Feasibility Study Report
Generation Interconnection Request # GI-2016-29

150MW Solar Photovoltaic Facility
Comanche – Midway 230kV Line (#5413)
Pueblo County, Colorado

Transmission Planning West
Xcel Energy
April 21, 2017

Executive Summary

The "GI-2016-29" (GI) is a 150MW solar photovoltaic generation facility that will be located in Pueblo County, Colorado. The GI request was received by PSCo on January 10, 2017 and a scoping meeting was held on January 6, 2017. This study report is based on the information provided by the Interconnection Customer ("Customer") and assumptions stated in the Feasibility study agreement.

The Customer proposed both a primary and a secondary Point of Interconnection (POI). The Primary POI requested is a tap on the Comanche – Midway 230kV line (#5413), at approximately 8.15 miles from the Comanche Substation. The secondary POI requested is a tap on the Comanche – Boone 230kV line, at approximately 8.15 miles from the Comanche Substation. The tap point will constitute a new substation in order to accommodate the GI interconnection. The new substation will be referred to as "GI-2016-29 Substation" in this report.

The GI facility will consist of seventy five (75) Schneider Electric CS 2000 inverters connected to twenty (20) 575volt/34.5kV, 2100kVA Generator Step-up Transformers (GSU)s, organized in five groups. The five groups will interconnect to a 34.5/230kV, 168MVA Main Step-Up Transformer which will interconnect to the POI using a Customer owned 230kV transmission tie-line, which is expected to be 0.4 miles long and strung with 336 kcmil "Linnet" conductor.

The proposed Commercial Operation Date (COD) and backfeed date for the GI are December 15, 2020 and October 15, 2020 respectively

The GI feasibility study request is submitted for both Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection Service (ERIS) analysis.

PSCo load is assumed to be the sink for GI-2016-29 generation.

The scope of this report includes steady state (power flow) analysis and short circuit analysis. The studies were performed using a Western Electricity Coordinating Council (WECC) approved 2022 Heavy Summer ("2022HS1") base case and dispatched to reflect a heavy south-north flow on the Comanche – Midway – Jackson Fuller – Daniels Park transmission system.

The GI-2016-29 interconnection request was studied as a stand-alone project. That is, the study did not include any other Generator Interconnection Requests (GIR) existing in PSCo's or any affected party's GIR queue, other than the interconnection requests that are considered to be planned resources for which Power Purchase Agreements have been signed.

The affected parties for this study are Colorado Springs Utilities (CSU), Black Hills Colorado Electric (BHCE), Tri-State Generation and Transmission Inc. (TSGT) and Intermountain Rural Electric Association (IREA).

Steady State Contingency Analysis Results:

Single Contingency Analysis Results:
The following PSCo facility overload is attributable to the interconnection of GI-2016-29

- Greenwood – Monaco 230kV line loading increased from 100.0% to 103.1%.

This single contingency overload will need to be mitigated by upgrading six 1272 dual jumpers at PSCo's Monaco Substation to sufficiently increase the rating of the Greenwood-Monaco 230kV transmission line.

Multiple Contingency Analysis Results:

The implementation of the Palmer Lake – Monument 115kV Line operating procedure eliminated some of the overloads on the CSU and IREA facilities.

The study case was created by dispatching renewable resources at 85% of the nameplate capacity, natural gas generators at 90% of the nameplate capacity, fossil fuel generators at 100% of the nameplate capacity, and wind generation at 40% of the nameplate capacity resulting in heavy south – north flows on the Comanche – Midway – Jackson Fuller – Daniels Park transmission system. Since the study case represents a stressed condition on the PSCo system, the multiple contingency overloads on the PSCo facilities will be addressed by PSCo system readjustments (including generation curtailment) implemented via operating practices. PSCo facility overloads due to multiple contingencies are not attributed to the GI-2016-29 interconnection.

The incremental overloads on the following BHCE facilities are attributable to the interconnection of GI-2016-29

- Fountain Valley – Desertcove 115kV line loading increased from 100.0% to 106.5%
- Fountain valley – Midway BR 115kV line loading increased from 99.4% to 104.9

The Interconnection Customer will need to contact BHCE to determine how these incremental overloads on their system due to multiple contingencies need to be mitigated.

Short Circuit

The fault current levels and Thevenin impedance values for three phase and single line to ground faults at the POI are given in Table-1. The breaker duty study determined that no breaker replacements are needed in neighboring substations.

Conclusion

Energy Resource Interconnection Service (ERIS): The benchmark case has 100% contingency loading on the Greenwood – Monaco 230kV line under a single contingency condition. Also, the Fountain Valley – Desertcove 115kV line and Fountain Valley – MidwayBR 115kV line are loading to 100% and 99.4% respectively for the double circuit outage of the Comanche – Daniels Park 345kV lines. Due to these pre-existing thermal overloads in the benchmark case, the GI-2016-29 output for ERIS is 0 MW for the studied generation dispatch scenario. However, higher generation output at the proposed facility may become feasible on an as-available basis depending on the prevailing dispatch of existing generation resources located in the electrical vicinity of GI-2016-29 (Jackson Fuller, Comanche, Midway and Lamar areas, CSU system and BHCE system).

Network Resource Interconnection Service (NRIS): Implementing the Network Upgrades needed to mitigate the above single contingency thermal overload on the BHCE system will allow GI-2016-29 to achieve full NRIS of 150MW. The Interconnection Customer has to work with BHCE in order to identify mitigation measures required to eliminate the overloads on these facilities caused due to GI-2016-29 interconnection. The cost estimates provided in this report do not include costs for eliminating the BHCE overloads.

Cost Estimates

The total estimated cost of the recommended system improvements to interconnect the project is approximately $12.48 million and includes:

- $ 1.05 million for PSCo-Owned, Customer-Funded Transmission Provider Interconnection Facilities
- $ 11.408 million for PSCo-Owned, PSCo-Funded Network Facilities for Interconnection
- $ 0.022 million for PSCo Network Upgrades for Delivery to PSCo Loads

A Certificate of Public Convenience and Necessity (CPCN) will be required before the construction of the GI-2016-29 Substation can commence. PSCo anticipates that it will take eighteen months from the receipt of the Customer's Notice to Proceed (NTP) to file and obtain a CPCN from the Colorado Public Utilities Commission. This is in addition to the estimated eighteen month project duration. The total period from NTP to COD is assumed to be thirty-six months.

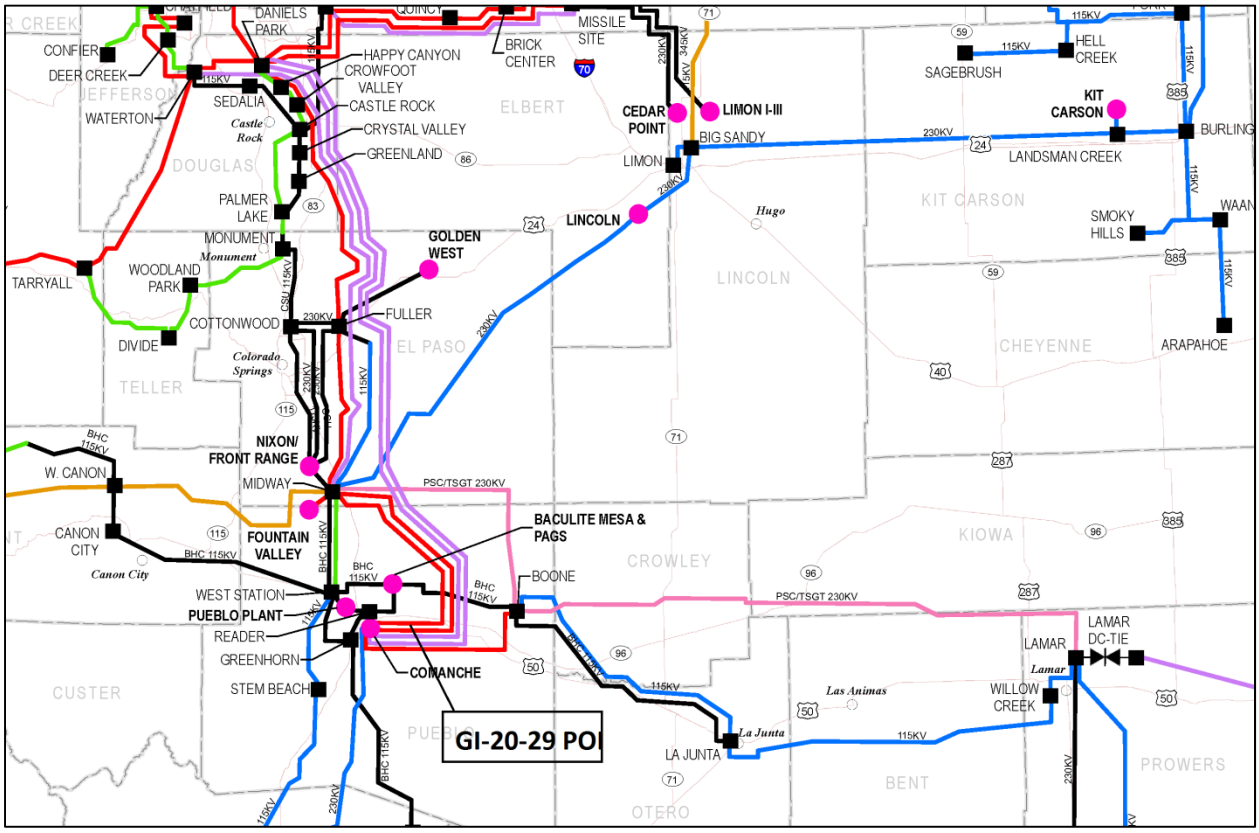

Figure 1 – GI-2016-29 Primary POI and Study area

Introduction

The “GI-2016-29” (GI) is a 150MW solar photovoltaic generation facility that will be located in Pueblo County, Colorado. The GI request was received by PSCo on January 10, 2017 and a scoping meeting was held on January 6, 2017. This study report is based on the information provided by the Interconnection Customer (“Customer”) and assumptions stated in the Feasibility study agreement.

The Customer proposed both a primary and a secondary Point of Interconnection. The Primary POI requested is a tap on the Comanche – Midway 230kV line (#5413), at approximately 8.15 miles from the Comanche Substation. The secondary POI requested is a tap on the Comanche – Boone 230kV line, at approximately 8.15 miles from the Comanche Substation. The tap point will constitute a new substation in order to accommodate the GI interconnection. The new substation will be referred to as the “GI-2016-29 Substation” in this report.

The GI facility will consist of seventy five (75) Schneider Electric CS 2000 inverters connected to twenty (20) 575volt/34.5kV, 2100kVA Generator Step-up Transformer (GSU)s, organized in five groups. The five groups will interconnect to a 34.5/230kV, 168MVA Main Step-Up Transformer which will interconnect to the POI using a Customer owned 230kV transmission tie-line, which is expected to be 0.4 miles long and strung with 336 kcmil “Linnet” conductor.

The proposed Commercial Operation Date (COD) and backfeed date of the GI are December 15, 2020 and October 15, 2020 respectively

The GI feasibility study request is submitted for both Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection Service (ERIS) analysis.

PSCo load is assumed to be the sink for GI-2016-29 generation.

Study Scope and Analysis Criteria

The scope of the feasibility study report includes steady state (power flow) analysis, short circuit analysis, breaker duty study and, indicative level cost estimates for interconnection and identified PSCo Network Upgrades. The power flow analysis identifies thermal and voltage violations in the PSCo system and the affected party’s system as a result of the interconnection of the GI. Several single and multiple contingencies are studied. Short circuit analysis determines the maximum available fault current at the POI. In addition, the breaker duty study determines if breaker replacements are needed in the neighboring substations due to the fault current contribution from the GI.

PSCo adheres to applicable NERC Reliability Standards & WECC Reliability Criteria, as well as internal criteria for planning studies. The steady state analysis criteria are as follows:

P0 - System Intact conditions:
Thermal Loading: <=100% of the normal facility rating
Voltage range: 0.95 to 1.05 per unit
P1-P2 – Single Contingencies:
Thermal Loading: <=100% Normal facility rating

Voltage range: 0.90 to 1.10 per unit
Voltage deviation: <=5% of pre-contingency voltage
P3-P7– Multiple Contingencies:
Thermal Loading: <=100% Emergency facility rating
Voltage range: 0.90 to 1.10 per unit
Voltage deviation: <=5% of pre-contingency voltage

The thermal and voltage analysis criteria for Black Hills Colorado Electric (BHCE), Tri-State Generation and Transmission Inc. (TSGT), Colorado Springs Utilities (CSU) and Intermountain Rural Electric Association (IREA) facilities are the same as above.

The feasibility study analysis for the GI-was performed for both Energy Resource Interconnection Service (ERIS) and Network Resource Interconnection Service (NRIS).

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.

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 generating facilities to serve native load customers; or (2) in an RTO 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.

The affected parties for this GI study are CSU, BHCE, TSGT and IREA.

Power Flow Study Models

The study was performed using the Western Electricity Coordinating Council (WECC) 2022 Heavy Summer ("2022HS1") approved power flow case released on August 31, 2016. The case was reviewed by all effected parties to include updates. Some of the major changes included modeling of TSGT's 75MW TwinButtes generation near Lamar 230kV bus (expected in service date of December 12, 2017), PSCo's Rush Creek Generation (the expected in service date of 2019) and PSCo's Pawnee – Daniels Park 345kV Project. Also, the Lamar – Burlington 230kV line is modeled out-of-service.

The generation dispatch in the WECC base case was adjusted to create a heavy south to north flow on the Comanche – Midway - Jackson Fuller – Daniels Park transmission system. This was accomplished by adopting the generation dispatch given in Table-9 below. PSCo's generation in zones 700, 704, 709, 710 and 712 was dispatched such that wind generation is dispatched at 85% of name plate capacity, solar generation is dispatched at 80% of name plate capacity, conventional non-coal generation is dispatched at 90% of name plate capacity and

coal generation is dispatched at 100% of name plate capacity. The wind generation at Missile Site was dispatched at 40% name plate capacity.

The generation dispatch for the effected party's system was provided by the effected parties. The Lamar DC tie, the Colorado Green and the Twin Buttes wind generators are dispatched such that the total combined injection at the Lamar 230kV bus was 350MW.
The GI-2016-29 interconnection request was studied as a stand-alone project. That is, the study did not include any other Generator Interconnection Requests (GIR) existing in PSCo's or an affected party's GIR queue, other than the interconnection requests that are considered to be planned resources for which Power Purchase Agreements have been signed.

Two power flow cases were created for evaluating the feasibility of GI-2016-29 interconnection – the benchmark case and the study case. The benchmark case modeled the system without GI-2016-29, whereas the study case included GI-2016-29. The GI was modeled using the PSSE modeling data provided by the Interconnection Customer. PSCo's Fort Saint Vrain #1 unit was used as the sink for the 150 MW generation injection from GI-2016-29.

Even though the Customer proposed COD is December 2020, a 2022HS1 case used in order to study the effect of the Pawnee-Daniels park 345kV project.

Power Flow Study Process

The steady state analysis was performed using PTI's PSSE Ver. 33.6.0 program and the ACCC contingency analysis tool. Contingencies were performed in accordance with the NERC Standard TPL-001-4. These are described below.

The analysis was performed for P0, P1, P2, P4 and P7 contingencies. The P3, P5 and P6 contingencies were not run; Instead, the P4, P7 contingencies were run which are worst case.

- The P0 analysis was run on all of area 70.
- The P1 single contingencies were run on zones 121, 700, 703, 704, 705, 709, 710, 712, 752 and 757.
- The P2 single contingencies were run on all of area 70, area 73 and zone 121.
- The P4 and P7 contingencies were run on zones 121, 700, 703, 704, 705, 709, 710, 712, 752 and 757.

The same list of contingencies was run on the benchmark case and the study case, and the results were compared. Violations are attributed to the GI interconnection as stated below

PSCo:The thermal violations on PSCO facilities attributed to the GI interconnection included any facilities without a pre-existing thermal violation but resulted in a thermal loading >100% post GI interconnection and contributed to a >=2% increase in the facility loading compared to the benchmark case loading.

Also, pre-existing thermal violations in the benchmark case are attributable to the GI interconnection if the planned PSCo upgrade is insufficient to mitigate the (increased) thermal violation in the study case. In such case, only the additional facility rating increase (beyond the PSCo planned uprate) required to accommodate the NRIS will be attributed to the GI.

The voltage violations attributed to the GI included any new voltage range and voltage deviation violations. Pre-existing voltage violations are attributed to the GI if the voltage range or voltage deviation change from the benchmark case is significant.

Effected party
For effected party facilities, all new thermal violations with loading >100% are attributable to the GI interconnection. For pre-existing thermal violations, only the incremental overload above the benchmark case overload is attributed to the GI interconnection. The voltage violations attributed to the GI included any new voltage range and voltage deviation violations. Pre-existing voltage violations are attributed to the GI if the voltage range or voltage deviation change from the benchmark case is significant.

The study area is the electrical system consisting of PSCo's transmission system and the affected party's transmission system that is impacted or that will impact interconnection of the GI. The study area for GI-2016-29 includes WECC designated zones 121, 700, 703, 704, 705, 710, 712, 752 and 757.

Voltage Regulation and Reactive Power Capability

The Customer is required to interconnect the 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 Southeast Colorado - Region 4 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 non-synchronous 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 etc) 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. Finally, 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).

In addition, wind generating facility interconnections must also fulfill the performance requirements specified in FERC Order 661-A.

Power Flow Results

Single Contingency Analysis:

The benchmark case and study case did not show any system intact (P0) thermal or voltage violations.

The results of the single contingency analysis (P1 and P2) are given in Table-5. The results show that the interconnection of GI-2016-29 contributed to an increase in the existing thermal overloads on six facilities and caused new overloads on five facilities. Out of these, the Midway 230kV Bus tie (new overload), Brairgate S – Cottonwood S 115kV (pre-existing overload), Cottonwood N – KettleCreek S 115kV (pre-existing overload), Kelker N – RD_Nixon 230kV (new overload), Monument – Flyhorse N 115kV (new overload) and Flyhorse S – KettleCreek N 115kV (new overload) were eliminated when the Palmer Lake Line operating procedure was implemented. The results of the single contingency analysis (P1 and P2) with the Palmer Lake line operating procedure implemented are given in Table-6. This operating procedure involves opening the Palmer Lake-Monument 115kV branch for certain overloads on the CSU system. PSCo has planned projects to remove the terminal equipment limitations on the following lines. The new ratings on these lines would be adequate to accommodate the post GI-2016-29 flows.

- Daniels Park – Prairie1 230kV line rating will be increased from 478MVA to 574MVA (in-service 2019)
- Waterton – Martin1tap 115kV line rating will be increased from 138MVA to 159MVA (in-service 6/2017)
- Waterton – Martin2tap 115kV line rating will be increased from 127 to 139MVA (in-service 3/2019)

The following PSCo facility overload is attributable to the interconnection of GI-2016-29

- Greenwood – Monaco 230kV line loading increased from 100% to 103.1%

This single contingency overload will need to be mitigated by upgrading six 1272 dual jumpers at PSCo's Monaco Substation to sufficiently increase the rating of the Greenwood-Monaco 230kV transmission line.

Addition of GI-2016-29 did not cause any new voltage violations and increases in the existing voltage violations are small as to not require monitoring. There were no voltage violations attributable to GI-2016-29 addition.

Multiple Contingency Analysis:

The results of the multiple contingency analyses are given in Table-7 and Table-8. The implementation of the Palmer Lake – Monument 115kV Line operating procedure eliminated some of the overloads on the CSU and IREA facilities as evident in the results shown in Table-9. Addition of GI-2016-29 did not cause any new voltage violations and increases in the existing voltage violations are small as to not require monitoring. There were no voltage violations attributable to GI-2016-29 addition.

Since the study simulated heavy south – north flows with renewable resources dispatched at 85% of the nameplate capacity, the multiple contingency overloads on the PSCo facilities will be addressed by PSCo system readjustments (including generation curtailment) implemented via operating practices. PSCo facility overloads due to multiple contingencies are not attributed to the GI-2016-29 interconnection.

The incremental overloads on the following BHCE facilities are attributable to the interconnection of GI-2016-29

- Fountain Valley – Desertcove 115kV line loading increased from 100% to 106.5%
- Fountain valley – Midway BR 115kV line loading increased from 99.4% to 104.9%

The Interconnection Customer will need to contact BHCE to determine how these incremental overloads on their system due to multiple contingencies need to be mitigated.

Short Circuit

The calculated short circuit levels and Thevenin system equivalent impedances at the GI-2016-29 230kV Switching Station are tabulated below. The breaker duty study determined that no breaker replacements are needed in neighboring substations.

Table 1 – Short Circuit Parameters at the GI-2016-29 230kV Switching Station

	Without GI-2016-29 Interconnection	After GI-2016-2929 Interconnection
Three phase Fault Current (A)	13881	14024
Single Line to Ground Fault Current (A)	11270	13580
Positive Sequence Impedance (Ohms)	0.876+j9.582	0.876+j9.582
Negative Sequence Impedance (Ohms)	0.893+j9.588	0.893+j9.587
Zero Sequence Impedance (Ohms)	4.024+j15.807	2.079+j10.416

Conclusion

Energy Resource Interconnection Service (ERIS): The benchmark case has 100% loading on the Greenwood – Monaco 230kV line under single contingency condition. Also the fountain Valley – Desertcove and Fountain Valley – MidwayBR 115kV lines are loading to 100% and 99.4% respectively for the double circuit outage of the Comanche – Daniels Park 345kV lines. Due to these pre-existing thermal overloads in the benchmark case, GI-2016-29 output for ERIS is 0 MW for the studied generation dispatch. However, higher generation output may become feasible on an as-available basis depending on the prevailing dispatch of existing generation resources located in the electrical vicinity of GI-2016-29 (Jackson Fuller, Comanche, Midway and Lamar areas, CSU system and BHCE system).

Network Resource Interconnection Service (NRIS): Implementing the Network Upgrades on the Greenwood – Monaco 230kV and the BHCE facilities wil allow GI-2016-29 to achieve full NRIS of 150MW. The Interconnection Customer has to work with BHCE in order to identify mitigation measures required to eliminate the overloads on the BHCE facilities caused due to GI-2016-29 interconnection. The cost estimates provided in this report do not include costs for eliminating the BHCE overloads.

Costs Estimates and Assumptions

PSCo Engineering has developed Indicative level cost estimates (IE) for Interconnection Facilities and Network/Infrastructure Upgrades required for the interconnection of the Interconnection Customer's proposed generation facility. Indicative Estimates are based upon typical construction costs for previously performed similar construction projects; however they have no specified level of accuracy. The cost estimates are in 2017 dollars with escalation and contingencies applied. AFUDC is not included. 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 Customer owned equipment and associated design and engineering.

The estimated total cost for the required Interconnection Facilities and Network/Infrastructure Upgrades is $12,480,000.00

Figure 2 below is a conceptual one-line of the proposed interconnection. The Point of Interconnection (POI) will be a tap on the Comanche to Midway 230kV Transmission Line. The POI is located approximately 8.15 miles from the Comanche Substation.

The following (Tables 2-4) list the improvements required to accommodate the interconnection and the delivery of the Customer's 150 MW solar facility generation output. The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines. System improvements are subject to revision as a more detailed and refined design is produced.

A Certificate of Public Convenience and Necessity (CPCN) will be required before the construction of the GI-2016-29 Substation can commence. PSCo anticipates that it will take eighteen months from the receipt of the Customer's Notice to Proceed (NTP) to file and obtain a CPCN from the Colorado Public Utilities Commission. This is in addition to the estimated eighteen month project duration. The total period from NTP to COD is assumed to be thirty-six months.

- No level of accuracy is specified for IE's.
- Labor is estimated for straight time only – no overtime included.
- Lead times for materials were considered for the schedule.
- PSCo (or it's Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- 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 in-service dates.
- Customer will string OPGW fiber into PSO's 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 115 kV line terminating into Proposed Switching Station.
- The Customer's Generation Facility is not in PSCo's retail service territory. Therefore, no costs for retail load metering are included in these estimates.

Table 2 – PSCo Owned; Customer Funded Transmission Provider Interconnection Facilities

Element	Description	Cost Estimate (Millions)
GI-2016-29 Substation	Interconnect Customer to the 230kV bus at the Proposed Switching Station. The new equipment includes: • One (1) motor operated 230kV disconnect switch • Three (3) 115kV 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	**$1.000**
	Transmission line tap into substation. Conductor, hardware, and installation labor.	**$0.050**
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	**$1.050**
Time Frame	**Design, procure and construct**	**18 Months**

Table 3: PSCo Owned; PSCo Funded Interconnection Network Facilities

Element	Description	Cost Estimate (Millions)
GI-2016-29 Substation	Interconnect Customer to the 230kV bus at the Proposed Switching Station. The new equipment includes: • Three (3) 230kV circuit breaker • Eight (8) 230kV gang switches • One (1) 230kV CCVT • 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	**$11.000**
	In/Out Tap on the Comanche to Midway 230kV Line, located at the Proposed Switching Station.	**$0.323**
	Siting and Land Rights support for substation land acquisition and construction.	**$0.085**
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	**$11.408**
Time Frame	**Site, design, procure and construct**	**18 Months**

Table 4 – PSCo Owned; Network Upgrades for Delivery

Element	Description	Cost Estimate (Millions)
PSCo's Monaco 230kV Transmission Substation	Upgrade/replace limiting substation equipment to achieve required MVA ratings on circuit 5281 Monaco-Greenwood OH/UG Line: • Six - 1272 dual jumpers	**$0.022**
	Total Cost Estimate for PSCo Network Upgrades for Delivery Facilities	**$0.022**
Time Frame	**Design, procure and construct**	**18 months**
	Total Project Estimate	**$12.48**

A. Power Flow Contingency Analysis Results

Notes –

1. All thermal loadings are highlighted in yellow and violations attributed to the GI are identified in red. % change highlighted in black is for information only and does not represent a violation
2. For Single Contingency Analysis, thermal overloads are calculated using the applicable Normal Rating of the facility.

Table 5 – Summary of Thermal Violations from Single Contingency Analysis Without the Palmer Lake– Monument 115kV Line Operating Procedure

				Facility Loading Without GI-2016-29		Facility Loading With GI-2016-29			
Monitored Facility (Line or Transformer)	**Type**	**Owner**	**Branch Rating MVA (Norm/Emer)**	**N-1 Flow MVA**	**N-1 Flow % of Rating (Norm/Emer)**	**N-1 Flow MVA**	**N-1 Flow % of Rating (Norm/Emer)**	**% Change**	**NERC Single Contingency**
Daniels Park – Prairie1 230kV	Line	PSCo	478/478	504.6	104.3%/104.3%	511	106.9%/106.9%	2.6%	Daniels Park – Prairie3 230kV
Greenwood – Monaco 230kV	Line	PSCo	405/481	405	100.0%/84.2%	417.5	103.1%/86.8%	3.1%	Smoky – Buckley – Jewell - Tollgate – Leetsdale 230kV
Midway 230kV Tie	Line	PSCo/ WAPA	430/478	402.5	93.6%/84.2%	450.6	104.8%/94.3%	11.2%	Midway – Fuller 230kV
Palmer Lake – Monument 115kV	Line	PSCo/ CSU	142/157	145.7	102.6%/92.8%	162.7	114.6%/103.6%	12%	Daniels park – Fuller 230kV
Waterton – Martin1 Tap 115kV	Line	PSCo	138/152	151.2	109.6%/99.5%	154.1	111.7%/101.4%	2.1%	Arapahoe 115/230kV #T5
Waterton – Martin 2 Tap 115kV	Line	PSCo	127/140	131.2	103.3%/93.7%	134.9	106.2%/96.3%	2.9%	Sodalakes 115/230kV #T2
Brairgate S – Cottonwood S 115kV	Line	CSU	150/192	179.5	119.7%/93.5%	189.7	126.5%/98.8%	6.8%	Cottonwood N – KettleCreek S 115kV
Cottonwood N – KettleCreek S 115kV	Line	CSU	162/180	194.7	120.2%/108.2%	206.4	127.4%/114.7%	7.2%	Brairgate S – Cottonwood S 115kV
Kelker N – RD_Nixon 230kV	Line	CSU	376/376	366.6	97.5%/97.5%	380.1	101.1%/101.1%	3.6%	Kelker S- Front Range 230kV
Monument – Flyhorse N 115kV	Line	CSU	142/157	137.3	96.7%/87.5%	153.8	108.3%/97.9%	11.6%	Daniels Park – Fuller 230kV
Flyhorse S – KettleCreek N 115kV	Line	CSU	162/180	150.8	93.1%/83.8%	167.8	103.6%/93.2%	10.5%	Daniels Park – Fuller 230kV

Notes –

1. All thermal loadings are highlighted in yellow and violations attributed to the GI are identified in red. % change highlighted in black is for information only and does not represent a violation
2. For Single Contingency Analysis, thermal overloads are calculated using the applicable Normal Rating of the facility.

Table 6 – Summary of Thermal Violations from Single Contingency Analysis With the Palmer Lake – Monument 115kV Line Operating Procedure

				Facility Loading Without GI-2016-29		Facility Loading With GI-2016-29			
Monitored Facility (Line or Transformer)	**Type**	**Owner**	**Branch Rating MVA (Norm/Emer)**	**N-1 Flow MVA**	**N-1 Flow % of Rating (Norm/Emer)**	**N-1 Flow MVA**	**N-1 Flow % of Rating (Norm/Emer)**	**% Change**	**NERC Single Contingency**
Daniels Park – Prairie1 230kV	Line	PSCo	478/478	504.8	105.6%/105.6%	517.2	108.2%/108.2%	2.6%	Daniels Park – Prairie3 230kV
Greenwood – Monaco 230kV	Line	PSCo	405/481	405	100.0%/84.2%	417.1	103.0%/86.7%	3.0%	Smoky – Buckley – Jewell - Tollgate – Leetsdale 230kV
Midway 230kV Tie	Line	PSCo/ WAPA	430/478	375.8	87.4%/78.6%	420.5	97.8%/88.0%	10.4%	Midway – Fuller 230kV
Palmer Lake – Monument 115kV	Line	PSCo/ CSU	142/157	N/A	N/A	N/A	N/A	N/A	Daniels park – Fuller 230kV
Waterton – Martin1 Tap 115kV	Line	PSCo	138/152	149.6	108.4%/98.4%	152.3	110.4%/100.2%	2.0%	Arapahoe 115/230kV #T5
Waterton – Martin 2 Tap 115kV	Line	PSCo	127/140	128.1	100.9%/91.5%	131.4	103.5%/93.9%	2.6%	Sodalakes 115/230kV #T2
Brairgate S – Cottonwood S 115kV	Line	CSU	150/192	139.8	93.2%/72.8%	144.5	96.1%/75.1%	2.9%	Cottonwood N – KettleCreek S 115kV
Cottonwood N – KettleCreek S 115kV	Line	CSU	162/180	146.3	90.3%/81.3%	151.5	93.5%/84.1%	3.2%	Brairgate S – Cottonwood S 115kV
Kelker N – RD_Nixon 230kV	Line	CSU	376/376	350.8	93.3%/93.3%	362.5	96.4%/96.4%	3.1%	Kelker S- Front Range 230kV
Monument – Flyhorse N 115kV	Line	CSU	142/157	53	37.3%/33.7%	59.6	42.0%/38.0%	4.7%	Daniels Park – Fuller 230kV
Flyhorse S – KettleCreek N 115kV	Line	CSU	162/180	66.4	41.0%/36.9%	73.4	45.3%/40.8%	4.3%	Daniels Park – Fuller 230kV

Notes –

1. All thermal loadings are highlighted in yellow and violations attributed to the GI are identified in red. % change highlighted in black is for information only and does not represent a violation
2. For Multiple Contingency Analysis, thermal overloads are calculated using the applicable Emergency Rating of the facility.

Table 7 – Summary of Thermal Violations from Multiple Contingency Analysis Without the Palmer Lake – Monument 115kV Line Operating Procedure

				Facility Loading Without GI-2016-29		Facility Loading With GI-2016-29			
Monitored Facility (Line or Transformer)	**Type**	**Owner**	**Branch Rating MVA (Norm/Emer)**	**Flow MVA**	**Flow % of Rating (Norm/Emer)**	**Flow MVA**	**Flow % of Rating (Norm/Emer)**	**% Change**	**NERC Multiple Contingency**
Arapahoe – SantaFe 230kV	Line	PSCo	300/319	313.8	104.6%/98.4%	321.3	107.1%/100.7%	2.3%	Breaker Failure: Greenwood 230kV
Daniels Park – SantaFe 230kV	Line	PSCo	319/319	353.4	110.8%/110.8%	365.6	114.6%/114.6%	3.8%	Breaker Failure: Greenwood 230kV
Daniels Park – Fuller 230kV	Line	PSCo	478/478	536.3	112.2%/112.2%	562.6	117.7%/117.7%	5.5%	Double Ckt: Comanche – Daniels park 345kV #1 & 2
Fountain Valley – Desertcove 115kV	Line	BHCE	119/119	119	100.0%/100.0%	126.8	106.5%/106.5%	6.5%	Double Ckt: Comanche – Daniels park 345kV #1 & 2
Fountain Valley – MidwayBR 115kV	Line	BHCE	119/119	118.3	99.4%/99.4%	124.8	104.9%/104.9%	5.5%	Double Ckt: Comanche – Daniels park 345kV #1 & 2
Midway 230kV Tie	Line	PSCo/ WAPA	430/478	571.9	133.0%/119.6%	635.5	147.8%/132.9%	13.3%	Double Ckt: Midway – Waterton 345kV & Midway – Fuller 230kV
Palmer Lake – Monument 115kV	Line	CSU/PS Co	142/157	222.4	156.6%/141.6%	245.1	172.6%/156.1%	14.5%	Double Ckt: Midway – Waterton 230kV & Daniels Park – Fuller 230kV
Waterton – Martin1 tap 115kV	Line	PSCo	138/152	155.3	112.5%/102.2%	160.9	116.6%/105.9%	3.7%	Double Ckt: SOdalake – Chatfield-Waterton 230kV & SOdalake-Deer Creek – Martin – Waterton 115kV
Waterton – Martin2 Tap 115kV	Line	PSCo	127/140	142.5	112.2%/101.8%	147.6	116.2%/105.4%	3.6%	Breaker Failure: Sodalakes 230kV
Greenland – Crystal Valley 115kV	Line	IREA	162/178.2	174.8	107.9%/98.1%	192	118.5%/107.7%	9.6%	Double Ckt: Midway – Waterton 230kV & Daniels Park – Fuller 230kV
Cottonwood N – KettleCreek S 115kV	Line	CSU	162/180	196.7	121.4%/109.3%	214.5	132.4%/119.2%	9.9%	Double Ckt: Midway – Waterton 230kV & Daniels Park – Fuller 230kV
Monument - Flyhorse N 115kV	Line	CSU	142/157	208.9	147.1%/133.0%	231.0	162.7%/147.1%	14.1%	Double Ckt: Midway – Waterton 230kV & Daniels Park – Fuller 230kV

Table 7 – Summary of Thermal Violations from Multiple Contingency Analysis Without the Palmer Lake – Monument 115kV Line Operating Procedure									
				Facility Loading Without GI-2016-29		Facility Loading With GI-2016-29			
Monitored Facility (Line or Transformer)	**Type**	**Owner**	**Branch Rating MVA (Norm/Emer)**	**Flow MVA**	**Flow % of Rating (Norm/Emer)**	**Flow MVA**	**Flow % of Rating (Norm/Emer)**	**% Change**	**NERC Multiple Contingency**
Flyhorse S - KettleCreek N 115kV	Line	CSU	162/180	222.4	137.3%/123.6%	245.8	151.7%/136.5%	12.9%	Double Ckt: Midway – Waterton 230kV & Daniels Park – Fuller 230kV

Notes –

1. All thermal loadings are highlighted in yellow and violations attributed to the GI are identified in red. % change highlighted in black is for information only and does not represent a violation
2. For Multiple Contingency Analysis, thermal overloads are calculated using the applicable Emergency Rating of the facility.

Table 8 – Summary of Thermal Violations from Multiple Contingency Analysis With the Palmer Lake– Monument 115kV Line Operating Procedure

				Facility Loading Without GI-2016-29		Facility Loading With GI-2016-29			
Monitored Facility (Line or Transformer)	**Type**	**Owner**	**Branch Rating MVA (Norm/Emer)**	**Flow MVA**	**Flow % of Rating (Norm/Emer)**	**Flow MVA**	**Flow % of Rating (Norm/Emer)**	**% Change**	**NERC Multiple Contingency**
Arapahoe – SantaFe 230kV	Line	PSCo	300/319	318.1	106.0%/99.7%	326.2	108.7%/102.3%	2.6%	Breaker Failure: Greenwood 230kV
Daniels Park – SantaFe 230kV	Line	PSCo	319/319	357.8	112.2%/112.2%	319	116.1%/116.1%	3.9%	Breaker Failure: Greenwood 230kV
Daniels Park – Fuller 230kV	Line	PSCo	478/478	625.5	130.8%/130.8%	658.4	137.7%/137.7%	6.9%	Double Ckt: Comanche – Daniels park 345kV #1 & 2
Fountain Valley – Desertcove 115kV	Line	BHCE	119/119	115.2	96.8%/96.8%	121.8	102.3%/102.3%	5.5%	Double Ckt: Comanche – Daniels park 345kV #1 & 2
Fountain Valley – MidwayBR 115kV	Line	BHCE	119/119	113.9	95.7%/95.7%	119.7	100.6%/100.6%	4.9%	Double Ckt: Comanche – Daniels park 345kV #1 & 2
Midway 230kV Tie	Line	PSCo/ WAPA	430/478	542.4	126.1%/113.5%	603.1	140.3%/126.2%	12.7%	Double Ckt: Midway – Waterton 345kV & Midway – Fuller 230kV
Palmer Lake – Monument 115kV	Line	CSU/PS Co	142/157	N/A	N/A	N/A	N/A	N/A	N/A
Waterton – Martin1 tap 115kV	Line	PSCo	138/152	153.3	111.1%/100.9%	158.7	115.0%/104.4%	3.5%	Double Ckt: SOdalake – Chatfield-Waterton 230kV & SOdalake-Deer Creek – Martin – Waterton 115kV
Waterton – Martin2 Tap 115kV	Line	PSCo	127/140	141.3	111.3%/101%	146	114.9%/104.3%	3.3%	Breaker Failure: Sodalakes 230kV
Greenland – Crystal Valley 115kV	Line	IREA	162/178.2	7.2	4.5%/4.0%	7.1	4.4%/4.0%	0%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Cottonwood N – KettleCreek S 115kV	Line	CSU	162/180	113.3	69.9%/62.9%	121.8	75.2%/67.7%	4.8%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Monument - Flyhorse N 115kV	Line	CSU	142/157	85.7	60.3%/54.6%	95.5	67.3%/60.8%	6.5%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV

Table 8 – Summary of Thermal Violations from Multiple Contingency Analysis With the Palmer Lake– Monument 115kV Line Operating Procedure									
				Facility Loading Without GI-2016-29		Facility Loading With GI-2016-29			
Monitored Facility (Line or Transformer)	**Type**	**Owner**	**Branch Rating MVA (Norm/Emer)**	**Flow MVA**	**Flow % of Rating (Norm/Emer)**	**Flow MVA**	**Flow % of Rating (Norm/Emer)**	**% Change**	**NERC Multiple Contingency**
Flyhorse S - KettleCreek N 115kV	Line	CSU	162/180	99.3	61.3%/55.2%	109.7	67.7%/60.9%	5.9%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV

Table 9 – Generation Dispatch in the Study Area (Gross Capacity in MW's)

PSCo:

Bus	LF ID	MW
Comanche PV	S1	102
Comanche	C1	360
Comanche	C2	365
Comanche	C3	795
Lamar DC Tie	DC	101
Fountain Valley	G1	36
Fountain Valley	G2	36
Fountain Valley	G3	36
Fountain Valley	G4	36
Fountain Valley	G5	36
Fountain Valley	G6	36
Colorado Green	W1	64.8
Colorado Green	W2	64.8
Twin Butte	W1	60
Jackson Fuller	W1&W2	198.5
Alamosa CT	G1	15.3
Alamosa CT	G2	12.6
Cogentrix	S3	25.5
Greater Sandhill	S1	16.1
Blanca Peak	S1	19.5
SLV Solar	S1	44.2

BHE:

Bus	LF ID	MW
BUSCHWRTG1	G1	4.0
BUSCHWRTG2	G2	4.0
BUSCHWRTG2	G3	4.0
E Canon	G1	0
PP_MINE	G1	0
PuebloDiesels	G1	0
Pueblo Plant	G1	0
Pueblo Plant	G2	0.0
R.F. Diesels	G1	0.0
Airport Diesels	G1	0.0
Baculite 1	G1	90
Baculite 2	G1	90
Baculite 3	G1	40.0
Baculite 3	G2	40.0
Baculite 3	S1	21
Baculite 4	G1	40.0
Baculite 4	G2	0.0
Baculite 4	S1	21
Baculite 5	G1	6

DRAFT

Rattle snake Wind	G1	8

CSU:

Bus	LF ID	MW
Birdsale1	1	0.0
Birdsale 2	1	0.0
Birdsale 3	1	0.0
RD_Nixon	1	208
Tesla	1	13.2
Drake 5	1	0.0
Drake 6	1	70.2
Drake 7	1	128.9
Nixon CT 1	1	0.0
Nixon CT 2	1	0.0
Front Range CC 1	1	138.8
Front Range CC 2	1	139.6
Front Range CC 3	1	161.7

TSGT:

Bus	LF ID	MW
San Isabel Solar	S1	25.67
Twin Butte-II	W1	60

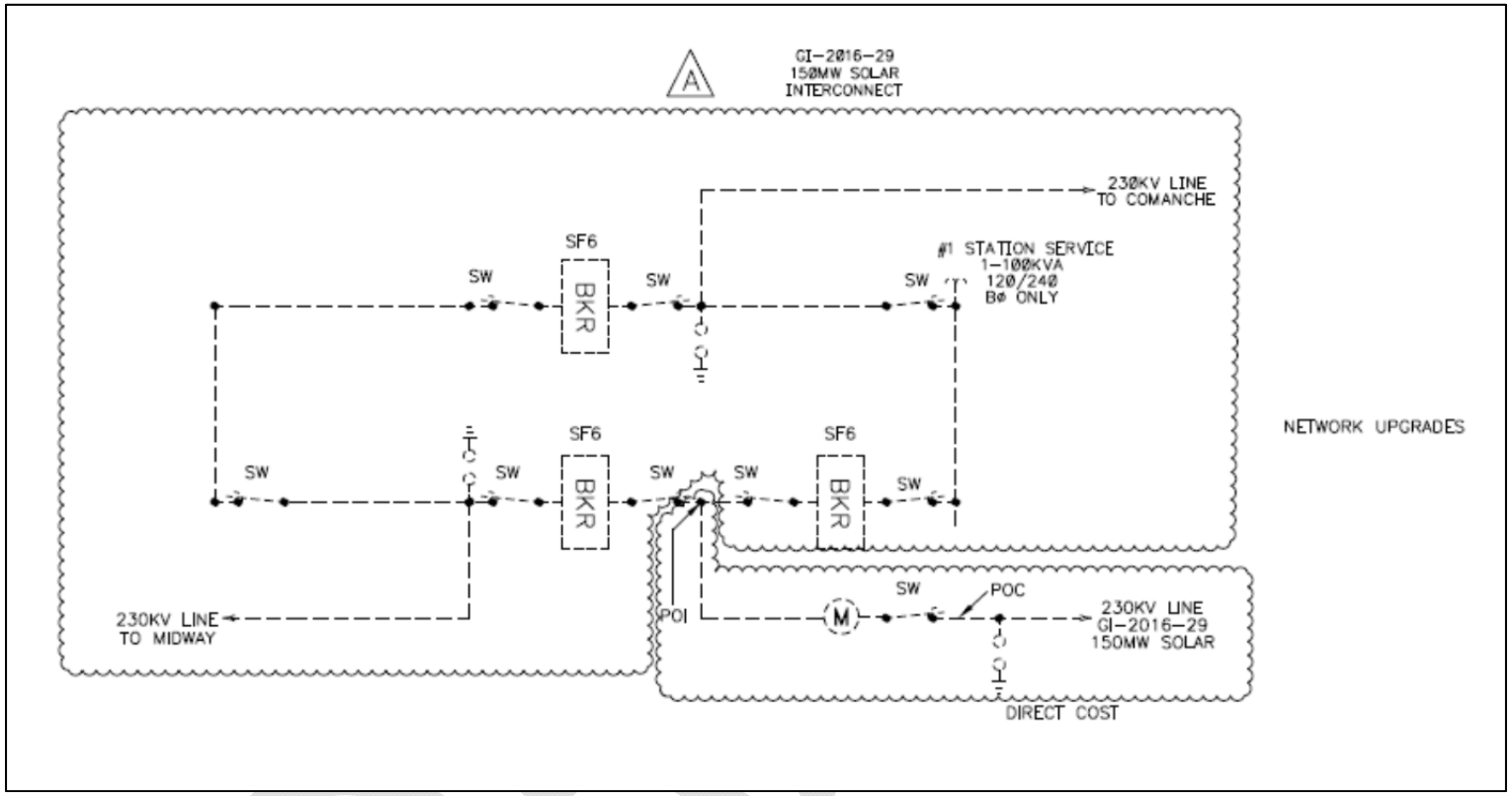

Figure 2- GI-2016-29 Substation One-line Diagram