

Interconnection Feasibility Study Report Request # GI-2004-8

80MW Wind Generation Facility
North of Wolcott, Colorado

Xcel Energy Transmission Planning
February 2005

Executive Summary

Public Service Company of Colorado (PSCo) Transmission received a generation interconnection request to determine the feasibility of interconnecting 80 MW of new Customer wind turbine generation into the PSCo transmission system at a new tap on the PSCo Foidel Creek-Wolcott 230 kV line, approximately eight miles north of the Wolcott Substation. The Customer proposed commercial operation date is December 1, 2006 with an assumed back feed date of June 1, 2006. This request was evaluated as both an Energy Resource (ER) and as a Network Resource (NR). The request was studied primarily as a stand-alone project. Other projects in the PSCo queue¹ were considered, but it was determined that none of the higher-queued projects would significantly affect this GI-2004-8 request.

Energy Resource:

This study determined that the Customer could not provide any firm energy without the construction of network reinforcements. This determination is based on existing limitations to the Tot 5 transfer path. Non-firm transmission capability may be available to accommodate the full 80 MW depending on marketing activities, dispatch patterns, demand levels, and the status of transmission facilities. The total estimated cost of the recommended upgrades required for interconnection of the project for non-firm transmission service is **\$4.36 million** and includes:

- \$ 0.34 million for PSCo-Owned, Customer Funded Interconnection Facilities
- \$ 4.02 million for PSCo Network Upgrades for Interconnection

The time required to engineer, permit, and construct the facilities required for interconnection is estimated to be at least **20** months. A one-line diagram of the network upgrades required for interconnection is shown in Figure No. 1. A diagram of the regional system is shown in Figure No. 2

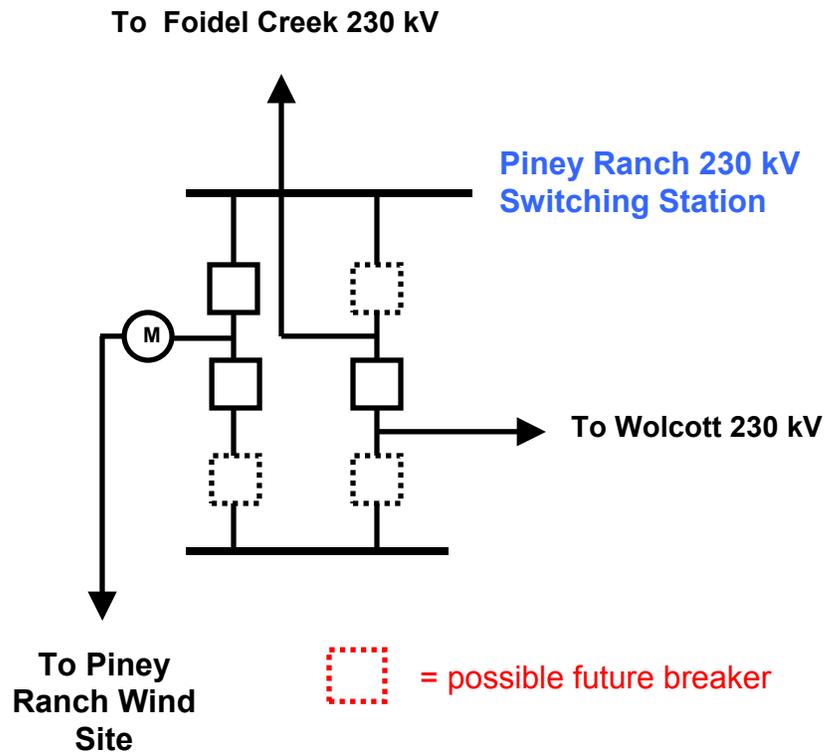
Network Resource:

The proposed project is west of the transfer path known as Tot 5. Tot 5 consists of the transmission facilities that cross the Continental Divide in Colorado. The transfer path

¹ Posted on the Rocky Mountain Area OASIS web site www.rmao.com

has a WECC-approved non-simultaneous west-to-east rating of 1675 MW. PSCo's firm transfer capability rights in the west-to-east direction the path are fully committed. In order to deliver the 80 MW into the PSCo system on a firm basis, the Tot 5 path would have to be modified to increase its transfer capacity. Based on regional planning study experience, the upgrades would be extensive, involve participation from all path owners, and require adherence to strict rating procedures set forth by the Western Electricity Coordinating Council (WECC). Therefore, Transmission Planning judgment is that it is not feasible to implement the proposed project as a firm network resource by the requested in-service date of December 2006.

Figure No. 1 – Network Upgrades for Interconnection for the Piney Ranch Facility



Introduction

PSCo Transmission received a transmission interconnection request to interconnect twenty-seven 3 MW, Vestas V90 doubly fed induction generator (DFIG) wind turbines for a total of approximately 80 MW. The Customer proposed a commercial operations date of December 31, 2006 and these studies assumed a back-feed date of June 1, 2006. The location of the proposed wind farm is approximately eight miles north of Wolcott, Colorado and would interconnect via a radial 230 kV line at a location near the point of interconnection on the Foidel Creek-Wolcott 230 kV line eight miles north of Wolcott. This study assumed that that the collection site and the interconnection location can be at approximately the same location.

Study Scope and Analysis

The Interconnection Feasibility Study consisted of power flow and short circuit analyses. The power flow analysis identified any thermal or voltage limit violations resulting from the interconnection. The short circuit analysis identified circuit breaker short circuit capability limits exceeded as a result of the Interconnection and delivery of the proposed generation.

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:

The power flow study models were created from an existing WECC 2007 heavy summer base case. The studies were performed using the Power Technologies, Inc (PTI) PSS/E program to do power transfer limit and contingency analysis. The 80 MW wind farm was modeled as one 80 MW conventional generator with a 0.95 pu lagging power factor (overexcited) and a 0.90 pu leading power factor (underexcited) capability to simulate the VAR requirements of the generators, which were assumed to be Vestas V90 3.0 MW DFIG turbines. The proposed generation was scheduled to the PSCo system by reducing generation in eastern Colorado.

The Point of Interconnection (POI) between the Customer and PSCo was modeled as a new switching station on the Foidel Creek-Wolcott 230kV single circuit line,

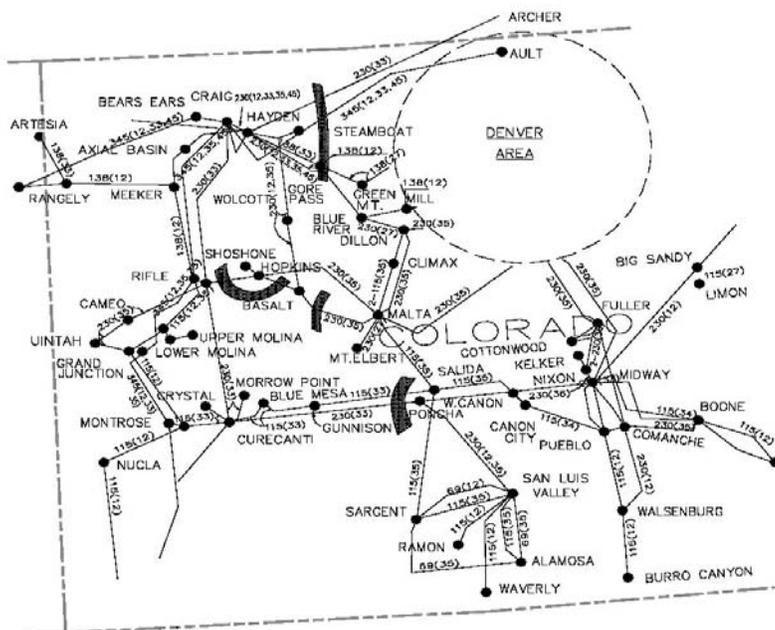
approximately eight miles north of Wolcott Substation. This study modeled 2007 peak summer demand conditions for the PSCo system and neighboring utilities in Colorado.

The proposed point-of-interconnection would be located west of the Tot 5 Transfer Path. The Tot 5 Transfer Path consists of transmission facilities that connect generation facilities in western Colorado with the load areas in eastern Colorado. A diagram of the Tot 5 Transfer Path can be in Figure No. 3. Table No. 1 lists the transmission facilities that comprise the Tot 5 Transfer Path:

Table No. 1 – Tot 5 Transmission Facilities

Transmission Facility	Metered End
Hayden-Archer 230 kV	Archer
Craig-Ault 345 kV	Craig
Gore Pass-Blue River 230 kV	Blue River
Hayden-Gore Pass 138 kV	Gore Pass
Gore Pass 138-115 kV Transformer	Gore Pass 230
Gunnison-Poncha 115 kV	Poncha
Curecanti-Poncha 230 kV	Curecanti
Basalt-Malta 230 kV	Basalt
Basalt-Hopkins 115 kV	Basalt
Rifle-Hopkins 230 kV	Rifle

The WECC-approved Tot 5 Path rating is 1675 MW in the west-to-east direction. Operating practices are needed to achieve this rating. These practices include tripping transmission facilities or ramping down generation to unload overloaded transmission elements. The consequence of tripping a facility or facilities is that flow on the overloaded path shifts to parallel facilities, eventually causing parallel facilities to overload. The transmission capability of the path is divided among Western Area Power Administration, Platte River Power Authority, Tri-State G&T, and PSCo. To evaluate the capabilities and system requirements for non-firm transfer levels, the power flow models were modified to simulate high Tot 5 path flows. The Tot 5 path flows were modeled with a west-to-east flow of approximately 1400 MW and 1675 MW (TOT 5 Limit = 1675 MW).

Figure 3 Tot 5 Transfer Path


Power Flow Study Results and Conclusions

Study cases were created with increasing Tot 5 west-to-east flows. To accomplish this, western Colorado generation was set to maximum levels and the power was scheduled to the Denver Metro Area. These schedules were followed by schedules from Arizona to the Denver Metro Area across Tot 2B (and west-to-east across Tot1A) using the Pinto and Sigurd phase-shifting transformers to control schedules. Further increases in Tot 5 were accomplished by scheduling from New Mexico to the Denver Metro Area across Tot 2A using the San Juan and Shiprock phase-shifting transformers to control schedules. Contingencies of transmission elements were simulated as the Tot 5 flows were increased to identify criteria violations. The outage of the Poncha-San Luis 230 kV line was not simulated as that outage coupled with the high San Luis Valley summer demand and high Tot 5 transfers causes the case to diverge due to a lack of reactive support in the San Luis Valley area. This is a known problem and PSCo and Tri-State G&T is cooperating to resolve this issue. The Tot 5 Transfer Path requires the use of operating practices to achieve high Tot 5 transfer levels. Using these operating practices, with Tot 5 at 1402 MW the path is at its limit for the conditions assumed. At a Tot 5 Transfer Path flow of 1402 MW, an outage of the Cabin Creek-Dillon 230 kV line coupled with two operating practices (called OP4 for a trip of the Cabin Creek-Georgetown 115 kV line and OP5 for a trip of the Mary's Lake 115-69 kV transformer) result in PSCo's Malta-Tarryall 230 kV line reaching 100.1% of its 434.6 MVA rating. The Malta 230-115 kV transformer flow reaches 108.1% of its nominal rating of 100

MVA. The four-hour emergency rating of the Malta 230-115 kV transformer is 115%; therefore, the flow of 108.1% was ignored. The Piney Ranch generating facility was added to the case on the Foidel Creek-Wolcott 230 kV line and the generation level was set to 80 MW and the power scheduled to the east. The Tot 5 flow was adjusted to 1402 MW (the Tot 5 limit for the conditions studied). At that level, PSCo's Malta-Tarryall 230 kV line loads 101.6%. Therefore, the Piney Ranch generation increased the flow on the Malta-Tarryall 230 kV line approximately one-and-one-half percent. This represents a very small impact on the line. The Malta 230-115 kV transformer flow is below the emergency rating. From this we conclude that the addition of the Piney Ranch generation should not significantly impact the ability of the system to absorb this generation on a non-firm basis. The results are shown in Table No. 2.

Table No. 2 Results of Power Flow Simulations

Case Name	Piney Gen	Tot 3	Tot 5	Tot 7	Operating Practice(s)	Limiting Element	% O/L	Limiting Contingency
7HS1402 -G0	0	1428	1402	835	None	MALTA 115-230 XFMR	108.1	BRECKRDG-MALTA 230
					OP4, OP5	MALTA-TARRYALL 230	100.1	CABINCRK-DILLON 230
7HS1402 -G80	80	1436	1402	831	None	MALTA 115-230 XFMR	112.8	BRECKRDG-MALTA 230
					OP4, OP5	MALTA-TARRYALL 230	101.6	CABINCRK-DILLON 230
7HS1675 -G0	0	1490	1675	824	None	MALTA 115-230 XFMR	114.3	BRECKRDG-MALTA 230
					None	CABINCRK-DILLON 230	103.6	CRAIG-AULT 230
					None	CABINCRK-DILLON 230	99.9	MALTA-TARRYALL 230
					None	BLUERIVR 230	0.85	CRAIG-AULT 230
					None	DILLON 230	0.86	CRAIG-AULT 230
					None	BRECKRDG 230	0.86	CRAIG-AULT 230
					None	GOREPASS 230	0.87	CRAIG-AULT 230
None	TARRYALL 230	0.87	CRAIG-AULT 230					
7HS1674 -G80	80	1497	1674	819	None	MALTA 115-230 XFMR	118.8	BRECKRDG-MALTA 230
					None	CABINCRK-DILLON 230	103.1	CRAIG-AULT 230
					None	CABINCRK-DILLON 230	101.1	MALTA-TARRYALL 230
					None	BLUERIVR 230	0.86	CRAIG-AULT 230
					None	DILLON 230	0.87	CRAIG-AULT 230
					None	BRECKRDG 230	0.88	CRAIG-AULT 230
None	GOREPASS 230	0.88	CRAIG-AULT 230					
None	TARRYALL 230	0.88	CRAIG-AULT 230					

The Tot 5 transfer level was increased to 1675 MW. The studies demonstrate the need for reactive support in the study area at that level. This was especially true whenever operating practices were utilized to unload overloaded elements. The system was not able to recover (i.e. diverging cases) following the application of some of the operating practices that were used to remedy criteria violations following severe outages. The inclusion of the Piney Ranch facility did not appear to significantly change these study results.

Short Circuit Study Results

The short circuit analysis was conducted at the affected switchyards in the study area with three-phase and phase-to-ground faults. The short circuit study results showed that the addition of the 80 MW wind farm and the PSCo Network Upgrades for Interconnection did not significantly affect the fault currents at existing substations in the study area. Due to the lack of Customer-supplied, or other available wind-turbine generator short circuit model data, all fault values analyzed for this Feasibility Study assume no fault current contribution from the Customer wind-turbine generators. More detailed short circuit models, and associated possible Customer generation fault contribution may need to be addressed in subsequent studies.

Costs Estimates and Assumptions:

The estimated total cost for the required upgrades for interconnection and delivery is

\$4.36 million

The estimated cost shown is an “indicative” (+/-30%) preliminary budgetary cost in 2006 dollars and is 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 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 describe the network upgrades for interconnection that would be required for both ER and NR requests. The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines.

System Improvements (subject to change upon more detailed analysis):

Table 3 Customer Interconnection Facilities

Substation	Description	Cost
New 230kV Switching Station	Interconnect Customer’s 230kV line to a new 230kV switchyard. The new equipment required includes: <ul style="list-style-type: none"> • 230kV bi-directional revenue metering • associated relaying and metering controls • required foundations and steel structures 	
	Total Estimated Cost for Customer Interconnection Facilities	\$335k

Table 4 PSCo Network Upgrades Required for Interconnection

Substation	Description	Cost
New 230kV Switching Station	Install a new three-breaker ring bus switchyard approximately adjacent to PSCo's existing Foidel Creek-Wolcott 230kV transmission line. The new equipment required includes: <ul style="list-style-type: none"> • three (3) 230kV, 3000 amp, 50kA circuit breakers • ten (10) 230kV, 2000 amp switches • six (6) 230kV, 2000-12000 amp CCVT's • new electric equipment enclosure (EEE, control bldg.) • supporting bus, cable, structures and foundations • associated communication upgrades, transmission line and bus relaying and testing • miscellaneous building wiring, grounding and materials • fencing, earthwork and yard surfacing 	\$3,647k
	Transmission line tap structure & line	\$178k
	Siting and Land Rights for required easements, reports, permits and licenses	\$194k
	Total Estimated Cost for PSCo Network Upgrades Required for Interconnection	\$4,019k
Time Frame		20 Months

Assumptions:

- The estimated costs provided are "scoping estimates" with an accuracy of $\pm 30\%$.
- All applicable overheads are included. AFUDC has been removed
- Estimates are based on 2006 dollars.
- PSCo (or its contractor) crews will perform all construction and wiring associated with PSCo-owned and maintained equipment.
- It is anticipated that to construct the Network Upgrades required for the interconnection (switchyard only) a Certificate of Public Convenience and Necessity (CPCN) will not be required from Colorado Public Utility Commission (CPUC). The estimated time for siting, permitting, acquisition, design and construction for the PSCo network upgrades required for the interconnection (switchyard only) is at least 20 months after the Interconnection Agreement has been signed.
- It is anticipated that a Certificate of Public Convenience and Necessity (CPCN) will be required from Colorado Public Utility Commission (CPUC) for the network

upgrades required for delivery. The application for a CPCN will not be submitted until after the Customer has executed an Interconnection Agreement.

- A siting study and public involvement may be required for the network upgrades required for delivery. The estimated time for siting, permitting, acquisition, design and construction for the PSCo network upgrades required for delivery is at least 30 months after the Interconnection Agreement has been signed, and based upon other identified assumptions for Siting and Land Rights, Substation Engineering and Transmission Engineering (see below).
- New switchyard for the wind farm interconnection will be located adjacent to or under the existing Foidel Creek-Wolcott 230kV transmission line.
- The last span into the new 230kV new Wind Farm Switchyard from the Customer owned 230kV 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 structure.
- Acquire a five-acre site in fee for the new Wind Farm Switchyard.