



# Interconnection Feasibility Study Report

## Request # GI-2016-4

### Draft Report

300 MW Wind Generating Facility  
Missile Site 345 kV Substation, Colorado

Public Service Company of Colorado  
Transmission Planning  
May 25, 2016

#### **Executive Summary**

Public Service Company of Colorado (PSCo) received an Interconnection Request (IR) on February 24, 2016 which was assigned GI-2016-4 queue position. GI-2016-4 is a wind generating facility rated at 300 MW gross electrical output that will be located in Elbert, Lincoln and Kit Carson Counties in Colorado. The point of interconnection (POI) requested for GI-2016-4 is the 345 kV bus within the PSCo Missile Site Substation.

The proposed 300 MW generating facility is expected to consist of approximately 150 wind turbine generators (WTG), where each WTG is rated ~2.0 MW and is equipped with a 0.69/34.5 kV step-up transformer. Preliminary information on the wind generating facility's layout suggests that the 150 WTG's will be grouped together into one or two 34.5 kV collector systems, and each 34.5 kV collector system will connect to a 34.5/345 kV main step-up transformer (MST). The one or two MST's will be connected to the POI by using the same 85 miles, 345 kV radial transmission line that is expected to be constructed for interconnecting the previously proposed GI-2016-3 600 MW wind generating facility to the same POI.

**Figure 1** below (on page 8) is a conceptual one-line diagram of the proposed GI-2016-4 and previously proposed GI-2016-3 interconnections at the Missile Site Substation 345 kV bus (the POI).

The commercial operation date (COD) requested for the generating facility is December 31, 2018. Based on the requested COD, the assumed back-feed date for the facility is August 31, 2018. The IR indicated that this Feasibility Study should include studies for both Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection Service (ERIS).

The main purpose of this Feasibility Study is to determine the feasibility of aggregate injection at the Missile Site 345 kV POI (for delivery to PSCo network loads) resulting due to the 300 MW output of GI-2016-4 plus the previously proposed 600 MW output of GI-2016-3 to be interconnected at the same POI. Towards this purpose, the study also identifies the transmission improvements needed to enable delivery of the aggregate



900 MW electrical output to PSCo network loads – that is, for GI-2016-4 to qualify as NRIS in addition to GI-2016-3 as NRIS.

The Feasibility Study consisted of steady state (power flow) and short-circuit analyses. The power flow analyses were performed using two power flow models developed for GI-2016-4, which are based on the WECC 2021 heavy summer (2021HS) base case. The two power flow models are:

- a Benchmark Case which models the transmission system prior to the GI-2016-4 interconnection (i.e. Before GI-2016-4 case).  
This model includes the previously proposed generator interconnection at the same POI (i.e. GI-2016-3) and the planned 2021 transmission system topology, which includes the network upgrades identified for GI-2016-3 (i.e. the Pawnee – Daniels Park 345 kV project.)
- a Study Case that includes the 300 MW generation under study (i.e. After GI-2016-4 case).

The Pawnee – Daniels Park 345 kV project<sup>1</sup> is a PSCo planned project for which the Colorado Public Utility Commission (CPUC) has approved a Certificate of Public Convenience and Necessity (CPCN) that includes an in-service date of May 2022. Therefore, this Feasibility Study evaluated the effectiveness of Pawnee – Daniels Park 345 kV project for delivery of the proposed 900 MW cumulative rated output of GI-2016-4 and GI-2016-3.

As is evident from the power flow analysis results provided in Table A.1 in the Appendix (see page 10), the Pawnee – Daniels Park 345 kV project's facilities are sufficient as the network upgrades for delivery of the proposed 900 MW cumulative rated output of GI-2016-4 and GI-2016-3 interconnections. Therefore, no new network upgrade(s) are needed for the proposed GI-2016-4 interconnection.

Consequently this Feasibility Study concludes that the GI-2016-4 interconnection would achieve 300 MW NRIS<sup>^</sup> (in addition to the 600 MW NRIS of GI-2016-3) provided the Pawnee – Daniels Park 345 kV project is in service.

As noted in the 2016 project update<sup>2</sup>, advancing the in-service date to October 2019 for Smoky Hills – Daniels Park portion of the project is intended by petitioning CPUC to modify their previous decision.

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<sup>1</sup> More information at: <http://www.transmission.xcelenergy.com/Projects/Colorado>

<sup>^</sup> Network Resource Interconnection Service allows Interconnection Customer's Large Generating Facility to be designated as a Network Resource, up to the Large Generating Facility's full output, on the same basis as existing Network Resources interconnected to Transmission Provider's Transmission System, and to be studied as a Network Resource on the assumption that such a designation will occur. (*section 3.2.2 of Attachment N in Xcel Energy OATT*)

<sup>2</sup> More information at:  
<http://www.transmission.xcelenergy.com/staticfiles/microsites/Transmission/Files/PDF/Projects/CO/Pawnee-Daniels/CO-Transmission-Pawnee-Daniels-March-2016-Project-Update.pdf>



Prior to the Pawnee – Daniels Park 345 kV project (i.e. GI-2016-3 network upgrades) being in-service, GI-2016-4 may be interconnected as ERIS\* to deliver its output using the existing firm or non-firm transmission capacity on an “as available” basis.

Therefore, for GI-2016-4 interconnection:

NRIS (before the GI-2016-3 network upgrades) = 0 MW

ERIS (before GI-2016-3 network upgrades) = 0 to 300 MW on “as-available” basis

NRIS and/or ERIS (after the GI-2016-3 network upgrades) = 300 MW

Assuming the Interconnection Facilities and Network Upgrades for GI-2016-3 are in-service, **no** transmission improvements are needed for the interconnection and delivery of GI-2016-4 generation output as ERIS and/or NRIS.

Therefore, as shown in **Tables 1–3**, the cost for the Interconnection Facilities and the Network Upgrades for Delivery is **\$0**.

**Total Estimated Cost for Interconnecting GI-2016-4 as ERIS and/or NRIS = \$0**  
*(assuming the Interconnection Facilities and Network Upgrades for GI-2016-3 are in service)*

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\* 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. [\(section 3.2.1 of Attachment N in Xcel Energy OATT\)](#)

## **Power Flow N-1 Contingency Analysis**

The 2021HS base case was updated to dispatch the existing and planned generation within the Pawnee and Missile Site “generation pockets” (i.e. aggregate of generation in the local area) at their respective highest coincident output deemed appropriate for the planning of adequate transmission capacity. This was done in accordance with the generation dispatch assumptions practiced by PSCo Transmission Planning function to study the feasibility and system impact of generator interconnection requests as a Transmission Provider. Accordingly, the existing, planned and proposed generating plants at Pawnee and Missile Site stations were dispatched as noted below.

### Pawnee local “generation pocket”

- ✓ Pawnee Fossil Fuel generation = 100% of rated capacity = 536 MW
- ✓ Manchief Gas generation = 90% of rated capacity = 252 MW
- ✓ Peetz Logan Wind generation = 40% of rated capacity = 230 MW

***Aggregate Generation Dispatched at Pawnee in all Cases = 1018 MW***

### Missile Site local “generation pocket”

- ✓ Cedar Point (Missile Site 230kV) = 80% of rated capacity = 200 MW
- ✓ Limon I, II, III (Missile Site 345kV) = 80% of rated capacity = 480 MW
- ✓ GI-2016-3 (Missile Site 345kV) = 100% of rated capacity = 600 MW
- ✓ GI-2016-4 (Missile Site 345kV) = 100% of rated capacity = 300 MW

***Aggregate Generation Dispatched at Missile Site in Benchmark Case = 1280 MW***

***Aggregate Generation Dispatched at Missile Site in Study Case(s) = 1580 MW***

The GI-2016-4 *Benchmark Case* was derived from the 2021HS base case by changing the generation dispatch at Pawnee and Missile Site as noted above. The previously proposed GI-2016-3 generating plant was added at the Missile Site 345kV bus and dispatched at 600 MW rated output. Transmission facilities comprising the Pawnee – Daniels Park project modeled in the 2021HS case were retained in the Benchmark Case since they comprise the network upgrades identified for GI-2016-3.

The GI-2016-4 *Study Case* was created by adding the proposed GI-2016-4 generating plant in the Benchmark Case and dispatching it at 300 MW rated output, thus resulting in 900 MW aggregate injection at the Missile Site 345kV bus.

PSCo adheres to all applicable NERC Standards & WECC Criteria for Bulk Electric System (BES) acceptable performance, as well as its internal transmission planning criteria for all studies. During system intact (N-0) conditions, PSCo’s steady-state performance criteria require the transmission bus voltages remain within 0.95 – 1.05 per unit of nominal and the power flows stay below the applicable normal ratings of the transmission facilities. Following a single contingency, the steady state bus voltages must remain within 0.90 – 1.05 per unit of nominal, and the power flows must continue



to stay below the applicable normal facility ratings. For N-1 post-contingency system conditions, the applicable normal rating is the seasonal continuous rating of the transmission facility – but PSCo allows use of eight-hour facility rating for transformers for which it is available. Further, PSCo does not rely on 30-minute emergency ratings of transmission facilities for meeting N-1 system performance in planning studies.

As is evident from the power flow analysis results provided in Table A.1 in the Appendix (see page 10), the Pawnee – Daniels Park 345 kV project's facilities are sufficient as the network upgrades for delivery of the proposed 900 MW cumulative rated output of both GI-2016-4 and GI-2016-3 interconnections. Therefore, no new network upgrade(s) are needed for the proposed GI-2016-4 interconnection.

Prior to the Pawnee – Daniels Park 345 kV project (i.e. GI-2016-3 network upgrades) being in-service, GI-2016-4 may be interconnected as ERIS\* to deliver its output using the existing firm or non-firm transmission capacity on an “as available” basis.

Therefore, for GI-2016-4 interconnection:

NRIS (before the GI-2016-3 network upgrades) = 0 MW

ERIS (before GI-2016-3 network upgrades) = 0 to 300 MW on “as-available” basis

NRIS and/or ERIS (after the GI-2016-3 network upgrades) = 300 MW

### **Voltage Regulation and Reactive Power Capability**

Interconnection Customers are required to interconnect its Large Generating Facility with Public Service of Colorado's (PSCo) Transmission System in accordance with the *Xcel Energy Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater Than 20 MW* (available at:

<http://www.transmission.xcelenergy.com/staticfiles/microsites/Transmission/Files/PDF/Interconnection/Interconnections-POL-TransmissionInterconnectionGuidelineGreat20MW.pdf>).

In addition, wind generating plant interconnections must also fulfill the performance requirements specified in FERC Order 661-A. Accordingly, the following voltage regulation and reactive power capability requirements at the POI are applicable to this interconnection request:

- To ensure reliable operation, all Generating Facilities interconnected to the PSCo transmission system are expected to adhere to the *Rocky Mountain Area Voltage Coordination Guidelines (RMAVCG)*. Accordingly, since the POI for this interconnection request is located within Northeast Colorado - Region 7 defined in the *RMAVCG*; the applicable ideal transmission system voltage profile range is 1.02 – 1.03 per unit at regulated buses and 1.0 – 1.03 per unit at non-regulated buses.

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\* 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. ([section 3.2.1 of Attachment N in Xcel Energy OATT](#))



- Xcel Energy’s OATT requires all Interconnection Customers to have the reactive capability to achieve +/- 0.95 power factor at the POI, with the maximum reactive capability (corresponding to rated output) available at all output levels. Furthermore, Xcel Energy requires all Generating Facilities to have dynamic voltage control capability and maintain the POI voltage specified by the Transmission Operator as long as the generating plant is on-line, producing power and it is not called upon to operate outside its 0.95 lag – 0.95 lead power factor range capability at the POI.
- It is the responsibility of the Interconnection Customer to determine the type (switched shunt capacitors and/or switched shunt reactors, etc.), the size (MVAR), and the locations (34.5 kV or 345 kV bus) of any additional static reactive power compensation needed within the generating plant in order to have adequate reactive capability to meet the +/- 0.95 power factor and the 1.02 – 1.03 per unit voltage range standards at the POI. Further, for wind generating plants to meet the LVRT (Low Voltage Ride Through) performance requirements specified in FERC Order 661-A, an appropriately sized and located dynamic reactive power device (DVAR, SVC, etc.) may also need to be installed within the generating plant.
- The Interconnection Customer is required to demonstrate to the satisfaction of PSCo Transmission Operations prior to the commercial in-service date of the generating plant that it can safely and reliably operate within the required power factor and voltage ranges (noted above).

**Short Circuit Analysis**

The short circuit study results show that no circuit breakers in the Missile Site station (or any adjoining station) will be over-dutied by interconnecting the proposed GI-2016-4 wind generation facility.

**GI-2016-4 Impact on Short Circuit Levels and Breaker Duty Margins at Missile Site 345 kV POI**

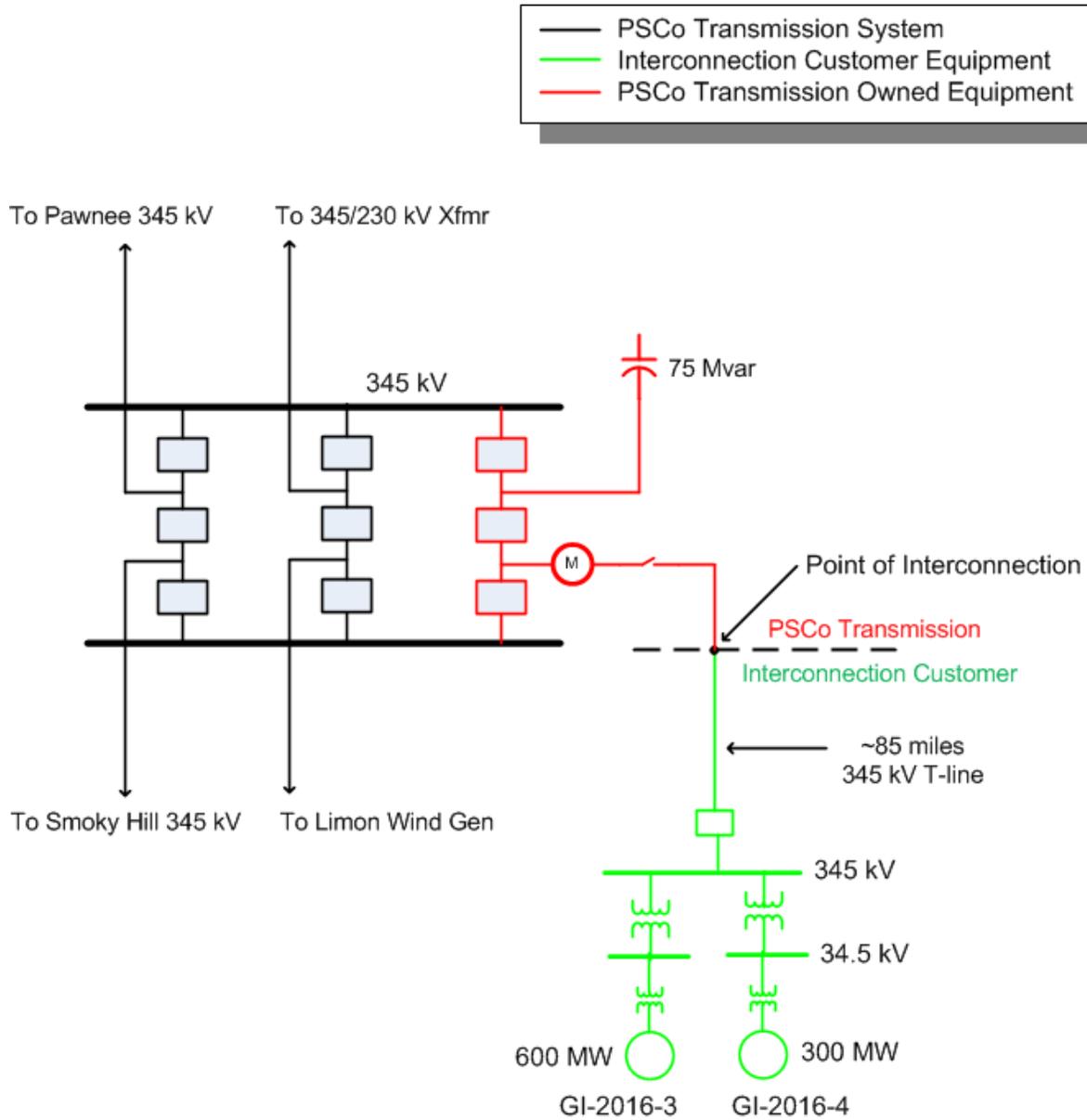
System Condition	Three-Phase (3-Ph) Fault Level (Amps)	Single-Line-to-Ground (SLG) Fault Level (Amps)	Breaker Duty Margin for 3-Ph Fault	Breaker Duty Margin for SLG Fault
Before GI-2016-4 Y2017-18	10,910	10,151	82.7 %	83.9 %
After GI-2016-4 Y2017-18	11,967	11,208	81.0 %	82.2 %

## Costs Estimates and Assumptions

**Figure 1** below is a conceptual one-line diagram of the proposed GI-2016-4 and previously proposed GI-2016-3 interconnections at the Missile Site Substation 345 kV bus (the POI).

Assuming the Interconnection Facilities and Network Upgrades for GI-2016-3 are in-service, **no** transmission improvements are needed for the interconnection and delivery of GI-2016-4 generation output as NRIS. Therefore, as shown in **Tables 1–3** below, the cost for the Interconnection Facilities and the Network Upgrades for Delivery is **\$0**.

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**Figure 1      GI-2016-4 Interconnection to 345kV Bus in Missile Site Substation**



**Table 1: PSCo Owned; Interconnection Customer Funded Interconnection Facilities  
(assuming the Interconnection Facilities for GI-2016-3 are in-service)**

Element	Description	Cost Est. (Millions)
<b>PSCo's Missile Site 345 kV Transmission Substation</b>	Interconnect Customer to the 345kV bus at the Missile Site Substation.	\$0
<b>Customer's 345 kV Substation</b>	Load Frequency/Automated Generation Control (LF/AGC) RTU and associated equipment.	\$0
	<b>Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities</b>	\$0
<b>Time Frame</b>	<b>Site, design, procure and construct</b>	<b>N/A</b>

**Table 2: PSCo Owned; PSCo Transmission Provider Funded Interconnection Facilities  
(assuming the Interconnection Facilities for GI-2016-3 are in-service)**

Element	Description	Cost Estimate (Millions)
<b>PSCo's Missile Site 345 kV Transmission Substation</b>	Interconnect Customer to the 345kV bus at the Missile Site Substation.	\$0
	<b>Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities</b>	\$0
<b>Time Frame</b>	<b>Site, design, procure and construct</b>	<b>N/A</b>

**Table 3: PSCo Network Upgrades for Delivery  
(assuming the Network Upgrades identified for GI-2016-3 are in-service)**

Element	Description	Cost Estimate (Millions)
<b>None</b>		\$0
	<b>Total Cost Estimate for PSCo Network Upgrades for Delivery</b>	\$0
<b>Time Frame</b>	<b>Site, design, procure and construct</b>	<b>N/A</b>

## Appendix – Power Flow N-1 Contingency Analysis Results

### High Coincidence Generation Dispatch at Pawnee & Missile Site:

**Pawnee 230kV (100% Coal + 90% Gas + 40% Wind) = 1018 MW;**

**Missile Site 345kV Wind = 480 MW (80%); Missile Site 230kV Wind = 200 MW (80%)**

**600 MW output from GI-2016-3 is dispatched to sink at Spindle (268 MW), Ft St Vrain (264 MW) & Ft Lupton (50 MW)**

**300 MW output from GI-2016-4 is dispatched to sink at Comanche #1, #2**

**Table A.1 – Differential Impact<sup>3</sup> of GI-2016-4 on Facility Loadings  
With GI-2016-3 Network Upgrades (i.e. Pawnee – Daniels Park 345kV Project) In Service**

				Branch N-1 Loading Before 300 MW GI (600 MW Total Injection)		Branch N-1 Loading After 300 MW GI (900 MW Total Injection)			
Monitored Facility (Line or Transformer)	Type	Owner	Summer Normal (Continuous) Facility Rating in MVA	Flow in MVA	Flow in % of Summer Normal Rating	Flow in MVA	Flow in % of Summer Normal Rating	Differential Impact of GI-2016-4	N-1 Contingency Outage
Smoky Hill 230/345 kV # T4/T5	Xfmr	PSCo	560	392.9	70.2%	406.6	72.7%	2.5%	Smoky Hill 230/345 kV # T5/T4*
Missile Site – Daniels Park 230kV	Line	PSCo	741	480.0	64.7%	533.1	72.3%	7.6%	Missile Site – Smoky Hill 345 kV
Clark – Jordan 230 kV	Line	PSCo	331	269.0	81.4%	280.0	88.0%	6.6%	Smoky Hill -- Leetsdale 230 kV

\* This is the worst outage – the outage of Harvest Mile 230/345 kV # T1 or outage of Smoky Hill – Harvest Mile 230 kV line results in lower MVA flows.

<sup>3</sup> Due to proposed 600 MW generation increase at Missile Site 345 kV Station