GENERATION INTERCONECTION

REQUEST # GI-2009-8

FEASIBILITY STUDY REPORT

40 MW PV SOLAR, ALAMOSA COUNTY, COLORADO

PSCO TRANSMISSION ASSET MANAGEMENT

July 2011

Xcel Energy℠

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1.0 EXECUTIVE SUMMARY

Public Service Company of Colorado (PSCo) and the Customer signed a Generation Interconnection Feasibility Study Agreement to evaluate the feasibility of interconnecting 40 MW of solar photovoltaic in San Luis Valley (SLV), Colorado. The primary point of interconnection is at Alamosa Terminal 69 kV substation. The Customer's solar facility consists of photovoltaic solar arrays, interconnecting to a 12.47 kV collector bus with one (1) dedicated 12.47/69 kV step-up transformer, see figure 1. Figure 2 shows the conceptual one-line of the interconnection at the Alamosa Terminal 69 kV yard.

The proposed commercial operation in-service date is March 31, 2013 with an assumed back feed date of September 31, 2012. During the course of the study, PSCo has determined that it is feasible to interconnect to the grid at the proposed point of interconnection with no major network upgrades.

This request was studied both as Energy Resource (ER)[1], and Network Resource (NR)[2]. This investigation included steady-state power flow study and preliminary short circuit analysis. The request was studied as a stand-alone project, with no evaluations made of other potential new generation requests that may exist in the LGIP queue, other than the generation projects that are already approved and planned to be in service by the spring of 2012.

Energy Resource

The ER portion of this study determined that the Customer can provide 40 MW without major network upgrades. The existing San Luis Valley – Alamosa 115 kV line has adequate capacity for an additional 40 MW of injection.

Network Resource

As an NR request, PSCo evaluated the network to determine the upgrades required to deliver the full 40 MW of the solar facility to PSCo native loads.

The cost for the transmission interconnection (in 2011 dollars)

The total estimated cost to interconnect the project is approximately **$2,260,000** and includes:

- $1,050,000 for PSCo-Owned, Customer-Funded interconnection facilities
- $1,210,000 for PSCo-Owned, PSCo-Funded interconnection facilities

[1] **Energy Resource Interconnection Service** shall mean an Interconnection Service that allows the Interconnection Customer to connect its Generating Facility to the Transmission Provider's Transmission System to be eligible to deliver the Generating Facility's electric output using the existing firm or non-firm capacity of the Transmission Provider's Transmission System on an as available basis. Energy Resource Interconnection Service in and of itself does not convey transmission service

[2] **Network Resource Interconnection Service** shall mean an Interconnection Service that allows the Interconnection Customer to integrate its Large Generating Facility with the Transmission Provider's Transmission System (1) in a manner comparable to that in which the Transmission Provider integrates its generating facilities to serve native load customers; or (2) in an RTO or ISO with market based congestion management, in the same manner as all other Network Resources. Network Resource Interconnection Service in and of itself does not convey transmission service.

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See cost and schedule for an approximate in service date in Table 3 and Table 4. There are no major network upgrades needed to the current transmission system to transfer full power to PSCo native loads.

Any Interconnection Agreement (IA) requires that certain conditions be met, as follow:

1. The conditions of the Interconnection Guidelines[1] are met.

2. A single point of contact is given to Operations to manage the Transmission System reliably for all projects as found in the Interconnection Guidelines.

3. Customer must show the ability to operate the solar generation within the required +/- 0.95 power factor range during all operating conditions (0 MW to 40 MW) as measured at the Point of Interconnection (POI). The MVAR output shall be proportional with the output of the plant.

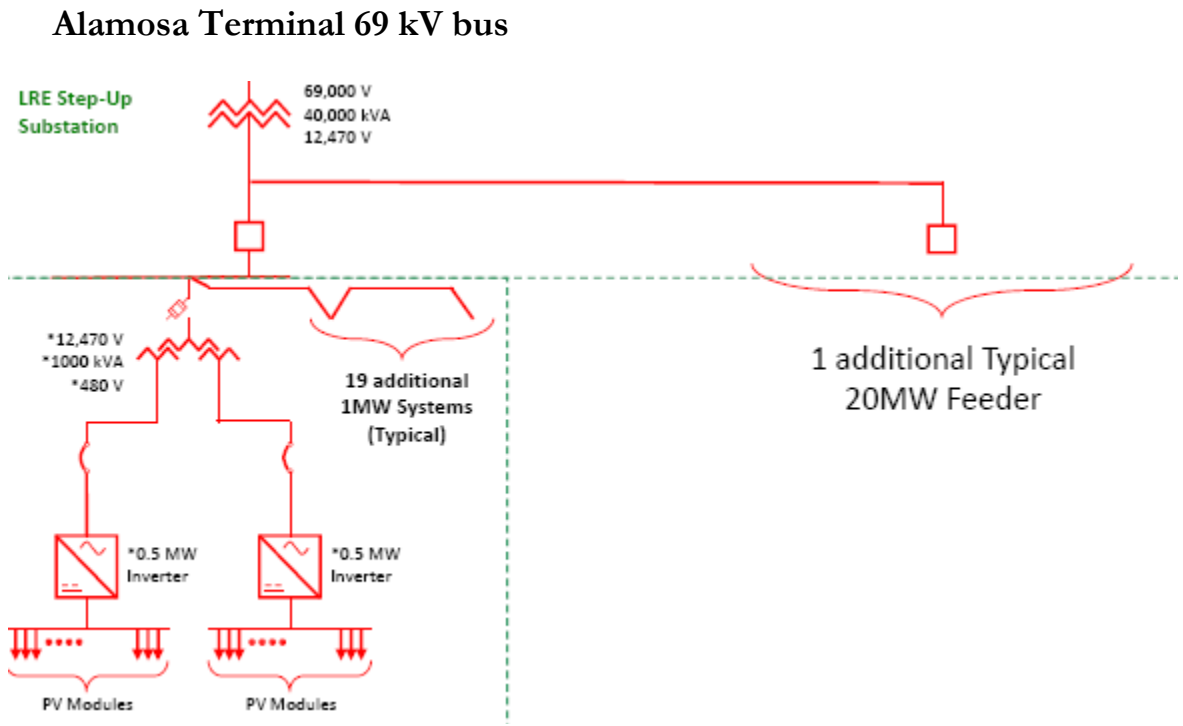

Figure 1: One-line diagram of the Customer's solar generation facility

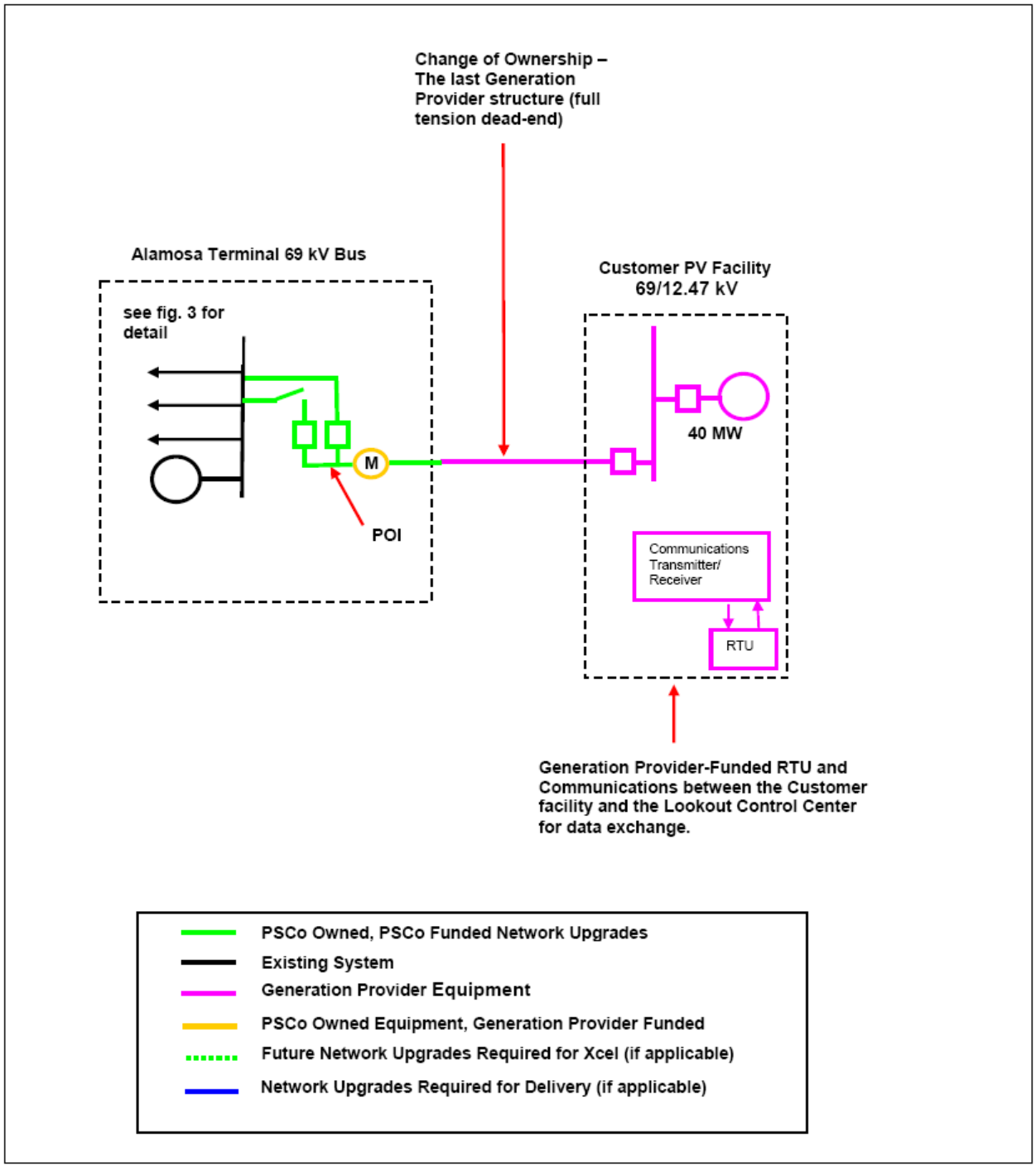

Figure 2: Generation interconnection diagram

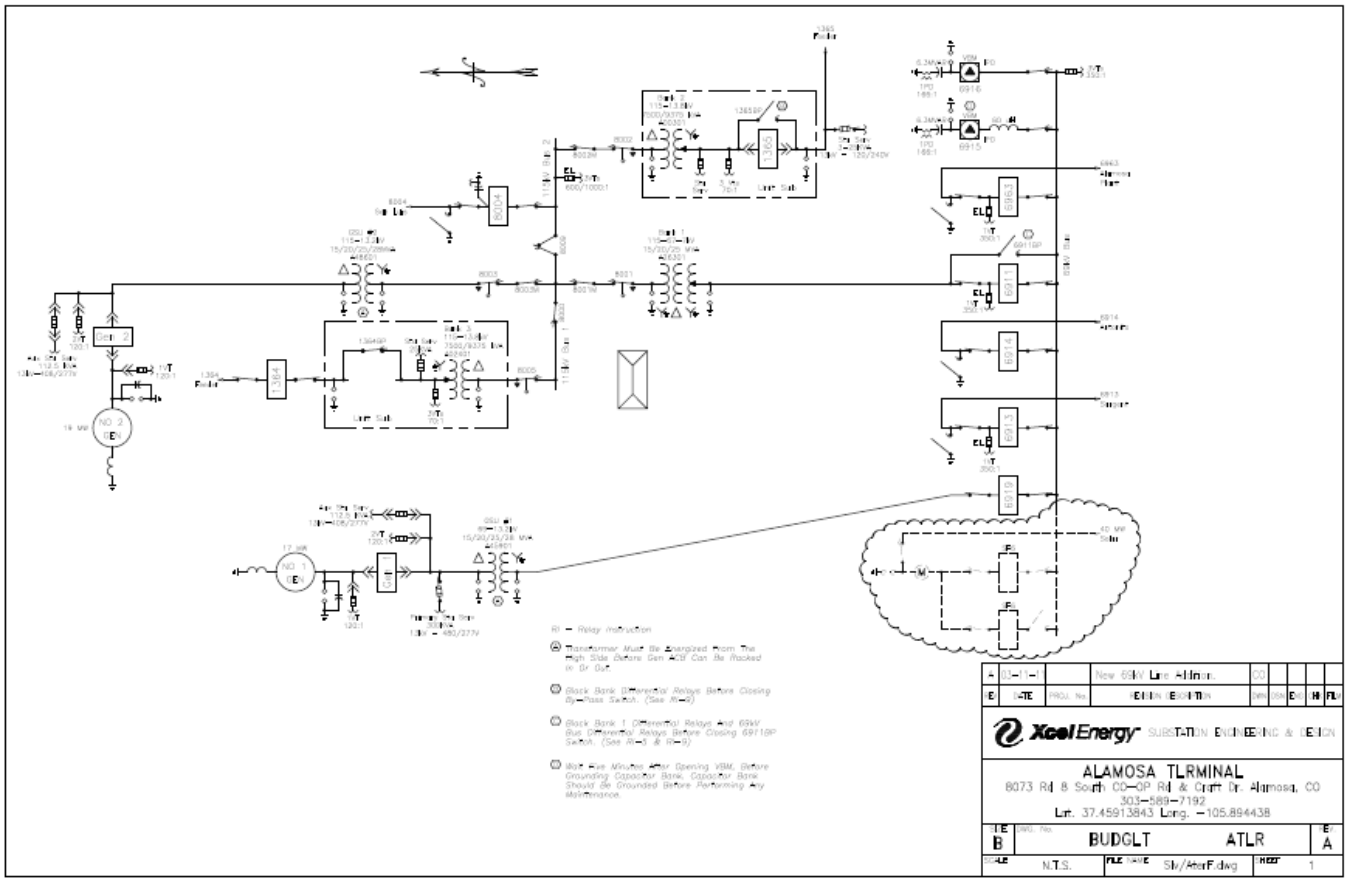

Figure 3. One-line of Alamosa Terminal

2.0 INTRODUCTION

2.1 Performance Criteria

PSCo adheres to NERC / WECC Reliability Criteria, as well as internal Company criteria for planning studies. During system intact conditions, criteria are to maintain transmission system bus voltages between 0.95 and 1.05 per-unit of system nominal / normal conditions, and steady state power flows within 1.0 per-unit of all elements' thermal (continuous current or MVA) ratings. Operationally, PSCo tries to maintain a transmission system voltage profile ranging from 1.02 per-unit or higher at generation buses, to 1.0 per-unit or higher at transmission load buses. Following a single contingency element outage, transmission system steady state bus voltages must remain within 0.90 per-unit to 1.10 per-unit, and power flows within 1.0 per-unit of the elements continuous thermal ratings.

3.0 METHODOLOGY

3.1 Assumptions

The following assumptions are consistent for all study scenarios unless otherwise noted.

- This study will evaluate this request as a "stand alone" project and will not model higher queued projects. Generation in the region of study, which is expected to be in service, will be modeled on line and at or near maximum output.
- This study assumes the power from the generation facility will be delivered to PSCo native load. PSCo will model the appropriate generation dispatch for the study.
- This study does not analyze any transmission service from the interconnection point to any specific point on the grid.
- Estimates are based on the current year U.S. dollars.

3.2 Procedures

3.2.1 Base Case Development and Description of Cases

The power flow studies were based on PSCo 2012 summer base case, which was derived from the 2012 WECC base case. Generation was dispatched for relatively high south-to-north stressing, with further regional stressing created by modeling the Comanche 3 close to full output (804 MW), Comanche 1 and Comanche 2 near full output (725 MW), and the Lamar DC Tie at the contractual output (101 MW importing from East to West). All wind farm generation facilities were modeled at 12.5% output level, consistent with other study procedures.

The Customer's 40 MW solar facility was modeled as one (1) lumped equivalent on the 12.47 kV bus using the conventional generator model assuming unity power factor (without any additional VAR support). The default operating mode for the inverters within the plant is fixed unity power factor. In this operating mode, the reactive power dispatch (Qgen) and associated limits (Qmax and Qmin) were all set equal to zero. The inverters themselves have the capability to operate over a range of power factors from 0.95 lagging to 0.95 leading. The generator was tied to a dedicated 12.47/69 kV, 40 MVA main step-up transformers, 69 kV Customer transmission line connecting the generating facility to the POI. For dispatching to the PSCo native loads, the Customer's generation was scheduled (re-dispatched) to offset other PSCo generation in the northern PSCo system by reducing generation in that area.

Table 1 – Pertinent modeling adjustments:

Base Case	Generation Resources	Net Output (MW)
2012 HS	Alamosa CT's	OFF
	PV Solar at Mosca	8
	PV Solar Greater Sand Hill	16
	PV Solar San Luis Solar LLC	30
	PV Solar Cogentrix of Alamosa LLC	30

3.2.2 List of Contingencies

An N-1 contingency analysis was performed for the San Luis Valley region. Based on engineering judgment, only lines in the San Luis Valley region were selected because they represent a good cross section of potential contingencies that would stress the system.

3.2.3 Thermal and Voltage Analysis

Two study cases using proper generation dispatch to stress the power flows as mentioned above were evaluated under system intact and outage conditions. The first case was used as a benchmark with no additions made to the budget case. The second case includes the proposed 40 MW solar generation facility and associated interconnection facilities. Automated contingency power flow simulations (ACCC) were completed on these cases, switching out single elements one at a time for all of the elements (lines and transformers) in the study area (zone 710) in the San Luis Valley. The studies were then compared to each other, identifying criteria violations in the study area that were direct results of the addition of the 40 MW solar generation facility connected to the SLV substation and delivering power to PSCo native load customers.

3.2.4 Short-Circuit Analysis

Short-circuit analyses were performed with and without GI-2009-8 generation interconnected into the PSCo control area. These consisted of substation

three phase to ground and phase to ground faults. The fault simulations were conducted at the point of interconnection. The object of these analyses was to determine the incremental fault current contribution from the additional generation and determine if the existing breakers in the surrounding area will safely accommodate this additional fault current without exceeding their interruption ratings.

4.0 POWERFLOW ANALYSIS RESULTS

The studies indicated no new violations due to the new generation interconnection. The same rationale could be made about the voltage violation. There was no new voltage limit violation due to the new generation interconnection.

Energy Resource (ER) Study Results

The ER portion of this study determined that the Customer could provide 40 MW without major network upgrades.

Network Resource (NR) Study Results

As an NR request, PSCo evaluated the network to determine the upgrades required to deliver the full 40 MW of the solar facility to PSCo native loads. There are no major network upgrades needed to the current transmission system to transfer the full power output to PSCo native loads.

5.0 SHORT-CIRCUIT ANALYSIS RESULTS

A short circuit study was conducted to determine the fault currents (single-line-to-ground or three-phase) at the Alamosa Terminal 69 kV bus. Table 2 summarizes the approximate fault currents at the Alamosa Terminal 69 kV bus with the addition of the 40 MW solar facility.

Table 2a – Short-circuit study results at Alamosa Terminal 69 kV bus.

System Condition	3Φ (A)	S-L-G (A)	Thevenin (R, X p.u.)
System Intact	I1=3364 @ -75.7 I2=I0=0 IA=IB=IC= 5298 (-75.7, 164.3, 44.3 deg)	I1=I2=1450 @ -77.3 3I0=4350 @ -77.3 IA=4350 @ -77.3 IB=IC=0	Z1=0.06129, 0.24110 Z2=0.06129, 0.24111 Z0=0.00398, 0.08088

Table 2b – Short-circuit study results at the GSU low side 12.47 kV bus.

System Condition	3Φ (A)	S-L-G (A)	Thevenin (R, X p.u.)
System Intact	I1=10,396 @ -82.1 I2=I0=0 IA=IB=IC= 10,396 (-82.1, 157.9, 37.9 deg)	I1=I2=4668 @ -82.9 3I0=14,005 @ -82.9 IA=14,005 @ -82.9 IB=IC=0	Z1=0.06129, 0.44110 Z2=0.06129, 0.44111 Z0=0.00067, 0.10189

PSCo Substation Engineering indicated that the addition of the 40 MW solar facility is not expected to necessitate the replacement of circuit breakers, switches or other substation equipment due to the increased fault current levels at the Alamosa Terminal 69 kV substation.

6.0 COST ESTIMATES

Scoping level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by Xcel Energy/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, 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 **$2,260,000.** 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 3 – PSCo Owned; Customer Funded Interconnection Facilities

Element	Description	Cost Est. (Millions)
PSCo's Alamosa Terminal 69 kV Transmission Substation	Interconnect Customer to the 69kV bus at the Alamosa Terminal Substation. The new equipment includes: • One 69 kV, 1200 amp gang switch • Three 69 kV combination CT/PT metering units • Three 69 kV lightning arresters • Primary metering for Load Frequency/Automated Generation Control • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures • Associated transmission line communications, fiber, relaying and testing.	$0.565
SLV-Alamosa 69 kV Transmission Line	In and out transmission line tap into Alamosa Terminal 69 kV Substation	$0.260
	Siting and Land Rights and Project Management support	$0.010
Customer's 69 kV Substation	Load Frequency/Automated Generation Control (LF/AGC) RTU and associated equipment	$0.215
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	**$1.050**
Time Frame	**Site, design, procure and construct**	**12 Months**

Table 4 – PSCo Owned; PSCo Funded Interconnection Facilities

Element	Description	Cost Estimate (Millions)
PSCo's Alamosa Terminal 69 kV Transmission Substation	Interconnect Customer to the bus at the Alamosa Terminal Substation. The new equipment includes: • Two 69 kV, 3000 amp circuit breakers • Four 69 kV, 1200 amp gang switches • One Electrical Equipment Enclosure (control bldg.) • 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, and fencing	$1.210
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	**$1.210**
Time Frame	**Site, design, procure and construct**	**12 Months**

Cost Estimate Assumptions

- Scoping level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by Xcel Energy/PSCo Engineering.
- Estimates are based on 2011 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 San Luis Valley Rural Electric Co-op 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 12 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 back-feed dates.