Interconnection Feasibility and System Impact Study Report
Request # GI-2014-9

70 MW Solar Photovoltaic Generation Facility
Tapping Comanche – Midway 230 kV Line
Pueblo County, Colorado

Public Service Company of Colorado
Transmission Planning
February 15, 2016

Executive Summary

This study report analyses the Feasibility and System Impact Study results of interconnecting a 70MW solar photovoltaic generating facility (GI-2014-9) on the Comanche – Midway 230 kV line (L5413), tapping the line at approximately 5.5 miles from the Comanche Substation (primary Point of Interconnect [POI]). The generation facility will be located in Pueblo County, Colorado.

The secondary POI requested by the Interconnection Customer is a tap on the Comanche – Boone 230 kV line at approximately 5.5 miles from the Comanche Substation. The generation facility will interconnect to the POI using a customer owned 230 kV transmission line.

The Interconnection Customer has proposed the generation facility's Commercial Operation Date (COD) as December 1, 2016 and Back Feed Date as April 24, 2016.

The interconnection study request is for a combined Feasibility and System Impact Study for both Energy Resource Interconnection Service (ERIS) and Network Resource Interconnection Service (NRIS). The affected parties for this study are Colorado Springs Utilities (CSU), Black Hills Energy (BHE) and Intermountain Rural Electric Association (IREA).

This generation interconnection request was evaluated as a stand-alone project. That is, its feasibility is studied without including the potential impact of other interconnection requests existing in PSCo's Generator Interconnection Request queue, other than the interconnection requests that are PSCo's planned resource acquisitions for which Power Purchase Agreements have been signed.

The studies showed no thermal or voltage violations that can be attributed to the addition of GI-2014-9.
Energy Resource Interconnection Service (ERIS) capacity = 70 MW

Network Resource Interconnection Service (NRIS) capacity = 70 MW

Short Circuit

The POI is a new substation that will be designed for the maximum fault current level, so short circuit analysis at the POI is not applicable.

Cost Estimates

Cost estimates are in 2015 dollars. The total estimated cost of the recommended system improvements to interconnect GI-2014-9 is approximately **$8.03 Million** and includes:

- $ 1.012 million for PSCo-Owned, Customer-Funded Transmission Provider Interconnection Facilities
- $ 7.02 million for PSCo-Owned, PSCo-Funded Interconnection Network Facilities
- $ 0 million for PSCo Network Upgrades for Delivery

This work can be completed in thirty six (36) months following receipt of authorization to proceed. This timeline includes the time to obtain a Certificate for Public Convenience and Necessity (CPCN) from the Colorado Public Utilities Commission and construction of Interconnection Facilities and Network Upgrades. Based on this timeline, the December 1, 2015 COD proposed by the Customer is not feasible.

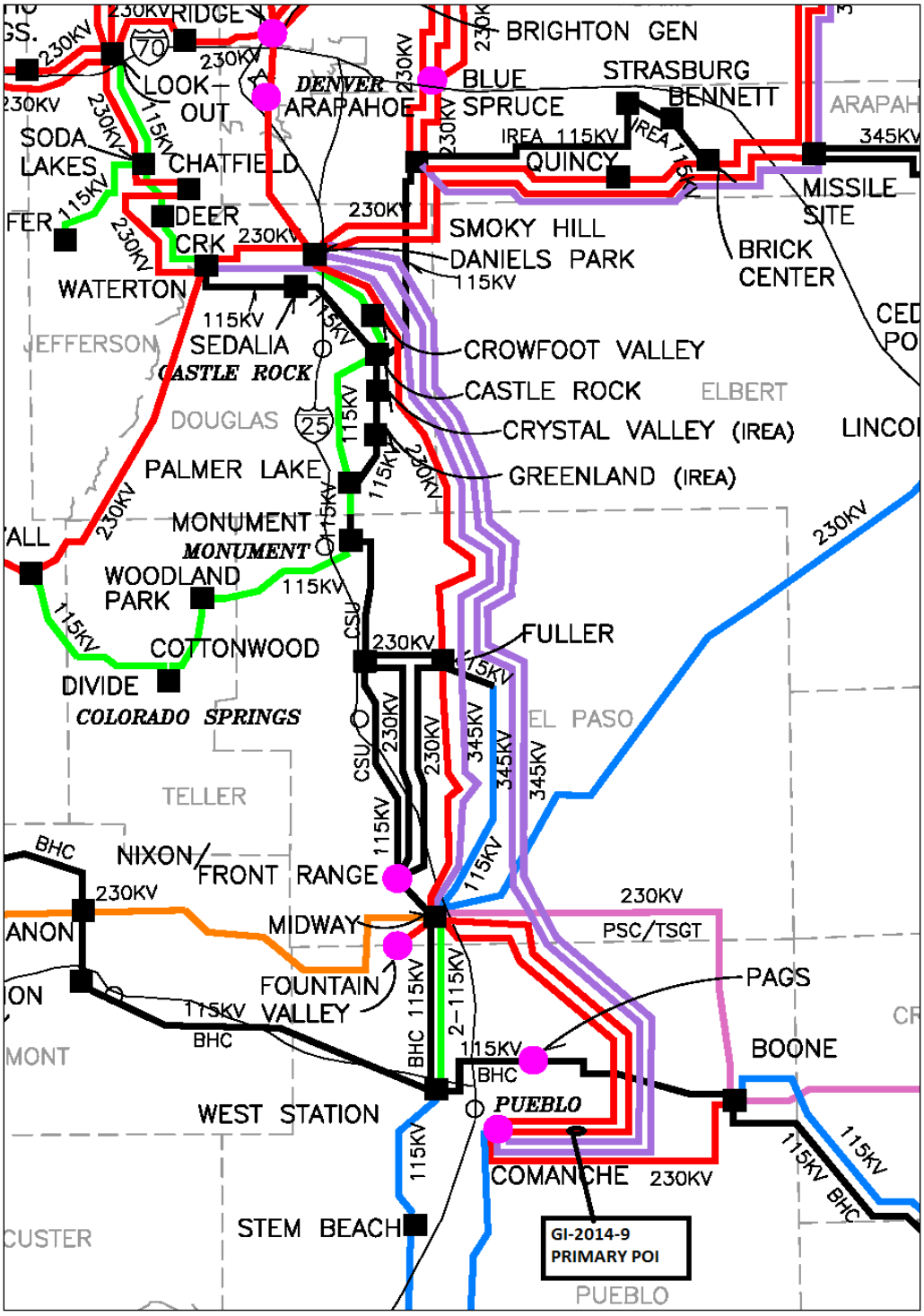

Figure-1: GI-2014-9 Primary Point of Interconnection and Surrounding Study Area

Introduction

Xcel Energy Transmission Planning West received a study request for the Interconnection of a 70MW solar photovoltaic generation facility (GI-2014-9) on October 10, 2014. The original capacity of GI-2014-9 specified in the interconnection study request letter was 120 MW. The Interconnection Customer later reduced the GI-2014-9 capacity to 70 MW on December 22, 2014. The geographical location of GI-2014-9 will be in Pueblo County, Colorado. The generation facility will be comprised of eighteen (18) Power Conversion Stations (PCS) and each PCS will have one PROSOLAR GE LV5 Type 1 inverter rated for 550V 4MVA and one 4MVA 34.5kV step up transformer. The generation facility will have one 34.5/230kV main step up transformer.

The primary Point of Interconnection (POI) requested by the Interconnection Customer is a tap on the Comanche – Midway 230kV line (L5413) at approximately 5.5 miles from the Comanche Substation. The secondary POI requested by the Interconnection Customer is a tap on the Comanche – Boone 230kV line (L5415) at approximately 5.5 miles from the Comanche Substation. The generation facility will interconnect to the POI using a customer owned 230kV transmission line.

The Interconnection Customer has proposed December 1, 2016 as the Commercial Operation Date (COD) of the generation facility. The Interconnection Customer did not provide a back-feed date, so it is assumed to be June 1, 2016; six months before the COD.

The interconnection request is for a combined Feasibility and System Impact Study for both Energy Resource Interconnection Service (ERIS) and Network Resource Interconnection Service (NRIS). The Customer initially requested a Feasibility study only, but, the study request was revised to include System Impact Study during the scoping meeting held on November 7, 2014.

Study Scope and Analysis

The scope of a combined Feasibility and System Impact Study includes power flow analysis, dynamic stability analysis and short circuit analysis. The power flow analysis identifies any thermal or voltage limit violations in the PSCo system and the surrounding transmission system resulting from the installation of the proposed generation; several single and double contingencies are studied. The short circuit analysis identifies any new circuit breakers overdutied due to the proposed generation addition. The System Impact study generally includes dynamic stability analysis to identify any transient and oscillatory stability impacts due to the addition of the new generation.

Power Flow Analysis Criteria: PSCo adheres to NERC & WECC Reliability Criteria, as well as internal Company criteria for planning studies. During system intact conditions, transmission system bus voltage is maintained between 0.95 and 1.05 per unit of nominal and steady-state power flows should remain below the normal thermal rating of

the facility. Operationally, PSCo tries to maintain a transmission system voltage of 1.02 per unit or higher at regulating (generator) buses and 1.0 per unit or higher at transmission load buses in the Midway and Comanche area.

Following a single or double contingency, transmission system steady state bus voltages must remain within 0.90 - 1.05 per unit, and power flows must remain within 100% of the facility's continuous thermal ratings. Also, voltage deviations should not exceed 5%.

Note-CSU operates its facilities at emergency ratings following single or double contingency. Si this report analyzed thermal overloads on the CSU facilities based on emergency rating.

Transient stability criteria require that all generating machines remain in synchronism and all power swings should be well damped. Also, transient voltage performance should meet the following criteria:

- Following fault clearing for Category B contingencies, voltage may not dip more than 25% of the pre-fault voltage at load buses, more than 30% at non-load buses, or more than 20% for more than 20 cycles at load buses**.**
- Following fault clearing for Category C contingencies, voltage may not dip more than 30% of the pre-fault voltage at any bus or more than 20% for more than 40 cycles at load buses.

In addition, transient frequency performance should meet the following criteria:

- Following fault clearing for Category B contingencies, frequency should not dip below 59.6 Hz for 6 cycles or more at a load bus.
- Following fault clearing for Category C contingencies, frequency should not dip below 59.0 Hz for 6 cycles or more at a load bus.

Note that load buses include generating unit auxiliary loads.

The proposed facility was requested to be studied as both Energy Resource and Network Resource interconnection.

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 Interconnecting 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 Colorado Springs Utilities (CSU), Black Hills Energy (BHE) and Intermountain Rural Electric Association (IREA).

Power Flow Study Models

The study was performed using 2017HS power flow case created by CCPG. This case was created from the WECC 2015HS power flow case released on December 5, 2014. The updates included topology, generation, load and rating updates to the entire Rocky Mountain Region.

To assess the impact of the proposed generation on the interconnected transmission system, the generation dispatch in the reference case was adjusted to create a south to north power flow stress on the Comanche – Midway - Jackson Fuller – Daniels Park transmission path. This was accomplished by adopting the generation dispatch described in Table - 8 below. PSCo generation dispatch in zones 700, 703, 704, 705, 706, 709, 710 and 712 is dispatched such that wind generation is at 85% name plate capacity, solar generation is at 80% name plate capacity and conventional non-coal generation is at 90% name plate capacity, coal generation is dispatched at 100% name plate capacity. The study did not include any generation resources that are in the Generation Interconnection queue except resources for which a Power Purchase Agreement (PPA's) has been signed. The Twin Buttes 75 MW expansion is modeled in the power flow case.

Two power flow cases were created for evaluating the impact of the proposed generator – the benchmark case and the study case. The benchmark case modeled the system before GI-2014-9 interconnection addition and the study case included GI-2014-9 model. PSCo's Fort Saint Vrain#1 was used as the sink for the generation addition. The GI was modeled using the PSSE modeling data provided by the Customer.

Power Flow Study Process

The power flow studies were completed on the benchmark case and the study case using PTI's PSSE Ver. 33.6.0 program and the ACCC contingency analysis tool. For single contingency analysis bus-bus contingencies were run on both Area 70 and 73, also a comprehensive list of breaker-breaker contingencies are run for area 70. The double contingency analysis was performed using selected outages in the PSCo, TSGT, CSU, IREA and BHCE systems. The results from the benchmark case and study case were compared, any new thermal overloads or existing thermal overloads which increased by more than 1% are monitored, any new voltage violations are monitored, changes in existing voltage violations are monitored if the change is significant. The

monitored transmission system included zones 700, 703, 704, 705, 706, 709, 710, 712, 752, 757, 791 and 121.

Voltage Regulation and Reactive Power Capability

Interconnection Customers are required to interconnect their Large Generating Facilities with Public Service of Colorado's (PSCo) Transmission System in conformance to the *Xcel Energy Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater Than 20 MW* (available at http://www.xcelenergy.com/staticfiles/xe/Regulatory/Transmission-Interconnection-Guidelines-Great-20MW.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 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 1.03 – 1.05 per unit at non-regulated buses.
- Xcel Energy's OATT requires all Interconnection Customers to have the reactive capability to achieve +/– 0.95 power factor at the POI, with the maximum "full output" reactive capability available at all output levels. Furthermore, Xcel Energy requires all Interconnection Customers to have dynamic voltage control and maintain the voltage specified by the Transmission Operator within the limitation of +/– 0.95 power factor at the POI, as long as the generating plant is on-line and producing power.
- 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) of any additional static reactive power equipment needed within the generating plant in order to have the reactive capability to meet the +/– 0.95 power factor and the 1.02 – 1.03 per unit voltage range standards at the POI.
- 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).

A voltage set point of 0.98 was considered at the POI to determine the GI facility's maximum capacity to provide reactive power since of the supply of the reactive power to the system is most needed when voltages are low. In a similar manner, the absorption of reactive power from the system is most needed when voltages are high and thus a POI voltage of 1.05 p.u. was tested for maximum leading capacity.

With all facilities in service and 70 MW of generation from GI-2014-9, the wind farm is able to deliver 17.8 Mvar at the POI without the installation of any additional shunt compensation. At 0.95 power factor, the required Mvar injection for 70 MW is 23 Mvar. Thus additional reactive support is needed to meet the power factor requirement.

With all facilities in service and 70 MW of generation from the wind generators, the wind farm is able to absorb 49 Mvar, there by maintaining 0.95 power factor at the POI.

Power Flow Results

Single Contingency Analysis:

The thermal violations (marked in red) resulting from single contingencies are given in Table 5. From the results in Table 5, it is evident that the addition of GI-2014-9 increased the existing thermal overloads in the PSC0 and CSU systems. The thermal overloads in the CSU system are eliminated when the Palmer Lake- Monument 115kV line operating procedure is implemented. Since the thermal overloads in the PSCo system are pre-existing (before the addition of GI-2014-9), they are not attributable to the addition of GI-2014-9). The results of the single contingency analysis with the Palmer Lake – Monument 115kV line operating procedure are given in Table 6.

Addition of GI-2014-9 did not cause any new voltage violations and increases in the existing voltage violations are small as to not require monitoring. So there were no voltage violations attributable to the interconnection of GI-2014-9.

Energy Resource Interconnection Service (ERIS): Since the study did not find any thermal and voltage violations that can be attributed to GI-2014-9; GI-2014-9 output for ERIS is 70 MW.

Network Resource Interconnection Service (NRIS): Since the study did not find any thermal and voltage violations that can be attributed to GI-2014-9; GI-2014-9 output for NRIS is 70 MW.

Note - The December 2016 Commercial Operation Date proposed by the Interconnection Customer is not feasible based on the 36 month construction schedule given in Table 3.

Dynamic Stability Analysis – Results

Recognizing the 0.92 lead – 0.92 lag adjustable power factor capability of the inverters, along with the proprietary information on Voltage Ride Through (VRT) capability of the PROSOLAR GE LV5 type 1 inverters provided by the Interconnection Customer, a transient stability study to assess and/or verify the interconnecting generating facility's

voltage ride-through for normally cleared faults was not deemed necessary. Furthermore, it is the responsibility of the Interconnection Customer to ensure that its generating facility is capable of meeting the voltage ride-through and frequency ride-through (VRT and FRT) performance specified in the NERC Reliability Standard PRC-024-1. It is also recognized that since the inverters constitute an asynchronous interface of the PV solar generating plant to the transmission system, this interconnection does not contribute any electromechanical oscillations that may adversely impact the rotor-angle stability of existing synchronous generators.

Short Circuit

The Point of Interconnection is a new substation that will be designed for the maximum fault current level, so short-circuit analysis at the POI is not applicable.

Costs Estimates and Assumptions

Scoping level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by PSCo Engineering. The cost estimates are in 2015 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.

The estimated total cost for the required upgrades is **$8,032,000.** These estimates do not include costs for any other Customer owned equipment and associated design and engineering.

Figure 1 below is a conceptual one-line of the proposed primary POI.

The following (Tables 1, 2 and 3) list the improvements required to accommodate the interconnection and the delivery of the GI-2014-9 70 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.

Table 1: PSCo Owned; Customer Funded Transmission Provider Interconnection Facilities

Element	Description	Cost Est. (Millions)
PSCo's Proposed New 230kV Transmission Substation	Interconnect Customer to the 230kV bus at PSCo's proposed new 230kV Substation. The new equipment includes: • One (1) 230kV gang switch • Three (3) 230kV combination CT/PT metering units • Power Quality Metering (230kV line from Customer) • Three (3) 230kV lightning arresters • One (1) relay panel (transformer breaker panel) • Associated communications, supervisory and SCADA equipment • Associated line relaying and testing • Associated bus, wiring and equipment • Associated foundations and structures • Associated transmission line communications, relaying and testing	**$1.012**
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	**$1.012**
Time Frame	**Design, procure and construct**	**18 Months**

Table 2: PSCo Owned; PSCo Funded Interconnection Network Facilities

Element	Description	Cost Estimate (Millions)
PSCo's Proposed New 230kV Transmission Substation	Construction of PSCo's proposed new 230kV Substation. The new equipment includes: • Three (3) 230kV Circuit Breakers • Eight (8) 230kV gang switch • Six (6) 230kV lightning arresters • Six (6) relay panels • Electrical Equipment Enclosure (EEE) • Associated communications, supervisory and SCADA equipment • Associated line relaying and testing • Associated bus, wiring and equipment • Associated foundations and structures • Associated transmission line communications, relaying and testing	**$6.940**
	Siting and Land Rights support for substation land acquisition and construction.	**$0.080**
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	**$7.020**
Time Frame	**Site, design, procure and construct**	**18 Months**

Table 3 – PSCo Network Upgrades for Delivery

Element	Description	Cost Est. (Millions)
	None Identified to Date.	**$0.0**
	Total Cost Estimate for PSCo Network Upgrades for Delivery	**$0.0**
	Design, procure and construct	**N/A**

Cost Estimate Assumptions

- Scoping level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by PSCo Engineering.
- Estimates are based on 2015 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.
- GI-2014-9 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.
- A CPCN will be required for the interconnection facilities construction and will add 18 months in front of the siting, design, procure construct window (of 18 months) totaling an estimated 36 month window to complete from authorization to proceed
- Customer will string OPGW fiber into substation as part of the transmission line construction scope.
- Line and substation bus outages will be required during the construction period to meet backfeed. Outage restrictions due to seasonal loading or other limiting factors may delay any proposed construction schedule.
- Power Quality Metering (PQM) will be required on the Customer's 230 kV line terminating into PSCo's proposed new substation.

A. Power Flow Contingency Analysis Results

Notes –

1. All thermal 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 5 – Summary of thermal violations from Single Contingency Analysis
Without Palmer Lake– Monument 115 kV Line Operating Procedure

				Branch Contingency Loading Without GI-2014-9		Branch Contingency Loading With GI-2014-9			
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**	**NERC Single Contingency**
Daniels Park – Prairie1 230 kV	Line	PSCo	478/478	492.3	103%/103%	510.5	106.8%/106.8%	3.8%	Daniels Park – Prairie3 230 kV Line
Greenwood – Monaco12 230 kV	Line	PSCo	404/480	406.4	100.6%/84.7%	417.3	103.3%/86.9%	2.7%	Buckley – Smoky Hill 230 kV Line
Waterton – Martin2Tap 115 kV	Line	PSCo	125/138	129.6	103.7%/93.9%	131.9	105.5%/95.6%	1.8%	Sodalakes 230/115 kV #T2
Brairgate S – Cottonwood S 115 kV	Line	CSU	150/192	176.6	117.7%/91.9%	179.9	119.9%/93.7%	N/A	Cottonwood N-KettleCreek S 115 kV
Cottonwood N - KettleCreek S 115 kV	Line	CSU	162/180	190.4	117.8%/100.6%	194.4	120.0%/108%	7.4%	Brairgate S – Cottonwood S 115 kV
Kelker S 230/115 kV #1	Xfmr	CSU	280/322	279.4	99.8%/86.8%	281.7	100.6%/87.5%	N/A	Kelker N 230/115 kV # 1
Monument – Flyhorse N 115 kV	Line	CSU	142/156	142.6	100.4%/91.4%	150.8	104.4%/95%	N/A	Daniels Park – Jackson Fuller 230 kV
BLKFORTP – BLK SQMV 115 kV	Line	CSU	81/81	82.5	101.8%/101.8%	85.0	105%/105%	3.2%	Flyhorse S – Flyhorse N 115 kV

Notes –

1. All thermal 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 6 – Summary of thermal violations from Single Contingency Analysis
With Palmer Lake – Monument 115 kV Line Operating Procedure

				Branch Contingency Loading Without GI-2014-9		Branch Contingency Loading With GI-2014-9			
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**	**NERC Cat B Contingency**
Daniels Park – Prairie1 230 kV	Line	PSCo	478/478	497.1	104%/104%	515.8	107.9%/107.9%	3.9%	Daniels Park – Prairie3 230 kV Line
Greenwood – Monaco12 230 kV	Line	PSCo	404/480	405.6	100.4%/84.5%	416.9	103.2%/86.9%	2.8%	Buckley – Smoky Hill 230 kV Line
Waterton – Martin2Tap 115 kV	Line	PSCo	125/138	127.5	102%/92.4%	129.6	103.7%/93.9%	1.7%	Sodalakes 230/115 kV #T2
Cottonwood N - KettleCreek S 115 kV	Line	CSU	162/180	144	88.9%/80.0%	145.8	90%/81%	N/A	Brairgate S – Cottonwood S 115 kV
BLKFORTP – BLK SQMV 115 kV	Line	CSU	81/81	62.1	76.7%/76.7%	63.6	78.5%/78.5%	N/A	Flyhorse S – Flyhorse N 115 kV

Notes –

1. All thermal 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 Double Contingency Analysis

Without Palmer Lake– Monument 115 kV Line Operating Procedure

				Branch Contingency Loading Without GI-2014-9		Branch Contingency Loading With GI-2014-9			
Monitored Facility (Line or Transformer)	**Type**	**Owner**	**Branch Rating MVA (Norm/Emer)**	**N-2 Flow MVA**	**N-2 Flow % of Rating**	**N-2 Flow MVA**	**N-2 Flow % of Rating**	**% Change**	**NERC Cat C Contingency**
MidwayPS – Northridge 115 kV	Line	BHCE	100/100	107	107%/107%	108.2	108.2%/108.2%	1.2%	Baculite – West Station 115 kV#1 &2
PuebloPlant – Reader 115 kV	Line	BHCE	160/160	159	99.4%/99.4%	162.2	101.4%/101.4%	2%	Baculite – West Station 115 kV#1 &2
DesertCove – West Station 115 kV	Line	BHCE	120/120	175.3	146.1%/146.1%	182.4	152%/152%	5.9%	Midway BR 230 kV breaker failure
Arapahoe – SantaFe 230 kV	Line	PSCo	300/330	317.1	105.7%/96%	329.4	109.8%/99.8%	N/A	Greenwood- Prairie – Daniels Park 230 kV # 1&2
Daniels Park - SantaFe 230 kV	Line	PSCo	319/319	352.8	110.6%/110.6%	365.3	114.5%/114.5%	3.9%	Greenwood 230 kV breaker failure
Daniels Park – Fuller 230 kV	Line	PSCo	478/478	605	126.6%/126.6%	631.4	132.1%/132.1%	5.5%	Comanche – Daniels Park 345 kV #1&2
Fountain Valley – DesertCov 115 kV	Line	BHCE	115/115	152.6	132.7%/132.7%	159.6	138.8%/138.8%	6.1%	Midway BR 230 kV breaker failure
Fountain Valley – MidwayBR 115 kV	Line	BHCE	115/115	151.5	131.7%/131.7%	158.4	137.7%/137.7%	6%	Midway BR 230 kV breaker failure
Midway 230/115 kV #T1	Xfmr	PSCo	97/97	126.2	130.1%/130.1%	130.5	134.5%/134.5%	4.4%	Comanche – Daniels Park 345 kV #1&2
Waterton 345/230 kV # 1	Xfmr	PSCo	560/672	546.6	97.6%/81.3%	566.2	101.1%/84.3%	N/A	Comanche – Daniels Park 345 kV #1&2
Midway 345/230 kV #1	Xfmr	PSCo	560/672	548.2	97.9%/81.6%	565.6	101%/84.2%	N/A	Comanche – Daniels Park 345 kV #1&2
Midway – waterton 345 kV	Line	PSCo	560/644	574	102.5%/89.1%	598	106.8%/92.9%	N/A	Comanche – Daniels Park 345 kV #1&2
MidwayPS-Midway BR 230 kV	Bus tie	WAPA	430/478	545.7	126.9%/114.1%	578.8	134.6%/121.0%	6.9%	Comanche – Daniels Park 345 kV #1&2

Table 7 – Summary of thermal violations from Double Contingency Analysis

Without Palmer Lake– Monument 115 kV Line Operating Procedure

				Branch Contingency Loading Without GI-2014-9		Branch Contingency Loading With GI-2014-9			
Monitored Facility (Line or Transformer)	**Type**	**Owner**	**Branch Rating MVA (Norm/Emer)**	**N-2 Flow MVA**	**N-2 Flow % of Rating**	**N-2 Flow MVA**	**N-2 Flow % of Rating**	**% Change**	**NERC Cat C Contingency**
		/ PSCo							
Palmer Lake – Monument 115 kV	Line	CSU	142/157	176.2	124.1%/112.2%	183.7	129.4%/117.0%	4.8%	Comanche – Daniels Park 345 kV #1&2
BrairigateS-CottonwoodS 115 kV	Line	CSU	162/180	193.4	119.4%/107.5%	196.8	121.5%/109.4%	1.9%	Cottonwood North 115 kV Bus outage
CottonwoodN-KettlecreekS 115 kV	Line	CSU	150/192	162.6	108.4%/84.7%	165.8	110.5%/86.3%	N/A	Cottonwood North 115 kV Bus outage
BlackForest Tap – BLK SQMV 115kV	Line	CSU	81/81	127.1	156.9%/156.9%	129.7	160.1%/160.1%	3.2%	Cottonwood 115 kV tie breaker outage
BLk SQMV – Fuller 115 kV	Line	CSU	143/143	150.3	105.1%/105.1%	152.9	106.9%/106.9%	1.8%	Cottonwood 115 kV tie breaker outage
Fountain S-RD_Nixon 115kV	Line	CSU	195/212	243.8	125%/115%	245.9	126.1%/116%	1%	KelKer 230 kV Tie breaker outage
Waterton – Martin1tap 115kV	Line	PSCo	139/153	145.4	104.6%/95%	147.6	106.2%/96.5%	N/A	Sodalakes – Waterton 230 kV & 115 kV
Waterton – martin2tap 115 kV	Line	PSCo	125/138	142.5	114%/103.3%	145.5	116.4%/105.4%	2.1%	Sodalakes 230 kV breaker failure
FlyhorseS-KettlecreekN 115 kV	Line	CSU	162/180	196.5	121.3%/109.2%	204.3	126.1%/113.5%	4.3%	Comanche – Daniels Park 345 kV # 1&2– Fuller 230 kV
Monument – FlyhorseN 115 kV	Line	CSU	142/156	185.3	130.5%/118.8%	193	135.9%/123.7%	4.9%	Comanche – Daniels Park 345 kV # 1&2
MidwayBR – Rancho 115 kV	Line	CSU	92/92	96.2	104.6%/104.6%	99.2	107.8%/107.8%	3.2%	Comanche – Daniels Park 345 kV # 1&2
Geesen – LorsonRanch 115 kV	Line	CSU	90/90	89.3	99.2%/99.2%	92.2	102.4%/102.4%	3.2%	Comanche – Daniels Park 345 kV # 1&2
Rancho – LorsonRanch 115 kV	Line	CSU	92/92	94.4	102.6%/102.6%	97.3	105.8%/105.8%	3.2%	Comanche – Daniels Park 345 kV # 1&2

Table 8- Generation Dispatch of Major Generating Units in the Study area (MW is Gross value)

PSCo:

Bus	LF ID	MW
Comanche PV	S1	102
Comanche	C1	360
Comanche	C2	365
Comanche	C3	805
Lamar DC Tie	DC	140
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	81
Colorado Green	2	81
Twin Butte	1	75
Twin Butte-II	W1	75
Jackson Fuller	W1	200
Alamosa CT	G1	0
Alamosa CT	G2	0
Cogentrix	S1	25.5
Greater Sandhill	S1	14.5
Blanca Peak	S1	19.5
SLV Solar	S1	44.2

BHE:

Bus	LF ID	MW
BUSCHWRTG1	G1	3.6
BUSCHWRTG2	G2	3.6
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	24
Baculite 4	G1	40.0

Baculite 4	G2	40.0
Baculite 4	S1	24
Baculite 5	G1	90

CSU:

Bus	LF ID	MW
Birdsale1	1	0.0
Birdsale 2	1	0.0
Birdsale 3	1	0.0
RD_Nixon	1	225.39
Tesla	1	13.2
Drake 5	1	49.65
Drake 6	1	81.19
Drake 7	1	138.03
Nixon CT 1	1	0.0
Nixon CT 2	1	0.0
Front Range CC 1	1	125.4
Front Range CC 2	1	125.8
Front Range CC 3	1	124.0

Figure -1-GI-2014-9 Conceptual One-Line Diagram of the primary POI