

Feasibility Study Report Request # GI-2007-4

300 MW Wind Powered Generator Expansion (600 MW Total)
Interconnecting at Ault Substation in 4th Quarter 2013

PSCo Transmission Planning
August 2007

Executive Summary

PSCo Transmission received a generator interconnection request to determine the feasibility of interconnecting 300 MW expansion of new Customer wind turbine generation into the PSCo transmission system. The requested Point of Interconnection (POI) will be at Ault Substation 230 kV bus. GI-2007-4 was studied as a 300 MW expansion of GI-2007-3 wind generation project for a total of 600 MW injection at Ault. The Customer proposed commercial operation date is October 15, 2013 with a back feed date of February 15, 2014. 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 because TOT 7 capacity is fully committed by existing firm uses and reservations and there are system criteria violations at higher levels 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 600 MW of the wind facility to PSCo native load customers.

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.

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.

Power flow studies demonstrate that PSCo's transmission system cannot accommodate this interconnection request from the POI under operating scenarios studied without significant transmission additions. The 600 MW generation injection crosses TOT 7, which is a constrained path because during high demand conditions, TOT 7 capacity is fully committed by existing firm reservations and there are system criteria violations. Generation injection will require significant transmission additions.

The recommended Network Upgrades for Delivery that will accommodate the full 600 MW from this combined project are listed below with an estimated total cost of the these upgrades at approximately **\$69.57 million** and include:

- \$0.86 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 230 kV 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 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 months⁴, therefore making delivery of the full 600 MW feasible by the Customer proposed October 15, 2013 commercial operation date.

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 interconnection request. This study did not examine or propose new transfer limit of the

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

⁴ Assumptions at the end of the report state that 60 months include the Colorado CPCN process for the recommended Network Upgrades for Delivery.

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 both GI-2007-3 and GI-2007-4 (600 MW total). 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.

Any Interconnection Agreement (IA) requires that certain conditions be met, as follows:

1. The conditions of the Interconnection Guidelines⁵ are met.
2. A single point of contact is given to Operations to manage the Transmission System reliably for all wind projects (GI-2007-3 and GI-2007-4) as found in the Interconnection Guidelines.
3. Customer must show the ability to control power factor and provide voltage support as measured at the POI, across the required +/- 0.95 power factor range.

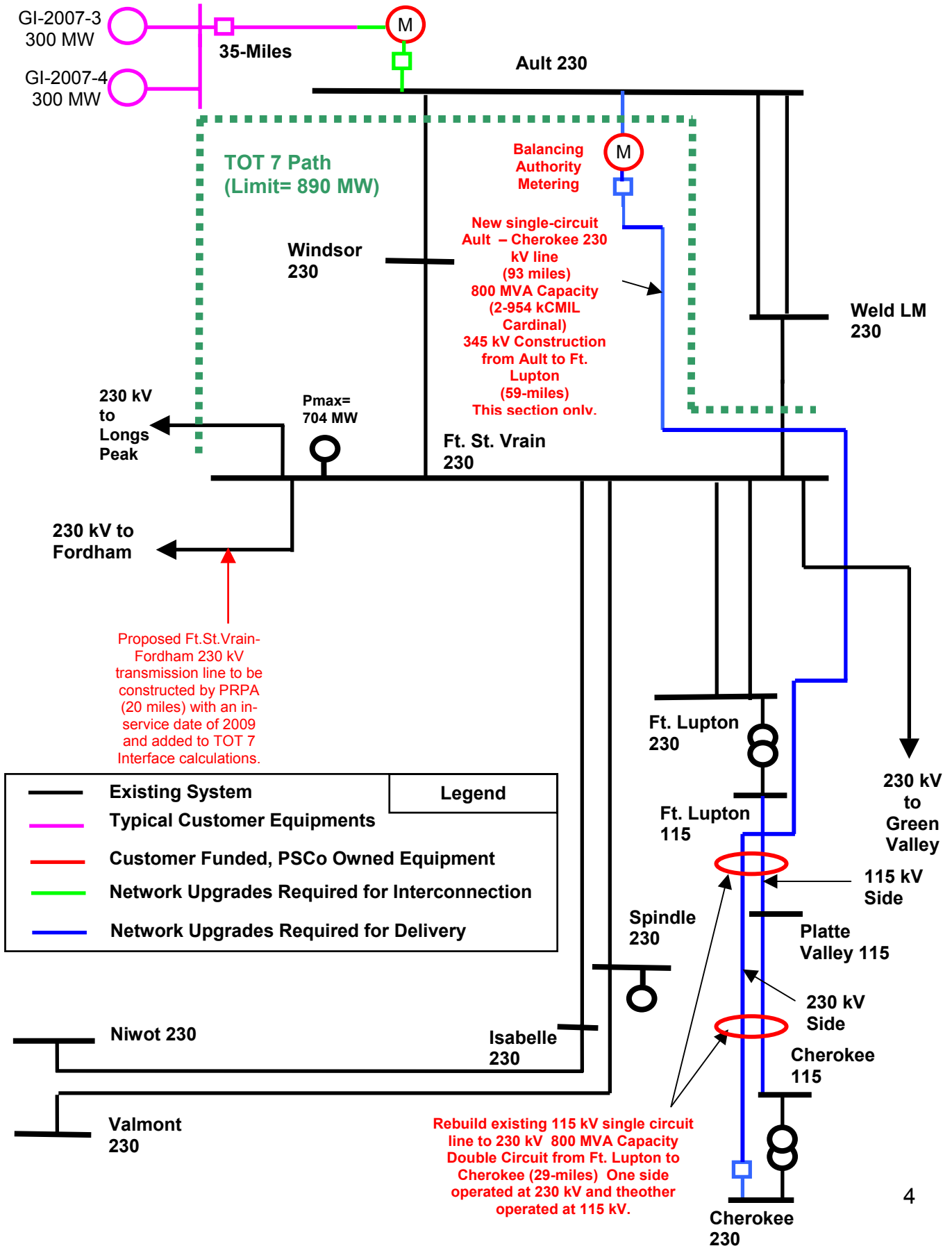
These studies indicated that the current Customer's transmission line design at full wind output 600 MW does not meet the voltage and power factor requirements, without installing additional static and/or dynamic VAR support equipment at either the Customer's site or near the Ault POI. A heavy summer power flow model case shows that without this additional VAR support equipment, the Customer's wind farm is not able to maintain the +/- 0.95 power factor requirement as measured at the POI.

The Customer needs to determine a solution to the generators or transmission line⁶ to meet the voltage and power factor guidelines described in the Interconnection guidelines. Additional transmission reinforcements may be required that have not been evaluated in this study, and would be determined in the following System Impact Study.

⁵ Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater than 20 MW, version 3.0 12/31/06.

⁶ This study used a 2-conductor bundled 1033 kCMIL ACSR attached to typical PSCo 230 kV structures as per the Customer's request.

Figure 1: GI-2007-4 300 MW or 600 MW Wind Interconnection and Delivery



Introduction

PSCo Transmission received a large generator interconnection request (GI-2007-4) 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. This request would be an expansion of the proposed 300 MW wind farm G-2007-3 and would also be located Northwest of Ft. Collins, Colorado. This facility would interconnect into the PSCo transmission system via a proposed Customer-owned 35-mile radial 230 kV line terminating at the POI, which would be Ault Substation. 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 the power transfer path TOT 7⁷. 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 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 WECC-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, aka PRPA) and PSCo. The facilities for this study that comprise TOT 7 are as follows:

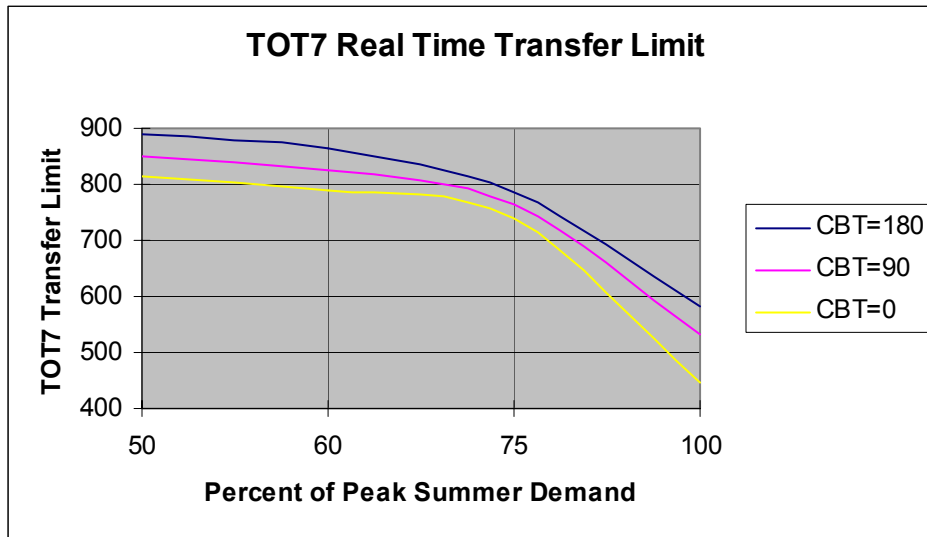
<u>Transmission Line</u>	<u>Metered End</u>
Ault-Windsor 230 kV	Ault
WeldPS-Ft.St.Vrain 230 kV	Weld
Longs Peak-Ft.St.Vrain 230 kV	Ft.St.Vrain

The 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 the 2007 Summer 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. For the 2007 Summer, at a demand level of 50% of summer peak demand and with CBT generation at 180 MW, the TOT 7 Transfer Limit is 890 MW, the WECC-accepted rating of the transmission

⁷ The TOT 7 transfer path is shared between PSCo and PRPA.

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 (2007 Summer)



The local area has experienced a steady increase in demand over the 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 alternatives that could increase the transfer limits and rating of the TOT 7 Path.

Study Scope and Analysis

The Generator Feasibility Study evaluated the feasibility of providing 600 MW of firm energy from the POI at 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 0.92 per unit to 1.07 per unit at load

busses for PRPA, 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 2015 HS1SA approved base case (approved on April 6, 2007) that was modified for 2014 summer conditions (Base Case).

Power Flow Study Results and Conclusions

PSCo Transmission Planning began studying more significant Network Upgrades to accommodate the 600 MW interconnection request. It was clear that transmission upgrades would be needed to increase the TOT 7 transfers under heavy summer demand conditions.

Transmission alternatives were developed to allow an increase of the TOT 7 transfers assuming 2014 heavy summer demand conditions with CBT generation on-line along with the proposed 600 MW wind facility interconnecting at Ault.

The preferred alternative 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 alternative allowed the 600 MW of wind generation 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 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 24,204 Amps for a single-line to ground fault and 23,912 Amps for a three-phase fault. These values assume little to no fault current contribution from the proposed wind facility.

Costs Estimates and Assumptions

The estimated total cost for the required upgrades for is **\$ 69,570,000**

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 1 – 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
	Transmission tie line into substation.	\$0.20
	Customer Generator Communication to Lookout.	\$0.07
	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	\$0.86
Time Frame		12 Months

Table 2: 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

Table 3 – 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 Cost of Project	\$69.57
Time Frame		60 Months

Assumptions for Alternatives

- 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 Wind Site is not in PSCo's service territory. The local utility will provide station service power to the generator. Assumed no additional metering is required.
- 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 28 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 and 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

Contingency Analysis Comparison

Table 4: Contingency Comparison

Contingency Analysis Results Interconnection Study GI-2007-4 @ 600 MW							Branch Loading		Branch Loading With GI-2007-4						Contingency		
							Without GI-2007-4	No Reinf Base	345 Ault- Cherokee 230 Ault- POI 10a	345 Ault- GrnVal Alt 11	345 Ault- FSV- Cherokee Alt 11a	345 Ault- Pawnee Alt 12	230 Ault- Cherokee Alt 13				
** From bus *** To bus ** CKT	Type	Branch Rating	%	%	%	%	%	%	%	%							
70107 CHEROKEE 230 70609 SILVSADL 230 1	LN	326.0	94.3			105.5	105.4				70192 FTLUPTON 230 70529 JLGREEN 230 1						
70192 FTLUPTON 230 70410 ST.VRAIN 230 1	LN	435.0	108.0	138.9		129.4	128.3	129.3			70192 FTLUPTON 230 70410 ST.VRAIN 230 2						
70192 FTLUPTON 230 70410 ST.VRAIN 230 2	LN	435.0	108.0	138.9		129.4	128.3	129.3			70192 FTLUPTON 230 70410 ST.VRAIN 230 1						
70192 FTLUPTON 230 70529 JLGREEN 230 1	LN	495.0	99.6	105.4		104.0	104.1	103.4			70192 FTLUPTON 230 70605 HENRYLAK 230 1						
70410 ST.VRAIN 230 70471 WELD PS 230 1	LN	500.0	<80.0	134.2				118.3			70474 WINDSOR 230 70651 GI20073T 230 1						
70410 ST.VRAIN 230 70474 WINDSOR 230 1	LN	495.0	83.0	120.9		114.0	114.0	114.0			70471 WELD PS 230 73212 WELD LM 230 1						
70447 VALMONT 230 70592 SPNDLE 230 1	LN	525.0	94.6	103.2		101.4	101.2	100.4			70410 ST.VRAIN 230 70544 ISABELLE 230 1						
70461 WASHINGT 230 70529 JLGREEN 230 1	LN	495.0	95.6	101.3				100.1			70192 FTLUPTON 230 70605 HENRYLAK 230 1						
70470 WELD PS 115 70471 WELD PS 230 T1	TR	150.0	120.6	133.5							73211 WELD LM 115 73212 WELD LM 230 1						
70471 WELD PS 230 73212 WELD LM 230 1	LN	637.0	<80.0	129.4				116.0			70474 WINDSOR 230 70651 GI20073T 230 1						
70474 WINDSOR 230 70651 GI20073T 230 1	LN	495.0	<80.0	124.8		117.8	117.8	117.8			70471 WELD PS 230 73212 WELD LM 230 1						
70609 SILVSADL 230 70610 REUNION 230 1	LN	326.0	105.0			116.1	116.0				70192 FTLUPTON 230 70529 JLGREEN 230 1						
73004 ALCOVA 115 73137 MIRACLEM 115 1	LN	80.0	<80.0	112.2	114.0	113.0	113.1	112.5	113.9		70651 GI20073T 230 70652 GI20073 230 1						
73004 ALCOVA 115 73137 MIRACLEM 115 2	LN	80.0	<80.1		113.5	112.6	112.6	112.0	113.4		70651 GI20073T 230 70652 GI20073 230 1						
73008 ARCHER 115 73043 CHEYENNE 115 1	LN	80.0	<80.0		103.6				103.1		70651 GI20073T 230 70652 GI20073 230 1						
73011 AULT 230 73212 WELD LM 230 1	LN	478.0	96.7	127.9				118.0	102.1		73011 AULT 230 73212 WELD LM 230 2						
73011 AULT 230 73212 WELD LM 230 2	LN	478.0	96.7	127.9				118.0	102.1		73011 AULT 230 73212 WELD LM 230 1						
73078 HARMONY 230 73199 TIMBERLN 230 1	LN	472*	96.4	120.5				111.0			70471 WELD PS 230 73212 WELD LM 230 1						
73137 MIRACLEM 115 73572 MIRACLEM 230 1	TR	167.0	<80.0	100.7	101.8	101.3	101.3	100.8	101.7		70651 GI20073T 230 70652 GI20073 230 1						
73150 PEETZ 115 73179 SIDNEY 115 1	LN	109.0	113.9	132.2							73143 N.YUMA 230 73579 SPRNGCAN 230 1						
73150 PEETZ 115 73191 STERLING 115 1	LN	109.0	115.9	134.2							73143 N.YUMA 230 73579 SPRNGCAN 230 1						
73211 WELD LM 115 73212 WELD LM 230 1	TR	150.0	156.7	195.2				180.7			70471 WELD PS 230 73212 WELD LM 230 1						
Color Code																	
	WAPA																
	PSCo																
	PRPA																

* - Denotes that this line will have a rating of 733 MVA starting 12/07.

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