Generator Interconnection
System Impact Study
Request # GI-2010-19

120 MW Photo-Voltaic (PV) Solar Generation
Pueblo County, Colorado

Public Service Company of Colorado
Transmission Planning
May 21, 2014

A. Executive Summary

On November 16, 2010, Public Service Company of Colorado (PSCo) received an interconnection request (GI-2010-19) for a 120 MW photovoltaic (PV) solar generation facility in Pueblo County, Colorado. The proposed Point of Interconnection (POI) is the Comanche 230 kV bus within the Comanche 345/230/115 kV transmission substation (see Figure 1). The Commercial Operation Date (COD) requested by the Interconnection Customer is June 30, 2016, and accordingly the target Backfeed date is March 31, 2016.

The photovoltaic solar generation facility will consist of 100 Power Electronics Freesun HE 1200_U dc/ac inverters, each rated 1200 kVA ac, 390V ac, 0.90 lead – 0.90 lag adjustable power factor. The generation facility will consist of six (6) 34.5 kV feeders comprising the collector system — four feeders will have 16 daisy-chained inverters, and the remaining two feeders will have 18 daisy-chained inverters. One 390V / 34.5kV, 2640 kVA unit step-up transformer (UT) will be installed for every pair of inverters, resulting in 8 daisy-chained UTs in four feeders and 9 daisy-chained UTs in two feeders. The generating plant will have one main GSU rated 34.5/230 kV, 78/104/130 MVA, Z=10% and will connect to the Comanche 230kV bus POI via a 0.25 mile 795 ACSR overhead conductor line owned by the Interconnection Customer.

The system impact study consisted of steady-state power flow contingency analysis and short-circuits analysis. These analyses did not identify any thermal or voltage violations, nor any over-dutied circuit breakers, that may be attributed to the GI-2010-19 interconnection. However, the power flow analysis did identify several pre-existing thermal overloads that must be mitigated – PSCo Transmission Planning is in the process of evaluating potential transmission reinforcement alternatives to identify the preferred solution for implementation as a planned transmission upgrade project. The planned system upgrade will be designed to ensure that it provides sufficient transmission capacity to accommodate the 120 MW rated output of GI-2010-19.

No stability analysis was performed since the dynamic performance of the solar generation facility for normally cleared faults was expected to be satisfactory based on the proprietary

information on Voltage Ride Through (VRT) capability of the Power Electronics Freesun HE dc/ac inverters provided by the Interconnection Customer. 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.

Based on the system impact study, it is concluded that the full 120 MW rated output of the GI-2010-19 interconnection qualifies for Network Resource Interconnection Service (NRIS) without requiring any Network Upgrades for Delivery attributed to GI-2010-19. However, until the transmission reinforcement needed to mitigate the pre-existing thermal overloads is placed in-service, the GI-2010-19 output would be deliverable as Energy Resource Interconnection Service (ERIS) using the existing firm/non-firm transmission capacity on an as available basis.

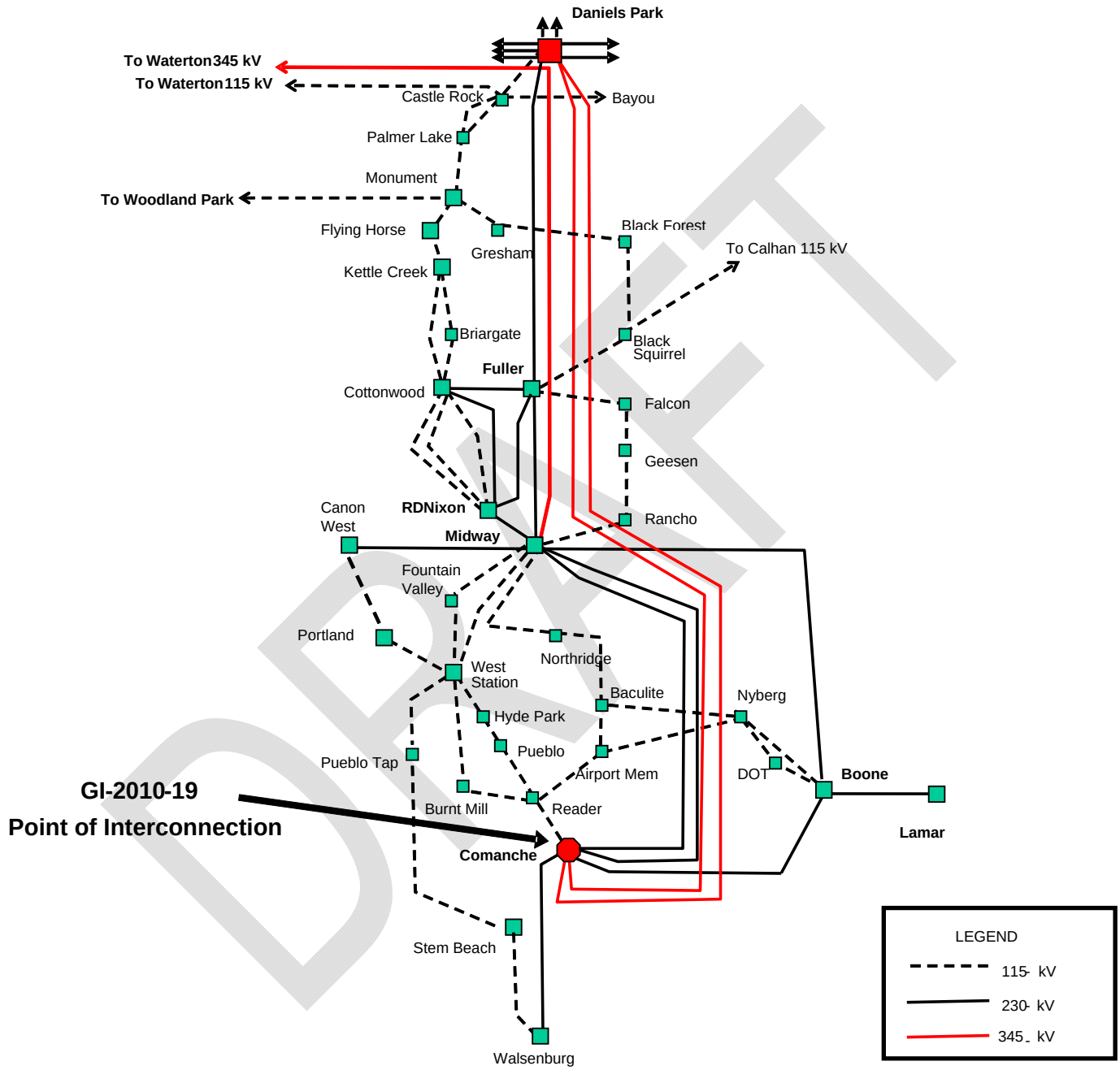
Cost Estimates

The total estimated cost of the required interconnection facilities at the Comanche Station (in 2014 dollars) is **$3.675 million** and includes:

- $ 1.362 million for PSCo-Owned, Customer-Funded Interconnection Facilities
- $ 2.313 million for PSCo-Owned, PSCo-Funded Network Upgrades for Interconnection

PSCo Engineering estimates that it will need 18 months to complete the Customer-Funded Interconnection Facilities and PSCo-Funded Network Upgrades for Interconnection in the Comanche 230 kV switchyard.

Figure 1 Comanche Station and Surrounding Transmission System (2016)



B. Introduction

On November 16, 2010, Public Service Company of Colorado (PSCo) received an interconnection request (GI-2010-19) for a 120 MW photovoltaic solar generation facility in Pueblo County, Colorado. The proposed Point of Interconnection (POI) is the Comanche 230 kV bus within the Comanche 345/230/115 kV transmission substation (see Figure 1 above). The Commercial Operation Date (COD) requested by the Interconnection Customer is June 30, 2016, and accordingly the target Backfeed date is March 31, 2016.

The photovoltaic solar generation facility will be located at the northeast corner of the Lime road and St. Charles road, immediately east of PSCo's Comanche generating plant, and it will be interconnected to the POI by a 0.25 mile radial 230 kV overhead transmission line owned by the Interconnection Customer. The generation facility will consist of 100 Power Electronics Freesun HE 1200_U dc/ac inverters, each rated 1200 kVA ac, 390V ac, 0.90 lead – 0.90 lag adjustable power factor. The generation facility will consist of six (6) 34.5 kV feeders comprising the collector system — four feeders will have 16 daisy-chained inverters, and the remaining two feeders will have 18 daisy-chained inverters. One 390V / 34.5kV, 2640 kVA unit step-up transformer (UT) will be installed for every pair of inverters, resulting in 8 daisy-chained UTs in four feeders and 9 daisy-chained UTs in two feeders. The generating plant will have one main GSU rated 34.5/230 kV, 78/104/130 MVA, Z=10% and will connect to the Comanche 230kV bus POI via a 0.25 mile 795 ACSR overhead conductor line.

A System Impact Study (SIS) Agreement was executed on January 17, 2014. The System Impact Study consists of steady-state power flow analyses to evaluate the thermal and voltage impact of the proposed generating plant on the transmission system, as well as determine the adequacy of the generating plant's power factor range (reactive power capability) at the POI. Based on the inverter technical specifications provided by the Interconnection Customer, it is expected that the inverters will have 0.90 lead – 0.90 lag adjustable power factor capability such that the PV solar generating plant's automatic voltage regulator will be capable of being operated in either voltage control or power factor control modes.

Recognizing the 0.90 lead – 0.90 lag adjustable power factor capability of the inverters, along with the proprietary information on Voltage Ride Through (VRT) capability of the 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. Further, 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.

C. Study Scope and Analysis

The System Impact Study evaluated the transmission impacts associated with the proposed wind farm. It consisted of power flow and short circuit analyses.

The power flow analysis identified any steady-state thermal or voltage limit violations resulting from the installation of the proposed wind farm and an identification of network upgrades required to deliver the proposed generation to PSCo loads.

PSCo adheres to NERC & WECC Reliability Criteria, as well as internal system performance criteria for transmission system planning studies. During system intact conditions, steady state transmission bus voltages must remain between 0.95 and 1.05 per unit, and power flows must remain below 100% of the normal (continuous) facility ratings. Following a single contingency, steady state transmission bus voltages must remain between 0.90 and 1.05 per unit, and power flows must remain below 100% of the normal (continuous) facility ratings. Operationally, PSCo tries to maintain a transmission system voltage profile ranging from 1.02 per unit or higher at regulating (generation) buses to 1.0 per unit or higher at transmission load buses.

This interconnection request was studied both as a Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection Service (ERIS).

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.

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.

For this project, potential Affected Parties are Colorado Springs Utilities (CSU), Tri-State Gas & Electric Transmission (TSGT) and the Intermountain Rural Electric Association (IREA).

D. Power Flow Study Models

The power flow studies were based on the WECC approved 17HS1AP_r32 case. PSCo loads in the case were adjusted to reflect the most recent (April 2013) PSCo load forecast. IREA load was also adjusted to reflect IREA's latest load forecast (November 2013). The topology was

also updated to reflect current project plans. Updates were included for the PSCo, IREA, CSU, TSG&T, WAPA, PRPA and BHCE systems.

The PSCo updates included the addition of the new Cherokee combined cycle plant and associated transmission upgrades. The new IREA Happy Canyon distribution substation connected to the Crowfoot Valley – Daniels Park 115 kV circuit was also included. A significant CSU case update was the re-termination of the Nixon end of the Kelker – Nixon 230 kV line to Front Range.

Two power flow cases were created for evaluating the system impact of the proposed generator – the reference case and the study case. The study case includes the 120 MW generation dispatch at Comanche 230 kV bus due to the proposed generator interconnection.

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 below that reflects the resource acquisitions approved in PSCo's 2013 Energy Resource Plan (ERP) for which Power Purchase Agreements (PPA's) have been signed. The six combustion turbines in Fountain Valley generating plant were dispatched at 242 MW rated output and the GI-2007-12 wind generation at Jackson Fuller was dispatched at 250 MW rated output. The Lamar dc tie was dispatched at 101 MW import into PSCo and the Colorado Green / Twin Buttes wind generation (interconnected at Lamar) was dispatched to 97.3 MW, the generation level at which loss of one of the two 230/115 kV transformers at Lamar resulted in a 100% of normal rating loading level on the other 230/115 kV transformer at Lamar. Other PSCo thermal generating units were dispatched according to their relative production costs (merit-order). It should be noted that the Area 70 (Area PSCOLORADO) swing machine in the WECC load flow case was moved to Fort Saint Vrain (FSV) Unit #1. The resulting PSCo (Area 70) generation dispatch can be found in Appendix B.

E. Power Flow Study Process

Contingency power flow studies were completed on the reference model and the model with the proposed new generation using PTI's PSSE Ver. 32.1.0 & 33.4.0 program. Results from the two cases were compared and new overloads or overloads that increased significantly in the new generation case were noted. Voltage criteria violations were also recorded. The PSSE Ver. 33.4.0 ACCC contingency analysis activity was used to perform the load flow contingency analysis. The PSCo Category B & C analysis was performed using contingency definitions that reflect breaker to breaker outages. Single branch switching was also performed for branches in Zones 700, 704, 705, 709, 712, 752, 757, and 791. Single unit outages were also modeled for generators in Zones 700, 704, 705, 709, 712, 752, 757, 790, and 791. The facilities in Zones 700, 704, 705, 709, 712, 752, 757, and 791 were monitored for overloads and voltage problems.

F. Power Flow Thermal Results

Network Resource Interconnection Service

The results of the Network Resource contingency analysis are summarized in the tables in the Appendix. The results of the Category B contingency analyses (see Table 5) show two transmission facilities with thermal overloads – both are owned by Colorado Springs Utilities. Since both transmission facilities are overloaded without the GI-2010-19 interconnection, none of these thermal overloads can be attributed to the proposed 120 MW injection at Comanche.

Energy Resource Interconnection Service

As defined in Section C above, Energy Resource Interconnection Service allows the Customer to deliver a 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. The ER analyses were performed using the same 2016 peak summer load flow cases as were used for the Network Resource contingency analyses.

G. 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). Wind and Solar generating plant interconnections (Variable Energy Resources) must also conform to the performance requirements in FERC Order 661-A. Accordingly, the following voltage regulation and reactive power capability requirements (at the POI) are applicable to this interconnection request:

- To ensure reliable operation, all Generating Facilities interconnected to the PSCo transmission system 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.
- 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 (690 V, 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 may need to perform additional studies for this purpose.
- 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 NERC Reliability Standard PRC-024-1.
- 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.

H. Dynamic Stability Analysis – Results

Recognizing the 0.90 lead – 0.90 lag adjustable power factor capability of the inverters, along with the proprietary information on Voltage Ride Through (VRT) capability of the 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. Further, 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.

I. Short Circuit

The calculated short circuit levels and Thevenin system equivalent impedances for the POI at the Comanche 230kV bus are tabulated below. No PSCo breakers were found to be overdutied due to the proposed interconnection.

Table 1 – Short Circuit Levels at the Comanche 230 kV POI

System Condition	Three-Phase Fault Level (Amps)	Single-Line-to-Ground Fault Level (Amps)	Thevenin System Equivalent Impedance (R +j X) (ohms)
System Intact	25214	29275	Z1(pos)= 0.31252+j5.28518 Z2(neg)= 0.33447+j5.29192 Z0(zero)= 0.19571+j3.0604

J. Study Conclusion

Based on the system impact study, it is concluded that the full 120 MW rated output of the GI-2010-19 interconnection qualifies for Network Resource Interconnection Service (NRIS) without requiring any Network Upgrades for Delivery attributed to GI-2010-19.

However, until the transmission reinforcement needed to mitigate the pre-existing thermal overloads is placed in-service, the GI-2010-19 output would be deliverable as Energy Resource Interconnection Service (ERIS) using the existing firm/non-firm transmission capacity on an as available basis.

Costs Estimates and Assumptions
GI-2010-19 (System Impact Study Report)
Revised 5/20/2014 (Ref. COMA-SEr1.)

The estimated costs shown are (+/-30%) estimates in 2014 dollars and are based upon typical construction costs for previously performed similar construction. These estimated costs include all applicable labor and overheads associated with the engineering, design, procurement 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 following tables list the improvements required to accommodate the interconnection and the delivery of the Project. The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines. System improvements are subject to change upon more detailed analysis.

Table 2 – PSCo Owned; Customer Funded Interconnection Facilities

Element	Description	Cost Est. (Millions)
PSCo's Comanche 230kV Transmission Substation	Interconnect Customer to the 230kV bus at the Comanche 230kV Substation. The new equipment includes: • Extend the 230kV Bus at to a new bay location • New overhead transmission line structures • One 230 kV gang switch and one grounding switch • Connect the new 230kV position to the bus • New relaying for the new transmission line. • Power Quality Metering (230kV line from Customer) • Three 230kV lightning arresters • One 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	**$1.072**
Customer's 230kV Substation	Load Frequency/Automated Generation Control (LF/AGC) RTU and associated equipment. Install a new relay panel at the customer generation site. Connect SCADA from the site to the Lookout Control Center.	**$0.290**
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	**$1.362**
Time Frame	**Design, procure and construct**	**18 Months**

Table 3 – PSCo Owned; PSCo Funded Interconnection Facilities

Element	Description	Cost Estimate (Millions)
PSCo's Comanche 230kV Transmission Substation	Interconnect Customer to the 230kV bus at the Comanche 230kV Substation. The new equipment includes: • Three 230 kV gang switches • Install a new 230 kV bay by extending the busses to the east • Five 230 kV gang switches • Two 230 kV breakers • Modify the relaying for the new bay position	**$2.313**
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	**$2.313**
Time Frame	**Site, design, procure and construct**	**18 Months**

Table 4 – PSCo Network Upgrades for Delivery - PSCo Funded

Element	Description	Cost Est. Millions
	Not Applicable	
	Total Estimated Cost for PSCo Network Upgrades for Delivery	**N/A**
Time Frame	Site, design, procure and construct	**N/A**

Assumptions

- Cost estimates are "scoping estimates" with an accuracy of +/- 30%.
- Estimates are based on 2014 dollars.
- Contingency and escalation are included in the estimates. AFUDC is not included.
- Labor is estimated for straight time only – no overtime included.
- The Generator is not in PSCo's retail service territory. Therefore no costs for retail load metering are included in these estimates.
- PSCo (or its Contractor) crews will perform all construction and wiring associated with PSCo owned and maintained facilities.
- The estimated time to site, design, procure (long lead time materials) and construct the interconnection facilities is at least 18 months, and is completely independent of other queued projects and their respective ISDs.
- A CPCN will not be required for interconnection facility construction.
- Customer will string OPGW fiber into substation as part of the transmission line construction scope.

- PSCo crews to perform checkout, relay panel construction and final commissioning.
- No new substation land required. Substation work to be completed within existing property boundaries.

Appendix

GI-2010-19 (120 MW) Interconnection at Comanche 230 kV POI

A. Power Flow Thermal Results – 2016 Summer Heavy Load (16HS) – Colorado South-North Flow Stress

PSCo 2013 Electric Resource Plan Generation: Fountain Valley CTs – 242 MW
Jackson Fuller Wind – 250 MW & SLV PV Solar – 50 MW

Lamar DC Tie – 101 MW Import
Colorado Green/Twin Buttes Wind – 97.3 MW

Table 5 – GI-2010-19 Summary Listing of Worst Case Overloaded Facilities[1] (Category B Contingencies)

				Branch Contingency Loading Without GI-2010-19		Branch Contingency Loading With GI-2010-19			
Monitored Facility (Line or Transformer)	Type	Line Owner	Branch Rating MVA (Norm/Emer)	Cat B Flow in MVA (Current Equiv*)	Cat B Flow in % Current Equiv of Normal/Emer Rating	Cat B Flow in MVA (Current Equiv*)	Cat B Flow in % Current Equiv of Normal/Emer Rating	% Change	NERC Category B Contingency Outage
Briar Gate – Cottonwood S 115 kV	LN	CSU	150 / 192	168.6	112.4% / 87.8%	177.0	116.6% / 92.2%	4.2% / 4.4%	Cottonwood N – Kettle Creek 115 kV
Cottonwood N – Kettle Creek 115 kV	LN	CSU	162 / 180	181.0	111.7% / 100.5%	188.5	116.1% / 104.5%	4.4% / 4.0%	Briar Gate – Cottonwood S 115 kV

*Current-corrected flows for transmission lines only.

[1] Includes facilities with an Impact Factor of 2% or more of the proposed 120 MW generation.

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Table 6 – GI-2010-19 Summary Listing of Worst Case Overloaded Facilities[1] (Category C Contingencies)

				Branch Contingency Loading Without GI-2010-19		Branch Contingency Loading With GI-2010-19			
Monitored Facility (Line or Transformer)	**Type**	**Line Owner**	**Branch Rating MVA (Norm/Emer)**	**Cat C Flow in MVA (Current Equiv*)**	**Cat C Flow in % Current Equiv of Normal/Emer Rating**	**Cat C Flow in MVA (Current Equiv*)**	**Cat C Flow in % Current Equiv of Normal/Emer Rating**	**% Change**	**NERC Category C Contingency Outage**
Daniels Park – Jackson Fuller 230 kV	LN	PSCo	478 / 478	498.1	104.2% / 104.2%	542.4	113.5% / 113.5%	9.3% / 9.3%	Double-Circuit Tower Comanche – Daniels Park 345 kV 1 & 2
Monument – Palmer Lake 115 kV	LN	PSCo / CSU	120 / 120	162.0	135.0% / 135.0%	176.4	148.5% / 148.5%	13.5% / 13.5%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Monument – Palmer Lake 115 kV	LN	PSCo / CSU	120 / 120	146.3	121.9% / 121.9%	159.1	132.6% / 132.6%	10.7% 10.7%	Double-Circuit Tower Comanche – Daniels Park 345 kV 1 & 2
Monument – Flying Horse 115 kV	LN	CSU	142 / 156	173.4	122.1% / 111.2%	189.6	133.8% / 121.5%	11.7% / 10.3%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Monument – Flying Horse 115 kV	LN	CSU	142 / 156			166.5	117.3% / 106.7%		Double-Circuit Tower Comanche – Daniels Park 345 kV 1 & 2
Kettle Creek – Flying Horse 115 kV	LN	CSU	162 / 180	183.4	113.2% / 101.9%	201.2	123.4% / 111.1%	10.2% / 9.2%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Kettle Creek – Flying Horse 115 kV	LN	CSU	162 / 180	163.5	100.9% / 90.8%	176.7	109.1% / 98.2%	9.2% / 7.4%	Double-Circuit Tower Comanche – Daniels Park 345 kV 1 & 2
Cottonwood N – Kettle Creek 115 kV	LN	CSU	162 / 180			177.6	107.9% / 97.1%		Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Cottonwood N – Kettle Creek 115 kV	LN	CSU	162 / 180	165.3	102.1% / 91.9%	173.0	106.7% / 96.1%	4.6% / 4.2%	Bus Fault Cottonwood 115 kV S bus
Briar Gate – Cottonwood S 115 kV (For Information Only)	LN	CSU	150 / 192	170.0	112.2% / 87.6%	170.0	112.2% / 87.6%	0% / 0%	Bus Fault Cottonwood 115 kV N bus

*Current-corrected flows for transmission lines only.

[1] Includes facilities with an Impact Factor of 2% or more of the proposed 120 MW generation.

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Series Reactor (X = 20.0%) Added in the Monument-Palmer Lake 115 kV Line

Table 7 – GI-2010-19 Summary Listing of Worst Case Overloaded Facilities (Category B Contingencies)

				Branch Contingency Loading Without GI-2010-19		Branch Contingency Loading With GI-2010-19			
Monitored Facility (Line or Transformer)	**Type**	**Line Owner**	**Branch Rating MVA (Norm/Emer)**	**Cat B Flow in MVA (Current Equiv*)**	**Cat B Flow in % Current Equiv of Normal/Emer Rating**	**Cat B Flow in MVA (Current Equiv*)**	**Cat B Flow in % Current Equiv of Normal/Emer Rating**	**% Change**	**NERC Category B Contingency Outage**
Briar Gate – Cottonwood S 115 kV	LN	CSU	150 / 192	150.3	100.2% / 78.3%	156.7	103.1% / 80.5%	2.9% / 2.2%	Cottonwood N – Kettle Creek 115 kV
Cottonwood N – Kettle Creek 115 kV	LN	CSU	162 / 180	158.9	98.1% / 88.3%	164.4	101.1% / 91.0%	3.0% / 2.7%	Briar Gate – Cottonwood S 115 kV

*Current-corrected flows for transmission lines only.

Xcel Energy

Series Reactor (X = 20.0%) Added in the Monument-Palmer Lake 115 kV Line

Table 8 – GI-2010-19 Summary Listing of Worst Case Overloaded Facilities (Category C Contingencies)

				Branch Contingency Loading Without GI-2010-19		Branch Contingency Loading With GI- GI-2010-19			
Monitored Facility (Line or Transformer)	**Type**	**Line Owner**	**Branch Rating MVA (Norm/Emer)**	**Cat C Flow in MVA (Current Equiv*)**	**Cat C Flow in % Current Equiv of Normal/Emer Rating**	**Cat C Flow in MVA (Current Equiv*)**	**Cat C Flow in % Current Equiv of Normal/Emer Rating**	**% Change**	**NERC Category C Contingency Outage**
Daniels Park – Jackson Fuller 230 kV	LN	PSCo	478 / 478	533.5	111.6% / 111.6%	577.6	122.6% / 122.6%	11.0% / 11.0%	Double-Circuit Tower Comanche – Daniels Park 345 kV 1 & 2
Monument – Palmer Lake 115 kV	LN	PSCo / CSU	120 / 120	80.9	67.4% / 67.4%	89.4	74.5% / 74.5%	7.1% / 7.1%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Briar Gate – Cottonwood S 115 kV	LN	CSU	150 / 192	153.1	102.1% / 79.7%	160.9	105.7% / 82.6%	3.6% / 2.9%	Bus Fault Cottonwood 115 kV N bus
Cottonwood N – Kettle Creek 115 kV	LN	CSU	162 / 180	147.2	90.9% / 81.8%	152.5	94.0% / 84.6%	3.1% / 2.8%	Bus Fault Cottonwood 115 kV S bus
Emil Anderson – Forest Lake 115 kV	LN	TSGT	58 / 58	56.6	97.6% / 97.6%	63.2	109.3% / 109.3%	11.7% / 11.7%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Kettle Creek – Flying Horse 115 kV	LN	CSU	162 / 180	133.7	82.5% / 74.3%	146.2	90.0% / 81.2%	7.5% / 6.9%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Monument – Flying Horse 115 kV	LN	CSU	142 / 156			136.1	95.5% / 87.2%		Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Black Squirrel – Jackson Fuller 115 kV	LN	TSGT	144 / 144	150.5	104.5% / 104.5%	156.2	108.5% / 108.5%	4.0% / 4.0%	Breaker Internal Fault Cottonwood 115 kV Tie Breaker
Jackson Fuller 230/115 kV T1 (Informational)	TR	TSGT	100 / 100	135.8	135.8% / 135.8%	137.2	137.2% / 137.2%	1.4% / 1.4%	Breaker Internal Fault Cottonwood 115 kV Tie Breaker

*Current-corrected flows for transmission lines only.

B. Generation Dispatch

Case Description: 2016 HS, Colorado South to North Generation Flow Bias, Fountain Valley Units On at Maximum, based on WECC 17hs1ap.sav with updates from CCPG companies.

Benchmark Case – GI-2007-12

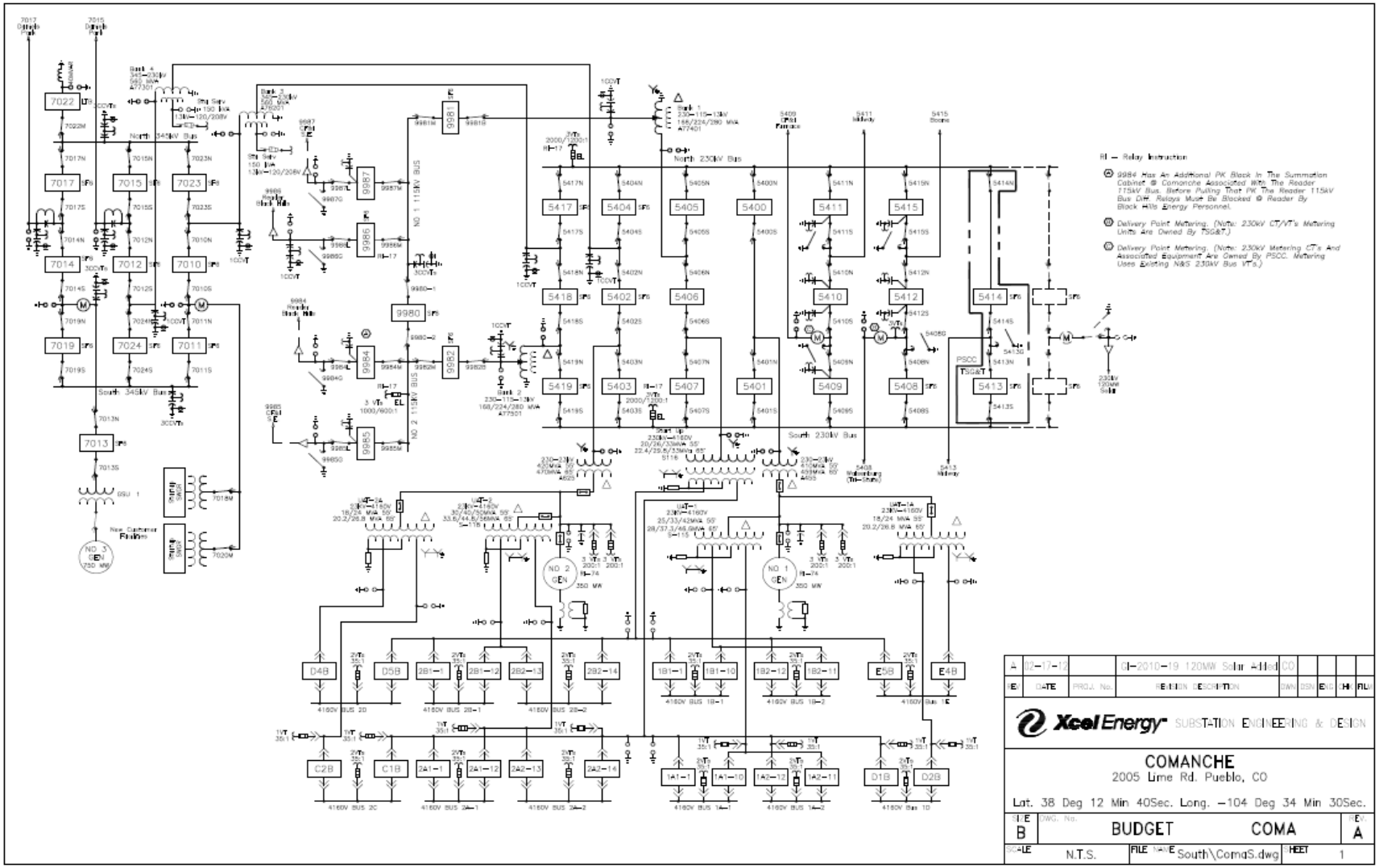
Arapahoe Unit 3 & 4	0 MW
Cabin Creek Units	210 MW
Cherokee Units 1 – 3	0 MW
Cherokee Unit 4	383 MW
Cherokee Unit 5-7	603.8 MW
Comanche Unit 1	360 MW
Comanche Unit 2	365 MW
Ft Lupton Units 1 & 2	0 MW
Pawnee Unit 1	536 MW
Manchief Units 1 & 2	0 MW
Ft St Vrain Units 1-4	700 MW
Valmont Unit 5	196 MW
Valmont Unit 6	0 MW
Alamosa Units 1 & 2	27 MW
QF Thermo – Ft Lup	266 MW
Brush Units 1, 3, & 4	0 MW
Brush Unit 2	0 MW
QF UNC	0 MW
Arapahoe Units 5-7	118 MW
Lamar DC Tie	101 MW Import from SPS
Spruce Units 1 & 2	0 MW
Brighton Units 1 & 2	85 MW
Fountain Valley Units	242 MW
Plains End Units	0 MW
RMEC Units 1-3	586 MW
Spindle Units 1 & 2	0 MW
Cedar Point Wind (MS 230 kV)	57.5 MW (23%)
Limon Wind (MS 345 kV)	138.1 MW (23%)
Peetz Logan 230 kV	132.4 MW (23%)
Comanche Unit 3	804 MW
Cedar Creek Wind	126.8 MW (23%)
San Luis Valley Solar	85.2 MW
Colorado Grn/Twin Buttes	97.3 MW
Ft St Vrain Units 5 & 6	134.5 MW
GI-2007-12 (J. Fuller 230kV)	249.9 MW (100%)

Lamar Units	0 MW (ARPA)
Baculite Mesa Plant	382 MW (BHE)
Busch Ranch Wind	28.8 MW (BHE)
Remaining BHE Gens	0 MW (BHE)
Birdsall	0 MW (CSU)
Nixon	224.8 MW (CSU)
Nixon CTs	0 MW (CSU)
Tesla	24.8 MW (CSU)
Drake	265.4 MW (CSU)
Front Range CC	404 MW (CSU)

GI-2010-19 Case Adjustments

Ft St Vrain Units 5 & 6	0 MW

C. One-Line of Proposed GI-2010-19 Interconnection at Comanche 230kV Station



D. Proposed Project Schedule

GI-2010-19 Generator Interconnection System Impact Study Report
120 MW Solar Interconnection, Comanche 230 kV

ID	Task Name	Duration
1	GI-2010-19 Generator SIS 120 MW Solar Interconnection	78w
2	Authorization to Proceed Agreement	0w
3	Sighting & Land Rights and Permitting	6w
4	Substation Design & Engineering	40w
5	Substation Materials Procurment	36w
6	Substation Construction	36w
7	Relay, Protection & Control Equipment Testing	10w
8	Final Commissioning	4w
9	Project Completion / Backfeed	0w
10