



Interconnection Feasibility Study Report Request # GI-2012-6

30 MW Solar Photovoltaic Generating Facility
Missile Site 230 kV Station, Colorado

Public Service Company of Colorado
Transmission Planning
April 2, 2014

Executive Summary

Public Service Company of Colorado (PSCo) received an interconnection request for a 30 MW solar photovoltaic generating facility on October 26, 2012 that was assigned GI-2012-6 as the queue number. The proposed generating facility will be located on 545 acres of currently farmed land approximately 0.5 miles away from PSCo's Missile Site 345/230 kV Station. The primary point of interconnection (POI) requested for GI-2012-6 is the Missile Site 230 kV bus and the generating facility will interconnect to the POI using a new 230 kV, 0.5-mile long transmission line. The in-service date (ISD) requested for GI-2012-6 generating facility is December 31, 2016, and the request will be studied as both a Network Resource and Energy Resource*.

This request was studied as a stand-alone generator interconnection that excluded any other new generation requests existing in the PSCo Generator Interconnection Request queue, except for the generator interconnection projects that are already planned to be in service by the summer of 2017. The main purpose of this Feasibility Study was to evaluate the potential impact on the interconnected transmission system of PSCo and its neighboring utilities (the affected parties) due to an additional 30 MW of generation injected into the Missile Site 230 kV bus. It should be noted that PSCo evaluated the capacity adequacy of the transmission system beyond the POI – the Interconnection Customer is responsible for ensuring that the 230 kV tie line to the POI is adequately rated for the proposed 30 MW generation.

The Feasibility Study results indicate that there are no affected parties due to the system impact of GI-2012-6.

Network Resource (NR)

* Energy Resource Interconnection Service allows Interconnection Customer to connect the Large Generating Facility to the Transmission System and be eligible to deliver the Large Generating Facility's output using the existing firm or non-firm capacity of the Transmission System on an "as available" basis. Energy Resource Interconnection Service does not in and of itself convey any right to deliver electricity to any specific customer or Point of Delivery.



At the primary POI at the Missile Site 230 kV substation, the proposed generation caused a 1.4% increase in contingency loading on the Smoky Hill 230/345 kV Transformer Nos. 1 and 2. The increased loading resulted in a loading equal to 100.9% of the 8-hour emergency rating of the transformers. Due to the high dispatch of wind generation in the Pawnee area for the study case it is highly unlikely for the contingency loading to go beyond the 8-hour emergency rating. Therefore, the Network Resource Capability of the proposed generation is as follows:

NR = 30 MW (at Missile Site 230 kV POI, without PSCo upgrades)

Energy Resource (ER)

At the primary POI at the Missile Site 230 kV substation, the proposed generation caused a 1.4% increase in contingency loading on the Smoky Hill 230/345 kV Transformer Nos. 1 and 2. The increased loading resulted in a loading equal to 100.9% of the 8-hour emergency rating of the transformers. Due to the high dispatch of wind generation in the Pawnee area for the study case it is highly unlikely for the contingency loading to go beyond the 8-hour emergency rating. Therefore, the Energy Resource Capability of the proposed generation is as follows:

ER = 30 MW (at Missile Site 230 kV POI, without PSCo upgrades)

Short Circuit

The short circuit study results showed no new circuit breakers overdutied due to the proposed solar generation facility.

Cost Estimates

The cost for the transmission interconnection (in 2013 dollars):

Transmission Proposal

The total estimated cost of the recommended system improvements to interconnect the project is approximately **\$1,565,000** and includes:

- \$0.965 million for PSCo-Owned, Customer-Funded Interconnection Facilities
- \$0.600 million for PSCo-Owned, PSCo-Funded Network Upgrades for Interconnection
- \$0.000 million for PSCo Network Upgrades for Delivery to PSCo Loads

This work can be completed in 15 months following receipt of authorization to proceed.

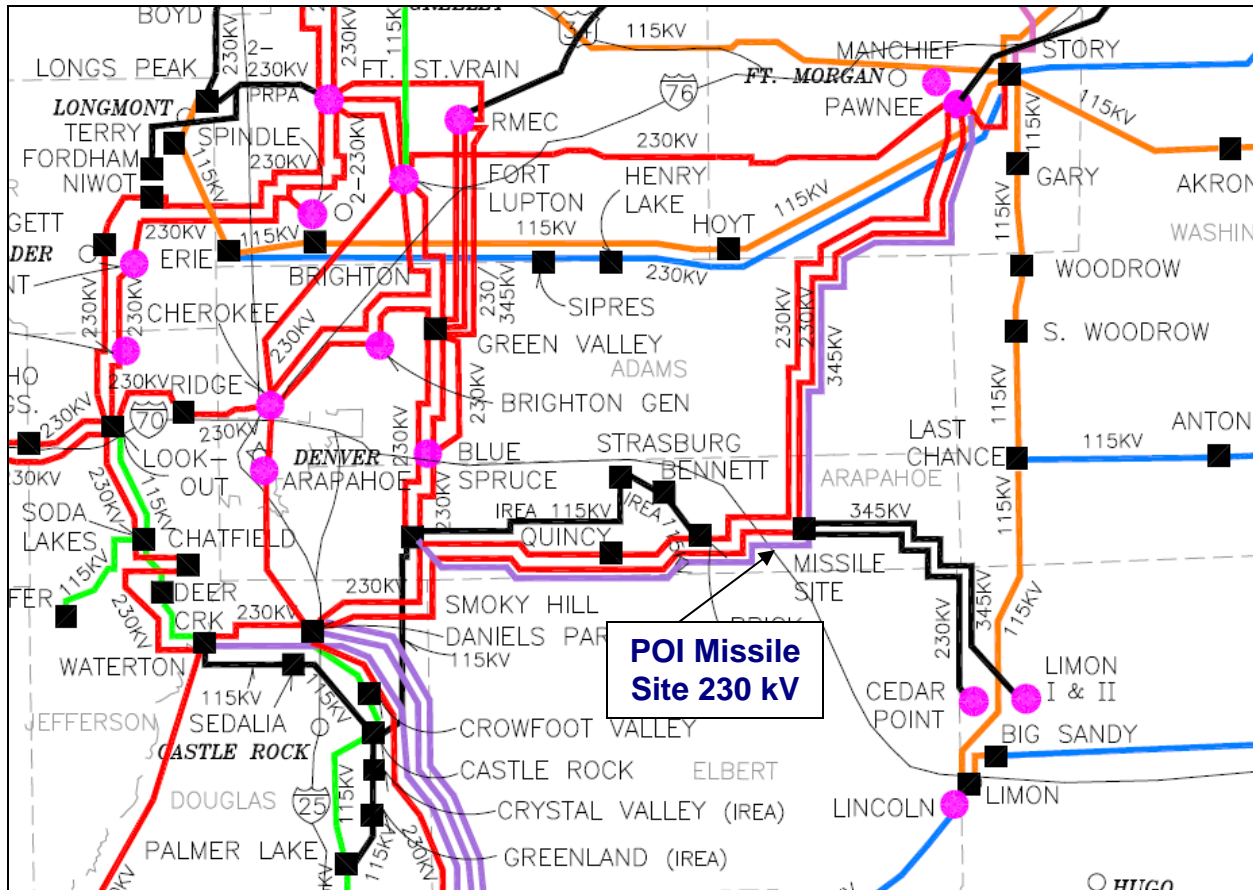


Figure 1 Missile Site, Pawnee, Daniels Park, and Surrounding Transmission System

Introduction

Public Service Company of Colorado (PSCo) received an interconnection request for a 30 MW solar photovoltaic generating facility on October 26, 2012 that was assigned GI-2012-6 as the queue number. The proposed generating facility will be located on 545 acres of currently farmed land approximately 0.5 miles away from PSCo's Missile Site 345/230 kV Station. The primary point of interconnection (POI) requested for GI-2012-6 is the Missile Site 230 kV bus and the generating facility will interconnect to the POI using a new 230 kV, 0.5- mile long transmission line. The in-service date (ISD) requested for GI-2012-6 generating facility is December 31, 2016.

Study Scope and Analysis

The Feasibility Study evaluated the transmission impacts associated with the proposed solar generation facility. The study consists of power flow and short circuit analyses. The power flow analysis identified thermal and 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 new circuit breakers overdutied 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 attempts 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 1.10 per unit, and power flows within 100% of the facilities' continuous thermal ratings. Also, voltage deviations should not exceed 5%.

The project was studied as a Network Resource and Energy Resource. Network Resource Interconnection Service shall mean an Interconnection Service that allows the Interconnection Customer to integrate its Large Generating Facility with the Transmission Provider's Transmission System: (1) in a manner comparable to that in which the Transmission Provider integrates its generation facilities to serve native load customers; or (2) in an TRO or ISO with market based congestion management, in the same manner as all other Network Resources. Network Resource Interconnection Service in and of itself does not convey transmission service.

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 elect output using the existing firm or non-firm capacity of the Transmission Provider's Transmission System on an as available bases. Energy Resource Interconnection Service in and of itself does not convey transmission service.

The Feasibility Study results indicate that there are no affected parties due to the system impact of GI-2012-6.

Power Flow Study Models

The GI-2012-6 Feasibility Study was performed using a 2017 heavy summer (2017HS) power flow base case. The study includes steady state power flow and short circuit analyses for the Benchmark case (Before GI-2012-6) and the Study case (After GI-2012-6). The 2017HS base case was updated to set the TOT-3 major path flow (north-south) at 825 MW and to dispatch the existing and planned wind generation interconnected at Pawnee and Missile Site stations at their maximum expected coincident output (based on 2012-13 winter operating data). The resulting Benchmark case was then used to create the Study case by adding GI-2012-6 at the Missile Site 230kV bus and dispatching the generator at 30 MW rated output. The wind and solar generation dispatch used at Pawnee and Missile Site stations in the two cases is as follows:



- ✓ Peetz Logan (Pawnee 230kV) = 80% of rated capacity = 461 MW
- ✓ Limon I and Limon II (Missile Site 345kV) = 97% of rated capacity = 392 MW
- ✓ Cedar Point (Missile Site 230kV) = 96% of rated capacity = 240 MW
- ✓ Planned Limon III (Missile Site 345kV) = 97% of rated capacity = 196 MW
- ✓ Proposed GI-2012-6 (Missile Site 230kV) = 100% of rated capacity = 30 MW

The study also assumed generation dispatch changes in other areas of the PSCo system to accommodate wind and solar dispatch and to more accurately represent the generation available in 2017. The changes to the two cases are as follows:

- ✓ Manchief Units 1 and 2 (Pawnee 230kV) = 0% of rated capacity = 0 MW
- ✓ Arapahoe Unit 7 (Arapahoe 115kV) = 100% of rated capacity = 45 MW
- ✓ Ft. St. Vrain Units 2-5 (Ft. St. Vrain 230 kV) = 0% of rated capacity = 0 MW
- ✓ Valmont Unit 5 (Valmont 115 kV) = 0% of rated capacity = 0 MW
- ✓ Spruce Units 1-2 (Spruce 230 kV) = 93% of rated capacity = 260 MW

Power Flow Study Process

Contingency power flow studies were completed on the reference models and the models with the proposed new generation using PTI's PSSE Ver. 33.4.0 program. Results from each of the two cases were compared and new overloads or overloads that increased significantly in the new generation case were noted. Voltage criteria violations were also recorded. PSSE's ACCC activity was used to perform the load flow contingency analysis. Areas 70 and 73 were used for contingency files (single branches and tielines). Monitored elements included branches in ties in zones 700, 703, 704, 705, 706, 710, 752, 753, 754, and 757.

Power Flow Results

Based on the results given in Table 1, it can be seen that the proposed generator interconnection results in both pre and post-contingency thermal overload on the Smoky Hill 230/345 kV auto-transformer remaining in-service after the forced outage of any one of the two identical Smoky Hill 230/345 kV auto-transformers, each rated at 560 MVA summer normal. The differential impact due to GI-2012-6 is a 1.6% increase in the post-contingency loading of the Smoky Hill auto-transformer – the power flow increases from 104.3% to 105.9% of the summer 8-hour emergency rating (644 MVA) of the auto-transformer.

No new violations of the voltage limit criteria (0.9 - 1.05 pu) or the voltage deviation criteria (< 5%) were caused in PSCo's interconnected transmission system due to the addition of GI-2012-6 generating facility.

N-1-1 and/or N-2 contingency analysis was not performed within this Feasibility Study. However, the effect of N-1-1 and/or N-2 contingencies may be evaluated in the system



impact study to identify significant operational constraints and potential need for operating procedures for their mitigation.

Network Resource (NR)

At the primary POI at the Missile Site 230 kV substation, the proposed generation caused a 1.4% increase in contingency loading on the Smoky Hill 230/345 kV Transformer Nos. 1 and 2. The increased loading resulted in a loading equal to 100.9% of the 8-hour emergency rating of the transformers. Due to the high dispatch of wind generation in the Pawnee area for the study case it is highly unlikely for the contingency loading to go beyond the 8-hour emergency rating. Therefore, the Network Resource Capability of the proposed generation is as follows:

NR = 30 MW (at Missile Site 230 kV POI, without PSCo upgrades)

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Power Flow N-1 Contingency Analysis Results

Table 1 – Differentially Overloaded Facilities ¹ for High Coincidence Wind/Solar Generation Dispatch at Pawnee and Missile Site

**Pawnee 230kV = 461 MW (80%); Missile Site 345kV = 588 MW (97%); Missile Site 230kV = 240 MW (96%)
30 MW output of GI-2012-6 (100%)**

					Branch N-1 Loading Before GI-2012-6		Branch N-1 Loading After GI-2012-6			
Monitored Facility (Line or Transformer)	Type	Owner	Summer Normal (Continuous) Facility Rating MVA	Summer 8-hour (2-hour) Emerg. Facility Rating MVA	N-1 Flow in MVA	N-1 Flow in % of 8-hour Rating	N-1 Flow in MVA	N-1 Flow in % of 8-hour Rating	Differential % Impact	N-1 Contingency Outage
Smoky Hill 230/345 kV # T4	Xfmr	PSCo	560	644 (700)	641	99.5%	650	100.9%	1.40%	Smoky Hill 230/345 kV # T5
Smoky Hill 230/345 kV # T5	Xfmr	PSCo	560	644 (700)	641	99.5%	650	100.9%	1.40%	Smoky Hill 230/345 kV # T4

¹ Due to proposed 30 MW generation increase at Missile Site 230 kV Station



Short Circuit Analysis

The short circuit study results show that no circuit breakers in the Missile Site 230kV switchyard will be over-dutied due to the proposed GI-2012-6 solar generation facility. The study assumed results from the prior GI-2012-5 feasibility study which found no over-dutied circuit breakers due to a 200 MW injection at Missile Site 230 kV switchyard.

Costs Estimates and Assumptions

GI-2012-6 (Feasibility Study Report)

October 16, 2013

Scoping level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by Xcel Energy/PSCo Engineering. The cost estimates are in 2013 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, material/equipment procurement 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 is **\$1,565,000**. Figure 2 below represents a conceptual design of the proposed expansion/interconnection at the Missile Site 230kV Substation/Bus. 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.

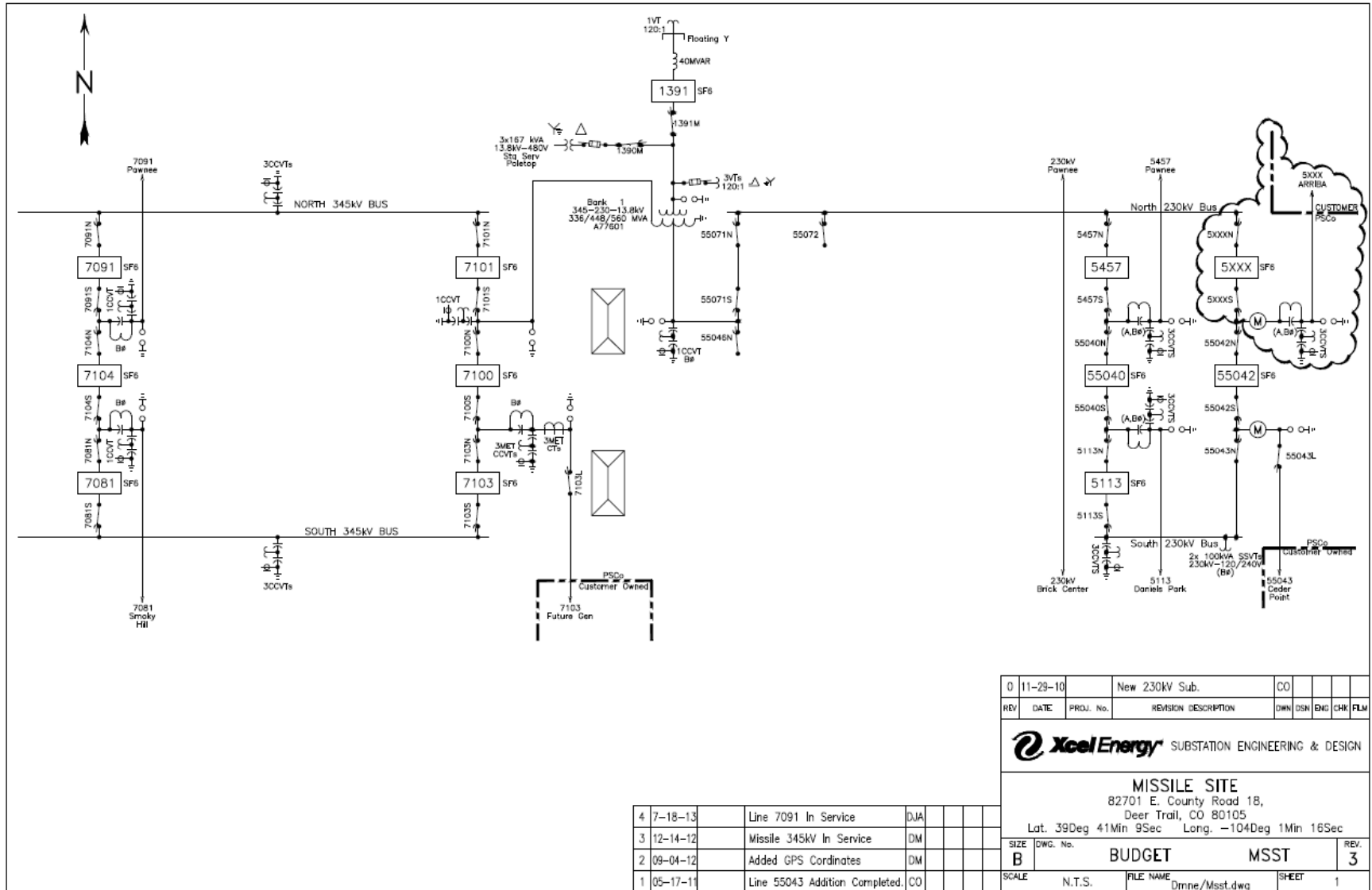


Figure 2 Missile Site Substation Interconnection



Table 1 – PSCo Owned; Customer Funded Transmission Provider Interconnection Facilities

Element	Description	Cost Est. (Millions)
PSCo's Missile Site 230kV Transmission Substation	Interconnect Customer to the 230kV bus at the Missile Site Substation. The new equipment includes: <ul style="list-style-type: none"> • One 230kV, 3000 amp gang switch • One 230kV combination CT/PT metering unit • Three 230kV lightning arresters • Primary metering for Load Frequency/Automated Generation Control • Power Quality Metering • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures • Associated transmission line communications, fiber, relaying and testing 	\$0.760
PSCo's Missile Site 230kV Transmission Substation	Transmission line tap from Customer's last line structure outside of PSCo's yard into new bay position (assumed 300' span, conductor, hardware and labor).	\$0.075
	Sitting and Land Rights and Project Management support	\$0.010
Customer's 69kV Substation	Load Frequency/Automated Generation Control (LF/AGC) RTU and associated equipment	\$0.120
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	\$0.965
Time Frame	Site, design, procure and construct	15 Months



Table 2: PSCo Owned; PSCo Funded Interconnection Network Facilities

Element	Description	Cost Estimate (Millions)
PSCo's Missile Site 230kV Transmission Substation	Interconnect Customer to the bus at the Missile Site Substation. The new equipment includes: <ul style="list-style-type: none"> • One 230kV, 3000 amp circuit breaker • One 230kV, 3000 amp gang switch • Associated station controls, communications, supervisory and SCADA equipment • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures • Associated equipment and system testing 	\$0.600
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	\$0.600
Time Frame	Site, design, procure and construct	15 months

Table 3 – PSCo Network Upgrades for Delivery

Element	Description	Cost Est. (Millions)
	Not Applicable	
	Total Cost Estimate for PSCo Network Upgrades for Delivery	\$0
Time Frame	Site, design, procure and construct	
	Total Project Estimate	\$1.565

Cost Estimate Assumptions

- Scoping level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by Xcel Energy/PSCo Engineering.
- Estimates are based on 2013 dollars (appropriate contingency and escalation applied).
- AFUDC has been excluded.
- Engineering will be contracted out to a Design Consultant.
- Lead times for materials were considered for the schedule.
- The Wind Generation Facility is not PSCo's retail service territory.
- PSCo (or it's Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- Construction labor is estimated for straight time only – no overtime included.
- The estimated time to site (support), design, procure and construct the interconnection facilities is approximately 15 months after authorization to proceed has been obtained.
- This project is completely independent of other queued projects and their respective ISD's.
- A CPCN will not be required for the interconnection facilities construction.



- Line and substation bus outages will be authorized during the construction period to meet requested backfeed dates.