Generation Interconnection Re-Study Facilities Study Report
Request # GI-2009-08

30 MW PV Solar Generation
Alamosa County, Colorado

Public Service Company of Colorado
Transmission Planning West

December, 2015

I. Executive Summary

This Re-Study of the Facilities Study Report, issued on July 24, 2013, which 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 30 x 1 MW Solar PV generation facility in Alamosa County, Colorado.

The new Solar PV generation is proposed to interconnect to the Alamosa Terminal 69 kV substation (see Figure 1). The Solar PV generating facilities are located approximately 1 mile southwest of Alamosa, Colorado and would be connected via a customer owned radial 69 kV line. The requested commercial in-service date was March 31, 2013. This date is already past and cannot be met. The in-service date of the interconnection facilities will be 18 months after receiving authorization to proceed.

The total estimated cost for the facilities required for interconnection is **$2.471 million**[1] and includes one (1) 69 kV circuit breaker, three (3) 1200 A switches and bus work, metering, communications and transmission line bus tie connection.

- $2.169 million for PSCo-Owned, Customer-Funded Interconnection Facilities
- $0.302 million for PSCo-Owned, PSCo-Funded Network Upgrades for Interconnection

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.

Please note that in addition to the facilities identified and estimated in this Facilities Study, PSCo is reviewing a requirement to add Power Quality monitoring capability to all solar photovoltaic generating facilities to monitor power quality compliance at the Point of Interconnection with IEEE Standard 519 and the Xcel Energy Interconnection Guidelines. PSCo reserves the right to add this monitoring capability some time in the future.

A proposed Station One-Line diagram for the Alamosa Terminal Switchyard is shown in Figure 2.

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

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

Figure 1: Network Diagram with Proposed POI at Alamosa Terminal 69 kV

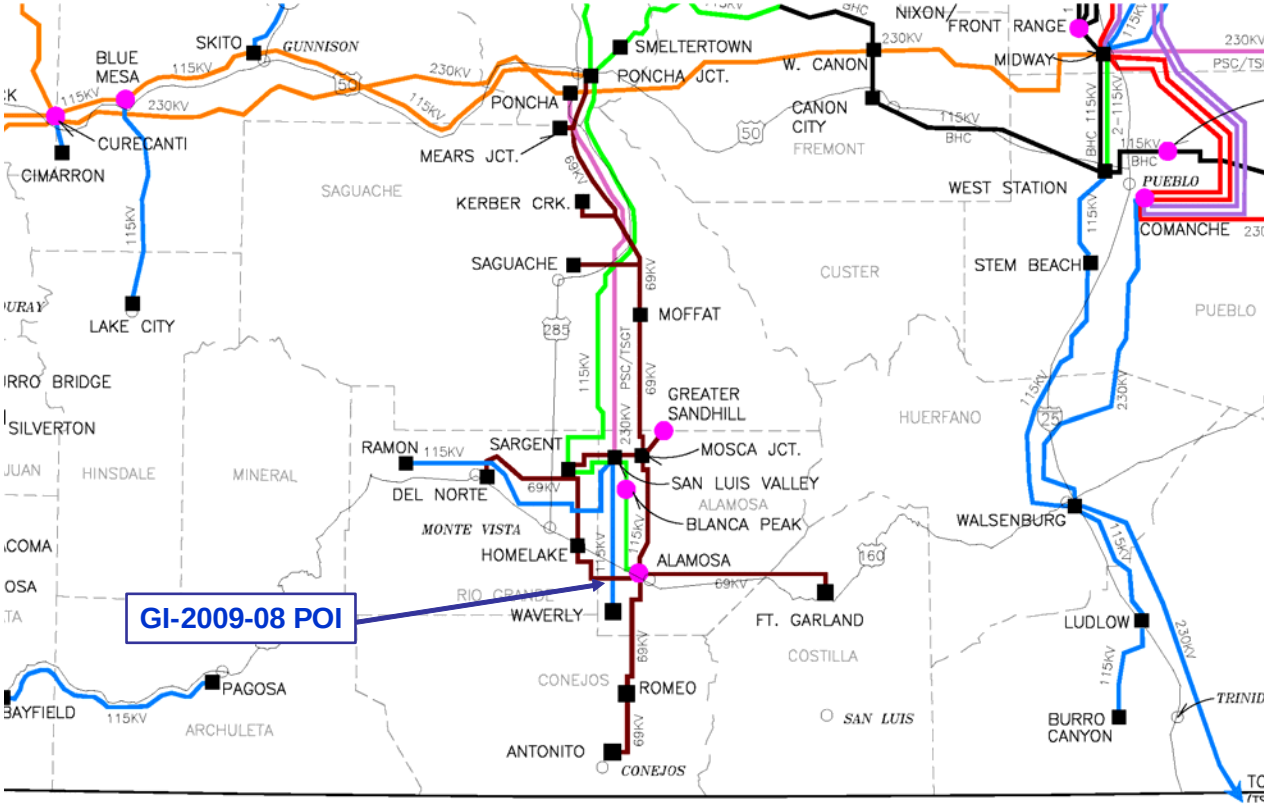
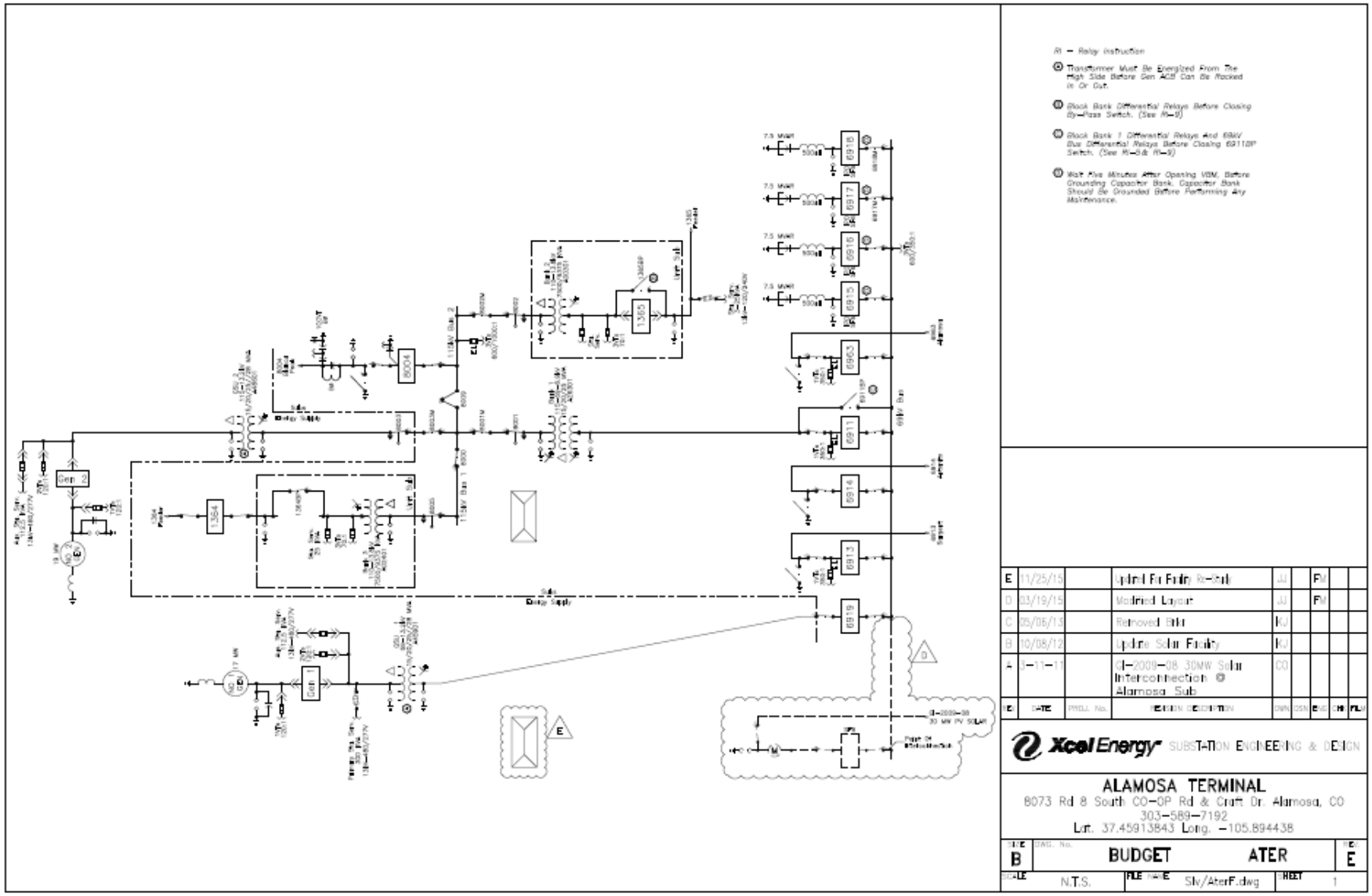


Figure 2: Alamosa Terminal 69 kV Substation Budget One-Line Diagram



II. Introduction

On July 15, 2009 PSCo Transmission received a generation interconnection request for 40 MW of solar photovoltaic generation injecting into the Alamosa Terminal 69 kV substation in Alamosa County, Colorado. The results of the Feasibility Study were issued in July 2011. Subsequently, the request was reduced to **30 MW** of solar PV and the results of the System Impact Study were issued in October 2012. An agreement for a Facility Study was executed March 21, 2013. This report documents the results of PSCo's Facilities Study efforts. Please note that the requested commercial in-service date was March 31, 2013. This date is already past and cannot be met. This Facilities Study Report is a Re-Study of the Facilities Study Report issued on July 24, 2013.

III. General Interconnection Facilities Description

I. Project Purpose & Scope

This project is to connect a 30 MW solar power plant into the 69 kV bus at Alamosa terminal substation. The bus is a straight bus layout, so the interconnection will be implemented using a single breaker, 3 gang switches, and a metering unit. The project is split into four estimates to account for (1) the Xcel funded station improvements, (2) the customer funded equipment of the interconnection, (3) the customer funded communication at the substation, (4) and the customer funded LFAGC RTU at the generation site.

Future Considerations

There are no future expansion plans on the 69 kV bus, but there are a couple projects are happening at this site. The existing EEE building will be full after 115kV Bus Differential and Bank # 1 replacement projects are done. A new EEE will be installed as part of this project.

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.

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

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

No transmission line capacity will be impacted by this project.

B. Fault Current

The fault current studies include cases with the present transformer (A263), new transformer (A779), and the new line to solar plant in service with the results as below.

Type of Fault / Location	Three Phase (A)	Single-Line-to-Ground (A)
69 kV Bus	5,280.51 A	6,622.15 A

C. Electrical Removals & Relocations

The existing 69 kV bus dead end will be removed and a new dead end structure will be installed per the below section.

D. Electrical Installations (Major Equipment)

As a part of this project, two (2) new dead end towers will be installed with one new bay at the 69 kV bus. The dead end structure will have a mounted gang disconnect switch for metering maintenance, three (3) arresters and three (3) meters on structures below the dead end. The bay will contain a circuit breaker and 2 gang switches. The existing 69 kV bus will be extended to accommodate the new bay.

Electrical Equipment Enclosure (EEE)

A new EEE will be installed as a part of this project.

E. AC System

The existing AC system is adequate for the new breaker and relaying. All AC cable will be routed to the old AC panel from the new EEE.

F. DC System

The existing DC system is adequate for the new breaker and relaying. All DC cable will be routed to the old AC panel from the new EEE.

G. Grounding

The assumption is existing grounding is adequate. No grounding analysis was performed. There will be some modification for new EEE grounding and new equipment.

H. Lightning Protection

Additional shielding will be installed as result of the new bay structures and EEE.

Trenching & Cable

Two new pull pits will be installed: (1) cable from AC-DC panels from old control building can be routed through the basement to a new pull pit on the west side of the old building to (2) a new pull pit on the east side of the new EEE. New conduit will be installed into the pull pit on the east side of the new EEE. This conduit will run south to the new breaker and metering installation.

V. Civil Features

I. Grading & Fencing

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

J. SPCC (Oil Containment)

N/A

K. Civil Removals & Relocations

The 69 kV bus dead-end will be removed and replaced.

L. Foundations & Structures

The following foundations will be installed:

a) **Quantity**	b) **Description**	c) **Approx. Size**
d) 8	e) Dead-end foundations	f) 4’ x 4’
1	69 kV Breaker	6’x8’
2	69 kV Gang Switch	2’ x 2’
6	Arresters and meters	2’ x 2’
4	Bus support foundation	2’ x 2’
1	EEE	15’ x 30’

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

Structure Quantity	**Steel Description**	h) **Steel Wt./ Structure**	**Drilled Piers**		
			Pier Qty/ Structure	**Approx. Size**	
				Dia.	**Depth**
6	Arrester/metering unit Stand			10/16”	
1	Switch structure			10/16”	
4	69 kV dead end tower			6’	
2	69 kV bus support			10/16”	

Structure Quantity	Steel Description	h) Steel Wt./ Structure	Drilled Piers		
			Pier Qty/ Structure	Approx. Size	
				Dia.	Depth
1	3-conductor bus support			10/16”	
1	69 kV dead end structure			10/16”	

All structures will be master or previously designed structures. The 69 kV deadend structure will be tubular steel; all others will be rolled steel.

VI. Protection Features

Below is the analysis and recommendation from system protection dated This project involves the interconnection of a 30MW solar plant into the 69kV bus at Alamosa Terminal substation.

The primary protection for the new bus tie interconnection to the solar plant is a line current differential scheme utilizing a SEL-411L 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 BKR1. Further, a separate output on the PKG-P relay initiates breaker failure for BKR1.

The secondary protection for the new bus tie interconnection to the solar plant is a step distance and ground overcurrent scheme utilizing a SEL-311C relay (PKG-S). The PKG-S relay also implements a POTT pilot 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 BKR1. Further, a separate output on the PKG-S relay initiates breaker failure for BKR1.

Breaker failure and sync check for BKR1 are implemented utilizing a SEL-351S relay (BKR1 PKG-BF). The breaker failure scheme is initiated by the operation of the primary SEL-411L relay (PKG-P), secondary SEL-311C relay (PKG-S), and the 69kV bus lockout relay (86B-69). The trip output of the breaker failure relay operates the breaker failure lockout relay (BKR1 86BF), which consequently initiates DTT to the remote terminal at the Solar plant via the PKG-P using mirrored-bits. The BKR1 86BF lockout relay also blocks closing of BKR1. A separate output on the PKG-BF relay will be used to trip the 69kV bus lockout relay (86B-69). There is no auto-reclosing on BKR1. 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 sync check failure alarm.

The primary DTT scheme to the remote terminal at the solar plant is implemented using the 87L bits on the primary line protection SEL-411L relay (PKG-P). The communication cutoff switch, 85CO-1, can be used to disable the DTT scheme. A breaker failure lockout relay (BKR1 86BF) contact wired to an input on the SEL-411L relay (PKG-P) initiates sending DTT to the remote terminal in case of BKR1 breaker failure. In case of receiving DTT from the remote terminal, an output on the SEL-411L relay (PKG-P) operates an auxiliary relay, 94DTT-P, which consequently operates the trip coil #1 of BKR1 and block closing of the same breaker.

The existing 69kV bus differential summation cabinet is to be modified to add CTs from BKR1. The BKR1 CTs are to have a full ratio of 1200/5, with the bus differential CT at the full ratio of 1200/5 to match the existing bus differential CTs. Further, the existing 86B-69 lockout relay control circuit should be modified to add contacts to trip and block closing of BKR1.

A summary of the protection

- Primary Line Package: PKG-P, SEL411L

- Part Number: 0411L1X4X5B8DCXH57424XX
- Firmware Version: R115

- Secondary Line Package: PKG-S, SEL311C-3
  - Part Number: 0311C31HP3J5421
  - Firmware Version: R507
- Breaker Failure Package: PKG-BF, SEL351S
  - Part Number: 0351S6XHD3J5421 (Rack Mount)
  - Firmware Version: R515

VII. Control Features

General

This part based on the analysis and recommendation from communication design, issued in March 19th, 2015.

RTU
The existing RTU is a GE D20 M++ with adequate I/O for this project.

Local Annunciation:
The existing LCU is a GE Powerlink HMI which can be utilized for this project.

Telephone Protection:
Telephone is existing and adequate for this installation.

Substation Wide Area Network (WAN):
This substation is on the Xcel Owned microwave and was scheduled to be upgraded to digital microwave in 2015. This infrastructure is operated by the Xcel Business Systems which will provide a network connection for the substation LAN per a Mercury request submittal.

Relay Remote Access/Substation LAN:
A transmission LAN will be established, featuring a Checkpoint CIP1200R, Ruggedcom RX1501 switch, and SEL-3530 Real-Time Automation Controller (RTAC) to be installed on a new communication rack in the substation control building.

Programmable Logic Controller
Not applicable for this facility.

Protection Communication

Transmission Line Protection Pilot Schemes
Solar Line:
The primary, secondary, and DTT pilot channels will be provided via new OPWG installed with the transmission line to the customer's facility.

Removals

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

Communications Plan Recommendation Summary:
Phone Isolation Wall Board:

- N/A – phone will be supplied by the microwave system

Communications Panel:

- Substation Router: Checkpoint CIP1200R (Qty 1)
- Substation Switch: Ruggedcom RX1501 (QTY 1).
  Part Number: RX1501-L2-RM-HI-L2SE-6TX01-6TX01-6TX01-6TX01-6TX01-6TX01-XX
  Includes
  - Layer 2 with Security Software
  - 19" Horizontal Rack Mount
  - 88-300VDC/85-264VAC Power Supply
  - 36X 10/100TX RJ45 Ports
- Serial Port Server: SEL-3530 (Qty 1)
  Part Number: 3530AB0XX211X0XXXXXX
  Includes:
  - Horizontal Rack Mount, 1U, 48/125VDC;120VAC
  - Client-Server Protocols: SEL, DNP3, Modbus, C37.118 Synchrophasors, L&G 8979, SES-92, IEC60870-5-101/104
  - Seventeen EIA-232/IA-485 Serial Ports
- GPS Clock: SCHWEITZER SEL-2407
  Part Number: SEL-24070001B
  Includes
  - GPS Antenna (235-0113) with 75-feet of Cable (C960),
  - 19" Horizontal Rack Mount with Bracket

VIII. Project Operating Concerns and Outages

Outages/Temporary Configurations

An outage on the 69 kV bus will be required to extend the bus and install the new bay. This is not currently anticipated to be an issue.

IX. Material Staging Plan

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

X. Related Projects

Transmission WO 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: The project has not officially begun so no surveying was completed.

☒ Soil boring results are not available. Explain: The project has not officially begun so no surveying was completed.

☐ 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 69 kV bus 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: Added new shield wires for new bay.

☐ 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

GI-2009-8 (Facilities Study Report)
Revised December 8, 2015

Appropriation level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 20% accuracy) were developed by Xcel Energy/PSCo Engineering. The cost estimates are in 2015 dollars with escalation and contingencies applied (AFUDC is not included) and are based upon typical construction costs for previously performed similar construction. These estimated costs include all applicable labor and overheads associated with the siting support, engineering, design, material/equipment procurement and construction of these new PSCo 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 **$2,471,000.** Figure 3 below represents a conceptual one-line of the proposed expansion/interconnection at the Alamosa Terminal 69kV 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 3: Diagram of the GI-2009-08 Interconnection on Alamosa Terminal 69 kV bus

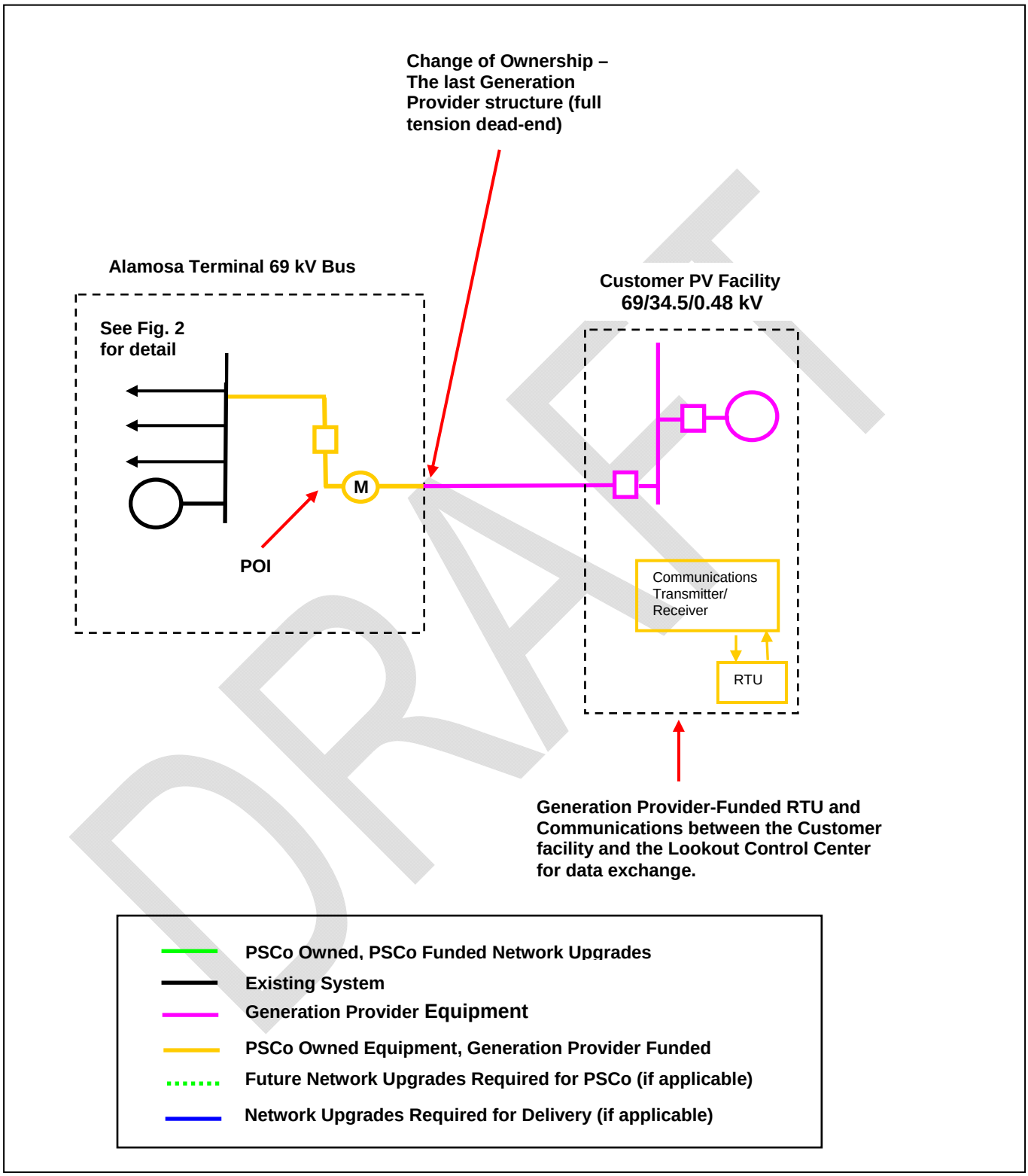


Table 1 – PSCo Owned; Customer Funded Transmission Provider Interconnection Facilities

Element	Description	Cost Est. (Millions)
PSCo's Alamosa Terminal 69kV Transmission Substation	Interconnect Customer to the 69kV bus at the Alamosa Terminal Substation. The new equipment includes: • One 69kV, gas circuit breaker • Three 69kV, 1200 amp gang switches • One set (3) 69kV combination CT/PT metering units • Three 69kV lightning arresters • Primary metering for Load Frequency/Automated Generation Control • Power Quality Metering • Control Building (Electrical Equipment Enclosure) • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures • Associated transmission line communications, fiber, relaying and testing	**$1.886**
PSCo's Alamosa Terminal 69kV Transmission Substation	Transmission line tap from Customer's last line structure outside of PSCo's yard into new bay position (assumed 300' span, conductor, hardware and labor).	**$0.057**
	Sitting and Land Rights and Project Management support	**$0.010**
Customer's 69kV Substation	Load Frequency/Automated Generation Control (LF/AGC) RTU and associated equipment	**$0.216**
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	**$2.169**
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 Alamosa Terminal 69kV Transmission Substation	Interconnect Customer to the bus at the Alamosa Terminal Substation. The new equipment includes: • Associated station controls, communications, supervisory and SCADA equipment • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures • Associated equipment and system testing • Associated yard surfacing, landscaping, fencing	**$0.302**
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	**$0.302**
Time Frame	**Site, design, procure and construct**	**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	**$2.471**

Cost Estimate Assumptions

Cost Estimate Assumptions

- Appropriation level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 20% accuracy) were developed by Xcel Energy/PSCo Engineering.
- Estimates are based on 2015 dollars (appropriate contingency and escalation applied).
- AFUDC has been excluded.
- Engineering will be contracted out to a Design Consultant.
- Lead times for materials were considered for the schedule.
- The Solar Generation Facility is in PSCo's retail service territory.
- PSCo (or it's Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- Construction labor is estimated for straight time only – no overtime included.
- The estimated time to site (support), design, procure and construct the interconnection facilities is approximately 18 months after authorization to proceed has been obtained.
- This project is completely independent of other queued projects and their respective ISD's.
- A CPCN will not be required for the interconnection facilities construction.

- Line and substation bus outages will be authorized during the construction period to meet requested backfeed dates.

V. Engineering, Procurement & Construction Schedule

Figure 4: GI-2009-08 Estimated Schedule

GI-2009-8 Facilities (Re)-Study Report
30 MW Solar Interconnection @ Alamosa 69kV Substation

ID	Task Name	Duration
1	GI-2009-8 (Re)-Study Report 30 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