



DRAFT

GENERATION INTERCONNECTION REQUEST # GI-2014-11

FACILITY STUDY REPORT 50 MW PV SOLAR, ALAMOSA COUNTY, COLORADO

XCEL ENERGY – PSCO TRANSMISSION PLANNING WEST
July 12, 2016

A. Executive Summary

This Interconnection Facility Study Report summarizes the analysis performed by Public Service Company of Colorado (PSCo), designated as GI-2014-11, to specify and estimate the cost of the siting, engineering, equipment procurement and construction needed to physically and electrically connect the GI-2014-11, 50 MW photovoltaic (PV) generation facility (GF) in Alamosa County, Colorado.

The requested Point of Interconnection (POI) is on the San Luis Valley 230 kV bus. The Customer's GF will connect 50 MW of solar photovoltaic generation to the SLV 230 kV bus via an approximate 0.5 mile generator tie line. A total of twenty-three (23) Power Conversion Stations (PCS) and associated PV modules will be connected to a common 34.5 kV collector bus. The GF will include 23 PCS (2.5 MVA SMA Solar Technology inverter), and one 34.5/230 kV step-up transformer (GSU) for delivery.

Figure 1 is a diagram of the SLV area. Figure 2, in Appendix A, shows the budget one-line of the SLV Substation. The proposed commercial operation in-service date is November 1, 2016 with an assumed back feed date of six months prior to Commercial Operation Date (COD¹).

This request was studied both as an Energy Resource Interconnection Service (ERIS)² and a Network Resource Interconnection Service (NRIS)³. The System Impact Study consisted of power flow (steady-state) contingency, dynamics, and short circuit analyses. The power flow analysis results identified a contingency violation that can be attributed to the GI-2014-11

¹ **Commercial Operation Date** of a unit shall mean the date on which the Generating Facility commences Commercial Operation as agreed to by the Parties pursuant to Appendix E to the Standard Large Generator Interconnection Agreement.

² **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. ERIS in and of itself does not convey transmission service

³ **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. NRIS in and of itself does not convey transmission service.

facility. While this is an ERIS and NRIS study report, the purpose of this study is neither to guarantee transmission service nor to serve as documentation for the GF to be a designated network resource for PSCo. Per PSCo's Operations' document posted on the Open Access Same-Time Information System (OASIS), there is zero available transfer capability between Poncha/SLV and the Denver Metro area. PSCo has yet to determine the network upgrades for delivery to mitigate the criteria violations in San Luis Valley to allow the export of power from any new generation interconnection to the Denver Metro area. There is an ongoing joint transmission study effort between PSCo and Tri-State Generation and Transmission (TSGT) for the SLV area through the Colorado Coordinated Planning Group (CCPG). Phase 1 was completed in early 2016 and Phase 2 is underway with the expected completion date of the 4th quarter of 2016. The Phase 1 study report can be found on the WestConnect website under "San Luis Valley Subcommittee".

This Interconnection Facility Study Report summarizes the analysis performed by PSCo to specify and estimate the cost of the siting, engineering, equipment procurement and construction needed to interconnect a 50 MW solar photovoltaic generation facility at the San Luis Valley 230 kV Substation in Alamosa County, Colorado.

There are four proposed components for this scope of work:

Customer Funded Interconnection

- \$1.017 million for the customer funded portion of the 230 kV 50 MW Solar Interconnect

Customer Funded LFAGC RTU ("LFAGC RTU" is a load frequency/automated generation control RTU)

- \$0.182 million for the LFAGC RTU installed at the new 50 MW Solar Interconnect site

Xcel Funded Interconnection and Network Upgrades

- \$2.300 million for the Xcel funded portion of the 230 kV Solar interconnection project at SLV Substation

Xcel Funded RTU

- \$0.345 million for the RTU installation for the 230 kV solar interconnection project at SLV Substation (new RTU to be installed in a new EEE (“EEE” is an electrical equipment enclosure similar to a control building))

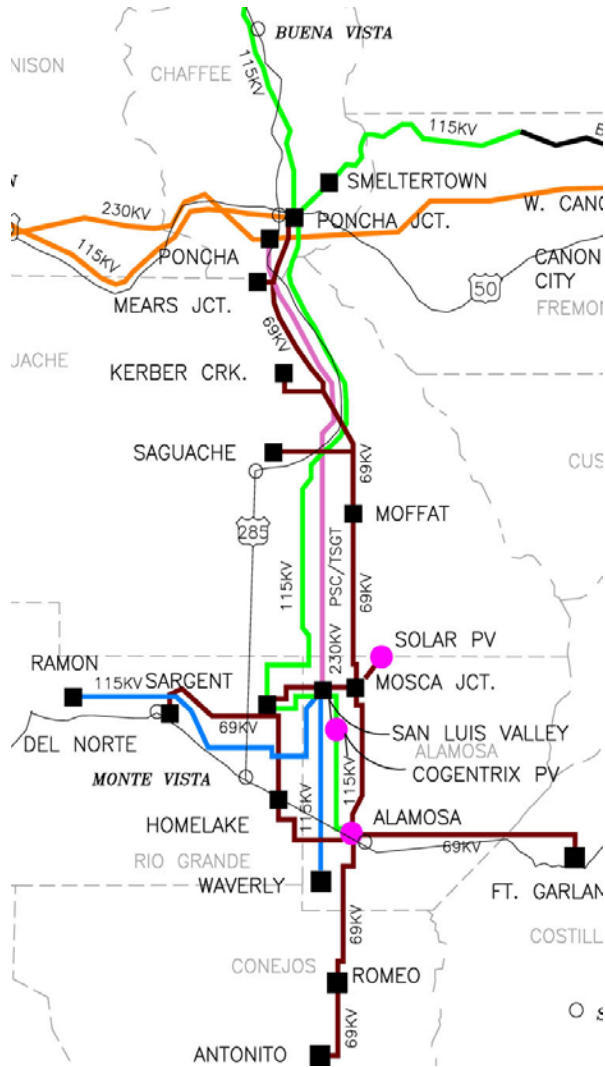
The estimated time required to site, engineer, procure and construct the facilities described is at least 18 months from the date the customer meets all applicable milestones as agreed to in any future Large Generator Interconnection Agreement (LGIA). An Engineering & Procurement Agreement can be executed to facilitate completion of the interconnection facilities.

The proposed station one-line diagram for the expansion of the San Luis Valley 230 kV Substation to a five breaker ring bus configuration is shown in Figure 2.

The total estimated cost of the recommended system upgrades to interconnect the project is approximately **\$ 3.844 million** and includes:

- \$1.199 million for PSCo Owned, Customer Funded Interconnection Facilities.
- \$2.645 million for PSCo Owned, PSCo Funded Interconnection Facilities.
- \$0.000 million for PSCo Network Upgrades for Delivery (pending future studies).

Figure 1: San Luis Valley region



B. Introduction

PSCo and a Generation Provider (the “Customer”) signed an Interconnection Facility Study request (GI-2014-11) to provide cost estimates, a project schedule, and to address the impacts, as identified in the System Impact Study, of interconnecting a 50 MW PV generation facility to the 230 kV bus at PSCo’s San Luis Valley Substation. The Customer’s GF will consist of twenty-three (23) Power Conversion Stations (PCS) and associated PV modules will be connected to a common 34.5 kV collector bus. The GF will include twenty-three (23) PCS (2.5 MVA Solar Technology inverter), and one 34.5/230 kV step-up transformer for delivery. The proposed commercial operation in-service date is November 1, 2016 with an assumed back feed date of six months prior to Commercial Operation Date (COD). However, based on results of the System Impact Study, the COD for Network Resource Interconnection Service cannot be met until after the overload has been mitigated in the San Luis Valley and additional transmission line(s) constructed to export additional generation out of the San Luis Valley to the Denver Metro area.

There is an ongoing joint transmission study effort between PSCo and Tri-State Generation and Transmission (TSGT) for the SLV area through the Colorado Coordinated Planning Group (CCPG). Phase 1 of the SLV Coordinated Planning Study has been completed and the study report can be found on the WestConnect website. Phase 2 has just been kicked off and the study is underway to analyze different transmission alternatives beyond Poncha Substation.

The purpose of Interconnection Facility Study is to specify and estimate the cost of the equipment, engineering, procurement and construction work needed to implement the conclusions of the Interconnection System Impact Study in accordance with Good Utility Practice to physically and electrically connect the GI-2014-11 large generating facility to PSCo’s transmission system at the SLV 230 kV Substation.

C. General Interconnection Facilities Description

PSCo’s requirements for interconnection can be found in the [Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater Than 20 MW – Version 8.0](#), last revised in August 2015. Xcel Energy requires the interconnection customer to construct the

Interconnection Facilities in compliance with this document. The guidelines describe the technical and protection requirements for connecting new generation to the Xcel Energy Operating Company transmission system and also requires that the Interconnection Customer be in compliance with all applicable criteria, guidelines, standards, requirements, regulations, and procedures issued by the North American Electric Reliability Council (NERC), Colorado Public Utility Commission (CPUC) or their successor organizations.

I. FERC and/or NERC Compliance Requirements

Critical Infrastructure Protection (CIP) Asset

The CIP status of this site (San Luis Valley 230 kV Substation) was verified by Real Time Transmission Planning on June 03, 2016. The scope of this project will not change or affect the CIP Status of this site.

Facility Ratings

The substation will meet the new facility rating methodology.

II. Right of Way/Permitting

The expansion of this substation will not require the purchase of any additional land. All land needed for the expansion is currently owned by either Xcel Energy or Tri-State.

Any costs for a new transmission line easement will be the responsibility of the customer to determine.

III. Electrical Features

Transmission Lines: Current Carrying Capacity of Affected/Tapped/New

The new 230 kV transmission line will be installed by the Customer with enough capacity to carry the expected current. The substation bays will be rated to at least 2000 amps.

Fault Current

All the equipment is being designed to withstand a 40 kA fault.

Location \ Type of fault	Three Phase (amps)	Single-Line-to-Ground (amps)
Existing 230 kV ring bus Fault Currents (Year 2016)	3085	3801
Future 230 kV ring bus Fault Currents (Year 2018 w/new generation online)	3318	4144

Electrical Installations (Major Equipment)

- The 230 kV ring bus yard will consist of five (5) 230 kV breakers (and associated disconnects, etc.) for the lines to Poncha 230 kV Substation (WAPA), Hooper Substation, the San Luis Valley 230/115 kV transformer Bank one and Bank two, and the new Customer’s solar line as shown on Figure 2 “Project One-Line of the San Luis Valley Substation”. The 230 kV bus will be arranged in a ring bus configuration. Any future line addition will require changing the bus configuration to breaker-and-half setup to comply with Xcel’s standard of practice.
- Note that the GI-2014-11 50 MW Solar Generation Facility line side equipment will be customer funded and covered in the Customer upgrades portion of the estimate.

Mobile Substation or Transformer

A mobile is not expected to be needed as part of the construction.

Electrical Equipment Enclosure (EEE)

A 27’x55’ EEE will be required to house the new harmonized standard relays and RTU for the project. This installation will facilitate future modifications at the station.

AC System

The existing AC system for the 230 kV yard consists of two (2) three phase 75 kVA Station Service Voltage Transformer's (padmount). New primary and backup station service should be installed to provide power to the new EEE (assumed 150 kVA each). Additional analysis will be performed during detailed design determine source of station service.

DC System

DC calculations show that the existing battery is not adequate for the existing equipment loads per Xcel standards. The existing battery charger will not need to be replaced; however, in order to meet worst case tripping loads the existing battery bank will need to be upgraded.

A new battery bank and charger will also be installed in the new EEE as part of this project.

Grounding

A new ground grid and ground leads will be installed as required for the substation expansion. The existing ground grid will be checked during detailed design to verify it meets standard requirements. The assumption made for this estimate development is that the existing ground grid is adequate for the existing and new fault current.

Lightning Protection

Surge arresters will be installed on the Customer's new incoming 230 kV line. Static wires will be installed as needed on new transmission towers and substation dead-ends. Substation dead-end structures will be furnished with the shield spikes on each side of the structures. In addition, there will be two standalone static masts installed to protect the new area of the yard.

Trenching & Cable

New cable trench will be installed to accommodate the 230 kV yard expansion. This new cable trench will connect to the existing cable trench as well as the new Electrical Equipment Enclosure (EEE).

IV. Civil Features

Grading & Fencing

Grading will be required and a new chain-link fence will be installed around the new 230 kV yard expansion area to the north of the existing 230 kV yard. This area is anticipated to be 80 feet by 372.5 feet

Storm Water Permit

Since the site will be expanded on less than one acre of land, a storm water permit will not be required.

SPCC (Oil Containment)

No equipment with large oil volume will be added or removed so no SPCC modification will be needed.

Foundations & Structural

Foundations for the new circuit breaker, switch stand, bus supports, dead-end structure, lightning arresters, EEE, static mast and metering unit stands will be required and are detailed in the civil installations section.

Civil Removals & Relocations

Six bus support structures and foundations for the existing bus section linking breakers 282 and 382 will be removed to minimum of 18 inches below grade. Two existing yard lighting fixtures and part of the north side fence will be removed along with the associated fence grounding.

Civil Installations

Standard designs are anticipated (drilled piers, slabs, etc.)

Required foundations/structures to be funded by PSCo

The following concrete slab foundations will be installed:

<u>Quantity</u>	<u>Description</u>
1	230 kV breaker foundation

The following drilled pier foundations will be installed:

<u>Quantity</u>	<u>Description</u>
2	230 kV Static Mast
2	230 kV Switch Stands
9	Bus Supports

The following concrete vault foundations will be installed:

<u>Quantity</u>	<u>Description</u>
1	EEE (27 feet by 55 feet)

The following galvanized steel structures with drilled pier foundations will be installed:

Structure Quantity	Steel Description
1	230 kV Switch Stand
7	230 kV Low Bus Support (1 phase)
1	230 kV Low Bus Support (3 phase)
2	230 kV Static Mast

Required equipment/foundations to be funded by the Customer

The following drilled pier foundations will be installed:

Quantity	Description
2	230 kV Dead-End
7	230 kV Bus Supports
3	230 kV Metering unit Stand
3	230 kV Lightning Arrester Stands

The following galvanized steel structures with drilled pier foundations will be installed:

Structure Quantity	Steel Description
3	230 kV Low Bus Support (1 phase)
2	230 kV High Bus Support (1 phase)
1	230 kV High Bus Support (3 phase)
1	230 kV Dead-End
3	230 kV Lightning Arrester Stand
3	230 kV Metering unit Stand

V. Control Features

Transmission Breaker Protection

The existing protection for BKR 182 is provided by an SEL-501 relay. This protection is adequate and will not be upgraded during this project.

The existing protection for BKR 282 is SEL-351 at this time. This protection is adequate and will not be upgraded during this project.

The existing protection for BKR 382 is provided by an SEL-501 relay. This protection is adequate and will not be upgraded during this project.

The existing protection for BKR 482 is provided by an SEL-501 relay. This protection is adequate and will not be upgraded during this project.

The new breaker will be protected using SEL-351S per latest Xcel energy standards.

Transmission Line Protection

The existing protection from San Luis Valley to Hooper is provided by an SEL-411L primary protection system and an SEL-311C secondary protection system. This protection is adequate and will not be upgraded during this project.

The existing protection from San Luis Valley to Poncha line is provided by an SEL-311C primary protection system and an SEL-321 secondary protection system. This protection is adequate and will not be upgraded during this project.

The new protection from San Luis Valley to Customer's power generation facility will be provided by an SEL-411L primary protection system and an SEL-311C secondary protection system.

Transmission Bus Protection

No bus protection will be required at 230 kV yard.

Transformer Protection

The protection for the existing 230/115 kV autotransformer, Bank 1, is provided by an SEL-387 primary differential protection system, two (2) SEL-311C secondary distance protection systems, and an SEL-501 secondary ground overcurrent protection system. This protection is adequate and will not be upgraded during this project. This equipment is owned by Tri-State and may be upgraded if requested.

The protection for the existing 230/115kV autotransformer, Bank 2, is provided by an SEL-387 primary differential protection system, two (2) SEL-311C secondary distance protection systems, and an SEL-501 secondary ground overcurrent protection system. This protection is adequate and will not be upgraded during this project. This equipment is owned by Tri-State and may be upgraded if requested.

Control Panel Locations

The new breaker control, line protection, metering and RTU panels will be installed in the new EEE.

VI. Communication Features

Relay Remote Access

New remote relay access will be implemented at the new EEE.

RTU

New Orion LX RTU and HMI will be installed at the new EEE to connect all new digital, analog and control points.

LF/AGC RTU

A new Load Frequency/Automated Generation Control (LFAGC) RTU will be installed by the customer at interconnection customer's site and will have SCADA connection to Lockout Control Center.

Fiber Optic cable

The new line from San Luis Valley Substation to Customer's Substation will have forty-eight (48) strand single mode OPGW. The fiber will be utilized for line protection and communications to the existing control building. Standard ST connectors will be used wherever possible.

VII. Project Operating Concerns and Outages

The expansion of the ring bus configuration will require minimal outages. These outages will be staged to construct large portions of the project in order to minimize system impact. A large portion of the station expansion can be built in the clear. The proposed construction sequence is as follows:

- Demolish existing fence and grounding. Build a new substation pad expansion in the clear.

- Build the new dead-end, customer funded metering equipment and arresters in the clear and terminate the new Customer's solar line into the dead-end.
- Open Breaker 282, 382 and associated disconnect switches. Once these breakers and disconnects are open, the San Luis-Hooper 230kV line will be taken out of service for a half day so that switch 387 can be opened to de-energize the bus to be removed.
- After opening switch 387, breaker 382 and associated disconnects can be closed to re-energize the San Luis Valley-Hooper 230kV line.
- Breaker 282, and associated disconnects as well as switch 387 will remain out while the existing bus section is removed and the new low bus, breaker and switch is installed. The San Luis Valley-Hooper 230 kV line can remain in service during this work. Prior to installing the high bus section, breaker 382 and associated disconnects will need to be opened to take a 3-4 day outage on the San Luis Valley-Hooper 230 kV line to maintain adequate working clearance from the high bus.
- After the high bus is installed switch 387 can be closed under no load conditions. Once switch 387 is closed breaker 382 and associated disconnects can be closed to put the San Luis Valley-Hooper 230 kV line back into service.
- As long as the new Customer's line switch remains open, Breaker 282 and the new breaker can be closed to complete the ring bus until the interconnection customer is ready to go on-line.

Note: The cost impacts (if any) of taking the San Luis Valley-Hooper 230 kV line out of service will need to be analyzed in more detail during the design and planning phase. Lost generation costs are not currently included in this estimate.

VIII. Material Staging Plan

All major equipment will be shipped directly to site and stored in the existing 230 kV yard. Ample space is available for staging.

D. Costs Estimates and Assumptions

The cost responsibilities associated with the facilities described in the following estimates shall be handled per current FERC guidelines. The estimated engineering, procurement & construction schedule can be found below.

Appropriation level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 20% 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 factors 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 upgrades for is \$3,844,000. These estimates do not include costs 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 generation output. The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines. System improvements are subject to change upon a more detailed and refined design.

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

Element	Description	Cost Est. (Millions)
PSCo's San Luis Valley Transmission Substation	Customer into PSC's San Luis Valley 230 kV Substation. The scope includes all switches, arresters, instrument transformers, bus, wiring, foundations, structures, relaying, and LFAGC RTU.	\$1.199
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	\$1.199
Time Frame	Site, design, procure and construct	18 Months

Table 2: PSCo Owned; PSCo Funded Interconnection Network Facilities

Element	Description	Cost Estimate (Millions)
PSCo's San Luis Valley 230 kV Transmission Substation	Expand the San Luis Valley 230 kV Substation. The scope includes: the expansion of the existing 230 kV bus to add on a new ring bus position with all associated breaker, switches, arresters, bus, wiring, site development, foundations, relaying, new EEE, and new RTU.	2.645
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	\$2.645
Time Frame	Site, design, procure and construct	18 months

Table 3: PSCo Owned; PSCo Funded Network Upgrades for Delivery

Element	Description	Cost Est. (Millions)
PSCo's San Luis Valley 230 kV Transmission Substation	Customer to tap at the San Luis Valley 230 kV Substation. The new equipment includes: Not applicable. See assumptions below.	
	Total Cost Estimate for PSCo Network Upgrades for Delivery Facilities	
Time Frame	Site, design, procure and construct	

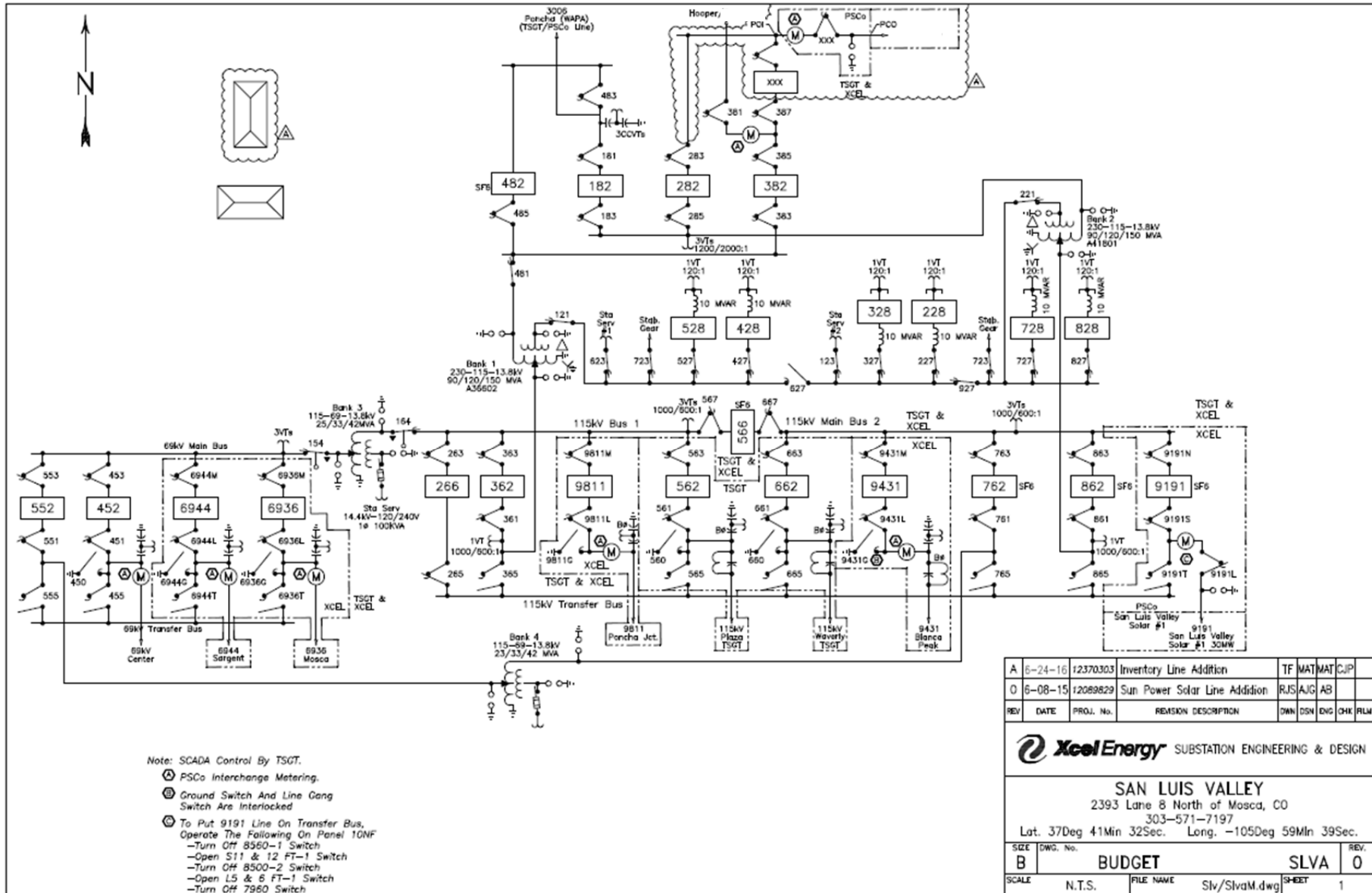
Cost Estimate Assumptions

- Referenced Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater Than 20 MW.
- Appropriations level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 20% accuracy) were developed by PSC Engineering.
- Estimates are based on 2016 dollars (appropriate contingency and escalation applied).
- Labor is estimated for straight time only – no overtime included. Assumes contracted construction for the majority of the work.
- Lead times for materials were considered for the schedule.
- The Solar Generation Facility is in PSC's retail service territory. Therefore, costs for retail load metering are included in these estimates.
- PSC (or it's Contractor) crews will perform all construction, wiring, and testing and commissioning for PSC owned and maintained facilities.
- The estimated time to site, design, procure and construct the network upgrades for delivery for is approximately 18 months after authorization to proceed has been obtained.
- A CPCN will not be required for the interconnection facilities construction.

Customer will string optical ground wire (OPGW) cable into the substation as part of the transmission line construction scope.

Appendix

A. Figure 2. Project One-Line of the San Luis Valley Substation



Note: SCADA Control By TSGT.
 Ⓢ PSCo Interchange Metering.
 Ⓢ Ground Switch And Line Gang Switch Are Interlocked
 Ⓢ To Put 9191 Line On Transfer Bus, Operate The Following On Panel 10NF
 -Turn Off 8560-1 Switch
 -Open S11 & 12 FT-1 Switch
 -Turn Off 8500-2 Switch
 -Open L5 & 6 FT-1 Switch
 -Turn Off 7960 Switch

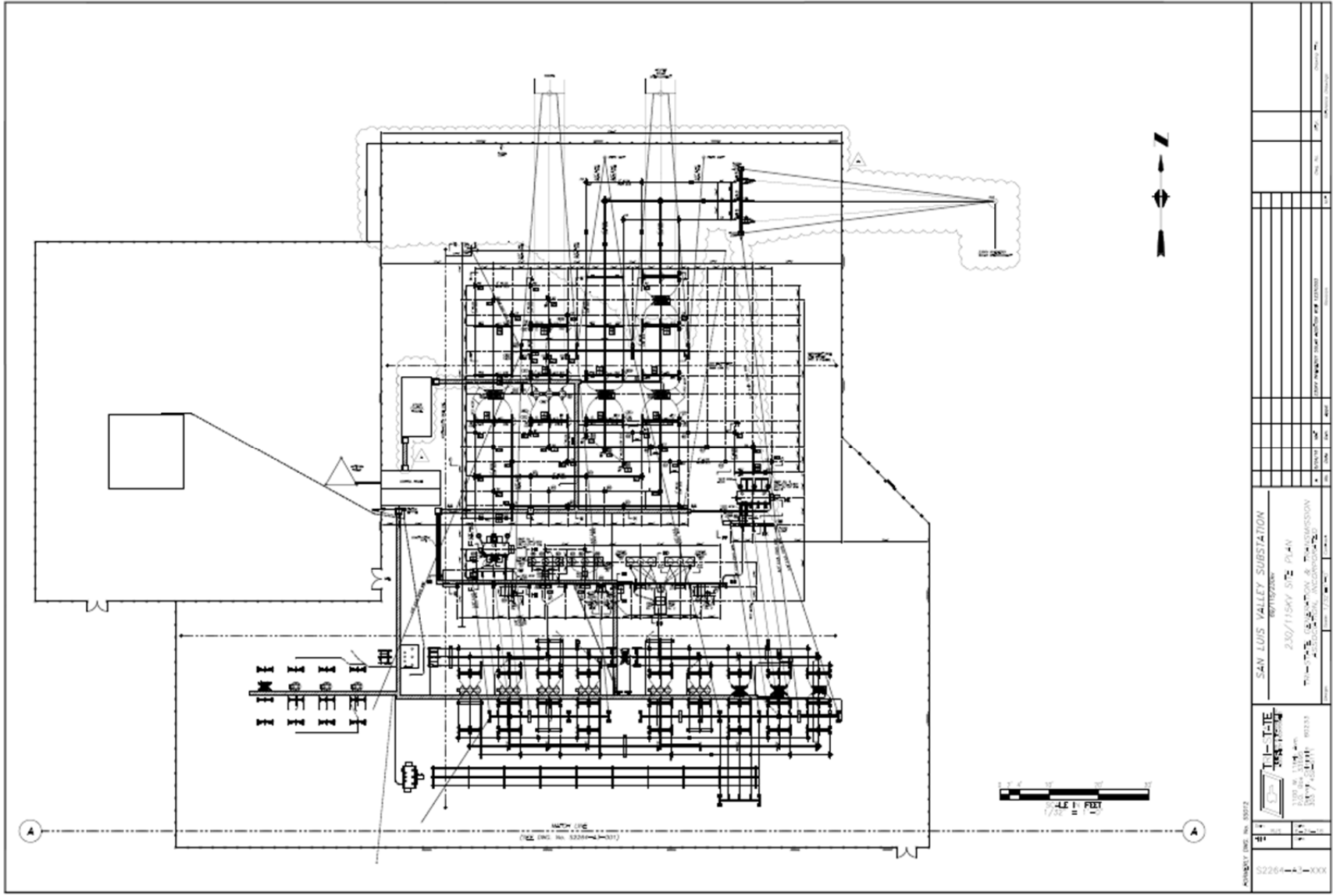
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0	6-08-15	12089829	Sun Power Solar Line Addition			RJS	AJG	AB	

SUBSTATION ENGINEERING & DESIGN

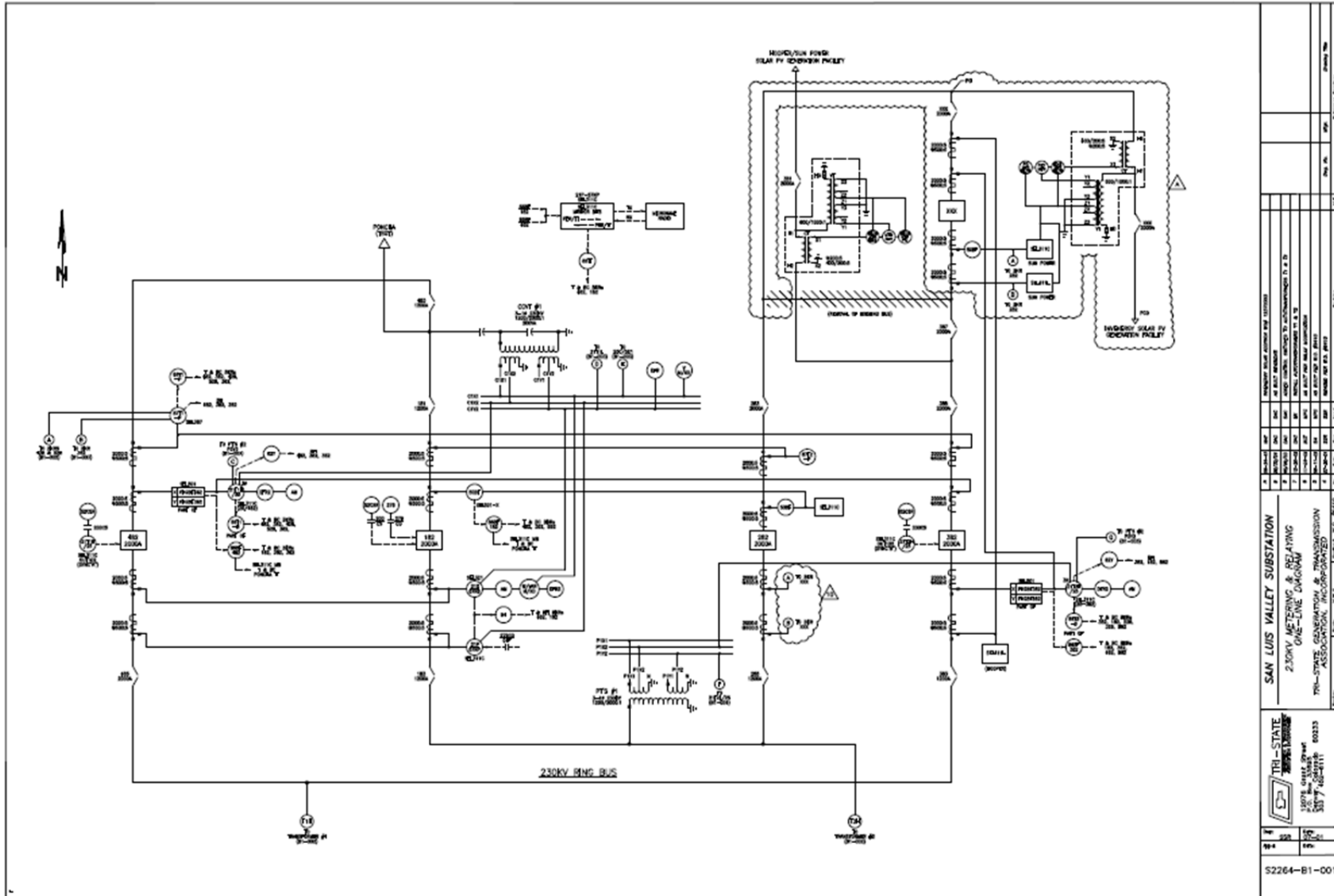
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 303-571-7197
 Lat. 37Deg 41Min 32Sec. Long. -105Deg 59Min 39Sec.

SIZE	DWG. No.	REV.
B	BUDGET	SLVA 0
SCALE	N.T.S.	FILE NAME Slv/SlvaM.dwg SHEET 1

B. Figure 3. Project General Arrangement at San Luis Valley Substation



C. Figure 4. Metering and Relays



		SAN LUIS VALLEY SUBSTATION 230KV METERING & RELAYING ONE-LINE DIAGRAM TRIP-SPECIFICATION FOR PROTECTION	
NO.	REV.	DATE	DESCRIPTION
1	1	11/11/11	ISSUED FOR CONSTRUCTION
2	1	11/11/11	ISSUED FOR CONSTRUCTION
3	1	11/11/11	ISSUED FOR CONSTRUCTION
4	1	11/11/11	ISSUED FOR CONSTRUCTION
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90	1	11/11/11	ISSUED FOR CONSTRUCTION
91	1	11/11/11	ISSUED FOR CONSTRUCTION
92	1	11/11/11	ISSUED FOR CONSTRUCTION
93	1	11/11/11	ISSUED FOR CONSTRUCTION
94	1	11/11/11	ISSUED FOR CONSTRUCTION
95	1	11/11/11	ISSUED FOR CONSTRUCTION
96	1	11/11/11	ISSUED FOR CONSTRUCTION
97	1	11/11/11	ISSUED FOR CONSTRUCTION
98	1	11/11/11	ISSUED FOR CONSTRUCTION
99	1	11/11/11	ISSUED FOR CONSTRUCTION
100	1	11/11/11	ISSUED FOR CONSTRUCTION

D. Figure 5. Preliminary Project Schedule

**GI-2014-11 Facilities Study Report
50 MW Solar Interconnection @ SLV 230kV Substation**

ID	Task Name	Duration	Day 1	1Q	2Q	3Q	4Q	5Q	6Q	ISD	
1	GI-2014-11 Facilities Study Report 50 MW Solar Interconnection	78w	◆	[Blue bar spanning from Day 1 to end of 6Q]							
2	Authorization to Proceed: Execution of Interconnection Agreement	0w	◆								
3	Sighting & Land Rights and Permitting	6w	◆	[Blue bar for 6 weeks]							
4	Substation Design/Transmission Line Design & Engineering	40w	◆	[Blue bar spanning from Day 1 to end of 4Q]							
5	Substation/Transmission Line Material Procurement	36w			◆	[Blue bar spanning from start of 2Q to end of 5Q]					
6	Substation/Transmission line Construction	36w				◆	[Blue bar spanning from start of 3Q to end of 6Q]				
7	Relay, Protection & Control Equipment Testing	10w						◆	[Blue bar for 10 weeks]		
8	Final Commissioning	4w							◆	[Blue bar for 4 weeks]	
9	Project Completion / Backfeed	0w								◆	
10											