

System Impact Study Report Request # T-2006-4

**900 MW Firm Point-to-Point Transmission Service Request
from Wyoming to Colorado**

**PSCo Transmission Planning
December 20, 2007**

Executive Summary

Public Service Company of Colorado (PSCo) received a transmission service request (TSR) to determine the feasibility and system impact of evaluating 900 MW point-to-point transmission service of coal fired and wind generation request into the PSCo transmission system from Wyoming for the period of January 1, 2010 through January 1, 2040. However, this System Impact Study shows that the time frame to build the transmission infrastructure required for delivery of power to PSCo loads is at least 65 months after approval of a Certificate of Public Convenience and Need (CPCN). Therefore, it is not feasible to construct the Network Upgrades for full Firm Delivery of this project before the requested in-service date. This System Impact Study was modeled with generators interconnecting to the Laramie River Station (LRS) and other locations in Wyoming via the Customer's proposed 345kV integrated transmission line. The Customer's 345 kV integrated transmission line will connect LRS to the PSCo transmission system at a future Pawnee 345kV bus.

The power flow base case utilized in this System Impact Study was based from the Wyoming Joint Queue Study (WJQS)¹ projects, which are depicted in Figure 1. Other study assumptions are depicted in Appendix A.

As a firm point-to-point 900 MW Transmission Service Request, PSCo evaluated the network to determine the upgrades required to deliver the full 900 MW to PSCo native load customers. The total estimated cost of the recommended system upgrades to accommodate the project is approximately **\$224.58²** million and includes:

- Expand the existing Pawnee Station and Smoky Hill Switchyard to a 345kV switchyard and build 345kV transmission from Pawnee to Smoky Hill to Daniels Park
- Build 230kV transmission from Ault Substation to Cherokee Substation

The costs and time frames are summarized in the table below. The details of the transmission proposals are examined in the next section.

¹ These projects will be discussed in the Power Flow Results section

² PSCo has filed on October 31, 2007 a CPCN for the Pawnee – Smoky Hill 345kV Transmission Project with a cost estimate of \$120 million and, if this CPCN is approved, the differential cost would be \$104.58 million.

Total Costs / Time Estimates

Table 1 – Cost Summary Table

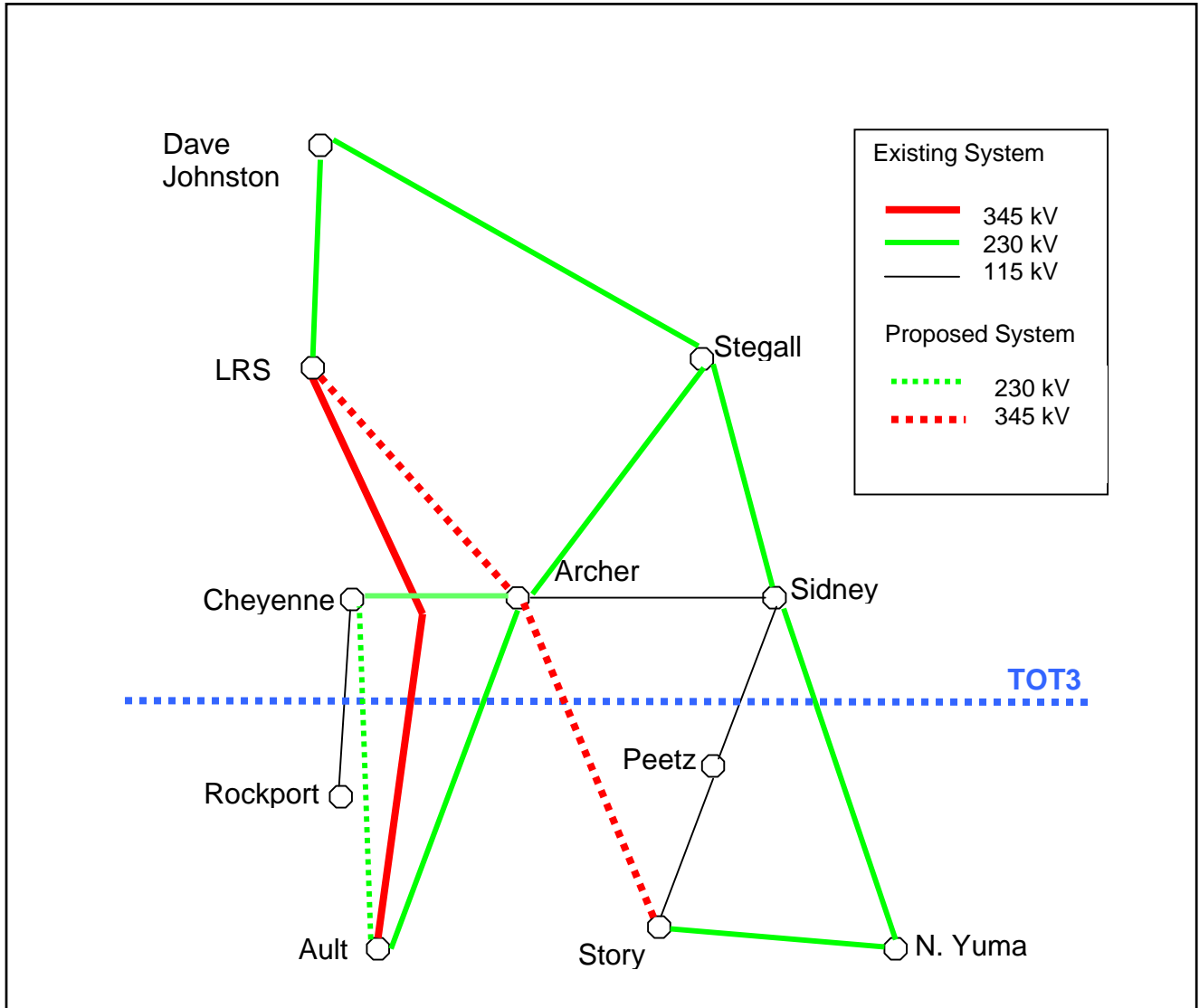
Item	Cost - \$ Million	Time – Months
Customer Funded PSCo Owned Upgrades for Interconnection	\$1.12	12 months
PSCo Upgrades for Interconnection	\$7.78	45 months
Delivery Infrastructure <ul style="list-style-type: none"> • 345kV line from Pawnee to Smoky Hill to Daniels Park • TOT7 expansion 	\$147.35	65 months
	\$68.33	60 months
Total	\$224.58	65 months

The PSCo system between the Ault Substation and the PSCo System includes one WECC³ recognized TOT 7 transfer path. The TOT 7 transfer path is a constrained interface between the Northern Colorado Area and North Denver Metro Area. The TOT 7 transfer limit depends on the local demand and the level of generation from the Colorado-Big Thompson (CBT) Hydro Project units.

Joint transmission studies would be required with all affected utilities to obtain regulatory and industry acceptance of a new TOT 7 transfer limit along with the proposed infrastructure improvements, if the Customer chooses to continue this transmission service request. This study did not examine or propose new transfer limit of the path or allocate rights between TOT 7 owners PSCo and Platte River Power Authority (PRPA). This study only examined system criteria violations before and after the integration of the present transmission service request. The WECC path rating process requires joint transmission studies to demonstrate that the new rating would not negatively impact other transfer paths and neighboring systems.

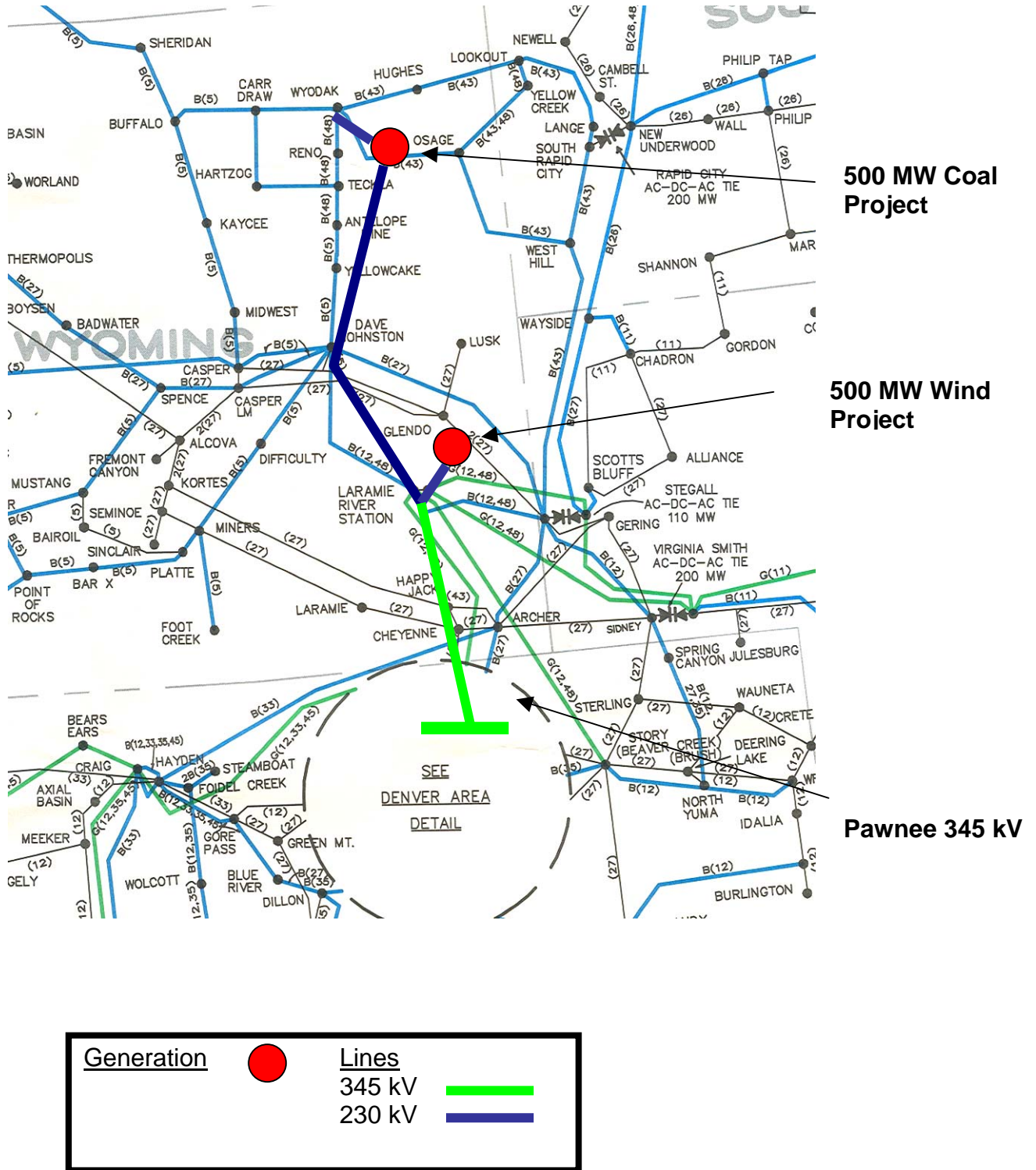
³ Western Electricity Coordinating Council (WECC)

Figure 1- Wyoming Joint Queue Study Projects



A partial one-line diagram depicting the customer's generation and transmission lines is shown in Figure 2.

Figure 2- Customer's Generators and Transmission in Wyoming



Transmission Planning Results

Firm Point-to-Point Request:

As a firm point-to-point TSR, PSCo Transmission Planning evaluated the network to determine the upgrades required to deliver the full 900 MW of the coal-fired and wind generation facilities to PSCo native load customers. One alternative has been recommended and includes transmission enhancements in two different regions in Colorado. These transmission enhancements have been divided in two parts: Part (I) Pawnee upgrades and Part (II) TOT 7 upgrades.

Transmission Proposal (Part I): Pawnee upgrades

The total estimated cost of the recommended system upgrades to accommodate the project for the Pawnee area is approximately **\$155.29⁴** million and includes:

- \$ 0.54 million for PSCo-Owned, Customer Funded Interconnection Facilities
- \$7.40 million for PSCo Network Upgrades for Interconnection
- \$147.35 million for PSCo Network Upgrades for Delivery

These basic upgrades including interconnection as shown in Figure 3 would consist of:

- Constructing a new 96-mile 345 kV line from Pawnee to Smoky Hill Substation. The new transmission can be described in three sections:
 - The first section consists of 79-miles of new 345 kV single circuit steel structures in new right of way from Pawnee and then join the existing PSCo transmission corridor near Brick Center Substation
 - Replace 15-miles of an existing single circuit line between Brick Center and Smoky Hill (part of the Pawnee-Daniels Park 230 kV line) with double circuit 345 kV capable structures. One side will operate at 230 kV to maintain the existing circuit. The other side will operate at 345 kV and make up the second section.
 - The final (third) section consists of constructing 1 mile of new 345 kV transmission double-circuit capable.
- Two 345/230kV 560 MVA autotransformers at Pawnee
- Four 345/230kV 250 MVA single phase autotransformers at Smoky Hill
- Constructing a new 20-mile 345 kV line from Smoky Hill Substation to Daniels Park. The new transmission can be described as:
 - Build a 20-mile 345kV double circuit capable transmission line in the existing 230kV transmission corridor.

A partial one-line of Pawnee Station detailing the Interconnection is shown in Figure 4.

⁴ The CPCN for The Pawnee – Smoky Hill 345kV Transmission Project has been filed with a cost of \$120 million and, if approved, the differential cost for this portion of the transmission proposal would be \$35.29 million.

Figure 3- Transmission Proposal (Part I): Pawnee upgrades

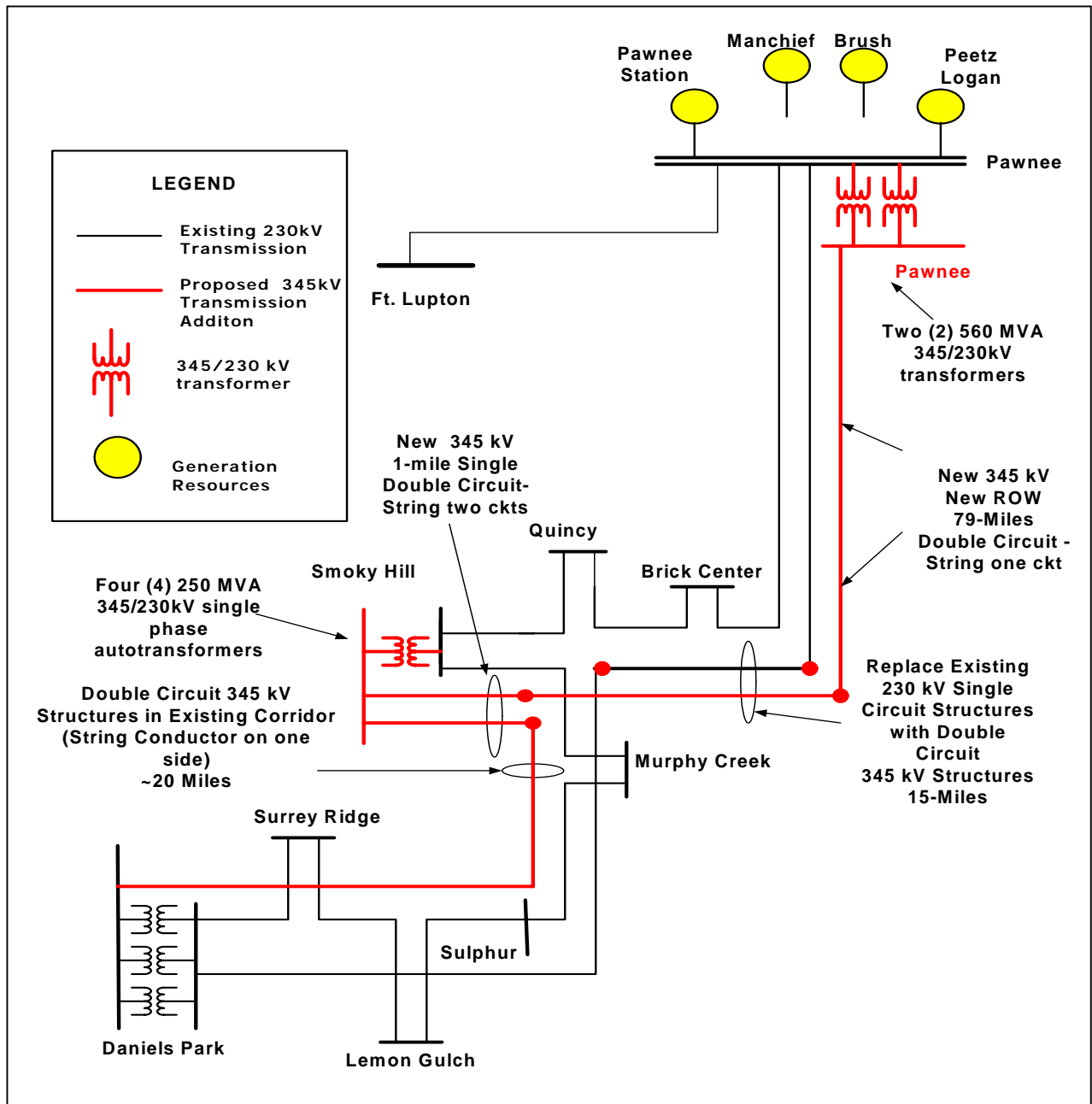
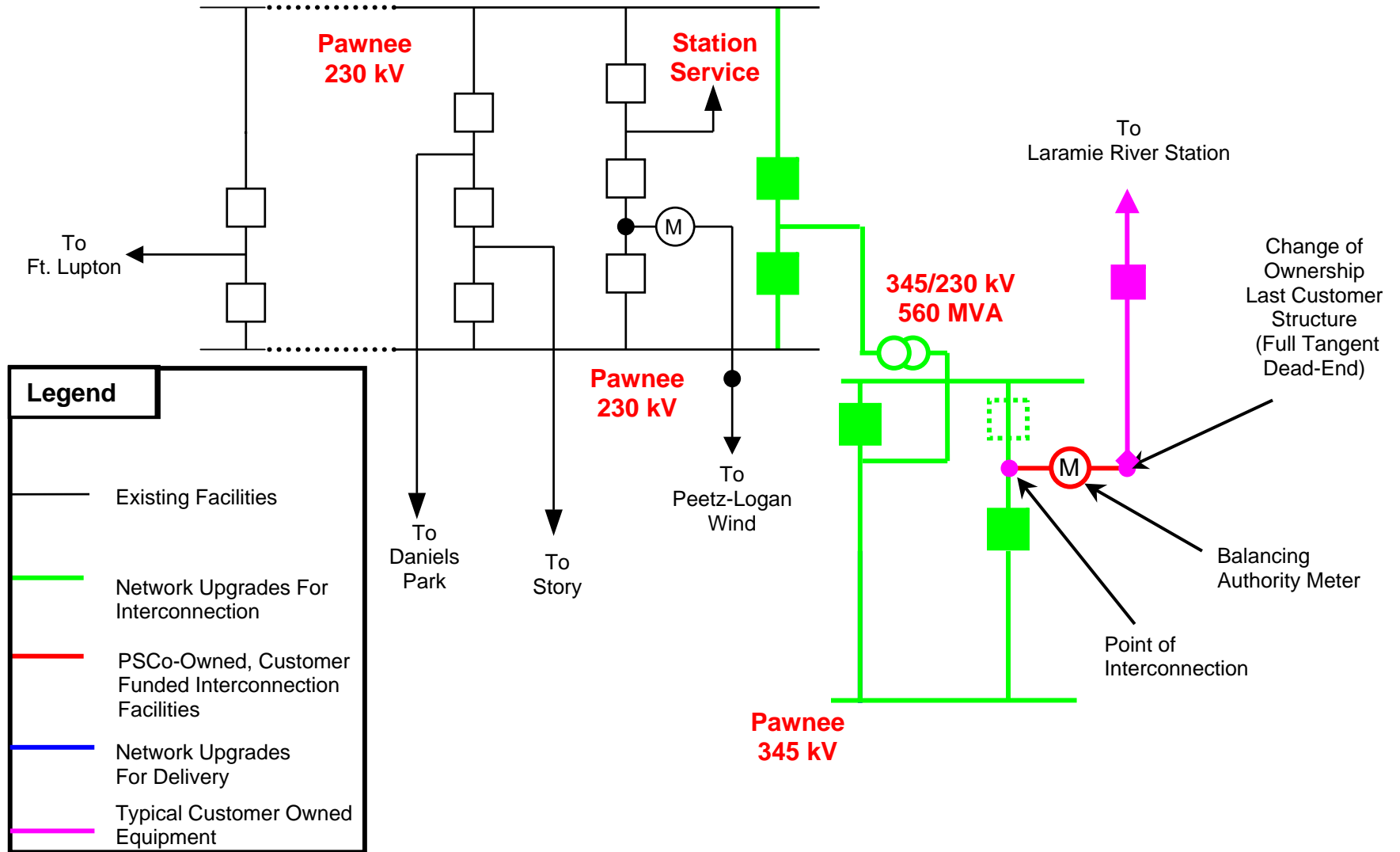


Figure 4: Pawnee Station One-line with Interconnection of T-2006-4



The estimated time required to engineer, permit, and construct all the required PSCo facilities for interconnection is estimated to be 45 months. The estimated time required to obtain a CPCN approval, engineer, permit, and construct the Network Upgrade facilities for delivery is 65 months concurrent with the interconnection. According to the transmission service request, the Customer will engineer, permit, construct, and finance all facilities up to the point of interconnection at the Pawnee Station. *Therefore, transmission studies show that it will not be feasible to deliver the full 900 MW by the requested commencement date of January 2010.*

Transmission Proposal (Part II): TOT 7 upgrades

The total estimated cost of the recommended system upgrades to accommodate the project for TOT 7 constraints is approximately **\$69.29** million and includes:

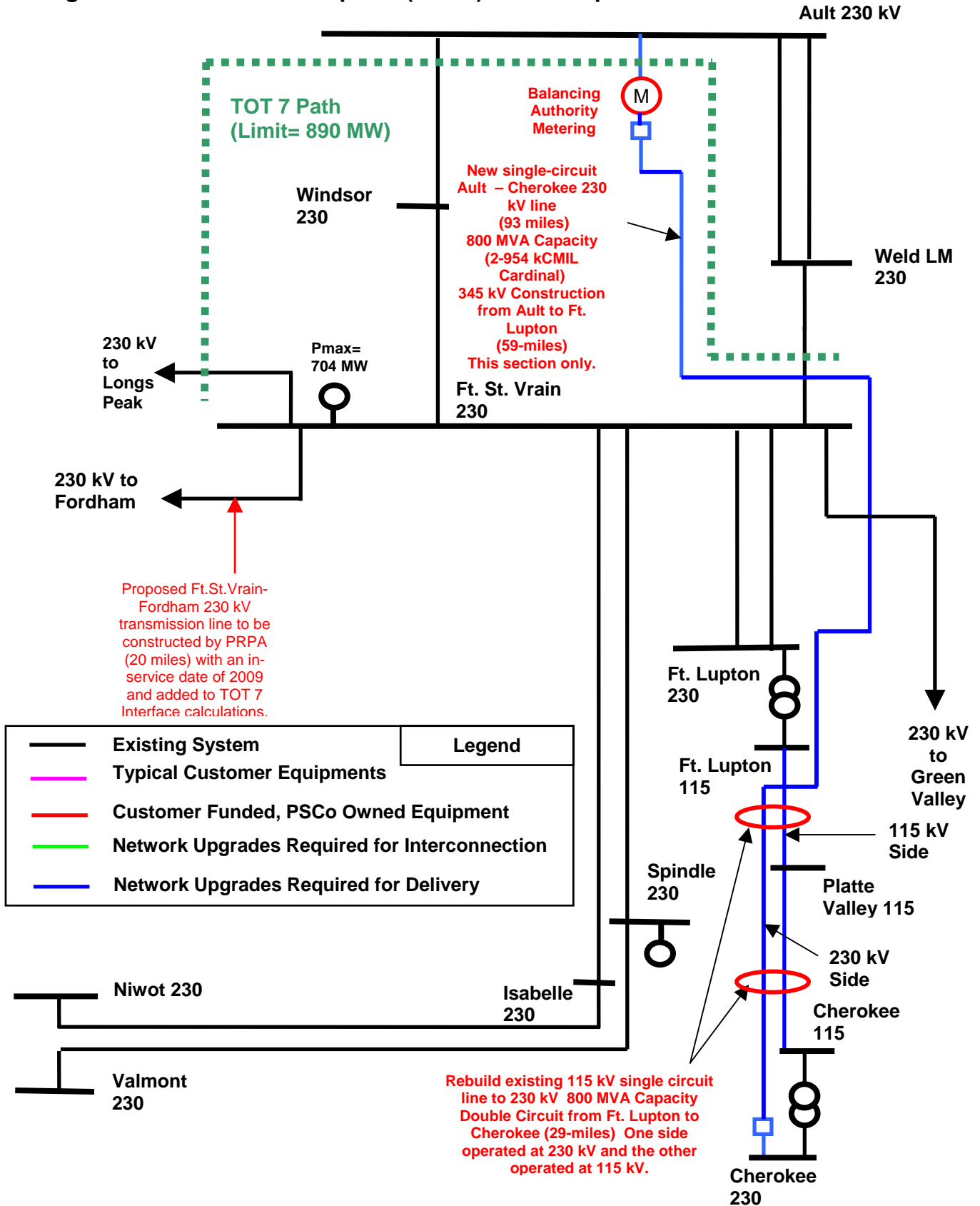
- \$0.58 million for Customer Funded PSCo Interconnection Facilities
- \$0.38 million for PSCo Network Upgrades for Interconnection
- \$68.33 million for PSCo Network Upgrades for Delivery

The required Network Upgrade for Delivery include the following:

- Construct a new 85-mile 230kV transmission line using 2-conductor bundle of 954 kcmil "Cardinal" conductor per phase from the Ault Substation to Cherokee Substation rated at 800 MVA. This will consist of a single 59-mile line from Ault to just outside of Ft. Lupton. From this point the line will become a 26-mile double circuit 230kV line by rebuilding the existing 115kV line from Ft. Lupton to Cherokee where one side is operated at 115kV for the TSGT load serving substations and the other side will be operated at 230kV completing the circuit from Ault to Cherokee.

PSCo Transmission Engineering and PSCo Substation Engineering evaluated the transmission enhancements listed in Part II above and developed cost and time frame estimates for the new transmission facilities. The cost of the new transmission facilities is approximately \$69.57 million. The estimated cost is an "indicative" (+/- 30%) preliminary cost in 2007 dollars and is based on typical construction costs for similar construction previously performed. The estimated time length required to complete the project is at least 60 months from the initiation of the project under the terms of a signed TSR. *Therefore, transmission studies show that it will not be feasible to deliver the full 900 MW by the requested commencement date of January 2010.*

Figure 5. Transmission Proposal (Part II): TOT 7 expansion



Study Scope and Analysis

The Interconnection System Impact Study evaluated the transmission requirements associated with the proposed 900 MW TSR to PSCo native load. It consisted of power flow analysis and transient stability analyses. The power flow analysis provided a preliminary identification of any thermal or voltage limit violations resulting for the interconnection, and for a firm TSR, a preliminary identification of network upgrades required to deliver the proposed generation to PSCo loads. The short circuit analysis identified any circuit breaker short circuit capability limits exceeded as a result of the Interconnection and for a firm TSR, the delivery of the proposed generation to PSCo loads.

PSCo adheres to NERC / WECC Reliability Criteria, as well as internal Company criteria for planning studies. During system intact conditions, criteria are to maintain transmission system bus voltages between 0.95 and 1.05 per-unit of system nominal / normal conditions, and steady state power flows within 1.0 per-unit of all elements' thermal (continuous current or MVA) ratings. Operationally, PSCo tries to maintain a transmission system voltage profile ranging from 1.03 per-unit or higher at generation buses, to 1.0 per-unit or higher at transmission load buses. Following a single contingency element outage, transmission system steady state bus voltages must remain within 0.90 per-unit to 1.10 per-unit, and power flows within 1.0 per-unit of the elements continuous thermal ratings.

Study Models

The power flow studies were based on a 2011 power flow case that was developed from the approved Western Electricity Coordinating Council (WECC). Additional comments were gathered from affected parties, including the entities involved in the WJQS, TOT 3 and TOT 7 owners. These changes are depicted in Appendix A and are shown incrementally starting from the approved 2011 base case and continuing with the WJQS case to finalize with the T-2006-4. The Customer's generation units were modeled with Customer provided details and a +/-0.95 per unit (p.u.) power factor capability to simulate required VAR output. The project generation was dispatched to replace southern PSCo generation.

Customer's transmission was also included and modeled in the power flow case. The transmission included:

- Single 230kV transmission line from Wyodak to Dave Johnson
- Single 230kV transmission line from Dave Johnson to LRS
- Single 345kV transmission from LRS to a future 345kV Pawnee Station

Other transmission modeled in the power flow case in Wyoming is described in Appendix A.

To evaluate the capabilities and system requirements for firm transfer levels, efforts were made to model a 2014 time frame power flow case since the proposed transmission infrastructure improvement in the PSCo system would take at least 65 months to build. The studies assumed 2014 peak summer demand conditions in the PSCo system and in other utility systems.

Power Flow Study Results and Conclusions

Firm Point-to-Point Study Results

The customer's 900 MW TSR was evaluated using a 2014 heavy summer base case, which was modified from the 2011 approved case and obtained from the WECC bulletin board. This case represents the approximate expected system conditions for the 2014 summer period and contains only projects modeled that have been approved in the internal PSCo transmission planning Capital Budget. The most significant transmission expansion projects modeled in the 2014 base case, which are not part of the integrated PSCo transmission system in 2007, are:

- Comanche Unit No.3 and Squirrel generation units
- Comanche to Daniels Park 345kV transmission
- Midway to Waterton 345kV transmission
- Chambers 230/115 kV transformation project

The modified case was sent to the affected parties⁵ in this TSR for comment and the suggested changes were incorporated and modeled in the benchmark case to create the Wyoming Joint Queue Study (WJQS)⁶ case, which most significant changes consisted of:

- Sectionalize the existing LRS to Story 345kV transmission at a new 345kV Archer substation and adding a 345-230kV transformation at Archer.
- New Archer to Cheyenne 230kV transmission

900 MW TSR:

The Customer's generation and transmission were modeled and incorporated to the WJQS base case, in which the transfer between balancing authorities was adjusted to deliver 900 MW to PSCo Network Native Loads. Dispatching PSCo generation south of Daniels Park substation was necessary to offset the transfer. The Customer project included:

- 500 MW coal fired plant interconnecting at Wyodak
- 500 MW wind facilities interconnecting at LRS
- Single 230 kV transmission from Wyodak to Dave Johnson to LRS
- Single 345 kV transmission from LRS to a future 345 kV Pawnee Station

⁵ Affected parties include Platte River Power Authority (PRPA), Western Area Power Administration (WAPA), Tri-State Generation and Transmission (TSGT), Black Hills Power (BHP) and Basin Electric Power Cooperative (BEPC)

⁶ Report can be found at <http://www.oatioasis.com/LAPT/LAPTdocs/Wyoming-Joint-Queue-Study.pdf>

This base case is named T-2006-4 in the contingency tables.

Transmission studies show that there is not enough capacity from Pawnee station to deliver the 900 MW TSR to PSCo Network Native Load without building transmission infrastructure. Furthermore, TOT7 and SoSV transmission lines experience great contingency overloads. The results are summarized in Appendix C.

Transmission studies shows that the loss of the Pawnee – Brick Center 230kV transmission line overloads the Pawnee – Ft. Lupton 230kV line up to 116% of its rating. Similarly, the loss of the Pawnee – Daniels Park 230kV line overloads the Pawnee – Ft. Lupton 230kV line up to 109% of its rating. The contingency analysis also depicts significant overloads south of Ault Substation including TOT 7 transmission elements and transmission lines south of Ft. St. Vrain and south of Ft. Lupton.

To mitigate the contingency overloads across TOT 7, PSCo Transmission Planning proposes the following project:

- Build 230kV transmission from Ault Substation to the Cherokee Station

This transmission proposal identified would be to construct an 85-mile Ault to Cherokee 230 kV line rated at 800 MVA not interconnecting at Ft. St. Vrain or Ft. Lupton. This project would allow power to be scheduled across TOT 7 without violating any system criteria. A detailed TOT 7 analysis was not conducted in this study, but should the Customer continue the request to System Impact Study, more detailed TOT 7 impacts will be evaluated.

The proposed Ault – Cherokee 230kV transmission line does not mitigate all the contingency overloads south of Ft. St. Vrain and Ft. Lupton. It also causes the 115kV transmission system around Cherokee Station to overload during certain contingencies and also causes the LRS – Ault 345kV line to overload 103% of its 956 MVA rating with the loss of the new LRS – Archer 345kV line. Therefore, additional transmission infrastructure would be required to mitigate these overloads. Moreover, the loss of the LRS – Ault 345kV transmission line causes system instability and requires a SVC to sustain voltage levels.

To mitigate the contingency overloads around the Pawnee region and balance the power transfers across TOT 3 to sustain system integrity and reliability during contingencies, PSCo Transmission Planning proposes to develop a 345kV transmission system consisting of:

- Develop a 345 kV switchyard at Pawnee Station and Smoky Hill Substation
- Build 345 kV transmission from Pawnee to Smoky Hill to Daniels Park

The proposed 345 kV transmission expansion project shows some significant positive impacts in the PSCo transmission system. This project alleviates all

contingency overloads south of Ault and Pawnee Substations. This project also improves the voltage profiles in the PSCo transmission system.

Stability Analyses Results and Conclusions

The power flow case used in stability studies assumed the wind generation to be four independent 125 MW wind farms connected together to a common 230kV bus, which was connected to the Laramie River Station (LRS) 230kV bus with a 20-mile 230kV transmission line. Each one of the four (4) 125 MW wind farm was modeled as a composite 84 1.5 MW GE-turbines connected to a 0.575kV bus and stepped to a 34.5kV collector system. A 230kV switching station was modeled, which connected the collector system to the high-voltage transmission system. In addition, the coal power plant located near Gillette, Wyoming was modeled using machine characteristics similar to the existing Pawnee facility.

The stability analysis consisted of 3-phase faults near the points of interconnection in southeastern Wyoming and northeastern Colorado. These locations included LRS, Ault and Pawnee. Normal fault clearing time was used in this study and consisted of 4-cycle for 345kV facilities and 5-cycles for 230kV facilities. Stuck breaker cases were not considered in this study.

Table 2: Transient Stability Results – Case with T-2006-4 and Network Upgrades for Delivery

	Fault Location	Action	Result
1	3PH at Pawnee 230 kV bus; 5 cycles	Trip Pawnee-Brick Center 230 kV line	System Stable
2	3PH at Pawnee 230 kV bus; 5 cycles	Trip Pawnee-Smoky Hill 230 kV line	System Stable
3	3PH at Pawnee 345 kV bus; 4 cycles	Trip Pawnee 345/230kV autotransformer	System Stable
4	3PH at Pawnee 345 kV bus; 4 cycles	Trip Pawnee–Smoky Hill 345 kV line	System Stable
5	3PH at Pawnee 345 kV bus; 4 cycles	Trip Pawnee–LRS 345 kV line	System Stable
6	3PH at LRS 345 kV bus; 4 cycles	Trip LRS-Pawnee 345 kV line	System Stable
7	3PH at LRS 345 kV bus; 4 cycles	Trip LRS-Ault 345 kV line	System Stable
8	3PH at LRS 345kV bus; 4 cycles	Trip Ault-LRS 345 kV line	System Stable
9	3PH at LRS 345 kV bus; 4 cycles	Trip LRS 345/230kV autotransformer	System Stable
10	3PH at LRS 230 kV bus; 5 cycles	Trip LRS 345/230kV autotransformer	System Stable
11	3PH at Ault 230 kV bus; 5 cycles	Trip Ault-Cherokee 230kV line	System Stable

The results show that for the faults studied the PSCo transmission system is stable.

Costs Estimates and Assumptions

Transmission Proposal (Part I): Pawnee to Metro Denver Area

The estimated total cost for the required upgrades for this transmission (Part I) is **\$155,290,000**.

The estimated costs shown are “scoping” (+/-30%) estimates in 2007 dollars and are based upon typical construction costs for previously performed similar construction. These estimated costs include all applicable labor and overheads associated with the engineering, design, and construction of these new PSCo facilities. This estimate does not include any costs for any Customer owned, supplied, and installed equipment and associated design and engineering. This estimate also does not include any costs that may be required for other entities’ systems. The following tables list the improvements required to accommodate the interconnection and the delivery of the Project. The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines. System improvements are subject to change upon more detailed analysis.

The estimated costs for interconnection are detailed in Tables 3 and Table 6. The Customer is responsible for the construction of all facilities from the generating stations in Wyoming to the points of interconnection at Pawnee Station and Ault Substation.

Table 3– PSCo Owned Customer Funded Interconnection Facilities

Element	Description	Cost Est. Millions
Pawnee Station	Interconnect Customer to tap PSCo's new 345 kV bus. The new equipment includes 345 kV bi-directional metering, relaying and associated equipment and material.	\$0.43
	LF/AGC for boundary control	\$0.11
Total Cost Estimate for Customer Interconnection Facilities		\$0.54

Table 4 – PSCo Network Upgrades for Interconnection

Element	Description	Cost Est. Millions
Pawnee Station	Interconnect Customer's generation into the new 345 kV Yard and tying the 345 kV yard into the existing 230 kV yard. The new equipment required includes: <ul style="list-style-type: none"> • Two new 345 kV 3000 A, 50kA circuit breakers • Two 230 kV 3000 A, 50kA, circuit breakers • One 345/230 kV 560 MVA autotransformer • Eight 345 kV switches • Four 230 kV switches • transmission line relaying and testing • required steel supporting structures and foundations 	\$7.31
Lookout Center	Communications with Plant	\$0.09

Element	Description	Cost Est. Millions
	Total Cost Estimate for PSCo Network Upgrades for Interconnection	\$7.40
Time Frame		45 Months

Table 5 – PSCo Network Upgrades for Delivery –Pawnee (Part I)

Element	Description	Cost Est. Millions
Pawnee Station	New 345kV Line terminal to Smoky Hill requiring the following equipment: <ul style="list-style-type: none"> • Three 345 kV, 3000 Amp, 50kA circuit breaker • Two 345/230 kV 560 MVA autotransformer • Eight 345 kV 3000 Amp gang switches • Three 230 kV 3000 Amp, 50kA circuit breakers • Six 230 kV 3000 Amp gang switches • required steel and foundations • electrical bus work • metering, control, relaying and testing 	\$15.72
Daniels Park	New 345 kV Line Terminal to Pawnee. The following equipment will be required: <ul style="list-style-type: none"> • Two 345 kV 3000 Amp 50kA circuit breakers • Six 345 kV 3000 Amp gang switches • required supporting steel and foundations • electrical bus work • metering, control, relaying, and testing 	\$1.49
Smoky Hill	Construction and upgrades for the Smoky Hill 345kV Substation: <ul style="list-style-type: none"> • Four 345-230kV, 250 MVA autotransformers • Three 345kV circuit breakers • Ten 345kV gang operated switches • Nine 345kV CCVT's • Three 230kV circuit breakers • Six 230kV gang operated switches • Two 230kV CCVT's 	\$26.77
Pawnee – Smoky Hill 345kV transmission	Add a new single circuit 345 kV line from Pawnee –Smoky Hill. This includes: <ul style="list-style-type: none"> • Single Circuit 345kV from Pawnee to just outside of Brick Center Switching Station including new ROW (79 –Miles). • Rebuild existing Pawnee-Daniels Park single circuit 230 kV line from Brick Center to outside of Smoky Hill (16-miles) to double circuit 345kV line. One side operated at 345 and the other operated at 230kV for the Pawnee-Daniels Park line. • Construct new double circuit 345kV line from just outside of Smoky Hill to Smoky Hill utilizing existing ROW (1-mile). 	\$74.08

Element	Description	Cost Est. Millions
Smoky Hill – Daniels Park 345kV transmission	Construct a new 345kV transmission line from Smoky Hill to Daniels Park Substation: <ul style="list-style-type: none"> Construct new double circuit 345kV line from Smoky Hill to Daniels Park utilizing existing ROW (20-mile) but string only 1 ckt. 	\$20.21
Siting and Permitting	Obtain necessary siting, permits, and ROW as required	\$9.08
	Total Cost Estimate for PSCo Network Upgrades for Delivery	\$147.35
	Total Cost of Project	\$155.29
Time Frame		65 Months

Assumptions for Transmission Proposal (Part I)

- The estimates and time frames given are for reference only are subject to change with a more detailed system study.
- The cost estimates provided are “scoping estimates” with an accuracy of +/- 30%.
- Estimates are based on **2007** dollars.
- PSCo crews will perform all construction and wiring associated with PSCo owned and maintained facilities. Contractor crews may perform the transmission line construction.
- Implementation of the recommended infrastructure for delivery will require that existing facilities be taken out of service for sustained periods. In most cases, these outages cannot be taken during peak load periods due to operational constraints. As a result, the estimated time frame for implementation could be increased.
- The 345 kV transmission line construction will require up to 200-foot wide easements along the planned route.
- The 345 kV transmission line construction will require up to 20 temporary staging areas of 5 acres each, which are included in the estimate.
- The interconnection and delivery portions of this project go through several counties and entities including Morgan County, Adams County, Arapahoe County, Douglas County, City of Aurora and City of Parker.
- It is anticipated that in order to construct the PSCo network upgrades for delivery and interconnection, a Certificate of Public Convenience and Necessity (CPCN) will be required by the Colorado Public Utilities Commission (CPUC). The application for a CPCN for the Pawnee – Smoky Hill 345kV transmission project has been submitted on October 31, 2007. The estimated time frame for the CPCN process is at least 6 months.
- The Customer will be responsible for funding and constructing all facilities from the proposed generation facilities in Wyoming to the future Pawnee 345kV bus.
- The last span into Pawnee Station from the Customer owned 345 kV line will be a slack span between the PSCo substation dead-end and the Customer’s last structure, which is assumed to be a dead-end tangent structure.

- A siting study will be required for network upgrades for delivery. Extensive public involvement is anticipated. Permit applications and possible minor right-of-way acquisition will be required. Land use permits will be required from multiple local jurisdictions.

Transmission Proposal (Part II): TOT 7 expansion

The estimated total cost for the required upgrades for is **\$ 69,290,000**

The estimated costs shown are (+/-30%) estimates in 2007 dollars (no escalation applied) and are based upon typical construction costs for previously performed similar construction. These estimated costs include all applicable labor and overheads associated with the engineering, design, and construction of these new PSCo facilities. This estimate did not include the cost for any other Customer owned equipment and associated design and engineering.

The following tables list the improvements required to accommodate the interconnection and the delivery of the Project. The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines. System improvements are subject to change upon more detailed analysis.

Table 6 – PSCo Owned; Customer Funded Interconnection Facilities

Element	Description	Cost Est. Millions
Western's Ault 230kV Substation	Interconnect Customer at Western's Ault 230kV Substation. The new equipment includes 230 kV bi-directional metering, Balancing Authority metering, relaying and associated equipment and material.	\$0.47
	LF/AGC for boundary control	\$0.11
	Total Cost Estimate for Customer Interconnection Facilities	\$0.58
Time Frame		12 Months

Table 7 – PSCo Interconnection Facilities

Element	Description	Cost Est. Millions
Western's Ault 230kV Substation	Interconnect Customer at Western's Ault 230kV Substation. New 230kV line termination requiring the following equipment: <ul style="list-style-type: none"> • one 230kV 40 kA, 3000 amp, circuit breaker • two 230kV, 3000 amp gang switches • electrical bus work • required steel and foundations • minor site work (station wiring, grounding) 	\$0.38

Time Frame		12 Months
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Table 8 – PSCo Network Upgrades for Delivery

Element	Description	Cost Est. Millions
Western’s Ault 230kV Substation	New 230kV line termination requiring the following equipment: <ul style="list-style-type: none"> • two 230kV 40 kA, 3000 amp, circuit breakers • four 230kV, 3000 amp gang switches • electrical bus work • metering, control, relaying and testing • required steel and foundations • minor site work (grading, fencing, grounding) 	\$0.79
PSCo’s Cherokee 230kV Switching Station	New 230kV line termination requiring the following equipment: <ul style="list-style-type: none"> • one 230kV, 50 kA, 3000 amp circuit breaker • two 230kV 3000 amp gang switches • electrical bus work • metering, control, relaying and testing • required steel and foundations 	\$0.51
230kV Transmission Line Construction	New single circuit Ault –Ft. Lupton 230kV line (59 miles) 800 MVA capacity, bundled 954 kcmil (Cardinal) conductor.	\$34.68
	Convert the existing 115kV line from Ft. Lupton to Cherokee to double circuit 230kV operation with 800 MVA capacity. One circuit will connect to the new Ault 230kV line just outside of Ft. Lupton where as the other will be operated at 115kV to serve the 115 kV stations along the way to Cherokee (29-miles).	\$25.16
Siting and Permitting	Obtain necessary siting, permits, easements and ROW as required.	\$7.19
	Total Cost Estimate for PSCo Network Upgrades for Delivery	\$68.33
	Total Project Cost	\$69.29
Time Frame		60 Months

Assumptions for TOT 7 expansion

- The cost estimates provided are “scoping estimates” with an accuracy of +/- 30%.
- Estimates are based on 2007 dollars (no escalation applied).
- There is no contingency added to the estimates.
- AFUDC is included for network upgrades, excluded in delivery upgrades.
- Labor is estimated for straight time only – no overtime included.
- PSCo (or it’s Contractor) crews will perform all construction and wiring associated with PSCo owned and maintained facilities.
- The estimated time for design and construction of PSCo network upgrades for interconnection is at least 60 months, and is completely independent of other queued projects and their respective ISD’s.

- It is anticipated that in order to construct the PSCo network upgrades for delivery, a Certificate of Public Convenience and Necessity (CPCN) will be required by the Colorado Public Utilities Commission (CPUC). The application for a CPCN will not be submitted until the Interconnection Agreement is fully executed. The estimated time frame for the CPCN process, siting, permitting, easement and right-of-way acquisition, design and construction for the PSCo network upgrades is at least 60 months from the time the Interconnection Agreement is fully executed. This time frame is also based on other identified assumptions for Siting and Land Rights, Substation Engineering and Transmission Engineering as listed below.
- Implementation of the recommended infrastructure for delivery will require that existing facilities be taken out of service for sustained periods. In most cases, these outages cannot be taken during peak load periods due to operational constraints. As a result, the estimated time frame for implementation could be increased by 3-6 months.
- A siting study will be required if network upgrades for delivery. Extensive public involvement is anticipated. Permit applications and possible minor right-of-way acquisition will be required. Land use permits will be required from multiple local jurisdictions.
- No additional land will be required at Ault Substation. It is assumed that there is room in existing yard for the proposed additions and the two required line positions are available.
- Western will be contacted to provide estimates at Ault for any additional studies.
- Western will construct and maintain all facilities at Ault.



Appendix A

Power Flow Base Case Changes



- I.** WECC 2011 Heavy Summer approved base case
 - A.** Approved projects modeled

- II.** 2011 Heavy Summer approved base case with high TOT3 and TOT 7 transfers
 - A.** Increased Laramie River Station (LRS) from 1,004.5 MW to 1,170 MW
 - B.** Reversed Sydney DC Tie from 196 MW exporting to 200 MW importing
 - C.** Increased the flows on Stegal DC Tie from 60 MW importing to 100 MW importing

- III.** Wyoming Joint Queue Study Projects (WJQS)
 - A.** Increased Wyoming Gen 2 and 3 (equivalent of 200 MW)
 - B.** Re-dispatched NSS CT1 and CT2 (equivalent of 80 MW)
 - C.** Re-dispatched Drake Unit No. 7 (126 MW)
 - 1. Hartzog-Casper 230 kV line created
 - 2. Casper-Miracle Mile 230 kV line created
 - 3. Wyodak-Donkey Creek 230 kV line created
 - 4. Donkey Creek-Reno 230 kV line created
 - 5. Donkey Creek-Hartzog 230 kV line created
 - 6. Old Wyodak-Reno 230 kV line purged from the case (replaced by Wyodak-Donkey Creek and Donkey Creek-Reno lines)
 - D.** Sectionalize the existing LRS to Story 345 kV line at Archer
 - E.** Archer to Cheyenne 230 kV line modeled

- IV.** T-2006-4 Transmission Service Request
 - A.** Increased Interchange between Balancing Authorities 900 MW
 - B.** Re-Dispatched against PSCo generation units south of Daniels Park
 - C.** Modeled single 230 kV transmission from Wyodak to Dave Johnson to LRS
 - D.** Modeled single 345 kV transmission from LRS to Pawnee
 - E.** Modeled upgrades required to mitigate overloads in PSCo transmission system

Appendix B

Path Definitions

Path Definitions

The TSR impacts two power transfer paths – the TOT7 Path and the South of Ft. St. Vrain Path. The TOT 7 path provides one path for power transfers into the northern metro Denver area and is also known as Path 40 in the WECC Path Rating Catalog. The South of Ft. St. Vrain (SoSV) transfer path is a conduit for power transfers across TOT7 and generation schedules at Ft. St. Vrain in the Denver Metro area. These paths are described in details below.

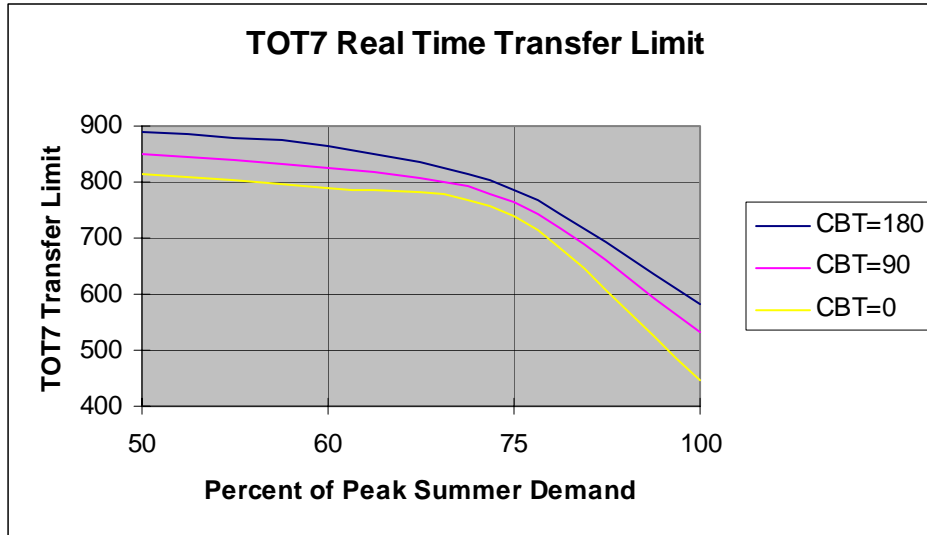
TOT7

“TOT7” is a Western Electricity Coordinating Council (WECC) defined power transfer path located in the vicinity of the study area. TOT7 is comprised of transmission lines that allow power to be transferred between northeast Colorado and the north Denver Metro Area. The path is shown in Figure No. 5. The path has a maximum accepted north-to-south rating of 890 MW. However, the real-time path rating is highly dependant on the level of demand in the Foothills Area and the on-line generation in the area called the Colorado-Big Thompson generation. The TOT7 path owners include Platte River Power Authority (Platte River) and PSCo. The facilities that comprise TOT7 are as follows:

- Ault to Windsor 230 kV transmission
- Weld PSCo to Ft. St. Vrain 230 kV transmission
- Longs Peak to Ft. St. Vrain 230 kV transmission

The ability to transfer power across the TOT7 Transfer Path is impacted by the level of demand in the Foothills Area and level of hydroelectric generation of the Colorado-Big Thompson system. The Foothills Area includes the transmission system that extends from the north Boulder area in the south to the Colorado/Wyoming border in the north and from Estes Park in the east to Greeley in the west. As demand in the Foothills Area increases, the TOT7 real-time transfer limit decreases. Similarly, as the Colorado-Big Thompson (CBT) generation decreases, the TOT7 real time rating decreases. Figure B-1 below illustrates this effect and summarizes the results from a previous operating study. The TOT7 transfer limit for various levels of Foothills Area demand (expressed as a percentage of the peak summer demand) and various levels of CBT generation are plotted. The blue line represents the TOT7 transfer limit with CBT generation at 180 MW. At a Foothills Area demand level of 50% of summer peak demand, the TOT7 Transfer Limit is 890 MW, the WECC-accepted rating of the transmission path. With CBT generation fixed at 180 MW, as Foothills Area demand increases, the TOT7 Real Time Transfer Limit decreases to approximately 580 MW at the point where the Foothills Area demand reaches 100% of summer peak. Similarly, plots of the TOT7 Real Time Transfer Limit for levels of Foothills Area demand at a CBT generation fixed at 90 MW and fixed at 0 MW are also displayed. The graph demonstrates the decrease in the TOT7 Real Time Transfer Limit as CBT generation decreases.

Figure B-1 TOT7 Real Time Transfer Limit



The Foothills Area has experienced a steady increase in demand over that last few years. As a result, the real-time rating of the TOT7 transfer path has decreased. In response to this large demand increase and the corresponding decrease in the TOT7 real-time rating, the TOT7 Path owners, PSCo and Platte River, have initiated transmission planning studies to identify ways to restore the TOT7 real-time rating to the 890 MW, the level of the accepted rating. PSCo and Platte River area must continue to meet their contractual obligations as the Foothills Area demand increases. Recently, PSCo performed an evaluation of the TOT7 Transfer Path facilities to determine if there are minor equipment modifications that can be made to address the decrease in real-time rating in the near term until significant transmission facilities can be constructed. The minor equipment modifications are described in the report.

Evaluation of TOT7: Summer 2007

PSCo Transmission Planning, Transmission Engineering, and Substation Engineering studied the transmission lines that comprise TOT7 and South of Ft. St. Vrain paths and identified minor equipment upgrades to increase the TOT7 and South of Ft. St. Vrain transfer limits. These include CT replacements and jumper additions at the Ault, Windsor, Weld and Ft. St. Vrain substations, together with higher wind speed assumptions (4 ft/sec instead of 2 ft/sec) for the lines connecting these substations. Assuming these minor modifications were incorporated, the TOT7 transfer limit for the 2007 heavy summer season was recalculated. After these additions, the transfer limit increased to approximately 740 MW (with CBT generation at 180 MW) and increased to approximately 682 MW (with CBT generation off-line). Although this was a significant improvement, these levels are significantly less than the 890 MW transfer limit for the TOT7 path and transmission constraints still exist in TOT7.

In this present study evaluating the 900 MW TSR in the 2011 time frame, the TOT7 transfer levels are expected to drop considerably due to the highly dependence on load levels in the Front Range region, as was depicted in Figure 5. Therefore, although the

transfer capacity of TOT7 was not determined for the 2011 time frame it is still expected to be a significant constraint with capacity not higher than 735 MW⁷. This present study will evaluate enhancements across TOT7 to increase the transfer capacity from northern Colorado into the Denver Metro Area.

South of Ft. St. Vrain (SoSV)

“South of Ft. St. Vrain” (SoSV) Path is a PSCo internal power transfer path in the vicinity of the study area. South of Ft. St. Vrain is comprised of 230kV transmission lines that allow power to be transferred into the Denver Metro Area from Ft.St.Vrain. The South of Ft. St. Vrain path must accommodate the TOT7 flow along with generation at Ft. St. Vrain. The path is shown in Figure No. 4 listed above. The north-to-south path rating is approximately 1,500 MW and is comprised of the following transmission facilities:

- Ft. St. Vrain to Ft. Lupton 230 kV transmission
- Ft. St. Vrain to Green Valley 230 kV transmission
- Ft. St. Vrain to Valmont 230 kV transmission
- Ft. St. Vrain to Isabelle 230 kV transmission

Transmission studies show that for high transfer levels across TOT7⁸ the transmission comprising the SoSV internal PSCo transfer path experience contingency overloads. This present study will monitor and evaluate enhancements SoSV to improve the transfer capacity into the Denver Metro Area.

The customer’s generation and transmission projects to transfer the generation in Wyoming to PSCo native loads in Colorado is expected to cause a significant impacts on TOT7 and SoSV path and internal path to PSCo system due to the nature of the integrated LRS system and interconnection of customer’s generation to the LRS system. Furthermore, transmission studies show that some of the proposed WJQS projects, specifically the Basin Electric Power Cooperative (BEPC) project consisting of sectionalizing the existing LRS to Story 345 kV transmission at a new 345 kV Archer substation, change the dynamics of the TOT3 transfers from Wyoming into northern Colorado creating higher transfer across TOT7 rather than out of Pawnee station with increased TOT3 levels.

These issues have been closely monitored in the course of the present study and will be discussed further in the power flow and results section. Details on the power flow can be found in Appendix C.

⁷ Observe the contingency table in Appendix C depicts Weld to Ault 230 kV transmission overloads at 735 MW transfers across TOT7

⁸ An approximate level of 774 MW obtained from the Operating studies for 2007

Appendix C

Summary of Contingency Results

Table C-1: Contingency Analysis Details

Benchmark Results		Contingency / Loaded Element																							
Description	Case	MVA Rating	150	200	280	150	150	224	600	478	637	495	495	500	472	478	495	495	135	956	319	200	478	365	525
WECC Base Case Approved Heavy Summer 2011	11hs1bp		118%	-	-	107%	142%	116%	-	-	-	-	-	-	-	-	-	-	-	-	101%	123%	-	-	-
Base Case 11hs1bp modified with Wyoming Joint Queued Projects	WJQS		118%	-	-	109%	144%	101%	-	-	-	-	-	-	-	-	-	-	-	-	-	106%	-	-	-
Base Case WJQS modified with Customer's 900 MW request	T-2006-4		119%	-	104%	106%	163%	133%	118%	111%	111%	106%	102%	116%	109%	119%	109%	104%	106%	91%	112%	141%	95%	98%	103%
2014 HNHS	2014		115%	140%	117%	114%	177%	101%	120%	124%	125%	119%	114%	131%	119%	133%	121%	117%	112%	98%	101%	77%	117%	106%	114%
2014 HNHS with Ault - Cherokee 230kV line	2014A		114%	135%	109%	109%	147%	-	121%	99%	96%	90%	85%	96%	100%	103%	102%	100%	113%	103%	78%	75%	100%	86%	103%
2014 HNHS with Ault - Cherokee 230kV line Pawnee - SH - DP 345kV line	2014B		114%	102%	102%	114%	142%	-	128%	90%	83%	77%	72%	80%	82%	92%	90%	86%	108%	90%	87%	63%	70%	85%	93%

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