

Generation Interconnection Feasibility Study Report Request # GI-2007-8

86 MW Wind Generation Facility, near Lamar, Colorado

PSCo Transmission Planning
September 1, 2010

Executive Summary

Public Service Company of Colorado (PSCo) and the Customer signed a Generation Interconnection Feasibility Study Agreement to evaluate the feasibility of interconnecting an 86 MW wind farm in Southeast Colorado. The 86 MW wind farm consists of forty-one (41) Suzlon 2.1 MW wind turbines, interconnecting to a 34.5 kV collector bus with a dedicated 34.5/230 kV step-up transformer.

The Customer requested the primary point of interconnection to be on the Lamar – Colorado Green 230 kV line. The GI-2007-8 interconnection request is an expansion of the existing Twin Buttes wind project, which has an existing interconnection agreement for 150 MW. The substation was modeled at approximately 40 miles south of Lamar substation. See figure 1 and 2. The generator was modeled as a lumped equivalent unit at 86 MW with no additional reactive capability. Additional reactive power may be required at the POI and Customer's facility to meet the +/- 0.95 power factor requirement according to the large generator interconnection guideline (LGIP). PSCo Engineering group has evaluated the interconnection at Lamar and found that the substation equipment is capable of handling at least 398 MW.

Per Customer's request, this generation interconnection was studied only as an Energy Resource (ER)¹. This investigation included steady-state power flow study and preliminary short circuit analysis. The request was studied as a stand-alone project, with no evaluations made of other potential new generation requests that may exist in the LGIP queue, other than the generation projects that are already approved and planned to be in service by the summer of 2011.

Energy Resource

The ER portion of this study determined that the Customer could provide 0 MW of real power on a firm basis before network upgrades for delivery would be required. Non-firm transmission capability may be available depending on marketing activities, dispatch patterns, generation levels, demand levels, and the status of transmission facilities.

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 non-firm 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.



The generator interconnection would require a new 4-breaker ring substation at approximately 40 miles south of Lamar substation. The Customer will be responsible to build the substation and deliver the power to the point of interconnection which is at Lamar 230 kV bus.

PSCo Engineering and Siting and Land Rights conducted studies and determined that the time required for work to be done at Lamar 230 kV substation to accommodate Twin Buttes III interconnection is approximately 6 months from the Authorization to Proceed. Refer to the schedule in the cost estimate section for more details.

Additional details of the study can be found in the Appendix A. Any Interconnection Agreement (IA) requires that certain conditions be met, as follow:

1. The conditions of the Interconnection Guidelines² are met.
2. A single point of contact is given to Operations to manage the Transmission System reliably for all wind projects (GI-2007-8) as found in the Interconnection Guidelines.
3. Customer must show the ability to operate the wind generation within the required +/- 0.95 power factor range during all operating conditions (0 MW to 86 MW) as measured at the Point of Interconnection (POI).

The estimated total cost for the required upgrades for interconnection is **\$ 53,000**.

² Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater than 20 MW, version 3.0 12/31/06.

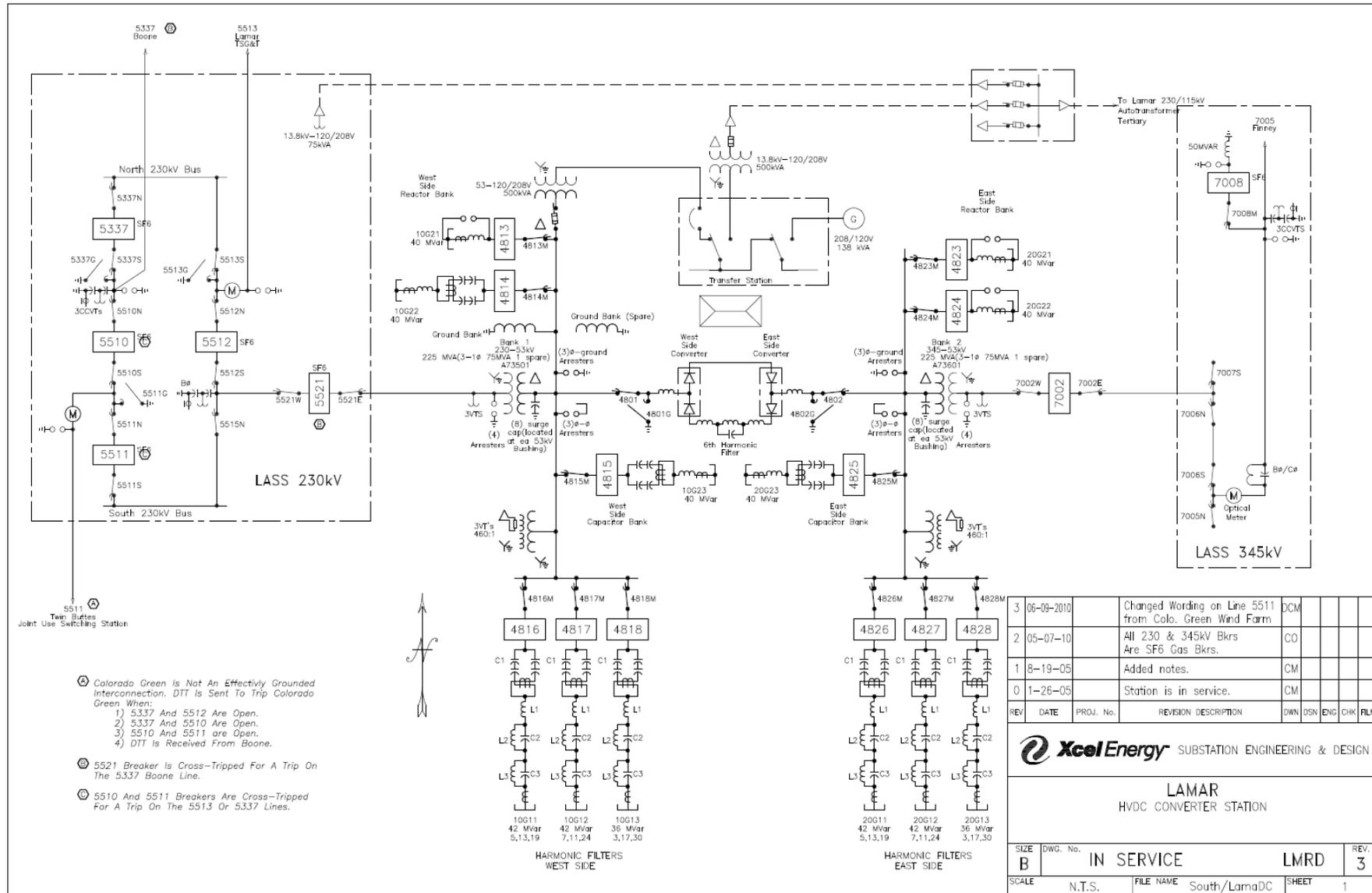


Figure 1: GI-2007-8 interconnection portion of the Feasibility Study



Introduction

PSCo Transmission received a large generator interconnection request (GI-2007-8) to interconnect forty-one (41) Suzlon 2.1 MW wind turbine generators, for a total of 86 MW of generation, with a commercial operation date of April, 2011 and a back feed date of November, 2010. The proposed wind facility will be located in Prowers County, Colorado and will be interconnected into the PSCo transmission system via a substation 40 miles south of Lamar on the Lamar to Colorado Green 230 kV line. The Customer has requested that this Project be evaluated an Energy Resource (ER) with the energy going to PSCo customers.

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 provided a preliminary identification of any thermal or voltage limit violations resulting for the interconnection, and for a NR request, a preliminary identification of network upgrades required to deliver the proposed generation to PSCo loads. The short circuit analysis identified any circuit breaker short circuit capability limits exceeded as a result of the Interconnection and for a NR request, the delivery of the proposed generation to PSCo loads.

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.

For this project, affected party is Tri-State Generation and Transmission (TSGT). PSCo will notify and work with the affected party during the system impact study (SIS) phase.

Power Flow Study Models

The power flow studies were based on the Western Electricity Coordinating Council (WECC) approved 2011 heavy summer base case. Generation was dispatched for relatively high south-to-north stressing, with further regional stressing created by modeling the Colorado Green at full output (162 MW), Twin Buttes I at full output (75 MW), and the Lamar DC Tie at full output (101 MW importing from East to West). Other wind farm generation facilities are modeled at 12.5% output level, consistent with other study procedures.

Table 1. Pertinent modeling adjustments:

- Other generation at Lamar was modeled at full output.



Base Case	Generation Resources	Gross Output (MW)
2011 HS	Colo. Green	162
	Twin Buttes I	75
	Lamar DC Tie	101 (East -> West)
	GI-2007-8	86
	Total Generation on-line at Lamar:	424

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 the Twin Buttes substation.

Power Flow Study Results and Conclusions

Energy Resource (ER) Study Results

The ER portion of this study determined that the Customer could provide 0 MW of power on a firm basis before network upgrades for delivery would be required. Non-firm transmission capability may be available depending on marketing activities, dispatch patterns, generation levels, demand levels, and the status of transmission facilities.

Voltage Control at the Point of Interconnection

Interconnecting to the PSCo bulk transmission system involves the Customer adhering to certain interconnection requirements. These requirements are contained in the Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater than 20 MW (Guidelines). The Guidelines make reference to interconnection requirements from FERC Order 661A. FERC Order 661A describes the interconnection requirements for wind generation plants. In addition, PSCo System Operations conducts commissioning tests prior to the commercial in-service date for a Customer's facilities. Some of the requirements that the Customer must complete include the following:

1. A wind generating plant shall maintain a power factor within the range of 0.95 leading to 0.95 lagging, measured at the POI, if the Transmission Provider's System Impact Study shows that such a requirement is necessary to ensure safety or reliability.
2. The System Impact Study will investigate pertinent demand, dispatch, and outage scenarios based on the defined study area that includes the proposed POI. The study will conform to the NERC Transmission System Planning Performance Requirements (TPL standards).
3. The results of the System Impact Study (mentioned in Item 1 and 2 above) do not absolve the Customer from its responsibility to demonstrate to the satisfaction of PSCo System Operations prior to the commercial in-service date that it can safely operate within the required power factor and voltage ranges.
4. Reactive Power Control at the POI is the responsibility of the Customer. Additional Customer studies should be conducted by Customer to ensure that the facilities can meet the power factor control test and the voltage controller test when the facility is undergoing commissioning testing.
5. PSCo System Operations will require the Customer to perform operational tests prior to commercial operation that would verify that the equipment installed by the Customer meets operational requirements.



6. It is the responsibility of the Customer to determine what type of equipment (DVAR, added switched capacitors, SVC, reactors, etc.), the ratings (MVAR, voltage - 34.5 kV or 230 kV), and the locations of those facilities that may be needed for acceptable performance during the commissioning testing.
7. PSCo requires the Customer to provide a single point of contact to coordinate compliance with the power factor and voltage regulation at the POI. The reactive flow at the end of 230 kV line near the POI will need to be controlled according to the Interconnection Guidelines

Item 1 makes reference to the wind generating plant maintaining a power factor within the range of 0.95 leading to 0.95 lagging, measured at the POI, if the Transmission Provider's System Impact Study shows that such a requirement is necessary to ensure safety or reliability.

Short Circuit Study Results

A short circuit study was conducted to determine the fault currents (single-line-to-ground or three-phase) at the Lamar substation 230 kV bus. Table 2 summarizes the approximate fault currents at the Lamar 230 kV bus with the addition of the 86 MW wind facility.

Table 2. Short-Circuit Study Results

System Condition	3-Phase (amps)	SLG (amps)
System Intact	IA=IB=IC=1716	IA=2185 IB=IC=0

PSCo Substation Engineering indicated that the addition of the 86 MW wind farm is not expected to necessitate the replacement of circuit breakers, switches or other substation equipment due to the increased fault current levels at the Lamar 230 kV substation.

Costs Estimates and Assumptions

Scoping level cost estimates for Interconnection Facilities (+/- 30% accuracy) and scoping level cost estimates for Network Upgrades (+/- 30% accuracy) were developed by PSCo Engineering. The cost estimates are in 2010 dollars with escalation and contingencies applied (AFUDC is not included) 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 support, engineering, design, and construction of these new PSCo facilities. This estimate does not include the cost for any other Customer owned equipment and associated design and engineering.

The estimated total cost for the required upgrades for interconnection is **\$ 53,000**. This estimate does not include the cost for any other Customer owned equipment and associated design and engineering. Table 3 lists the improvements required to accommodate the interconnection 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 a more detailed and refined design.



Table 3. PSCo Owned; Customer Funded Interconnection Facilities

Element	Description	Cost Est. (Millions)
Lamar Substation	Interconnect Customer into the Lamar Substation. The scope of work includes: <ul style="list-style-type: none"> • Relocate the remote termination of the Lamar to Colorado Green Transmission Line (5511) to a new termination at the Twin Buttes Switchyard. • Engineering and design. • Associated transmission line communications, relaying and testing. 	\$0.043
	Siting and Land Rights support for required easements, reports, permits and licenses.	\$0.010
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	\$0.053
Time Frame		6 Months

Cost Estimate Assumptions

- Scoping level cost estimates for Interconnection Facilities (+/- 30% accuracy) were developed by PSCo Engineering.
- Estimates are based on 2010 dollars (appropriate contingency and escalation applied).
- AFUDC has been excluded.
- Labor is estimated for straight time only – no overtime included.
- Lead times for materials were considered for the schedule.
- Existing metering is adequate for generation addition.
- PSCo (or it's Contractor) crews will perform all construction and wiring associated with PSCo owned and maintained facilities.
- The estimated time to site, design, procure, construct and test the interconnection facilities is at least 6 months.
- A CPCN will not be required for interconnection facility construction.