



## **Feasibility Study Report Generation Interconnection Request # GI-2017-3**

100MW Solar Photovoltaic Facility  
Comanche 230kV Substation  
Pueblo County, Colorado

Transmission Planning West  
Xcel Energy  
May 24, 2017

### **Executive Summary**

The “GI-2017-3” (GI) is a 100MW solar photovoltaic generation facility that will be located in Pueblo County, Colorado. The GI request was received by PSCo on January 23, 2017 and a scoping meeting was held on February 1, 2017. This study report is based on the information provided by the Interconnection Customer (“Customer”) and assumptions stated in the Feasibility study agreement.

The Primary POI requested is at Comanche 230kV Substation. The Customer did not request an alternative POI to be studied.

The GI facility will consist of forty one (41) Sungrow 2.75MVA (2.5MW) inverters connected in four groups. Three of the groups will have an aggregate capacity of 25MW each and the fourth group will have an aggregate capacity of 27.5MW, resulting in a total capacity of 100MW at the POI after losses. Each group will connect to a 550v/34.5kV, 2750KVA transformer, which will be stepped up to 230kV using a 34.5/230kV, 68/90/113 MVA main step-up transformer. The GI facility will be connected to the POI using a 3.22-mile (17,000 feet) 361MVA, 795kcmil ACSR “Drake” 230kV tie-line owned by the Customer.

The proposed Commercial Operation Date (COD) of the GI are December 1, 2019. For the study purpose, backfeed date is assumed to be July 1, 2019, approximately six (6) months before the proposed COD.

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

PSCo load is assumed to be the sink for GI-2017-3 generation.

The scope of this report includes steady state (power flow) analysis and short circuit analysis. The studies were performed using a Western Electricity Coordinating Council (WECC) approved 2022 Heavy Summer (“2022HS1”) base case and dispatched per PSCo renewable energy dispatch guidelines that results in a higher south-north flow on the Comanche – Midway – Jackson Fuller – Daniels Park transmission system.

The GI-2017-3 interconnection request was studied as a stand-alone project. That is, the study did not include any other Generator Interconnection (GI) Requests existing in PSCo's or any affected party's GI queue, other than the interconnection requests that are considered to be planned resources for which Power Purchase Agreements have been signed.

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

Steady State Contingency Analysis Results:

Single Contingency Analysis Results:

The following PSCo facility overload is attributable to the interconnection of GI-2017-3

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

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

Multiple Contingency Analysis Results:

The results of the multiple contingency analyses are given in Table-7 and Table-8. The implementation of the Palmer Lake – Monument 115kV Line operating procedure eliminated some of the overloads on the CSU and IREA facilities as evident in the results shown in Table-9. The addition of GI-2017-3 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-2017-3 addition.

The renewable resources in the study area were dispatched at 85% of the nameplate capacity resulting in a higher south – north flows on the Comanche – Midway – Jackson Fuller – Daniels Park transmission system, so multiple contingencies overloads on the PSCo facilities will be addressed by PSCo system readjustments (including generation curtailment) implemented via operating practices. PSCo facility overloads due to multiple contingencies are not considered attributable to the GI-2017-3 interconnection.

The incremental overloads on the following BHCE facilities are attributable to the interconnection of GI-2017-3

- Fountain Valley – Desertcove 115kV line loading increased from 100% to 109.0%
- Fountain valley – Midway BR 115kV line loading increased from 99.4% to 107.9%

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

## **Short Circuit**

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

## **Conclusion**

Energy Resource Interconnection Service (ERIS): The benchmark case has 100% contingency loading on the Greenwood – Monaco 230kV line under a single contingency condition. Also, the Fountain Valley – Desertcove 115kV line and Fountain Valley – MidwayBR 115kV line are loading to 100% and 99.4% respectively for the double circuit outage of the Comanche – Daniels Park 345kV lines. Due to these pre-existing thermal overloads in the benchmark case, the GI-2017-3 output for ERIS is 0 MW for the studied generation dispatch scenario. However, higher generation output at the proposed facility may become feasible on an as-available basis depending on the prevailing dispatch of existing generation resources located in the electrical vicinity of GI-2017-3 (Jackson Fuller, Comanche, Midway and Lamar areas, CSU system and BHCE system).

Network Resource Interconnection Service (NRIS): The contingency overload of the Greenwood-Monaco 230kV line will need to be mitigated by upgrading six 1272 kcmil dual jumpers at PSCO's Monaco Substation to sufficiently increase the rating of the Greenwood-Monaco 230kV transmission line. Implementing the Network Upgrades needed to mitigate the above single contingency thermal overload on the BHCE system will allow GI-2017-3 to achieve full NRIS of 100MW. The Interconnection Customer has to work with BHCE in order to identify mitigation measures required to eliminate the overloads on these facilities caused due to GI-2017-3 interconnection. The cost estimates provided in this report do not include costs for eliminating the BHCE overloads.

## **Cost Estimates**

The total estimated cost of the recommended system improvements to interconnect the project is approximately \$3.207 million and includes:

- \$ 1.050 million for PSCo-Owned, Customer-Funded Transmission Provider Interconnection Facilities
- \$ 2.135 million for PSCo-Owned, PSCo-Funded Network Facilities for Interconnection
- \$ 0.022 million for PSCo Network Upgrades for Delivery to PSCo Loads

The estimated project duration is eighteen (18) months from the receipt of the Customer's Notice to Proceed (NTP) to the GI-2017-3 backfeed date. The cost estimates do not include costs for eliminating overloads on affected party facilities.

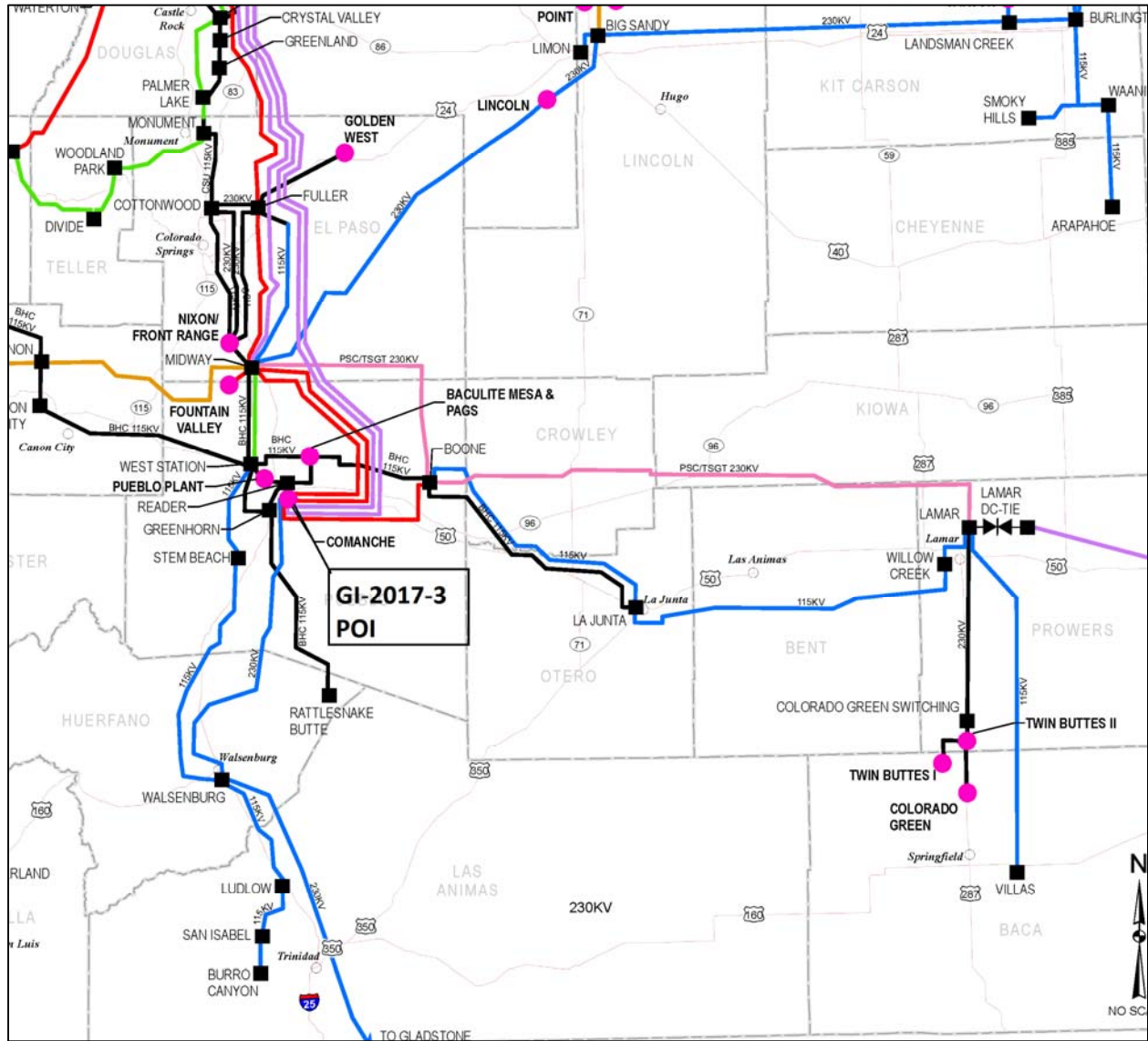


Figure 1 – GI-2017-3 Primary POI and Study area



## **Introduction**

The “GI-2017-3” (GI) is a 100MW solar photovoltaic generation facility that will be located in Pueblo County, Colorado. The GI request was received by PSCo on January 23, 2017 and a scoping meeting was held on February 1, 2017. This study report is based on the information provided by the Interconnection Customer (“Customer”) and assumptions stated in the Feasibility study agreement.

The Primary POI requested is at Comanche 230kV Substation. The Customer did not request an alternative POI to be studied.

The GI facility will consist of forty one (41) Sungrow 2.75MVA (2.5MW) inverters connected in four groups. Three of the groups will have an aggregate capacity of 25MW each and the fourth group will have an aggregate capacity of 27.5MW, resulting in a total capacity of 100MW at the POI after losses. Each group will connect to a 550v/34.5kV, 2750KVA transformer, which will be stepped up to 230kV using a 34.5/230kV, 68/90/113 MVA main step-up transformer. The GI facility will be connected to the POI using a 3.22-mile (17,000 feet) 361MVA, 795kcmil ACSR “Drake” 230kV tie-line owned by the Customer.

The proposed Commercial Operation Date (COD) of the GI are December 1, 2019. For the study purpose, backfeed date is assumed to be July 1, 2019, approximately six (6) months before the proposed COD.

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

PSCo load is assumed to be the sink for GI-2017-3 generation.

## **Study Scope and Analysis Criteria**

The scope of the feasibility study report includes steady state (power flow) analysis, short circuit analysis, a breaker duty study and indicative level cost estimates for the 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 Black Hills Colorado Electric (BHCE), Tri-State Generation and Transmission Inc. (TSGT), Colorado Springs Utilities (CSU) and Intermountain Rural Electric Association (IREA).

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

### **P0 - System Intact conditions:**

Thermal Loading:  $\leq 100\%$  of the normal facility rating



Voltage range: 0.95 to 1.05 per unit

P1-P2 – Single Contingencies:

Thermal Loading: <=100% Normal facility rating

Voltage range: 0.90 to 1.10 per unit

Voltage deviation: <=5% of pre-contingency voltage

P3-P7– Multiple Contingencies:

Thermal Loading: <=100% Emergency facility rating

Voltage range: 0.90 to 1.10 per unit

Voltage deviation: <=5% of pre-contingency voltage

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

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

Energy Resource Interconnection Service shall mean an Interconnection Service that allows the Interconnection Customer to connect its Generating Facility to the Transmission Provider's Transmission System to be eligible to deliver the Generating Facility's electric output using the existing firm or non-firm capacity of the Transmission Provider's Transmission System on an as available basis. Energy Resource Interconnection Service in and of itself does not convey transmission service.

Network Resource Interconnection Service shall mean an Interconnection Service that allows the Interconnection Customer to integrate its Large Generating Facility with the Transmission Provider's Transmission system (1) in a manner comparable to that in which the Transmission Provider integrates its generating facilities to serve native load customers; or (2) in an RTO or ISO with market based congestion management, in the same manner as all other Network Resources. Network Resource Interconnection Service in and of itself does not convey transmission service.

**Power Flow Study Models**

The study was performed using the Western Electricity Coordinating Council (WECC) 2022 Heavy Summer ("2022HS1") approved power flow case released on August 31, 2016. The case was reviewed by all effected parties to include updates. Some of the major changes included modeling of TSGT's 75MW Twin Buttes generation near Lamar 230kV bus (the expected in service date of December 12, 2017), PSCo's Rush Creek Generation (the expected in service date of 2018) and PSCo's Pawnee – Daniels Park 345kV Project (the expected in service date of 2019). Also, the Lamar – Burlington 230kV line is modeled out-of-service.

The generation in the study case was dispatched per PSCO renewable energy dispatch guidelines and resulted in a higher south-north flow on the Comanche – Midway – Jackson Fuller – Daniels Park transmission system.

The generation dispatch is given in Table-9 below. PSCo's generation in zones 700, 704, 709, 710 and 712 was dispatched such that wind generation is dispatched at 85% of name plate capacity, solar generation is dispatched at 80% of name plate capacity, conventional non-coal

generation is dispatched at 90% of name plate capacity and coal generation is dispatched at 100% of name plate capacity. The wind generation at Missile Site was dispatched at 40% name plate capacity.

The generation dispatch for the effected party's system was provided by the effected parties. The Lamar DC tie, the Colorado Green and the Twin Buttes wind generators are dispatched such that the total combined injection at the Lamar 230kV bus was 350MW.

The GI-2017-3 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-2017-3 interconnection – the benchmark case and the study case. The benchmark case modeled the system without GI-2017-3, whereas the study case included GI-2017-3. 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-2017-3.

Even though the Customer proposed COD is December 2019, a 2022HS1 case was used in order to study the effect of the Pawnee-Daniels park 345kV project.

### **Power Flow Study Process**

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

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

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

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

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

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 a case, only the additional facility rating increase (beyond the PSCo planned update) required to accommodate the NRIS will be attributed to the GI.

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

### Affected Parties

The study case was dispatched per PSCo renewable energy dispatch guidelines which resulted in a higher south-north flow on the Comanche – Midway – Jackson Fuller – Daniels Park transmission system. Affected party facilities include all new thermal violations with loading >100% are attributable to the GI interconnection. For pre-existing thermal violations, only the incremental overload above the benchmark case overload is attributed to the GI interconnection. The voltage violations attributed to the GI included any new voltage range and voltage deviation violations. Pre-existing voltage violations are attributed to the GI if the voltage range or voltage deviation change from the benchmark case is significant.

The study area is the electrical system consisting of PSCo's transmission system and the affected party's transmission system that is impacted or that will impact interconnection of the GI. The study area for GI-2017-3 includes WECC designated zones 121, 700, 703, 704, 705, 710, 712, 752 and 757.

### Voltage Regulation and Reactive Power Capability

The Customer is required to interconnect the Large Generating Facility with Public Service of Colorado's (PSCo) Transmission System in accordance with the *Xcel Energy Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater Than 20 MW* (available at:

<http://www.transmission.xcelenergy.com/staticfiles/microsites/Transmission/Files/PDF/Interconnection/Interconnections-POL-TransmissionInterconnectionGuidelineGreat20MW.pdf>).

Accordingly, the following voltage regulation and reactive power capability requirements at the POI are applicable to this interconnection request:

- To ensure reliable operation, all Generating Facilities interconnected to the PSCo transmission system are expected to adhere to the *Rocky Mountain Area Voltage Coordination Guidelines (RMAVCG)*. Accordingly, since the POI for this interconnection request is located within Southeast Colorado - Region 4 defined in the *RMAVCG*; the applicable ideal transmission system voltage profile range is 1.02 – 1.03 per unit at regulated buses and 1.0 – 1.03 per unit at non-regulated buses.
- Xcel Energy's OATT (Attachment N effective 10/14/2016) requires all non-synchronous Generator Interconnection (GI) Customers to provide dynamic reactive power within the power factor range of 0.95 leading to 0.95 lagging at the high side of the generator substation. Furthermore, Xcel Energy requires every Generating Facility to have dynamic voltage control capability to assist in maintaining the POI



voltage schedule specified by the Transmission Operator as long as the Generating Facility does not have to operate outside its 0.95 lag – 0.95 lead dynamic power factor range capability.

- It is the responsibility of the Interconnection Customer to determine the type (switched shunt capacitors and/or switched shunt reactors, etc.), the size (MVAR), and the locations (34.5 kV or 230 kV bus etc.) of any additional static reactive power compensation needed within the generating plant in order to have adequate reactive capability to meet the +/- 0.95 power factor and the 1.02 – 1.03 per unit voltage range standards at the POI. Further, for wind generating plants to meet the LVRT (Low Voltage Ride Through) performance requirements specified in FERC Order 661-A, an appropriately sized and located dynamic reactive power device (DVAR, SVC, etc.) may also need to be installed within the generating plant. Finally, it is the responsibility of the Interconnection Customer to compensate their generation tie-line to ensure minimal reactive power flow under no load conditions.
- The Interconnection Customer is required to demonstrate to the satisfaction of PSCo Transmission Operations prior to the commercial in-service date of the generating plant that it can safely and reliably operate within the required power factor and voltage ranges (noted above).

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

### **Power Flow Results**

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

#### **Single Contingency Analysis:**

The results of the single contingency analysis (P1 and P2) are given in Table-5. The results show that the interconnection of GI-2017-3 contributed to an increase in the existing thermal overloads on five (5) facilities and caused new overloads on two facilities. Out of these, the pre-GI and post-GI overloads on the Brairgate S – Cottonwood S 115kV (pre-existing overload), the Cottonwood N – KettleCreek S 115kV (pre-existing overload) and the Monument - Flyhorse N 115kV (new overload) were eliminated when the Palmer Lake Line operating procedure was implemented. The results of the single contingency analysis (P1 and P2) with the Palmer Lake line operating procedure implemented are given in Table-6. This operating procedure involves opening the Palmer Lake-Monument 115kV branch for certain overloads on the CSU system. PSCo has planned projects to remove the terminal equipment limitations on the following lines. The new ratings on these lines would be adequate to accommodate the post GI-2017-3 flows.

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

- Waterton – Martin2tap 115kV line rating will be increased from 127 to 139MVA (in-service 3/2019)

Based on the results of Table-5 & 6, the only facility overload attributable to the interconnection of GI-2017-3 is:

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

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

The addition of GI-2017-3 did not cause any new voltage violations and increases in the existing voltage violations are small as to not require mitigation. There were no voltage violations attributable to GI-2017-3 addition.

#### Multiple Contingency Analysis:

The results of the multiple contingency analyses are given in Table-7 and Table-8. The implementation of the Palmer Lake – Monument 115kV Line operating procedure eliminated some of the overloads on the CSU and IREA facilities as evident in the results shown in Table-9. Addition of GI-2017-3 did not cause any new voltage violations and increases in the existing voltage violations are small as to not require mitigation. There were no voltage violations attributable to GI-2017-3 addition.

The renewable resources in the study area were dispatched at 85% of the nameplate capacity resulting in a higher south – north flows on the Comanche – Midway – Jackson Fuller – Daniels Park transmission system, so multiple contingencies overloads on the PSCo facilities will be addressed by PSCo system readjustments (including generation curtailment) implemented via operating practices. PSCo facility overloads due to multiple contingencies are not considered attributable to the GI-2017-3 interconnection.

The incremental overloads on the following BHCE facilities are attributable to the interconnection of GI-2017-3:

- Fountain Valley – Desertcove 115kV line loading increased from 100% to 109.0%
- Fountain Valley – Midway BR 115kV line loading increased from 99.4% to 107.9%

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

#### **Short Circuit**

The calculated short circuit levels and Thevenin system equivalent impedances at the GI-2017-3 230kV Switching Station are tabulated below. The breaker duty study determined that no breaker replacements are needed in neighboring substations.

**Table 1 – Short Circuit Parameters at the GI-2017-3 230kV Switching Station**

	<b>Without GI-2017-3 Interconnection</b>	<b>After GI-2017-3 Interconnection</b>
Three phase Fault Current (A)	25695	25855
Single Line to Ground Fault Current (A)	30363	30610
Positive Sequence Impedance (Ohms)	0.322+j5.185	0.322+j5.185
Negative Sequence Impedance (Ohms)	0.341+j5.192	0.341+j5.192
Zero Sequence Impedance (Ohms)	0.170+j2.808	0.167+j2.771

### **Conclusion**

**Energy Resource Interconnection Service (ERIS):** The benchmark case has 100% loading on the Greenwood – Monaco 230kV line under single contingency condition. Also the fountain Valley – Desertcove and Fountain Valley – MidwayBR 115kV lines are loading to 100% and 99.4% respectively for the double circuit outage of the Comanche – Daniels Park 345kV lines. Due to these pre-existing thermal overloads in the benchmark case, GI-2017-3 output for ERIS is 0 MW for the studied generation dispatch. However, higher generation output may become feasible on an as-available basis depending on the prevailing dispatch of the existing generation resources located in the electrical vicinity of GI-2017-3 (Jackson Fuller, Comanche, Midway and Lamar areas, CSU system and BHCE system).

**Network Resource Interconnection Service (NRIS):** The contingency overload of the Greenwood-Monaco 230kV line will need to be mitigated by upgrading six 1272 kcmil dual jumpers at PSCO’s Monaco Substation to sufficiently increase the rating of the Greenwood-Monaco 230kV transmission line. Implementing the Network Upgrades needed to mitigate the above single contingency thermal overload on the BHCE system will allow GI-2017-3 to achieve full NRIS of 100MW. The Interconnection Customer has to work with BHCE in order to identify mitigation measures required to eliminate the overloads on these facilities caused due to GI-2017-3 interconnection. The cost estimates provided in this report do not include costs for eliminating the BHCE overloads.

### **Costs Estimates and Assumptions**

PSCo Engineering has developed indicative level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades required for the interconnection of the Interconnection Customer’s proposed generation facility. Indicative Estimates (IE) are based upon typical construction costs for previously performed similar construction projects; however they have no specified level of accuracy. The cost estimates are in 2017 dollars with escalation and contingencies applied. AFUDC is not included. These estimated costs include all applicable labor and overheads associated with the siting support, engineering, design, and construction of these new PSCo facilities. This estimate does not include the cost for any Customer owned equipment and associated design and engineering.



The estimated total cost for the required Interconnection Facilities and Network/Infrastructure Upgrades is \$3.207 million,

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

The following (Tables 2-4) 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.

The estimated project duration is eighteen (18) months from the receipt of the Customer's Notice to Proceed (NTP) to GI-2017-3 backfeed.

- Labor is estimated for straight time only – no overtime included.
- Lead times for materials were considered for the schedule.
- PSCo (or it's Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- Line and substation bus outages will be necessary during the construction period. Outage availability could potentially be problematic and extend requested backfeed date due.
- The cost estimates and schedule for this GI are completely independent of other queued projects and their respective in-service dates.
- Customer will string OPGW fiber into PSO's substation as part of the transmission line construction scope.
- The Customer will be required to design, procure, install, own, operate and maintain a Load Frequency/Automated Generation Control (LF/AGC) RTU at their Customer Substation. PSCo / Xcel will need indications, readings and data from the LFAGC RTU.
- Power Quality Metering (PQM) will be required on the Customer's 115 kV line terminating into Proposed Switching Station.
- The Customer's Generation Facility is not in PSCo's retail service territory. Therefore, no costs for retail load metering are included in these estimates.
- Line and substation bus outages will be necessary during the construction period. Outage availability could potentially be problematic and extend requested backfeed date due.

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

Element	Description	Cost Estimate (Millions)
<b>PSCo's Comanche 230kV Transmission Substation</b>	Interconnect Customer to the 230kV bus at the Proposed Switching Station. The new equipment includes: <ul style="list-style-type: none"> <li>• One (1) motor operated 230kV disconnect switch</li> <li>• Three (3) 230kV combination CT/PT metering units</li> <li>• Power Quality Metering (230kV line from Customer)</li> <li>• Three (3) surge arresters</li> <li>• Two (2) relay panels</li> <li>• Associated bus, wiring and equipment</li> <li>• Associated foundations and structures</li> <li>• Associated transmission line communications, relaying and testing</li> </ul>	<b>\$1.000</b>
	Transmission line tap into substation. Conductor, hardware, and installation labor.	<b>\$0.050</b>
	<b>Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities</b>	<b>\$1.050</b>
<b>Time Frame</b>	<b>Design, procure and construct</b>	<b>18 Months</b>

**Table 3: PSCo Owned; PSCo Funded Interconnection Network Facilities**

Element	Description	Cost Estimate (Millions)
<b>PSCo's Comanche 230kV Transmission Substation</b>	Interconnect Customer to the Comanche 230kV bus. The new equipment includes: <ul style="list-style-type: none"> <li>• Two (2) 230kV circuit breaker</li> <li>• Five (5) 230kV gang switches</li> <li>• One (1) 230kV CCVT</li> <li>• Associated communications, supervisory and SCADA equipment</li> <li>• Associated line relaying and testing</li> <li>• Associated bus, miscellaneous electrical equipment, cabling and wiring</li> <li>• Associated foundations and structures</li> <li>• Associated road and site development, fencing and grounding</li> </ul>	<b>\$2.000</b>

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

**Table 4 – PSCo Owned; Network Upgrades for Delivery**

<b>Element</b>	<b>Description</b>	<b>Cost Estimate (Millions)</b>
<b>PSCo's Monaco 230kV Transmission Substation</b>	Upgrade/replace limiting substation equipment to achieve required MVA ratings on circuit 5281 Monaco-Greenwood OH/UG Line: <ul style="list-style-type: none"> <li>• Six - 1272 dual jumpers</li> </ul>	<b>\$0.022</b>
	<b>Total Cost Estimate for PSCo Network Upgrades for Delivery Facilities</b>	<b>\$0.022</b>
<b>Time Frame</b>	<b>Design, procure and construct</b>	<b>18 months</b>
	<b>Total Project Estimate</b>	<b>\$3.207</b>



## A. Power Flow Contingency Analysis Results

### Notes –

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

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

				Facility Loading Without GI-2017-3		Facility Loading With GI-2017-3			
Monitored Facility (Line or Transformer)	Type	Owner	Branch Rating MVA (Norm/Emer)	N-1 Flow MVA	N-1 Flow % of Rating (Norm/Emer)	N-1 Flow MVA	N-1 Flow % of Rating (Norm/Emer)	% Change	NERC Single Contingency
Daniels Park – Prairie1 230kV	Line	PSCo	478/478	504.6	104.3%/104.3%	513.4	107.4%/107.4%	3.1%	Daniels Park – Prairie3 230kV
Greenwood – Monaco 230kV	Line	PSCo	405/481	408.1	100.0%/84.2%	422.3	104.3%/87.8%	4.3%	Smoky – Buckley – Tollgate – Jewell – Leetsdale 230kV
Palmer Lake – Monument 115kV	Line	PSCo/ CSU	142/157	145.7	102.6%/92.8%	155.5	109.5%/99.0%	6.9%	Daniels Park – Fuller 230kV
Waterton – Martin1 Tap 115kV	Line	PSCo	138/152	151.2	109.6%/99.5%	152.9	110.8%/100.6%	1.2%	Arapahoe 115/230kV #T5
Waterton – Martin 2 Tap 115kV	Line	PSCo	127/140	131.2	103.3%/93.7%	133.6	105.2%/95.4%	1.9%	Soda Lakes 115/230kV #T2
Brairgate S – Cottonwood S 115kV	Line	CSU	150/192	179.5	119.7%/93.5%	184.8	123.2%/96.2%	3.5%	Cottonwood N – KettleCreek S 115kV
Cottonwood N – KettleCreek S 115kV	Line	CSU	162/180	194.7	120.2%/108.2%	200.7	123.9%/111.5%	3.7%	Brairgate S – Cottonwood S 115kV
Monument – Flyhorse N 115kV	Line	CSU	142/157	137.3	96.7%/87.5%	146.5	103.2%/93.3%	6.5%	Daniels Park – Fuller 230kV



**Notes –**

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

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

				Facility Loading Without GI-2017-3		Facility Loading With GI-2017-3				
Monitored Facility (Line or Transformer)	Type	Owner	Branch Rating MVA (Norm/Emer)	N-1 Flow MVA	N-1 Flow % of Rating (Norm/Emer)	N-1 Flow MVA	N-1 Flow % of Rating (Norm/Emer)	% Change	NERC Single Contingency	
Daniels Park – Prairie1 230kV	Line	PSCo	478/478	504.8	105.6%/105.6%	517.2	108.2%/108.2%	2.6%	Daniels Park – Prairie3 230kV	
Greenwood – Monaco 230kV	Line	PSCo	405/481	405	100.0%/84.2%	417.1	103.0%/86.7%	3.0%	Smoky – Buckley – Tollgate – Jewell – Leetsdale 230kV	
Palmer Lake – Monument 115kV	Line	PSCo/CSU	142/157	N/A	N/A	N/A	N/A	N/A	N/A	
Waterton – Martin1 Tap 115kV	Line	PSCo	138/152	149.6	108.4%/98.4%	152.3	110.4%/100.2%	2.0%	Arapahoe 115/230kV #T5	
Waterton – Martin 2 Tap 115kV	Line	PSCo	127/140	128.1	100.9%/91.5%	131.4	103.5%/93.9%	2.6%	Soda Lakes 115/230kV #T2	
Brairgate S – Cottonwood S 115kV	Line	CSU	150/192	139.8	93.2%/72.8%	144.6	96.4%/75.1%	2.9%	Cottonwood N – KettleCreek S 115kV	
Cottonwood N – KettleCreek S 115kV	Line	CSU	162/180	146.3	90.3%/81.3%	151.5	93.5%/84.1%	3.2%	Brairgate S – Cottonwood S 115kV	
Monument – Flyhorse N 115kV	Line	CSU	142/157	53	37.3%/33.7%	59.6	42.0%/38.0%	4.7%	Daniels Park – Fuller 230kV	





**Notes –**

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

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

				Facility Loading Without GI-2017-3		Facility Loading With GI-2017-3			
Monitored Facility (Line or Transformer)	Type	Owner	Branch Rating MVA (Norm/Emer)	Flow MVA	Flow % of Rating (Norm/Emer)	Flow MVA	Flow % of Rating (Norm/Emer)	% Change	NERC Multiple Contingency
Arapahoe – SantaFe 230kV	Line	PSCo	300/319	313.8	104.6%/98.4%	325.2	108.4%/101.9%	3.5%	Breaker Failure: Greenwood 230kV
Daniels Park – SantaFe 230kV	Line	PSCo	319/319	353.4	110.8%/110.8%	365.6	114.6%/114.6%	3.8%	Breaker Failure: Greenwood 230kV
Daniels Park – Fuller 230kV	Line	PSCo	478/478	536.3	112.2%/112.2%	571.2	119.5%/119.5%	7.3%	Double Ckt: Comanche – Daniels park 345kV #1 & 2
Fountain Valley – Desertcove 115kV	Line	BHCE	119/119	119	100.0%/100.0%	129.7	109.0%/109.0%	9.0%	Double Ckt: Comanche – Daniels park 345kV #1 & 2
Fountain Valley – MidwayBR 115kV	Line	BHCE	119/119	118.3	99.4%/99.4%	128.4	107.9%/107.9%	8.5%	Double Ckt: Comanche – Daniels park 345kV #1 & 2
Midway 230kV Tie	Line	PSCo/ WAPA	430/478	571.9	133.0%/119.6%	606.3	141.0%/126.8%	8.4%	Double Ckt: Midway – Waterton 345kV & Midway – Fuller 230kV
Palmer Lake – Monument 115kV	Line	CSU/PS Co	142/157	222.4	156.6%/141.6%	236.4	166.5%/150.6%	9.0%	Double Ckt: Midway – Waterton 230kV & Daniels Park – Fuller 230kV
Waterton – Martin1 tap 115kV	Line	PSCo	138/152	155.3	112.5%/102.2%	157.7	114.3%/103.8%	1.6%	Double Ckt: Soda Lakes – Chatfield- Waterton 230kV & Soda lakes-Deer Creek – Martin – Waterton 115kV
Waterton – Martin2 Tap 115kV	Line	PSCo	127/140	142.5	112.2%/101.8%	145.7	114.7%/104.0%	2.2%	Breaker Failure: Soda Lakes 230kV
Greenland – Crystal Valley 115kV	Line	IREA	162/178.2	174.8	107.9%/98.1%	186.1	114.9%/104.4%	6.3%	Double Ckt: Midway – Waterton 230kV & Daniels Park – Fuller 230kV
Cottonwood N – KettleCreek S 115kV	Line	CSU	162/180	196.7	121.4%/109.3%	205.7	127.0%/114.3%	5.0%	Double Ckt: Midway – Waterton 230kV & Daniels Park – Fuller 230kV

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

Monitored Facility (Line or Transformer)	Type	Owner	Branch Rating MVA (Norm/Emer)	Facility Loading Without GI-2017-3		Facility Loading With GI-2017-3		% Change	NERC Multiple Contingency
				Flow MVA	Flow % of Rating (Norm/Emer)	Flow MVA	Flow % of Rating (Norm/Emer)		
Monument - Flyhorse N 115kV	Line	CSU	142/157	208.9	147.1%/133.0%	222.1	156.4%/141.4%	8.4%	Double Ckt: Midway – Waterton 230kV & Daniels Park – Fuller 230kV
Flyhorse S - KettleCreek N 115kV	Line	CSU	162/180	222.4	137.3%/123.6%	235.7	145.5%/131%	7.4%	Double Ckt: Midway – Waterton 230kV & Daniels Park – Fuller 230kV
Palmer Lake – Greenland 115kV	Line	IREA	162/178.2	180.63	111.5%/101.4%	192	118.5%/107.7%	6.3%	Double Ckt: Midway – Waterton 230kV & Daniels Park – Fuller 230kV

**Notes –**

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

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

				Facility Loading Without GI-2017-3		Facility Loading With GI-2017-3			
Monitored Facility (Line or Transformer)	Type	Owner	Branch Rating MVA (Norm/Emer)	Flow MVA	Flow % of Rating (Norm/Emer)	Flow MVA	Flow % of Rating (Norm/Emer)	% Change	NERC Multiple Contingency
Arapahoe – SantaFe 230kV	Line	PSCo	300/319	318.1	106.0%/99.7%	329.8	109.9%/103.4%	3.7%	Breaker Failure: Greenwood 230kV
Daniels Park – SantaFe 230kV	Line	PSCo	319/319	357.8	112.2%/112.2%	369.6	115.9%/115.9%	3.7%	Breaker Failure: Greenwood 230kV
Daniels Park – Fuller 230kV	Line	PSCo	478/478	625.5	130.8%/130.8%	669.7	140.1%/140.1%	6.9%	Double Ckt: Comanche – Daniels park 345kV #1 & 2
Fountain Valley – Desertcove 115kV	Line	BHCE	119/119	115.1	96.7%/96.7%	125.8	105.7%/105.7%	5.5%	Double Ckt: Comanche – Daniels park 345kV #1 & 2
Fountain Valley – MidwayBR 115kV	Line	BHCE	119/119	113.8	95.6%/95.6%	124.3	104.5%/104.5%	4.9%	Double Ckt: Comanche – Daniels park 345kV #1 & 2
Midway 230kV Tie	Line	PSCo/WAPA	430/478	542.4	126.1%/113.5%	575.3	133.8%/120.4%	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	N/A
Waterton – Martin1 tap 115kV	Line	PSCo	138/152	153.3	111.1%/100.9%	155.6	112.8%/102.4%	3.5%	Double Ckt: Soda Lakes – Chatfield-Waterton 230kV & Soda Lakes-Deer Creek – Martin – Waterton 115kV
Waterton – Martin2 Tap 115kV	Line	PSCo	127/140	141.3	111.3%/101%	142.6	112.3%/101.8%	3.3%	Breaker Failure: Soda Lakes 230kV
Greenland – Crystal Valley 115kV	Line	IREA	162/178.2	7.2	4.5%/4.0%	7.2	4.5%/4.0%	0%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Cottonwood N – KettleCreek S 115kV	Line	CSU	162/180	113.3	69.9%/62.9%	117.1	72.3%/65.3%	4.8%	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**

Monitored Facility (Line or Transformer)	Type	Owner	Branch Rating MVA (Norm/Emer)	Facility Loading Without GI-2017-3		Facility Loading With GI-2017-3		% Change	NERC Multiple Contingency
				Flow MVA	Flow % of Rating (Norm/Emer)	Flow MVA	Flow % of Rating (Norm/Emer)		
Monument - Flyhorse N 115kV	Line	CSU	142/157	85.7	60.3%/54.6%	91.2	64.2%/58.1%	6.5%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Flyhorse S - KettleCreek N 115kV	Line	CSU	162/180	99.3	61.3%/55.2%	104.8	64.7%/58.2%	5.9%	Double Ckt: Midway – Waterton 345kV & Daniels Park – Fuller 230kV
Palmer Lake – Greenland 115kV	Line	IREA	162/178.2	3.1	1.8%/1.7%	3.1	1.9%/1.7%	0%	Double Ckt: Midway – Waterton 230kV & Daniels Park – Fuller 230kV

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

**PSCo:**

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

**BHE:**

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



Rattle snake Wind      G1                      8

**CSU:**

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

**TSGT:**

<b><u>Bus</u></b>	<b><u>LF ID</u></b>	<b><u>MW</u></b>
San Isabel Solar	S1	25.67
Twin Butte-II	W1	60

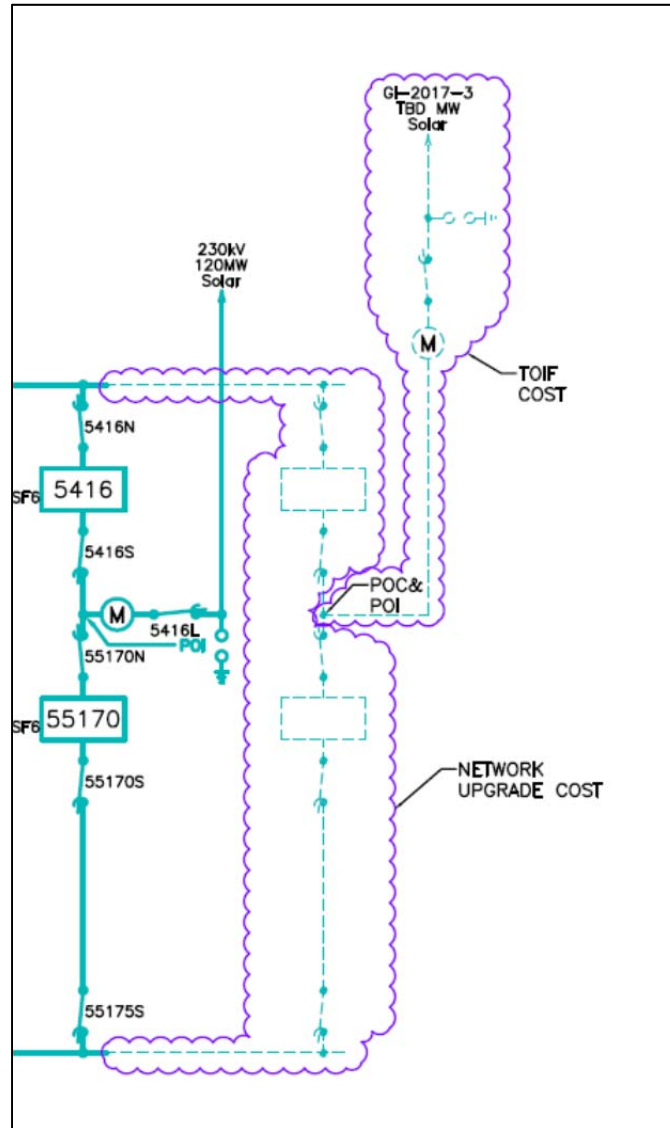


Figure 2- GI-2017-3 Substation One-line Diagram