Feasibility Study Report
Generation Interconnection Request # GI-2016-11

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

Transmission Planning West
Xcel Energy
January 25, 2017

Executive Summary

This report evaluates the feasibility of interconnecting GI-2016-11, a 100MW expansion of GI-2014-8 (a 60MW solar photovoltaic generation facility), resulting in a total combined capacity of 160MW interconnection at the Boone 230kV bus. The generation facility will consist of KACO new energy BP1000 PV inverters. The Primary Point of Interconnection (POI) requested by GI-2016-11 is the Boone 230kV Substation, the same primary POI as GI-2014-8. Both GI-2016-11 and GI-2014-8 will interconnect to the Primary POI using a single Interconnection Customer owned 230kV tie-line and will use the same POI. The Interconnection Customer did not request a secondary POI.

The proposed Commercial Operation Date (COD) of both GI-2014-8 and GI-2016-11 is December 31, 2018. The backfeed date is assumed to be June 31, 2018 for this study purpose, approximately six months before the COD. As agreed in the study agreement, this study evaluated the feasibility of interconnecting a 100MW solar photovoltaic facility in addition to the 60MW as part of GI-2014-8. The GI-2016-11 generation interconnection study request is for both Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection Service (ERIS). PSCo load is assumed to be the sink for GI-2016-11 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 2018 heavy summer base case by simulating heavy south-north flow on the Comanche – Midway – Jackson Fuller – Daniels Park transmission path.

The GI-2016-11 interconnection request was studied as a stand-alone project. That is, the study did not include any prior-queued GI requests existing in PSCo's or any affected party's GI queue except those which are:
(a) considered to be PSCo planned resources in recognition of their signed Power Purchase Agreements, or
(b) assumed in-service as per the agreed-upon study assumptions with the Interconnection Customer.

As requested by the Interconnection Customer, the GI-2016-11 interconnection request was studied by assuming the prior-queued GI-2014-8 is in-service at 60 MW electrical output. Since

both GI requests have the same POI, this study effectively determines the feasibility of 160 MW aggregate electrical output injected at the Boone 230kV bus.

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

Steady State contingency analysis results:

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

The following single contingency thermal violations on PSCo facilities are attributable to the GI-2016-11 addition:

- Daniels Park – Prairie1 230kV line thermal loading was 100.8% in the benchmark case, 104% after the GI-2014-8 addition, and increased to 109.1% after the GI-2016-11 addition.
- Portland – Skala 115kV line thermal loading was 99.5% in the benchmark case, 102.4% after the GI-2014-8 addition, and increased to 107.2% after the GI-2016-11 addition.

PSCo has a planned project to increase the rating of the Daniels Park – Priaire1 230kV line. The new line rating would be adequate to eliminate the post GI-2016-11 thermal overload on this line; therefore the cost for increasing the line rating of this line would not be attributed to GI-2016-11.

The addition of GI-2016-11 did not cause any new voltage violations and increases in the existing voltage violations are too small to require monitoring. There were no voltage violations attributable to the GI-2016-11 addition.

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-2016-11

- Canyon City – Skala 115kV line
- Fountain Valley – DesertCove 115kV line
- Fountain Valley – Midway BR 115kV line
- Portland – Skala 115kV line
- Desertcove – West Station 115kV line
- West Canyon 230/115kV #T1 transformer

The incremental overload on the following CSU facility is attributable to the interconnection of GI-2016-11

- Fountain Valley – RD_Nixon 115kV line
- Monument – Gresham 115kV line

The incremental overloads on the following TSGT facilities are attributable to the interconnection of GI-2016-11

- BLKFORTP – BLK SQMV line loading increased from 194.3% to 197.4%
- BLK SQMV – Fuller 115kV line loading increased from 125% to 126.8%

Incremental overloads on PSCO facilities (after the addition of the GI-2016-11 interconnection) for multiple contingencies were observed. However, 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 will not be attributed to the GI-2016-11 interconnection.

Short Circuit

The GI-2016-11 is a solar photovoltaic facility, so the fault current contribution from the inverters is minimal and not long enough to cause breaker duty to exceed. No breaker duty violations are attributable to GI-2016-11 interconnection. The breaker duty study determined that no breaker replacements are needed at the Boone Substation or at neighboring substations.

Energy Resource Interconnection Service (ERIS): GI-2016-11 output for ERIS is 0 MW for the studied generation dispatch scenario due to the single contingency overload on the BHCE system and multiple contingency thermal overloads on the CSU, BHCE and TSGT facilities listed above. However, higher output may become feasible on an as-available basis depending on the prevailing dispatch of existing generation resources located in the electrical vicinity of GI-2016-11 (Jackson Fuller, Comanche, Midway and Lamar areas, CSU system and BHCE system).

Network Resource Interconnection Service (NRIS): Implementing the Network Upgrades needed to mitigate the above mentioned thermal overloads on CSU, TSGT and BHCE systems will allow GI-2016-11 to achieve full NRIS of 100MW. The Interconnection Customer has to work with CSU, TSGT and BHCE in order to identify mitigation measures to eliminate the above mentioned CSU and BHCE facility overloads attributed to GI-2016-11 interconnection.

Cost Estimates

The cost for the transmission interconnection (in 2016 dollars):

The total estimated cost of the recommended system improvements to interconnect the project is approximately **$2.726 Million** and includes:

- $ 1.381 Million for PSCo-Owned, Interconnection Customer-Funded Interconnection Facilities
- $ 1.345 Million for PSCo-Owned, PSCo-Funded Network Upgrades for Interconnection
- $ 0 for PSCo Network Upgrades for Delivery to PSCo Loads

This work can be completed in 18 months following receipt of authorization to proceed. The cost estimates for BHCE, TSGT and CSU Network Upgrades attributed to GI-2016-11 are not included in this report.

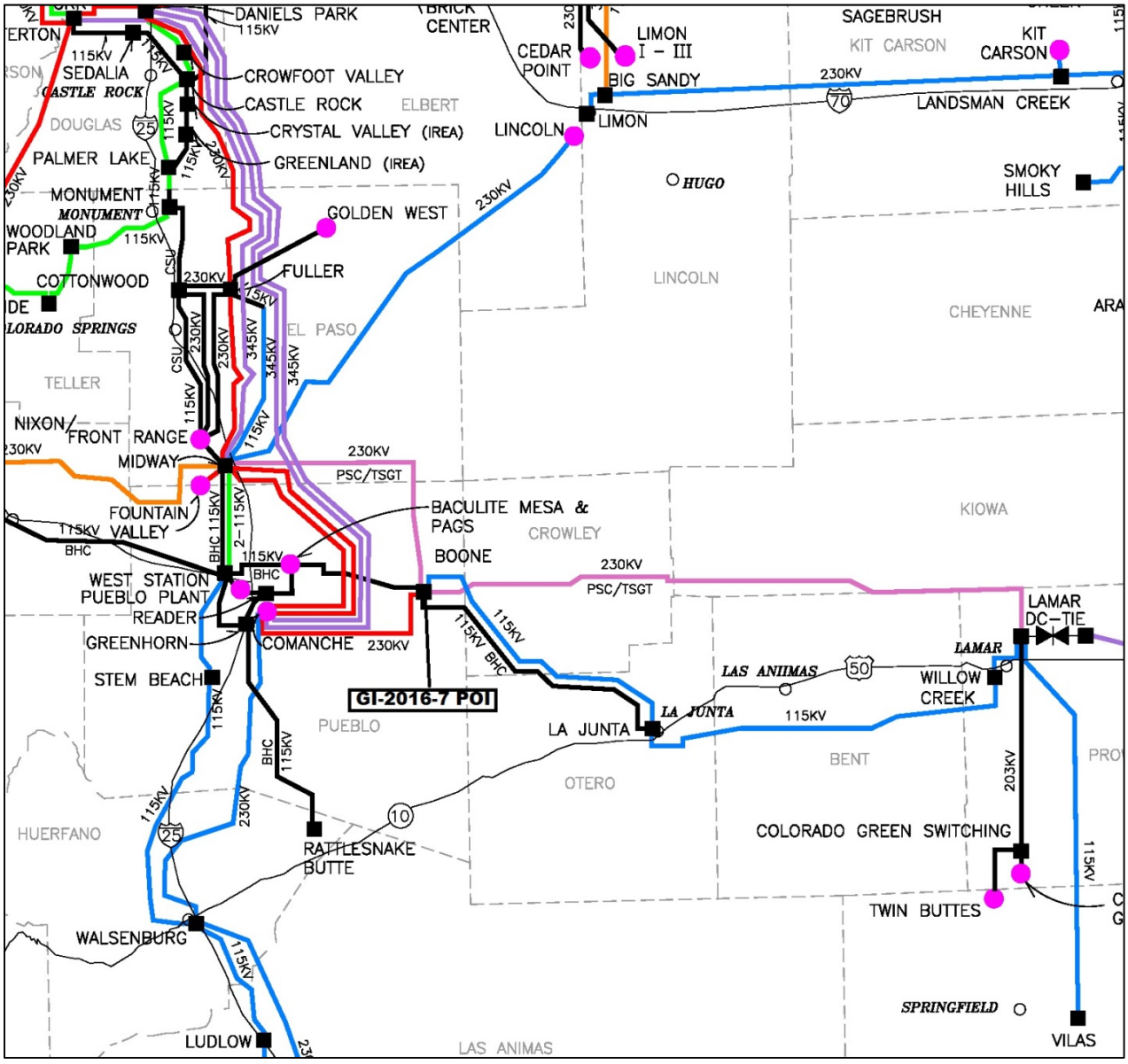

Figure 1 - GI-2016-11 Boone Point of Interconnection and Study Area

Introduction

The “GI-2016-11” (GI) is a 100MW solar photovoltaic generation facility located in Pueblo County, Colorado. The GI request was received by PSCo on June 9, 2016 and a scoping meeting was held on July 8, 2016. The GI-2016-11 will be an expansion of GI-2014-8 which is a 60MW solar photovoltaic generation facility, resulting in a total combined generation capacity of 160MW. The GI-2016-11 solar photovoltaic generation facility will be comprised of KACO new energy BP1000 PV inverters.

The Primary Point of Interconnection (POI) requested by GI-2016-11 is the Boone 230kV Substation, the same primary POI as GI-2014-8. Both GI-2016-11 and GI-2014-8 will interconnect to the Primary POI using a single Interconnection Customer owned 230kV tie-line and will use the same POI. The Interconnection Customer did not request a secondary POI.

The proposed Commercial Operation Date (COD) of both GI-2014-8 and GI-2016-11 is December 31, 2018. The backfeed date is assumed to be June 31, 2018 for this study purpose, approximately six months before the COD. As agreed in the study agreement this study evaluated the feasibility of interconnection 100MW solar photovoltaic facility in addition to the 60MW as part of GI-2014-8.

The GI-2016-11 generation interconnection study request is for both Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection Service (ERIS).

PSCo load is assumed to be the sink for GI-2016-11 generation.

Study Scope and Analysis Criteria

GI-2016-11 is a 100MW expansion of GI-2014-8. As stated in the study agreement, this report identified the feasibility of interconnecting the additional 100MW generation capacity requested in GI-2016-11. Due to the existing system changes anticipated for 2018 with completion of GI-2014-8, this study also re-evaluated the thermal analysis of GI-2014-8; however, the report mainly addresses the feasibility of interconnecting the GI-2016-11 expansion.

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-2014-8 and the expansion by GI-2016-11. 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-2014-8 and additional capacity expansion requested by GI-2016-11.

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.

The GI-2016-11 expansion 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.

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), the 30MW San Isabel Solar generator interconnected on the Ludlotap – Pinoncanyon 115kV line (existing facility), the replacement of the Lamar 230/115kV transformer #T1 with a 150MVA unit (expected in-service date of 12/2017) and the 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-9 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-2016-11 interconnection request was studied as a stand-alone project. That is, the study did not include any prior-queued GI requests existing in PSCo's or any affected party's GI queue except those which are:
(a) considered to be PSCo planned resources in recognition of their signed Power Purchase Agreements, or
(b) assumed in-service as per the agreed-upon study assumptions with the Interconnection Customer.

As requested by the Interconnection Customer, the GI-2016-11 interconnection request was studied by assuming the prior-queued GI-2014-8 is in-service at 60 MW electrical output. Since both GI requests have the same POI, this study effectively determines the feasibility of 160 MW aggregate electrical output injected at the Boone 230kV bus.

Three power flow cases were created for evaluating the feasibility of GI-2016-11 expansion interconnection – the benchmark case, GI-2014-8 study case and GI-2016-11 the study case. The benchmark case modeled the system without GI-2014-8 and GI-2016-11, the GI-2014-8 study case modeled the 60MW solar photovoltaic facility interconnection at Boone 230kV bus, and the GI-2016-11 study case modeled a 160MW solar photovoltaic generation facility at Boone 230kV bus. 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 modeled generation addition in GI-2014-8 study case and GI-2016-11 study case.

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 cases, and the results were compared.

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

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

For effected party facilities, all new thermal violations with loading >100% are attributable to the GI interconnection. For pre-existing thermal violations, only the incremental loading increase is attributed to the GI interconnection.

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

The study area is the electrical system consisting of PSCo's transmission system and the affected party's transmission system that is impacted or that will impact interconnection of the GI. The study area for GI-2016-11 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, GI-2014-8 study case and GI-2016-11 study case did not have any system intact (P0) thermal or voltage violations. The tables 5, 6, 7 and 8 show the results of the thermal analysis as a result of GI-2014-8 addition and GI-2016-11 100MW expansion.

The results of single contingency analysis are given in Table-5. Addition of GI-2016-11 caused one new overload and increased existing thermal overloads caused by GI-2014-8 addition. The implementation of the Palmer Lake – Monument 115kV line operating procedure mitigated all overloads except Daniels Park – Paririe1 230kV line (PSCo facility) overload and Portland – Skala 115kV line (BHCE facility) overload. The results of the steady state analysis after implementing the Palmer Lake – Monument 115kV line operating procedure are given in Table-6. These two overloads are attributable to the interconnection of GI-2016-11.

PSCo has a project planned to increase the line rating of the Daniels Park – Prairie1 230kV line by upgrading the terminal equipment. The new rating of this line would be adequate to eliminate the post GI-2016-11 thermal overload, so cost estimates to increase the rating of this line are not included in Table-4 below.

The single contingency analysis 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-2016-11 addition.

Multiple Contingency Analysis:

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

The incremental overloads on the following BHCE facilities are attributable to the interconnection of GI-2016-11

- Canyon City – Skala 115kV line
- Fountain Valley – DesertCove 115kV line
- Fountain valley – Midway BR 115kV line
- Portland – Skala 115kV line
- Desertcove – West Station 115kV line
- West Canyon 230/115kV #T1 transformer

The incremental overload on the following CSU facility is attributable to the interconnection of GI-2016-11

- Fountain Valley – RD_Nixon 115kV line
- Monument – Gresham 115kV line

The incremental overloads on the following TSGT facilities are attributable to the interconnection of GI-2016-11

- BLKFORTP – BLK SQMV line loading increased from 194.3% to 197.4%
- BLK SQMV – Fuller 115kV line loading increased from 125% to 126.8%

Incremental overloads on PSCO facilities (after the addition of the GI-2016-11 interconnection) for multiple contingencies were observed. However, 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 will not be attributed to the GI-2016-11 interconnection.

Short Circuit

The GI-2016-11 is a solar photovoltaic facility, so the fault current contribution from the inverters is minimal and the duration not long enough to cause breaker duties to be exceeded. No breaker duty violations are attributable to GI-2016-11 addition. The breaker duty study determined that no breaker replacements are needed at Boone Substation or at neighboring substations.

The calculated short circuit levels and Thevenin system equivalent impedances at the Boone 230kV POI are tabulated below.

Table 1 – Short Circuit Parameters at the Boone 230 kV POI

System Condition	Three-Phase Fault Level (Amps)	Single-Line-to-Ground Fault Level (Amps)	SLG X/R	3 Phase X/R
System Intact	9505.7	8629.8	13.871	10.089

Conclusion

Energy Resource Interconnection Service (ERIS): GI-2016-11 output for ERIS is 0 MW for the studied generation dispatch scenario due to the single contingency marginal loading on the Daniels Park – Priaire1 230kV line in the benchmark case, and the benchmark case multiple contingency thermal overloads on the BHCE and TSGT facilities listed above. However, higher output may become feasible on an as-available basis depending on the prevailing dispatch of existing generation resources located in the electrical vicinity of GI-2016-11 (Jackson Fuller, Comanche, Midway and Lamar areas, CSU system and BHCE system).

Network Resource Interconnection Service (NRIS): Implementing the Network Upgrades needed to mitigate the above mentioned thermal overloads on CSU, TSGT and BHCE systems will allow GI-2016-11 to achieve full NRIS of 100MW. The Interconnection Customer has to

work with CSU, TSGT and BHCE in order to identify mitigation measures to eliminate the above mentioned CSU and BHCE facility overloads attributed to GI-2016-11 interconnection.

Costs Estimates and Assumptions

PSCo Engineering has developed Indicative level (IE) cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery. Indicative Estimates are based upon typical construction costs for previously performed similar construction projects; however they have no specified level of accuracy. The cost estimates are in 2016 dollars with escalation and contingencies applied (AFUDC is not included) and are based upon typical construction costs for previously performed similar construction. 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 **$2,726,000.**

Figure 2 below is a conceptual one-line of the proposed interconnection. The Point of Interconnection will be the Boone 230kV Transmission substation.

The following (Tables 2, 3 and 4) list the improvements required to accommodate the interconnection and the delivery of the customer's combined 160 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.

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- Indicative level project cost estimates for Interconnection Facilities were developed by PSCo Engineering. No level of accuracy is specified for Indicative Estimates
- 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 it's Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- The estimated time to design, procure and construct the interconnection facilities is approximately 18 months after authorization to proceed has been obtained.
- This project is completely independent of other queued projects and their respective ISD's.
- A CPCN will not be required for the interconnection facilities 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 Boone Substation.

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

Element	Description	Cost Est. (Millions)
PSCo's Boone 230kV Transmission Substation	Interconnect Customer to the 230kV bus at the Boone Substation. 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	**$1.280**
	Transmission line tap into substation. Conductor, hardware, and installation labor.	**$0.101**
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	**$1.381**
Time Frame	**Design, procure and construct**	**18 Months**

Table 3: PSCo Owned; PSCo Funded Interconnection Network Facilities

Element	Description	Cost Estimate (Millions)
PSCo's Boone 230kV Transmission Substation	Interconnect Customer to the 230kV bus at the Boone 230kV Substation. The new equipment includes: • One (1) 230kV circuit breaker • Two (2) 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	**$1.345**
	Siting and Land Rights support for substation land acquisition and construction.	**$0.000**
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	**$1.345**
Time Frame	**Site, design, procure and construct**	**18 Months**

Table 4 – PSCo Network Upgrades for Delivery

Element	Description	Cost Est. (Millions)
	None identified at this time.	
	Total Cost Estimate for PSCo Network Upgrades for Delivery	**$0.00**
	Design, procure and construct	**N/A**
	Total Project Estimate	**$2.726**

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 Palmer Lake– Monument 115kV Line Operating Procedure

				Facility Loading Pre GI System		Facility Loading With GI-2014-8			Facility Loading With GI-2016-11			
Monitored Facility (Line or Transformer)	**Type**	**Owner**	**Branch Rating MVA (Norm/ Emer)**	**N-1 Flow MVA**	**N-1 Flow % of Rating**	**N-1 Flow MVA**	**N-1 Flow % of Rating**	**% Change**	**N-1 Flow MVA**	**N-1 Flow % of Rating**	**% Change (over GI-2014-8)**	**NERC Single Contingency**
Daniels Park – Prairie1 230kV	Line	PSCo	478/478	477.5	99.9%/99.9%	492.3	103.0%/103.0%	3.1%	516.2	108.0%/108.0%	5.0%	Daniels Park – Prairie3 230kV Line
Midway 230kV Bus tie	Line	PSCo/ WAPA	430/478	300.4	90.8%/81.7%	409.8	95.3%/85.7%	4.5%	442.9	103.0%/92.7%	7.7%	MidwayPS – Jackson Fuller 230kV
Portland – Skala 115kV	Line	BHCE	111/111	108.7	97.9%/97.9%	111.8	100.7%/100.7%	2.8%	117	105.4%/105.4%	4.7%	MidwayBR – West Canyon 230kV
Cottonwood N - KettleCreek S 115kV	Line	CSU	162/180	191.2	118%/106.2%	194.8	120.3%/108.2%	2.0%	200.9	124.0%/111.6%	3.4%	Brairgate S – Cottonwood S 115kV
BLKFORTP – BLK SQMV 115kV	Line	TSGT	81/81	84.6	104.4%/104.4%	87.2	107.7%/107.7%	3.3%	91.6	113.1%/113.1%	5.4%	Flyhorse S – Kettlecreek N 115kV
Fuller 230/115kV	Xfmr	TSGT	100/100	100	100.0%/100.0%	100.8	100.8%/100.8%	0.8%	102	102.0%/102.0%	1.6%	MidwayBR – 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 Palmer Lake– Monument 115kV Line Operating Procedure

				Facility Loading Pre GI System		Facility Loading With GI-2014-8			Facility Loading With GI-2016-11			
Monitored Facility (Line or Transformer)	**Type**	**Owner**	**Branch Rating MVA (Norm/ Emer)**	**N-1 Flow MVA**	**N-1 Flow % of Rating**	**N-1 Flow MVA**	**N-1 Flow % of Rating**	**% Change**	**N-1 Flow MVA**	**N-1 Flow % of Rating**	**% Change (over GI-2014-8)**	**NERC Single Contingency**
Daniels Park – Prairie1 230kV	Line	PSCo	478/478	481.8	100.8%/100.8%	497.1	104.0%/104.0%	3.2%	521.5	109.1%/109.1%	5.1%	Daniels Park – Prairie3 230kV Line
Midway 230kV Bus tie	Line	PSCo/ WAPA	430/478	370.2	86.1%/77.4%	388.6	90.4%/81.3%	4.3%	420.11	97.7%/87.9%	7.3%	MidwayPS – Jackson Fuller 230kV
Portland – Skala 115kV	Line	BHCE	111/111	110.4	99.5%/99.5%	113.7	102.4%/102.4%	2.9%	119	107.2%/107.2%	4.8%	MidwayBR – West Canyon 230kV
Cottonwood N - KettleCreek S 115kV	Line	CSU	162/180	147.7	91.2%/82.1%	149.3	92.2%/82.9%	0.8%	151.8	93.7%/84.3%	1.4%	Brairgate S – Cottonwood S 115kV
BLKFORTP – BLK SQMV 115kV	Line	TSGT	81/81	68.9	85%/85%	70.3	86.8%/86.8%	1.8%	72.7	89.8%/89.8%	3.0%	Flyhorse S – Kettlecreek N 115kV
Fuller 230/115kV	Xfmr	TSGT	100/100	86.9	86.9%/86.9%	87.1	87.1%/87.1%	0.3%	87.3	87.3%/87.3%	0.2%	MidwayBR – 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.
3. For Double 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 Palmer Lake– Monument 115kV Line Operating Procedure

				Facility Loading Pre GI System		Facility Loading With GI-2014-8			Facility Loading With GI-2016-11			
Monitored Facility (Line or Transformer)	**Type**	**Owner**	**Branch Rating MVA (Norm /Emer)**	**Flow MVA**	**Flow % of Rating**	**Flow MVA**	**Flow % of Rating**	**% Change**	**Flow MVA**	**Flow % of Rating**	**% Change (over GI-2014-8)**	**NERC Multiple Contingency**
Arapahoe – SantaFe 230kV	Line	PSCo	300/319	295.5	98.5%/92.6%	305.6	101.9%/95.8%	3.2%	321.6	107.2%/100.8%	5.0%	Double Ckt: Daniels Park – Prairie – Greenwood 230kV 1&2
Daniels Park – SantaFe 230kV	Line	PSCo	319/319	332.4	104.2%/104.2%	342.5	107.4%/107.4%	3.2%	358.9	112.5%/112.5%	5.1%	Double Ckt: Daniels Park – Prairie – Greenwood 230kV 1&2
Canyon City – Skala 115kV	Line	BHCE	119/119	110.2	92.6%/92.6%	113.9	95.8%/95.8%	3.2%	120.2	101%/101%	5.2%	Breaker Failure: MidwayPS – J.Fuller 230kV
Fountain Valley – DesertCove 115kV	Line	BHCE	119/119	150.9	126.8%/126.8%	157.9	132.7%/132.7%	5.9%	169.3	142.3%/142.3%	9.6%	Breaker Failure: MidwayPS – J.Fuller 230kV
Fountain Valley – MidwayBR 115kV	Line	BHCE	119/119	149.7	125.8%/125.8%	156.7	131.7%/131.7%	5.9%	168.1	141.3%/141.3%	9.6%	Breaker Failure: MidwayPS – J.Fuller 230kV
DesertCove – West Station 115kV	Line	BHCE	119/119	172.2	144.7%/144.7%	179.3	150.6%/150.6%	5.9%	190.8	160.3%/160.3%	9.7%	Breaker Failure: MidwayPS – J.Fuller 230kV
Portland – Skala 115kV	Line	BHCE	111/111	115.2	103.8%/103.8%	119	107.2%/107.2%	3.4%	125.3	112.9%/112.9%	5.7%	Breaker Failure: MidwayPS – J.Fuller 230kV
Midway 230kV Bus tie	Line	PSCo/ WAPA	430/478	565.0	131.4%/118.2%	591.3	137.5%/123.7%	5.5%	635.5	147.8%/132.9%	9.2%	Double Ckt: MidwayPS – Waterton 345kV & MidwayPS – J. Fuller 230kV
Palmer Lake – Monument 115kV	Line	PSCo/ CSU	142/157	182.7	128.7%/116.4%	191.9	134.6%/121.7%	5.3%	204.6	144.1%/130.3%	8.6%	Double Ckt: MidwayPS – Waterton 345kV & Daniels Park – J. Fuller 230kV
Cottonwood N – Kettle Creek S 115kV	Line	CSU	162/180	187.8	115.9%/104.3%	193.6	119.5%/107.6%	3.3%	202.8	125.2%/112.7%	5.1%	Double Ckt: MidwayPS – Waterton 345kV & Daniels Park – Fuller 230kV

Table 7 – Summary of thermal violations from Multiple Contingency Analysis Without Palmer Lake– Monument 115kV Line Operating Procedure												
				Facility Loading Pre GI System		Facility Loading With GI-2014-8			Facility Loading With GI-2016-11			
Monitored Facility (Line or Transformer)	**Type**	**Owner**	**Branch Rating MVA (Norm /Emer)**	**Flow MVA**	**Flow % of Rating**	**Flow MVA**	**Flow % of Rating**	**% Change**	**Flow MVA**	**Flow % of Rating**	**% Change (over GI-2014-8)**	**NERC Multiple Contingency**
Monument – Flyhorse N 115kV	Line	CSU	142/157	204.3	143.9%/130.1%	212.8	149.8%/135.5%	5.4%	226.8	159.7%/144.4%	8.9%	Double Ckt: MidwayPS – Waterton 345kV & Daniels Park – Fuller 230kV
Flyhorse S – Kettle Creek N 115kV	Line	CSU	162/180	215.6	133.1%/119.8%	224.1	138.4%/124.5%	4.7%	238	147.0%/132.3%	7.8%	Double Ckt: MidwayPS – Waterton 345kV & Daniels Park – Fuller 230kV
BLKFORTP – BLK SQMV 115kV	Line	TSGT	81/81	129.2	159.5%/159.5%	131.9	162.9%/162.9%	3.4%	136.2	168.1%/168.1%	5.2%	Breaker Failure: Cottonwood 115kV Tie
BLK SQMV – Fuller 115kV	Line	TSGT	143/143	150.5	105.2%/105.2%	153.2	107.1%/107.1%	1.9%	157.6	110.2%/110.2%	3.1%	Breaker Failure: Cottonwood 115kV Tie
Fountain S – RD_Nixon 115 kV	Line	CSU	195/212	257.6	132.1%/121.5%	260	133.3%/122.6%	1.1%	263.4	135.1%/124.3%	1.7%	Breaker Failure: Kelker 230kV Tie
West Canyon 230/115 kV # T1	Line	BHCE	100/100	103.8	103.8%/103.8%	104.4	104.4%/104.4%	0.6%	105.2	105.2%/105.2%	0.8%	Double Ckt: Portland – West Station 115kV #1 & 2

Note – Double circuit Daniels Park – Comanche 345 kV outage caused divergence of the power flow case

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.
3. For Double 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 Palmer Lake– Monument 115kV Line Operating Procedure

				Facility Loading Pre GI		Facility Loading Without GI-2014-8			Facility Loading With GI-2016-11			
Monitored Facility (Line or Transformer)	**Type**	**Owner**	**Branch Rating MVA (Norm/ Emer)**	**Flow MVA**	**Flow % of Rating**	**Flow MVA**	**Flow % of Rating**	**% Change**	**Flow MVA**	**Flow % of Rating**	**% Change (over GI-2014-8)**	**NERC Multiple Contingency**
Arapahoe – SantaFe 230kV	Line	PSCo	300/319	297.6	99.2%/93.3%	307.8	102.6%/96.5%	3.2%	324.3	108.1%/101.7%	5.2%	Double Ckt: Daniels Park – Prairie – Greenwood 230kV 1&2
Daniels Park – SantaFe 230kV	Line	PSCo	319/319	334.6	104.9%/104.9%	344.8	108.1%/108.1%	3.2%	361.4	113.3%/113.3%	5.2%	Double Ckt: Daniels Park – Prairie – Greenwood 230kV 1&2
Canyon City – Skala 115kV	Line	BHCE	119/119	110.7	93.0%/93.0%	114.4	96.1%/96.1%	3.1%	120.7	101.4%/101.4%	5.3%	Breaker Failure: MidwayPS – J.Fuller 230kV
Fountain Valley – DesertCove 115kV	Line	BHCE	119/119	147.2	123.7%/123.7%	153.9	129.3%/129.3%	5.6%	164.9	138.6%/138.6%	9.3%	Breaker Failure: MidwayPS – J.Fuller 230kV
Fountain Valley – MidwayBR 115kV	Line	BHCE	119/119	146.0	122.7%/122.7%	152.7	128.3%/128.3%	5.6%	163.7	137.6%/137.6%	9.3%	Breaker Failure: MidwayPS – J.Fuller 230kV
DesertCove – West Station 115kV	Line	BHCE	119/119	168.4	141.5%/141.5%	175.1	147.2%/147.2%	5.7%	186.2	156.5%/156.5%	9.3%	Breaker Failure: MidwayPS – J.Fuller 230kV
Portland – Skala 115kV	Line	BHCE	111/111	115.7	104.2%/104.2%	119.5	107.7%/107.7%	3.5%	125.9	113.4%/113.4%	5.7%	Breaker Failure: MidwayPS – J.Fuller 230kV
Midway 230kV Bus tie	Line	PSCo/ WAPA	430/478	543.1	126.3%/113.6%	568.5	132.2%/118.9%	5.3%	611.0	142.1%/127.8%	8.9%	Double Ckt: MidwayPS – Waterton 345kV & MidwayPS – J. Fuller 230kV
Palmer Lake – Monument 115kV	Line	PSCo/ CSU	142/157	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Double Ckt: MidwayPS – Waterton 345kV & Daniels

Table 8 – Summary of thermal violations from Multiple Contingency Analysis With Palmer Lake– Monument 115kV Line Operating Procedure												
				Facility Loading Pre GI		Facility Loading Without GI-2014-8			Facility Loading With GI-2016-11			
Monitored Facility (Line or Transformer)	Type	Owner	Branch Rating MVA (Norm/ Emer)	Flow MVA	Flow % of Rating	Flow MVA	Flow % of Rating	% Change	Flow MVA	Flow % of Rating	% Change (over GI-2014-8)	NERC Multiple Contingency
												Park – J. Fuller 230kV
Cottonwood N – Kettle Creek S 115kV	Line	CSU	162/180	113.9	70.3%/63.3%	116.5	71.9%/64.7%	1.4%	121	74.7%/67.2%	2.5%	Double Ckt: MidwayPS – Waterton 345kV & Daniels Park – Fuller 230kV
Monument – Flyhorse N 115kV	Line	CSU	142/157	96	67.6%/61.2%	99.6	70.1%/63.4%	2.2%	105.8	74.5%/67.4%	4.0%	Double Ckt: MidwayPS – Waterton 345kV & Daniels Park – Fuller 230kV
Flyhorse S – KettleCreek N 115kV	Line	CSU	162/180	107.2	66.2%/59.5%	110.8	68.4%/61.6%	2.1%	117	72.2%/65.0%	3.4%	Double Ckt: MidwayPS – Waterton 345kV & Daniels Park – Fuller 230kV
BLKFORTP – BLK SQMV 115kV	Line	TSGT	81/81	157.4	194.3%/194.3%	159.3	196.6%/196.6%	2.3%	161.7	199.6%/199.6%	3.0%	Breaker Failure: Cottonwood 115kV Tie
BLK SQMV – Fuller 115kV	Line	TSGT	143/143	178.7	125%/125%	180.6	126.3%/126.3%	1.3%	183.3	128.2%/128.2%	1.9%	Breaker Failure: Cottonwood 115kV Tie
Monument – Gresham	Line	CSU	145/145	148.3	102.3%/102.3%	150.3	103.6%/103.6%	1.3%	152.4	105.1%/105.1%	1.5%	Breaker Failure: Cottonwood 115kV Tie
Fountain S – RD_Nixon 115 kV	Line	CSU	195/212	251.6	129%/118.6%	253.3	129.9%/119.5%	0.9%	256.0	131.3%/120.8%	1.3%	Breaker Failure: Kelker 230kV Tie
West Canyon 230/115 kV # T1	Line	BHCE	100/100	104.3	104.3%/104.3%	104.9	104.9%/104.9%	0.6%	105.8	105.8%/105.8%	0.9%	Double Ckt: Portland – West Station 115kV #1 & 2

Note – Double circuit Daniels Park – Comanche 345 kV outage caused divergence of the power flow case

Table 9 – Generation Dispatch in the Study area (MW is Gross Capacity)

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	1	64.8
Colorado Green	2	64.8
Twin Butte	1	60
Twin Butte-II	W1	60
Jackson Fuller	W1&W2	199.9
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
Pueblo Diesels	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	40.0

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	220.9
Tesla	1	13.2
Drake 5	1	0.0
Drake 6	1	81.6
Drake 7	1	138.2
Nixon CT 1	1	0.0
Nixon CT 2	1	0.0
Front Range CC 1	1	142.6
Front Range CC 2	1	142.6
Front Range CC 3	1	141.9

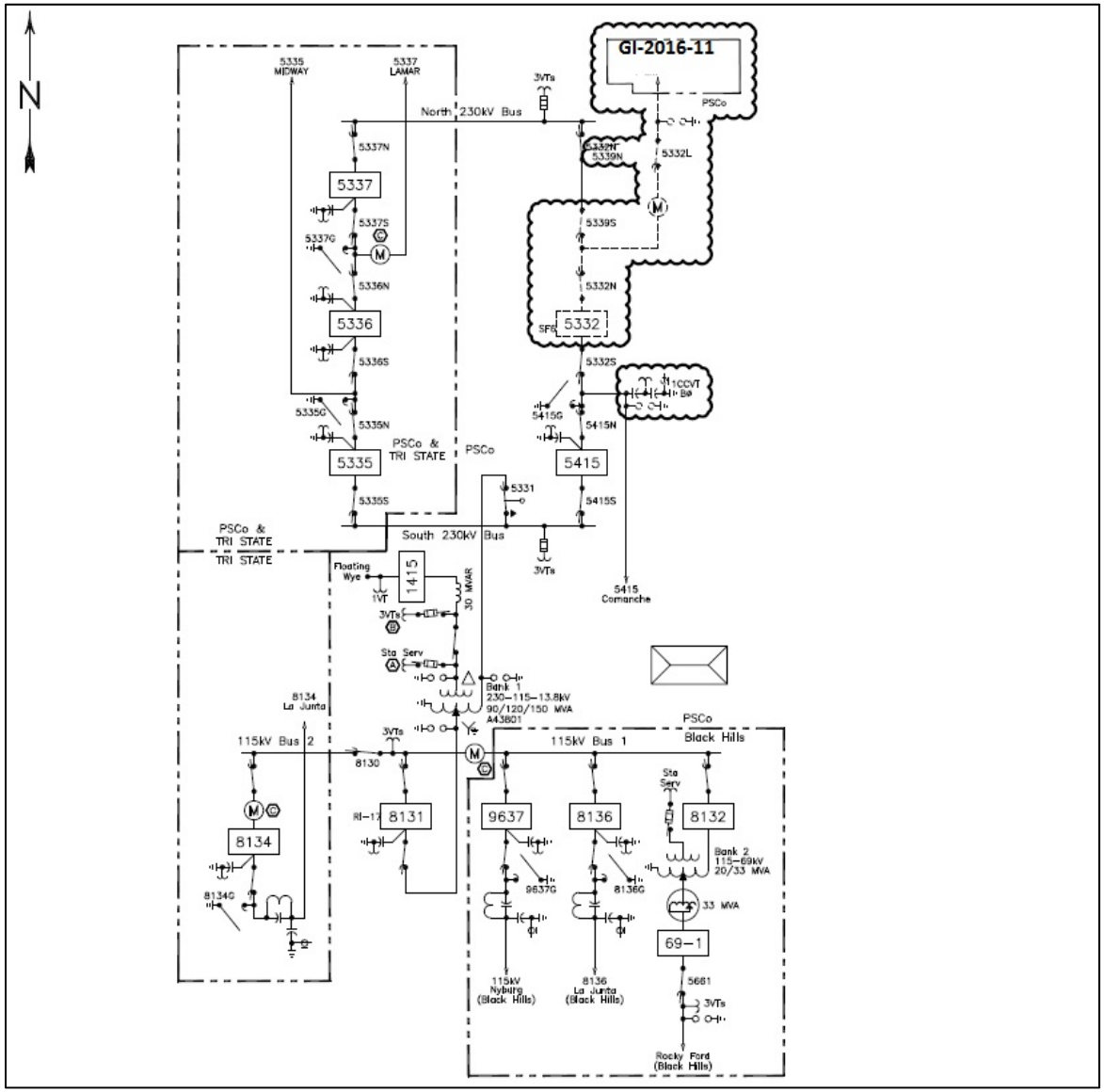

Figure 2 – GI-2016-11 Conceptual One-Line Diagram of the POI