Feasibility Study Report
Generation Interconnection Request # GI-2016-18

120MW Solar Photovoltaic Facility
Comanche 230kV Substation
Pueblo County, Colorado

Transmission Planning West
Xcel Energy
May 24, 2017

Executive Summary

The "GI-2016-18" (GI) is a 120MW solar photovoltaic generation facility located in Pueblo County, Colorado. The GI request was received by PSCo on August 31, 2016 and a scoping meeting was held on September 26, 2016. The GI-2016-18 solar photovoltaic generation facility will be comprised of sixty (60) SMA 2200KVA inverters.

The Primary POI requested by the Interconnection Customer is the existing 230kV Point of Interconnection at the Comanche 230kV Substation where the Comanche 120MW Solar Generation facility interconnects. The GI will use the same tie-line as the Comanche 120MW solar generation facility. The GI Customer did not request a secondary POI.

The proposed Commercial Operation Date (COD) is November 1, 2018. Since the POI is existing and already backfed, a backfeed date is not required for GI-2016-18.

The GI-2016-18 generation interconnection study request is for both Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection Service (ERIS).

PSCo load is assumed to be the sink for GI-2016-18 generation.

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 studies were performed using a Western Electricity Coordinating Council (WECC) approved 2018HS heavy summer base case and modeled heavy south-north flow on the Comanche – Midway – Jackson Fuller – Daniels Park transmission system.

The GI-2016-18 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 benchmark case and study case did not have any system intact (P0) thermal or voltage violations.

The results of the single contingency analysis (P1 and P2) are given in Table-5 and Table-6. The following single contingency BHCE facility overload is attributable to the interconnection of GI-2016-18. The transmission line normal ratings are used for single contingency analyses.

- Portland – Skala 115kV line loading increased from 99.5% to 104.8%

There were no single contingency voltage violations attributable to GI-2016-18 addition.

Multiple Contingency Analysis Results:

The results of the multiple contingency analyses are given in Table-7 and Table-8. The transmission line emergency ratings are used for multiple contingency analyses.

The incremental overload on the following CSU facility is attributable to the interconnection of GI-2016-18

- Fountain Valley – RD_Nixon 115kV line loading increased from 118.6% to 119.8% for double circuit outage of the Kelker S – Front range 230kV & Kelker N – RD_Nixon 230kV lines

The incremental overloads on the following TSGT facilities are attributable to the interconnection of GI-2016-18

- BLKFORTP – BLK SQMV line loading increased from 194.3% to 197.2% for Cottonwood 115kV tie breaker outage
- BLK SQMV – Fuller 115kV line loading increased from 125% to 126.7% for Cottonwood 115kV tie breaker outage
- Fuller 230/115kV transformer loading increased from 149.3% to 149.6% for Cottonwood 115kV tie breaker outage
- Monument – Gresham 115kV line loading increased from 102.3% to 103.9% for Cottonwood 115kV tie breaker outage

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 and overloads caused by PSCo contingencies will be addressed by system readjustments (including generation curtailment) implemented via operating practices. PSCo facility overloads and effected party facility overloads caused by PSCo contingency are not attributed to the GI-2016-18 interconnection.

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 study results showed that the Portland – Skala 115kV BHCE line is marginally overload (99.5%) in the benchmark case and several multiple contingency thermal overloads exist in the CSU and TSGT systems after implementation of the Palmer Lake – Monument Line operating procedure. Due to these pre-existing thermal overloads in the benchmark case, GI-2016-18 output for ERIS is 0 MW for the studied generation dispatch scenario. However, higher 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-2016-18 (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 and the incremental overloads on the CSU and TSGT systems will allow GI-2016-18 to achieve full NRIS of 120MW. The Interconnection Customer has to work with the facility owners in order to identify mitigation measures to eliminate the above mentioned overloads and incremental overloads attributed to GI-2016-18 interconnection.

Cost Estimates (in 2017 dollars)

The total estimated cost of the recommended system improvements to interconnect the project is approximately $3.185 million and includes:

- $ 1.05 million for PSCo-Owned, Customer-Funded Transmission Provider Interconnection Facilities
- $ 2.135 million for PSCo-Owned, PSCo-Funded Network Facilities for Interconnection
- $ 0 million for PSCo Network Upgrades for Delivery to PSCo Loads

The estimated time to design, procure and construct the interconnection facilities is approximately 18 months after authorization to proceed has been obtained

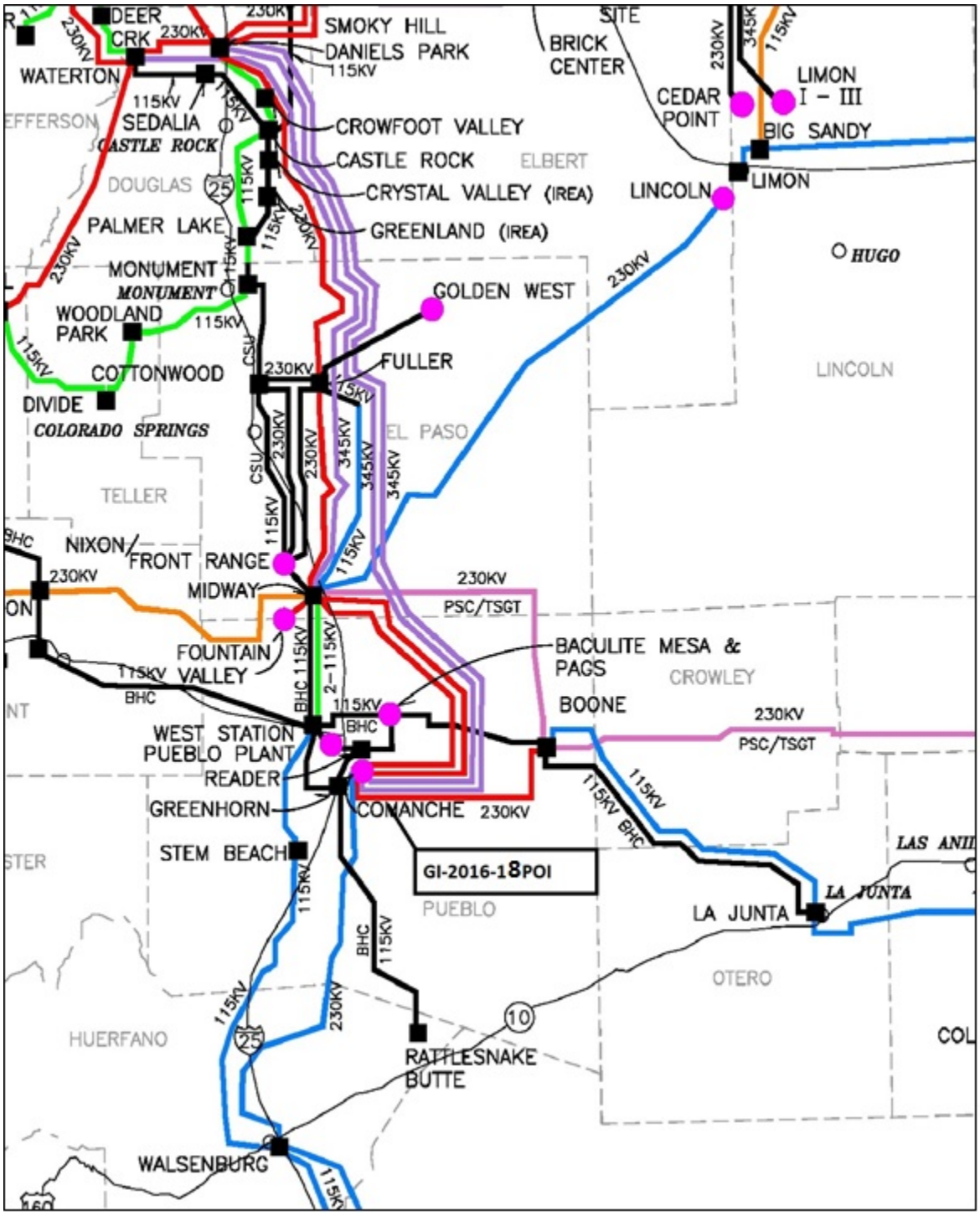

Figure 1 – Comanche 230kV Primary POI and Study area

Introduction

The “GI-2016-18” (GI) is a 120MW solar photovoltaic generation facility located in Pueblo County, Colorado. The GI request was received by PSCo on August 31, 2016 and a scoping meeting was held on September 26, 2016. The GI-2016-18 solar photovoltaic generation facility will be comprised of sixty (60) SMA 2200KVA inverters, each inverter terminating at a 385V/34.5kV, 2.2MVA Generation Step-up Transformer and, equally distributed over five groups. The five groups will interconnect to a 34.5/230kV 75/100/125MVA Main Step-up Transformer.

The Primary POI requested by the Interconnection Customer is the existing 230kV Point of Interconnection at the Comanche 230kV Substation where the Comanche 120MW Solar Generation facility terminates. The GI will use the same tie-line as the Comanche 120MW solar generation facility. The GI Customer did not request a secondary POI.

The proposed Commercial Operation Date (COD) is November 1, 2018. Since the POI is existing and already backfed, a backfeed date is not required for GI-2016-18.

The GI-2016-18 generation interconnection study request is for both Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection Service (ERIS).

PSCo load is assumed to be the sink for GI-2016-18 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 identified 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.

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

PSCo adheres to applicable NERC Reliability Standards & WECC Reliability Criteria, as well as internal criteria for planning studies. For the steady state analysis the 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.

GI-2016-18 was studied 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.

Power Flow Study Models

The study was performed using the Western Electricity Coordinating Council (WECC) 2018HS3 power flow case released on 02/02/2016. The case was updated to include the 75MW Twin Buttes generation expansion (expected in-service date of 12/2017), 30MW San Isabel Solar generator interconnected on the Ludlotap – Pinoncanyon 115kV line (existing facility), replacement of Lamar 230/115kV #T1 with 150MVA unit (expected in-service date of 12/2017) and Drake#5 generator retirement (effective 2016).

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. For BHCE, the Baculite Mesa units were dispatched at 100% of name plate rating and the remaining generation is dispatched at Rattlesnake Wind (recommended by BHCE because of the Boone POI).

The generation dispatch for CSU machines was provided by CSU.

The Lamar DC tie, the Colorado Green and the Twin Buttes wind generators are dispatched such that the total combined injection at Lamar 230kV bus was 350MW.

The GI-2016-18 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-2016-18 interconnection – the benchmark case and the study case. The benchmark case modeled the system without GI-2016-18, whereas the study case included GI-2016-18. 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 120 MW generation injection from GI-2016-18.

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.

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 GI.

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 loading increase is attributed to the GI interconnection.

The voltage violations attributed to GI included any new voltage range and voltage deviation violations.

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-2016-18 includes WECC designated zones 121, 700, 703, 704, 705, 709, 710, 712, 752 and 757.

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 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 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. 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).

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-2016-18 caused new thermal overloads on the Portland – Skala 115kV line (BHCE facility), Daniels Park – Prairie1 230kV line (PSCo facility) and Fuller 230/115kV transformer (TSGT facility). The GI-2016-18 interconnection also resulted in an increase in the existing thermal overloads on the Cottonwood N – KettleCreek S 115kV Line (CSU facility) and BLKFORTP – BLK SQMV 115kV line (TSGT facility). The two (2) pre-existing thermal overloads and the Fuller transformer 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 a planned project (expected ISD 2017) to increase the rating of the Daniels Park – Prairie1 230kV line which will be sufficient to eliminate the post GI thermal overload, so this thermal violation is not attributed to GI-2016-18 interconnection.

The following single contingency BHCE facility overload is attributable to the interconnection of GI-2016-18.

- Portland – Skala 115kV line loading increased from 99.5% to 104.8%

Addition of GI-2016-18 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-2016-18 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 facilities as evident in the results shown in Table-8.

The incremental overload on the following CSU facility is attributable to the interconnection of GI-2016-18

- Fountain Valley – RD_Nixon 115kV line loading increased from 118.6% to 119.8% for double circuit outage of the Kelker S – Front range 230kV & Kelker N – RD_Nixon 230kV lines

The incremental overloads on the following TSGT facilities are attributable to the interconnection of GI-2016-18

- BLKFORTP – BLK SQMV line loading increased from 194.3% to 197.2% for Cottonwood 115kV tie breaker outage
- BLK SQMV – Fuller 115kV line loading increased from 125% to 126.7% for Cottonwood 115kV tie breaker outage
- Fuller 230/115kV transformer loading increased from 149.3% to 149.6% for Cottonwood 115kV tie breaker outage

- Monument – Gresham 115kV line loading increased from 102.3% to 103.9% for Cottonwood 115kV tie breaker outage

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 and overloads caused by PSCo contingencies will be addressed by system readjustments (including generation curtailment) implemented via operating practices. PSCo facility overloads and effected party facility overloads caused by PSCo contingency are not attributed to the GI-2016-18 interconnection.

The single and multiple contingency analyses did not find new voltage violations.

Short Circuit

The calculated short circuit levels and Thevenin system equivalent impedances at the Comanche 230kV Substation 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-2016-18 230kV POI

	Without GI-2016-18 Interconnection	After GI-2016-18 Interconnection
Three phase Fault Current (A)	25276	25443
Single Line to Ground Fault Current (A)	29972	30204
Positive Sequence Impedance (Ohms)	0.324+j5.272	0.324+j5.272
Negative Sequence Impedance (Ohms)	0.344+j5.279	0.344+j5.279
Zero Sequence Impedance (Ohms)	0.170+j2.808	0.167+j2.776

Where necessary, assumptions were made to complete the short circuit calculations and the breaker duty study. The generator tie-line impedance was assumed based on the map provided. The transformer zero sequence and tertiary impedances were assumed based on positive sequence impedance provided.

Conclusion

Energy Resource Interconnection Service (ERIS): The study results showed that the Portland – Skala 115kV BHCE line is marginally overload (99.5%) in the benchmark case and several multiple contingency thermal overloads exist in the CSU and TSGT systems after application of the Palmer Lake – Monument Line operating procedure. Due to these pre-existing thermal overloads in the benchmark case, GI-2016-18 output for ERIS is 0 MW for the studied generation dispatch scenario. However, higher 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-2016-18 (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 and the

incremental overloads on the CSU and TSGT systems will allow GI-2016-18 to achieve full NRIS of 120MW. The Interconnection Customer has to work with the facility owners in order to identify mitigation measures to eliminate the above mentioned overloads and incremental overloads attributed to GI-2016-18 interconnection.

Costs Estimates and Assumptions

PSCo Engineering has developed Indicative level (IE) cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades required for Delivery of the Interconnection Customer's generation. 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. The estimates do not include the cost for any Customer owned equipment and associated design and engineering.

The estimated total cost for the required upgrades is $3,185,000.00

Figure 2 below is a conceptual one-line of the proposed interconnection. The Point of Interconnection (POI) will be on the Comanche 230kV Substation bus.

The following (Tables 2, 3 and 4) list the improvements required to accommodate the interconnection and the delivery of the customer's 120MW 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.

- 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.
- The Solar Generation Facility is not in PSCo's retail service territory. Therefore, no costs for retail load metering are included in these estimates.
- PSCo (or it's Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- The estimated time to design, procure and construct the interconnection facilities is approximately 18 months after authorization to proceed has been obtained.
- This project is completely independent of other queued projects and their respective ISD's.
- PSCo does not anticipate that a CPCN will be required for the interconnection facilities construction.
- 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.
- Customer will string OPGW fiber into substation as part of the transmission line construction scope.

- Breaker duty study determined that no breaker replacements are needed in neighboring substations.
- Line and substation bus outages will be necessary during the construction period. Outage availability could potentially be problematic and extend requested backfeed date due.
- Power Quality Metering (PQM) will be required on the Customer's 230 kV line terminating into Proposed Switching Station.

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

Element	Description	Cost Est. (Millions)
PSCo's Comanche 230kV Transmission Substation	Interconnect Customer to the Comanche 230kV bus. The new equipment includes: • 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	**$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)
PSCo's Comanche 230kV Substation	Interconnect Customer to the Comanche 230kV bus. 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	**$2.000**

	230kV transmission line tap/upgrades into substation. Last span to substation on Customer line.	**$0.050**
	Siting and Land Rights support for substation land acquisition and construction.	**$0.085**
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	**$2.135**
Time Frame	**Site, design, procure and construct**	**18 Months**

Table 4 – PSCo Network Upgrades for Delivery

Element	Description	Cost Est. (Millions)
N/A	None identified at this time.	**N/A**
	Total Cost Estimate for PSCo Network Upgrades for Delivery	**$0.000**
	Design, procure and construct	**N/A**
	Total Project Estimate	**$3.185**

A. Power Flow Contingency Analysis Results

Notes –

1. All thermal loadings are highlighted in yellow and violations are identified in red.
2. For Single Contingency Analysis, thermal overloads on PSCo facilities are calculated using the applicable Normal Rating.

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

				Facility Loading Without GI-2016-18		Facility Loading With GI-2016-18			
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**
Portland – Skala 115kV	Line	BHCE	111/111	108.7	97.9%/97.9%	114.3	103.0%/103.0%	5.1%	Midway BR – West Canyon 230kV
Daniels Park – Prairie1 230kV	Line	PSCo	478/478	477.5	99.9%/99.9%	506.7	106.0%/106.0%	6.1%	Daniels Park – Prairie3 230kV
Cottonwood N – KettleCreek S 115kV	Line	CSU	162/180	191	117.9%/106.1%	197	121.6%/109.4%	3.7%	Braigate S – Cottonwood S 115kV
BLKFORTP – BLK SQMV	Line	TSGT	81/81	84.5	104.3%/104.3%	88.8	109.6%/109.6%	5.3%	Flyhorse S – Kettle Creek N 115kV
Fuller 230/115kV	Xfmr	TSGT	100/100	100	100.0%/100.0%	101.3	101.3%/101.3%	1.3%	Midway BR – Rancho 115kV

Notes –

1. All thermal loadings are highlighted in yellow and violations are identified in red.
2. For Single Contingency Analysis, thermal overloads on PSCo facilities are calculated using the applicable Normal Rating.

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

				Facility Loading Without GI-2016-18		Facility Loading With GI-2016-18			
Monitored Facility (Line or Transformer)	**Type**	**Owner**	**Branch Rating MVA (Norm/Emer)**	**N-1 Flow MVA**	**N-1 Flow % of Ratin (Norm/Emer)**	**N-1 Flow MVA**	**N-1 Flow % of Rating (Norm/Emer)**	**% Change**	**NERC Single Contingency**
Portland – Skala 115kV	Line	BHCE	111/111	110.4	99.5%/99.5%	116.3	104.8%/104.8%	5.3%	Midway BR – West Canyon 230kV
Daniels Park – Prairie1 230kV	Line	PSCo	478/478	481.8	100.8%/100.8%	511.9	107.1%/107.1%	6.3%	Daniels Park – Prairie3 230kV
Cottonwood N – KettleCreek S 115kV	Line	CSU	162/180	147.8	91.2%/82.1%	150.3	92.8%/83.5%	1.6%	Brairgate S – Cottonwood S 115kV
BLKFORTP – BLK SQMV	Line	TSGT	81/81	68.8	85.0%/85.0%	71.3	88.0%/88.0%	3.0%	Flyhorse S – Kettle Creek N 115kV
Fuller 230/115kV	Xfmr	TSGT	100/100	86.9	86.9%/86.9%	87.2	87.2%/87.2%	0.3%	Midway BR – Rancho 115kV

Notes –

1. All thermal loadings are highlighted in yellow and violations are identified in red.
2. For Single Contingency Analysis, thermal overloads on PSCo facilities are calculated using the applicable Emergency Rating.

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

				Facility Loading Without GI-2016-18		Facility Loading With GI-2016-18			
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**
Daniels Park – SantaFe 230kV	Line	PSCo	319/319	332.4	104.2%/104.2%	352.2	110.4%/110.4%	6.2%	Double Ckt: Daniels Park – Prairie – Greenwood 230 kV 1&2
Daniels Park – Fuller 230kV	Line	PSCo	478/478	585.7	122.5%/122.5%	618.2	129.3%/129.3%	6.8%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
Fountain Valley – Desertcove 115kV	Line	BHCE	119/119	137.5	115.6%/115.6%	144.7	121.6%/121.6%	6.0%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
Fountain Valley – MidwayBR 115kV	Line	BHCE	119/119	136.3	114.5%/114.5%	143.4	120.5%/120.5%	6.0%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
HydePark – West Station 115kV	Line	BHCE	120/120	122.3	101.9%/101.9%	130.2	108.5%/108.5%	6.6%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
DesertCove – West Station 115kV	Line	BHCE	119/119	160.7	135.0%/135.0%	167.7	140.9%/140.9%	5.9%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
Portland – Skala 115kV	Line	BHCE	111/111	132.4	119.2%/119.2%	141.1	127.2%/127.2%	8.0%	Breaker Failure: MidwayBR - Fuller 230kV
Canyon City – Skala 115kV	Line	BHCE	119/119	127.1	106.8%/106.8%	135.7	114.1%/114.1%	7.3%	Breaker Failure: MidwayBR - Fuller 230kV
Midway 230kV Bus tie	Line	PSCo/ WAPA	430/478	565.02	131.4%/118.2%	607.2	141.2%/127.0%	8.8%	Double Ckt: Midway – Waterton 345kV & Midway – Fuller 230kV
Palmer Lake – Monument 115kV	Line	CSU/PSCo	142/157	182.7	128.7%/116.4%	196.2	138.2%/125.0%	8.6%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Cottonwood N – KettleCreek S 115kV	Line	CSU	162/180	187.8	115.9%/104.3%	197.3	121.8%/109.6%	5.3%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Monument - Flyhorse N 115kV	Line	CSU	142/157	204.3	143.9%/130.1%	218.1	153.6%/138.9%	8.8%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Flyhorse S - KettleCreek N 115kV	Line	CSU	162/180	215.6	133.1%/119.8%	229.5	141.7%/127.5%	7.7%	Double Ckt: Midway – Waterton 345kV & 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-2016-18		Facility Loading With GI-2016-18			
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
Fountain_S – RD_Nixon 115kV	Line	CSU	195/212	257.6	132.1%/121.5%	261.3	134.0%/123.2%	1.7%	Double Ckt: Kelker S – Frontrange 230kV & Kelker N – RD_Nixon 230kV
BLKFORTP – BLK SQMV 115kV	Line	TSGT	81/81	129.2	159.5%/159.5%	133.6	164.9%/164.9%	5.4%	Breaker Failure: Cottonwood 115kV Tie
BLK SQMV – Fuller 115kV	Line	TSGT	143/143	150.4	105.2%/105.2%	154.9	108.3%/108.3%	3.1%	Breaker Failure: Cottonwood 115kV Tie
Fuller 230/115kV	Xfmr	TSGT	100/100	127.9	127.9%/127.9%	129.4	129.4%/129.4%	1.5%	Breaker Failure: Cottonwood 115kV Tie

Notes –

1. All thermal loadings are highlighted in yellow and violations are identified in red.
2. For Single Contingency Analysis, thermal overloads on PSCo facilities are calculated using the applicable Normal Rating.

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

				Facility Loading Without GI-2016-18		Facility Loading With GI-2016-18			
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**
Daniels Park – SantaFe 230kV	Line	PSCo	319/319	334.6	104.9%/104.9%	354.7	111.2%/111.2%	6.3%	Double Ckt: Daniels Park – Prairie – Greenwood 230 kV 1&2
Daniels Park – Fuller 230kV	Line	PSCo	478/478	663.6	138.8%/138.8%	700.1	146.5%/146.5%	7.7%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
Fountain Valley – Desertcove 115kV	Line	BHCE	119/119	133.7	112.4%/112.4%	140	117.6%/117.6%	5.2%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
Fountain Valley – MidwayBR 115kV	Line	BHCE	119/119	132.4	111.3%/111.3%	138.7	116.5%/116.5%	5.2%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
HydePark – West Station 115kV	Line	BHCE	120/120	122.8	102.3%/102.3%	130	108.4%/108.4%	6.1%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
DesertCove – West Station 115kV	Line	BHCE	119/119	157.1	132.0%/132.0%	163.0	137.0%/137.0%	5.0%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
Portland – Skala 115kV	Line	BHCE	111/111	132.5	119.4%/119.4%	141.4	127.3%/127.3%	7.9%	Breaker Failure: MidwayBR - Fuller 230kV
Canyon City – Skala 115kV	Line	BHCE	119/119	127.2	106.9%/106.9%	135.9	114.2%/114.2%	7.3%	Breaker Failure: MidwayBR - Fuller 230kV
Midway 230kV Bus tie	Line	PSCo/ WAPA	430/478	543.1	126.3%/113.6%	576.2	134.0%/120.5%	6.9%	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	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Cottonwood N – KettleCreek S 115kV	Line	CSU	162/180	113.9	70.3%/63.3%	118.2	73.0%/65.7%	2.4%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Monument - Flyhorse N 115kV	Line	CSU	142/157	96	67.6%/61.1%	101.9	71.8%/64.9%	3.8%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Flyhorse S - KettleCreek N	Line	CSU	162/180	107.2	66.2%/59.5%	113.2	69.8%/62.9%	3.4%	Double Ckt: Midway – Waterton 345kV &

Table 8 – Summary of thermal violations from Multiple Contingency Analysis With the Palmer Lake– Monument 115kV Line Operating Procedure									
				Facility Loading Without GI-2016-18		Facility Loading With GI-2016-18			
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**
115kV									Daniels Park – Fuller 230kV
Fountain_S – RD_Nixon 115kV	Line	CSU	195/212	251.5	129.0%/118.6%	254.1	130.3%/119.8%	1.2%	Double Ckt: Kelker S – Frontrange 230kV & Kelker N – RD_Nixon 230kV
BLKFORTP – BLK SQMV 115kV	Line	TSGT	81/81	157.4	194.3%/194.3%	159.7	197.2%/197.2%	2.9%	Breaker Failure: Cottonwood 115kV Tie
BLK SQMV – Fuller 115kV	Line	TSGT	143/143	178.7	125.0%/125.0%	181.2	126.7%/126.7%	1.7%	Breaker Failure: Cottonwood 115kV Tie
Fuller 230/115kV	Xfmr	TSGT	100/100	149.3	149.3%/149.3%	149.6	149.6%/149.6%	0.3%	Breaker Failure: Cottonwood 115kV Tie
Monument – Gresham 115kV	Line	TSGT	145/145	148.3	102.3%/102.3%	150.6	103.9%/103.9%	1.6%	Breaker Failure: Cottonwood 115kV Tie

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

PSCo:

Bus	LF ID	MW
Comanche PV	S1	102
Comanche	C1	357
Comanche	C2	365
Comanche	C3	795
Lamar DC Tie	DC	100
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	250
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	23.0
BUSCHWRTG2	G2	23.0
BUSCHWRTG2	G3	23.0
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
Canyon City	C1	0
Canyon City	C1	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	0

CSU:

Bus	LF ID	MW
Birdsale1	1	0.0
Birdsale 2	1	0.0
Birdsale 3	1	0.0
RD_Nixon	1	220.47
Tesla	1	13.2
Drake 5	1	0.0
Drake 6	1	80.6
Drake 7	1	137.1
Nixon CT 1	1	0.0
Nixon CT 2	1	0.0
Front Range CC 1	1	137.3
Front Range CC 2	1	136.9
Front Range CC 3	1	161.25

TSGT:

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

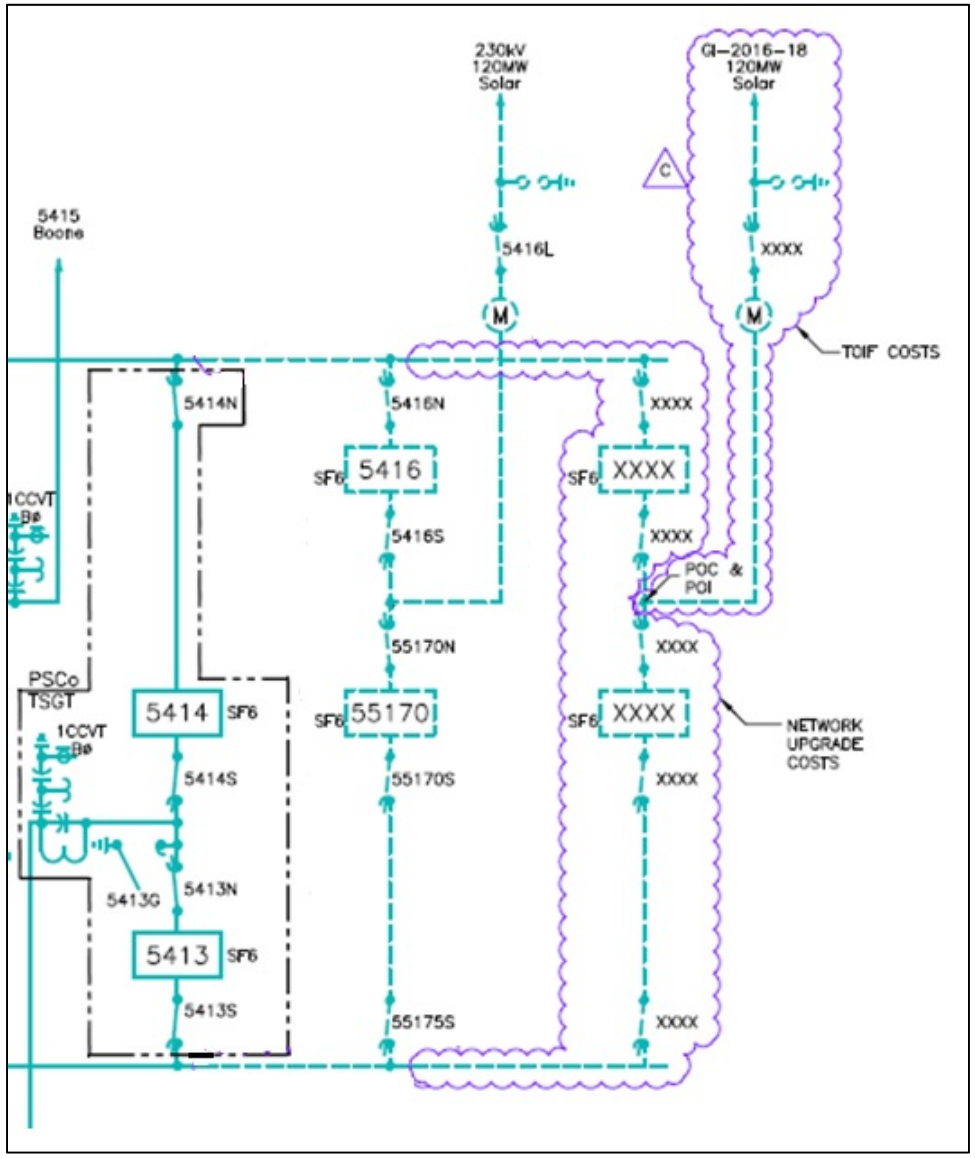

Figure 2 –Conceptual One-Line Diagram of the GI-2016-18 230kV Switching Station