



**Generation Interconnection Facilities Study Report
Request # GI-2014-9**

**70 MW Photovoltaic Solar Generation
Tapping the Comanche – Midway 230 kV Line (L5413)
Pueblo County, Colorado**

Transmission Planning West – Xcel Energy
August 29, 2016



I. Executive Summary

This Interconnection Facilities Study Report summarizes the analysis performed by Public Service Company of Colorado (PSCo) to specify and estimate the cost of the siting, engineering, equipment procurement and construction needed to interconnect a 70 MW Solar Photovoltaic generator on the Comanche – Midway 230kV Line (L5413). The Point of Interconnection (POI) will be located on the Comanche – Midway 230kV Line at approximately 5.5 miles from the Comanche Substation. The generation facility will be located in Pueblo County, Colorado.

The Feasibility and System Impact Study report for this Interconnection Request was posted on February 15, 2016. The report concluded that the ERIS and NRIS capacity of GI-2014-9 is 70 MW. The Interconnection Customer has originally proposed the generation facility's Commercial Operation Date (COD) as December 1, 2016, but has revised it to December 15, 2018 during Facility Study stage.

The total estimated cost for the facilities required for interconnection is **\$7.024M¹**

- \$0.877 million for PSCo-Owned, Customer-Funded Interconnection Facilities
- \$6.147 million for PSCo-Owned, PSCo-Funded Network Upgrades for Interconnection
- \$0.00 million for PSCo Network Upgrades for Delivery

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 LGIA. A CPCN will be required for the interconnection facilities construction and will add 18 months in front of the siting, design, procure construct window (of 18 months) totaling an estimated 36 month window to complete from authorization to proceed. An Engineering & Procurement Agreement can be executed to facilitate completion of the interconnection facilities.

¹ Appropriation estimates are considered to have an accuracy of +/- 20%.

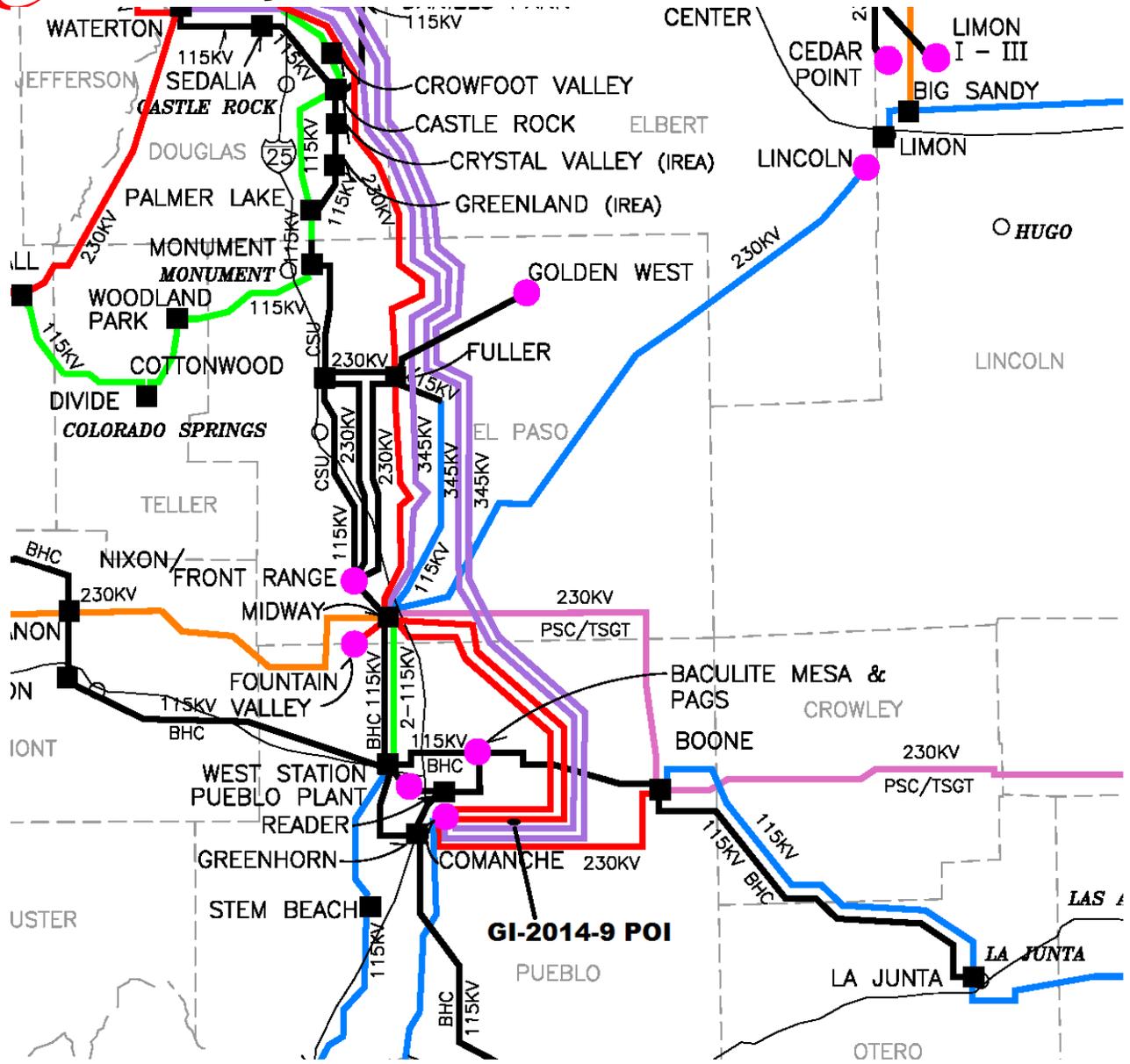


Figure 1 GI-2014-9 Primary Point of Interconnection and Surrounding Transmission System

II. Introduction

Xcel Energy Transmission Planning West received a study request for the Interconnection of a 70 MW solar photovoltaic generation facility (GI-2014-9) on October 10, 2014. The Interconnection Customer has originally specified GI-2014-9 capacity as 120 MW, and has later revised it to 70 MW on December 22, 2014. The generation facility will be comprised of nineteen (19) Power Conversion Stations (PCS) and each PCS will have one PROSOLAR GE LV5 Type 1 inverter rated for 550V 4MVA and one 4MVA 34.5kV step up transformer (number of inverters as provided by the Customer during Facility Study Stage). The generation facility will have one 34.5/230kV main step up transformer. The geographical location of GI-2014-9 will be in Pueblo County, Colorado.

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

The final Feasibility and System Impact Study report for GI-2014-9 was issued on February 15, 2016. The Feasibility Analysis did not identify any thermal or voltage violations that may be attributed to the GI-2014-9 interconnection. Recognizing the 0.92 lead – 0.92 lag adjustable power factor capability, along with the proprietary information on Voltage Ride Through (VRT) capability of the PROSOLAR GE LV5 type 1 inverters provided by the Interconnection Customer, a transient stability study to assess and/or verify the interconnecting generating facility's voltage ride-through for normally cleared faults was not deemed necessary. Furthermore, it is the responsibility of the Interconnection Customer to ensure that the 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 Feasibility and System Impact Study, the ERIS and NRIS capacity of GI-2014-9 is 70 MW. Since the primary POI is feasible for full capacity, secondary POI is not considered.

An agreement for a Facility Study was executed on April 13, 2016. During the Facility Study agreement, the Customer has revised the COD of GI-2014-9 to December 15, 2018.

III. General Interconnection Facilities Description

A. Project Purpose & Scope

The Customer (GI-2014-9) has requested an interconnection on the Comanche – Midway 230kV Line, at approximately 5.5miles from the Comanche Substation

end. Xcel Energy will be responsible for building the new switching station at the POI (“POI switching Station”), as well as any necessary substation land/equipment upgrades. The Customer will be responsible for the construction of their facility, the interconnecting tie-line, and the LFAGC RTU.

Notable Items

Substation Protection Engineering has recommended that the relay panel that is currently at Comanche Substation for the Midway Line be moved to the new 230kV Switching station and a new relay panel will be installed at Comanche to replace the removed panel.

Distribution vs. Transmission Asset Ownership and Cost Responsibility

The project costs are given in Tables 1, 2 and 3.

The switching station primary function will be Transmission.

B. FERC and/or NERC Compliance Requirements

Critical Infrastructure Protection (CIP) Asset

The CIP status of the new switching station at the POI will be verified at a later date.

Power System Restoration Plan Impact

The impact of this new switching station will be verified at a later date.

Facility Ratings and Smart One-Lines

This POI switching station will have Bulk Electric System facilities.

A smart one-line diagram does not yet exist for this switching station. A smart one-line diagram will be created as part of this project. Facility ratings will be reviewed and approved per the Procedure for Review and Approval of GIST2-Created Facility Ratings and/or facility rating changes for the non-BES facilities will be managed via the existing pre-GIST2 rating processes.

C. Right of Way/Permitting

The land for the new POI switching station will need to be purchased. A location has not yet been selected, but it will be approximately 5.5 miles from Comanche Substation along the line to Midway, L5413

D. Electrical Features

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

The POI switching station will be sized appropriately for all Transmission terminations and the 230kV Customer owned tie-line

Fault Current

A system study will be performed to determine the expected fault levels at the new switching station.

Location	Type of Fault	Three Phase (A)	Single-Line-to-Ground (A)
230kV Switching Station		TBD	TBD

Electrical Removals & Relocations

There will be no removals or relocations as part of this project.

Electrical Installations (Major Equipment)

The new electrical equipment installation required for GI-2014-9 are given in Table 1,2 and 3.

Electrical Equipment Enclosure (EEE)

A new harmonized design 27'x55' EEE will be installed.

AC System

An AC study will be performed to correctly size a new AC system for the new POI Switching station.

DC System

A DC study will be performed to correctly size new batteries and a battery charger for the new POI switching station.

Grounding

A new ground grid will be installed and all equipment will be connected to the ground grid per IEEE Std 80-2000 and Xcel Energy standards. Equipment connections will use #4/0 AWG copper and 8-ft sectional ground rods. All below grade connections will be Cadweld. The ground grid will extend 3 ft beyond the fence and gate swings.

A soil resistivity test will need to be completed in order to validate the grounding grid analysis.

Lightning Protection

A rolling sphere study will be performed to ensure the new switching station equipment will be completely protected from direct stroke lightning strikes.

Trenching & Cable

Concrete incased duct bank will be installed between all equipment, pull pits and the EEE for this project.

Wave/Line Traps

Wave Traps will not be needed for this project

E. Civil Features

Grading & Fencing

Grading, fencing, and drainage, to be designed and detailed by the civil engineer, will conform to standard PSCo civil specifications and practices. Colorado surface soils typically have relatively high electrical resistivity, and a 4-inch thick layer of crushed rock will be placed on the surface of the caliche layer.

Storm Water Permit

If required Storm Water Permit will be facilitated by the civil engineer.

SPCC (Oil Containment)

Oil containment will not be required.

Civil Removals & Relocations

There are no civil removals or relocations for this project

Foundations & Structures

The following concrete slab foundations will be installed:

Quantity	Description	Approx. Size
3	230kV Breaker Slabs	10' x 8' x 2'6"

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

Structure Quantity	Rolled Steel Description	Steel Wt./ Structure	Drilled Piers		
			Pier Qty/ Structure	Approx. Size	
				Dia.	Depth
13	230kV Switch Stands	3097	2	3'0"	10'0"
9	230kV CCVT/PT Stands	442	1	3'0"	10'0"
37	230kV Low Bus Support	475	1	3'0"	10'0"
4	230kV High Bus Support	675	1	3'0"	10'0"
4	230kV 3-Phase Bus Supports	2851	2	3'0"	10'0"
	Total Rolled Steel Weight	75918			

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

Structure Quantity	Tapered Tubular Steel Description	Steel Wt./ Structure	Drilled Piers		
			Pier Qty/ Structure	Approx. Size	
				Dia.	Depth
4	230kV Dead Ends	18758	2	5'0"	18'0"
1	230kV Static Mast	3817	1	5'0"	18'0"
	Total Taper Tubular Steel Weight	78849			

Fire protection (Fire protection wall, and fire protection layer around EEE)

Fire protection is not required for this project.

F. Protection Features

Transmission Line Protection (230kV)

Primary protection will consist of an SEL-411L line current differential relay using two (2) fibers for communication. A SCADA controllable pilot cut-off switch will be installed to cut off SEL-411L communications.

Secondary protection will consist of a SEL-311C set up in a Permissive Overreaching Transfer Trip (POTT) scheme using two (2) fibers for communication. A SCADA control and soft buttons on the 311C provide the pilot cut-off.

Transfer trip will be used using the SEL-2506 and the fiber connection.

Transmission Breaker Protection (230kV)

Breaker failure protection will be handled by an SEL-351S relay (one for each breaker). Breaker trip coil 1 will initiate breaker fail using the SEL-351S, breaker trip coil 2 will also initiate breaker fail using the SEL-351S.

General

The control design will follow the harmonized standard.

Transmission Breaker Reclosing Controls

Each transmission line will have reclosing for their breakers controlled by the line relays protecting that line. The line relays will send a reclose initiate signal to the respective SEL-351S breaker control relay. Each line has a recloser cutout switch that can be controlled remotely by SCADA.

Digital Fault Recorder

A DFR will not be installed.

Control Panel Locations

Control Panel locations will be determined during detailed design.

The Midway line panel at Comanche Substation will be removed and relocated to the new control house at the new 230kV switching station.

Removals

There will be no removals at the new 230kV switching station site. The Midway line panel at Comanche Substation will be removed and relocated.

G. Communication Features

RTU

A new RTU will be installed under a separate Communications WO.

Local Annunciation

Annunciation will be done

Relay Remote Access

Remote relay access will occur through the Ethernet switch. A Satellite Clock will synchronize the time in all relays and the RTU. This equipment will be installed under a separate Communications work order.

Fiber Optic Cable

Fiber optic cable will be utilized on all lines incoming to the switching station.

Removals

There will not be any removals associated with this project.

H. Project Operating Concerns and Outages

Outages/Temporary Configurations

The 230kV Line from Comanche to Midway will need an outage to be re-terminated into the new 230kV switching station.

Mobile Substation or Transformer

A mobile substation or transformer will not be required for this project.

Environmental

There are no environmental concerns at this time.

I. Material Staging Plan

It is preferred to have major material shipped directly to the job site rather than to an Xcel Energy warehouse location.

Stock materials will be ordered and staged through Purchasing department.

J. Related Projects

There are no related projects at this time.

K. Estimate Discussion

The standard contingency factors for estimates are as follows:

- Scoping Est. Contingency Factors: Material: 10%; Labor and Equipment: 20%
- The estimate for this project utilizes the standard contingency levels

L. Risk Check List

Risk factors identified at the time the Design Guide Package was prepared are indicated below. Explanations indicate the action taken, if any, in the estimate as a result, such as additional contingencies or multipliers that were applied.

- Survey information is not available. Explain:
- Soil boring results are not available. Explain:
- Unusual soils or environmental conditions exist. Explain:
- Key materials or items need decisions or approvals. Explain:
- Potential permitting delays or unusual requirements exist. Explain:
- There are difficult or seasonal outage requirements. Explain:
- There are conflicting outage requirements. Explain:
- There are risks due to who will construct the project and their availability.
Explain:
- Unusual construction techniques will be required. Explain:
- There are risks associated with plans to reuse existing material. Explain:

- There are potential alternatives still under consideration. Explain:
- Material prices are likely to change or volatile. Explain:
- Material lead times are likely to be longer than estimated. Explain:
- Labor prices are likely to change. Explain:
- There are existing erosion problems. Explain:
- The existing oil containment may not be adequate. Explain:
- The existing lightning protection may not be adequate. Explain:
- The existing bus and equipment ampacity may not be adequate. Explain:

- The existing drawings are incomplete and inaccurate. Explain:

Notes and Comments:

IV. Cost Estimates and Assumptions

Appropriation level cost estimates (+/- 20% accuracy) for the Transmission Provider Interconnection Facilities and Network Upgrades for Delivery were developed by Public Service Company of Colorado / Xcel Energy Engineering and are provided in Tables 1, 2 and 3 below. Estimates are developed assuming typical construction costs for similar previously completed projects. These cost estimates include all applicable labor and overheads associated with the siting support, engineering, design, material/equipment procurement, construction, testing and commissioning of the new POI switching station and transmission line facilities. These cost estimates do not include the cost for any Customer owned Interconnection Facilities and associated design and engineering.

The estimated total cost for the interconnection is **\$7.024 million**. The cost estimates are in 2016 dollars with escalation and contingency included. AFUDC is not included.

The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines.

Figure B below represents a conceptual one-line of the new POI Switching station (Primary POI) tapping the Comanche – Midway 230kV Line (L5413).

- Appropriation level project cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 20% 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 Solar 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 its Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- This project is completely independent of other queued projects and their respective in-service dates.
- Customer will string OPGW fiber into switching station as part of its transmission line construction scope.
- Line and substation bus outages will be required during the construction period to meet backfeed. Outage restrictions due to seasonal loading or other limiting factors may delay any proposed construction schedule.
- Power Quality Metering (PQM) will be required on the Customer's 230kV tie-line terminating into PSCo's new switching station at the POI.
- A CPCN will be required for the interconnection facilities construction and will add 18 months in front of the siting, design, procure construct window

(of 18 months) totaling an estimated 36 month window to complete from authorization to proceed.

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

Element	Description	Cost Est. (Thousands)
New 230kV POI Transmission Switching station	Interconnect Customer to the 230kV bus at PSCo's proposed new 230kV POI switching station. The new equipment includes: <ul style="list-style-type: none"> • One (1) 230kV gang switch • Three (3) 230kV combination CT/PT metering units • Power Quality Metering (230kV line from Customer) • Three (3) 230kV lightning arresters • One (1) relay panel (transformer breaker panel) • Associated communications, supervisory and SCADA equipment • Associated line relaying and testing • Associated bus, wiring and equipment • Associated foundations and structures • Associated transmission line communications, relaying and testing 	\$0.877
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	\$0.877
Time Frame	Site, design, procure and construct	18 Months

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

	Description	Cost Estimate (Thousands)
New 230kV POI switching station	Construction of PSCo's proposed new 230kV POI Switching station. The new equipment includes: <ul style="list-style-type: none"> • Three (3) 230kV Circuit Breakers • Eight (8) 230kV gang switches • Six (6) 230kV lightning arresters • Six (6) relay panels • Electrical Equipment Enclosure (EEE) • Associated communications, supervisory and SCADA equipment • Associated line relaying and testing • Associated bus, wiring and equipment • Associated foundations and structures • Associated transmission line communications, relaying and testing 	\$6.067
	Siting and Land Rights support for switching station land acquisition and construction.	\$0.080
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	\$6.147
Timefame	2. <u>Site, design, procure and construct</u>	18 Months

Table 3 – PSCo Network Upgrades for Delivery

Element	Description	Cost Est. (Millions)
	Not Applicable	
	Total Cost Estimate for PSCo Network Upgrades for Delivery	\$0
Time Frame	Site, design, procure and construct	
	Total Project Estimate	\$7.024

V. Engineering, Procurement & Construction Schedule

GI-2014-9 Facilities Study Report
 70 MW Photovoltaic Solar Generation Facility Comanche – Midway 230kV Line
 (Sighting through Construction and Commissioning)

ID	Task Name	Duration	Q2 18		Q3 18				Q4 18				Q1 19				Q2 19				Q3 19				Q4 19				Q1 20		
			Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar							
1	GI-2014-9: 70MW PV Solar Generation Interconnection	76w																													
2	Receipt of CPCN	0w																													
3	Sighting & Land Rights and Permitting	36w																													
4	Substation Design & Engineering	40w																													
5	Substation Materials Procurement	36w																													
6	Substation Construction	36w																													
7	Relay, Protection & Control Equipment Testing	10w																													
8	Final Commissioning	4w																													
9	Project Completion	0w																													
10																															

Figure A - Project One-Line of the New POI Switching Station at the Point of Interconnection on the Comanche – Midway 230kV Line (L5413)

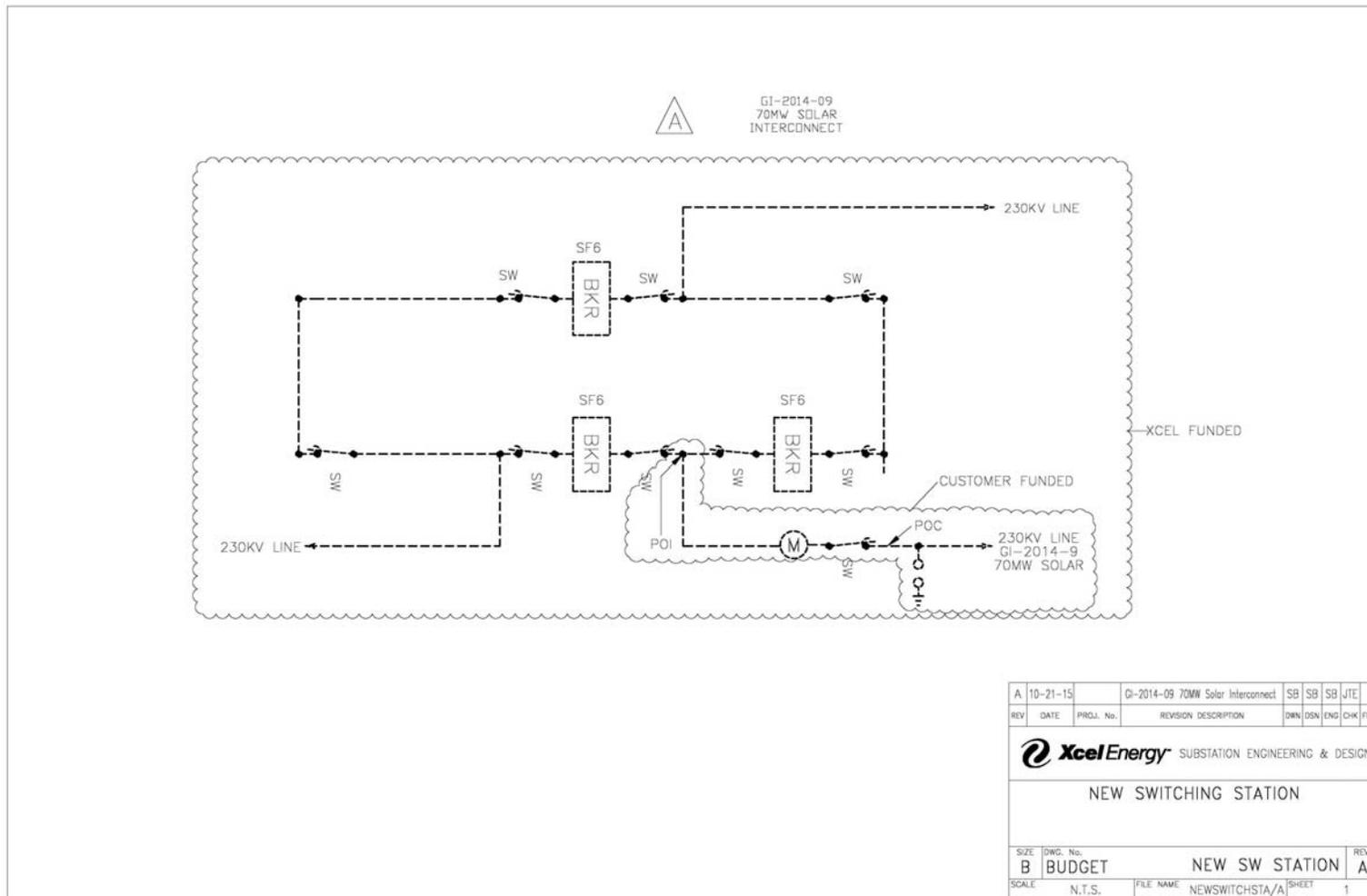


Figure B - General Arrangement of the new POI switching station at the POI tapping the Comanche – Midway 230kV Line (5413)

