Interconnection Facilities Study Report
Request # GI-2014-5
Final Draft

50 MW Solar Photovoltaic Generating Facility
Missile Site 230 kV Station, Colorado

Public Service Company of Colorado
Transmission Planning
June 30, 2015

A. Executive Summary

This Interconnection Facilities Study Report summarizes the analysis performed by Public Service Company of Colorado (PSCo), designated as GI-2014-5, to specify and estimate the cost of the siting, engineering, equipment procurement, and construction needed to interconnect a 50 MW solar photovoltaic (PV) generation to the existing Missile Site Substation in Arapahoe County, Colorado.

The new solar PV generation is proposed to interconnect to PSCO's Missile Site 230 kV bus (see Figure 1). This facility will be located on 545 acres of currently farmed land and will connect to Missile Site Substation with an approximately 0.5 mile 230 kV line. The Customer will be responsible for construction of the short transmission line from the generation facility to Missile Site. The requested commercial in-service date is December 31, 2016.

The GI-2014-5 System Impact Study determined the proposed 50 MW solar PV generation facility may interconnect as an Energy Resource and Network Resource. The interconnection caused a 102.2% contingency loading of the 8-hour emergency rating of the Smoky Hill 345/230 kV transformers but the assumed high output of wind and solar generation is unlikely to occur at the same time. Therefore, the loading on the Smoky Hill transformers is not expected to go beyond the 8-hour emergency rating.

There are no PSCo Network Upgrades for Delivery required for this Interconnection.

The total estimated cost of the recommended system improvements to interconnect the project is approximately **$1.161 million** and includes:

- $0.647 million for PSCo-Owned, Customer-Funded Interconnection Facilities
- $0.514 million for PSCo-Owned, PSCo-Funded Network Upgrades for Interconnection
- $0.000 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 Large Generator Interconnection Agreement (LGIA). An Engineering & Procurement Agreement can be executed to facilitate completion of the interconnection facilities.

A conceptual one-line of the proposed Interconnection is shown in Figure 1 below.

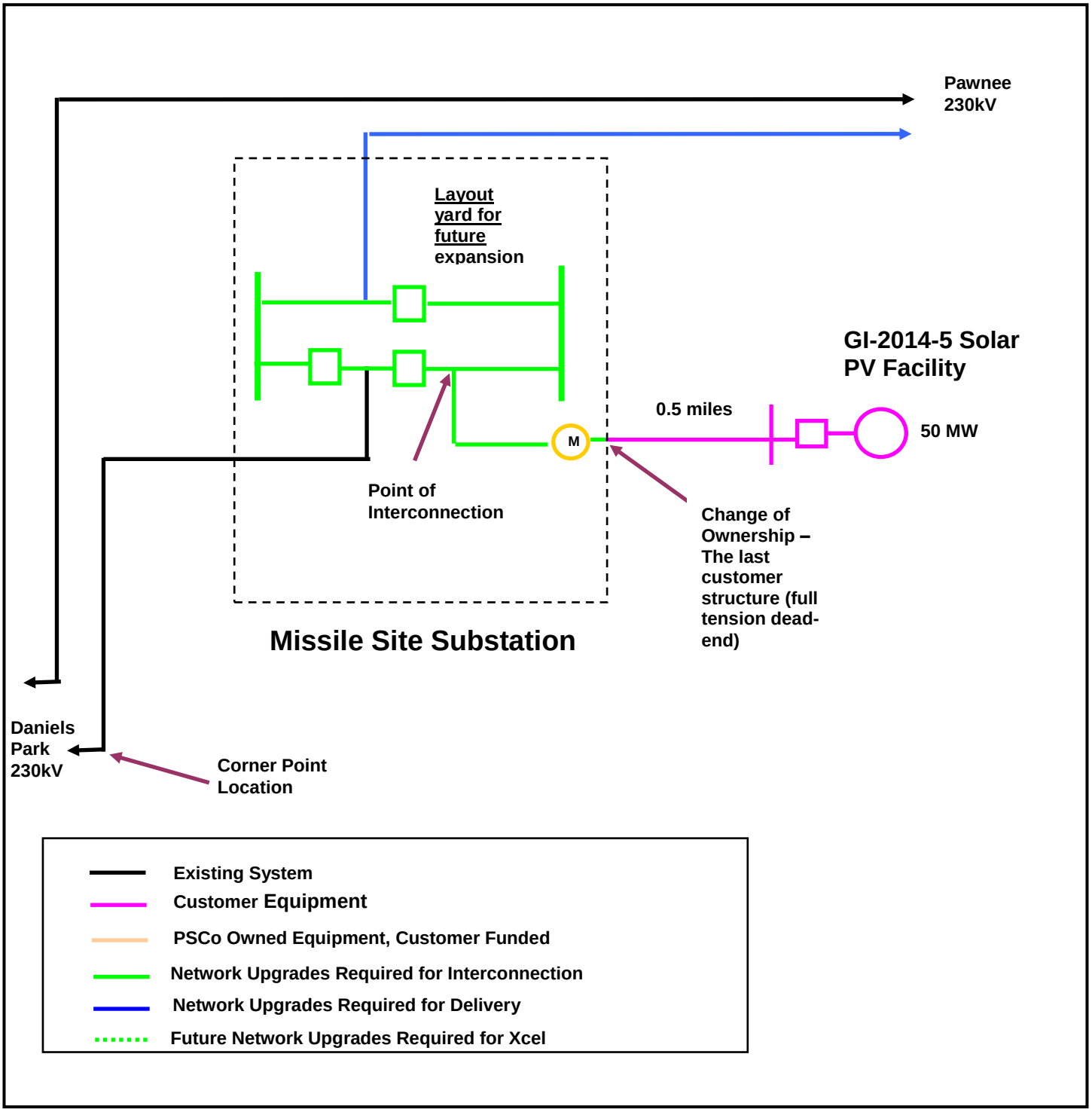

Figure 1: One-line diagram of GI-2014-5

B. Introduction

On March 31, 2015, Public Service Company of Colorado (PSCo) and a Generation Provider (Customer) signed an Interconnection Facilities Study request to provide cost estimates, a project schedule, and address the impacts of interconnecting a 50 MW solar PV generator at PSCo's 230 kV Missile Site Substation. The proposed generating facility will be located on 545 acres of currently farmed land approximately 0.5 miles away from PSCo's Missile Site 345/230 kV Station. The primary point of interconnection (POI) requested for GI-2014-5 is the Missile Site 230 kV bus and the generating facility will interconnect to the POI using a new 230 kV, 0.5- mile long transmission line. Generation from the expansion was modeled as supplying the PSCo Balancing Authority (BA) and was delivered to PSCo native load customers. The in-service date (ISD) requested for GI-2014-5 generating facility is December 31, 2016.

The System Impact Study was completed on December 18, 2014. The study found a 102.2% contingency loading of the 8-hour emergency rating of the Smoky Hill 345/230 kV Transformer Nos. 1 and 2. The increased loading resulted in a 2.7% increase in contingency loading due to the proposed generation interconnection. The result of this loading was greatly affected by the modeling of maximum output of wind generation interconnected at Missile Site, and high output of wind generation at Pawnee for the study case. Since the output of the regional wind generation is unlikely to operate at maximum levels at the same time that the solar generation is at peak output, the contingency loading on the Smoky Hill transformers is not expected to go beyond the 8-hour emergency rating. The study found no criteria violations in the pre-project or post-project transient stability analysis for any of the studied outages. Therefore, the study determined the transmission system is adequate to accommodate the generation interconnection.

C. Generation 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 6.0[1], found on the Xcel Energy website. Xcel Energy requires the Interconnection Generation Provider 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 Generation Provider be in compliance with all applicable criteria, guidelines, standards, requirements, regulations, and procedures issued by the North American Electric Reliability Council, Public Utility Commission or their successor organizations.

I. Project Purpose & Scope

This project is to connect a 50 MW solar photovoltaic generating facility into the 230 kV yard at Missile substation. The interconnection will consist of a single

breaker, 3 gang switches, and 3 metering units. The project is split into two estimates to account for the customer funded equipment of the interconnect and the Xcel Energy funded station improvements.

Future Considerations

The existing design of the 230 kV yard terminates 3 transmission lines and 1 autotransformer. The ultimate design of the 230 kV yard considers the possible termination of 3 generation ties, 2 autotransformers, and 6 transmission lines.

Interconnection / Customer Cost Responsibility

The project cost will be split between Xcel Energy and the generation customer. Each estimate prepared has a cost responsibility owner in the assumptions.

II. FERC and/or NERC Compliance Requirements

Critical Infrastructure Protection (CIP) Asset

The CIP status of this substation was verified with Richard McLean of Xcel Energy on 6/4/2015.

III. Right of Way/Permitting

No land purchases or right of way/permitting are required for the substation portion of this project.

IV. Electrical Features

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

No transmission line capacity will be impacted by this project.

Fault Current

Table 1: Fault Current

Type of Fault / Location	Three Phase (A)	Single-Line-to-Ground (A)
Before 50 MW PV Interconnection	14,143 A	12,005 A
After 50 MW PV Interconnection	14,393 A	13,791 A

Electrical Removals & Relocations

A section of the 230 kV bus will be removed to accommodate the two new gang switches and new circuit breaker.

Electrical Installations (Major Equipment)

As a part of this project, an existing dead end structure will have a mounted gang disconnect switch for metering maintenance, 3 metering units, and 3 arresters on structures below the dead end. The 230kV bay will contain a new circuit breaker and 2 new gang switches. The associated low bus will be installed to accommodate the new equipment.

Electrical Equipment Enclosure (EEE)

The existing EEE has sufficient space to hold the new equipment for this project.

AC System

The existing AC system is adequate for the new breaker and relaying.

DC System

The existing DC system is adequate for the new breaker and relaying.

Grounding

The existing grounding is adequate.

Lightning Protection

The existing lightning protection is adequate. A new shield wire will be installed as a part of the transmission portion of this project.

Trenching & Cable

New conduit will be installed into the duct on the east side of the 230 kV bay. Conduit will run north to the new breaker and west to the new metering units.

V. Civil Features

Grading & Fencing

The existing grading and rock is adequate, although some will be disturbed and reinstalled as a part of this project.

SPCC (Oil Containment)

N/A

Civil Removals & Relocations

N/A

Foundations & Structures

The following concrete slab foundations will be installed:

Table 2: Concrete Slabs

Quantity	Description	Approx. Size
1	230 kV breaker	10' X 10'

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

Table 3: Galvanized Steel Structures

Structure Quantity	Steel Description	Steel Wt./ Structure	Drilled Piers		
			Pier Qty/ Structure	Approx. Size	
				Dia.	Depth
3	230 kV metering unit stand	700 lbs	3	30"	10'
3	230 kV surge arrester stand	700 lbs	3	30"	10'

All structures will be master or previously designed structures.

VI. Protection Features

The primary protection for the new bus tie interconnection to the solar plant is a line current differential scheme utilizing a SEL-311L relay (PKG-P). The PKG-P relay also implements a backup step distance and ground overcurrent scheme. A normally closed cutoff switch, 85CO-1, can be used to disable the pilot scheme. The operation of the trip output of the PKG-P relay, by either the pilot scheme or the backup step distance and ground overcurrent, operates the trip coil #1 of BKR55045. Further, a separate output on the PKG-P relay initiates breaker failure for BKR55045.

The secondary protection for the new bus tie interconnection to the solar plant is a line current differential scheme utilizing a SEL-311L relay (PKG-S). The PKG-S relay also implements a backup step distance and ground overcurrent scheme. A normally closed cutoff switch, 85CO-2, can be used to disable the pilot scheme. The operation of the trip output of the PKG-S relay, by either the pilot scheme or the backup step distance and ground overcurrent, operates the trip coil #2 of BKR55045. Further, a separate output on the PKG-S relay initiates breaker failure for BKR55045.

Breaker failure and synch check for BKR55045 are implemented utilizing a SEL-351 relay (BKR55045 PKG-BF). The trip output of the breaker failure relay operates the breaker failure lockout relay (BKR55045 86BF), which consequently initiates DTT to the remote terminal at the Solar plant via the PKG-P and PKG-S relays using mirrored-bits. An output on the PKG-BF relay operates the close coil

of BKR1 for a manual close. Another output on the PKG-BF relay provides SCADA synch check failure alarm.

VII. Control Features

General

RTU

The existing RTU is a D20. Sufficient spare points exist to accommodate this project.

Removals

No panels will be removed as a part of this project.

Control Panel Locations

Table 4: Control Panels

Panel #	Panel Description	Size
1	Interconnect protection	24"

VIII. Project Operating Concerns and Outages

Outages/Temporary Configurations

An outage on the 230 kV north bus and Bank #1 will be required to remove a section of the 230 kV low bus and install the new 230 kV breaker, gang switches, and associated bus work. In addition, rework of the transformer differential and the relay panel for the gen tie will be installed during this outage.

IX. Material Staging Plan

All major material will be delivered to the site and staged there.

X. Related Projects

A Transmission WO is required to build the line into the sub. No work order currently exists.

XI. Risk Check List

Risk factors identified at the time the Design Guide Package was prepared are indicated below. Explanations, where applicable indicate the action, if any, taken 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: The 230 kV north bus / Bank #1 outage may be difficult to accomplish in the summer during the anticipated construction window.
- ☐ 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:

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D. 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 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 **$1,161,000.** Figure 2 below represents a conceptual one-line of the proposed interconnection into the 230kV bus at the Missile Site Transmission 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 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.

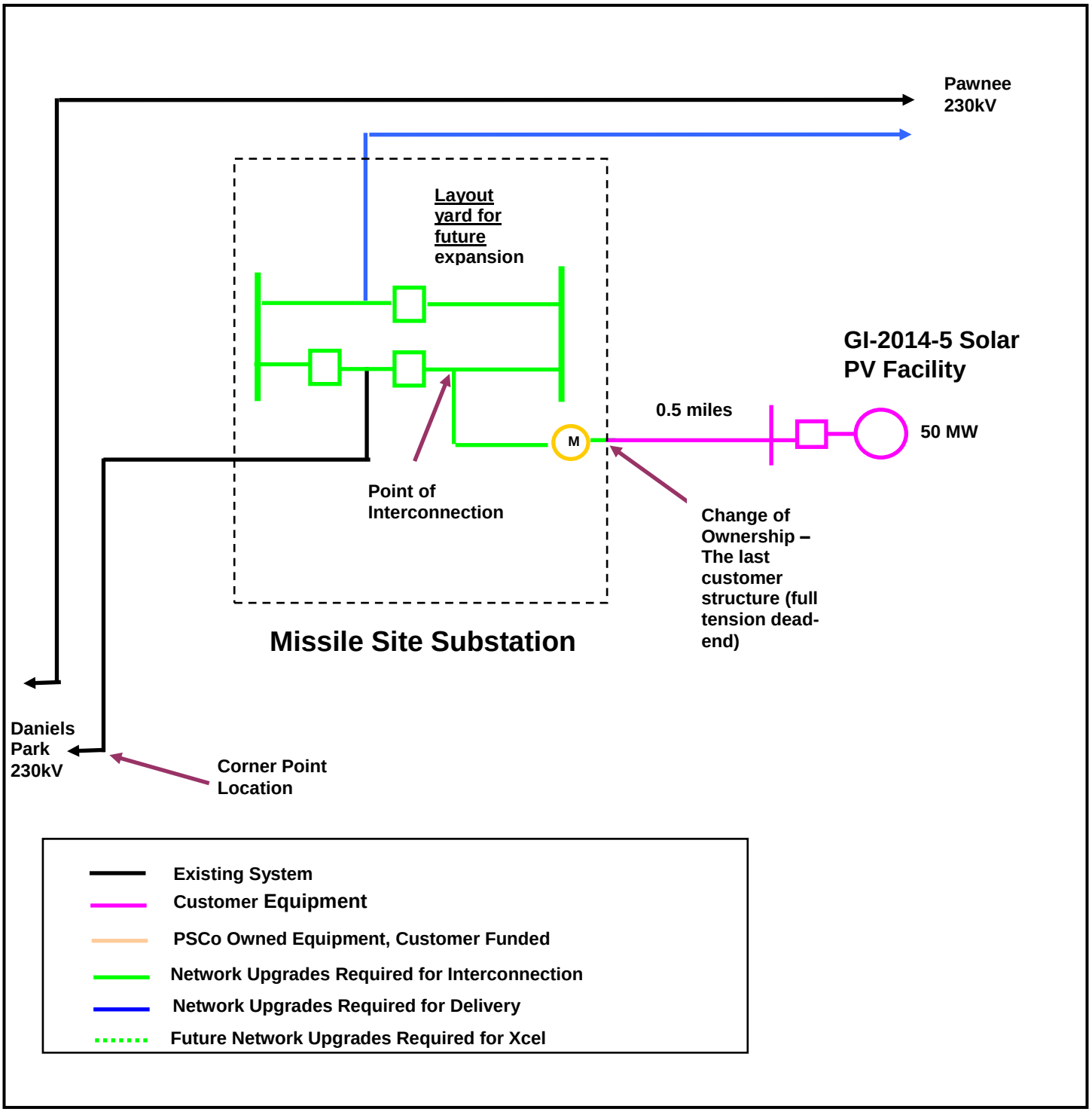

Figure 2: One line diagram of GI-2014-5

Table 5: PSCo Owned; Customer Funded Transmission Provider Interconnection Facilities

Element	Description	Cost Est. (Millions)
Missile Site 230kV Transmission Substation	Interconnect Customer to the Missile Site 230kV Transmission Substation (into the 230kV bus). The new equipment includes: • One 230kV gang switch • Three 230kV arresters • One set (of three) 230kV CT/PT metering units • AR15 communications equipment • Associated bus, wiring and equipment • Associated site development, grounding, foundations and structures • Associated transmission line communications, station controls, relaying and testing	**$0.467**
	Transmission line relocation and tap into substation. Structures, conductor, insulators, hardware and labor.	**$0.160**
	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	**$0.647**
Time Frame	**Site, design, procure and construct**	**18 Months**

Table 6: PSCo Owned; PSCo Funded Interconnection Network Facilities

Element	Description	Cost Estimate (Millions)
Missile Site 230kV Transmission Substation	Interconnect Customer to the Missile Site 230kV Transmission Substation (into the 230kV bus). The new equipment includes: • One 230kV circuit breaker • Two 230kV gang switches • Associated communications, supervisory and SCADA equipment • Associated line relaying, station controls and testing • Associated bus, miscellaneous electrical equipment, cabling and wiring • Associated foundations and structures • Associated road and site development, fencing and grounding	**$0.494**
	Siting and Land Rights support for substation land acquisition and construction.	**$0.020**
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	**$0.514**
Time Frame	**Site, design, procure and construct**	**18 Months**

Table 7: PSCo Network Upgrades for Delivery

Element	Description	Cost Est. (Millions)
	N/A	

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 factors 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. 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.
- No new substation land will need to be acquired.
- Breaker duty study determined that no breaker replacements are needed in neighboring substations.

Appendix

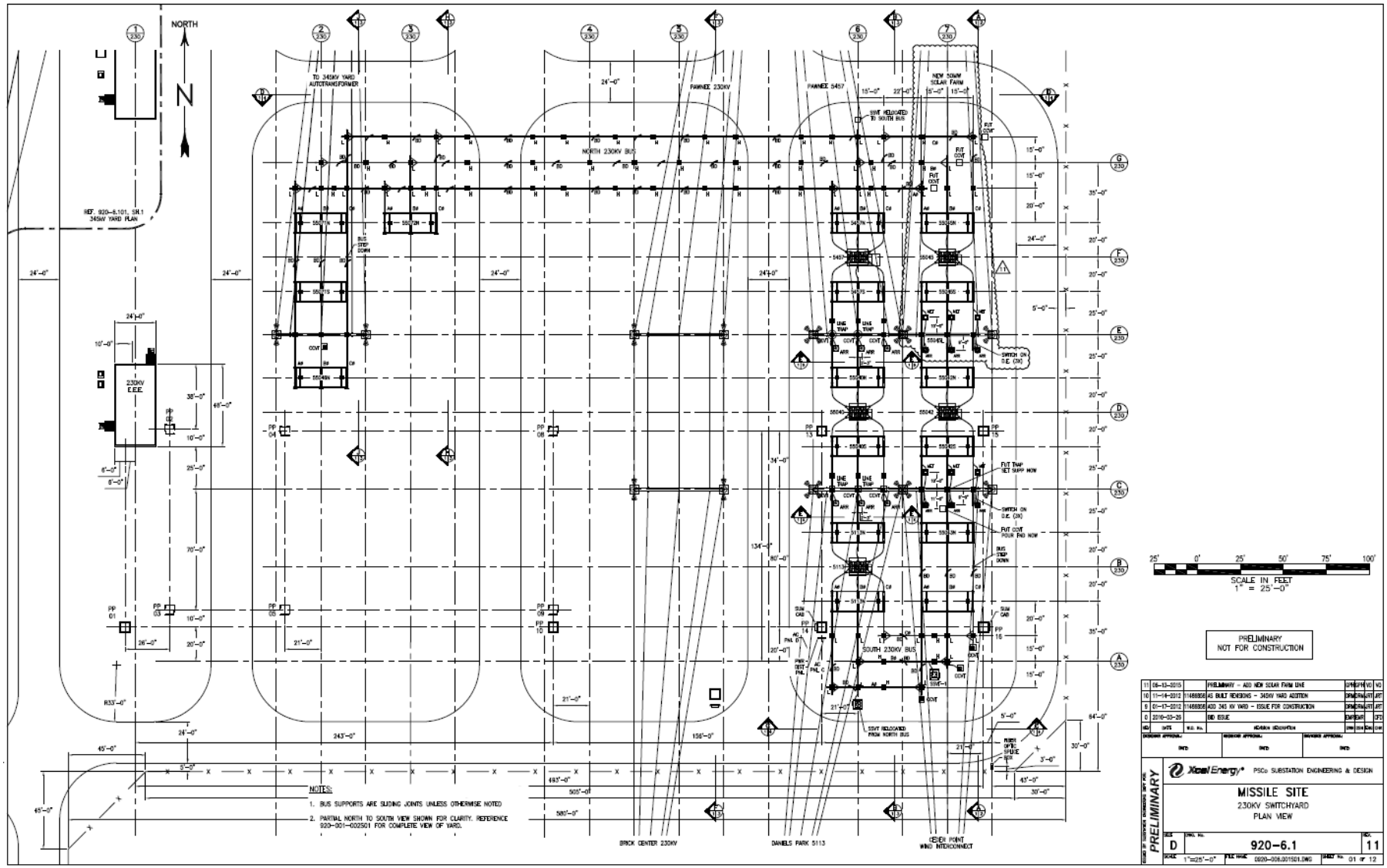

Figure 3: Missile Site 230 kV Switchyard Plan View

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

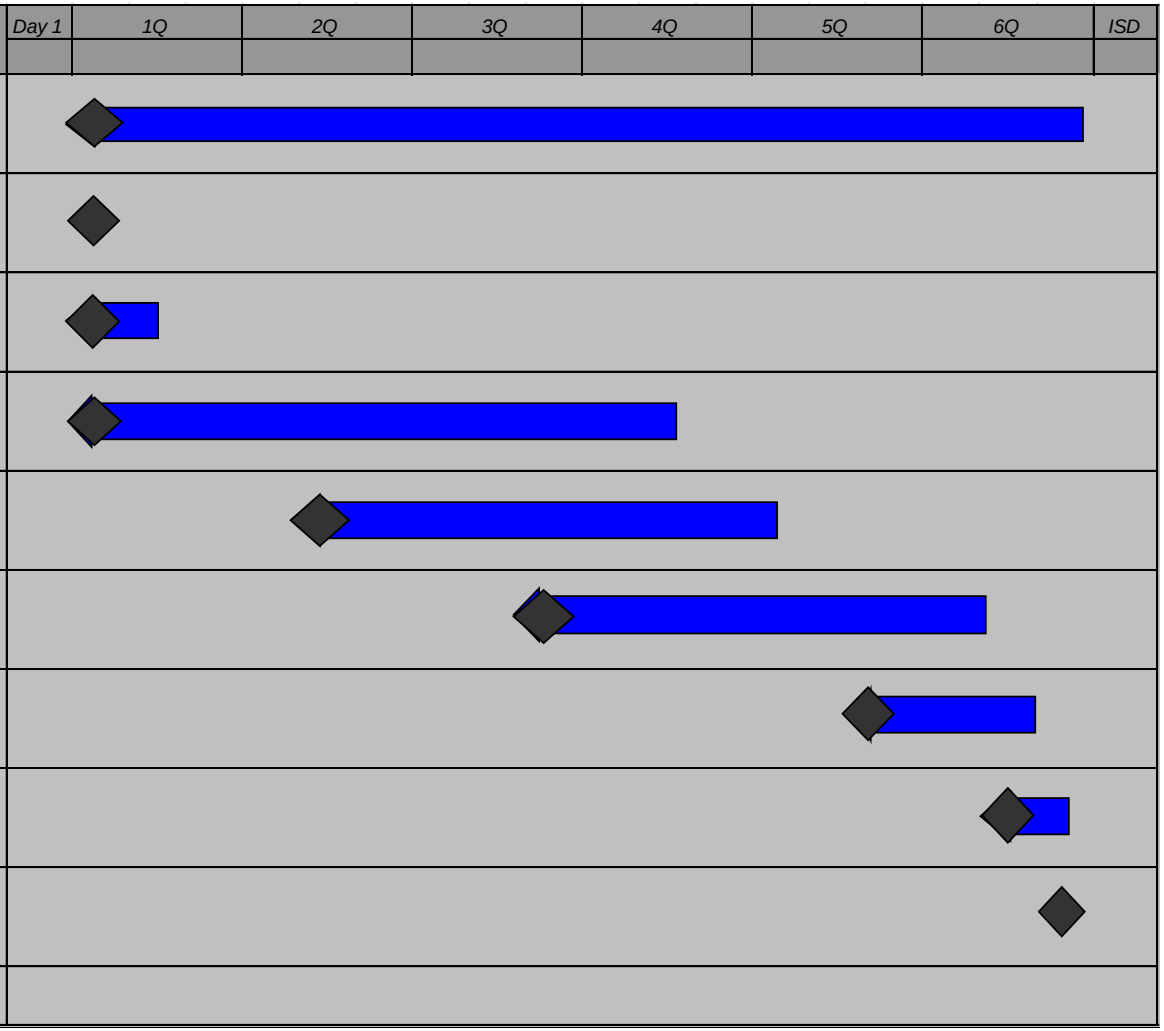

Figure 4: Project Schedule