



# **Generation Interconnection Facilities Study Report Request # GI-2014-6**

100 MW Photovoltaic Solar Generation  
At Midway 115kV Substation, Colorado

Public Service Company of Colorado  
Transmission Planning

December 17th, 2015



## 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 100 MW Solar Photovoltaic generator at the Midway 115kV Substation in El Paso County, Colorado.

The proposed solar generation plant will consist of sixty (60) Eaton Power Xpert dc/ac inverters and will be located approximately 0.9 miles from the Midway Substation. GI-2014-6 will be connected to the Midway 115kV Substation using a customer owned 115kV tie line. The proposed solar generating facility is planned to be in-service in June 2017.

The total estimated cost for the facilities required for interconnection is **\$1.230M<sup>1</sup>**

- \$1.230 million for PSCo-Owned, Customer-Funded Interconnection Facilities
- \$0.00 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. An Engineering & Procurement Agreement can be executed to facilitate completion of the interconnection facilities.

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

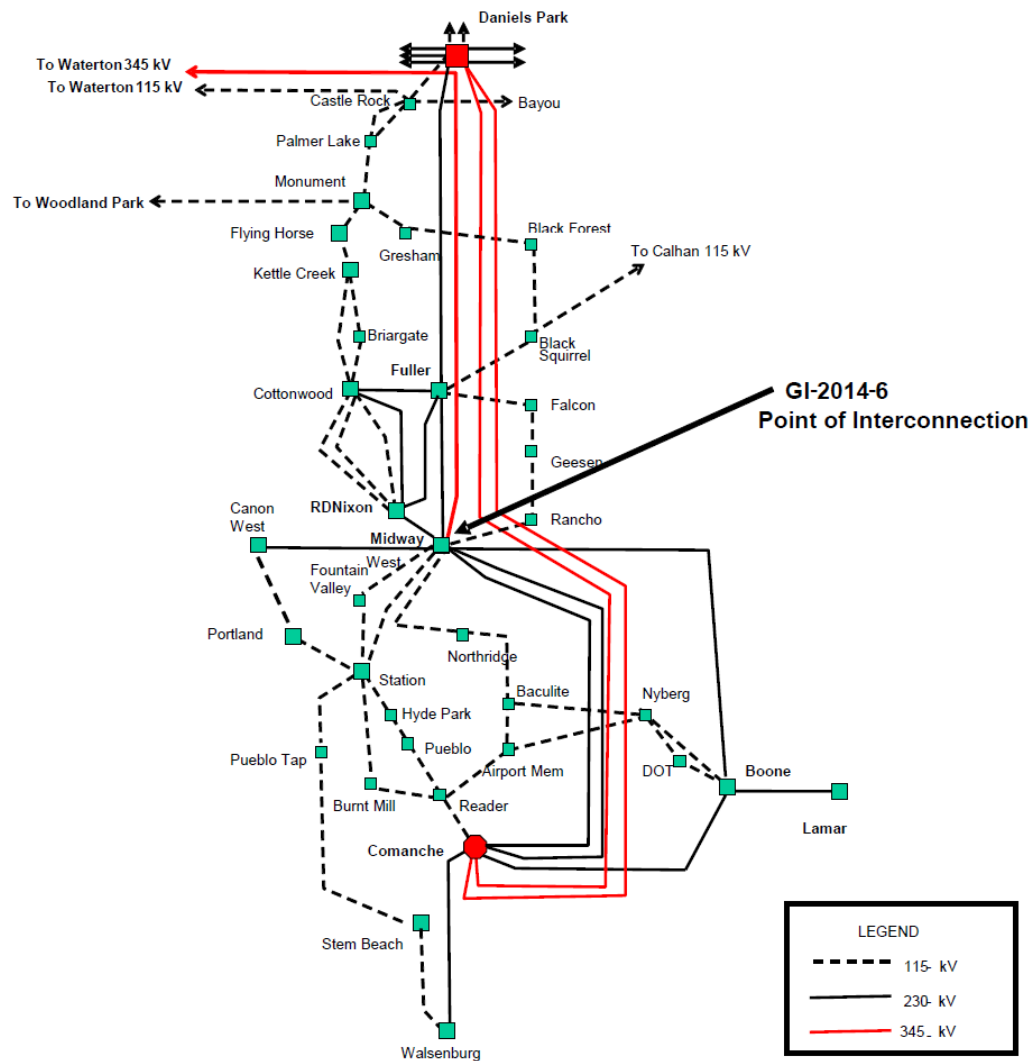


Figure 1 Midway Substation and Surrounding Transmission System

## **II. Introduction**

PSCo received an interconnection request (GI-2014-6) for a 100MW Photovoltaic Solar generation facility on May 22, 2014. The proposed GI-2014-6 will consist of Eaton Power Xpert inverters and will be located approximately 0.9 miles from the Midway Substation. An agreement for a Facility Study was executed on September 4, 2015. The final Feasibility and System Impact Study reports for GI-2014-6 were issued on January 22, 2015 and June 30, 2015 respectively. The Interconnection System Impact Study did not identify any thermal or voltage violations that may be attributed to the GI-2014-6 interconnection. However, the power flow analysis did identify several pre-existing thermal overloads on Colorado Springs Utilities' (CSU) 115kV lines that must be mitigated. PSCo and CSU have agreed to use an operating procedure as the planned mitigation solution. The operating procedure is sufficient to accommodate the 100MW rated output of GI-2014-6 as both Energy Resource Interconnection Service (ERIS) and Network Resource Interconnection Service (NRIS). Until the operating procedure is implemented to mitigate the thermal overloads, the GI-2014-6 generation output would be deliverable only as ERIS.

## **III. General Interconnection Facilities Description**

### **A. Project Purpose & Scope**

The Customer (GI-2014-6) has requested an interconnection to PSCo Facilities at a 115kV bus position at the Midway Substation. Xcel Energy will not be responsible for any costs associated with upgrading the bus and bay position for this project. The Customer will be responsible for the construction of their facility, the interconnecting T-line, and cost of the Xcel installed bus and bay position at Midway Substation, and the LFAGC RTU. The Point of Change of Ownership and the Point of Interconnection are detailed in Appendix A of this report.

### **Background**

Front Range Midway Solar Project (GI-2014-6) has requested an interconnection to PSCo Facilities at the 115kV bus at Midway Substation. The bus is currently a main and transfer arrangement with a tie breaker connecting it to a WAPA owned 115kV yard. The PSCo yard contains one transformer connection and two 115kV lines owned by Black Hills Power. There is one additional bay where a third line has been removed and substation equipment abandoned and is owned by Black Hills Power. A third line terminal will be added to the west for the solar interconnection per Appendix B of this report.

### **Notable Items**

This is an interconnection project. The final ownership and payment terms will be discussed in the LGIA.

The estimate request mentioned a five position 115kV bus arrangement, but this assumes three existing transmission lines. One line to Black Hills was removed, leaving two 115kV lines to Black Hills sites and a PSCo owned 230/115kV transformer. An additional line terminal will be added to the existing main and transfer bus. Xcel Energy standards dictate a ring or breaker and a half arrangement when the fourth element is added to a site, but an exemption has been obtained in this case since there is no PSCo power flow on the bus.

The customer funded work order includes all the equipment for the line termination; the deadend structure, metering units, line arresters, line relaying, line switch, disconnect switches, circuit breaker, and buswork.

An LFAGC RTU will be installed at the remote solar customer's substation and funded by the customer.

### **Distribution vs. Transmission Asset Ownership and Cost Responsibility**

The substation primary function is presently defined as Transmission. This project will not change the primary function of the substation when complete assuming no other changes. The project cost for Transmission Asset Management (TAM) is given in Tables 1,2 and 3.

### **Interconnection / Customer Cost Responsibility**

The project cost will be reimbursable by the customer as per the LGIA.

## **B. FERC and/or NERC Compliance Requirements**

### **Critical Infrastructure Protection (CIP) Asset**

The CIP status of this substation has been verified.

### **Facility Ratings and Smart One-Lines**

This substation has Bulk Electric System facilities.

A smart one-line already exists for this substation. The existing smart one-line will be updated to include the changes made by this project. Facility ratings changes will be handled via the GIST2 system, and will be reviewed and approved per the Procedure for Review and Approval of GIST2-Created Facility Ratings.

### **C. Right of Way/Permitting**

The new 115kV line termination will fit in the existing Midway substation. No site expansion will be required.

### **D. Electrical Features**

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

The addition of 100MW of generation capacity to Midway Substation will not require any upgrade of existing equipment. A new transmission line will be installed by the interconnection customer with enough capacity to carry the expected current. The new bay position and line termination will be installed by Xcel Energy and will be designed to exceed the expected amount of current, including contingency for an N-1 condition.

#### **Fault Current**

Location	Type of Fault	Three Phase (A)	Single-Line-to-Ground (A)
115kV Bus (Existing)		11,902	10,998
115kV Bus (After GI-20104-6)		11,902	11,538

#### **Electrical Removals & Relocations**

No electrical equipment will be removed.

#### **Electrical Installations (Major Equipment)**

The new 115kV line termination will be overhead from the GI-2014-6 Facility. The line will terminate at a new dead-end at the west end of the 115kV main and transfer bus. The conductor will drop down to a line disconnect switch, arresters and metering units, breaker and associated disconnect switches before connecting to the PSCo 115kV main bus.

Construction will need to be coordinated with GI-2014-6 Customer, who is responsible for the construction of the transmission line from their facility to the Midway Substation termination point.

#### **Electrical Equipment Enclosure (EEE)**

This project will not require a new EEE. The additional relaying will be added to the existing EEE. There is currently room to the north of the phone and transducer panels. The area was measured as 90" long and 84" of panel space is required. The EEE should be re-verified during detailed design.

## **AC System**

The AC system is adequate for the proposed additions.

## **DC System**

There are spare DC panelboard positions for this installation and the battery size is assumed to be sufficient since there is no change in the worst case trip scenario. The current worst case trip at the substation is a 230kV bus fault, which would require a trip for five 230kV circuit breakers. After this installation, an 115kV bus fault would require a trip for only four 115kV circuit breakers.

## **Grounding**

All new equipment will be connected to the ground grid per IEEE and PSCo standards. It is assumed that the existing grid is sufficient and new equipment will be tied to it.

## **Lightning Protection**

A static wire will be added from the new deadend structure to the transformer deadend to protect the new equipment. The existing static wires appear to be sufficient to protect the existing equipment. The interconnection customer will install static wires on the transmission line to their generation facility.

## **Trenching & Cable**

New conduit and cable will be installed for the new breaker and metering units. No precast cable trench or underground duct bank will be used. It is assumed that there is adequate space for additional cables from substation yard to enter the EEE with no modifications.

## **E. Civil Features**

### **Grading & Fencing**

The site is not being expanded and no additional grading or fencing will be required.

The standard crushed rock will be installed in any area that is disturbed by construction.

### **Storm Water Permit**

Since the site will not be expanded and the project will disturb 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 & Structures

A soil boring report will need to be generated in order to accurately size the foundations. All structures will be standard Xcel Energy structures used on previous jobs, when possible.

The following concrete slab foundations will be installed:

Quantity	Description	Approx. Size
1	115kV Breaker Foundation	7' x 5' x 1.5'

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

Structure Quantity	Steel Description	Steel Wt./ Structure	Drilled Piers		
			Pier Qty/ Structure	Approx. Size	
				Dia.	Depth
3	Single Structure Supports	450	1	3'	TBD
2	Switch Structure	2000	2	3'	TBD
1	Dead-End Towers	10000	2	5'	TBD
3	115kV Metering Unit Supports	375	1	3'	TBD

## F. Protection Features

This protection recommendation is for the installation of new transmission line protection for an 115kV line from Midway to GI-2014-6 100MW solar plant. This line will be connected to a new main and transfer position in the Midway 115kV yard.

The primary protective scheme is a line current differential (87L) scheme utilizing a SEL-411L relay (PKG-P). The SEL-411L relay will also implement a backup step distance and ground overcurrent scheme. A normally closed (NC) cutoff switch can be used to disable the pilot scheme. The operation of the trip output of the SEL-411L, by the pilot scheme or the backup step distance and ground overcurrent, will operate the new breaker trip coil #1 and initiate breaker failure. Further, it will initiate reclose. An output on the SEL-411L relay is used as SCADA channel alarm.



The secondary protection scheme is a line current differential (87L) scheme utilizing a SEL-411L relay (PKG-S). The SEL-411L relay will also implement a backup step distance and ground overcurrent scheme. A normally closed (NC) cutoff switch, 85CO-2 PKG-S, can be used to disable the pilot scheme. The operation of the trip output of the SEL-411L, by the pilot scheme or the backup step distance and ground overcurrent, will operate the circuit breaker trip coil #2 and initiate breaker failure. Further, it will initiate reclose. An output on the SEL-411L relay is used as SCADA channel alarm.

A Direct Transfer Trip (DTT) scheme is implemented in an SEL-2506. A normally closed (NC) cutoff switch, 85CO-3 DTT, can be used to disable the DTT. The DTT keying will be initiated by the breaker failure lockout relays. Receiving DTT from the remote terminal will operate an output on the SEL-2506. This output operates auxiliary relay, 94 DTT, which will consequently operate trip coil #1 and block close the breaker.

Breaker failure, sync check, and reclosing are implemented using SEL-351 relay. The breaker failure scheme will be initiated by the operation of the primary SEL-411L relay (PKG-P) and secondary SEL-411L relay (PKG-S). The trip output of the breaker failure relay will operate the breaker lockout relay, which will consequently trip and block closing and initiate a direct transfer trip (DTT) to the remote terminal via the SEL 2506. The reclosing can be blocked remotely through SCADA or manually using a normally closed cutoff switch, 79CO. The reclosing can be initiated by the primary SEL-411L relay (PKG-P) or the secondary SEL-411L relay (PKG-S). The close output of the relay will operate the close coil. Another output provides SCADA reclose-enable status. Further, an output is used to provide SCADA alarm in case of sync failure.

### **A summary of the protection:**

#### **Line Protection**

- Primary Line Protection: PKG-P, SEL-411L
  - Part Number: 0411L1X4X5B8DCXH57424XX
  - Firmware Version: R115
- Secondary Line Protection: PKG-S, SEL-411L
  - Part Number: 0411L1X4X5B8DCXH57424XX
  - Firmware Version: R115
- Breaker Failure, Sync Closing, Reclosing 5332 PKG-BF, SEL-351
  - Part Number: 0351S6XHD3J5421
  - Firmware Version: R515
- Direct Transfer Trip Communications: SEL 2506
  - Part Number: 250603414X
  - Firmware Version: NA

### **G. Control Features**

## General

New Relaying and controls will be installed as part of this project. Three new relay panels for the line, breaker, and metering will be installed in the EEE.

## Transmission Breaker Reclosing Controls

There will be supervisory control of the breaker.

Sync Check and Reclosing will be initiated by the SEL 351.

## Control Panel Locations

Panel #	Panel Description	Size
(TBD)	New 115kV Line	28" x 90"
(TBD)	New 115kV Breaker Control	28" x 90"
(TBD)	New 115kV Power Quality Metering	28" x 90"

## Removals

No equipment will be removed from the EEE.

## H. Communication Features

### Relay Remote Access/Substation LAN

The Midway substation already has a router and remote relay access. The site will be upgraded to the current communication standard in 2016 as part of a separate project. No communications upgrades are required for this interconnection.

### Remote Terminal Unit (RTU)

Substation RTU—The existing substation D20 RTU has adequate I/O for this installation.

Real-Time/Boundary Area Metering—The existing boundary area RTU and communication link will be utilized for this installation with the addition of a new SEL-735 meter for the new line metering. A power quality metering panel will be installed for this installation.

### Local Annunciation

The existing HMI/LCU is assumed to be adequate.

### Telephone Protection

The telephone protection is not being considered with this scope.

### **Programmable Logic Controller**

Not applicable for this facility.

### **Protection Communication**

#### Transmission Line Protection Pilot Schemes

New Interconnection Line Protection—A primary line differential with backup POTT scheme is implemented over OPGW requiring 2 separate protection channels will be installed as part of the new transmission line being constructed by the customer to the new solar collector substation.

### **I. Project Operating Concerns and Outages**

This is an interconnection project. There will need to be extensive coordination and communication with the interconnection customer in order to successfully complete this project.

#### **Outages/Temporary Configurations**

To perform work on the new bay position, an outage will be required on both the main and transfer busses. Black Hills Power owns two lines connected to the Midway 115kV bus and any bus outages will need to be coordinated. WAPA owns a 115kV yard connected to the PSCo 115kV bus with a tie switch and the outage will need to be coordinated with them as well. Obtaining a bus outage when desired will be required to meet the in service date.

### **J. Material Staging Plan**

Materials will be staged at the site location when appropriate. If the site does not have sufficient fenced area, materials will be delivered to the Xcel Energy Service Center in Pueblo, CO.

### **K. Related Projects**

No Substation WO's exist at this time. When Capital WO's are created, the Customer funded and T-Line work will need to be coordinated

### **L. Estimate Discussion**

The standard contingency factors for estimates are as follows:

- Appropriation Est. Contingency Factors: Material:10%, Labor and Equipment:10%

**M. 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: Soil borings will be required for this project.
- ☐ Unusual soils or environmental conditions exist. Explain:
- ☒ Key materials or items need decisions or approvals. Explain: An LGIA will determine many aspects of this project, including ownership, cost allocation, and final schedules.
- ☒ Potential permitting delays or unusual requirements exist. Explain: This is an interconnection project. Interconnection with non-utility party will require detailed coordination.
- ☒ There are difficult or seasonal outage requirements. Explain: Outages will need to be coordinated with Black Hills Power and WAPA since they have assets connected to the Midway PSCo 115kV bus.
- ☐ There are conflicting outage requirements. Explain:
- ☒ There are risks due to who will construct the project and their availability.  
Explain: The interconnection customer is constructing the transmission line and the LFAGC.
- ☐ 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: Materials have not been ordered or lead times established.
- ☐ 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:

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#### IV. Cost Estimates and Assumptions

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 2015 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 interconnection is **\$1.230 million**. Figure 2 below represents a conceptual one-line of the proposed interconnection into the 115kV bus at the Midway 115kV Substation. 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 Customer's 100MW solar 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 Interconnection Facilities**

<b>Element</b>	<b>Description</b>	<b>Cost Est. (Millions)</b>
<b>Midway 115kV Transmission Substation</b>	Interconnect Customer to the 115kV bus at the Midway 115kV Substation. The new equipment includes: <ul style="list-style-type: none"> <li>• Install one 115kV line position</li> <li>• One 115kV circuit breaker</li> <li>• Three 115 kV line arresters</li> <li>• Three 115kV Metering Units</li> <li>• Three 115kV disconnect switches</li> <li>• One 115kV line switch</li> <li>• One 115kV deadend structure</li> <li>• One relay panel</li> <li>• One breaker control panel</li> <li>• One power quality panel</li> <li>• Associated line relaying and testing</li> <li>• Associated bus, wiring and equipment</li> <li>• Associated foundations and structures</li> <li>• Associated transmission line communications, relaying and testing</li> </ul>	<b>\$1.006</b>
<b>Customer's 115kV Transmission Substation</b>	Load Frequency/Automated Generation Control (LF/AGC) RTU and associated equipment. Install a new relay panel at the customer generation site. Connect SCADA from the site to the Lookout Control Center	<b>\$0.224</b>
	<b>Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities</b>	<b>\$1.230</b>
<b>Time Frame</b>	<b>Site, design, procure and construct</b>	<b>18 Months</b>

**Table 2: PSCo Owned; PSCo Funded Interconnection Facilities**

	Description	Cost Estimate (Millions)
Midway 115kV Transmission Substation	<ul style="list-style-type: none"> <li>Not Required</li> </ul>	
	<b>Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities</b>	<b>\$0</b>
	<u>Site, design, procure and construct</u>	<b>N/A</b>

**Table 3 – PSCo Network Upgrades for Delivery**

Element	Description	Cost Est. (Millions)
	Not Required	
	<b>Total Cost Estimate for PSCo Network Upgrades for Delivery</b>	<b>\$0</b>
<b>Time Frame</b>	<u>Site, design, procure and construct</u>	<b>N/A</b>
	<b>Total Project Estimate</b>	<b>\$1.230</b>










### Cost Estimate Assumptions

- 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 2015 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 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 after authorization to proceed has been obtained.
- A CPCN will not be required for the interconnection and network delivery facilities construction.

- The Customer will be required to design, procure and install a Load Frequency/Automated Generation Control (LF/AGC) RTU at their Customer Substation.
- Customer will string OPGW fiber into substation as part of the transmission line construction scope.
- No new substation land will need to be acquired.
- There are only two 115kV Black Hills lines currently at Midway substation.



## V. Engineering, Procurement & Construction Schedule

	GI-2014-6 Facility Study Report											
	100MW Solar Interconnection @ Midway 115kV Substation											
ID	Task Name	Duration	Day 1	1Q	2Q	3Q	4Q	5Q	6Q	ISD		
2	Authorization to Proceed: Execution of the Interconnection Agreement	0w										
3	Siting and Land Rights and Permitting	4w										
4	Substation Design and Engineering	24w										
5	Substation Material Procurement	62w										
6	Substation Construction	12w										
7	Relay, Protection & Control Equipment Testing	8w										
8	Final Commissioning	4w										
9	Project Completion/Backfeed	0w										

# Appendix

## A. Project One-Line of the Midway Substation with GI-2014-6 Interconnection

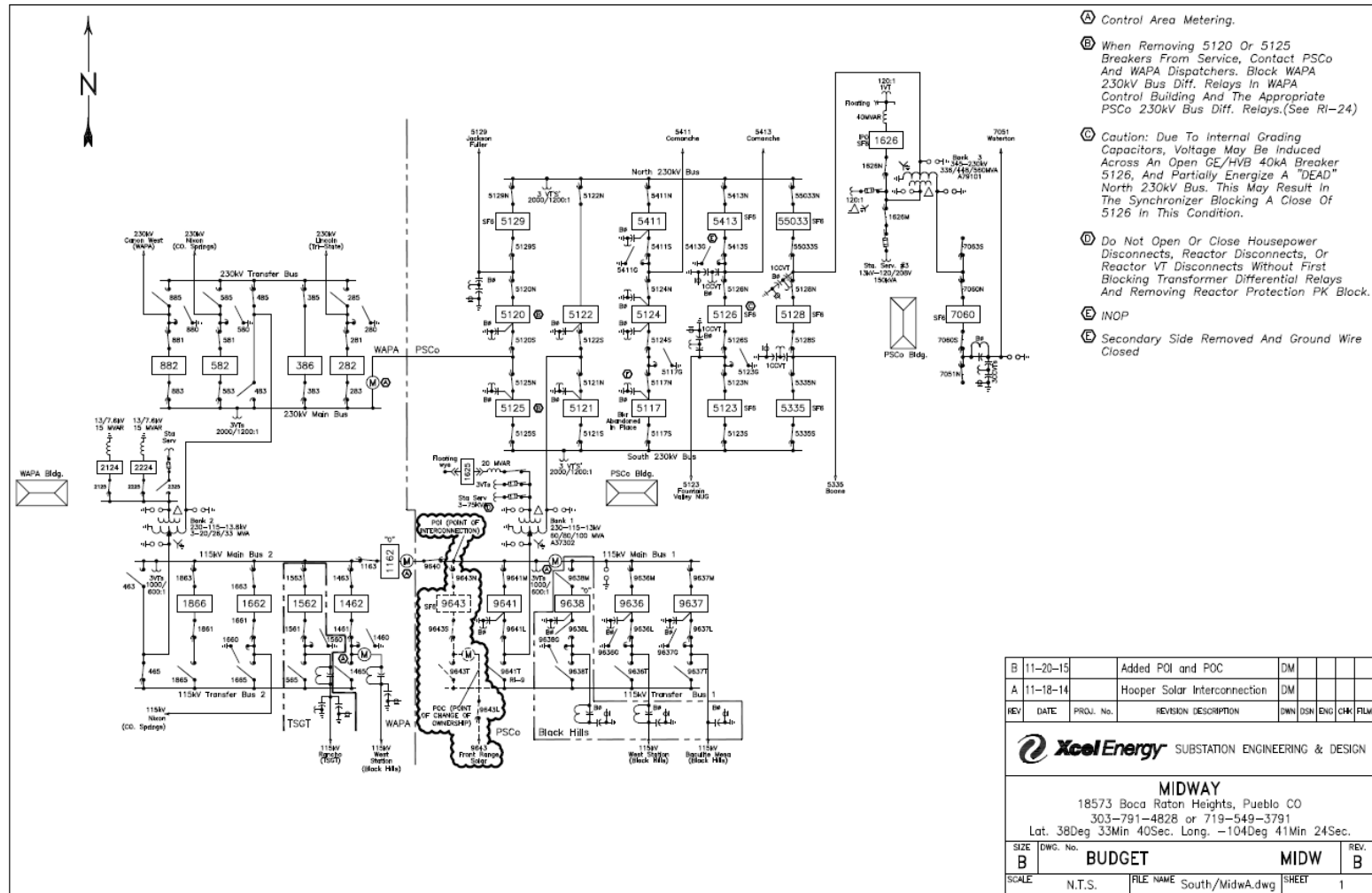


Figure 2 - Midway Substation One-Line with GI-2014-6

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