Feasibility Study Report
Generation Interconnection Request # GI-2016-17

50MW Solar Photovoltaic Facility
Comanche 115kV Substation
Pueblo County, Colorado

Transmission Planning West
Xcel Energy
September 18, 2017

Executive Summary

The GI-2016-17 ("GI") is a 50MW solar photovoltaic generation facility that will be located in Pueblo County, Colorado. The GI facility will be made up of SMA 2200KVA inverters. The proposed Point of Interconnection (POI) is the 115kV bus at PSCo's Comanche Substation. The GI Customer did not request a secondary POI.

The proposed Commercial Operation Date (COD) is November 1, 2018, accordingly, the backfeed date is assumed to be June 30, 2019, approximately six (6) months before the COD.

The GI-2016-17 generation interconnection study request was for both Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection Service (ERIS).

The GI output is assumed to be serving PSCo native load, so existing PSCo generation is used as its sink.

The following single contingency BHCE facility overload is attributable to the interconnection of GI-2016-17:

- Portland – Skala 115kV line loading increased from 99.5% to 102.6%

The multiple contingency analysis resulted in the incremental overloads on the following facilities attributable to the interconnection of GI-2016-17:

- Fountain Valley – Desertcove 115kV line loading increased from 115.6% to 122.4% (BHCE line)
- Fountain Valley – Midway BR 115kV line loading increased from 114.5% to 121.3% (BHCE line)
- HydePark – West Station 115kV line loading increased from 102.3% to 112.3% (BHCE line)
- Desertcove – West Station 115kV line loading increased from 135.0% to 142.2% (BHCE line)
- Portland – Skala 115kV line loading increased from 119.4% to 123.4% (BHCE line)
- Canyon City – Skala 115kV line loading increased from 106.9% to 110.6% (BHCE line)
- Fountain Valley S – RD_Nixon 115kV line loading increased from 118.6% to 119.4% (CSU line)
- BLKFORTP – BLK SQMV 115kV line loading increased from 194.3% to 196.0% (TSGT line)
- BLK SQMV – Fuller 115kV line loading increased from 125.0% to 126.0% (TSGT line)
- Monument – Gresham 115kV line loading increased from 102.3% to 103.3% (TSGT line)

All incremental overloads due to multiple contingencies – whether on PSCO's System or an Affected party's System (i.e. BHCE, CSU and TSGT facilities) – will be addressed by system readjustments

(including generation curtailment) implemented via operating procedures developed by PSCo prior to commercial operation of the GI-2016-17 interconnection.

Since the Portland – Skala 115kV BHCE line is loaded at its rated capacity (99.5%) in the benchmark caseGI-2016-17 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 PSCo, BHCE, TSGT and CSU generation resources located in the electrical vicinity of GI-2016-17.

The breaker-duty studied did not identify any breaker overloads.

Implementing the Network Upgrades needed to mitigate the single contingency thermal overload on the BHCE Portland – Skala 115kV line will allow GI-2016-17 to achieve NRIS of 50MW. The Interconnection Customer will need to work with BHCE to identify the required Network Upgrade.

ERIS = 0 MW

NRIS = 50 MW (after Portland – Skala line overload mitigation)

The total estimated cost of the recommended system improvements to interconnect the project is approximately $20.185 million and includes:

- $ 1.05 million for PSCo-Owned, Customer-Funded Transmission Provider Interconnection Facilities
- $ 19.135 million for PSCo-Owned, PSCo-Funded Network Facilities for Interconnection
- $ 0 million for PSCo-Funded Network Upgrades for Delivery

The construction timeframe is estimated to be 36 months. However, it is anticipated that outage scheduling for construction will be very difficult, so potential extended delays (upto several years) in the construction period are to be expected, potentially making the Customer's 11/1/2018 COD infeasible. So the GI-2016-17 interconnection request is deemed infeasible.

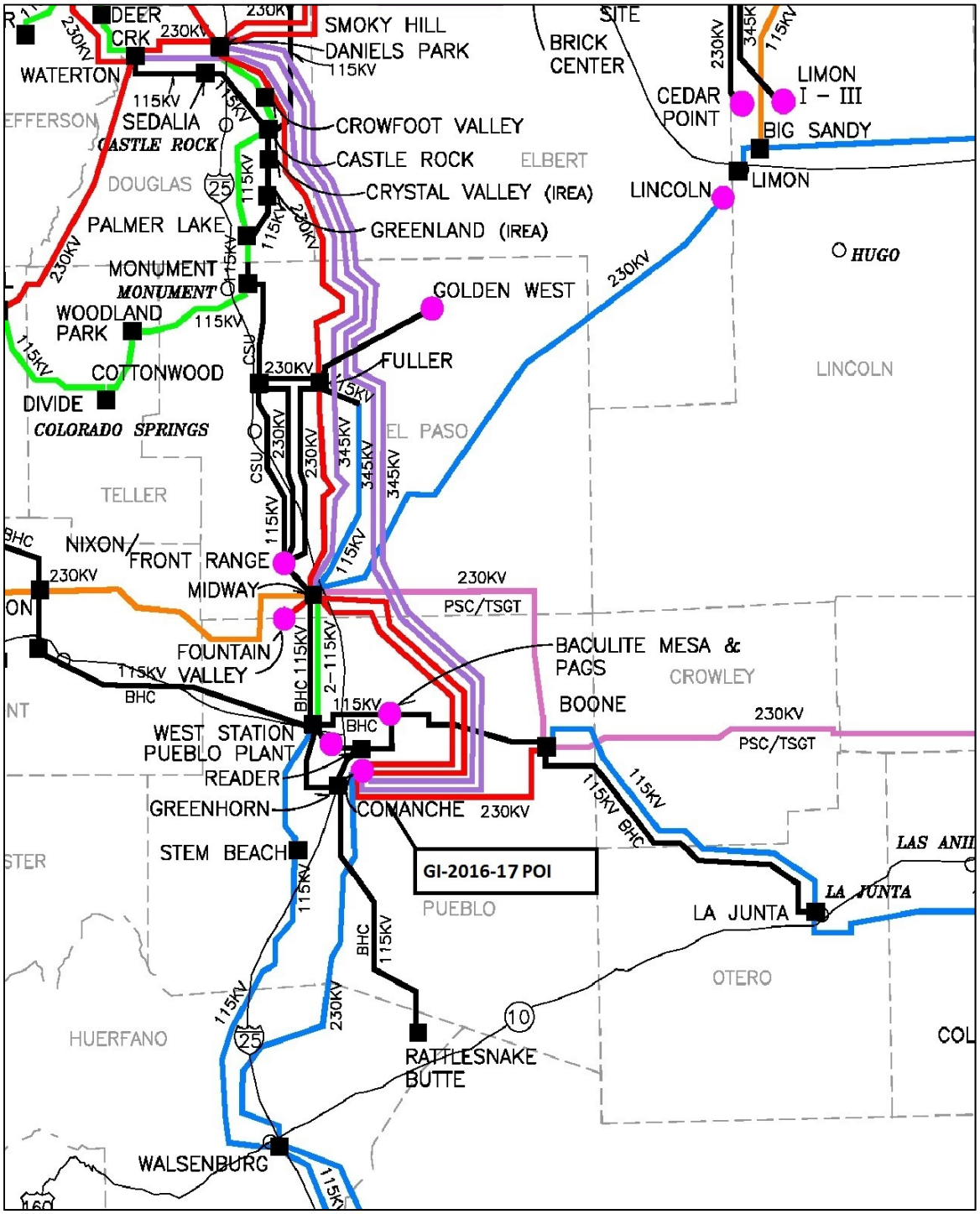

Figure 1 – GI-2016-17 proposed POI and study area

Introduction

The GI-2016-17 ("GI") is a 50MW solar photovoltaic generation facility that will be located in Pueblo County, Colorado. Public Service Company of Colorado (PSCo) received the feasibility study request for the GI on August 31, 2016, and a scoping meeting was held on September 26, 2016. The GI facility will be made up of SMA 2200KVA inverters connected to a 385V/34.5kV, 2.2MVA Generator Step-up Transformer (GSU) organized in two groups. The first group will consist of twelve (12) inverters and GSUs, and the second group will consist of thirteen (13) inverters and GSUs. The two groups will interconnect to a 34.5/115kV, 30/40/50MVA Main Step-Up Transformer which will interconnect to the Primary POI using a Customer owned 115kV transmission tie-line.
The study request did not identify a secondary POI.

The proposed Commercial Operation Date (COD) is November 1, 2018, accordingly, the backfeed date is assumed to be June 1, 2018, approximately six (6) months before the COD.

The study request includes both Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection Service (ERIS).

The GI output is assumed to be serving PSCo native load, so existing PSCo generation is used as its sink.

The potential Affected Parties for this GI are Colorado Springs Utilities (CSU), Black Hills Colorado Electric (BHCE) and Tri-State Generation and Transmission Inc. (TSGT).

Study Scope and Analysis Criteria

The scope of this report includes steady state (power flow) analysis, short circuit analysis and indicative level cost estimates. 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 contingencies were studied. Short circuit analysis determines the maximum available fault current at the POI. In addition, the breaker duty study determines if any breakers in the neighboring substations exceed their breaker duty ratings and need to be replaced.

PSCo adheres to applicable NERC Reliability Standards & Western Electricity Coordinating Council (WECC) Reliability Criteria, as well as its internal transmission planning criteria for 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 GI 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.

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 the Lamar 230kV bus was 350MW.

The GI-2016-17 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-2016-17 interconnection – the benchmark case and the study case. The benchmark case modeled the system without GI-2016-17, whereas the study case included GI-2016-17. 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 50 MW generation injection from GI-2016-17.

Power Flow Study Process

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-2016-17 includes WECC designated zones 121, 700, 703, 704, 705, 709, 710, 712, 752 and 757. Figure-1 shows the general study area and the POI.

The steady state analysis was performed using PTI's PSSE Ver. 33.6.0 program and the ACCC contingency analysis tool. The analysis was performed for P0, P1, P2, P4 and P7 contingencies of North American Reliability Council standard TPL001-4. 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 facility 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 full NRIS capacity will be attributed to GI.

For affected 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. Increments in the existing voltage violations are attributed to the GI if the increase is fairly significant.

Voltage Regulation and Reactive Power Capability

Interconnection Customers are required to interconnect its Large Generating Facility with Public Service of Colorado's (PSCo) Transmission System in accordance with the *Xcel Energy Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater Than 20 MW* (available at: http://www.transmission.xcelenergy.com/staticfiles/microsites/Transmission/Files/PDF/Interconnection/Interconnections-POL-TransmissionInterconnectionGuidelineGreat20MW.pdf).
In addition, wind generating plant interconnections must also fulfill the performance requirements specified in FERC Order 661-A. Accordingly, the following voltage regulation and reactive power capability requirements at the POI are applicable to this interconnection request:

- To ensure reliable operation, all Generating Facilities interconnected to the PSCo transmission system are expected to adhere to the *Rocky Mountain Area Voltage Coordination Guidelines (RMAVCG)*. Accordingly, since the POI for this interconnection request is located within 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 115 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-2016-17 caused new thermal overloads on the Portland – Skala 115kV line (BHCE line) and the Daniels Park – Prairie1 230kV line (PSCo line). The GI-2016-17 interconnection also resulted in an increase in the existing thermal overloads on the Cottonwood N – KettleCreek S 115kV Line (CSU line) and BLKFORTP – BLK SQMV 115kV line (TSGT line). The two (2) pre-existing thermal overloads on the CSU line and the TSGT line 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 on this line, so this thermal violation is not attributed to GI-2016-17 interconnection.

Hence, only the following single contingency BHCE facility overload is attributable to the interconnection of GI-2016-17.

- Portland – Skala 115kV line loading increased from 99.5% to 102.6%

The single contingency analysis did not show any voltage limit violations due to the addition of GI-2016-17.

Multiple Contingency Analysis:

The results of the multiple contingency analysis 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-9. As evident from the results, all multiple contingency overloads are pre-existing and the addition of the GI resulted in an incremental increase in the existing overload.

Addition of the GI caused the following incremental overloads in the BHCE system.

- Fountain Valley – Desertcove 115kV line loading increased from 115.6% to 122.4%
- Fountain valley – Midway BR 115kV line loading increased from 114.5% to 121.3%

- HydePark – West Station 115kV line loading increased from 102.3% to 112.3%
- Desertcove – West Station 115kV line loading increased from 135% to 142.2%
- Portland – Skala 115kV line loading increased from 119.4% to 123.4%
- Canyon City – Skala 115kV line loading increased from 106.9% to 110.6%

Addition of the GI caused the following incremental overload in the CSU system.

- Fountain Valley S – RD_Nixon 115kV line loading increased from 118.6% to 119.4%

Addition of the GI caused the following incremental overload in the TSGT system.

- BLKFORTP – BLK SQMV line loading increased from 194.3% to 196.0%
- BLK SQMV – Fuller 115kV line loading increased from 125% to 126.0%
- Monument – Gresham 115kV line loading increased from 102.3% to 103.3%

All incremental overloads due to multiple contingencies – whether on PSCO's System or an Affected Party's System (i.e. BHCE, CSU and TSGT facilities) – will be addressed by system readjustments (including generation curtailment) implemented via operating procedures developed by PSCo prior to commercial operation of the GI-2016-17 interconnection.

The multiple contingency analysis did not show any voltage limit violations due to the addition of GI-2016-17.

Short Circuit

The breaker duty study did not find any circuit breaker over duty limitation exceedance.

Table 1 – Short Circuit Parameters at the Comanche 115kV POI

	Without GI-2016-17	With GI-2016-17
Three Phase Fault Current at the POI	15440A	15607A
Single Line to Ground Fault Current at the POI	11371A	12243A
Positive Sequence Impedance	0.836+j8.560 ohms	0.836+j8.560 ohms
Negative Sequence Impedance	0.848+j8.559 ohms	0.848+j8.559 ohms
Zero Sequence Impedance	4.224+j17.414 ohms	3.582+j16.026 ohms

Conclusion

Energy Resource Interconnection Service (ERIS): Since the Portland – Skala 115kV BHCE line is loaded at its rated capacity (99.5%) in the benchmark caseGI-2016-17 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 PSCo, BHCE and CSU generation resources located in the electrical vicinity of GI-2016-17.

Network Resource Interconnection Service (NRIS): Implementing the Network Upgrades needed to mitigate the single contingency thermal overload on the BHCE Portland – Skala 115kV line will allow GI-2016-17 to achieve NRIS of 50MW. The Interconnection Customer will need to work with BHCE to identify the required Network Upgrade.

ERIS for GI-2017-10 = 150MW
NRIS for GI-2017-10 = 150MW (after Portland – Skala 115kV line overload mitigation)

Costs Estimates and Assumptions

The costs for upgrading the affected party facilities are not included in this report.

PSCo Engineering has developed Indicative level cost estimates (IE's) for Interconnection Facilities and Network/Infrastructure Upgrades required for Delivery of the Interconnection Customer's generation. The cost estimates are in 2017 dollars with appropriate escalation and contingency applied. AFUDC is not included. Indicative Estimates (IE's) 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 $20,185,000.00

Figure-2 below is a conceptual one-line of the proposed interconnection. The Point of Interconnection (POI) will be on the Comanche Substation 115kV bus.

The following tables 3, 4 and 5 list the improvements required to accommodate the interconnection and the delivery of the customer's 50MW 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.

It is anticipated that outage scheduling for construction will be very difficult, so potential extended delays (upto several years) in the construction period are to be expected, potentially making the Customer's 11/1/2018 COD infeasible. So the GI-2016-17 interconnection request is deemed infeasible.

- Labor is estimated for straight time only – no overtime included.
- Lead times for materials were considered for the schedule.
- Interconnection facilities design complies with current 115kV Substation Design Standards. No exceptions to the standards are taken.
- The existing substation is large enough to accommodate the relocation and expansion of the 115kv substation.
- The need for Certificate of Public Convenience and Necessity will be evaluated during the System Impact Study stage.
- 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.
- Breaker duty study determined that no breaker replacements are needed in neighboring substations.
- In addition to the PSCo Line and substation bus outages that will be necessary during the construction period; Transmission Customer outages will be required. Outage availability could potentially be problematic and extend requested backfeed date due.
- The estimated time to design, procure and construct the interconnection facilities is approximately 36 months after all required permits and authorization to proceed have been obtained.
- This project is completely independent of other queued projects and their respective ISD's.
- 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.
- Power Quality Metering (PQM) will be required on the Customer's 115kV line terminating into Proposed Switching Station.

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

Element	Description	Cost Est. (Millions)
PSCo's Comanche 115kV Transmission Substation	Interconnect Customer to the Comanche 115kV bus. The new equipment includes: • One (1) motor operated 230kV disconnect switch • Three (3) 115kV combination CT/PT metering units • Power Quality Metering (115kV 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**	**36 Months**

Table 3 - PSCo Owned; PSCo Funded Interconnection Network Facilities

Element	Description	Cost Estimate (Millions)
PSCo's Comanche 115kV Transmission Substation	Interconnect Customer to the Comanche 115kV bus. The new equipment includes: • Twelve (12) 115kV circuit breaker • Twenty-six (26) 115kV 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	**$19.000**
	115kV 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	**$19.135**
Time Frame	**Site, design, procure and construct**	**36 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	**$20.185**

Power Flow Contingency Analysis Results

Notes –

1. All thermal loadings are highlighted in yellow and violations are identified in red.
2. Thermal overloads are calculated using the 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-2016-17		Facility Loading With GI-2016-17			
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%	112	100.9%/100.9%	3.0%	Midway BR – West Canyon 230kV
Daniels Park – Prairie1 230kV	Line	PSCo	478/478	477.5	99.9%/99.9%	489.5	102.4%/102.4%	2.5%	Daniels Park – Prairie3 230kV
Cottonwood N – KettleCreek S 115kV	Line	CSU	162/180	191	117.9%/106.1%	193.8	119.6%/107.6%	1.7%	Brairgate S – Cottonwood S 115kV
BLKFORTP – BLK SQMV	Line	TSGT	81/81	84.5	104.3%/104.3%	86.6	106.9%/106.9%	2.6%	Flyhorse S – Kettle Creek N 115kV

Notes –

1. All thermal loadings are highlighted in yellow and violations are identified in red.
2. Thermal overloads are calculated using the 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-2016-17		Facility Loading With GI-2016-17			
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	110.4	99.5%/99.5%	113.9	102.6%/102.6%	3.1%	Midway BR – West Canyon 230kV
Daniels Park – Prairie1 230kV	Line	PSCo	478/478	481.8	100.8%/100.8%	494.2	103.4%/103.4%	2.6%	Daniels Park – Prairie3 230kV
Cottonwood N – KettleCreek S 115kV	Line	CSU	162/180	147.8	91.2%/82.1%	148.9	91.9%/82.7%	0.7 %	Brairgate S – Cottonwood S 115kV
BLKFORTP – BLK SQMV	Line	TSGT	81/81	68.8	85.0%/85.0%	70	86.4%/86.4%	1.4%	Flyhorse S – Kettle Creek N 115kV

Notes –

1. For Multiple Contingency Analysis, thermal overloads on all facilities are calculated using 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-2016-17		Facility Loading With GI-2016-17			
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%	340.7	106.8%/106.8%	2.6%	Double Ckt: Daniels Park – Prairie – Greenwood 230 kV 1&2
Daniels Park – Fuller 230kV	Line	PSCo	478/478	585.7	122.5%/122.5%	606.6	126.9%/126.9%	4.4%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
Fountain Valley – Desertcove 115kV	Line	BHCE	119/119	137.5	115.6%/115.6%	145.7	122.4%/122.4%	6.8%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
Fountain Valley – MidwayBR 115kV	Line	BHCE	119/119	136.3	114.5%/114.5%	144.3	121.3%/121.3%	6.8%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
HydePark – West Station 115kV	Line	BHCE	120/120	122.3	101.9%/101.9%	132.8	110.7%/110.7%	8.8%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
DesertCove – West Station 115kV	Line	BHCE	119/119	160.7	135.0%/135.0%	169.2	142.2%/142.2%	7.2%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
Portland – Skala 115kV	Line	BHCE	111/111	132.4	119.2%/119.2%	136.9	123.3%/123.3%	4.1%	Breaker Failure: MidwayBR - Fuller 230kV
Canyon City – Skala 115kV	Line	BHCE	119/119	127.1	106.8%/106.8%	131.5	110.5%/110.5%	3.7%	Breaker Failure: MidwayBR - Fuller 230kV
Midway 230kV Bus tie	Line	PSCo/ WAPA	430/478	565.02	131.4%/118.2%	581.4	135.2%/121.6%	3.4%	Double Ckt: Midway – Waterton 345kV & Midway – Fuller 230kV
Palmer Lake – Monument 115kV	Line	CSU/PS Co	142/157	182.7	128.7%/116.4%	188.9	133.0%/120.3%	3.9%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Cottonwood N – KettleCreek S 115kV	Line	CSU	162/180	187.8	115.9%/104.3%	192	118.5%/106.6%	2.3%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Monument - Flyhorse N 115kV	Line	CSU	142/157	204.3	143.9%/130.1%	210.4	148.2%/134.0%	3.9%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Flyhorse S - KettleCreek N 115kV	Line	CSU	162/180	215.6	133.1%/119.8%	221.8	136.9%/123.2%	3.4%	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-2016-17		Facility Loading With GI-2016-17			
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%	259.7	133.2%/122.5%	1.0%	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%	131.2	162.0%/162.0%	2.5%	Breaker Failure: Cottonwood 115kV Tie
BLK SQMV – Fuller 115kV	Line	TSGT	143/143	150.4	105.2%/105.2%	152.4	106.6%/106.6%	1.4%	Breaker Failure: Cottonwood 115kV Tie

Notes –

1. For Multiple Contingency Analysis, thermal overloads on all facilities are calculated using 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-2016-17		Facility Loading With GI-2016-17			
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%	342.6	107.4%/107.4%	2.5%	Double Ckt: Daniels Park – Prairie – Greenwood 230 kV 1&2
Daniels Park – Fuller 230kV	Line	PSCo	478/478	663.6	138.8%/138.8%	691.2	144.6%/144.6%	5.8%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
Fountain Valley – Desertcove 115kV	Line	BHCE	119/119	133.7	112.4%/112.4%	143.0	120.2%/120.2%	7.8%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
Fountain Valley – MidwayBR 115kV	Line	BHCE	119/119	132.4	111.3%/111.3%	141.6	119.0%/119.0%	7.7%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
HydePark – West Station 115kV	Line	BHCE	120/120	122.8	102.3%/102.3%	134.8	112.3%/112.3%	10.0%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
DesertCove – West Station 115kV	Line	BHCE	119/119	157.1	132.0%/132.0%	117	140.3%/140.3%	8.3%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
Portland – Skala 115kV	Line	BHCE	111/111	132.5	119.4%/119.4%	137	123.4%/123.4%	4.0%	Breaker Failure: MidwayBR - Fuller 230kV
Canyon City – Skala 115kV	Line	BHCE	119/119	127.2	106.9%/106.9%	131.6	110.6%/110.6%	3.7%	Breaker Failure: MidwayBR - Fuller 230kV
Midway 230kV Bus tie	Line	PSCo/ WAPA	430/478	543.1	126.3%/113.6%	558.1	129.8%/116.8%	3.2%	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%	115.8	71.5%/64.3%	1.0%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Monument - Flyhorse N 115kV	Line	CSU	142/157	96	67.6%/61.1%	98.6	69.4%/62.8%	1.7%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Flyhorse S - KettleCreek N 115kV	Line	CSU	162/180	107.2	66.2%/59.5%	109.7	67.7%/61.0%	1.5%	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-2016-17		Facility Loading With GI-2016-17			
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	251.5	129.0%/118.6%	253.1	129.8%/119.4%	0.8%	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%	158.8	196.0%/196.0%	1.7%	Breaker Failure: Cottonwood 115kV Tie
BLK SQMV – Fuller 115kV	Line	TSGT	143/143	178.7	125.0%/125.0%	180.2	126.0%/126.0%	1.0%	Breaker Failure: Cottonwood 115kV Tie
Monument – Gresham 115kV	Line	CSU	145/145	148.3	102.3%/102.3%	149.8	103.3%/103.3%	1.0%	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
Twin Butte-II	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

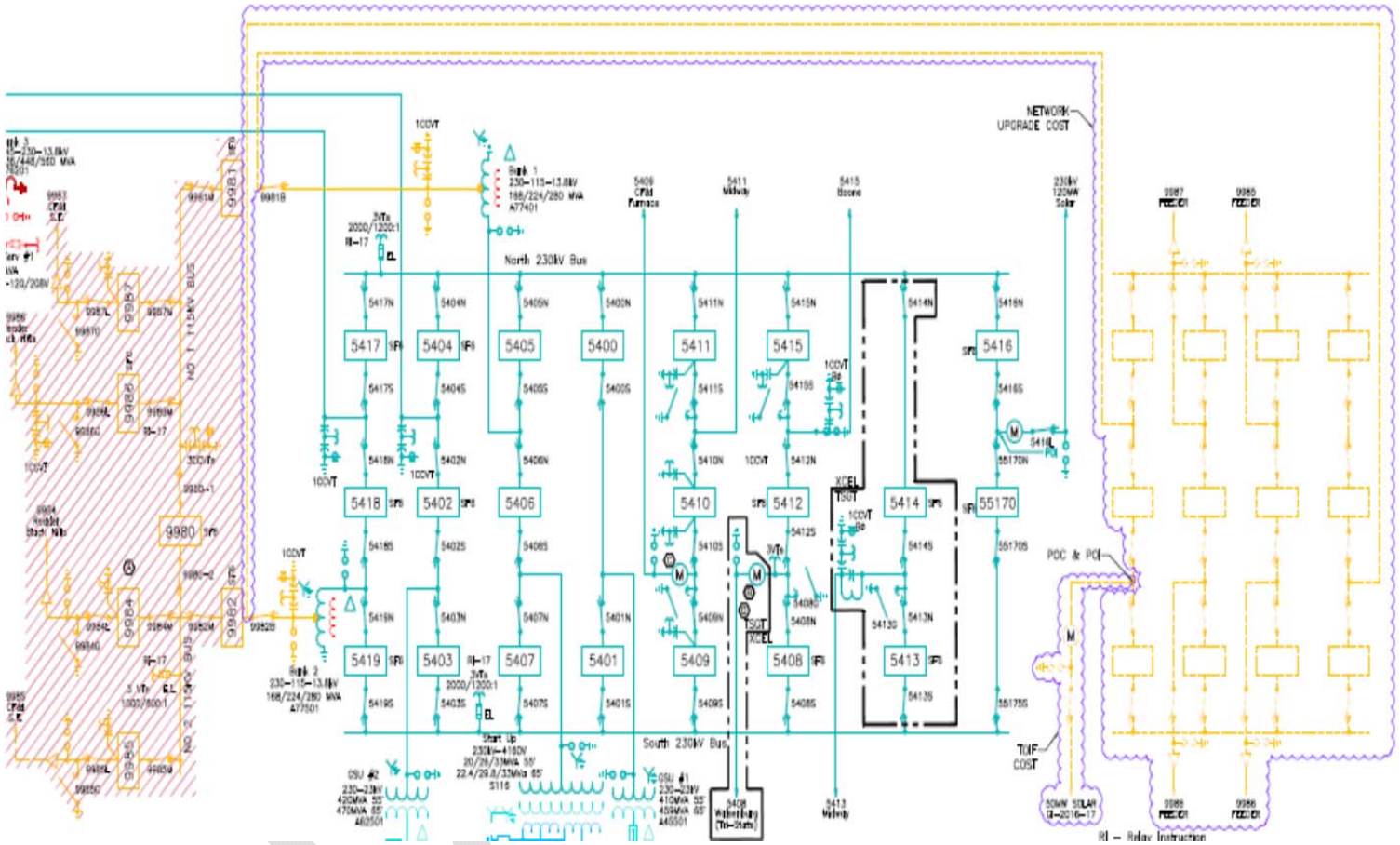

Figure 2 –Conceptual One-Line Diagram of the Comanche Switching Station after GI-2016-17 Interconnection