Feasibility Study Report
Generation Interconnection Request # GI-2016-16

100MW Solar Photovoltaic Facility
Tapping Comanche - Boone 230kV
Pueblo County, Colorado

Transmission Planning West
Xcel Energy
January 25, 2017

Executive Summary

The "GI-2016-16" (GI) is a 100MW solar photovoltaic generation facility located in Pueblo County, Colorado. The GI request was received by PSCo on June 16, 2016 and a scoping meeting was held on September 19, 2016. The GI-2016-16 solar photovoltaic generation facility will be comprised of forty (40) 2700KVA TMEIC Samurai Series Solar inverters.

The Primary POI requested by the Interconnection Customer is a tap on the Boone – Comanche 230kV line, at approximately five (5) miles from the Comanche Substation. The tap point will be a new substation which will be referred in this report as "GI-2016-16 230kV Switching Station". The GI-2016-16 will interconnect to the Primary POI using a 230kV tie-line that will be owned and constructed by the Interconnection Customer.

The Secondary POI requested by the Interconnection Customer is a tap on the Comanche – Midway 230kV line at approximately five (5) miles from the Comanche Substation.

The proposed Commercial Operation Date (COD) is December 31, 2018. A backfeed date of June 31, 2018 is assumed for the study purpose, approximately six months before the COD.

The GI-2016-16 generation interconnection study request is for Network Resource Interconnection Service (NRIS) only. PSCo load is assumed to be the sink for GI-2016-16 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 2018HS heavy summer base case and modeled heavy south-north flow on the Comanche – Midway – Jackson Fuller – Daniels Park study area.

The GI-2016-16 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-6 and Table-7. The following single contingency BHCE facility overload is attributable to the interconnection of GI-2016-16.

- Portland – Skala 115kV line loading increased from 99.5% to 104.1%

There were no voltage violations attributable to GI-2016-16 addition.

Multiple Contingency Analysis Results:

The results of the multiple contingency analyses are given in Table-8 and Table-9.The incremental contingency overloads on the following BHCE facilities are attributable to the interconnection of GI-2016-16

- HydePark – West Station 115kV line loading increased from 102.3% to 107.0%
- Fountain Valley – Desertcove 115kV line loading increased from 123.7% to 132.2%
- Fountain valley – Midway BR 115kV line loading increased from 122.7% to 131.3%
- Portland – Skala 115kV line loading increased from 104.2% to 109.6%
- Desertcove – West Station 115kV line loading increased from 141.5% to 150.1%

The incremental overload on the following CSU facility is attributable to the interconnection of GI-2016-16

- Fountain Valley – RD_Nixon 115kV line loading increased from 118.6% to 119.8%

The incremental overloads on the following TSGT facilities are attributable to the interconnection of GI-2016-16

- BLKFORTP – BLK SQMV line loading increased from 194.3% to 197.4%
- BLK SQMV – Fuller 115kV line loading increased from 125.0% to 126.8%
- Fuller 230/115kV transformer loading increased from 149.3% to 149.8%

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 system readjustments (including generation curtailment) implemented via operating practices.

Short Circuit

The POI will be a new substation; therefore, the circuit breakers at the new substation will be adequately rated. The fault current levels and Thevenin impedance values for three phase and

single line to ground faults at the POI are given in Table-2. The breaker duty study determined that no breaker replacements are needed in neighboring substations.

Conclusion

Network Resource Interconnection Service (NRIS): Implementing the Network Upgrades needed to mitigate the above mentioned single contingency thermal overload on the BHCE system and multiple contingency thermal overloads on the TSGT, CSU and BHCE facilities will allow GI-2016-16 to achieve full NRIS of 100MW. The Interconnection Customer should work with the facility owners in order to identify mitigation measures for the identified overloads.

Cost Estimates (in 2016 dollars)

The total estimated cost of the recommended system improvements to interconnect the project is approximately $10.267 million and includes:

- $ 0.205 million for PSCo-Owned, Customer-Funded Transmission Provider Interconnection Facilities
- $ 8.694 million for PSCo-Owned, PSCo-Funded Network Facilities for Interconnection
- $ 0.205 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. A CPCN will likely be required for the GI-2016-16 230kV Substation construction. The time to secure the CPCN would be approximately 18 months before any procurement and construction can be done. The total estimated time for design, procurement, and construction will be approximately 36 months from the time the necessary authorization to proceed has been obtained. The December 2018 COD requested by the Customer is not achievable due to the lead time required for construction and CPCN approval.

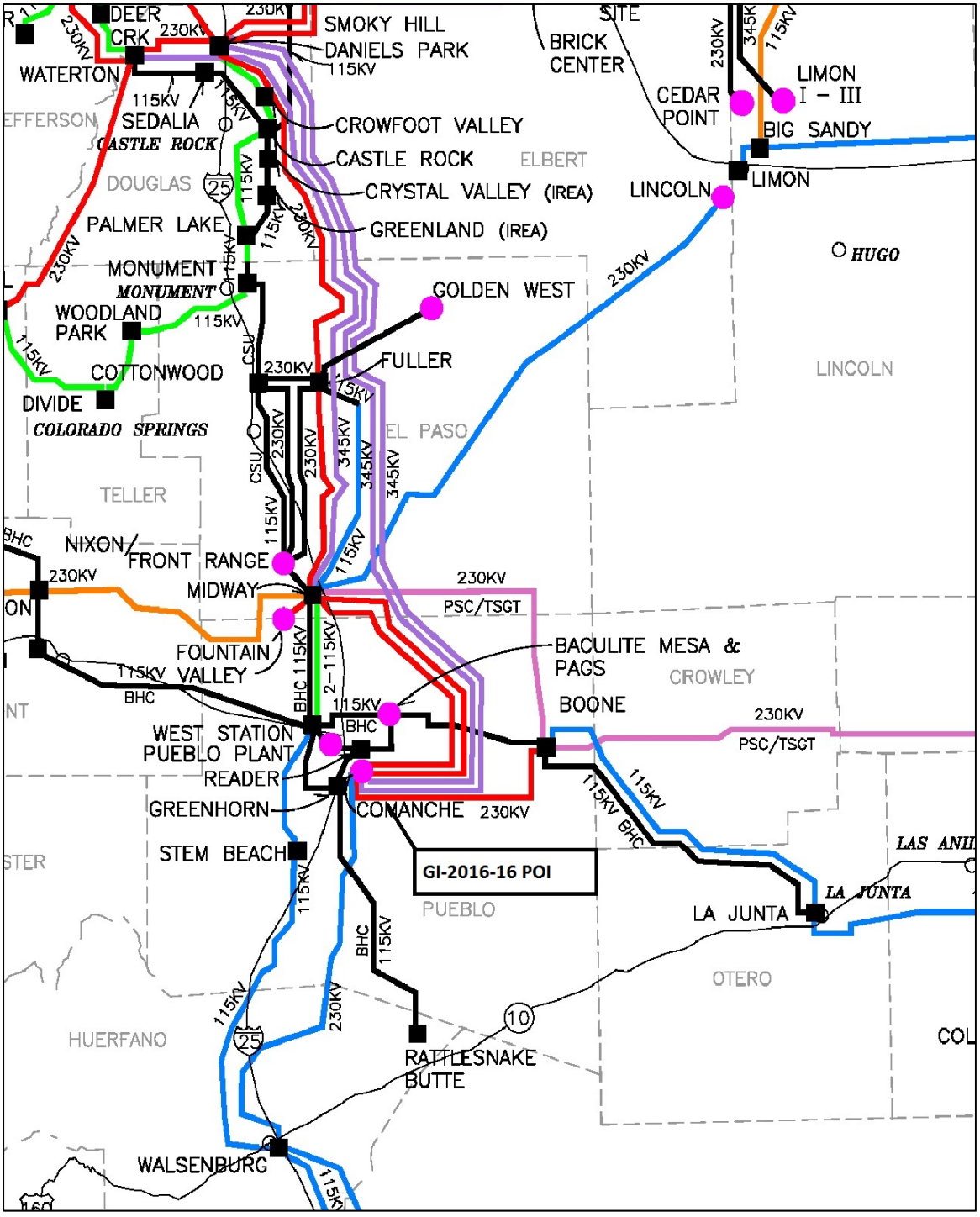

Figure 1 - GI-2016-16 Switching Station (Primary POI) on the Boone – Comanche 230kV line and Study Area

Introduction

The "GI-2016-16" (GI) is a 100MW solar photovoltaic generation facility located in Pueblo County, Colorado. The GI request was received by PSCo on June 16, 2016 and a scoping meeting was held on September 19, 2016. The GI-2016-16 solar photovoltaic generation facility will be comprised of forty (40) 2700KVA TMEIC Samurai Series Solar inverters.

The Primary POI requested by the Interconnection Customer is a tap on the Boone – Comanche 230kV line, at approximately five (5) miles from the Comanche Substation. The tap point will be a new Substation which will be referred in this report as "GI-2016-16 230kV Substation". The GI-2016-16 will interconnect to the Primary POI using a 230kV tie-line that will be owned and constructed by the Interconnection Customer.

The Secondary POI requested by the Interconnection Customer is a tap on the Comanche – Midway 230kV line at approximately five (5) miles from the Comanche Substation.

The proposed Commercial Operation Date (COD) is December 31, 2018. A backfeed date of June 31, 2018 is assumed for the study purpose, approximately six months before the COD.

The GI-2016-16 generation interconnection study request is for Network Resource Interconnection Service (NRIS) only.

PSCo load is assumed to be the sink for GI-2016-16 generation.

Study Scope and Analysis Criteria

The scope of this report includes steady state (power flow) analysis and short circuit analysis. 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 GI-2016-16. 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 neighboring substations due to the interconnection of GI-2016-16.

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) and Intermountain Rural Electric Association (IREA) facilities are the same as above.

The thermal and voltage analysis criteria for Colorado Springs Utilities (CSU) facilities are the same as above, except that the thermal analysis for single contingencies is calculated based on the emergency rating of the facility.

GI-2016-16 was studied for Network Resource Interconnection Service (NRIS) only.

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) 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 path. This was accomplished by adopting the generation dispatch given in Table-10 below. PSCo's generation in zones 700, 704, 709, 710 and 712 is dispatched such that wind generation is at 85% of name plate capacity, solar generation is at 80% of name plate capacity, conventional non-coal generation is at 90% of name plate capacity and, coal generation is dispatched at 100% of name plate capacity. For BHCE, the Baculite Mesa units are 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 is provided by CSU.

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

The GI-2016-16 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-2016-16 interconnection – the benchmark case and the study case. The benchmark case modeled the system without GI-2016-16, whereas the study case included GI-2016-16. 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 100 MW generation injection from GI-2016-16. The GI-2016-16 model provided by the customer resulted in a total injection of 98.5MW at the GI-Boone 230kV bus after losses on the GI-2016-16 interconnection facilities, so the Pmax of the generator model is increased such that the total injection at the primary POI is 100MW, consistent with the study request.

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 done 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 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 this 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-2016-16 includes WECC designated zones 121, 700, 703, 704, 705, 709, 710, 712, 752 and 757.

Voltage Regulation and Reactive Power Capability

The following voltage regulation and reactive power capability requirements are applicable to this interconnection request:

- To ensure reliable operation, all Generating Facilities interconnected to the PSCo transmission system should adhere to the Rocky Mountain Area Voltage Coordination Guidelines. Accordingly, since the POI for this interconnection request is located within Southeast Colorado Region 4; 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.
- The Interconnection Customer shall design their Generating Facility to maintain a composite power delivery at continuous rated power output at the Point of Interconnection at a power factor within the range of 0.95 leading to 0.95 lagging.
- Generating Facilities interconnected to the PSCo transmission system must meet the POI voltage schedule specified by the Transmission Operator, as long as the Generating Facility is on-line and producing power. The Generating Facilities are expected to achieve this by providing dynamic reactive power proportionate to the actual power (MW) output within the 0.95 leading to 0.95 lagging power factor range.
- The Interconnection Customer has the responsibility to determine the type (switched shunt capacitors and/or switched shunt reactors, etc.), the size (MVAR), and the locations (690 V, 34.5 kV or 230 kV bus) of any additional static reactive power equipment needed within the Generating Facility in order to provide the level of dynamic reactive power capability to meet the 0.95 leading to 0.95 lagging power factor standard. The Interconnection Customer may need to perform additional studies for this purpose.
- The Interconnection Customer has the responsibility to ensure that its generating facility is capable of meeting the voltage ride-through and frequency ride-through (VRT and FRT) performance specified in NERC Reliability Standard PRC-024-1.
- Prior to commercial operation, the Interconnection Customer must demonstrate to the satisfaction of PSCo Transmission Operator that the Generating Facility 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 have 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-2016-16 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-2016-16 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 is 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 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-2016-16 interconnection.

The following single contingency BHCE facility overload is attributable to the interconnection of GI-2016-16.

- Portland – Skala 115kV line loading increased from 99.5% to 104.1%

Addition of GI-2016-16 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-2016-16 addition.

Multiple Contingency Analyis:

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 overloads on the following BHCE facilities are attributable to the interconnection of GI-2016-16

- HydePark – West Station 115kV line loading increased from 102.3% to 107.0%
- Fountain Valley – Desertcove 115kV line loading increased from 123.7% to 132.2%
- Fountain valley – Midway BR 115kV line loading increased from 122.7% to 131.3%
- Portland – Skala 115kV line loading increased from 104.2% to 109.6%
- Desertcove – West Station 115kV line loading increased from 141.5% to 150.1%

The incremental overload on the following CSU facility is attributable to the interconnection of GI-2016-16

- Fountain Valley – RD_Nixon 115kV line loading increased from 118.6% to 119.8%

The incremental overloads on the following TSGT facilities are attributable to the interconnection of GI-2016-16

- BLKFORTP – BLK SQMV line loading increased from 194.3% to 197.4%
- BLK SQMV – Fuller 115kV line loading increased from 125% to 126.8%
- Fuller 230/115kV transformer loading increased from 149.3% to 149.8%

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 system readjustments (including generation curtailment) implemented via operating procedures. PSCo facility overloads due to multiple contingencies are not attributed to the GI-2016-16 interconnection.

Short Circuit

The POI is a new substation; therefore, the circuit breakers at the new substation will be adequately rated. The calculated short circuit levels and Thevenin system equivalent impedances at the GI-2016-16 230kV Switching Station are tabulated below.

Table 1 – Short Circuit Parameters at the GI-2016-16 230kV Switching Station

	Existing System	After GI-2016-16 Interconnection
Three phase Fault Current (A)	15542	15542
Single Line to Ground Fault Current (A)	13867	14135
Positive Sequence Impedance (Ohms)	0.709+j8.514	0.709+j8.514
Negative Sequence Impedance (Ohms)	0.727+j8.521	0.727+j8.521
Zero Sequence Impedance (Ohms)	2.583+j11.409	2.411+j10.883

The breaker duty study determined that no breaker replacements are needed in neighboring substations.

Conclusion

Network Resource Interconnection Service (NRIS): Implementing the Network Upgrades needed to mitigate the above mentioned single contingency thermal overload on the BHCE system and multiple contingency thermal overloads on the TSGT, CSU and BHCE facilities will allow GI-2016-16 to achieve full NRIS of 100MW. The Interconnection Customer should work with the facility owners in order to identify mitigation measures for the identified overloads.

Costs Estimates and Assumptions

Indicative level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery were developed by PSCo Engineering. The cost estimates are in 2016 dollars with escalation and contingencies applied (AFUDC is not included). Indicative level cost 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. This estimate does not include the cost for any other Customer owned equipment and associated design and engineering.

The estimated total cost for the required upgrades is $10,267,000.00

Figure 2 below is a conceptual one-line of the proposed interconnection. The Point of Interconnection (POI) will be a tap (“GI-2016-16 Switching station”) on the Boone - Comanche 230kV Transmission Line approximately five (5) miles from the Comanche substation.

The following (Tables 2, 3 and 4) list the improvements required to accommodate the interconnection and the delivery of the customer’s 100 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.

- Indicative level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery No accuracy specified) were developed by PSCo Engineering.
- Estimates are based on 2016 dollars (appropriate contingency and escalation applied).
- AFUDC has been excluded.
- 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 its 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.
- A CPCN will be required for the PSCo interconnection facilities construction. The time to secure the CPCN will be approximately 18 months, in addition to the eighteen month duration estimated for the design, procure and construction.
- 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 Proposed 230kV Transmission Switching Station	Interconnect Customer to the 230kV bus at the Proposed Switching Station. 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	**$1.010**
	Transmission line tap into substation. Conductor, hardware, and installation labor.	**$0.358**
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	**$1.368**
Time Frame	**Design, procure and construct**	**18 Months**

Table 3: PSCo Owned; PSCo Funded Interconnection Network Facilities

Element	Description	Cost Estimate (Millions)
PSCo's Proposed 230kV Transmission Switching Station	Interconnect Customer to the 230kV bus at the Proposed 230kV Substation. 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	**$7.000**
	In/Out Tap on the 5415 Comanche – Boone 230kV Line the Proposed Switching Station.	**$0.914**
	Siting and Land Rights support for substation land acquisition and construction.	**$0.078**
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	**$8.694**
Time Frame	**Site, design, procure and construct**	**18 Months**

Table 4 – PSCo Network Upgrades for Delivery

Element	Description	Cost Est. (Millions)
PSCo's Comanche 230kV Sub.	Relay panel replacement.	**$0.205**
	Total Cost Estimate for PSCo Network Upgrades for Delivery	**$0.205**
	Design, procure and construct	**18 Months**
	Total Project Estimate	**$10.267**

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.
   - CSU facilities are calculated using the applicable Emergency Rating.

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

				Facility Loading Without GI-2016-16		Facility Loading With GI-2016-16			
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%	113.7	102.4%/102.4%	4.5%	Midway BR – West Canyon 230kV
Daniels Park – Prairie1 230kV	Line	PSCo	478/478	477.5	99.9%/99.9%	501.4	104.9%/104.9%	5%	Daniels Park – Prairie3 230kV
Cottonwood N – KettleCreek S 115kV	Line	CSU	162/180	191	117.9%/106.1%	196.3	121.2%/109.1%	3.0%	Brairgate S – Cottonwood S 115kV
BLKFORTP – BLK SQMV	Line	TSGT	81/81	84.5	104.3%/104.3%	88.2	108.9%/108.9%	4.6%	Flyhorse S – Kettle Creek N 115kV
Fuller 230/115kV	Xfmr	TSGT	100/100	100	100.0%/100.0%	101.1	101.1%/101.1%	1.1%	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.
   - CSU facilities are calculated using the applicable Emergency Rating.

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

				Facility Loading Without GI-2016-16		Facility Loading With GI-2016-16			
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%	115.6	104.1%/104.1%	4.6%	Midway BR – West Canyon 230kV
Daniels Park – Prairie1 230kV	Line	PSCo	478/478	481.8	100.8%/100.8%	506.7	106.0%/106.0%	5.2%	Daniels Park – Prairie3 230kV
Cottonwood N – KettleCreek S 115kV	Line	CSU	162/180	147.7	91.2%/82.1%	150	92.6%/83.3%	1.2%	Braigate S – Cottonwood S 115kV
BLKFORTP – BLK SQMV	Line	TSGT	81/81	68.9	85%/85%	71	87.6%/87.6%	2.6%	Flyhorse S – Kettle Creek N 115kV
Fuller 230/115kV	Xfmr	TSGT	100/100	86.9	86.9%/86.9%	87.1	87.1%/87.1%	0.2%	Midway BR – Rancho 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-2016-16		Facility Loading With GI-2016-16			
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%	349	109.4%/109.4%	5.2%	Double Ckt: Daniels Park – Prairie – Greenwood 230 kV 1&2
Daniels Park – Fuller 230kV	Line	PSCo	478/478	585	122.5%/122.5%	636.7	133.2%/133.2%	10.7%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
HydePark – West Station 115kV	Line	BHCE	120/120	122.2	101.8%/101.8%	137.2	114.3%/114.3%	12.5%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
Fountain Valley – DesertCove 115kV	Line	BHCE	119/119	150.9	126.8%/126.8%	161.5	135.7%/135.7%	8.9%	Breaker Failure: MidwayBR - Fuller 230kV
Fountain Valley – MidwayBR 115kV	Line	BHCE	119/119	149.7	125.8%/125.8%	160.3	134.7%/134.7%	8.9%	Breaker Failure: MidwayBR - Fuller 230kV
Portland – Skala 115kV	Line	BHCE	111/111	115.2	103.8%/103.8%	121.2	109.2%/109.2%	5.4%	Breaker Failure: MidwayBR - Fuller 230kV
DesertCove – West Station 115kV	Line	BHCE	119/119	172.2	144.7%/144.7%	182.9	153.7%/153.7%	9.0%	Breaker Failure: MidwayBR - Fuller 230kV
Midway 230kV Bus tie	Line	PSCo/ WAPA	430/478	565	131.4%/118.2%	602.9	140.2%/126.1%	7.9%	Double Ckt: Midway – Waterton 345kV & Midway – Fuller 230kV
Palmer Lake – Monument 115kV	Line	CSU/PS Co	142/157	182.8	128.7%/116.4%	194.5	137.0%/123.9%	7.5%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Cottonwood N – KettleCreek S 115kV	Line	CSU	162/180	187.8	115.9%/104.3%	196.2	121.1%/109%	4.7%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Monument - Flyhorse N 115kV	Line	CSU	142/157	204.3	143.9%/130.1%	216.4	152.4%/137.8%	7.7%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Flyhorse S - KettleCreek N 115kV	Line	CSU	162/180	215.5	133.0%/119.7%	262.4	162.0%/145.8%	26.1%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Fountain_S – RD_Nixon 115kV	Line	CSU	195/212	257.6	132.1%/121.5%	261	133.8%/123.1%	1.6%	Double Ckt: Kelker S – Frontrange 230kV & Kelker N – RD_Nixon 230kV

Table 7 – Summary of thermal violations from Multiple Contingency Analysis Without the Palmer Lake– Monument 115kV Line Operating Procedure									
				Facility Loading Without GI-2016-16		Facility Loading With GI-2016-16			
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
BLKFORTP – BLK SQMV 115kV	Line	TSGT	81/81	129.2	159.5%/159.5%	133	164.2%/164.2%	4.7%	Breaker Failure: Cottonwood 115kV Tie
BLK SQMV – Fuller 115kV	Line	TSGT	143/143	150.4	105.2%/105.2%	154.3	107.9%/107.9%	2.7%	Breaker Failure: Cottonwood 115kV Tie
Fuller 230/115kV	Xfmr	TSGT	100/100	127.9	127.9%/127.9%	129.2	129.2%/129.2%	1.3%	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-2016-16		Facility Loading With GI-2016-16			
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%	351.2	110.1%/110.1%	5.2%	Double Ckt: Daniels Park – Prairie – Greenwood 230 kV 1&2
Daniels Park – Fuller 230kV	Line	PSCo	478/478	663.6	138.8%/138.8%	687	143.7%/143.7%	4.9%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
HydePark – West Station 115kV	Line	BHCE	120/120	122.8	102.3%/102.3%	128.4	107%/107%	4.7%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
Midway 230/115kV	Xfmr	PSCo	97/97	111.7	115.2%/115.2%	128.4	132.4%/132.4%	17.2%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
Portland – Skala 115kV	Line	BHCE	111/111	116.8	105.2%/105.2%	123.2	111.0%/111.0%	5.8%	Double Ckt: Daniels Park – Comanche 345 kV 1&2
Fountain Valley – DesertCove 115kV	Line	BHCE	119/119	147.2	123.7%/123.7%	157.3	132.2%/132.2%	8.5%	Breaker Failure: MidwayBR - Fuller 230kV
Fountain Valley – MidwayBR 115kV	Line	BHCE	119/119	146.0	122.7%/122.7%	156.2	131.3%/131.3%	8.6%	Breaker Failure: MidwayBR - Fuller 230kV
Portland – Skala 115kV	Line	BHCE	111/111	115.7	104.2%/104.2%	121.7	109.6%/109.6%	5.4%	Breaker Failure: MidwayBR - Fuller 230kV
DesertCove – West Station 115kV	Line	BHCE	119/119	168.4	141.5%/141.5%	178.6	150.1%/150.1%	8.6%	Breaker Failure: MidwayBR - Fuller 230kV
Midway 230kV Bus tie	Line	PSCo	430/478	543.1	126.3%/113.6%	580.1	134.9%/121.3%	7.7%	Double Ckt: Midway – Waterton 345kV & Midway – Fuller 230kV
Palmer Lake – Monument 115kV	Line	CSU	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%	117.8	72.7%/65.4%	2.1%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Monument - Flyhorse N 115kV	Line	CSU	142/157	96	67.6%/61.1%	101.2	71.3%/64.4%	3.3%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Flyhorse S – Kettle Creek N	Line	CSU	162/180	107.2	66.2%/59.5%	112.5	69.4%/62.5%	3.0%	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-2016-16		Facility Loading With GI-2016-16			
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%	159.9	197.4%/197.4%	3.1%	Breaker Failure: Cottonwood 115kV Tie
BLK SQMV – Fuller 115kV	Line	TSGT	143/143	178.8	125%/125%	181.3	126.8%/126.8%	1.8%	Breaker Failure: Cottonwood 115kV Tie
Fuller 230/115kV	Xfmr	TSGT	100/100	149.3	149.3%/149.3%	149.8	149.8%/149.8%	0.5%	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

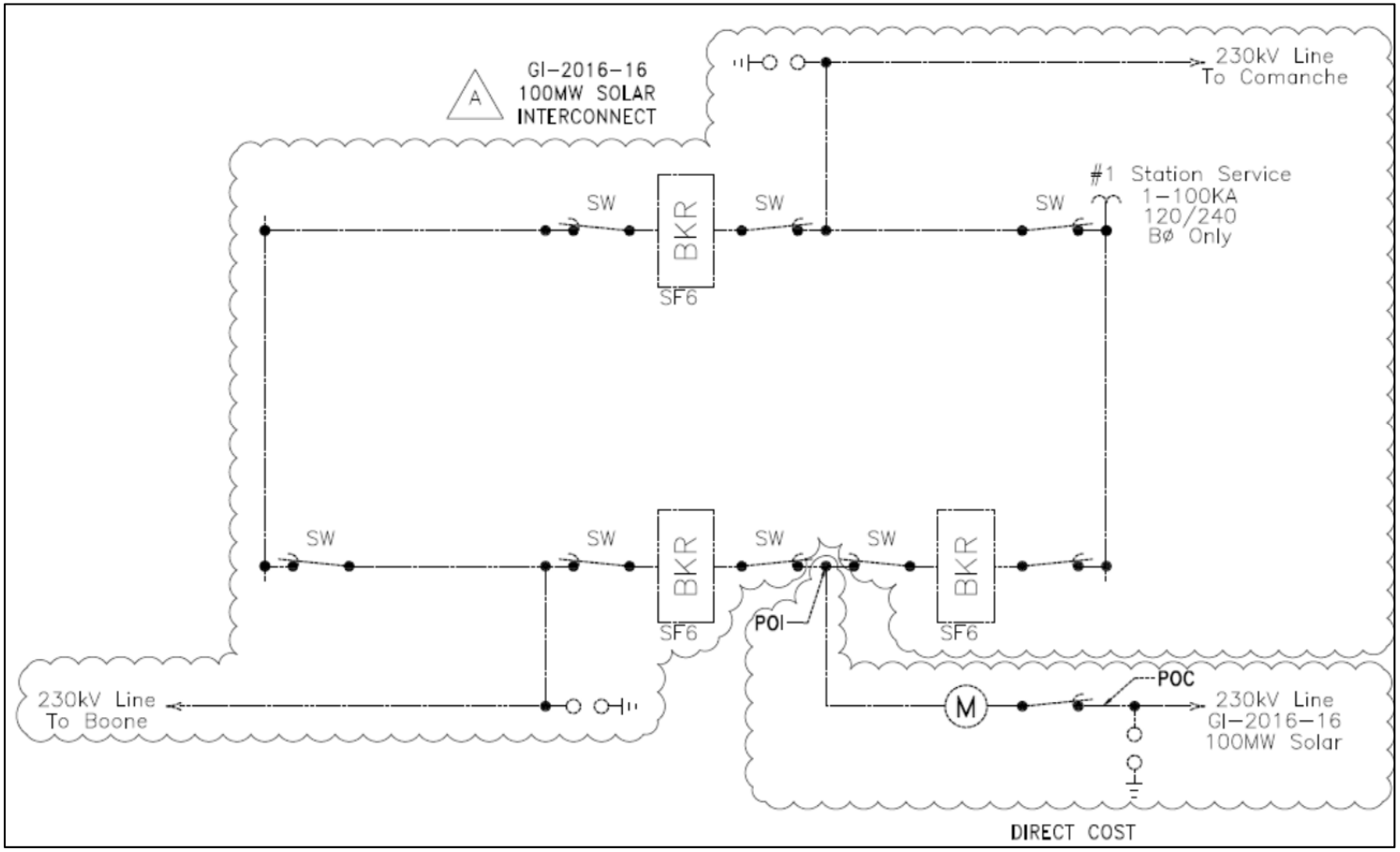

Figure 2 –Conceptual One-Line Diagram of the GI-2016-16 230kV Switching Station