

Feasibility Study Report Request # GI-2007-3

300 MW Wind Powered Generator Interconnecting 1-Mile South
of Ault Substation in 4th Quarter 2010

PSCo Transmission Planning
August 2007

Executive Summary

PSCo Transmission received a generation request to determine the Feasibility of interconnecting 300 MW of new Customer wind turbine generation into the PSCo transmission system. The requested Point of Interconnection (POI) will be on the PSCo Ault to Winsor 230 kV line 1-mile south of Ault. The Customer proposed commercial operation date is October 15, 2010 with a back feed date of February 15, 2010. This request was studied as both an Energy Resource¹ (ER) and a Network Resource (NR)².

Energy Resource

The ER portion of this study determined that the Customer could not provide any amount of firm energy without the construction of network reinforcements. This determination is based on existing limitations due to the limitations of TOT 7. Non-firm transmission capability may be available depending on marketing activities, dispatch patterns, demand levels and the status of transmission facilities.

Network Resource

As an NR request, PSCo evaluated the network to determine the upgrades required to deliver the full 300 MW of the wind facility to PSCo native load customers.

The PSCo system between the Ault Substation and the PSCo System includes one WECC³-recognized transfer path (TOT 7) and one PSCo internal transfer path (South of Ft. St. Vrain). 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

¹ **Energy Resource Interconnection Service (ER Interconnection Service)** shall mean an Interconnection Service that allows the Interconnection Customer to connect its Generating Facility to the Transmission Provider's Transmission System to be eligible to deliver the Generating Facility's electric output using the existing firm or nonfirm capacity of the Transmission Provider's Transmission System on an as available basis. Energy Resource Interconnection Service in and of itself does not convey transmission service.

² **Network Resource Interconnection Service** shall mean an Interconnection Service that allows the Interconnection Customer to integrate its Large Generating Facility with the Transmission Provider's Transmission System (1) in a manner comparable to that in which the Transmission Provider integrates its generating facilities to serve native load customers; or (2) in an RTO or ISO with market based congestion management, in the same manner as all other Network Resources. Network Resource Interconnection Service in and of itself does not convey transmission service.

³ **Western Electricity Coordinating Council (WECC)**

local demand and the level of generation scheduled from the Colorado Big Thompson (CBT) Hydro Project units. The South of Ft. St. Vrain path includes the 230 kV transmission lines that connect Ft. St. Vrain Substation to load areas in Denver Metro Area.

Power flow studies demonstrate that PSCo's transmission system cannot accommodate this interconnection request from the POI under all operating scenarios without significant transmission additions. The 300 MW generation injection crosses two constrained paths that are limited during high demand conditions. Generation injection would require significant transmission additions.

The recommended Network Upgrades for Delivery that will accommodate the full 300 MW from this project are listed below with an estimated total cost of the these upgrades at approximately **\$63.48 million** and include:

- \$0.52 million for Customer Funded PSCo Interconnection Facilities
- \$3.05 million for PSCo Network Upgrades for Interconnection
- \$59.91 million for PSCo Network Upgrades for Delivery

The required Network Upgrade for Delivery include the following:

- Construct a new 85-mile 230 kV transmission line using 2 conductor bundle of 636 kcmil "Grosbeak" conductor per phase from the Ault Substation to Cherokee Substation. 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 230 kV line by rebuilding the existing 115 kV line from Ft. Lupton to Cherokee where one side is operated at 115 kV for the TSGT load serving substations and the other side will be operated at 230 kV completing the circuit from Ault to Cherokee.

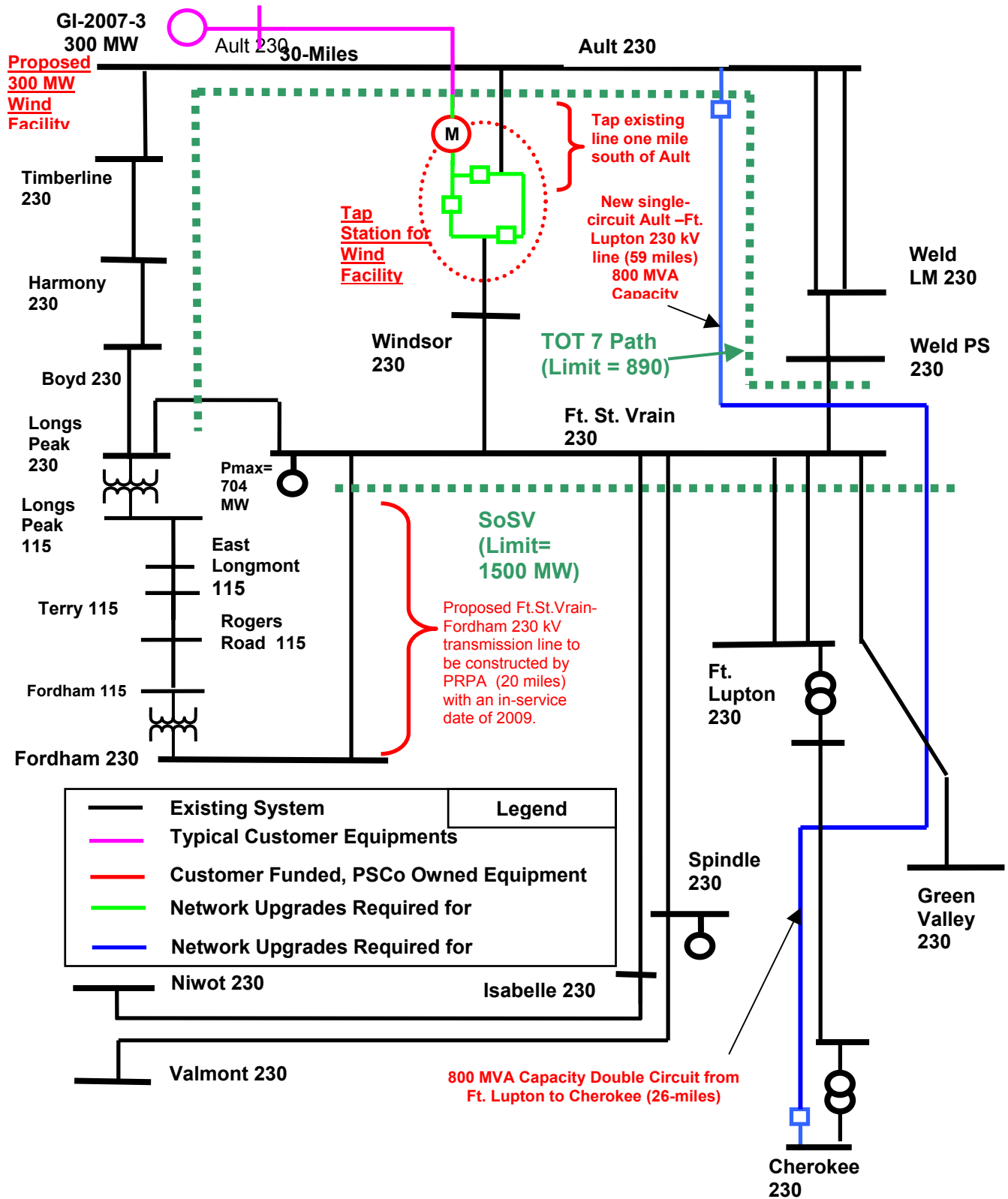
The estimated cost is an "indicative" (+/-30%) preliminary cost in 2007 dollars and is based on typical construction costs for previously performed similar construction. **The estimated length of time required to complete the project is 60 months, therefore making delivery of the full 300 MW not feasible by the Customer proposed October 15, 2010 commercial operation date.**

Should the Customer continue this interconnection request, joint transmission studies would be required with all affected utilities to obtain regulatory and industry acceptance of the new TOT 7 transfer limit along with the proposed infrastructure improvements. 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.

A system one-line diagram showing the proposed infrastructure to meet the delivery requirements is shown below in Figure No. 1 along with the interconnection details.

Additional details of the studies can be found under the Power Flow Study Results and in the Appendix A.

Figure No. 1 - Upgrades Required for the Transmission Service



Introduction

PSCo Transmission received a large generator interconnection request (GI-2007-3) to interconnect 300 MW, GE model SLE doubly fed induction generator (DFIG) wind turbines consisting of either the 1.5 MW or 3 MW models. The proposed wind farm (Project) would be located Northwest of Ft. Collins, Colorado and would interconnect into the PSCo transmission system via a proposed Customer-owned 30-mile radial 230 kV line terminating at the POI 1-mile South of Ault Substation on the Ault to Winsor 230 kV line. The Customer has requested that this Project be evaluated as a Network Resource (NR) and an Energy Resource (ER) with the energy going to PSCo customers.

Path Definitions

The generation interconnection request impacts two power transfer paths – the TOT 7 Path and the South of Ft. St. Vrain Path. The TOT 7 transfer path provides a 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” transfer path is a conduit for power transfers across TOT7 and generation schedules at Ft. St. Vrain in the Denver Metro Area. The loads in the study area consist of Zone 754 and Zone 706 in the WECC power flow case.

TOT 7

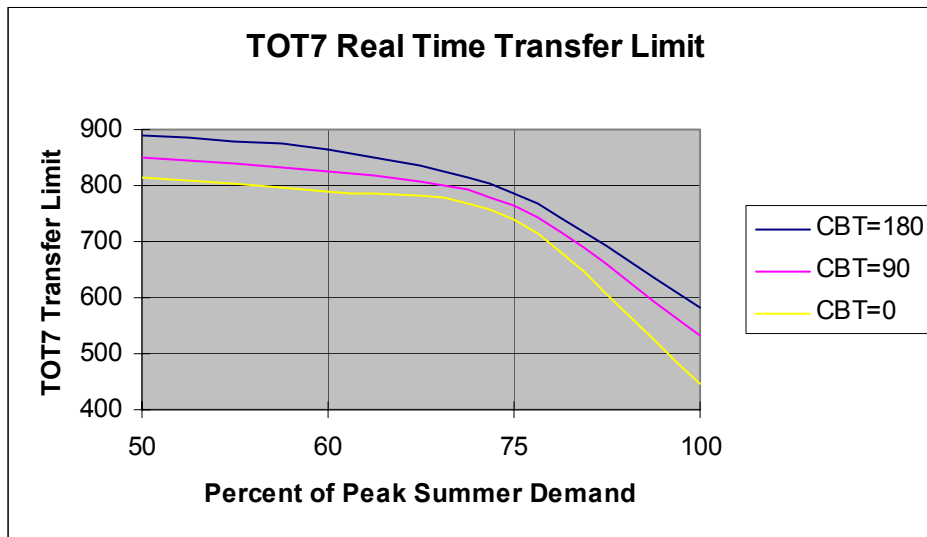
“TOT 7” is WECC defined power transfer path located in the vicinity of the study area. TOT 7 is comprised of transmission lines that allow power to be transferred between northeast Colorado and the north Denver Metro Area. The path is shown in Figure No. 1. The path has a maximum accepted north-to-south 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 TOT 7 path owners include Platte River Power Authority (Platte River) and PSCo. The facilities that comprise TOT 7 are as follows:

<u>Transmission Line</u>	<u>Metered End</u>
Ault-Windsor 230 kV	Ault
WeldPS-Ft.St.Vrain 230 kV	Weld
Longs Peak-Ft.St.Vrain 230 kV	Ft.St.Vrain

The TOT 7 Transfer Path has a WECC-accepted north-to-south rating of 890 MW. That means that it can transfer 890 MW of power while allowing for the possible occurrence of a transmission facility outage. The ability to transfer power across the TOT 7 Transfer Path is impacted by the level of local demand and level of hydroelectric generation of the Colorado-Big Thompson system. As demand in the local area increases, the TOT 7 real-time transfer limit decreases. Similarly, as the Colorado-Big Thompson (CBT) generation decreases, the TOT 7 real time rating decreases. Figure No. 2 below illustrates this effect. Figure No. 2 summarizes the results from a previous operating study. The TOT 7 transfer limit for various levels of demand (expressed as a percentage of the peak summer demand) and various levels of CBT generation are plotted. The

blue line represents the TOT 7 transfer limit with CBT generation at 180 MW. At a demand level of 50% of summer peak demand, the TOT 7 Transfer Limit is 890 MW, the WECC-accepted rating of the transmission path. With CBT generation fixed at 180 MW, as demand increases, the TOT 7 Real Time Transfer Limit decreases to approximately 580 MW at the point where the demand reaches 100% of summer peak. Similarly, plots of the TOT 7 Real Time Transfer Limit for levels of demand at a CBT generation fixed at 90 MW and fixed at 0 MW are also displayed. The graph demonstrates the decrease in the TOT 7 Real Time Transfer Limit as CBT generation decreases.

Figure No. 2: TOT 7 Real Time Transfer Limit



The local area has experienced a steady increase in demand over the last few years. As a result, the real-time rating of the TOT 7 transfer path has decreased. In response to this large demand increase and the corresponding decrease in the TOT 7 real-time rating, the TOT 7 Path owners, PSCo and Platte River, have initiated transmission planning studies to identify ways to restore the TOT 7 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 local area demand increases.

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 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 TOT 7 flow along with generation at Ft. St. Vrain. The path is shown in Figure No. 1 listed above. The north-to-south path rating is approximately 1500 MW and is comprised of the following transmission facilities:

<u>Transmission Line</u>	<u>Metered End</u>
Ft. St. Vrain-Ft. Lupton 230 kV #1	Ft. St. Vrain
Ft. St. Vrain-Ft. Lupton 230 kV #2	Ft. St. Vrain
Ft. St. Vrain-Green Valley 230 kV	Ft. St. Vrain
Ft. St. Vrain-Valmont 230 kV	Ft. St. Vrain
Ft. St. Vrain-Isabelle 230 kV	Ft. St. Vrain

Study Scope and Analysis

The Generator Feasibility Study evaluated the feasibility of providing 300 MW of firm energy from the POI near Ault Substation to the PSCo load center. The Study consisted of power flow analyses and provided a preliminary identification of thermal or voltage limit violations resulting from the transmission service request.

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 1.02 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.

Power Flow Study Models:

Western Electricity Coordinating Council (WECC) creates the operating and planning cases for transmission planning studies. For this study, PSCo used the 2011 HS1B approved base case (approved on January 11, 2007).

Power Flow Study Results and Conclusions

This case represents the system conditions at the 2011 Summer Peak and show that the TOT 7 Transfer Path and South of Ft. St. Vrain Transfer Path experience the most significant reductions in transfer capability. The TOT 7 Transfer Path should have a summer seasonal rating of 890 MW; however, demand increases in the local area have reduced the transfer limit to around 600 MW. The Colorado-Big Thompson (CBT) generation was set at 180 MW (high generation condition) to maximize the TOT 7 heavy summer season transfer limit. Additionally, transfers across TOT 7 were increased from 495 MW to approximately 682 MW⁴. The 682 MW transfer limit is considerably less than the 890 MW transfer limit that should be expected during heavy summer demand

⁴ It should be noted that all existing wind projects that are to be on-line by the In-service date of this project have been modeled at 10% of their total MW rating. This proposed facility has been modeled at the full 300 MW rating.

conditions. Reducing the CBT⁵ generation would decrease the TOT 7 transfer limit to a level less than 600 MW.

PSCo Transmission Planning, Transmission Engineering, and Substation Engineering studied the transmission lines that make up the TOT 7 and South of Ft. St. Vrain paths and identified equipment upgrades to increase the TOT 7 and South of Ft. St. Vrain transfer limits. Although this showed a significant improvement, the increase in transfer levels are significantly less than the 890 MW transfer limit for the TOT 7 path and therefore are not enough to accommodate the additional 300 MW generator interconnection request. In addition, the lines comprising the South of Ft. St. Vrain Transfer Path experience contingency overloads at the 740 MW TOT 7 transfer level.

PSCo Transmission Planning began studying more significant Network Upgrades to accommodate the 300 MW interconnection request. It was clear that these transmission upgrades would be needed to increase the TOT 7 transfer limit under heavy summer demand conditions.

Transmission alternatives were developed to achieve an increase of the TOT 7 transfer limit assuming 2011 heavy summer demand conditions with CBT generation on-line. The preferred alternative identified would be to construct a 85-mile Ault to Cherokee 230 kV line not interconnecting at Ft. St. Vrain or Ft. Lupton. This alternative allows the TOT 7 transfer limit to be relieved to an amount adequate enough to support the 300 MW generator interconnection request along with the TOT 7 approved transfer limit of 890 MW. The details of these alternative power flow studies can be found in “Appendix A – Contingency Analysis Comparison”.

Short Circuit Study Results

The short circuit study results show that the fault current levels for all buses studied are within the interrupting ratings of the breakers; therefore, the Project and associated infrastructure will not cause fault current to exceed the circuit breaker ratings.

The fault currents at the Tap Substation are 21,116 Amps for a single-line to ground fault and 22,860 Amps for a three-phase fault. These values assume little to no fault current contribution from the proposed wind facility.

⁵ **The Colorado-Big Thompson Project (CBT)** is a trans-mountain water diversion system that diverts water from the Colorado River headwaters on the western slope to the Big Thompson River, a South Platte River tributary on the eastern slope, for distribution to project lands and communities. Hydroelectric facilities on the Big Thompson River include Big Thompson 4.2 kV No. 1, Estes 6.9 kV No. 1, 2 and 3, Mary’s Lake Power Plant 6.9 kV No. 1, Pole Hill 13.8 kV No. 1, and Flat Iron 13.8 kV No. 1, 2 and 3. Operating studies conducted by PSCo and Platter River Power Authority have demonstrated that as the CBT generation decreases, the transfer limit of TOT7 decreases.

Costs Estimates and Assumptions

The estimated total cost for the required upgrades for is **\$ 63,450,000**

The estimated costs shown are (+/-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 siting, permitting, right of way, 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 1 – PSCo Owned; Customer Funded Interconnection Facilities

Element	Description	Cost Est. Millions
New 230kV Tap Switching Station	Interconnect Customer to tap PSCo's new 230 kV ring bus switching station (at the Ft. St. Vrain-WAPA Ault 230kV line). The new equipment includes 230 kV bi-directional metering, relaying and associated equipment and material.	\$0.33
	Transmission tie line into new switchyard.	\$0.02
	Customer Generator Communication to Lookout	\$0.05
	Customer LF/ACG and Generator Witness Testing	\$0.11
	Siting and Land Rights for required easements, reports, permits and licenses.	\$0.01
Total Cost Estimate for Customer Interconnection Facilities		\$0.52

Table 2: PSCo Interconnection Facilities

Element	Description	Cost
New 230kV Tap Switching Station	The major equipment and work required includes the construction of a new three ring bus design switching station: <ul style="list-style-type: none"> • three 230kV 40 kA, 3000 amp, circuit breakers • eight 230kV, 3000 amp gang switches • one electrical equipment enclosure (control bldg.) • electrical bus work • metering, control, relaying and testing • required steel and foundations • site work and fencing 	\$2.90
New Tap Switching Station	Siting and Land Rights – switching station land acquisition	\$0.05
Ft. St. Vrain 230kV Switching Station	Changes in metering, control, and relaying including testing	\$0.10
Total Estimated Cost for PSCo Interconnection Facilities		\$3.05

Table 3 – PSCo Network Upgrades for Delivery

Element	Description	Cost Est. Millions
Ault 230kV Switching Station	New 230 kV 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 three CCVT's 230kV electrical bus work metering, control, relaying and testing required steel and foundations 	\$1.05
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	New Ault – Cherokee 230kV line (85-miles) 800 MVA capacity split into the following segments: <ol style="list-style-type: none"> (1) New single circuit 59-mile 230 kV line from Ault to just outside of Ft. Lupton (2) New 26-mile double circuit 800 MVA 230 kV line from Just outside of Ft. Lupton and continuing on to Cherokee by rebuilding the existing 115 kV line from Ft. Lupton to Platte Valley to Cherokee utilizing the existing corridor. One side to be operated at 115 kV to accommodate the existing TSGT 115 kV loads while the other would be the continuation of the Ault-Ft. Lupton line. 	\$25.27 \$25.89
Siting and Permitting	Obtain necessary siting, permits, and ROW as required	\$7.19
	Total Cost Estimate for PSCo Network Upgrades for Delivery	\$59.91
	Total Cost of Project	\$63.48
Time Frame		60 Months

Assumptions for Estimates

- The cost estimates provided are “scoping estimates” with an accuracy of +/- 30%.
- Estimates are based on **2007** dollars.
- There is no contingency added to the estimates.
- Labor is estimated for straight time only – no overtime included.
- The Generator is not in PSCo’s retail service territory. Therefore no costs for retail load metering are included in these estimates.
- PSCo (or it’s Contractor) crews will perform all construction and wiring associated with PSCo owned and maintained facilities.
- The estimated time for the CPCN process, permitting, 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. If existing facilities can not be taken out of service for extended periods of time, then the estimated time frame for implementation will be increased by at least 3 to 6 months.

- 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. This time frame is also based on other identified assumptions for Siting and Land Rights, Substation Engineering and Transmission Engineering.
- 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.

APPENDIX A

Contingency Analysis Comparison

						Branch Loading	Branch Loading With GI-2007-3			
							No	230 kV		
						Without Before New Generation	Reinf	Line from POI To Cherokee	Line from Ault To Cherokee	
Overloaded Element						BASE	Alt 4	Alt 14		
** From bus	** **	To bus	** CKT	Type	Branch Rating	%	%	%	%	Contingency
70108 CHEROKEE	115	70126 CONOCO	115 1	LN	134.8	93.5		103.0	103.0	70107 CHEROKEE 230 70324 LACOMBE 230 1
70191 FTLUPTON	115	70192 FTLUPTON	230 T3	TR	280.0	96.6	101.0			70447 VALMONT 230 70592 SPNDLE 230 1
70192 FTLUPTON	230	70410 ST.VRAIN	230 1	LN	435.0	109.9	127.9			70192 FTLUPTON 230 70410 ST.VRAIN 230 2
70192 FTLUPTON	230	70410 ST.VRAIN	230 2	LN	435.0	109.9	127.9			70192 FTLUPTON 230 70410 ST.VRAIN 230 1
70192 FTLUPTON	230	70529 JLGREEN	230 1	LN	495.0	98.9	106.4			70192 FTLUPTON 230 70605 HENRYLAK 230 1
70244 LAFAYETT	115	70444 VALMONT	115 1	LN	135.0	103.6				70191 FTLUPTON 115 70192 FTLUPTON 230 T3
70345 RALSTON1	115	70444 VALMONT	115 1	LN	108.8	112.9	121.5			70447 VALMONT 230 70543 SIMMS 230 1
70410 ST.VRAIN	230	70471 WELD PS	230 1	LN	500.0		121.5			70474 WINDSOR 230 70651 GI20073T 230 1
70410 ST.VRAIN	230	70474 WINDSOR	230 1	LN	495.0	86.1	107.0			70471 WELD PS 230 73212 WELD LM 230 1
70447 VALMONT	230	70592 SPNDLE	230 1	LN	525.0	92.6	100.0			70410 ST.VRAIN 230 70544 ISABELLE 230 1
70461 WASHINGT	230	70529 JLGREEN	230 1	LN	495.0	95.4	102.8			70192 FTLUPTON 230 70605 HENRYLAK 230 1
70471 WELD PS	230	73212 WELD LM	230 1	LN	637.0		115.7			70474 WINDSOR 230 70651 GI20073T 230 1
70474 WINDSOR	230	70651 GI20073T	230 1	LN	495.0		111.4			70471 WELD PS 230 73212 WELD LM 230 1
70609 SILVSADL	230	70610 REUNION	230 1	LN	326.0	102.3	106.7			70192 FTLUPTON 230 70529 JLGREEN 230 1
70651 GI20073T	230	73011 AULT	230 1	LN	495.0			121.9		70651 GI20073T 230 70652 GI20073 230 1
73004 ALCOVA	115	73137 MIRACLEM	115 1	LN	80.0	171.8	111.3	112.5	112.6	70651 GI20073T 230 70652 GI20073 230 1
73004 ALCOVA	115	73137 MIRACLEM	115 2	LN	80.0	171.6	110.9	112.1	112.1	70651 GI20073T 230 70652 GI20073 230 1
73011 AULT	230	73212 WELD LM	230 1	LN	478.0	96.4	113.1			73011 AULT 230 73212 WELD LM 230 2
73011 AULT	230	73212 WELD LM	230 2	LN	478.0	96.4	113.1			73011 AULT 230 73212 WELD LM 230 1
73137 MIRACLEM	115	73572 MIRACLEM	230 1	TR	167.0	115.4	101.0	101.9	101.9	70651 GI20073T 230 70652 GI20073 230 1
73211 WELD LM	115	73212 WELD LM	230 1	TR	150.0	149.6	169.0			70471 WELD PS 230 73212 WELD LM 230 1

