Interconnection Feasibility Study Report
Request # GI-2008-32

250 MW Generator
Rio Grande County, Colorado

Public Service Company of Colorado
Transmission Planning
March 31, 2010

Executive Summary

Public Service Company of Colorado (PSCo) received an interconnection request (GI-2008-32) to install a 250 MW solar generation facility in Rio Grande County, Colorado. The generating plant is to consist of two 100 MW concentrated solar thermal generators and a 50 MW photovoltaic facility. The proposed interconnection point is 15-20 miles north of the San Luis Valley Substation connecting to the San Luis Valley-Poncha 230 kV circuit owned jointly by PSCo and Tri-State Generation & Transmission (TSG&T) (see Figures 1 & 2 below). The requested in service date is June 1, 2014 with a projected backfeed date of January 1, 2014.

This request was studied as a Network Resource at the full 250 MW rated output. The project's Energy Resource capability was also considered. These investigations included steady-state power flow and short circuit analyses. The request was studied as a stand-alone project only, with no evaluations made of other potential new generation requests that may exist in the Large Generator Interconnection Request (LGIR) queue, other than the generation projects that are already approved and planned to be in service by June 2014. The main purpose of this Feasibility Study was to evaluate the potential impact on the PSCo transmission infrastructure as well as that of neighboring utilities when injecting the proposed 250 MW of generation at the interconnection point on the San Luis Valley-Poncha 230 kV line, and delivering the additional generation to native PSCo loads. The costs to interconnect the project with the transmission system have been evaluated by PSCo Engineering.

Network Resource

Based on the results of the study, the Network Resource analysis indicates that the customer can provide 250 MW if the following is completed:

- Install the San Luis Valley – Calumet – Comanche transmission project. This project consists of two 230 kV lines from San Luis Valley to a new Calumet Substation, and two 345 kV lines from Calumet to Comanche Substation. The existing Comanche-Walsenburg 230 kV circuit will also be looped into Calumet and a second 230 kV line from Calumet to Walsenburg Substation will be installed (See Figure 3). This project is already planned and budgeted as a joint project between PSCo and TSG&T, with a projected in service date of June 2013. A CPCN request has been filed with the CPUC, but a decision has not yet been rendered. The Docket number is 09A-324E.

Energy Resource

Based on the results of the study, the Energy Resource analysis indicates that during light load conditions the proposed generating plant can be accommodated without network upgrades at a generation level of 165 MW. This assumes a San Luis Valley load level of 62.6 MW and a pre-existing solar generation level of 25 MW. During heavy load conditions, the proposed generating plant can be accommodated without network upgrades at a generation level of 222 MW. This assumes a San Luis Valley load level of 117.0 MW and a pre-existing solar generation level of 25 MW.

The cost for the transmission interconnection (in 2010 dollars):

Transmission Proposal
The total estimated cost of the recommended system improvements to interconnect the project is approximately **$184,523,000** and includes:

- $ 0.295 million for PSCo-Owned, Customer-Funded Attachment Facilities
- $ 4.228 million for PSCo-Owned, PSCo-Funded Attachment Facilities
- $ 180.000 million for PSCo Network Upgrades for Delivery to PSCo Loads

The Attachment Facilities can be completed in 18 months following receipt of authorization to proceed. The Network Upgrades for Delivery (San Luis Valley-Calumet-Comanche 230/345 kV transmission project) are planned for completion in 2013. This project must be completed prior to the generation in service date.

Figure 1 Proposed Interconnection Facilities on the San Luis Valley-Poncha 230 kV Circuit

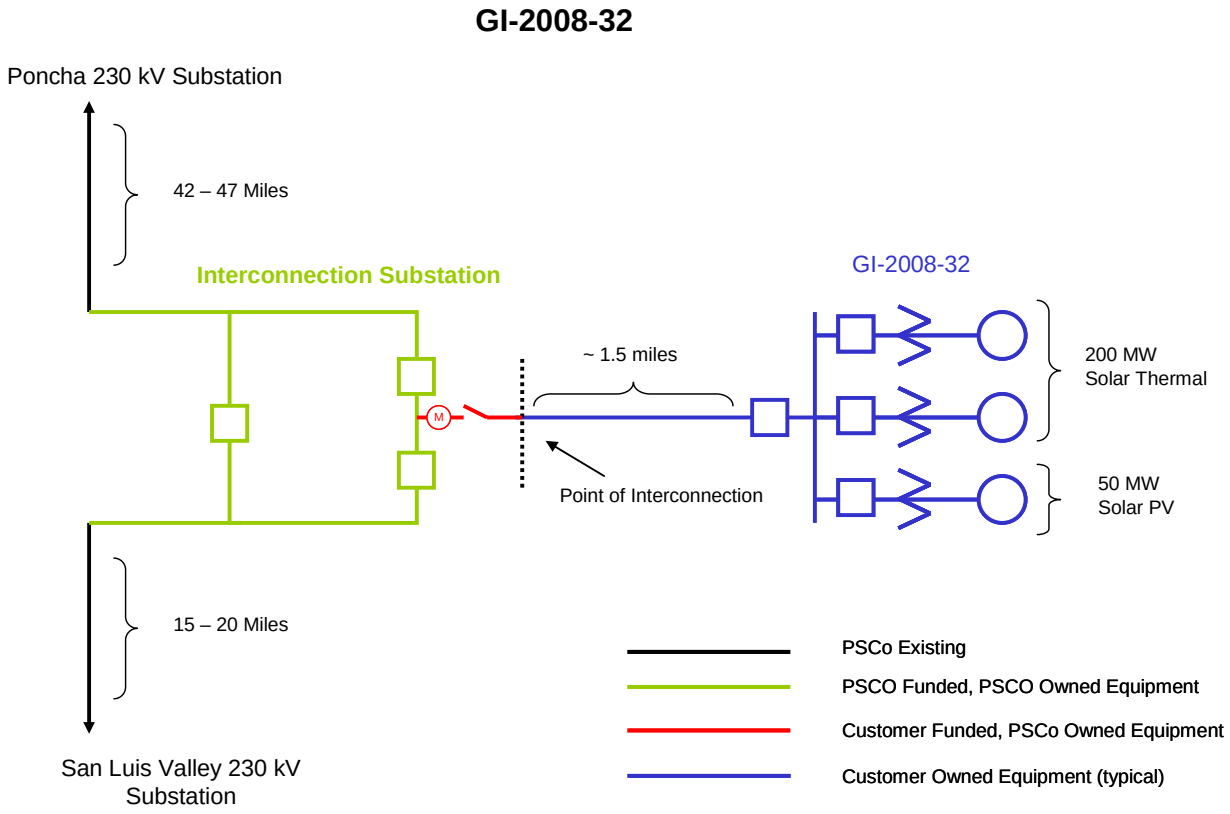


Figure 2 Proposed Point of Interconnection on the San Luis Valley-Poncha 230 kV Circuit

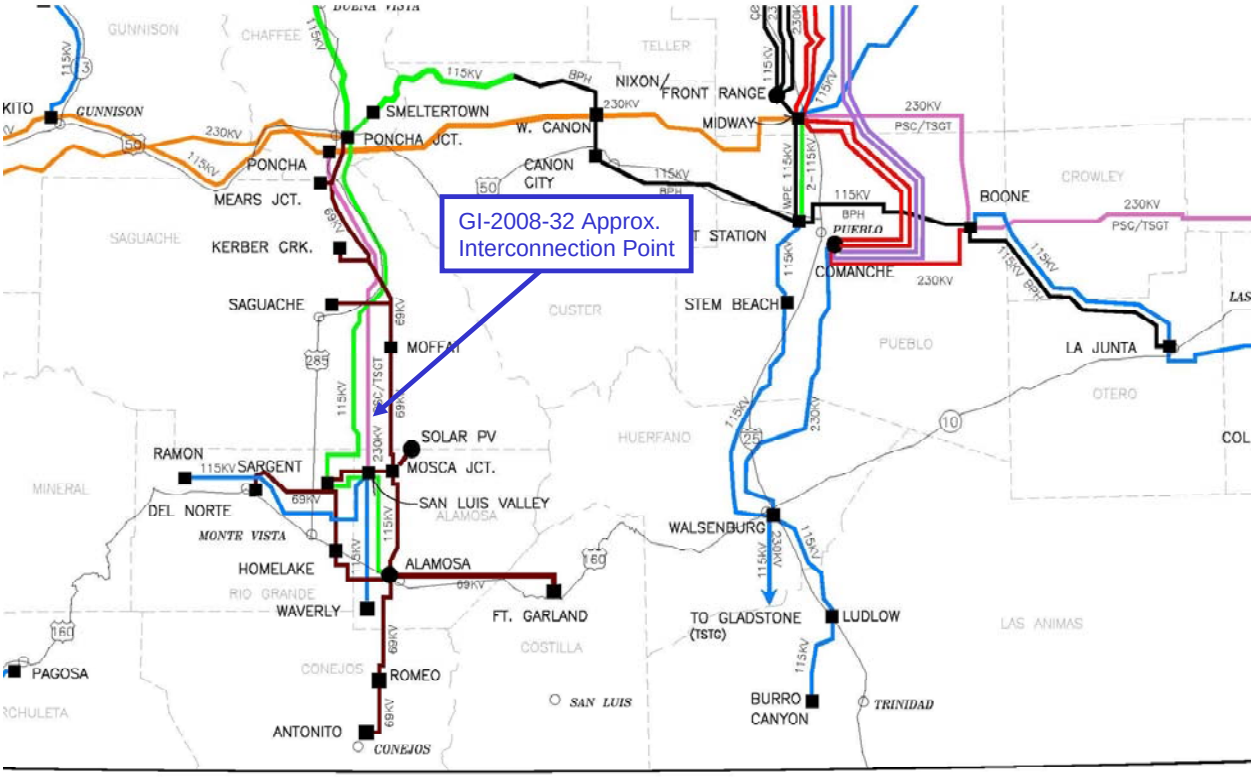
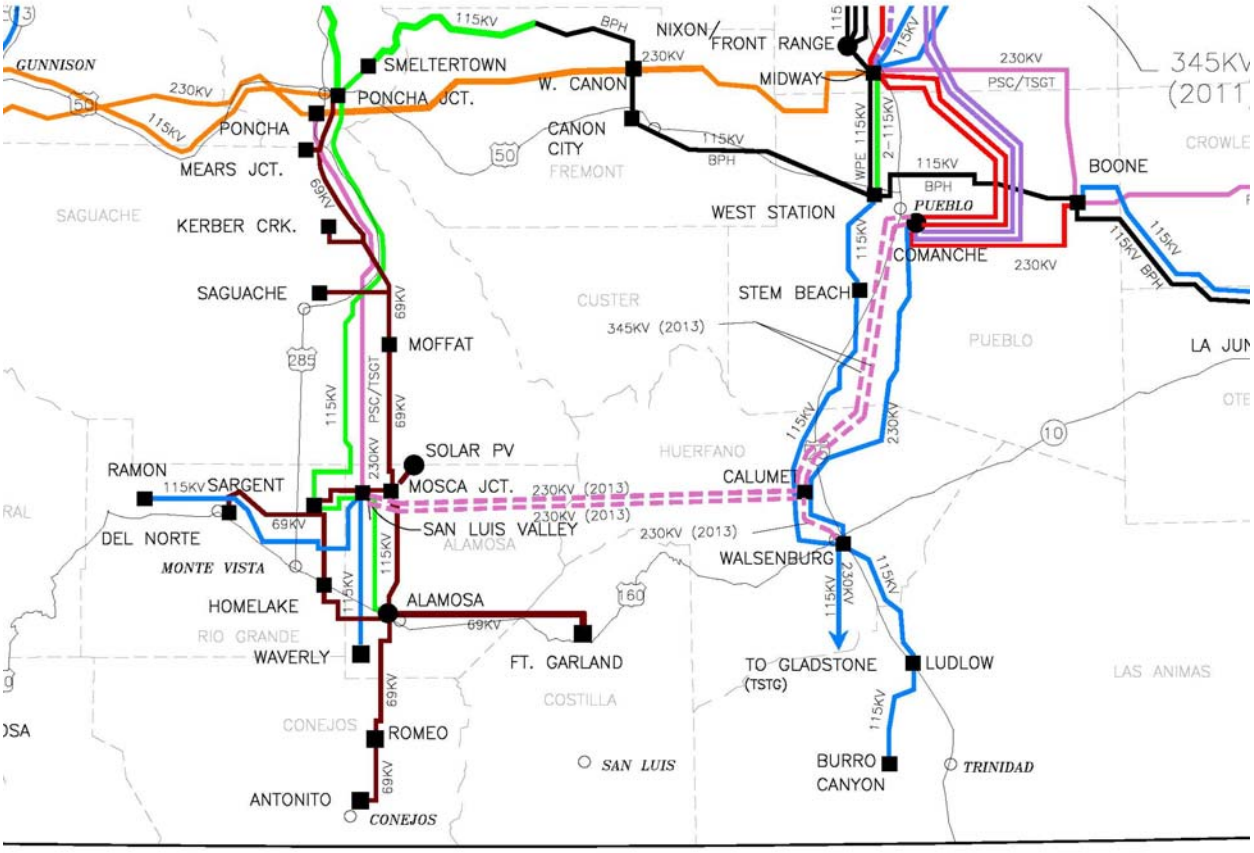


Figure 3 San Luis Valley-Calumet-Comanche 230/345 kV Project



Introduction

PSCo received an interconnection request (GI-2008-32) to install a 250 MW solar generation facility in Rio Grande County, Colorado. The generating plant is to consist of two 100 MW concentrated solar thermal generators and a 50 MW photovoltaic facility. The proposed interconnection point is 15-20 miles north of the San Luis Valley Substation connecting to the San Luis Valley-Poncha 230 kV circuit owned jointly by PSCo and TSG&T. The requested in service date is June 1, 2014 with a projected backfeed date of January 1, 2014.

This study determined the system reinforcements and associated costs required to facilitate the addition of the new generator to the transmission system as a Network Resource. The project's Energy Resource Capability was also evaluated. The reinforcements include the direct connection of the generator to the system and any network upgrades required to maintain the reliability of the transmission system.

Study Scope and Analysis

The Feasibility Study evaluated the transmission impacts associated with the proposed generating station. It consisted of power flow and short circuit analyses. The power flow analysis identified any thermal or voltage limit violations resulting from the interconnection and an identification of network upgrades required to deliver the proposed generation to PSCo loads. The short circuit analysis identified any circuit breakers that might exceed their fault interruption capability due to addition of the new generation.

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 nominal, and steady-state power flows below the thermal ratings of all facilities. Operationally, PSCo tries to maintain a transmission system voltage profile ranging from 1.02 per unit or higher at regulating (generation) buses to 1.0 per unit or higher at transmission load buses. Following a single contingency, transmission system steady state bus voltages must remain within 0.90 per unit to 1.10 per unit, and power flows within 100% of the facilities' continuous thermal ratings. Also, voltage deviations should not exceed 5%.

This project was studied as a Network Resource. 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.

The project's Energy Resource Capability was also evaluated. 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

For this project, potential affected parties include Tri-State Generation & Transmission (TSG&T), Black Hills Energy (BHE), and Western Area Power Administration (WAPA).

Power Flow Study Models

The power flow studies were based on two different base cases: the WECC approved 13LW1SAP case and the PSCo 2015 HS budget case. The WECC light winter case was included in the study because of known system problems associated with light loads and new generation. The load levels of the case were adjusted to reflect 2014 light winter system conditions. These conditions were developed by adjusting PSCo loads to 60% of the 2014 winter peak load forecast that was distributed in September 2009. San Luis Valley area load in this case (Zone 710) was 62.6 MW. This is 47% of the maximum load level (133 MW) between January 1, 2008 and August 23, 2009, which occurred on July 14, 2008. The topology was also updated to reflect current project plans. Updates were included for the PSCo, TSG&T, WAPA, and Black Hills Energy systems. The PSCo updates included the planned new transformer connecting the Poncha 230 kV and Poncha Junction 115 kV substations. This transformer is expected to be in service in 2013. The BHE updates included planned new generation (400 MW) at the Airport bus dispatched to match BHE load. 25 MW of existing and planned solar generation was also included in the San Luis Valley at Mosca Junction substation. In addition, the combustion turbines at Alamosa Terminal substation (36 MW) were taken out of service, since this generation is not normally started except following transmission outage conditions.

The PSCo 2015 HS budget case was created from the WECC 15HS2P case. To create a 2014 HS case, the load levels were adjusted to reflect 2014 summer peak conditions. PSCo loads reflected the forecast distributed in September 2009. San Luis Valley area load in this case (Zone 710) was 117.0 MW. This is less than the actual peak load of the San Luis Valley system (approximately 130 MW) but represents an expected peak level that is coincident with the rest of the transmission system. The PSCo topology was updated to reflect current project plans. Load and topology updates were also included in the case from TSG&T, WAPA, Black Hills Energy, IREA, and CSU. The Poncha transformer was included, as was the BHE Airport generators which were dispatched at the maximum 400 MW. The Mosca Junction solar generation was also included and the Alamosa generators were modeled out of service.

Of particular concern in the San Luis Valley area is loading on the San Luis Valley-Sargent-Poncha 115 kV circuit. The present rating of both branches of this circuit is 102 MVA. However, the limiting elements of these branches are various terminal equipment facilities at Sargent Substation. However, this equipment is planned for upgrade prior to the in-service date of the proposed project. Therefore, we used the line conductor rating in our analyses. The line conductor rating of the San Luis Valley-Sargent 115 kV line section is 159 MVA and the corresponding rating of the Sargent-Poncha 115 kV line section is 128 MVA.

The Project's steam turbine generators were modeled as two 112 MW gross machines, each connected to a 13.8 kV generator bus. 12 MW auxiliary loads were also connected to each generator bus. 13.8/230.0 kV, 167 MVA generator step-up transformers connect the generator buses to the San Luis Valley-Poncha 230 kV line through a 1.5 mile customer owned 230 kV circuit. The reactive capability of the two generators was based on information provided by the project customer and the generators were set to regulate such that their reactive output was close to zero. The 50 MW solar photovoltaic generation was modeled as a 50 MW generator with no reactive capability connected to a 34.5 kV bus. This bus was connected to the 1.5 mile 230 kV line through a 34.5/230 kV, 50 MVA transformer.

For the light winter and heavy summer cases, two main power flow generation dispatch scenarios were evaluated. One was created as a reference scenario and the other was created with the new generation. The TOT 5 transmission path limits transmission flows from western Colorado to the east to the 1675 MW path rating. In the heavy summer case, to assess the potential impacts of the proposed generation on the TOT 5 transmission path, the power flow models were modified to simulate higher flows from western Colorado to the east. To accomplish this, generation in western Colorado was dispatched to maximum output to increase flows over the TOT 5 transmission path. Generation in Arizona was also used to increase the transmission path flows. Generation in eastern Wyoming and northeastern Colorado as well as the Lamar DC Tie was used as a sink for the dispatch changes. In the heavy summer benchmark case, the TOT 5 flow level was increased to 1000 MW versus 354 MW in the 2015 HS budget case. In the corresponding generator case, the same power transfer dispatch resulted in a TOT 5 flow level of 988 MW.

PSCo control area (Area 70) wind generation facilities were dispatched to 100% of facility ratings in the light winter case and 12.5% in the heavy summer case.

Power Flow Study Process

Contingency power flow studies were completed on the reference model and the model with the proposed generation using PTI's PSSE Ver. 30.3.2 program. Results from the two cases were compared and new overloads or overloads that increased by greater

than 5% in the new generator case were noted. Voltage criteria violations were also recorded. The worst single outage for generation connecting to the San Luis Valley-Poncha 230 kV circuit is the loss of the 230 kV circuit north to the Poncha Substation during light load conditions. Therefore, this was the primary outage that was examined in the light winter case. PSSE's ACCC activity was used in the heavy summer case to evaluate the impact other contingencies due to the generation.

Power Flow Results

Light Winter Case:

Loss of the portion of the San Luis Valley-Poncha 230 kV circuit north of the proposed new generation is the worst single contingency during light load conditions because all of the generation less San Luis Valley load is transferred to the San Luis Valley - Sargent-Poncha Junction 115 kV circuit. The San Luis Valley -Sargent 115 kV and Sargent-Poncha Junction 115 kV circuits are each rated at 159 MVA and 128 MVA, respectively. In addition to thermal considerations, low voltage can also be a problem. The thermal and voltage problems depend on the levels of generation and load in the SLV. As mentioned earlier, the planned solar photovoltaic generation at Mosca Junction was modeled at its maximum output of 25 MW. However, the combustion turbine generation at Alamosa Terminal was modeled out of service. Also, San Luis Valley load was 62.6 MW.

In the benchmark case, loss of the San Luis Valley-Poncha 230 kV line resulted in satisfactory flows and voltages in the San Luis Valley system. With GI-2008-32 generation at 250 MW, loss of the GI-2008-32-Poncha 230 kV line section resulted in substantial overloads on the San Luis Valley -Sargent 115 kV and Sargent-Poncha Junction 115 kV circuits. These lines were each overloaded at 139.8% and 189.5% of their respective ratings.

In addition to the thermal problems, voltages at a number of 115 kV and 69 kV buses in the SLV system were in the upper 80% to low 90% range range. Subsequent analysis indicated that the reactive power margin was 5 Mvar, indicating that the case was close to a voltage collapse. TSG&T has installed an automatic under-voltage load shedding (AVLS) scheme that trips load in steps when voltages go below 93.0% of nominal. A case was created that simulated the AVLS action. The case with the loss of the San Luis Valley-Poncha 230 kV line did not converge. Subsequent analysis indicated that there was a reactive power deficit of 109 Mvar at the Poncha 115 kV bus. These results indicate that with the proposed generation, the AVLS scheme could actually result in a voltage collapse since more power is being transferred to the San Luis Valley-Sargent-Poncha Junction 115 kV circuit.

These thermal and voltage problems violate the established interconnection standards and require mitigation.

Heavy Summer Case:

Using this case, contingency analysis was performed to assess system performance under heavy summer conditions. Similar to the light winter case, the contingency loss of the GI-2008-32-Poncha 230 kV circuit caused an overload on the system. Specifically, with the proposed generation, loss of this circuit caused the Sargent-Poncha Junction 115 kV circuit to be overloaded by 123.3% of its 128 MVA rating. In the benchmark case, this contingency outage did not converge. This indicates a likely voltage collapse that would be addressed using Tri-State's under-voltage load shedding scheme.

In addition to the thermal problems, loss of the GI-2008-32-Poncha 230 kV circuit also caused voltage problems. Voltages dropped more than 5% at seven buses: Poncha 69 kV, Poncha 115 kV, Smelter 115 kV, Mears Junction 69 kV, Villa 69 kV, Kerber Creek 69 kV, and Oxcart 69 kV. This needs to be mitigated.

Energy Resource:

The Energy Resource capability of the proposed project was determined for both light load and heavy load conditions.. Using the light winter case, the proposed generation was reduced until the loading on the Sargent-Poncha Junction 115 kV circuit was at 100% of its 128 MVA rating. The generation level that resulted in this line loading was 165.9 MW. This assumed a San Luis Valley load level of 62.6 MW and a pre-existing solar generation level of 25 MW.

Using the heavy summer case, the proposed generation was also reduced until the loading on the Sargent-Poncha Junction 115 kV circuit was at 100% of its 128 MVA rating. The generation level that resulted in this line loading was 222.3 MW. This assumed a San Luis Valley load level of 117.0 MW and a pre-existing solar generation level of 25 MW.

Proposed Transmission Upgrades

To facilitate installation of new generation in the San Luis Valley, PSCo and TSG&T have jointly proposed the San Luis Valley – Calumet – Comanche transmission project. This project is included in the set of projects proposed by PSCo as required by the legislation SB 07-100 to facilitate new renewable generation installations. It consists of two 230 kV lines from San Luis Valley to a new Calumet Substation, and two 345 kV lines from Calumet to Comanche Substation. The existing Comanche-Walsenburg 230 kV circuit will also be looped into Calumet and a second 230 kV line from Calumet to Walsenburg Substation will be installed. The planned in service date for this project is June 2013. This project is currently included in PSCo's budget, but it does not yet have

a CPCN. PSCo and TSG&T have jointly filed for a CPCN with the CPUC, but a decision has not yet been rendered. The Docket number is 09A-324E.

Light winter and heavy summer cases were created with the proposed Calumet project in service. Loss of the GI-2008-32-Poncha 230 kV line section in the light winter case resulted in satisfactory flows and voltages. The same outage in the heavy summer case also resulted in satisfactory flows.

Network Resource (NR)

This study has determined that the requested generation increase injected at the interconnection point 10-15 miles north of the San Luis Valley Substation on the San Luis Valley-Poncha 230 kV circuit causes overloads and low voltages on the PSCo and TSG&T system in the San Luis Valley. Therefore, the 250 MWnet Network Resource value requested will require Transmission Network Upgrades.

NR = 250 MW (with required Network Upgrades)

Energy Resource (ER)

This study has determined that for light load conditions the proposed generating plant can be accommodated without network upgrades with a total net output of 165 MW. This assumes a San Luis Valley load level of 62.6 MW and a pre-existing solar generation level of 25 MW.

ER = 165 MW (without required Network Upgrades, Light Load)

This study has also determined that for heavy load conditions the proposed generating plant can be accommodated without network upgrades with a total net output of 222 MW. This assumes a San Luis Valley load level of 117.0 MW and a pre-existing solar generation level of 25 MW.

ER = 222 MW (without required Network Upgrades, Heavy Load)

Short Circuit Study Results

Short circuit calculations were performed to evaluate the impact of the proposed generation. The results indicate that the #6694 69 kV circuit breaker at the Sargent Substation is expected to exceed its interrupting capability following installation of the new generation (see Appendix B.). An estimate for its replacement can be found below. Table 1 contains the short circuit parameters that were calculated with the proposed generation in service.

Table 1 Short Circuit Parameters at the Point of Interconnection

System Condition	Three-Phase Fault Level (Amps)	Single-Line-to-Ground Fault Level (Amps)	Thevenin System Equivalent Impedance (R +j X) (ohms)
All Facilities in Service	7348	2599	Z1(pos)= 1.416 +18.017 Z2(neg)= 1.435 +j 18.193 Z0(zero)= 1.294 +14.712

Costs Estimates and Assumptions

GI-2008-32

The estimated total cost for the required interconnection facilities is **$4,523,000**. The San Luis Valley-Calumet-Comanche 230/345 kV Project is estimated to cost **$180,000,000**. Therefore, the total estimated cost is **$184,523,000**.

Table 2 PSCo Owned; Customer Funded Interconnection Facilities

Element	Description	Cost Est. (Millions)
New Substation on San Luis Valley – Poncha Jct Line	Interconnect customer to the 230 kV bus at the New Substation • 230 kV bidirectional metering • Three 230 kV combination CT/PT instrument transformers • Associated foundations and structures • Associated line relaying and testing • LF/AGC RTU	**$0.272**
	Customer Load Frequency and Generator Witness Testing. (Customer generation telemetry equipment, and witnessing the Customer generator commissioning testing).	**$0.013**
	Customer Generator Communication to Lookout.	**$0.010**
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	**$0.295**

Table 3 PSCo Owned; PSCo Funded Interconnection Facilities

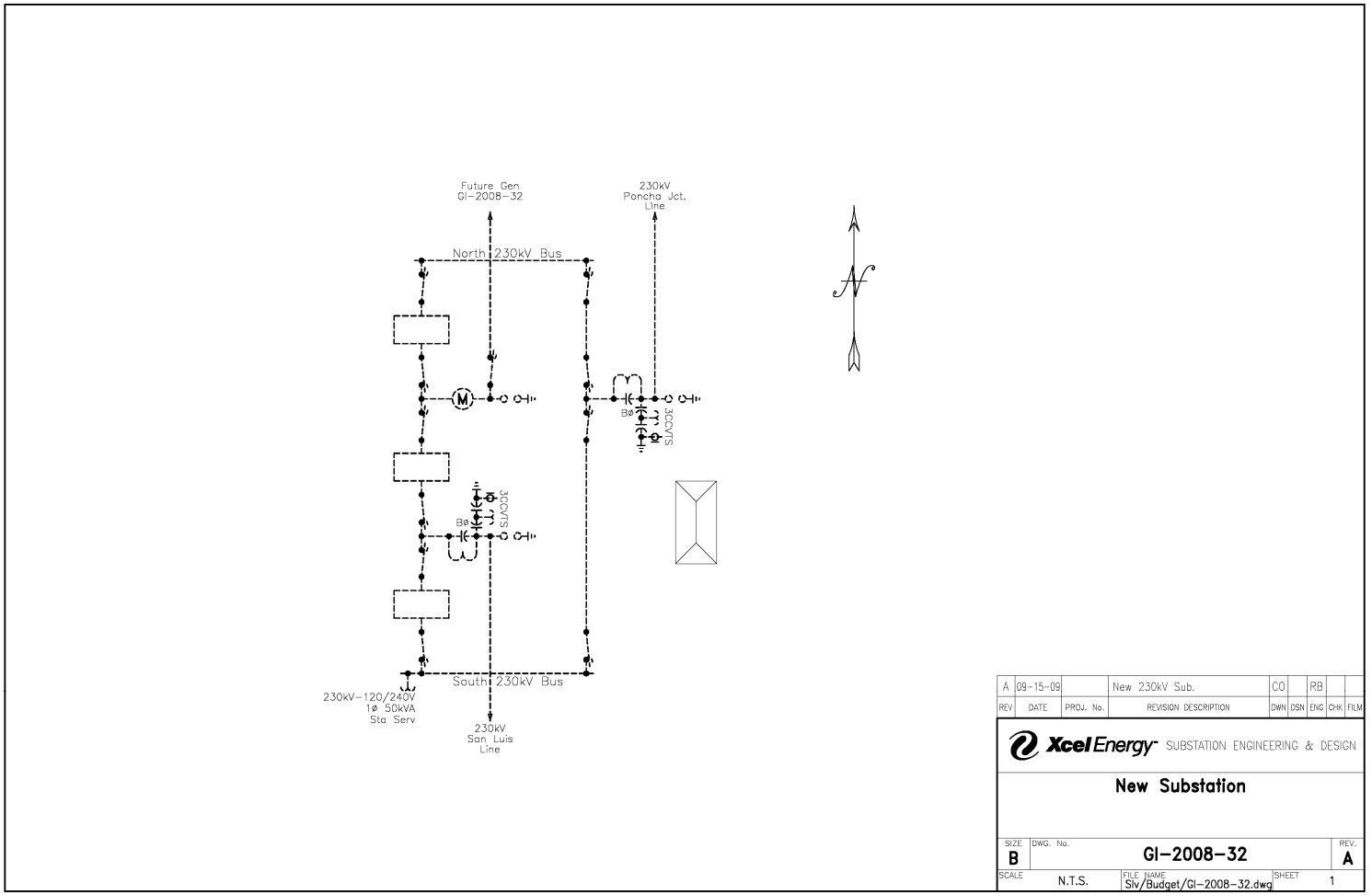
Element	Description	Cost Estimate (Millions)
New Substation on San Luis Valley – Poncha Jct Line	Interconnect Customer's to line at New Substation 230 kV. The new equipment includes: • Three 230 kV, 40 kA, Circuit Breakers • Twelve 230 kV, 3000 A, Gang Operated Switches • Transmission Line Relaying • Associated Structures and Foundations	**$3.890**
Sargent Substation	Replace breaker 6944 due to exceeding it's fault interrupting rating.	**$0.168**
	Land Acquisition	**$0.170**
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	**$4.228**

Assumptions for Alternatives

- The cost estimates provided are "scoping estimates" with an accuracy of +/- 30%.
- Estimates are based on 2010 dollars (no escalation applied).
- There is no contingency or AFUDC included in the estimates.
- Labor is estimated for straight time only – no overtime included.
- Lead times for materials were considered for the schedule.
- PSCo (or it's Contractor) crews will perform all construction and wiring associated with PSCo owned and maintained facilities.
- The estimated time for PSCo to site, engineer, procure and construct the scope of work identified in Tables 2 & 3 is **18 months** after authorization to proceed has been obtained. This is completely independent of other queued projects and their respective in-service dates.

Appendix

A. Proposed Interconnection Station One-line



B. Sargent Substation One-line