



## Request # GI-2009-5/6 Generation Interconnection Facility Study Report

30 MW Photovoltaic Facility, San Luis Valley, Colorado

PSCo Transmission Planning  
March 8, 2011

### Executive Summary

This Interconnection Facilities Study Report summarizes the analysis performed by Public Service Company of Colorado (PSCo) in GI-2009-5/6 to specify and estimate the cost of the equipment, engineering, procurement, and construction needed to interconnect a 30 MW solar generation facility at San Luis Valley (SLV) substation, located in Alamosa County, Colorado. The primary point of interconnection (POI) is on the 115 kV bus at SLV substation.

The Customer's solar generation facility would connect to the POI via a four-mile 115 kV transmission line. It is the responsibility of the Customer to construct the radial transmission line up to the last deadend structure outside the San Luis Valley substation. The requested Commercial Operation Date (COD) of this project is December 1, 2011 with the requested back-feed of August 1, 2011.

The GI-2009-5/6 combined Feasibility/System Impact Study determined that the Customer can provide 30 MW without major network upgrades.

The cost for the transmission interconnection (in 2011 dollars)

The total estimated cost to interconnect the project is approximately **\$1,761,000** and includes:

- \$805,000 for PSCo-Owned; Customer-Funded Transmission Provider Interconnection Facilities
- \$956,000 for PSCo-Owned; PSCo-Funded Interconnection Network Facilities

One-line of the Interconnection is shown in Figure 1 below.

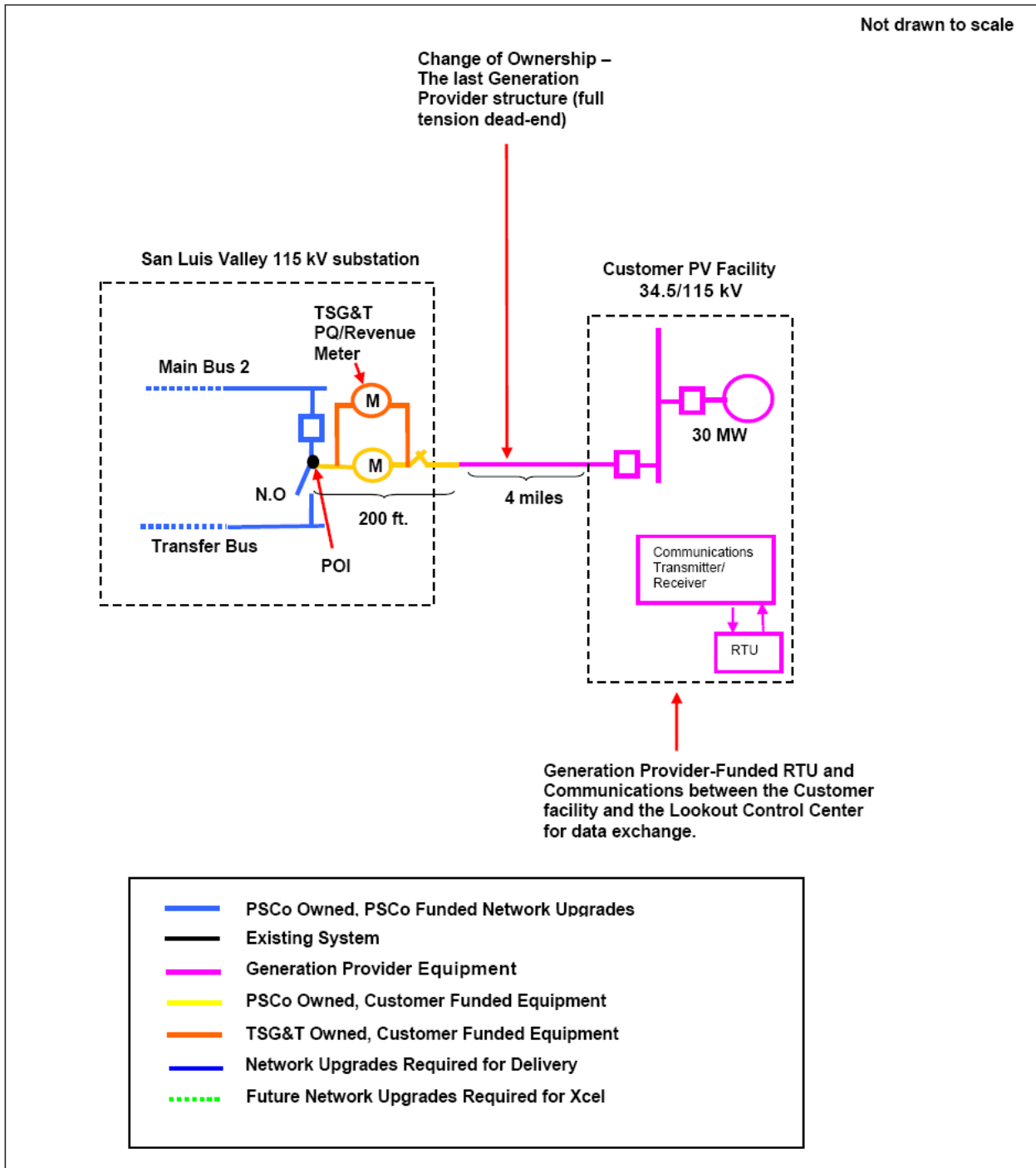


Figure 1: Diagram of the GI-2009-5/6 Interconnection



## I. Introduction

This Interconnection Facilities Study Report summarizes the analysis performed by Public Service Company of Colorado (PSCo) in GI-2009-5/6 to specify and estimate the cost of the equipment, engineering, procurement, and construction needed to interconnect a 30 MW solar generation facility at San Luis Valley (SLV) substation, located in Alamosa County, Colorado. The primary point of interconnection (POI) is on the 115 kV bus at SLV substation.

## II. General Interconnection Facilities Description

### A. Project Purpose and Scope

A new 115 kV line position will be provided at the San Luis Valley Substation (SLV) to serve as the Point of Interconnection (POI) for a new 30 MW solar photovoltaic facility. The Customer has requested a back feed date of August 1, 2011 and a commercial operation date of December 1, 2011. The SLV substation yard will need to be expanded for the addition of a new 115 kV line position. Modifications to existing RTU, protection and control schemes as well as the addition of new protection and control will be needed for the new 115 kV line position.

#### Background

The San Luis Valley substation is a jointly owned facility by Tri-State Generation and Transmission and Public Service Company of Colorado (PSCo) with a 50/50 cost sharing split under the Utility Services Agreement (USA). PSCo is initiating the project but TSG&T will be involved in the design of the interconnection issues that affect the equipment and devices presently owned and maintained by TSG&T. Final testing and commissioning for equipment operated and maintained by TSG&T will be performed by TSG&T personnel.

Refer to the “Combined Generation Interconnection Feasibility/System Impact Study Report,” request numbers GI-2009-5 & GI-2009-6 dated 2/4/2010 for more background information.

### B. Right of Way

The permitting activities for this project are expected to be minimal because all of the work will be performed inside of the substation fence or on USA property. Construction permits, and Grading, Erosion and Sediment Control (GESC) permits will be required. Transmission right of ways will be obtained by the Customer. The expansion of the yard will leave adequate space available on existing USA property for future transmission additions.



## C. Electrical Features

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

Per the Combined Generation Interconnection Feasibility/System Impact Study Report (request # GI-2009-5 and GI-2009-6) for this installation, there are no required upgrades to the surrounding transmission network. The impact study report also states that the substation is adequate to handle the increased current flow from the solar PV generation facility interconnection.

### Fault Current

Per the Combined Generation Interconnection Feasibility/System Impact Study Report (request # GI-2009-5 and GI-2009-6), the addition of the new 30 MW, 115 kV line position at San Luis Valley substation will require no changes or modifications to existing equipment within the substation yard for additional fault currents. Existing equipment is adequately rated for increased current loading and fault duty.

Location	Type of fault	
	Three Phase (A)	Single-Line-to-Ground (A)
SLV substation 115 kV bus (with 30 MW)	3787	4819

### Electrical Removals & Relocations

No removals or relocations will be required for this installation.

### Electrical Installations (Major Equipment)

The SLV 115 kV yard will be expanded to the east to accommodate the new line position. The new line conductors will slack span into the substation dead end structure from the customer provided dead end transmission structure. Customer-funded line disconnect switch, surge arresters and revenue CT/PT metering units will be installed at the POI inside the substation. A new 115 kV, SF6 power circuit breaker will tie the line position to the main 115 kV bus. The 115 kV disconnect switches will be provided on both the line and bus side of the new power circuit breaker. The line position will also connect to the 115 kV transfer bus to provide an alternate path for generation interconnection during breaker maintenance which will require modifications to the existing transfer breaker protection.

Main bus will be 5 inch aluminum tube per PSCo electrical engineering substation standards. Rigid aluminum tubular bus will be rated to meet PSCo loading standards and structural deflection limits.

### Mobile Substation or Transformer

Mobile transformer access will not be required for this installation.



### AC System

There are adequate spare circuits within the AC system for equipment in the installed 115kV line. The station service size will be verified during detailed design, but is assumed to be adequate at this time for the installation of the SF6 power circuit breaker and revenue CT/PT requirements.

### DC System

There are only 6 available spare DC circuits which will be used in future panel expansions of the substation so a new 125 VDC panel board will be installed for the 115 kV expansion. The existing 125 VDC battery bank and 50 A charger will be verified during detailed design, but is assumed to be adequate for this installation. The 48 VDC battery bank serves the PSCo communication system only not part of this scope of work.

### Grounding

Ground grid will be provided as required in the site expansion area.

### Lightning Protection

Lightning protection will be installed with and integrated into existing site lightning protection system. Lightning protection system additions will be provided to protect only equipment installed as part of this project. Verification of the adequacy of the existing lightning protection will be verified during detailed design.

### Trenching & Cable

Pre-cast concrete cable trench will be provided to connect the existing 230 kV yard cable trench to the existing 115 kV yard cable trench. The pre-cast trenching will be installed north-south between 115 kV breakers 662 and 562 and will include component type and vehicle crossing sections as required. The cable trench south of bank #1 will be extended to the existing cable vault as required to provide cable entrance into the control building.

New control cables will be provided as required for new 115 kV SF6 power circuit breaker and revenue CT/PT units.

## **D. Civil Features**

### Grading & Fencing

The 115 kV yard will be expanded 70 feet to the east from the south fence line to the centerline of the bank #2 dead-end structure immediately south of the bank #2 transformer to accommodate the new line termination. Grading and fencing will be required within this portion of the extended yard. The existing access road will be abandoned and a new access road provided from the road to the new gate location.



### Storm Water Permit

The substation site expansion described above does not disturb more than one acre of land so no storm water permit will be required for this installation.

### Foundations & Structural

All associated and supporting foundations, piers and equipment steel will be designed and installed in accordance with PSCo design and construction standards. No foundation or structural removals are required. Foundation standards are contingent on soil and/or steel design requirements and are subject to change.

Additional oil containment is not required for this installation.

### Civil Removals & Relocations

The east side of the 115 kV yard will be expanded requiring the removal of a section of existing fence. The access road at the south-east corner of the site will be relocated to accommodate the installed incoming 115 kV transmission line and required structures outside of the substation yard.

### Civil Installations

Estimated foundation sizes may vary depending on detailed steel design and/or soil report information. A geotechnical investigation and consequent report on soil conditions at site may be required if none exists in archive records. Depths of drilled piers cannot be estimated presently without a geotechnical investigation to reference for preliminary soil conditions.

### Electrical Equipment Enclosure (EEE) or Switchgear Building

No electrical equipment enclosure or switchgear building will be installed.

## **E. Control Features**

### Control Schemes

A differential scheme will be used for primary line relaying of the customer installed 115 kV transmission line from the Customer collector substation to San Luis Valley Substation. A step distance line relaying scheme will be used as secondary protection for the installed 115 kV transmission line. There will be a direct transfer trip piloting scheme on breaker failure of either breaker on each side of the solar generation facility transmission line. A stepped distance scheme will be used to protect the 115 kV transfer breaker. The transfer breaker protection retrofit will include a setting group for each of the possible connected lines i.e. Ramon, Waverly and new solar generation interconnect.

### Transmission Line Protection (115 kV)

- The primary protection for the new line from the Customer solar plant will be a line differential scheme using an SEL-311L with fiber optic communications.



- Backup protection for the new line will be a stepped distance scheme using an SEL-311C relay.
- Breaker failure and synchronizing will be applied to the line through an SEL-351 relay per our standard philosophy. The metering unit will have a minimum of two voltage windings, one of which will be used for sync check.

#### 115 kV Bus Protection

- New breaker 9191 will be added into the existing 115 kV bus differential scheme.

#### Bus Tie (Transfer) Breaker Protection

- The existing electromechanical stepped distance scheme will be replaced by microprocessor based stepped distance schemes with a setting group for each of the possible lines that could be connected to the transfer bus.
- This scheme will be implemented per Tri-State's standards, which have been communicated to Burns and McDonnell in drawing format.

#### Local Annunciation

No modifications to existing local annunciating schemes will be provided as part of this installation.

#### Control Panel Locations

Within the existing control house, there is very limited room for additional installations. The installation of the 115 kV line relaying protection and breaker control scheme panels will be required for the new installation of the 115kV line position. TSG&T also would like to modify the 115 kV transfer bus protection. During detailed design, close coordination between TSG&T and PSCo will be required to determine where additional panels can be installed. Initially, new panels could be installed in the control house at location 10NF and potentially location 9NF if required.

#### Digital Fault recorder

Existing digital fault recorder (DFR) #2 has 7 spare inputs available. There will be four current and one voltage input channels to DFR2 for the new 115kV line position.

#### Telephone protection

Existing telephone protection will not be modified for this installation.

#### PLC (programmable logic controller)/Feeder Load Monitoring/Information-flow/Others

Initially, it is assumed no PLC or load monitoring equipment will be installed for the new line position. This decision is contingent on detailed review by system operations personnel and TSG&T.



### Fiber Optic cable

Fiber optic cable will be used for communication and control between the solar generation facility and San Luis Valley substation. Single mode, 48-count, OPGW fiber will be used on the Customer provided transmission line which is approximately 4 miles long. The OPGW will be terminated on the last transmission structure outside of the San Luis Valley substation by the Customer. PSCo will coordinate the OPGW installation and termination into the substation.

### Equipment Details

Details of equipment for control, protection, communication, system monitoring, and SCADA will be made available later.

### Removals

No equipment removals will be required for this installation.

### Installations

Reference above sections for detailed protection and control relay installations required for the additional 115 kV line position installation.

## **F. Metering**

### Revenue Metering

Revenue metering will be provided according to the Transmission System Interconnection Guidelines and/or other contract provisions. The Customer interconnection revenue metering will be added to the current energy imbalance accounting with PSCo.

### Load Control Metering

Load control metering will be provided by a new SEL734 EXM meter serially connected to the new D20 load control RTU with its own 4-wire dedicated leased line to PSCo's EMS system. Communication between the SEL734 and the D20 shall be DNPV3.0.

### Power Quality Metering

Power quality metering will be installed at the SLV substation in conjunction with the new solar plant interconnection revenue meter. The installation of the PQ/revenue meter prior to the planned project may be provided to allow for baseline measurements to be obtained. This meter will be owned by TSG&T and funded by the Customer. San Luis Valley Rural Electric Cooperative will bill the Customer for house power at the point of interconnection. PSCo will only receive the net power output of the plant at the POI. San Luis Valley Rural Electric Cooperative will bill the Customer according to their standard rate structures at the POI based on power that flows into the plant.





## **G. Outages**

Outages will be coordinated with system operations personnel. Anticipated major outages include the 115 kV main bus #2, and the connected lines to Waverly, Alamosa Terminal, Bank T2, and Bank T4 and the 115 kV transfer bus. It will be difficult to take major outages during the summer peak in the San Luis Valley, but PSCo and TSG&T will do the best to meet the requested back feed and COD dates. If outages cannot be taken without jeopardizing the reliability of the system, the requested milestone dates for the project will have to be moved out.

## **H. Material Staging Plan**

All major materials will be delivered directly to the fenced substation yard and stored. Other materials will be delivered to the Alamosa Service Center.

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

Coordination with transmission installation by the Customer will be required. Access road construction activities could interfere with transmission line installations.

## J. 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: Existing soil borings may not be available for reference. The Customer has indicated they could share results of soil borings from their geotechnical investigation for transmission structures.
- Unusual soils or environmental conditions exist. Explain:
- Key materials or items need decisions or approvals. Explain: Coordination with TSG&T needs to occur to determine several aspects of detailed design.
- Potential permitting delays or unusual requirements exist. Explain: We are relying on the cooperation of the Customer.
- 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: Given desired accelerated timeline for backfeed, major material lead times could influence construction completion timeline.
- 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: The substation is a 50/50 cost sharing USA agreement and previous acquisition from Colorado-Ute Electric Association so drawing package is missing some information or could possibly be outdated.

### III. Costs Estimates and Assumptions

Scoping level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by PSCo Engineering. The cost estimates are in 2011 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, 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 **\$1,761,000**. 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)
<b>PSCo's San Luis Valley Transmission substation</b>	Interconnect Customer to the 115 kV bus at the SLV 115 kV substation. The new equipment includes: <ul style="list-style-type: none"> <li>• One 115 kV gang switch</li> <li>• Three 115 kV combination CT/PT metering units</li> <li>• Power Quality Metering (115 kV line from Customer's facility)</li> <li>• Three 115 kV lightning arresters</li> <li>• One relay panel (transformer breaker panel)</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>\$0.603</b>
	Transmission line tap into substation. Structure, conductor, hardware and installation labor.	<b>\$0.050</b>
<b>GI-2009-5/6 Customer's Facility</b>	Load Frequency/automated Generation Control (LF/AGC) RTU and associated equipment.	<b>\$0.152</b>
	<b>Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities</b>	<b>\$0.805</b>
<b>Time Frame</b>	<b>Design, procure and construct</b>	<b>12 Months</b>

**Table 2 – PSCo Owned; PSCo Funded Interconnection Network Facilities**

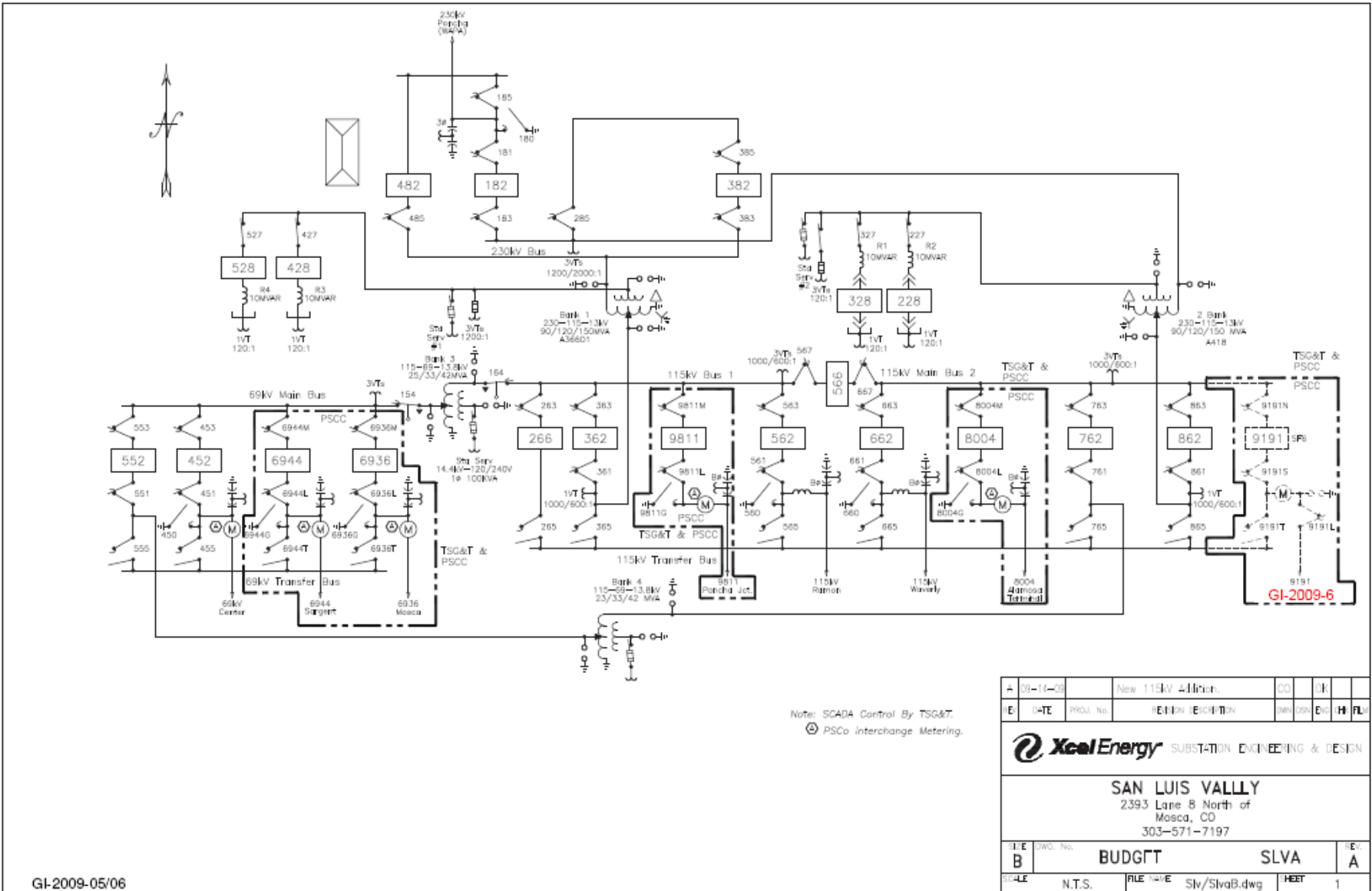
<b>Element</b>	<b>Description</b>	<b>Cost Estimate (Millions)</b>
<b>PSCo's San Luis Valley Transmission Substation</b>	Interconnect Customer to the 115 kV bus at the SLV 115 kV substation. The new equipment includes: <ul style="list-style-type: none"> <li>• One 115 kV circuit breaker</li> <li>• Three 115 kV gang switches</li> <li>• Associated communications, supervisory and SCADA equipment</li> <li>• Associated line relaying and testing</li> <li>• Associated bus, miscellaneous electrical equipment, cabling and wiring</li> <li>• Associated foundations and structures</li> <li>• Associated road and site development, fencing and grounding</li> </ul>	<b>\$0.946</b>
	Siting and Land Rights support for substation land acquisition and construction.	<b>\$0.010</b>
	<b>Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities</b>	<b>\$0.956</b>
<b>Time Frame</b>	<b>Site, design, procure and construct</b>	<b>12 Months</b>
	<b>Total Project Estimate</b>	<b>\$1.761</b>

## Cost Estimate Assumptions

- Scoping level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by PSCo Engineering.
- Estimates are based on 2011 dollars (appropriate contingency and escalation applied).
- 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 metering are included in these estimates.
- PSCo (or it's Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- The estimated time to design, procure and construct the interconnection facilities is approximately 12 months after authorization to proceed has been obtained.
- A CPCN will not be required for the interconnection facilities construction.
- Customer will string OPGW fiber into substation as part of the transmission line construction scope.
- Breaker duty study determined that no breaker replacements are needed in neighboring substations.
- It will be difficult to take major outages during the summer peak in the San Luis Valley, but PSCo and TSG&T will do their best to meet the requested back feed and COD dates. If outages cannot be taken without jeopardizing the reliability of the system, the requested dates for the project will have to be moved out.
- Power Quality Metering (PQM) will be required on the Customer's 115 kV line terminating San Luis Valley Sub. Evaluations continue on the need for PQM on the Poncha 230 kV line and Sargent 115 kV line.

# Appendix

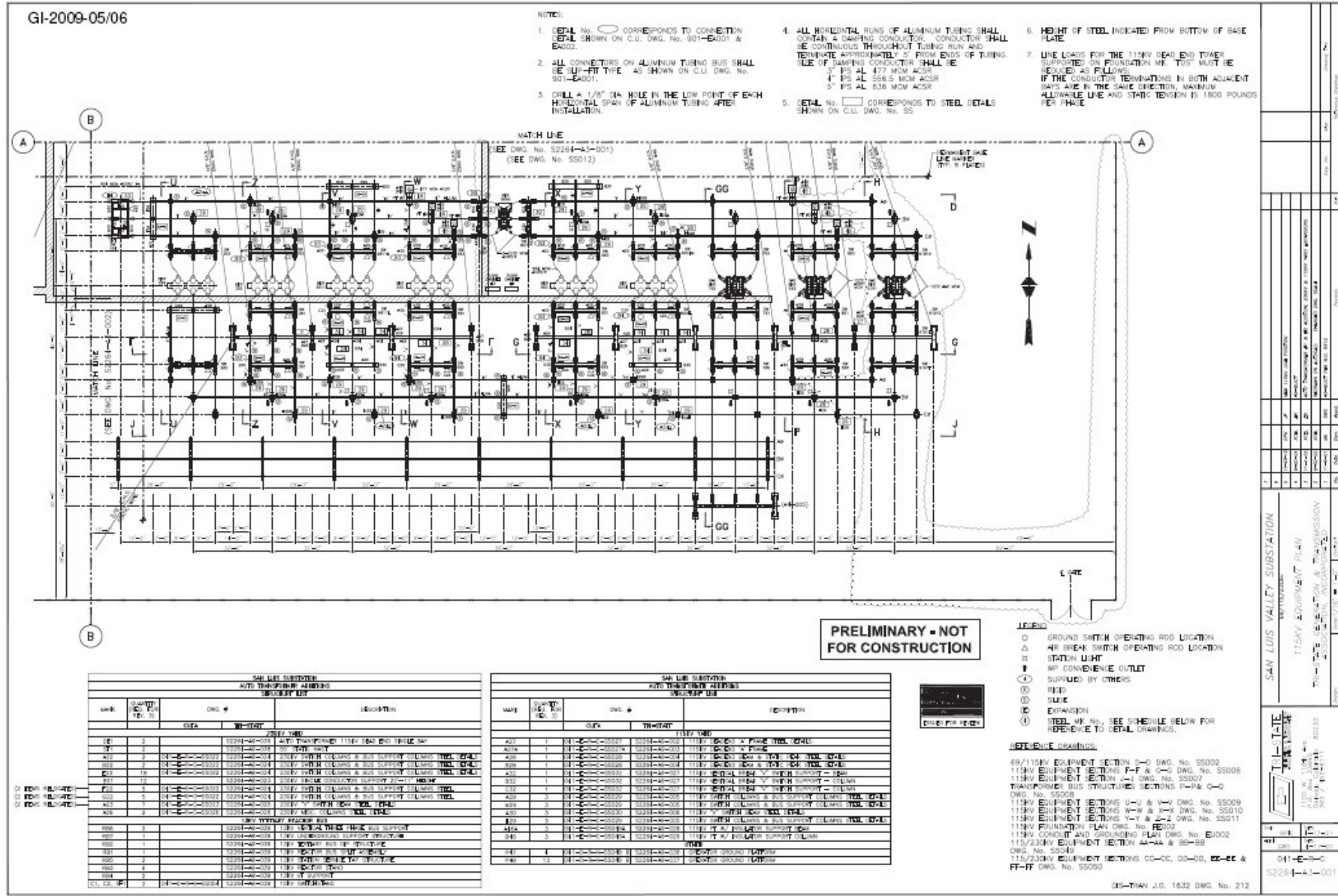
### A. Project One-Line of the Point of Interconnection



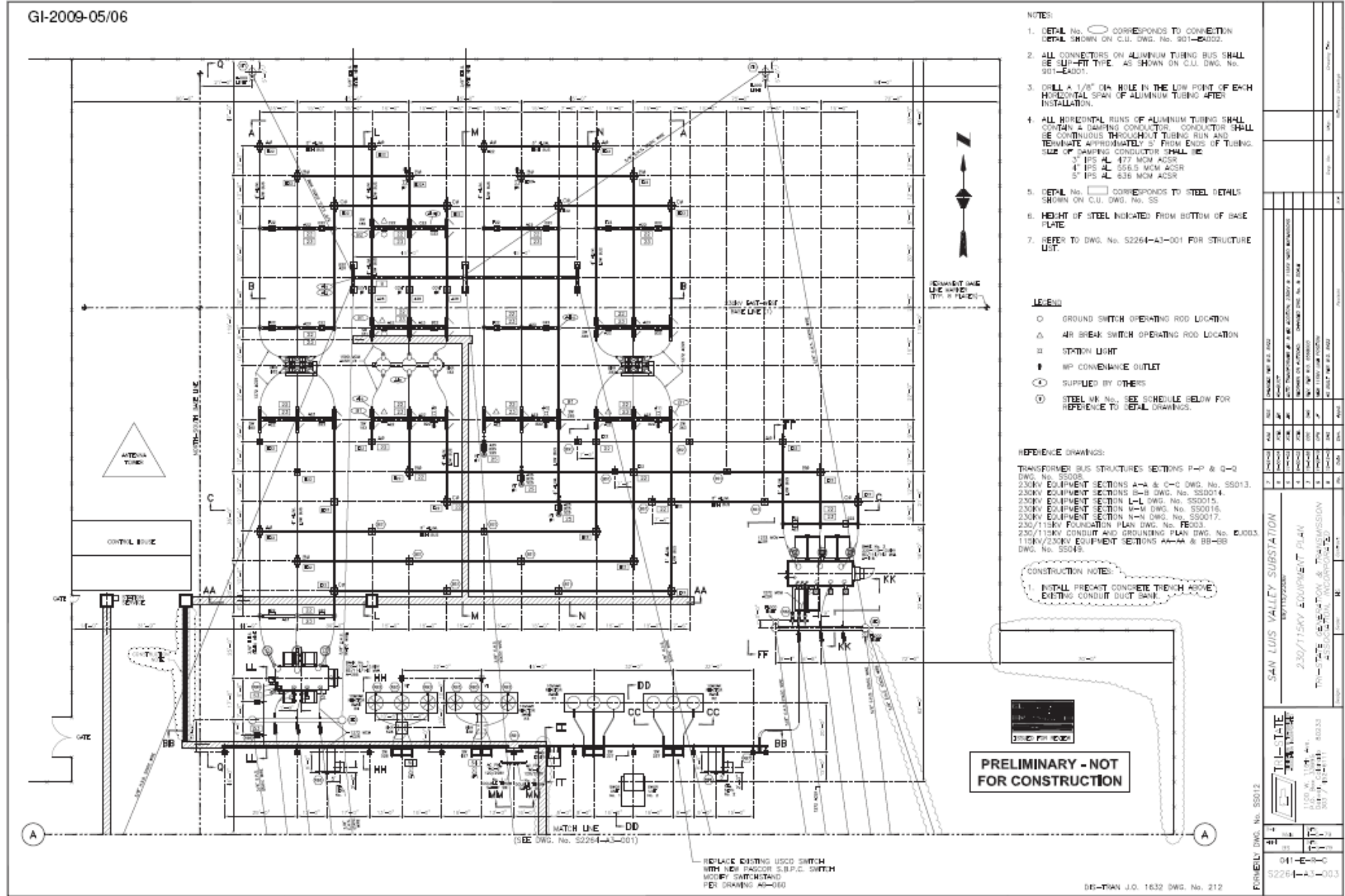
GI-2009-05/06



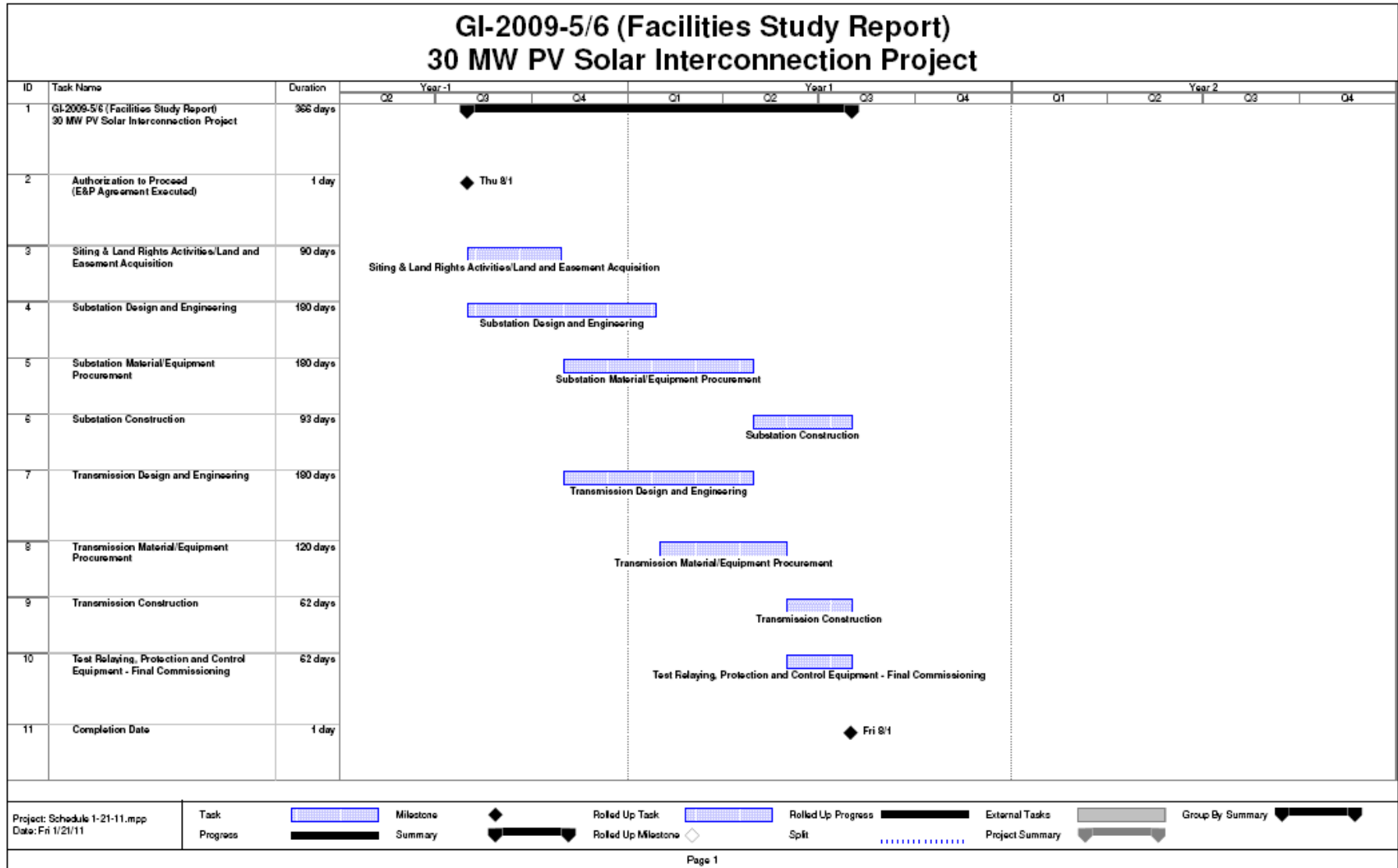
## B. Project General Arrangement Part 1



### C. Project General Arrangement Part 2



### D. Project Schedule PSCo (developed according to requested COD and requested back-feed dates)



## E. Solar Testing Procedures

Performance testing will be scheduled only after the following conditions have been met.

- 1) Interconnection Customer requests testing for a combined chosen capacity rating.
- 2) SCADA in place, including Lookout to Interconnecting Substation interconnection POI data points
- 3) Ring-down telephone from Lookout to Generator Operation Center in place to be used for test communications
- 4) PSCo meter shop crew at substation to witness testing.

Requirement	Specific Req.	Test	Pass	Conditions
Voltage control & Power Factor limits validation at Point of Interconnection (POI)	Maintain voltage setpoint	Set to, e.g., 1.02 p.u. voltage (~117.3 kV)	Voltage held within +/- 1%, subject to p.f. limits and available capacity. New voltage setpoint(s) may be selected. Log directives to Generator Operations Center.	0--full capacity rating, to follow solar availability (not curtailed).
	Lead/Lag 0.95 limits	Set voltage to demonstrate 0.950 p.f. Lead	Meter shop test equipment indicates 0.95 or better	Collect data at 25%, 50%, 75% and >92.5% of available capacity rating.
		Set voltage to demonstrate 0.950 p.f. Lag	Meter shop test equipment indicates 0.95 or better	Collect data at 25%, 50%, 75% and >92.5% of available capacity rating.
	Raise/lower setpoint	Series selected at time of test, e.g., "raise 0.5 kV"	right direction, e.g., raise not lower, as requested, subject to p.f. limits	>50% P(rated)
		Volt raise test #2, as above	right direction, e.g., raise not lower, as requested, subject to p.f. limits	>50% P(rated)
		Volt lower test #1, as above	right direction, e.g., raise not lower, as requested, subject to p.f. limits	>50% P(rated)
		Volt lower test #2, as above	right direction, e.g., raise not lower, as requested, subject to p.f. limits	>50% P(rated)