System Impact Study Report
Generation Interconnection Request # GI-2015-1

250 MW Wind Generation Facility
Comanche – Daniels Park 345kV Line (L7015)
Elbert County, Colorado

Transmission Planning West
Xcel Energy
August 9, 2016

Executive Summary

GI-2015-1 is a 250 MW wind generation facility that will be located in Elbert County, Colorado. The generation facility will be comprised of one hundred and forty (140) GE 1.79 MW wind turbines connected in two groups. Each group will consist of seventy (70) wind turbines, one 0.69/34.5kV 140 MVA generator step up transformer and one 34.5/345kV 140 MVA main step up transformer (MST). The 34.5/345kV 140 MVA main step-up transformer currently proposed by the Interconnection Customer is a grounded-wye / grounded- wye, buried delta tertiary transformer winding design, which differs from PSCo's preferred delta / grounded-wye winding design. Therefore, for this winding design to be accepted, the Interconnection Customer will be required to demonstrate that the proposed transformer is effectively grounded per IEEE standards.

The primary Point of Interconnection (POI) requested by the Interconnection Customer is a tap on the mid-point of the Comanche – Daniels Park 345kV line (L7015) at approximately 57.24 miles from the Comanche (or the Daniels Park) Substation. The generation facility's MST will interconnect to the POI using an approximately 45 miles long customer owned 345kV transmission line. The Interconnection Customer did not propose a secondary POI.

During the Feasibility Study phase, the Interconnection Customer proposed October 1, 2017 as the Commercial Operation Date (COD) of the generation facility. The COD has been changed to December 2018 during the System Impact Study per the email communication received from the Customer on March 22, 2016.

The report includes revised steady state (power flow) analysis for the December 2018 COD, short circuit analysis and transient stability analysis. The steady state and transient stability analyses were performed using the same 2018 heavy summer power flow case in PSSE and PSLF formats respectively. The base cases were stressed to simulate heavy south-north flow on the Comanche – Midway – Jackson Fuller – Daniels Park transmission path.

The GI-2015-1 interconnection request was studied as a stand-alone project. That is, its system impact has been 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 GI-2015-1 interconnection request was evaluated for both Energy Resource Interconnection Service (ERIS) and Network Resource Interconnection Service (NRIS). The affected parties for the system impact of GI-2015-1 are Colorado Springs Utilities (CSU), Black Hills Colorado Electric (BHCE) and Intermountain Rural Electric Association (IREA).

Steady State contingency analysis results: The benchmark case (before addition of GI-2015-1) showed thermal overloads on the PSCo system and the CSU system. The study case (after the addition of GI-2015-1) resulted in the pre-existing thermal overloads and also caused several new thermal overloads in the PSCo and BHCE systems. Implementing the Palmer Lake – Monument 115kV line operating procedure is effective in mitigating all the CSU thermal overloads in both benchmark and study cases. However, the operating procedure results in four (4) PSCo thermal violations and one (1) BHCE thermal overload in the study case. Therefore, Network Upgrades are needed to mitigate the following PSCo thermal overloads attributable to GI-2015-1:

- Greenwood – Prairie1 230kV line loading increased from 88.7% to 102.9%
- Greenwood – Prairie3 230kV line loading increased from 91.8% to 105.9%
- Greenwood – Monaco 230kV line loading increased from 96.2% to 105.9%
- Waterton – Martin2tap 115kV line loading increased from 96.5% to 101.8%

The Interconnection Customer is recommended to work with BHCE in order to mitigate the Portland – Skala 115kV line overload.

There were no voltage violations attributable to GI-2015-1.

Transient Stability Analysis: The results indicated that all generating units are stable (remain in synchronism) and display positive damping and the maximum transient voltage dips and frequency deviations are within criteria. Based on the results, it was concluded that there are no transient stability issues created by the interconnection of GI-2015-1 on the Comanche – Daniels Park 345kV line #2.

Short Circuit

The POI is a new substation ("GI-2015-1 Substation") that will be designed for the maximum fault current level, so short circuit analysis at the POI is not needed. Breaker

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

Energy Resource Interconnection Service (ERIS): Due to pre-existing thermal overloads, the GI-2015-1 output for ERIS is 0 MW for the studied generation dispatch scenario. However, higher GI-2015-1 output may become feasible on an as-available basis depending on the dispatch of existing generation resources located in the electrical vicinity of GI-2015-1 (such as Comanche, Midway and Jackson Fuller generators.)

Network Resource Interconnection Service (NRIS): Completing the Network Upgrades to mitigate the above mentioned thermal overloads will allow GI-2015-1 to achieve 250MW NRIS. All network upgrades consist of upgrading terminal equipment limiters on the overloaded facilities.

Cost Estimates

Cost estimates are in 2016 dollars. The total estimated cost of the recommended system improvements to interconnect the project is approximately **$10.396 Million** and includes:

- $2.425 million for PSCo-Owned, Customer-Funded Transmission Provider Interconnection Facilities
- $7.648 million for PSCo-Owned, PSCo-Funded Transmission Provider Interconnection Facilities
- $0.323 million for PSCo Network Upgrades for Delivery

It is estimate that 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.

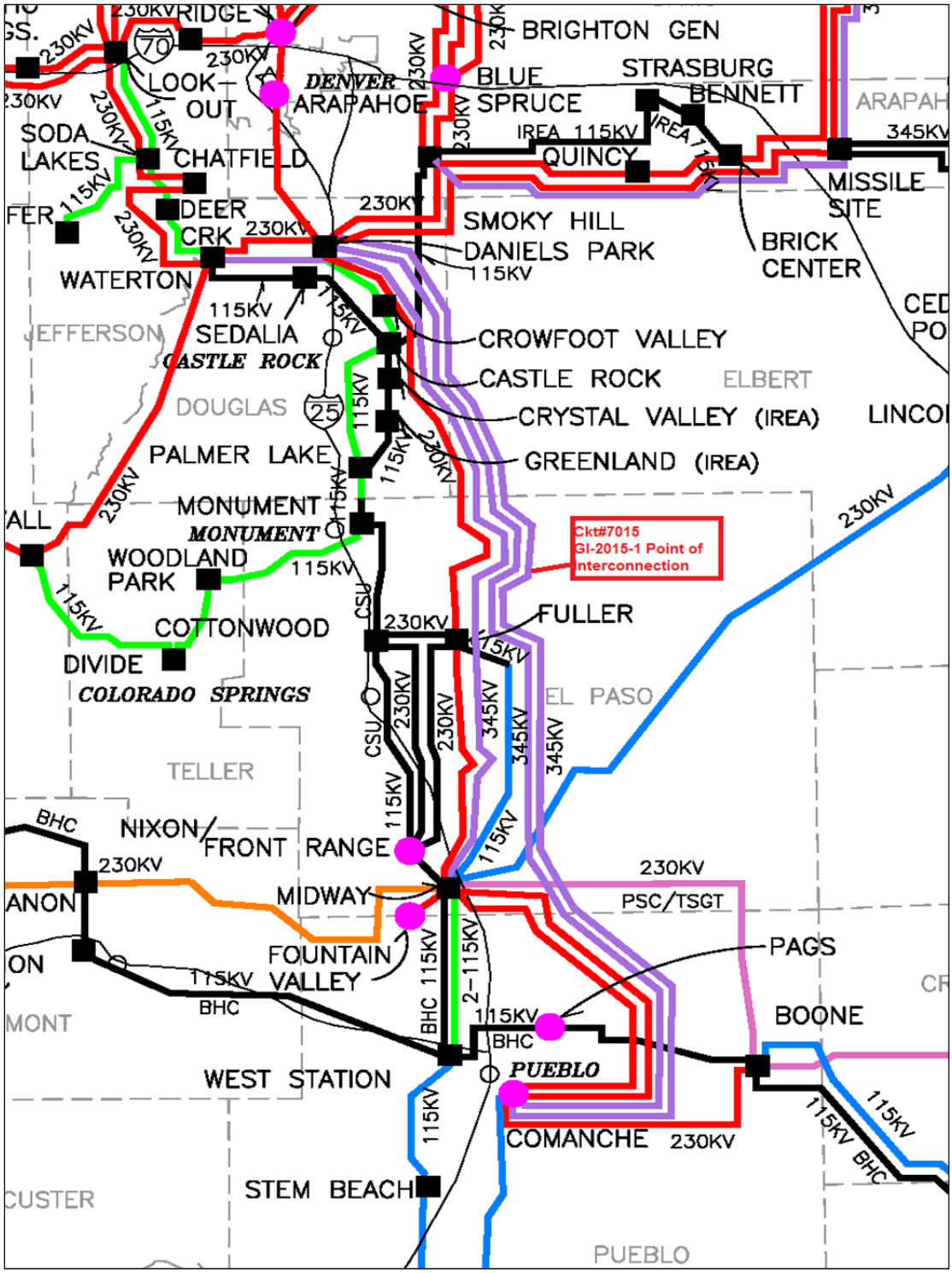

Figure-1: GI-2015-1 Point of Interconnection and Surrounding Study Area

Introduction

GI-2015-1 is a 250 MW wind generation facility that will be located in Elbert County, Colorado. The generation facility will be comprised of one hundred and forty (140) GE 1.79 MW wind turbines connected in two groups. Each group will consist of seventy (70) wind turbines, one 0.69/34.5kV 140 MVA generator step up transformer, and one 34.5/345kV 140 MVA main step up transformer (MST).

The primary Point of Interconnection (POI) requested by the Interconnection Customer is a tap at the mid-point on the Comanche – Daniels Park 345kV line (L7015), i.e., at approximately 57.24 miles from the Comanche (or the Daniels Park) Substation. The generation facility will interconnect to the POI using an approximately 45 miles long customer owned 345kV transmission line. The Interconnection Customer did not propose a secondary POI. The new Substation at the POI is being referred to as "GI-2015-1 Substation" in this report.

The Feasibility Study report was completed and posted on January 21, 2016. The Interconnection Customer has originally proposed October 1, 2017 as the Commercial Operation Date (COD) of the generation facility, but has revised it to December 2018 during System Impact study stage.

The 34.5/345kV, 140 MVA MST currently proposed by the Interconnection Customer is a grounded-wye / grounded-wye, buried delta tertiary transformer winding design, which differs from PSCo's preferred delta / grounded-wye winding design. Therefore, for this winding design to be accepted, the Interconnection Customer will be required to demonstrate that the proposed transformer is effectively grounded per IEEE standards.

The interconnection request is for both Energy Resource Interconnection Service (ERIS) and Network Resource Interconnection Service (NRIS).

Study Scope and Analysis

The scope of this report includes re-study of the Feasibility Analysis because of the change in the COD, transient stability analysis and short circuit analysis. The power flow analysis identifies 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.

PSCo adheres to NERC & WECC Reliability Criteria, as well as internal Company criteria for planning studies. During system intact conditions (Category A), transmission system bus voltages must remain between 0.95 and 1.05 per unit of nominal, and steady-state power flows must remain below the thermal ratings of all transmission facilities. Operationally, PSCo attempts 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. Following a single contingency (Category B) disturbance, PSCO transmission system steady state bus voltages must remain between 0.90 per unit to 1.10 per unit for transmission facilities rated 300kV and below and between 0.95 to 1.10 per unit for PSCO transmission facilities rated above 300kV, and power flows must remain below 100% of the facilities' continuous thermal ratings. Also, the maximum voltage deviation caused by switching of any shunt device (motor load, capacitor or inductor) under system intact conditions should not exceed 3% at any load serving bus. The maximum voltage deviation caused by switching of any shunt device (motor load, capacitor or inductor) during prior outage of the largest fault current contributing element should not exceed more than 5% at any load serving bus

Transient stability criteria require that all generating machines remain in synchronism and all power swings should be well damped for single contingency events. Also, transient voltage performance should meet the following WECC Disturbance-Performance criteria:

- Following fault clearing for singe contingencies:
  - Voltage may not drop 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 any bus.
  - Frequency man not drop below 59.6 Hz for 6 cycles or more at load buses.
- Following fault clearing for double contingencies:
  - Voltage may not drop more than 30% of the pre-fault voltage at any bus or more than 20% for more than 40 cycles at any bus.
  - Frequency may not drop below 59.0 Hz for 6 cycles or more at load buses.

GI-2015-1 is 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 Colorado Springs Utilities (CSU), Black Hills Colorado Electric (BHCE) and Intermountain Rural Electric Association (IREA).

Power Flow Study Models

The study was performed using the Western Electricity Coordinating Council 2018HS3 power flow case released on 02/02/2016. The case was updated to include the Lamar-Burlington 230kV line project and the 75MW Twin Buttes generation expansion.

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. Generation 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) has been signed. The Jackson Fuller wind is dispatched at 100% of the name plate capacity considering its geographical proximity to GI-2015-1.

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 the GI-2015-1 interconnection, whereas the study case included the GI-2015-1 model. PSCo's Fort Saint Vrain #1 is used as the sink for the generation addition. The GI was modeled using the PSSE modeling data provided by the Customer.

The transient stability studies are performed using the 2018HS3S PSLF case. The above mentioned updates and generation dispatch were implemented in the PSLF case.

Power Flow Study Process

The power flow studies were completed on the benchmark case and the study case using PTI's PSSE Ver. 33.4.0 program and the ACCC contingency analysis tool. For single contingency analysis bus-bus contingencies were run on both Area 70 and 73, in addition, a comprehensive list of breaker-breaker contingencies is run on zones 700, 703, 704, 705, 709, 710, 712, 752 and 757. The double contingency analysis was performed for all outages in zones 700, 703, 704, 705, 709, 710, 712, 752 and 757. 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 and existing voltage violations which increased are monitored. The monitored transmission system included zones 700, 703, 704, 705, 709, 710, 712, 752 and 757.

Transient Stability Study Process

Transient stability analysis was completed on the reference models and the models with the proposed new generation using GE's PSLF Ver. 18.1_02 program. Three phase faults were simulated for selected single contingencies as part of the analysis using standard clearing events. Bus voltage, bus frequency, and generator angle were recorded and analyzed per the WECC allowable criteria. Also, any generators that went out of synchronism were recorded. WECC's ALLDYNS EPCL program was used to simulate the disturbances.

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 827. Accordingly, 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.
- In accordance with FERC Order 827, all Interconnection Customers shall design their Generating Facility to maintain a composite power delivery at continuous rated power output at the high-side of the generator substation 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. In accordance with FERC Order 827, 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.
- In accordance with FERC Order 827, 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 thermal violations (marked in red) resulting from single contingencies, seen without and with Palmer Lake – Monument 115kV line operating procedure, are given in Table 5 and Table 6, respectively. From the results in Tables 5 and Table 6, it is evident that the addition of GI-2015-1 increased the existing thermal overloads and also caused two new thermal overloads. The thermal overloads in the CSU system are eliminated when the Palmer Lake- Monument 115kV line operating procedure is implemented. Therefore, the following four PSCo thermal overloads are attributable to the addition of GI-2015-1 (highlighted in yellow in Table 6). The pre-existing thermal overloads are not attributable to the addition of GI-2015-1.

- Greenwood – Prairie1 230kV line loading increased from 88.7% to 102.9%
- Greenwood – Prairie3 230kV line loading increased from 91.8% to 105.9%
- Greenwood – Monaco 230kV line loading increased from 96.2% to 105.9%
- Waterton – Martin2tap 115kV line loading increased from 96.5% to 101.8%

The Interconnection Customer is recommended to work with BHCE in order to mitigate the Portland – Skala 115kV line overload.

Addition of GI-2015-1 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-2015-1.

Transient Stability Study Results

The transient stability analysis for the GI-2015-1 System Impact Study simulated each of the twelve disturbances listed for both the benchmark case and study case. The results of each transient stability run were then analyzed to determine whether the

voltage and frequency performed within the WECC criteria and whether generators continued in synchronism before or after the proposed generation was interconnected.

The GI-2015-1 transient stability analysis found no WECC disturbance performance criteria violations in the pre-project and post-project cases for any of the studied contingency events (disturbances). Therefore, it is determined that GI-2015-1 produced no adverse system impact. The following results were obtained for every case and disturbance analyzed:

- ✓ No machines lost synchronism with the system
- ✓ No transient voltage drop violations were observed
- ✓ No transient frequency drop violations were observed
- ✓ Machine rotor angles displayed positive damping

Transient stability plots showing surrounding bus voltages, bus frequencies, generator terminal voltages, generator relative angles, generator speeds, and generator power output for each of the disturbances run for each study scenario have been created and documented in Appendix A.

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.

Conclusion

Energy Resource Interconnection Service (ERIS): Due to pre-existing thermal overloads (before the interconnection of GI-2015-1), GI-2015-1 output for ERIS is 0 MW. However, higher GI-2015-1 output may become feasible on an as-available basis depending on the generation dispatch of existing generation resources located in the electrical vicinity of GI-2015-1 (such as Comanche, Midway and Jackson Fuller generators.)

Network Resource Interconnection Service (NRIS): Network Upgrades to address the above mentioned thermal overloads will allow GI-2015-1 to achieve 250MW NRIS. The rating of the Greenwood – Prairie 1 and Greenwood – Prairie 3 230kV lines can be increased by upgrading the terminal equipment.

The estimated costs for the network upgrades are given in Table 3 below.

Short Circuit

The GI-2015-1 Substation will be designed for the maximum fault current level, so short-circuit analysis at the POI is not needed. Breaker duty study determined that no breaker replacements are needed in neighboring substations.

Costs Estimates and Assumptions

Scoping level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by Public Service Company of Colorado (PSCo) / Xcel Energy (Xcel) Engineering. The cost estimates are in 2016 dollars with escalation and contingency included. AFUDC is not included. Estimates are developed assuming typical construction costs for previous completed projects. These estimates include all applicable labor and overheads associated with the siting support, engineering, design, material/equipment procurement, construction, testing and commissioning of these new substation and transmission line 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 Interconnection Facilities and Network Upgrades for Delivery for GI-2015-1 is **$10,396,000.** Figure 1 below represents a conceptual one-line of the GI-2015-1 Substation tapping the Comanche – Daniels Park 345kV Line. These estimates do not include costs for any other Customer owned equipment and associated design and engineering. The following tables list the transmission system improvements required to accommodate the interconnection and delivery of GI-2015-1 output. The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines. These scoping level cost estimates are subject to change upon a more detailed and refined design.

- Scoping level project cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by PSCo / Xcel Engineering.
- Estimates are based on 2016 dollars (appropriate contingency and escalation included).
- AFUDC has been excluded.
- Labor is estimated for straight time only – no overtime included.
- Lead times for materials were considered for the schedule.
- The Wind Generation Facility is not in PSCo's retail service territory. Therefore, no costs for retail load (distribution) facilities and metering required for station service are included in these estimates.
- PSCo / Xcel (or our Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- The estimated time to site, design, procure and construct the interconnection and network delivery facilities is approximately 18 months.
- A CPCN will be required for the construction of interconnection facilities and network upgrades and will add approximately 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.
- The Customer will be required to design, procure and install a Load Frequency/Automated Generation Control (LF/AGC) RTU at their

Customer Substation. PSCo / Xcel will need indications, readings and data from the LFAGC RTU.

- Customer will string OPGW fiber into substation as part of the transmission line construction scope.
- Ten (10) acres of new substation land will need to be acquired.
- Breaker duty study determined that no breaker replacements are needed in neighboring substations.

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

Element	Description	Cost Est. (Millions)
GI-2015-1 345kV Transmission Substation	Interconnect Customer to tap at the new GI-2015-1 345kV Substation. The new equipment includes: • (1) 345kV line position & associated protective relaying • (2) 345kV circuit breakers • (3) 345kV CCVTs • (2) 345kV Line Traps • (3) 345kV Meter Units • (1) 345kV dead-end structure 20% land footprint, earthwork, ground grid	**$1.789**
	Transmission line relocation and tap into substation. Structures, conductor, insulators, hardware and labor.	**$0.616**
	Siting and Land Rights support for siting studies, land and ROW acquisition and construction.	**$0.020**
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	**$2.425**
Time Frame	**Site, design, procure and construct**	**18 Months**

Table 2: PSCo Owned; PSCo Funded Transmission Provider Interconnection Facilities

Element	Description	Cost Estimate (Millions)
GI-2015-1 345kV Transmission Substation	PSCo to construct new GI-2015-1 345kV Substation. The new equipment includes: • (2) 345kV line positions & associated protective relaying • (2) 345kV circuit breakers • (8) 345kV CCVTs • (1) EEE • (2) 345kV dead-end structures • (1) Lot 345kV buswork • (10) 345kV disconnect switches • (2) 345kV Line traps • (1) Station Service transformer unit • 345kV bus protection • RTU, DFR, SPABX, SCADA • 80% land footprint, earthwork, ground grid	**$7.440**
	Siting and Land Rights support for substation land acquisition and construction.	**$0.208**
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	**$7.648**
Time Frame	**Site, design, procure and construct**	**18 Months**

Table 3 – PSCo Network Upgrades for Delivery

Element	Description	Cost Est. (Millions)
Greenwood Substation	Uprated Line Trap and Associated Wiring	**$0.202**
Monaco Substation	Uprated Jumpers and Associated Equipment	**$0.035**
Prairie Substation	Uprated Jumpers and Associated Equipment	**$0.045**
Waterton Substation	Uprated Jumpers and Associated Equipment	**$0.041**
	Total Cost Estimate for PSCo Network Upgrades	**$0.323**
Time Frame	**Design, procure and construct**	**18 Months**

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 115kV Line Operating Procedure

				Branch Contingency Loading Without GI-2015-1		Branch Contingency Loading With GI-2015-1			
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 230kV	Line	PSCo	478/478	489.9	102.5%/102.5 %	556.9	116.5%/116.5%	14%	Daniels Park – Prairie3 230kV Line
Greenwood – Prairie1 230kV	Line	PSCo	478/478	419.2	87.7%/87.7%	486.1	101.7%/101.7%	14%	Daniels Park – Prairie3 230kV Line
Greenwood – Prairie3 230kV	Line	PSCo	478/478	434.0	90.8%/90.8%	500.9	104.8%/104.8%	14%	Daniels Park – Prairie1 230kV Line
Leetsdale – Monaco12 230kV	Line	PSCo	396/436	354.8	89.6%/81.4%	393.6	99.4%/90.2%	9.8%	Tollgate- SmokyHill 230kV Line
Greenwood – Monaco12 230kV	Line	PSCo	404/480	389.5	96.4%/81.1%	429	106.2%/89.3%	9.8 %	Tollgate- SmokyHill 230kV Line
Palmer Lake – Monument 115kV	Line	PSCo/ CSU	132/153	127.6	96.7%/83.4%	134.7	102.1%/88%	5.4%	Daniels Park – Jackson Fuller 230kV
Portland – Skala 115kV	Line	BHCE	111/111	105.8	95.3%/95.3%	112.5	101.4%/101.4%	6.1%	MidwayBR – West Canyon 230kV
Waterton – Martin2Tap 115kV	Line	PSCo	125/138	122.8	98.3%/88.98%	129.5	103.6%/93.8%	5.3%	Sodalakes 230/115kV #T2
Cottonwood N - KettleCreek S 115kV	Line	CSU	162/180	195.05	120.4%/108.4 %	200.9	124%/111.6%	3.2%	Brairgate S – Cottonwood S 115kV
BLKFORTP – BLK SQMV 115kV	Line	CSU	81/81	87.9	108.5%/108.5 %	92.0	113.7%/113.7%	5.2%	Flyhorse S – Kettlecreek N 115kV
Fuller 230/115kV #1	Xfmr	CSU	100/100	101.9	101.9%/101.9 %	103.2	103.2%/103.2%	1.3%	MidwayBR – Rancho 115kV

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 115kV Line Operating Procedure

				Branch Contingency Loading Without GI-2015-1		Branch Contingency Loading With GI-2015-1			
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**
Happy Canyon – Daniels Park 115kV	Line	PSCo	120/120	125.88	104.9%/104.9%	127.8	106.5%/106.5%	1.6%	Parker – Bayou 115kV
Daniels Park – Prairie1 230kV	Line	PSCo	478/478	494.9	103.5%/103.5%	562.4	117.7%/117.7%	14.2%	Daniels Park – Prairie3 230kV Line
Greenwood – Prairie1 230kV	Line	PSCo	478/478	423.9	88.7%/88.7%	491.8	102.9%/102.9%	14.2%	Daniels Park – Prairie3 230kV Line
Greenwood – Prairie3 230kV	Line	PSCo	478/478	438.8	91.8%/91.8%	506.2	105.9%/105.9%	14.1%	Daniels Park – Prairie1 230kV Line
Leetsdale – Monaco12 230kV	Line	PSCo	396/436	353.6	89.3%/81.1 %	392.8	99.2%/90.0%	9.9%	Tollgate- Smoky Hill 230kV Line
Greenwood – Monaco12 230kV	Line	PSCo	404/480	388.2	96.1%/80.8%	427.8	105.9%/89.1%	9.8 %	Tollgate- Smoky Hill 230kV Line
Palmer Lake – Monument 115kV	Line	PSCo/ CSU	132/153	N/A	N/A	N/A	N/A	N/A	Daniels Park – Jackson Fuller 230kV
Portland – Skala 115kV	Line	BHCE	111/111	107.6	97%/97%	114.5	103.2%/103.2%	6.2%	MidwayBR – West Canyon 230kV
Waterton – Martin2Tap 115kV	Line	PSCo	125/138	120.6	96.5%/87.4%	127.2	101.8%/92.2%	5.3%	Soda Lakes 230/115kV #T2
Cottonwood N - KettleCreek S 115kV	Line	CSU	162/180	148.4	91.6%/82.4%	151.1	93.3%/83.9%	1.5%	Brairgate S – Cottonwood S 115kV
BLKFORTP – BLK SQMV 115kV	Line	CSU	81/81	70.3	86.7%/86.7%	72.9	90%/90%	3.3%	Flyhorse S – Kettlecreek N 115kV
Fuller 230/115kV #1	Xfmr	CSU	100/100	88	88%/88%	88.4	88.4%/88.4%	0.4%	MidwayBR – Rancho 115kV

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 115kV Line Operating Procedure

				Branch Contingency Loading Without GI-2015-1		Branch Contingency Loading With GI-2015-1			
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**
Portland - Skala115kV	Line	BHCE	119/119	111	98%/98%	124.4	104.5%/104.5%	6.5%	Midway BR-MidwayPS 230kV & MidwayPS – Fuller 230kV
West Canyon 230/115kV	Xfmr	BHCE	100/100	103.6	103.6%/103.6%	104.9	104.9%/104.9%	1.3%	Portland – West Station 115kV#1 &2
DesertCove – West Station 115kV	Line	BHCE	120/120	158.0	131.7%/131.7%	166.8	139%/139%	7.3%	MIdwayBR 230kV bus outage & MidwayPS – Fuller 230kV
Arapahoe – SantaFe 230kV	Line	PSCo	300/330	298.1	99.4%/99.4%	314.7	104.9%/104.9%	5.5%	Greenwood 230kV Breaker Failure
Arapahoe – SantaFe 230kV	Line	PSCo	300/330	300.6	100.2%/100.2%	314.7	104.9%/104.9%	4.7%	Greenwood- Prairie – Daniels Park 230kV # 1&2
Daniels Park - SantaFe 230kV	Line	PSCo	319/319	334.6	104.9%/104.9%	380.2	119.2%/119.2%	14.3%	Greenwood 230kV Breaker Failure
Daniels Park - SantaFe 230kV	Line	PSCo	319/319	337.5	105.8%/105.8%	383.1	120.1%/120.1%	14.3%	Greenwood- Prairie – Daniels Park 230kV # 1&2
Fountain Valley – DesertCov 115kV	Line	BHCE	115/115	130.7	113.7%/113.7%	139.1	121.0%/121%	7.3%	Midway BR-MidwayPS 230kV & MidwayPS – Fuller 230kV
Fountain Valley – MidwayBR 115kV	Line	BHCE	115/115	129.6	112.7%/112.7%	138	120.0%/120%	7.3%	Midway BR-MidwayPS 230kV & MidwayPS – Fuller 230kV
CottonwoodN-KettlecreekS 115kV	Line	CSU	150/192	150.4	100.3%/78.3%	154.9	103.3%/80.7%	2.4%	Cottonwood S 115kV Bus outage
BlackForest Tap – BLK SQMV 115kV	Line	CSU	81/81	132.4	163.4%/163.4%	136.4	168.4%/168.4%	5%	Cottonwood 115kV tie breaker outage

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Table 7 – Summary of thermal violations from Double Contingency Analysis
Without Palmer Lake– Monument 115kV Line Operating Procedure

				Branch Contingency Loading Without GI-2015-1		Branch Contingency Loading With GI-2015-1			
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**
BLk SQMV – Fuller 115kV	Line	CSU	143/143	153.4	107.3%/107.3%	157.6	110.2%/110.2%	2.9%	Cottonwood 115kV tie breaker outage
Fuller 230/115kV	Xfmr	CSU	100/100	131.6	131.6%/131.6%	133.2	133.2%/133.2%	1.6%	Cottonwood 115kV tie breaker outage
Fountain S-RD_Nixon 115kV	Line	CSU	195/212	238.7	122.4%/112.6%	241.4	123.8%/113.8%	1.2%	KelKer 230kV Tie breaker outage
DanielsPark – Fuller 230kV	Line	PSCo	478/478	583.7	122.1%	N/A	N/A	N/A	Comanche – Daniels Park 345kV # 1&2
Fountain Valley – Desertcove 115kV	Line	BHCE	119/119	122.1	102.6%	N/A	N/A	N/A	Comanche – Daniels Park 345kV # 1&2
Fountain Valley – MidwayBR 115kV	Line	BHCE	119/119	120.9	101.6%	N/A	N/A	N/A	Comanche – Daniels Park 345kV # 1&2
Hydepark – West Station 115kV	Line	BHCE	120/120	123.2	77%	N/A	N/A	N/A	Comanche – Daniels Park 345kV # 1&2
MidwayPS 230/115kV	Xfmr	PSCo	97/120	101.8	105%	N/A	N/A	N/A	Comanche – Daniels Park 345kV # 1&2
MidwayPS - MidwayBR 230kV	Line	PSCo/ WAPA	430/478	422.2	98.2%	N/A	N/A	N/A	Comanche – Daniels Park 345kV # 1&2
Palmer Lake – Monument 115kV	Line	CSU	132/153	166.1	125.8%	N/A	N/A	N/A	Comanche – Daniels Park 345kV # 1&2
DesertCove – West Station 115V	Line	BHCE	119/119	144.5	121.4%	N/A	N/A	N/A	Comanche – Daniels Park 345kV # 1&2
Waterton 345/230kV	Xfmr	PSCo	560/756	532	95%	N/A	N/A	N/A	Comanche – Daniels Park 345kV # 1&2
FlyhorseS-KettlecreekN 115kV	Line	CSU	162/180	196.7	121.4%	N/A	N/A	N/A	Comanche – Daniels Park 345kV # 1&2
Midway – Waterton 345kV	Line	PSCo	560/644	548.2	97.9%	N/A	N/A	N/A	Comanche – Daniels Park 345kV # 1&2
Monument – FlyhorseN 115kV	Line	CSU	142/156	185.1	130.4%	N/A	N/A	N/A	Comanche – Daniels Park 345kV # 1&2
Cottonwood N – KettleCreekS 115kV	Line	CSU	150/192	171.3	105.7%	N/A	N/A	N/A	Comanche – Daniels Park 345kV # 1&2

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Table 7 – Summary of thermal violations from Double Contingency Analysis Without Palmer Lake– Monument 115kV Line Operating Procedure									
				Branch Contingency Loading Without GI-2015-1		Branch Contingency Loading With GI-2015-1			
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
Cottonwood N – KettleCreekS 115kV	Line	CSU	150/192	N/A	N/A	170	104.9%	N/A	Comanche – Daniels Park 345kV #1 & Comanche – GI-Tap 345kV #1
Monument – Flyhorse N 115kV	Line	CSU	142/157	N/A	N/A	183.9	129.5%	N/A	Comanche – Daniels Park 345kV #1 & Comanche – GI-Tap 345kV #1
Flyhorse S – Kettlecreek N 115kV	Line	CSU	162/180	N/A	N/A	195.4	120.6%	N/A	Comanche – Daniels Park 345kV #1 & Comanche – GI-Tap 345kV #1
MidwayPS 230/115kV	Xfmr	PSCo	560/756	N/A	N/A	102.6	105.8%	N/A	Comanche – Daniels Park 345kV #1 & Comanche – GI-Tap 345kV #1
Palmer lake – Monument 115kV	Line	CSU	132/153	N/A	N/A	164	124.2%	N/A	Comanche – Daniels Park 345kV #1 & Comanche – GI-Tap 345kV #1
DanielsPark – Fuller 230kV	Line	PSCo	478/478	N/A	N/A	678.2	141.9%	N/A	Comanche – Daniels Park 345kV #1 & Daniels Park – GI-Tap 345kV #1
Fountain Valley – Desertcove 115kV	Line	BHCE	119/119	N/A	N/A	147.5	124%	N/A	Comanche – Daniels Park 345kV #1 & Daniels Park – GI-Tap 345kV #1
Fountain Valley – MidwayBR 115kV	Line	BHCE	119/119	N/A	N/A	146.2	122.9%	N/A	Comanche – Daniels Park 345kV #1 & Daniels Park – GI-Tap 345kV #1
Hydepark – West Station 115kV	Line	BHCE	120/120	N/A	N/A	133.2	111%	N/A	Comanche – Daniels Park 345kV #1 & Daniels Park – GI-Tap 345kV #1
MidwayPS 230/115kV	Xfmr	PSCo	97/120	N/A	N/A	116.2	119.8%	N/A	Comanche – Daniels Park 345kV #1 & Daniels Park – GI-Tap 345kV #1
MidwayPS - MidwayBR 230kV	Line	PSCo/ WAPA	430/478	N/A	N/A	516.6	120.1%	N/A	Comanche – Daniels Park 345kV #1 & Daniels Park – GI-Tap 345kV #1
Palmer Lake – Monument 115kV	Line	CSU	132/153	N/A	N/A	192.7	146%	N/A	Comanche – Daniels Park 345kV #1 & Daniels Park – GI-Tap 345kV #1
DesertCove – West Station 115V	Line	BHCE	119/119	N/A	N/A	171.4	144%	N/A	Comanche – Daniels Park 345kV #1 & Daniels Park – GI-Tap 345kV #1
Waterton 345/230kV	Xfmr	PSCo	560/756	N/A	N/A	632.8	113%	N/A	Comanche – Daniels Park 345kV #1 & Daniels Park – GI-Tap 345kV #1

Table 7 – Summary of thermal violations from Double Contingency Analysis Without Palmer Lake– Monument 115kV Line Operating Procedure									
				Branch Contingency Loading Without GI-2015-1		Branch Contingency Loading With GI-2015-1			
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**
Midway – Waterton 345kV	Line	PSCo	560/644	N/A	N/A	632.8	113%	N/A	Comanche – Daniels Park 345kV #1 & Daniels Park – GI-Tap 345kV #1
Cottonwood N – KettleCreekS 115kV	Line	CSU	150/192	N/A	N/A	191.6	118.3%	N/A	Comanche – Daniels Park 345kV #1 & Daniels Park – GI-Tap 345kV #1
Monument – Flyhorse N 115kV	Line	CSU	142/157	N/A	N/A	213.1	150.1%	N/A	Comanche – Daniels Park 345kV #1 & Daniels Park – GI-Tap 345kV #1
Flyhorse S – Kettlecreek N 115kV	Line	CSU	162/180	N/A	N/A	225.1	138.9%	N/A	Comanche – Daniels Park 345kV #1 & Daniels Park – GI-Tap 345kV #1
BLKFORTP – BLK SQMV	Line	CSU	81/81	N/A	N/A	84.1	103.9%	N/A	Comanche – Daniels Park 345kV #1 & Daniels Park – GI-Tap 345kV #1

B. Transient Stability Study Results

Stability Scenarios							
#	Fault Location	Fault Type	Facility Tripped	Clearing Time (cycles)	Pre GI-2015-1	Post-Fault Voltage Recovery	Angular Stability
1	GI-2015-1Tap Point	3ph	Tap Point*-Comanche 345 kV	Primary (4.0)	N/A	Maximum transient voltage dips and frequency deviations within criteria	Stable with positive damping
2	GI-2015-1Tap Point	3ph	Tap Point*-Daniels Park 345 kV	Primary (4.0)	N/A	Maximum transient voltage dips and frequency deviations within criteria	Stable with positive damping
3	Comanche 345 kV	3ph	Comanche* - Tap Point 345 kV	Primary (4.0)	N/A	Maximum transient voltage dips and frequency deviations within criteria	Stable with positive damping
4	Comanche 345 kV	3ph	Comanche* - Daniels Park 345 kV	Primary (4.0)	Acceptable	Maximum transient voltage dips and frequency deviations within criteria	Stable with positive damping
5	Comanche 345 kV	3ph	Comanche 345/230 kV	Primary (4.0)	Acceptable	Maximum transient voltage dips and frequency deviations within criteria	Stable with positive damping
6	Daniels Park 345 kV	3ph	Daniels Park*-Tap Point 345 kV	Primary (4.0)	N/A	Maximum transient voltage dips and frequency deviations within criteria	Stable with positive damping
7	Daniels Park 345 kV	3ph	Daniels Park*-Comanche 345 kV	Primary (4.0)	Acceptable	Maximum transient voltage dips and frequency deviations within criteria	Stable with positive damping
8	Comanche 230 kV	3ph	Comanche*-Walsenburg 230 kV	Primary (5.0)	Acceptable	Maximum transient voltage dips and frequency deviations within criteria	Stable with positive damping
9	Comanche 230 kV	3ph	Comanche*-MidwayPS 230 kV	Primary (5.0)	Acceptable	Maximum transient voltage dips and frequency deviations within criteria	Stable with positive damping
10	Comanche 230 kV	3ph	Comanche*-Boone 230 kV	Primary (5.0)	Acceptable	Maximum transient voltage dips and frequency deviations within criteria	Stable with positive damping
11	Comanche 230 kV	3ph	Comanche*-CF&IFURN 230 kV	Primary (5.0)	Acceptable	Maximum transient voltage dips and frequency deviations within criteria	Stable with positive damping
12	Comanche 230 kV	3ph	Comanche*230/115 kV	Primary (5.0)	Acceptable	Maximum transient voltage dips and frequency deviations within criteria	Stable with positive damping

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	64.8
Colorado Green	2	64.8
Twin Butte	1	60
Twin Butte-II	W1	60
Jackson Fuller	W1&W2	250
Alamosa CT	G1	0
Alamosa CT	G2	0
Cogentrix	S3	25.5
Greater Sandhill	S1	16.1
Blanca Peak	S1	19.5
SLV Solar	S1	44.2
Arapahoe5&6	G5&G6	66.6
Arapahoe7	G7	40.5

BHE:

Bus	LF ID	MW
BUSCHWRTG1	G1	4.0
BUSCHWRTG2	G2	4.0
BUSCHWRTG2	G3	4.0
E Canon	G1	0
PP_MINE	G1	0
Pueblo Diesels	G1	0
Pueblo Plant	G1	0
Pueblo Plant	G2	0.0
R.F. Diesels	G1	0.0
Airport Diesels	G1	0.0
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	40

CSU:

Bus	**LF ID**	**MW**
Birdsale1	1	0.0
Birdsale 2	1	0.0
Birdsale 3	1	0.0
RD_Nixon	1	221
Tesla	1	13.2
Drake 5	1	47.7
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	142.0
Front Range CC 3	1	142.7

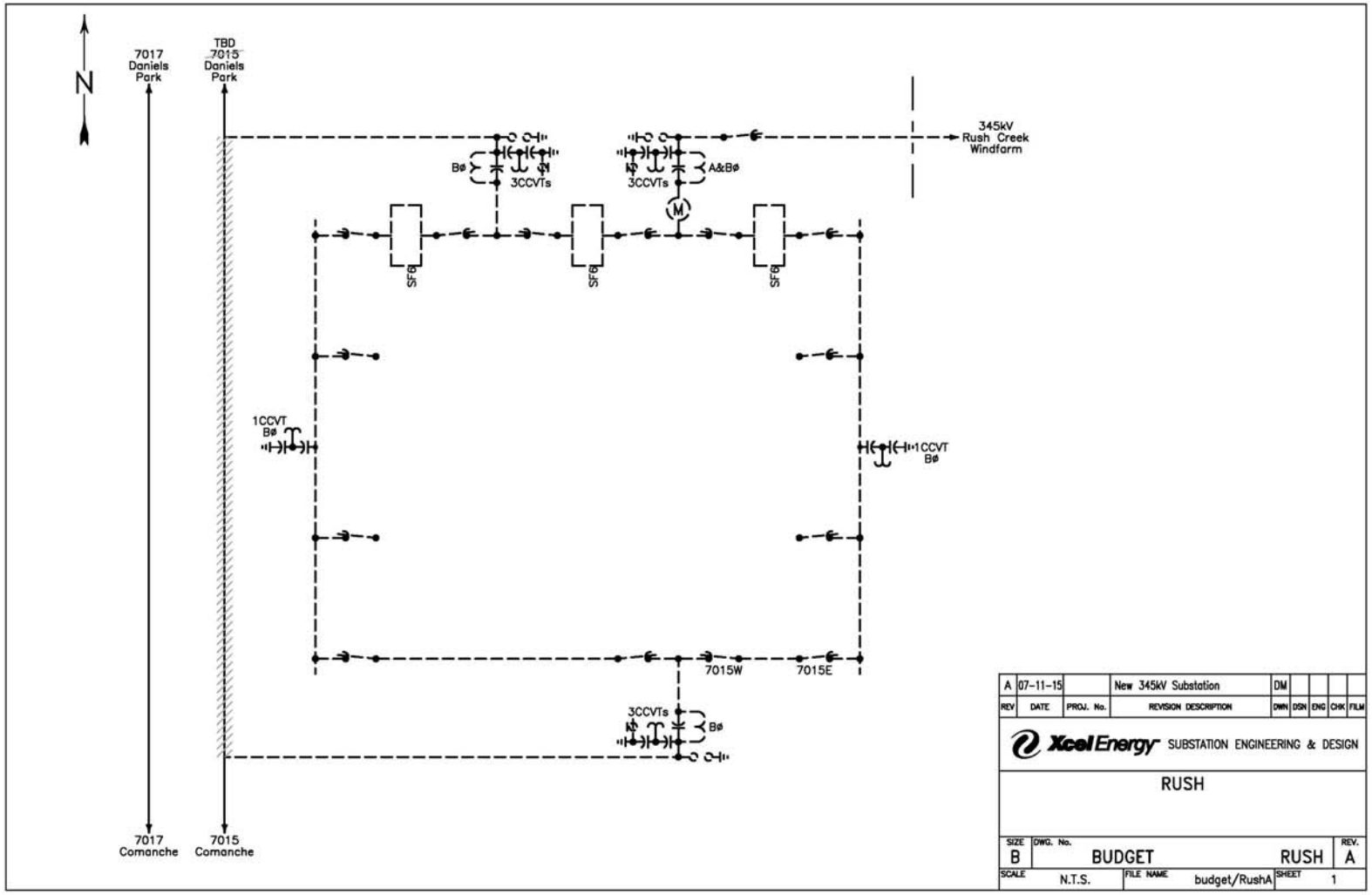

Figure -1-GI-2015-1 Conceptual One-Line Diagram of the GI-2015-1 Substation