	19
70932	HOOPER_PV 34.500		S2	70	PSCOLORADO	1	19.5	30
70933	COGENTRIX_PV34.500		S3	70	PSCOLORADO	1	19.5	30
70934	COMAN_S1 0.4180		S1	70	PSCOLORADO	1	100	125
70935	SUNPOWER 34.500		S1	70	PSCOLORADO	1	41.6	52
70950	ST.VR_5 18.000		G5	70	PSCOLORADO	1	140	157.4
70951	ST.VR_6 18.000		G6	70	PSCOLORADO	0	140	157.4
70994	SPANISH.PK 0.6200		PV	70	PSCOLORADO	1	80	100.2
71001	BAC_MSA GEN113.800		G1	70	PSCOLORADO	1	90	90
71002	BAC_MSA GEN213.800		G1	70	PSCOLORADO	1	90	90
71003	BAC_MSA GEN413.800		G1	70	PSCOLORADO	1	40	40
71003	BAC_MSA GEN413.800		G2	70	PSCOLORADO	1	40	40
71003	BAC_MSA GEN413.800		S1	70	PSCOLORADO	0	0	24.8
71004	BAC_MSA GEN513.800		G1	70	PSCOLORADO	1	40	40
71004	BAC_MSA GEN513.800		G2	70	PSCOLORADO	1	40	40
71004	BAC_MSA GEN513.800		S1	70	PSCOLORADO	0	0	24.8

Bus Number	Bus Name	Id	Area Num	Area Name	In Service	PGen (MW)	PMax (MW)
71005	BAC_MSA GEN613.800	G1	70	PSCOLORADO	1	40	40
71009	BUSCHRWTG1 0.7000	G1	70	PSCOLORADO	1	8	28.8
71013	BUSCHRNCH_LOO.7000	1	70	PSCOLORADO	1	20	60
71016	RTLSNKWNDLO 0.7000	G1	70	PSCOLORADO	1	22	60
72703	CRSL_GEN 0.7000	W	73	WAPA R.M.	1	75.6	150
72714	KC_GEN 0.6900	G1	73	WAPA R.M.	1	25.7	51.2
72719	CT_GEN 0.6900	W	73	WAPA R.M.	1	52.2	104.2
73054	ELBERT-1 11.500	1	73	WAPA R.M.	1	95	102.9
73129	MBPP-1 24.000	1	73	WAPA R.M.	1	275.6603	605
73130	MBPP-2 24.000	1	73	WAPA R.M.	1	500	605
73181	SIDNEYDC 230.00	1	73	WAPA R.M.	1	50	200
73226	YELLO1-2 13.800	1	73	WAPA R.M.	1	60	65.3
73226	YELLO1-2 13.800	2	73	WAPA R.M.	1	60	65.3
73227	YELLO3-4 13.800	3	73	WAPA R.M.	1	66	71.96
73227	YELLO3-4 13.800	4	73	WAPA R.M.	1	60	65.3
73289	RCCT1 13.800	1	73	WAPA R.M.	1	17	17
73291	RCCT2 13.800	2	73	WAPA R.M.	1	17	17
73292	RCCT3 13.800	3	73	WAPA R.M.	1	17	17
73293	RCCT4 13.800	4	73	WAPA R.M.	1	17	17
73299	BIGTHOMP 4.2000	1	73	WAPA R.M.	1	3	4.5
73302	BRLNGTN1 13.800	1	73	WAPA R.M.	0	0	48.4
73303	BRLNGTN2 13.800	1	73	WAPA R.M.	0	0	48.4
73306	ESTES1 6.9000	1	73	WAPA R.M.	1	12	15.7
73307	ESTES2 6.9000	1	73	WAPA R.M.	1	12	15.7
73308	ESTES3 6.9000	1	73	WAPA R.M.	1	12	15.7
73316	GREENMT1 6.9000	1	73	WAPA R.M.	1	11	14.444
73317	GREENMT2 6.9000	1	73	WAPA R.M.	1	11	14.444
73319	MARYLKPP 6.9000	1	73	WAPA R.M.	1	8	10.35
73324	POLEHILL 13.800	1	73	WAPA R.M.	1	33	37.8
73328	WILLMFRK 2.4000	1	73	WAPA R.M.	1	1.5	3
73332	ALCOVA1 6.9000	1	73	WAPA R.M.	1	16	19.8
73333	BOYSEN1 4.2000	1	73	WAPA R.M.	1	5	7.5
73333	BOYSEN1 4.2000	2	73	WAPA R.M.	1	5	7.5
73334	BBILL1-2 6.9000	1	73	WAPA R.M.	1	4	6.67
73334	BBILL1-2 6.9000	2	73	WAPA R.M.	1	4	6.67
73339	HEART MT 2.4000	1	73	WAPA R.M.	1	4	6.9
73341	NSS2 13.800	2	73	WAPA R.M.	1	90.7	88
73347	SHOSHONE 6.9000	1	73	WAPA R.M.	1	2	3.33
73349	FREMONT1 11.500	1	73	WAPA R.M.	1	27	33.4
73350	FREMONT2 11.500	1	73	WAPA R.M.	1	27	33.4



Bus Number	Bus Name	Id	Area Num	Area Name	In Service	PGen (MW)	PMax (MW)
73351	GLEND01 6.9000	1	73	WAPA R.M.	1	16	19
73352	GLEND02 6.9000	1	73	WAPA R.M.	1	16	19
73353	GUERNSY1 2.4000	1	73	WAPA R.M.	1	2	3.2
73356	KORTES1 6.9000	1	73	WAPA R.M.	1	10	13.8
73357	KORTES2 6.9000	1	73	WAPA R.M.	1	10	13.8
73358	KORTES3 6.9000	1	73	WAPA R.M.	1	10	13.8
73363	SEMINOE1-2 6.9000	1	73	WAPA R.M.	1	12	15
73363	SEMINOE1-2 6.9000	2	73	WAPA R.M.	1	12	15
73381	BIRDSAL1 13.800	1	73	WAPA R.M.	0	0	18
73382	BIRDSAL2 13.800	1	73	WAPA R.M.	0	0	18
73383	BIRDSAL3 13.800	1	73	WAPA R.M.	0	0	23
73418	RD_NIXON 20.000	1	73	WAPA R.M.	1	225.4	225
73424	TESLA1 13.800	1	73	WAPA R.M.	1	24.2	28
73428	DRAKE 6 13.800	1	73	WAPA R.M.	1	71.6	72
73429	DRAKE 7 13.800	1	73	WAPA R.M.	1	131.5	131.5
73434	NIXONCT1 12.500	1	73	WAPA R.M.	0	0	27
73435	NIXONCT2 12.500	1	73	WAPA R.M.	0	0	27
73438	ALCOVA2 6.9000	1	73	WAPA R.M.	1	16	19.8
73439	BBILL3-4 6.9000	1	73	WAPA R.M.	1	5	6.67
73441	SEMINOE3 6.9000	1	73	WAPA R.M.	1	12	15
73444	GUERNSY2 2.4000	2	73	WAPA R.M.	1	2	3.2
73448	FLATIRN1 13.800	2	73	WAPA R.M.	1	42	47.8
73449	FLATIRN2 13.800	1	73	WAPA R.M.	1	42	47.8
73449	FLATIRN2 13.800	3	73	WAPA R.M.	1	6	8.5
73461	ELBERT-2 11.500	1	73	WAPA R.M.	1	95	102.9
73462	SPIRTMTN 6.9000	1	73	WAPA R.M.	1	3	5
73477	FULLER 230.00	1	73	WAPA R.M.	1	9.4	35
73507	FTRNG1CC 18.000	1	73	WAPA R.M.	1	140.3	140.5
73508	FTRNG2CC 18.000	1	73	WAPA R.M.	1	141.1	141.3
73509	FTRNG3CC 21.000	1	73	WAPA R.M.	1	178.7	208.2
73520	BFDIESEL 4.2000	1	73	WAPA R.M.	0	0	10
73532	LINCOLN1 13.800	1	73	WAPA R.M.	1	40	68.5
73533	LINCOLN2 13.800	1	73	WAPA R.M.	1	40	62.5
73631	COHIWND_G1 0.6900	W	73	WAPA R.M.	1	30.1	67.1
73635	COHIWND_G2 0.6900	W	73	WAPA R.M.	1	12.1	23.1
73713	WILLIAMSCRK 34.500	1	73	WAPA R.M.	1	25.1	60
74014	NSS_CT1 13.800	1	73	WAPA R.M.	1	40	40
74015	NSS_CT2 13.800	1	73	WAPA R.M.	0	0	40
74016	WYGEN 13.800	1	73	WAPA R.M.	1	93	95
74017	WYGEN2 13.800	1	73	WAPA R.M.	1	100	100

Bus Number	Bus Name		Id	Area Num	Area Name	In Service	PGen (MW)	PMax (MW)
74018	WYGEN3	13.800	1	73	WAPA R.M.	1	105	115
74029	LNG_CT1	13.800	1	73	WAPA R.M.	0	0	40
74042	CLR_1	0.6000	1	73	WAPA R.M.	1	20	29.4
74043	SS_GEN1	0.6000	1	73	WAPA R.M.	1	26.7	42
74061	CPGSTN_1	13.800	G1	73	WAPA R.M.	1	40	40
74061	CPGSTN_1	13.800	G2	73	WAPA R.M.	1	40	40
74061	CPGSTN_1	13.800	S1	73	WAPA R.M.	1	24.8	24.8
74062	CPGSTN_2	13.800	G1	73	WAPA R.M.	1	40	40
74063	CPGSTN_3	13.800	G1	73	WAPA R.M.	0	0	50
74063	CPGSTN_3	13.800	G2	73	WAPA R.M.	0	0	50
74063	CPGSTN_3	13.800	S1	73	WAPA R.M.	0	0	24.8
74067	SDSUNINV	0.6000	1	73	WAPA R.M.	0	0	20
76301	ARVADA1	13.800	1	73	WAPA R.M.	0	0	7.2
76302	ARVADA2	13.800	1	73	WAPA R.M.	0	0	7.2
76303	ARVADA3	13.800	1	73	WAPA R.M.	0	0	7.2
76305	BARBERC1	13.800	1	73	WAPA R.M.	0	0	7.2
76306	BARBERC2	13.800	1	73	WAPA R.M.	0	0	7.2
76307	BARBERC3	13.800	1	73	WAPA R.M.	0	0	7.2
76309	HARTZOG1	13.800	1	73	WAPA R.M.	0	0	7.2
76310	HARTZOG2	13.800	1	73	WAPA R.M.	0	0	7.2
76311	HARTZOG3	13.800	1	73	WAPA R.M.	0	0	7.2
76313	TK_DVAR1	0.5000	1	73	WAPA R.M.	0	0	0
76314	TK_DVAR2	0.5000	1	73	WAPA R.M.	0	0	0
76351	RCDC W	230.00	1	73	WAPA R.M.	1	-130	200
76404	DRYFORK	19.000	1	73	WAPA R.M.	1	420	440
76502	SPFSHPRK	69.000	1	73	WAPA R.M.	0	0	4
79015	CRAIG 1	22.000	1	73	WAPA R.M.	1	400	470
79016	CRAIG 2	22.000	1	73	WAPA R.M.	1	400	470
79017	CRAIG 3	22.000	1	73	WAPA R.M.	1	449	478
79019	MORRO1-2	12.500	1	73	WAPA R.M.	1	75	81
79019	MORRO1-2	12.500	2	73	WAPA R.M.	1	75	81
79040	HAYDEN1	18.000	1	73	WAPA R.M.	1	175	202
79041	HAYDEN2	22.000	1	73	WAPA R.M.	1	250	285
79123	FONTNLE	4.1600	1	73	WAPA R.M.	1	8	11.111
79154	FLGORG1	11.500	1	73	WAPA R.M.	1	51	56.1
79155	FLGORG2	11.500	1	73	WAPA R.M.	1	51	56.1
79156	FLGORG3	11.500	1	73	WAPA R.M.	1	51	56.1
79157	BMESA1-2	11.500	1	73	WAPA R.M.	1	40	44
79157	BMESA1-2	11.500	2	73	WAPA R.M.	1	40	44
79162	CRYSTAL	11.500	1	73	WAPA R.M.	1	30	35

Bus Number	Bus Name		Id	Area Num	Area Name	In Service	PGen (MW)	PMax (MW)
79164	TOWAOC 6.9000		1	73	WAPA R.M.	1	9	12.1
79166	MOLINA-L 4.2000		1	73	WAPA R.M.	1	3	4.9
79172	MOLINA-U 4.2000		1	73	WAPA R.M.	1	6	8.6
79176	MCPHEE 2.4000		1	73	WAPA R.M.	1	1	1.3
79251	QFATLAS1 13.800		1	73	WAPA R.M.	0	0	30.7
79251	QFATLAS1 13.800		2	73	WAPA R.M.	0	0	15.4
79252	QFATLAS2 13.800		3	73	WAPA R.M.	0	0	15.4
79252	QFATLAS2 13.800		4	73	WAPA R.M.	0	0	15.4