



## **Interconnection Feasibility Study Report Request # GI-2012-2**

50 MW Wind Generation  
Jefferson County, Colorado

Public Service Company of Colorado  
Transmission Planning  
**October 31, 2012**

### **Executive Summary**

Public Service Company of Colorado (PSCo) received a Generator Interconnection Request (GI-2012-2) on April 9, 2012 for a 50 MW wind generation facility in Jefferson County, Colorado. The requested in-service date is June 1, 2014 with a back-feed date of January 1, 2014.

The Interconnection Customer requested a primary Point of Interconnection (POI) at the Eldorado Substation 115 kV bus. A secondary POI was not requested after the Scoping Meeting. The wind generation facility will be located 2.5 miles from the Eldorado Substation and will be connected to the POI using a 115 kV line.

This Generator Interconnection request was studied as a stand-alone project by disregarding all previous requests in PSCo's Generator Interconnection Request queue, other than those Generator Interconnection projects that are already planned to be in service by June 2014.

The main purpose of this Feasibility Study is to evaluate the potential impacts on the PSCo transmission system due to 50 MW injection from the wind generation facility into the Eldorado 115 kV substation and delivering the additional generation to native PSCo loads. This request was studied as an Energy Resource only. The studies were performed using 2014 heavy summer load conditions and included steady-state power flow and short circuit analyses.

The current ISD cannot be met and needs to be re-evaluated. The construction schedule will be 30 months after authorization has been granted to proceed.

### **Energy Resource (ER)**

For the primary Point of Interconnection (Eldorado 115 kV bus), there were no overload or voltage issues under system intact conditions, N-1 contingencies and selected N-2 contingencies. Therefore, the proposed 50 MW wind generation facility can be interconnected to the PSCo system as an Energy Resource.



## ER = 50 MW (at Eldorado 115 kV POI)

### Short Circuit

The short circuit study results (see Table 1) showed no overduty on circuit breakers due to the proposed wind generation facility.

### Cost Estimates

The total estimated cost of the recommended system improvements to interconnect the proposed wind generation project at Eldorado 115 kV bus is approximately **\$4,370,000** (in 2012 dollars):and includes:

- \$ 0.655 million for PSCo-Owned, Customer-Funded Transmission Provider Interconnection Facilities (see Table 2)
- \$ 0.000 million for PSCo-Owned, PSCo-Funded Interconnection Network Facilities (see Table 3)
- \$ 3.715 million for PSCo-Owned, PSCo-Funded Network Upgrades for Delivery (see Table 4)

### Construction and Future Considerations

This work can be completed in 30 months following receipt of authorization to proceed. The June 2014 in service date is not feasible based on the construction schedule and needs to be reevaluated.

A potential future Interconnection Agreement (IA) would require that certain conditions be met, as follows:

- 1 The conditions of the Large Generator Interconnection Guidelines (LGIG) are met.
- 2 PSCO will require testing of the full range of 0 MW to 50 MW operational capability of the facility to verify that the facility can safely and reliably operate within required power factor and voltage ranges.
- 3 A single point of contact needs to be provided to PSCo Operations to facilitate reliable management of the transmission system.



## **Introduction**

Public Service Company of Colorado (PSCo) received an interconnection request (GI-2012-2) for a 50 MW wind generation facility in Jefferson County, Colorado. The interconnection request was received on April 9, 2012.

The Customer requested a primary Point of Interconnection (POI) at the Eldorado 115kV bus. A secondary POI was not requested after the Scoping Meeting. The wind facility will be located approximately 2.5 miles from the Eldorado Substation and connected to the POI using a 115 kV line. The requested in-service date is June 1, 2014. The assumed backfeed date is January 1, 2014. Based on the construction schedule in Table 4, the Interconnection will not be able to meet the proposed back feed date of January 2014.

## **Study Scope and Analysis**

The Feasibility Study evaluated the transmission impacts associated with the proposed wind generation facility. It consisted of power flow and short circuit analyses. The power flow analysis identified any thermal or voltage limit violations resulting from the installation of the proposed generation and an identification of network upgrades required to deliver the proposed generation to PSCo loads. The short circuit analysis identified any over-duty on circuit breakers due to the proposed generation and the short circuit levels at the primary POI.

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 nominal, and steady-state power flows below the thermal ratings of all facilities. Operationally, PSCo tries to maintain a transmission system voltage profile ranging from 1.02 per unit or higher at regulating (generation) buses to 1.0 per unit or higher at transmission load buses. Following a single contingency, transmission system steady state bus voltages must remain within 0.90 per unit to 1.05 per unit, and power flows within 100% of the facilities' continuous thermal ratings.

The proposed facility was studied as an Energy Resource only. Energy Resource 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.

For this project, it was determined that PSCo is the only affected party.



## **Power Flow Study Models**

The wind facility interconnection was studied using 2014 heavy summer loading conditions. The 2014HS case was built using the WECC approved 2012HS4A base case. PSCo loads in the case were adjusted to reflect the most recent (Sept 2012) PSCo load forecast for 2014. The topology was updated to reflect current project plans and rating changes for 2014. Significant additions or modifications were the following:

**Eldorado – Plainview project:** This line rebuild project will increase the rating of the 115 kV line between Eldorado substation and Plainview substation to 800 Amps / 159 MVA.

**Pawnee-Smoky Hill project::** The project consists of the following: two 230/345 kV transformers at Smoky Hill, a 345 kV line from Smoky Hill to Missile Site, a 345 kV line from Missile Site to Pawnee and two 230/345 kV transformers at Pawnee,

**Missile Site wind generation project:** This project is the addition of a 400 MW wind generation facility interconnected to the Missile Site 345 kV substation.

**Boulder Hydro Generation Facility:** The Boulder hydroelectric plant was recently retrofitted with a new 5 MW generator.

Two main power flow generation dispatch scenarios were evaluated. One was created as a reference scenario and the other was created with the proposed generation. PSCo control area (Area 70) wind generation facilities were dispatched to 12.5%. Area solar resources were dispatched to 65%. Black Hills Corporation, Tri-State Generation and Transmission Inc., and Platt River Power Authority generators were mirrored in both cases to their 2013 heavy summer WECC case values submitted to PSCo in August 2012. The remaining generation was selectively dispatched to match loads.

In the second case with the proposed generation, the Customer provided a model of the proposed generation and transmission line between the facility and the Eldorado substation. The 50 MW of new wind generation was modeled as eight generators with maximum real power capability of 6 MW and minimum real power capability of 0 MW. The 115 kV transmission tie line was modeled using the 115 kV line parameters provided by the Customer. The Customer provided two transmission line options. PSCo decided to use the longer of the two lines for two reasons. First, a longer line would have more potential of the two to raise issues. Second, given the uncertainty of what path this line will be taking, modeling the longer of the two is a conservative approach.

The power factor of the proposed generation was set to unity for the thermal analysis.

## **Power Flow Study Process**

Power flow studies were completed on models without and with the proposed new generation interconnection using PTI's PSSE Ver. 32.1.0 program. The studies included



N-1 contingency analysis of the potentially impacted transmission system surrounding the proposed generation facility. PSCo also analyzed selected N-2 contingencies within the same area.

### **Power Flow Results**

Primary POI: Eldorado Substation

The proposed wind facility has not caused any thermal violations or voltage violations.

Therefore, the Energy Resource Capability of the proposed generation is:

**ER = 50 MW (at Eldorado 115 kV)**

### **Short Circuit**

The calculated short circuit parameters for the POI at the Eldorado 115 kV substation are shown in Table 1 below.

**Table 1 – Short Circuit Parameters at the Eldorado 115 kV POI**

| <b>System Condition</b>   | <b>Three-Phase Fault Level (Amps)</b> | <b>Single-Line-to-Ground Fault Level (Amps)</b> | <b>Thevenin System Equivalent Impedance (R +j X) (ohms)</b>                                |
|---------------------------|---------------------------------------|---|--|
| All Facilities in Service | 12,208                                | 7727  | Z1(pos)= 1.43486 +j 5.61126<br>Z2(neg)= 1.43919 +j 5.60737<br>Z0(zero)= 3.49191 +j 13.8938 |

For the Customer proposed interconnection at the Eldorado 115 kV primary POI, no circuit breakers are expected to exceed their capabilities following installation of the new generation.



## **Cost Estimates and Assumptions**

GI-2012-2 (Feasibility Study Report)

September 11, 2012

(Revised October 24, 2012)

Scoping level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by Public Service Company of Colorado (PSCo) Engineering. The cost estimates are in 2012 dollars with escalation and contingency 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, material/equipment procurement, construction, testing and commissioning 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 is **\$4,370,000**. Figure 1 below represents a conceptual one-line of the proposed interconnection at PSCo's Eldorado 115kV Transmission Substation. These estimates do not include costs 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 generation output. 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 2 – PSCo Owned; Customer Funded Transmission Provider Interconnection Facilities**

| Element  | Description   | Cost Est. (Millions) |
|--|---|----------------------|
| <b>PSCo's Eldorado 115kV Transmission Substation</b> | Interconnect Customer into PSCo's Eldorado 115kV Transmission Substation. The new equipment includes: <ul style="list-style-type: none"> <li>• Three (3) 115kV arresters</li> <li>• Four (4) instrument transformers (high-side metering)</li> <li>• Associated bus, wiring and equipment</li> <li>• Associated site development, grounding, foundations and structures</li> <li>• Associated transmission line communications, relaying and testing</li> </ul> | <b>\$0.310</b>       |
|  | Transmission line tap into substation. Structure, conductor, hardware and installation labor.   | <b>\$0.150</b>       |
| <b>Customer's 115kV Substation</b>                   | Load Frequency/Automated Generation Control (LF/AGC) RTU and associated equipment.  | <b>\$0.185</b>       |
|  | Siting and Land Rights support for siting studies, land and ROW acquisition and construction.   | <b>\$0.010</b>       |
|  | <b>Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities</b>   | <b>\$0.655</b>       |
| <b>Time Frame</b>                                    | <b>To site, design, procure and construct after receiving authorization to proceed.</b>   | <b>18 Months</b>     |

**Table 3: PSCo Owned; PSCo Funded Interconnection Network Facilities**

| Element  | Description | Cost Estimate (Millions) |
|--|-------------|--------------------------|
| <b>PSCo's Eldorado 115kV Transmission Substation</b> | N/A         |                          |



**Table 4 – PSCo-Owned, PSCo-Funded: Network Upgrades for Delivery**

| Element  | Description  | Cost Est. (Millions) |
|--|--|----------------------|
| <b>PSCo's Eldorado 115kV Transmission Substation</b> | Upgrade/Rebuild the Eldorado 115kV Substation to breaker and a half configuration. The scope includes: <ul style="list-style-type: none"> <li>• Six (6) 115kV oil circuit breakers</li> <li>• Seventeen (17) 115kV gang switches</li> <li>• Three (3) 115kV arresters</li> <li>• Six (6) instrument transformer</li> <li>• One (1) control building/EEE</li> <li>• Associated bus, wiring and equipment</li> <li>• Associated site development, grounding, foundations and structures</li> <li>• Associated transmission substation and line communications, relaying and testing</li> </ul> | <b>\$3.480</b>       |
| <b>PSCo's Valmont 115kV Transmission Substation</b>  | Upgrade the Valmont 115kV Substation line relaying and communications equipment.   | <b>\$0.125</b>       |
| <b>PSCo's Eldorado 115kV Transmission Substation</b> | Siting and Land Rights activities for substation land acquisition and permits.   | <b>\$0.110</b>       |
|  | Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities   | <b>\$3.715</b>       |
| <b>Time Frame</b>                                    | <b>To site, design, procure and construct after receiving authorization to proceed.</b>  | <b>30 Months</b>     |



### **Cost Estimate Assumptions**

- Referenced Interconnection Guidelines for > 20 MW.
- Radially fed generation interconnection customer at the Eldorado 115kV Substation. Customer is responsible to fund all interconnection facility upgrades.
- Scoping level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by PSCo Engineering.
- Estimates are based on 2012 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.
- The Wind Generation Facility is in PSCo's retail service territory. Therefore, costs for retail load metering are included in these estimates.
- PSCo (or it's Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- The estimated time to site, design, procure and construct the network upgrades for delivery is approximately 30 months after authorization to proceed has been obtained.
- A CPCN will not be required for the interconnection facilities construction.
- Customer will string OPGW fiber into substation as part of the transmission line construction scope.
- Additional substation land will need to be acquired.
- Breaker duty study determined that no breaker replacements are needed in neighboring substations.