

Interconnection Feasibility Study Report Request # GI-2004-9

300MW Wind Farm Near Limon, Colorado (Cedar Point)

Xcel Energy Transmission Planning
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Executive Summary

Public Service Company of Colorado (PSCo) Transmission received a generation interconnection request to determine the feasibility of interconnecting 300 MW of new Customer wind turbine generation into the PSCo transmission system at a new tap on the Pawnee to Daniels Park 230 kV line, approximately 54 miles south of Pawnee (Figure 1). The Customer proposed commercial operation date is December 1, 2006 with an assumed back feed date of June 1, 2006. This request was studied as both an Energy Resource (ER) and as a Network Resource (NR). The request was studied primarily as a “stand-alone” project, without considering other projects in the PSCo queue, as posted on the Rocky Mountain Area OASIS web site¹, but some sensitivity analysis was also performed to consider some higher queued projects.

Energy Resource:

The ER portion of this study determined that as a stand-alone project, the Customer could produce at least **280 MW** of power on a firm basis before Network Upgrades for delivery would be required. Additional non-firm capability may be available depending on marketing activities, dispatch patterns, demand levels and the status of transmission facilities.

Network Resource:

In order to deliver the full 300 MW into the PSCo system on a firm basis, Network Upgrades would be required. As a stand-alone project, the total estimated cost of the recommended upgrades to accommodate the project is **\$38.4 million** and includes:

- \$ 0.34 million for PSCo-Owned, Customer Funded Interconnection Facilities
- \$ 3.3 million for PSCo Network Upgrades for Interconnection
- \$34.8 million for PSCo Network Upgrades for Delivery

The time required to engineer, permit, and construct the facilities required for interconnection is estimated to be at least **20** months, and the estimated time required to engineer, permit, and construct the Network Upgrades required for delivery is at least **30** months. According to the interconnection request, the Customer will engineer, permit, construct and finance the 25-mile 230kV radial transmission line to the point of interconnection.

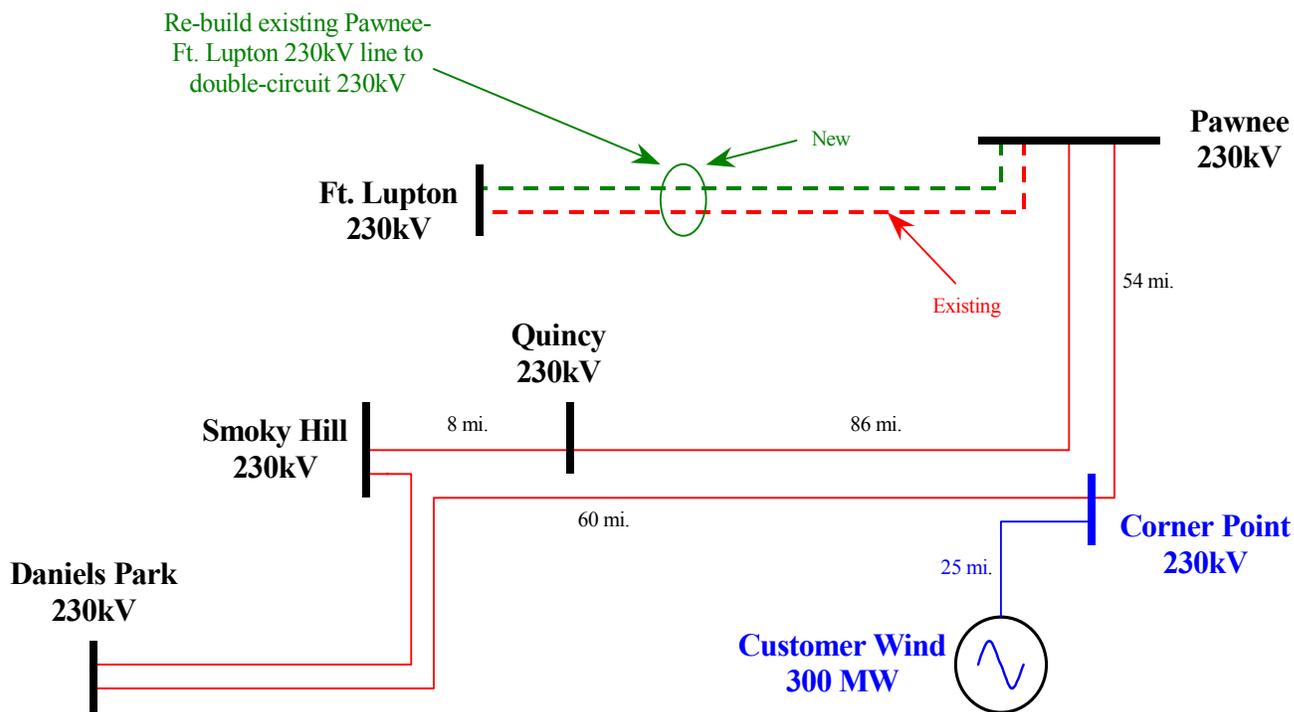
¹ www.rmao.com

The Network Upgrades required to deliver the 300 MW on a firm basis include:

- Upgrade the 64 mile, PSCo Pawnee – Ft. Lupton 230kV circuit to a 230kV double circuit transmission line (345kV construction, double-circuit towers, bundled 954 ACSR conductor, 800MVA rating per circuit at 230kV)

A one-line diagram of the regional system with recommended Network Upgrades is shown in Figure 1.

Figure 1 GI-2004-9 Network Upgrades Required for Delivery



If some other higher queued projects and associated system upgrades are considered to be in place, previous relevant studies indicate that the project could provide the full 300 MW of generation on a firm basis without any additional Network Upgrades. Any project that would interconnect at or near the Pawnee Station would require the Pawnee – Ft. Lupton transmission rebuild. If that project were already in place, then no further modifications would be required for this project.

Introduction

PSCo Transmission received a large generator interconnection request (GI-2004-9) to interconnect one hundred eighty-two (182) 1.65 MW, Vestas V82 doubly fed induction generator (DFIG) wind turbines for a total 300 MW generation, with a commercial operation date of December 31, 2006 and a back feed date of June 1, 2006. The proposed wind farm would be located near Limon, Colorado and interconnect via a 25-mile 230 kV line to a new switching station on the existing PSCo Pawnee – Daniels Park 230kV line, 54 miles south of the Pawnee station.

Study Scope and Analysis

The Interconnection Feasibility Study evaluated the transmission requirements associated with the proposed interconnection to the PSCo Transmission System. It consisted of power flow and short circuit analyses. The power flow analysis identified any thermal or voltage limit violations resulting from the interconnection and also identified network upgrades required to deliver the full amount of proposed generation to PSCo customers. 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.

Based on the results of other generator interconnection studies, impacts to TOT3 and the neighboring utilities are considered minimal. Should the Customer continue this request and move on to the System Impact Study, more detailed impacts may be identified.

Power Flow Study Models:

The power flow study models were created from an existing Western Electricity Coordinating Council (WECC) 2007 heavy summer base case. The studies were performed using the General Electric (GE) PSLF program to do power transfer limit and contingency analysis. The 300 MW wind farm was modeled as two (2) 150 MW conventional generators 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 V82 1.65 MW DFIG turbines. The proposed generation was scheduled to the PSCo system by reducing generation in southern Colorado.

The Point of Interconnection (POI) between the Customer and PSCo is assumed to be the point at which the 25-mile 230 kV transmission line meets the new Customer tap station on the Pawnee to Daniels Park 230kV double circuit line.

The 25-mile line and autotransformers were modeled as follows, per the customer provided information:

- A single-circuit 25-mile, 230 kV line using conventional 230 kV direct embedded steel pole construction with a single 795 ACSR conductor per phase (435 MVA rating).
- Two (2) 230-34.5 kV, 135/180/225 MVA Customer GSU transformers, located at the Customer collector site

This study modeled 2007 peak summer demand conditions for the PSCo system and neighboring utilities in Colorado. A 2006 peak summer model was also evaluated, which produced very similar system flows to the 2007 model. To evaluate the capabilities and system requirements for firm transfer levels, the power flow models were modified to simulate high TOT 3 path flows. The TOT 3 path flows were modeled with a North to South flow of approximately 1600 MW (TOT 3 Limit = 1605 MW). Transmission projects expected to be in-service for the 2007 summer season were represented in the models.

Power Flow Study Results and Conclusions

Energy Resource (ER) Study Results:

The results of the ER study indicate that with only the Customer Wind Facilities considered, the maximum amount of generation capability that can be accommodated with the existing system and existing firm path reservations is **280 MW**. Additional non-firm transmission capability on the PSCo system may be available depending on marketing activities, dispatch patterns, customer demand levels and the status of transmission facilities.

Network Resource (NR) Study Results:

The NR study determined the network upgrades that will be required to accept the full 300 MW from the proposed wind farm. Modeling the customer wind generation at 300 MW created local contingency overloads on the PSCo system. Table 1 shows contingency results with the full 300 MW injected at the point of interconnection.

Table 1 Critical Contingency Results

Critical Contingency	Limiting Element	Rating (MVA)	Pre-Load %	Cont-Load %
Pawnee-Quincy 230 Ckt1	CornerPt.-Daniels Park 230 Ckt1	637	81	102
Pawnee-Quincy 230 Ckt1	Pawnee-Ft.Lupton 230 Ckt1	413	80	119

From Table 1, the loss of the Pawnee-Quincy 230kV line will load the Pawnee-Ft. Lupton 230kV line to 119% of its thermal rating. Although the benchmark case exhibited loading beyond its rating for the same contingency, the Pawnee-Ft. Lupton 230kV line loading increases by 15% of the line rating. The significant line loading change prompts a network upgrade of this existing line.

The following is a general description of the recommended network upgrades required to alleviate the overloads and accommodate the generation for delivery:

- Upgrade the 64 mile, PSCo Pawnee – Ft. Lupton 230kV circuit to a 230kV double circuit transmission line (345kV construction, double-circuit towers, bundled 954 ACSR conductor, 800MVA rating per circuit @ 230kV)

Other delivery alternatives were analyzed in this study to accommodate the 300MW wind generation but were determined to be more costly than the recommended upgrade.

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 300 MW wind farm and network upgrades 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 (or lack thereof) will need to be addressed in later studies, such as the Interconnection System Impact Study (SIS), or following Interconnection Facilities Study.

Costs Estimates and Assumptions:

The estimated total cost for the required upgrades for interconnection and delivery is **\$38,072,000**.

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 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 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 2 Customer Interconnection Facilities

Substation	Description	Cost
New 230kV Switching Station (Corner Point)	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 • required steel supporting structures • associated metering control and relaying 	\$335k
	Total Estimated Cost for Interconnection Facilities	\$335k

Table 3 Network Upgrades required for Interconnection

Substation	Description	Cost
New 230kV Switching Station (Corner Point)	Install a new three breaker ring bus switchyard approximately adjacent to PSCo's existing 230kV Pawnee-Daniels Park Trans Line. The following equipment will be required: <ul style="list-style-type: none"> • three (3) 230kV 3000 amp 50kA circuit breakers • eight (8) 230kV switches • CCVT's • site development • control building • misc. supporting steel • electrical bus work • associated metering control and relaying 	\$2,896k
	Transmission line tap structure & tap	\$186k
	Siting and Land Rights acquisition & permitting	\$197k
	Total Estimated Cost for Network Upgrades for Interconnection	\$3,279k
Time Frame		20 Months

PSCo Network Upgrades required for delivery of the proposed 300 MW as an NR Request:

Below are the estimated costs associated with developing the transmission system in order to deliver the full 300 MW of generation. The cost of the Network Delivery facilities is the additional change in cost between Interconnection and Delivery.

Table 4 Network Upgrades Required for Delivery

Substation	Description	Cost
Pawnee Station	New 230 kV Line terminal to Ft. Lupton requiring the following equipment: <ul style="list-style-type: none"> • one new 230 kV breaker and half bay on the west side of the 230 kV switch yard • two (2) 3000 Amp, 50 kA circuit breakers • four (4) 230 kV switches • associated steel • electrical bus work • associated metering, control, and relaying Upgrade the 230 kV line from Pawnee to Story requires the following: <ul style="list-style-type: none"> • replace four (4) 230 kV 1600 Amp switches with 3000 Amp switches Upgrade the Pawnee to Smoky Hill 230 kV line requires the following: <ul style="list-style-type: none"> ○ replace six (6) 1600 Amp switches with 3000 Amp switches ○ replace 1200 Amp Line trap with 2000 Amp Line Trap 	\$1,430k

Ft. Lupton Station	New 230 kV 2000 Amp Line Terminal to Pawnee which will require rearranging of the existing line terminations for the Henry Lake and Green Valley lines. The following equipment will be required: <ul style="list-style-type: none"> • a new 230 kV breaker and a half bay on the east side of the station • three (3) 230 kV 3000 Amp 50 kA circuit breakers that includes replacing one 1600 Amp breaker • ten (10) 230 kV switches that includes four (4) new and six (6) replacements from 1600 Amp to 3000 Amp • misc. supporting steel • electrical bus work • associated metering control and relaying 	\$1,400k
Transmission	Rebuild existing 413 MVA 230 kV line from Pawnee to Ft. Lupton with new double circuit 230 kV 834 MVA transmission utilizing existing ROW as much as possible	\$31,360k
Siting and Permitting	Obtain necessary siting, permits, and ROW as required	\$603k
	Total Estimated Cost for Network Upgrades for Power Delivery	\$34,793k
Time Frame		30 Months

Assumptions:

- The estimated costs provided are “Scoping Estimates” with an accuracy of $\pm 30\%$.
- 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 Pawnee-Daniels Park 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.
- The Pawnee-Ft Lupton double circuit rebuild will be constructed within the existing ROW for the single circuit line. It has been assumed that the existing ROW will be sufficient for this rebuild and only minimal ROW acquisition is required.
- There will be an available termination position at the Ft. Lupton Switchyard for the double circuit rebuild.
- Acquire a four-acre site in fee for the new Wind Farm Switchyard.