



Interconnection Feasibility Study Report Request # GI-2004-10

Generation Interconnection Request for a 70 MW Wind Farm in
Adams County, Colorado

Xcel Energy Transmission Planning
March 2005

Executive Summary

PSCo Transmission received a generation request to determine the feasibility of interconnecting 70 MW of new Customer wind turbine generation into the PSCo transmission system at a new switching station on the Pawnee to Daniels Park 230 kV line, approximately 35 miles south of Pawnee. The Customer proposed commercial operation date is December 31, 2005.

This request was studied as a Network Resource (NR) only. As a Network Resource, this study determined that as a stand-alone project, the Customer could produce the full **70 MW** of energy without the construction of network reinforcements for delivery.

The total estimated cost for the project is approximately **\$3.614** million and consists of the following:

- **\$0.335** million for Customer Interconnection Facilities.
- **\$3.279** 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. Therefore, it is not feasible to interconnect the facility by the proposed in-service date. According to the interconnection request, the Customer will engineer, permit, and construct all facilities up to the point of interconnection at the new PSCo switching station.

A one-line diagram of the regional system with customer point of interconnection is shown in Figure 1. The one line for the interconnection is shown in Figure 2.



Figure 1 – Customer Wind GI-2004-10

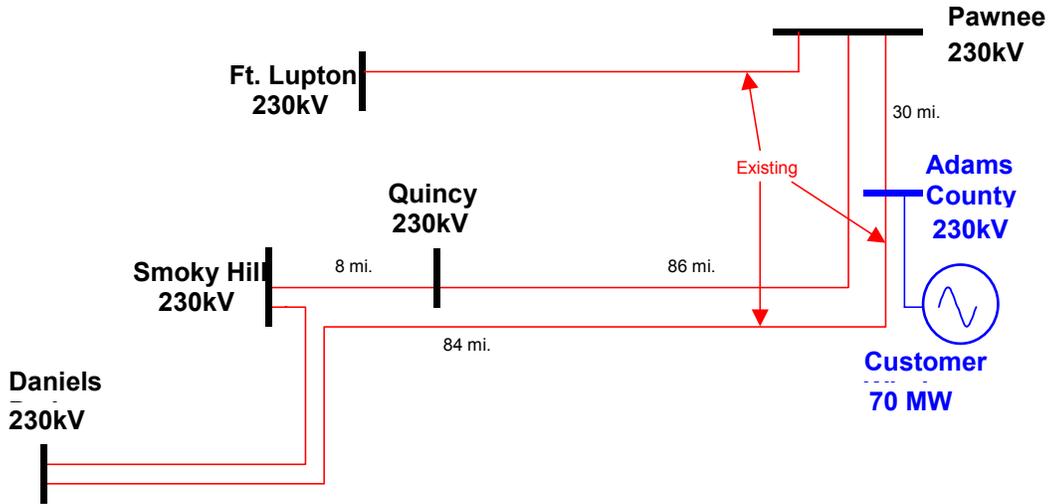
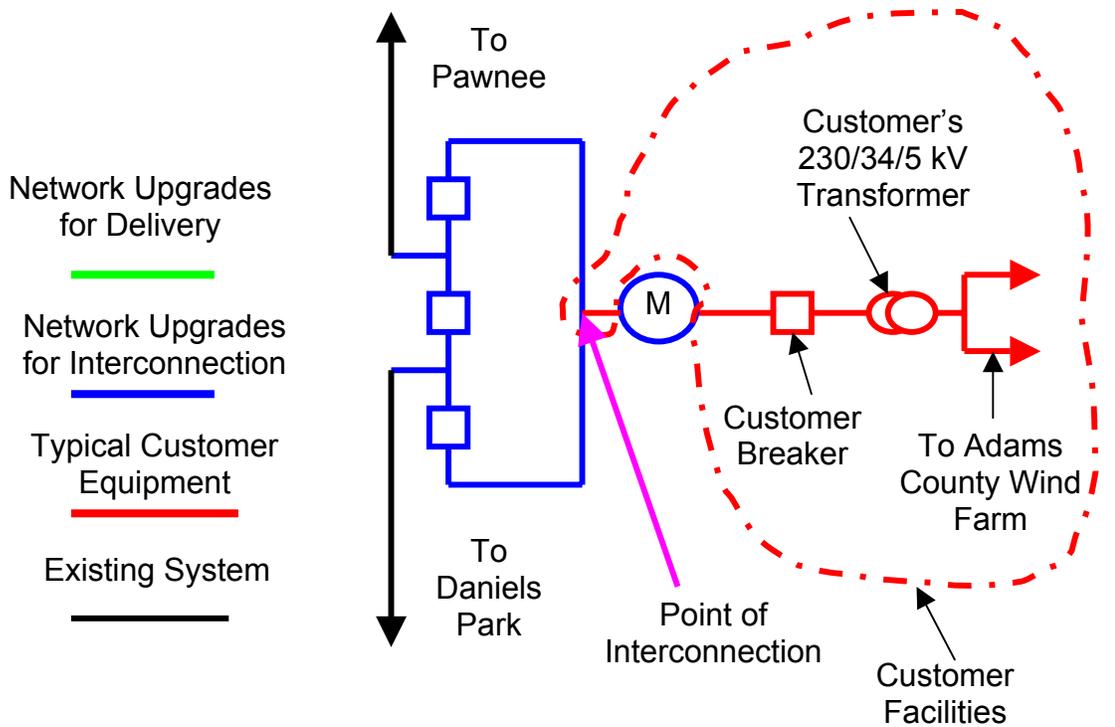


Figure 2 – Customer Wind Interconnection GI-2004-10





Introduction

PSCo Transmission received a large generator interconnection request (GI-2004-10) to interconnect forty-seven 1.5 MW, GE doubly fed induction generator (DFIG) wind turbines for a total of 70 MW generation, with a commercial operation date of December 31, 2005. The location of the proposed wind farm is located in Adams County, Colorado and will interconnect via a 230 kV transmission line at a location on the Pawnee – Daniels Park 230kV line, 35 miles south of the Pawnee station.

Study Scope and Analysis

The Interconnection Feasibility Study evaluated the feasibility of the proposed interconnection to the PSCo Transmission System. The Study 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.

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 GE's PSLF software to do power transfer limit and contingency analysis. The 70 MW wind farm was modeled as two 35 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. This is on the assumption that Customer will be using the GE 1.5 MW DFIG turbines. Customer generation was scheduled to the PSCo system by southern generation reduction.

The Point of Interconnection (POI) between the Customer and PSCo is assumed to be the point at which the Customer’s 230 kV transmission line connects to PSCo’s new 230kV Switching Station on the Pawnee to Daniels Park 230kV double circuit line.

The transmission line and autotransformers were modeled as follows, per the customer provided information:

- Two 6-mile 34.5kV lines using conventional wood pole construction with a single 954 ACSR conductor per phase
- One 230-34.5 kV, 80 MVA transformer, modeled grounded wye-wye with a 10% impedance, located at the Customer’s 230/34.5kV substation

This study assumed 2007 peak summer demand conditions for the PSCo system and neighboring utilities in Colorado. 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).

Power Flow Study Results and Conclusions

Network Resource (NR) Study Results:

The NR study determined if network upgrades would be required to accept the full 70 MW from the proposed wind farm. Modeling the customer wind generation at 70 MW did not cause any local contingency overloads on the PSCo and surrounding systems that would require network upgrades. Table 1 shows contingency results with the full 70 MW injected at the point of interconnection.

Table 1

Critical Contingency	Limiting Element	Rating (MVA)	Pre-Load %	Cont-Load %
Pawnee-Quincy 230 Ckt1	Pawnee-Daniels Park 230 kV Ckt #1	637	59	79
Pawnee-Quincy 230 Ckt1	Pawnee-Ft.Lupton 230 kV Ckt #1	413	74	108



From Table 1, the loss of the Pawnee-Quincy 230kV line will load the Pawnee-Ft. Lupton 230kV line to 108% 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 4% of the line rating. The line loading change does not prompt a network upgrade of this existing line.

Short Circuit Study Results

The short circuit analysis was conducted at the affected switchyards in the study area including faulting the 230kV busses at the Ft. St. Vrain, Customer Wind Tap, and other busses with three-phase and phase-to-ground faults. The short circuit study results showed that the addition of the 70 MW wind farm and network upgrades did not significantly affect the fault currents at existing substations in the study area.

All fault values calculated for this Feasibility Study assume no fault current contribution from the Customer wind-turbine generators. This is because of the lack of available wind turbine generator short circuit model data. More detailed short circuit models, and associated possible Customer generation fault contribution will need to be addressed in later studies, such as the Interconnection System Impact Study (SIS), or following Interconnection Facilities Study.

For all of the fault cases studied, the wind turbines were modeled as conventional synchronous generators. A more accurate short circuit model is not currently available for such short circuit programs as Aspen or CAPE. This study was performed on CAPE.

Costs Estimates and Assumptions:

To provide an interconnection and delivery for the Customer requested generation, network upgrades will not be required on the PSCo transmission system.

The estimated indicative total cost for Customer interconnection is:

\$3,614,000.

The estimated cost shown is a Scoping Estimate (+/-30%) 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, procurement 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 costs for interconnection and delivery that would be required for the NR request. The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines.

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

Customer Interconnection Facilities

Substation	Description	Cost
Customer Wind 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 • required steel supporting structures • associated metering control and relaying 	\$335k
	Total Estimated Cost for Interconnection Facilities	\$335k

Network Upgrades required for Interconnection

Substation	Description	Cost
Customer Wind Switching Station	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 230kV 3000 amp 50kA circuit breakers • eight 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

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.
- 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.
- Acquire a four-acre site in fee for the new Wind Farm Switchyard.