



Interconnection Feasibility Study Report Request # GI-2016-32

51.75 MW Solar Generating Facility
Interconnecting at
Missile Site 230 kV Substation, Colorado

Public Service Company of Colorado
Transmission Planning
May 2, 2017

Executive Summary

Public Service Company of Colorado (PSCo) received an Interconnection Request (IR) on December 20, 2016 which was assigned GI-2016-32 queue position. GI-2016-32 is a solar photovoltaic generating facility rated at 51.75 MW gross electrical output that will be located in Arapahoe County, Colorado. The Point Of Interconnection (POI) requested for GI-2016-32 is the 230 kV bus within PSCo's Missile Site Substation. As per the IR, GI-2016-32 is studied for both Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection Service (ERIS).

The proposed 51.75 MW generating facility is expected to consist of approximately 23 SMA inverters rated at 2.25 MW each. Preliminary information on the generating facility's layout suggests that the 23 inverters will be grouped together into a 34.5 kV collector system, and the 34.5 kV collector system will connect to a 34.5/230 kV main step-up transformer. The facility will connect to the POI via an approximately two mile 230 kV line.

The Commercial Operation Date (COD) requested for the generating facility is December 1, 2019. Based on the requested COD, the assumed back-feed date for the facility is June 1, 2019 (approximately six months before the COD).

Figure 1 below depicts the proposed POI for GI-2016-32 and the surrounding PSCo transmission system.



Convenience and Necessity (CPCN) and has an in-service date of October 31, 2019. Studies for GI-2016-3 demonstrated that the Pawnee – Daniels Park project is the network upgrade needed to deliver the 600 MW output of GI-2016-3 to the PSCo system. Therefore, that project was included in the power flow models.

The studies indicated that there were no adverse impacts to other systems. Therefore, no affected parties are identified for GI-2016-32.

Power flow analysis results provided in Table A.1 in the Appendix (see page 11) show that the additional 51.75 MW injection into Missile Site Substation has no significant differential impact on the transmission system and, therefore, no network upgrades are required. Consequently this Feasibility Study concludes that the proposed GI-2016-32 interconnection qualifies for 51.75 MW ERIS and NRIS² without any network upgrades.

That is, for GI-2016-32 interconnection:

NRIS = 51.75 MW

ERIS = 51.75 MW

As shown in **Tables 1–3**, the cost for the Interconnection Facilities and the Network Upgrades for Delivery is **\$1.803 million** and includes:

- \$0.855 million for PSCo-Owned, Interconnection Customer Funded Transmission Provider Interconnection Facilities
- \$0.948 million for PSCo-Owned, PSCo Funded Network Upgrades for Interconnection Facilities

It is estimated that this work can be completed in approximately 18 months, following receipt of authorization to proceed.

² 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](#))

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) = 80% of rated capacity = 480 MW
- ✓ GI-2016-32 (Missile Site 345kV) = 100% of rated capacity = 51.75 MW

Aggregate Generation Dispatched at Missile Site in Benchmark Case = 1160 MW

Aggregate Generation Dispatched at Missile Site in Study Case(s) = 1211.75 MW

The GI-2016-32 *Benchmark Case* was derived from the 2021HS base case by changing the aggregate area generation dispatch at Pawnee and Missile Site to 1018 MW and 1160 MW as noted above. The previously proposed GI-2016-3 generating plant was added at the Missile Site 345kV bus and dispatched at 480 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-2016-32 *Study Case* was created by adding the proposed GI-2016-32 solar generating plant in the Benchmark Case and dispatching it at 51.75 MW rated output.

PSCo adheres to all applicable NERC Standards and 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 performed for this study, the additional 51.75 MW generation injection into Missile Site Substation causes no significant differential impact (greater than 2 percent power flow change) on the transmission system. Therefore, no network upgrade is required for the proposed GI-2016-32 interconnection to achieve 51.75 MW NRIS.

Consequently, this Feasibility Study concludes that the proposed GI-2016-32 interconnection qualifies for 51.75 MW ERIS and NRIS.

Therefore, for GI-2016-32 interconnection at Missile Site 230 kV POI with no network upgrades:

NRIS = 51.75 MW

ERIS = 51.75 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>).

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.
- Xcel Energy's OATT (Attachment N effective 10/14/2016) requires all Generator Interconnection (GI) Customers to provide dynamic reactive power within the power factor range of 0.95 leading to 0.95 lagging at the high side of the generator substation. Furthermore, Xcel Energy requires every Generating Facility to have dynamic voltage control capability to assist in maintaining the POI voltage schedule specified by the Transmission Operator as long as the Generating Facility does not have to operate outside its 0.95 lag – 0.95 lead dynamic power factor range capability.



- 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 230 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, it is the responsibility of the Interconnection Customer to compensate their generation tie-line to ensure minimal reactive power flow under no load conditions.
- 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).
- The Interconnection Customer has the responsibility to ensure that its generating facility is capable of meeting the voltage ride-through and frequency ride-through (VRT and FRT) performance specified in NERC Reliability Standard PRC-024-2.

Short Circuit Analysis

The short circuit study results show that no circuit breakers in the Missile Site Substation (or in PSCo’s system) will be over-dutied by interconnecting the proposed GI-2016-32 solar generation facility. The base case scenario before GI-2016-32 included preliminary models for all expected transmission system improvements projected through the end of 2019 and also included preliminary modeling for the proposed GI-2016-3 project. The GI-2016-32 230 kV generator tie line impedance was estimated based on a length of two miles.

GI-2016-32 Impact on Short Circuit Levels and Breaker Duty Margins at Missile Site 230 kV POI

System Condition	Three-Phase (3-Ph) Fault Level (Amps)	Single-Line-to-Ground (SLG) Fault Level (Amps)	Thevenin System Equivalent Impedance (R + jX) (Ohms)
Before GI-2016-32 Y2019	19,872	18,574	Z1(pos)= 0.459 + j 6.667 Z2(neg)= 0.478 + j 6.665 Z0(zero)= 0.949 + j 8.034
After GI-2016-32 Y2019	20,079	19,003	Z1(pos)= 0.459 + j 6.667 Z2(neg)= 0.478 + j 6.665 Z0(zero)= 0.910 + j 7.845



Costs Estimates and Assumptions

PSCo Engineering has developed an Indicative Estimate (IE) for Transmission Provider Interconnection Facilities and Network Upgrades required for the proposed GI-2016-32 Interconnection. The cost estimates are in 2017 dollars with escalation and contingency applied (AFUDC is not included). Indicative Estimates are based upon typical construction costs for previously performed similar construction projects; however they have no specified level of accuracy. These estimated costs include all applicable labor and overheads associated with the siting support, engineering, design, and construction of these new PSCo facilities. These estimates do not include the costs for any other Customer owned equipment and the associated design and engineering.

Figure 2 below represents a conceptual one-line of the proposed interconnection of GI-2016-32 generating facility in the Missile Site Substation 230 kV bus

As shown in **Tables 1-3**, the total cost for the Transmission Provider Interconnection Facilities and Network Upgrades is **\$1.803 million**. 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.

The estimated project duration is eighteen (18) months from receipt of the Customer's Notice to Proceed (NTP) to the Backfeed date.

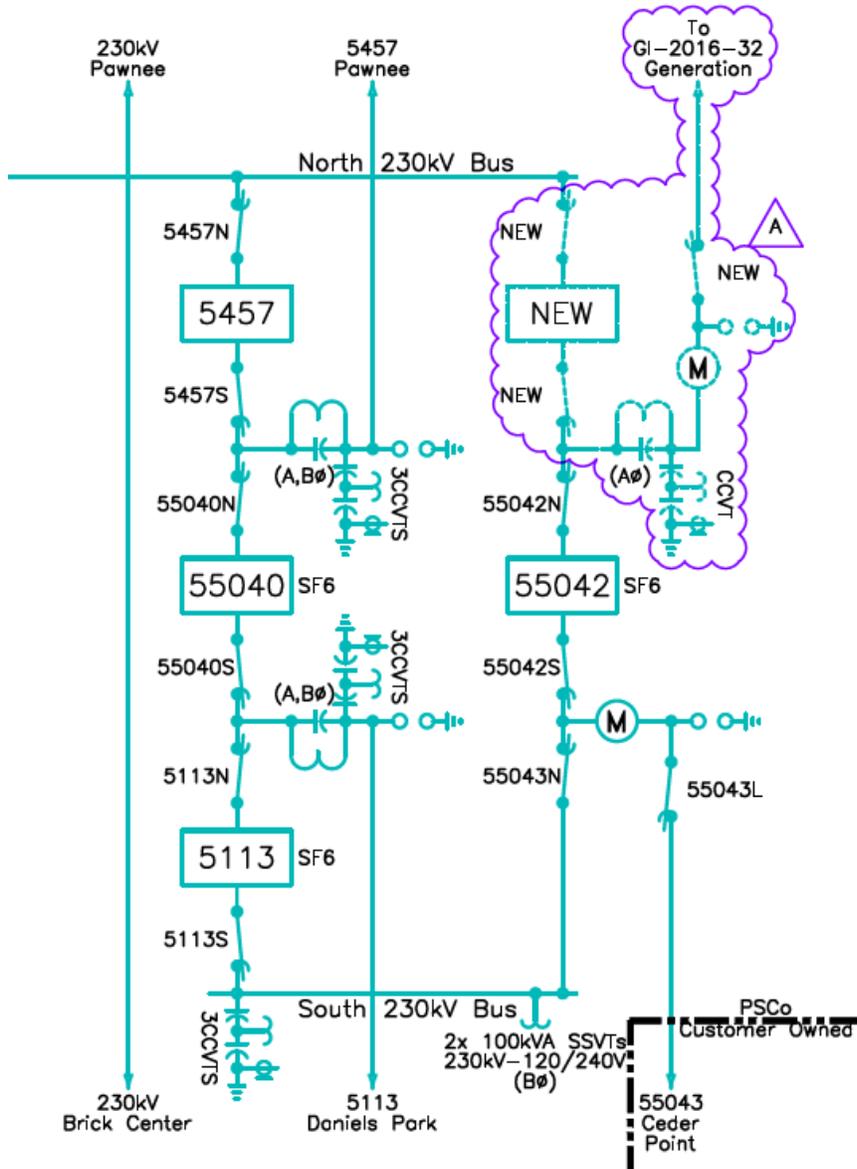


Figure 2: GI-2016-32 Interconnection to 230 kV Bus in Missile Site Substation



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

Element	Description	Cost Est. (Millions)
PSCo's Missile Site 230kV Transmission Sub Station	Interconnect Customer to the Missile Site Sub 230kV bus. The new equipment includes; <ul style="list-style-type: none"> • One (1) motor operated 230kV disconnect switch • Three (3) 230kV combination CT/PT metering units • Power Quality Metering (230kV line from Customer) • Three (3) surge arresters • Two (2) relay panels • Associated bus, wiring and equipment • Associated foundations and structures • Associated transmission line communications, relaying and testing 	\$0.805
	Transmission line tap into substation. Conductor, hardware, and installation labor.	\$0.050
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	\$0.855
Time Frame	Design, procure and construct	18 Months

Table 2 – PSCo Owned; PSCo Funded Network Upgrades for Interconnection

Element	Description	Cost Estimate (Millions)
PSCo's Missile Site 230kV Transmission Sub Station	Interconnect Customer to the Missile Site Sub 230kV bus. The new equipment includes; <ul style="list-style-type: none"> • One (1) 230kV circuit breaker • Two (2) 230kV gang switches • Associated communications, supervisory and SCADA equipment • Associated line relaying and testing • Associated bus, miscellaneous electrical equipment, cabling and wiring • Associated foundations and structures • Associated road and site development, fencing and grounding 	\$0.863
	Siting and Land Rights support for substation land acquisition and construction.	\$0.085
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	\$0.948
Time Frame	Design, procure and construct	18 Months



Table 3 – PSCo Owned; PSCo Funded Network Upgrades for Delivery

Element	Description	Cost Est. (Millions)
	None identified at this point	N/A
	Total Cost Estimate for PSCo Network Upgrades for Delivery Facilities	\$0
Time Frame	Design, procure and construct	N/A

Cost Estimate Assumptions:

- Indicative level project cost estimates (IE) for Interconnection Facilities and Network Upgrades were developed by PSCo Engineering. No level of accuracy is specified for IE's.
- Estimates are based on 2017 dollars (appropriate contingency and escalation applied).
- Allowance for Funds Used During Construction (AFUDC) has been excluded.
- Labor is estimated for straight time only – no overtime included.
- Lead times for materials were considered for the schedule.
- All substation construction can be accomplished within PSCo's existing property boundaries. No additional land is required.
- PSCo (or it's Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- The estimated time to design, procure and construct the interconnection facilities is approximately 18 months (after authorization to proceed has been obtained).
- Line and substation bus outages will be necessary during the construction period. Outage availability could potentially be problematic and extend requested backfeed date due.
- 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.
- Customer will string OPGW fiber into substation as part of the transmission line construction scope.
- The Customer will be required to design, procure, install, own, operate and maintain a Load Frequency/Automated Generation Control (LF/AGC) RTU at their Customer Substation. PSCo / Xcel will need indications, readings and data from the LFAGC RTU.
- Power Quality Metering (PQM) will be required on the Customer's 230 kV line terminating into Missile Site Substation.

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%)

480 MW output from GI-2016-3 is dispatched to sink at Blue Spruce, Rocky Mountain Energy Center, & Comanche

51.75 MW output from GI-2016-32 is dispatched to sink at Rocky Mountain Energy Center & Comanche

**Table A.1 – Differential Impact³ of GI-2016-32 on Facility Loadings
With Pawnee – Daniels Park 345kV Project In-Service**

				Branch N-1 Loading Before 51.75 MW GI		Branch N-1 Loading After 51.75 MW GI			
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-2016-32	N-1 Contingency Outage
Greenwood – Monaco 230 kV	Line	PSCo	404	391	96.1%	397	97.7%	1.6%	Smoky Hill -- Leetsdale 230 kV
Leetsdale – Monaco 230 kV	Line	PSCo	396	354	89.2%	360	90.7%	1.5%	Smoky Hill -- Leetsdale 230 kV

³ Due to proposed 51.75 MW generation increase at Missile Site 230 kV Substation