DRAFT

GENERATION INTERCONECTION
REQUEST # GI-2010-10

FEASIBILITY STUDY REPORT
130 MW PV SOLAR, ALAMOSA COUNTY, COLORADO

Performed by: TranServ International, Inc.
Reviewed by: PSCO Transmission Asset Management

PSCO TRANSMISSION ASSET MANAGEMENT

May 2012

Table of Contents

Legal Notice

Neither TranServ International, Inc. (TranServ), Public Service Company of Colorado (PSCo) nor Xcel Energy nor any person acting on or in the behalf, makes any warranty, expressed or implied, with respect to the use of any information or methods disclosed in this document, or assumes any liability with respect to the use of any information or methods disclosed in this Report. Recipients of this Report release TranServ, PSCo, and Xcel Energy from any liability for direct, indirect, consequential, or special loss or damage whether arising in contract, warranty, express or implied, tort or otherwise, and regardless of fault, negligence and/or strict liability.

Executive Summary

Public Service Company of Colorado (PSCo) and the Customer signed a Generation Interconnection Feasibility Study Agreement to evaluate the feasibility of interconnecting 130 MW of solar photovoltaic in San Luis Valley (SLV), Colorado. The primary point of interconnection is at San Luis Valley 230 kV substation. The Customer's solar facility consists of photovoltaic solar arrays, interconnecting to a 34.5 kV collector bus with one (1) dedicated 34.5/230 kV step-up transformer, see figure 1. Figure 2 shows the conceptual one-line of the interconnection at the San Luis Valley 230 kV yard. The proposed commercial operation in-service date is October 31st, 2014 with an assumed back feed date of March 31st, 2013. According to the 18-month schedule from the Authorization to Proceed date, the Customer will not be able to make the back-feed date.

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 Fall of 2014. This feasibility study investigated three loading conditions in the San Luis Valley: 1) 2015 Heavy Summer = 140 MW, 2) 2015 Heavy Spring – 60% of 140 MW, and 3) 2015 Winter = 60 MW of loads.

Network Resource (NR) – 101 MW (without PSCo upgrades)

The addition of the proposed generation will cause one PSCo 115 kV line, relatively close to the requested POI, to load beyond acceptable levels. The loading on the Sargent – Poncha 115 kV line increased from 58 MVA pre GI-2010-10 to 148 MVA post GI-2010-10 for loss of the San Luis Valley – Poncha 230 kV line. Since this line is rated at 128 MVA, the loading as a percent of the line rating increased from 45 % to 116%, an increase of 71 percentage points. GI-2010-10 generation

---

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.

levels in excess of 101 MW will cause the Sargent – Poncha 115 kV line to load beyond acceptable levels for loss of the San Luis Valley – Poncha 230 kV line. This constraint can be mitigated by increasing the capacity of the Sargent – Poncha 115 kV line to 148 MVA.

The loading on the Sargent – Poncha 115 kV line is considered a constraint by PSCo. Therefore, the Customer will need to mitigate this constraint before the requested interconnection service can be granted. The Network Resource Capability of the proposed generation without amelioration of this constraint is limited by the loading on the Sargent – Poncha 115 kV line and is as follows:

Also, the proposed generation has caused no new voltage violations. However it should be noted that dynamic reactive power capability is required of the GI-2010-10 generation as detailed throughout this report.

Energy Resource (ER) = 101 MW (without PSCo upgrades)

As indicated above, the addition of the GI-2010-10 generation, as proposed, will cause PSCo's Sargent – Poncha 115 kV line to load beyond acceptable levels. Beyond this overload, no other unacceptable impacts due to the GI-2010-10 generation were found. The Energy Resource Capability of the proposed generation without amelioration of this constraint is limited by the loading on the Sargent – Poncha 115 kV line and is as follows:

Again it should be noted that dynamic reactive power capability is required of the GI-2010-10 generation as detailed throughout this report.

Cost Estimate

The cost for the transmission interconnection (in 2012 dollars)

The total estimated cost to interconnect the project is approximately **<u>$3,075,000</u>** and includes:

- $1,195,000 for PSCo-Owned, Customer-Funded interconnection facilities
- $1,880,000 for PSCo-Owned, PSCo-Funded interconnection facilities

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.

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 130 MW) as measured at the Point of Interconnection (POI). The MVAR output shall be proportional with the output of the plant.

Figure 1: San Luis Valley region

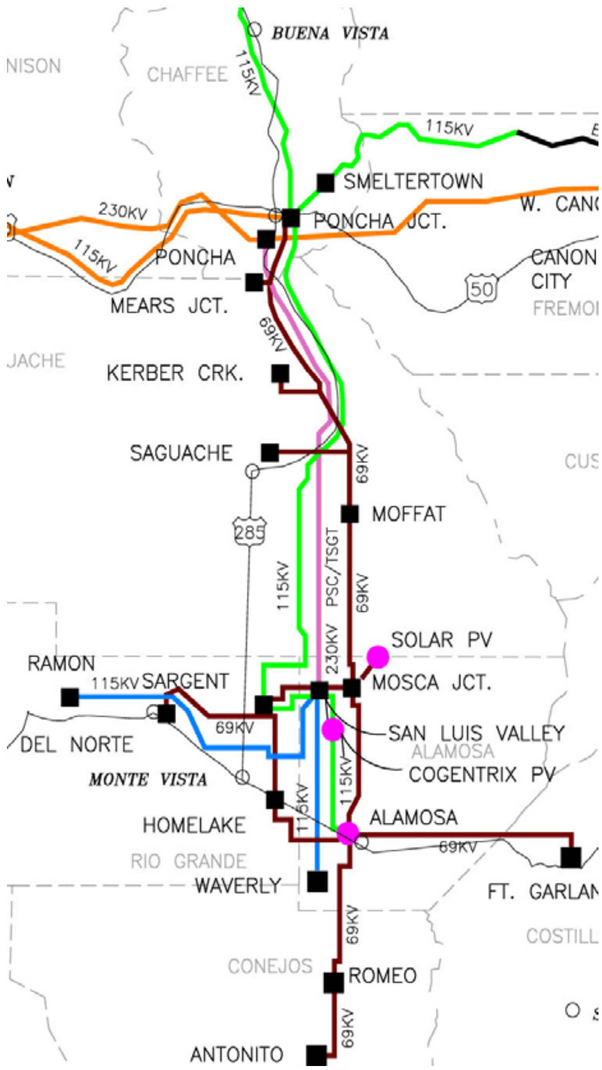
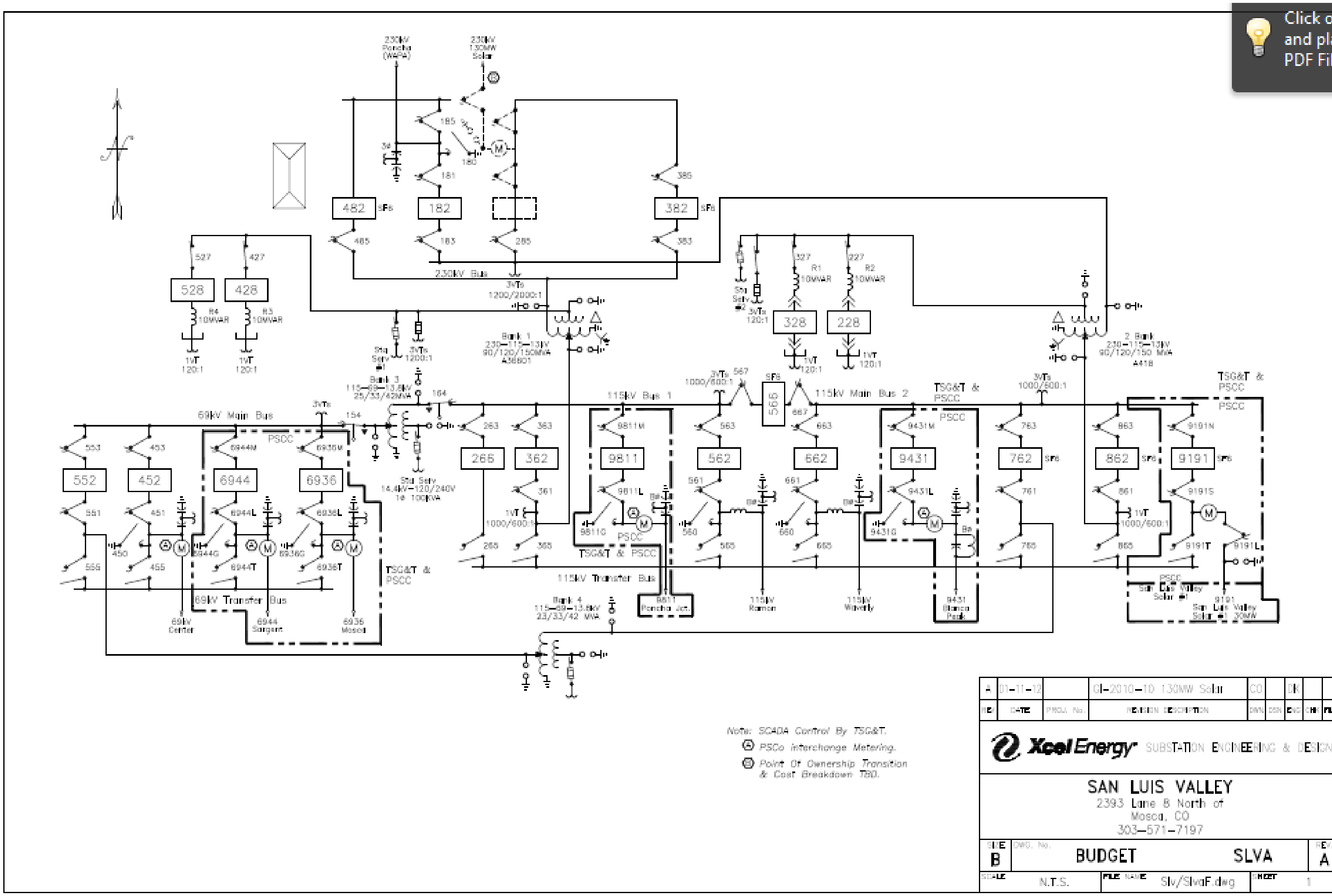


Figure 2: Proposed San Luis Valley substation One-line with Project Interconnection



Introduction

Public Service Company of Colorado (PSCo) and the Customer signed a Generation Interconnection Feasibility Study Agreement to evaluate the feasibility of interconnecting 130 MW of solar photovoltaic in San Luis Valley (SLV), Colorado. The primary point of interconnection is at San Luis Valley 230 kV substation. The Customer's solar facility consists of photovoltaic solar arrays, interconnecting to a 34.5 kV collector bus with one (1) dedicated 34.5/230 kV step-up transformer, see figure 1. Figure 2 shows the conceptual one-line of the interconnection at the San Luis Valley 230 kV yard. The proposed commercial operation in-service date is October 31st, 2014 with an assumed back feed date of March 31st, 2013.

Study Scope and Analysis

This is a joint Feasibility Study Report (FeS) by PSCo and TranServ. The FeS evaluated the transmission impacts associated with the proposed generation increase. It consisted of steady-state power flow and short circuit analyses. The steady-state power flow analysis identified any thermal or voltage limit violations resulting from the generation addition and determined the network upgrades required to mitigate the violations. The short circuit analysis evaluated the impact on the transmission system of the increase in available fault current due to the generation addition and determined the breaker upgrades required to accommodate the increase in available fault current. The steady-state analysis was performed by TranServ under PSCo direction. The study report was written by TranServ under PSCo direction. PSCo made the determination of injection constraints that are required to be mitigated by the interconnection Customer and developed the mitigation plan for interconnection. Planning level cost estimates were provided by PSCo.

This Generation Interconnection FeS analyzed the impact of this addition, located in South Central Colorado, in accordance with PSCo's study criteria. PSCo adheres to NERC and WECC Reliability Criteria, as well as internal Company criteria for planning studies. The criterion used to identify thermal injection constraints met or exceeded the following criteria:

- There was a detrimental change in the facility loading due to the subject request.
- The resultant facility loading exceeded 100% of the continuous rating (Rate A in PSS/E) system intact or post contingent.

The criterion used to identify voltage injection constraints met or exceeded the following criteria.

- There was a detrimental change in bus voltage due to the subject request.
- The resultant bus voltage was outside of the acceptable range of 0.95 to 1.05 pu system intact or 0.90 to 1.05 pu post contingent.

This project was studied as a Network Resource. NRIS shall mean an Interconnection Service that allows the Interconnection Customer to integrate its Large Generating Facility with the Transmission Provider's Transmission System in a manner comparable to that in which the Transmission Provider integrates its generating facilities to serve native load Customers. NRIS in and of itself does not convey transmission service.

For this project, Tri-State Generation and Transmission Association (TSG&T) is an affected party. PSCo will provide TSG&T with a copy of this feasibility study report and will work with TSG&T during the system impact study phase.

Power Flow Study Models

WECC coordinates the preparation of regional power flow cases for transmission planning purposes. PSCo Transmission developed a starting point model, 2015HS_PSSE-V32_11-21-11.sav, with a 2015 summer peak load representation from the WECC 2015HS2 base case that was approved in May of 2010 for use in the steady state analyses.

Modeling of Request

The GI-2010-10 generation was included in the starting point model, 2015HS_PSSE-V32_11-21-11.sav. The new 130 MW photovoltaic solar power plant will transform the collected solar energy to DC electricity and utilize an inverter to convert to AC electricity. The photovoltaic solar power plant will be connected through a dedicated step-up transformer with a terminal voltage of 34.5 kV. For study purposes, the photovoltaic solar power plant was initially modeled as rated at 130 MVA with no capability of producing or consuming reactive power. However as the study progressed it was determined that dynamic reactive power capability would be required to achieve a convergent power flow solution for loss of the San Luis Valley to Poncha 230 kV line. Thus all further study was completed with GI-2010-10 generation modeled as capable of achieving +/- 0.95 power factor at the San Luis Valley 230 kV bus. This facility will be interconnected to the PSCo system at the SLV 230 kV bus.

The following is a summary of Project GI-2010-10 parameters as modeled by PSCo in the 2015HS_PSSE-V32_11-21-11.sav steady state model:

Total Plant Capacity	= 130 MW
Reactive Capability	= +/- 0 MVARs initially modeled, +53.5 MVARs, -27.5 MVARs ultimately modeled by TranServ due to divergence issues. This represents +/- 0.95% power factor (+/- 40.5 MVARs after adjustment for 13 MVAR transformer losses when the transformer is carrying full GI-2010-10 output) at the San Luis Valley 230 kV bus.
Generator Step-up Transformer	= 34.5/115 kV step up transformer rated at 130 MVA, 10.5% positive sequence impedance on the transformer base, X/R Ratio of infinity, Winding ratio - 1.0
Voltage Regulation	= None initially modeled, 1.03 p.u at the San Luis Valley 230 kV bus ultimately modeled by TranServ due to divergence issues

Interconnecting to the PSCo bulk transmission system involves the Customer adhering to certain interconnection requirements. These requirements are contained in the Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater than 20 MW (Guidelines). In addition, PSCo System Operations conducts commissioning tests prior to the commercial in-service date for a Customer's facilities. Some of the requirements with which the Customer must comply include the following:

1. A generating plant shall maintain a power factor within the range of 0.95 leading to 0.95 lagging, measured at the POI, if the Transmission Provider's System Impact Study shows that such a requirement is necessary to ensure safety or reliability.

2. The results of the System Impact Study will not absolve the Customer from their responsibility to demonstrate to the satisfaction of PSCo System Operations prior to the commercial in-service date that it can safely operate within the required power factor and voltage ranges.
3. Reactive Power Control at the POI is the responsibility of the Customer. Additional Customer studies should be conducted by the Customer to ensure that the facilities can meet the power factor control test and the voltage controller test when the facility is undergoing commissioning testing.
4. PSCo System Operations will require the Customer to perform operational tests prior to commercial operation that would verify that the equipment installed by the Customer meets operational requirements.
5. It is the responsibility of the Customer to determine what type of equipment (DVAR, added switched capacitors, SVC, reactors, etc.), the ratings (MVAR, voltage--34.5 kV or 230 kV), and the locations of those facilities that may be needed for acceptable performance during the commissioning testing.
6. PSCo requires the Customer to provide a single point of contact to coordinate compliance with the power factor and voltage regulation at the POI. The reactive flow at the POI, SLV 230 kV bus, will need to be controlled according to the Interconnection Guidelines.

Post GI-2010-10 Model Development

Analyses were performed using a 2015 heavy summer, a 2015 heavy spring and a 2015 winter model, all derived from the 2015HS_PSSE-V32_11-21-11.sav model. The only modification made to the 2015HS_PSSE-V32_11-21-11.sav model to form the Post-GI-2010-10 2015 Heavy Summer Model was the addition of 40 MVARs of inductors (4x10) at the SLV 230 kV bus with Vhigh set at 1.04 p.u and Vlow set at 1.02 p.u. The specific modifications made to the 2015HS_PSSE-V32_11-21-11.sav model to form the Post-GI-2010-10 2015 Heavy Spring Model included:

- Scaling the Zone 710 (SLV) load to 60% of the summer peak level and adjusting the Cherokee Generation to compensate, a total adjustment of 57 MW.
- The addition of 40 MVARs of inductors (4x10) at the SLV 230 kV bus with Vhigh set at 1.04 p.u and Vlow set at 1.02 p.u.

The specific modifications made to the 2015HS_PSSE-V32_11-21-11.sav model to form the Post-GI-2010-10 2015 Winter Model included:

- Scaling the Zone 710 (SLV) load to 60 MW and adjusting the Cherokee Generation to compensate, a total adjustment of 80.3 MW.
- The addition of 40 MVARs of inductors (4x10) at the SLV 230 kV bus with Vhigh set at 1.04 p.u and Vlow set at 1.02 p.u.

The following Post- GI-2010-10 steady state models were initially developed.

- PSC-hs15aa.PostGI2010-10.sav - 2015 Summer Heavy.
- PSC-hsp15aa.PostGI2010-10.sav - 2015 Spring Heavy.
- PSC-wi15aa.PostGI2010-10.sav - 2015 Winter.

During the analysis of the above models, it was discovered that loss of the San Luis Valley to Poncha 230 kV line resulted in a divergent power flow condition due to the lack of GI-2010-10 dynamic reactive power capability. Thus the following additional Post- GI-2010-10 steady state models were also developed.

- PSC-hs15aa.PostGI2010-10var.sav - 2015 Summer Heavy.
- PSC-hsp15aa.PostGI2010-10var.sav - 2015 Spring Heavy.
- PSC-wi15aa.PostGI2010-10var.sav - 2015 Winter.

These models included the GI-2010 generation modeled with +53.5 MVARs, -27.5 MVARs of dynamic reactive power capability, holding 1.03 p.u voltage at the San Luis Valley 230 kV bus. More detailed modeling information is given in the Modeling of Request Section of this report.

Pre GI-2010-10 Model Development

The Post GI-2010-10 Models, described above, were modified by turning off the new generation to create the Pre GI-2010-10 Models. The Cherokee generation was incremented by 130 MW to compensate.

The following Pre- GI-2010-10 steady state models were developed.

- PSC-hs15aa.PreGI2010-10.sav- 2015 Summer Heavy.
- PSC-hsp15aa.PreGI2010-10.sav- 2015 Spring Heavy.
- PSC-wi15aa.PreGI2010-10.sav- 2015 Winter.

Models were solved with transformer tap, switched shunt, phase shifter, DC tap adjustment and area interchange adjustment enabled.

Power Flow Study Process

Siemens Power Technologies, Inc. (PTI) PSS/E and MUST computer power flow programs and evaluation software were used to determine system performance. A MUST activity ACC was used to determine system performance. Comparisons were made between the Pre and Post GI-2010-10 results.

The study area was defined as areas 70 PSCOLORADO and 73 WAPA R.M. in the study models. All study area elements were monitored. The study considered only the following contingency categories in the study area for the steady state analysis.

- Category A (System Intact).
- Category B (Single Contingencies including Poncha 230 kV Breaker Failure).

Thermal and voltage injection constraints were identified based on the following study criteria:

- The criterion used to flag thermal overloads was 100% of the monitored element's continuous rating (Rate A in PSS/E). Thermal overloads found on elements outside of Zone 710 which were both found as overloads in the Pre GI-2010-10 Analysis and only slightly impacted by the GI2010-10 generation were not considered constraints by PSCo.
- The criterion used to flag voltage violations met or exceeded the following criteria.
    - There was a detrimental change in bus voltage due to the subject request.
    - The resultant bus voltage was outside of the acceptable range of 0.95 to 1.05 p.u system intact or 0.90 p.u to 1.05 p.u during a single contingency. Voltage violations found on elements outside of Zone 710 which were both found as voltage violations in the Pre GI-2010-10 Analysis and only slightly impacted by the GI2010-10

generation were not considered constraints by PSCo. Also a few Zone 710 voltage violations found as outside of acceptable limits in the preGI-2010-10 analysis, identified as known issues by PSCo and only slightly impacted by the GI2010-10 generation were not considered constraints by PSCo.

The analysis was performed using MUST version 10.1 and PSS/E version 32. During the MUST AC contingency analysis, models were solved with transformer tap and switched shunt adjustments locked; phase shifter and DC tap adjustments enabled and area interchange adjustment disabled. The analysis results were obtained by comparing results from the Pre GI-2010-10 model to results from the Post GI-2010-10 model to determine the impact of the GI-2010-10 generation on the transmission system.

In addition to the traditional constraint analysis detailed above, a 5% voltage impact analysis was performed. The 5% voltage impact investigation consisted of identifying any contingency that would result in a voltage differential between the Pre GI-2010-10 results and the Post GI-2010-10 results of 5% or greater on any given bus regardless of whether or not the voltages were within acceptable limits. This analysis included all contingencies in the study area but due to the magnitude of the data involved was limited to monitoring only Zone 710 buses.

Power Flow Results

A contingency analysis was performed using models, criteria, and methodology described earlier in this report. The incremental impact of the 130 MW request was evaluated by comparing flows and voltages with and without the 130 MW request. This study has identified the system intact and single-event contingency (N-1) interconnection constraints. All system intact and N-1 interconnection constraints will require mitigation prior to granting the subject request.

It should be noted that the power flow solution diverged for loss of the San Luis Valley – Poncha 230 kV line, both prior to the addition of the GI-2010-10 generation and after the addition of the GI-2010-10 generation when it was modeled without reactive power generation capability. This is a known system deficiency that is currently ameliorated with the use of the TSG&T Under Voltage Load Shedding (UVLS) Scheme in place in the San Luis Valley. The TSG&T UVLS scheme results in the opening of breakers on the 115 kV lines from San Luis Valley to Stanley and San Luis Valley to Waverly and the 69 kV line from San Luis Valley to Hooper Tap, shedding approximately 50

MVA of TSG&T load in the San Luis Valley during summer peak conditions. This resolves the issue of low voltages and divergence observed for the loss of the San Luis Valley – Poncha 230 kV line, without causing any other thermal overloads or voltage violations. When the UVLS scheme was modeled, a convergent power flow solution was found for the San Luis Valley – Poncha 230 kV line contingency prior to the addition of the GI-2010-10 generation. After the addition of the GI-2010-10 generation, the power flow solution diverged regardless of the modeling of the UVLS scheme. When dynamic reactive power capability of +53.5 MVARs and -27.5 MVARs (+/- 0.95% power factor at the San Luis Valley 230 kV bus) was incorporated into the GI-2010-10 modeling, convergent power flow solutions were obtained for all contingencies involving the San Luis Valley – Poncha 230 kV line including the Poncha Breaker Failure 1, 2, and 3 contingencies. Thus all Pre-GI-2010-10 results for contingencies involving the San Luis Valley – Poncha 230 kV line given throughout this report include the modeling of the existing UVLS scheme and all Post-GI-2010-10 results for contingencies involving the San Luis Valley – Poncha 230 kV line given throughout this report include the modeling of dynamic reactive power capability of +53.5 MVARs and -27.5 MVARs for the GI-2010-10 generation. Thus the inclusion of such reactive power generation capability is an interconnection requirement for the GI-2010-10 generation.

With the modeling of the existing UVLS scheme for all Pre-GI-2010-10 contingencies involving the San Luis Valley – Poncha 230 kV line and the modeling of GI-2010-10 dynamic reactive power capability for all Post-GI-2010-10 contingencies involving the San Luis Valley – Poncha 230 kV line, a convergent power flow solution was obtained for all contingencies deemed relevant to this study by PSCo.

2015 Heavy Summer Analysis Results (140 MW of Loads in SLV)

Thermal

No 2015 Heavy Summer system intact or single contingency thermal constraints due to the subject request were found.

Voltage

No 2015 Heavy Summer system intact or single contingency voltage constraints due to the subject request were found.

2015 Heavy Spring Analysis Results (60% of Summer Peak Loads in SLV = 84 MW)

Thermal

No 2015 Heavy Spring system intact or single contingency thermal constraints due to the subject request were found.

Voltage

No 2015 Heavy Spring system intact or single contingency voltage constraints due to the subject request were found.

2015 Winter Analysis Results (60 MW of Loads in SLV)

Thermal

No 2015 Winter system intact thermal constraints due to the subject request were found.

The 2015 Winter single contingency thermal constraints due to the subject request are given in Table 1. It is important to note that the loading on the element listed in Table 1 was found to exceed the element rating under more than one contingency condition; however only the contingency resulting in the highest post project loading is listed in Table 1. A more detailed listing of results is shown in Appendix A.

Table 1 – 2015 Winter Thermal Constraints – N-1 Contingency Results

Limiting Element	Rating N/E	Pre Project		Post Project		DF	Percentage Point Increase	Partial Service Available	Contingency
		MVA	%	MVA	%				
PONCHA-SARGENT 115 kV	128	57.6	45	147.5	116	70%	70	101	PCABKR1

*PCABKR1 implies a Breaker Failure Contingency at the Poncha 230 kV Substation involving the San Luis Valley – Poncha 230 kV line and the Poncha 230-115 kV Transformer

As can be seen from Table 1, the Sargent – Poncha 115 kV line is loaded beyond acceptable levels in the 2015 Winter Analysis and is significantly detrimentally impacted by the subject request. This loading is considered to be a constraint by PSCo.

It should be noted that the PCABKR1 contingency, which includes loss of the San Luis Valley – Poncha 230 kV line, also included the modeling of the existing UVLS scheme in the Pre-GI-2010-10 analysis and also included the modeling of GI-2010-10 dynamic reactive power capability in the Post-GI-2010-10 analysis. It should be further noted that due to the voltage support provided by the GI-2010-10 generation, the UVLS scheme will not operate during the San Luis Valley – Poncha 230 kV line contingency when the GI-2010-10 generation is on-line at rated output of 130 MW with dynamic reactive power capability.

As can also be seen from Table 1, GI-2010-10 generation levels in excess of 101 MW will cause the Sargent – Poncha 115 kV line to load beyond acceptable levels for a breaker failure contingency at the Poncha 230 kV substation.

In addition the following can be seen from Table 1:

- The loading on the Sargent – Poncha 115 kV line increased from 57.6 MVA pre GI-2010-10 to 147.5 MVA post GI-2010-10 for a breaker failure contingency at the Poncha 230 kV substation. Since this line is rated at 128 MVA, the loading as a percent of the line rating increased from 45% to 116%, an increase of 71 percentage points.

Voltage

No 2015 Winter system intact or single contingency voltage constraints due to the subject request were found.

5% Voltage Impact Analysis

As discussed earlier, in addition to the traditional constraint analysis, a 5% Voltage Impact Analysis was performed. The results of this analysis identified that the only contingencies that would result in a voltage differential between the Pre GI-2010-10 results and the Post GI-2010-10 results of 5% or greater on any Zone 710 bus were contingencies involving loss of the San Luis Valley – Poncha 230 kV line. This condition will be further investigated in the GI-2010-10 System Impact Study.

Network Resource (NR) = 101 MW (without PSCo upgrades)

The addition of the proposed generation will cause one PSCo 115 kV line, relatively close to the requested POI, to load beyond acceptable levels. The loading on the Sargent – Poncha 115 kV line increased from 58 MVA pre GI-2010-10 to 148 MVA post GI-2010-10 for loss of the San Luis Valley – Poncha 230 kV line as well as breaker failure contingencies at the Poncha 230 kV substation involving the San Luis Valley – Poncha 230 kV line. Since this line is rated at 128 MVA, the loading as a percent of the line rating increased from 45 % to 116%, an increase of 71 percentage points. GI-2010-10 generation levels in excess of 101 MW will cause the Sargent – Poncha 115 kV line to load beyond acceptable levels for loss of the San Luis Valley – Poncha 230 kV line as well as breaker failure contingencies at the Poncha 230 kV substation involving the San Luis Valley – Poncha 230 kV line.

The proposed generation has caused no new voltage violations. However it should be noted that dynamic reactive power capability is required of the GI-2010-10 generation as detailed throughout this report.

Energy Resource (ER) = 101 MW (without PSCo upgrades)

As indicated above, the addition of the GI-2010-10 generation, as proposed, will cause PSCo's Sargent – Poncha 115 kV line to load beyond acceptable levels. Beyond this overload, no other unacceptable impacts due to the GI-2010-10 generation were found. The Energy Resource Capability of the proposed generation without amelioration of this constraint is limited by the loading on the Sargent – Poncha 115 kV line.

Again it should be noted that dynamic reactive power capability is required of the GI-2010-10 generation as detailed throughout this report.

Short Circuit

A short circuit study was conducted to determine the fault currents (single-line-to-ground or three-phase) at the San Luis Valley 230 kV bus. Table 2 summarizes the approximate fault currents at the San Luis Valley 230 kV bus with the addition of the 130 MW solar facility.

Table 2 – Short-circuit study results at San Luis Valley 230 kV bus.

System Condition	3Φ (A)	S-L-G (A)
System Intact	I1=2400	I1=I2=2900

Cost Estimate

The cost for the transmission interconnection (in 2012 dollars)

The total estimated cost to interconnect the project is approximately **$3,075,000** and includes:

- $1,195,000 for PSCo-Owned, Customer-Funded interconnection facilities
- $1,880,000 for PSCo-Owned, PSCo-Funded interconnection facilities

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.

Table 3 – PSCo Owned; Customer Funded Transmission Provider Interconnection Facilities

Element	Description	Cost Est. (Millions)
PSCo's San Luis Valley 230kV Transmission Substation	Interconnect Customer to tap at PSCo's San Luis Valley 230kV Transmission Substation (at the 230kV bus). The new equipment includes: • One 230kV gang switch • Three 230kv arresters • One set 230kV CT/PT metering units • Associated bus, wiring and equipment • Associated site development, grounding, foundations and structures • Associated transmission line communications, relaying and testing	**$0.870**
	Transmission line-tap into substation. Structure, conductor, hardware and installation labor.	**$0.075**
Customer's 230kV Substation	Load Frequency/Automated Generation Control (LF/AGC) RTU and associated equipment.	**$0.250**
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	**$1.195**
Time Frame	**Site, design, procure and construct**	**18 Months**

Table 4 – PSCo Owned; PSCo Funded Interconnection Network Facilities

Element	Description	Cost Estimate (Millions)
PSCo's San Luis Valley 230kV Transmission Substation	Interconnect Customer to tap at PSCo's San Luis Valley 230kV Transmission Substation (at the 230kV bus). The new equipment includes: • One 230kV circuit breaker • Two 230kV gang switches • One Electric Equipment Enclosure (control bldg.) • Associated communications, supervisory and SCADA equipment • Associated line relaying and testing • Associated bus, miscellaneous electrical equipment, cabling and wiring • Associated foundations and structures • Associated road and site development, fencing and grounding	**$1.870**
	Siting and Land Rights support for substation land acquisition and construction.	**$0.010**
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	**$1.880**
Time Frame	**Site, design, procure and construct**	**18 Months**

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 2012 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 site, design, procure and construct the interconnection facilities is approximately 18 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.
- No new substation land will need to be acquired.
- Breaker duty study determined that no breaker replacements are needed in neighboring substations.

GI-2010-10
Appendix A - Detailed Steady State Analysis Results

No 2015 Heavy Summer Thermal or Voltage constraints were found. Similarly no 2015 Heavy Spring Thermal or Voltage constraints were found. However some 2015 Heavy Spring Thermal and Voltage Results of interest are given in Tables 2 and 3. One 2015 Winter Thermal constraint was identified. It along with other 2015 Winter Thermal and Voltage Results of interest are also given in Tables 2 and 3.

Table 5 – Thermal Impacts of Interest

Limiting Element	Rating N/E	HS Pre GI-2010-10		HS Post GI-2010-10		HSP Pre GI-2010-10		HSP Post GI-2010-10		WI Pre GI-2010-10		WI Post GI-2010-10		Contingency
		MVA	%	MVA	%	MVA	%	MVA	%	MVA	%	MVA	%	
PONCHA-SARGENT 115 kV	128	5	4	66	51	36	28	124	97	58	45	148	116	PCABKR1
PONCHA-SARGENT 115 kV	128	5	4	65	51	38	29	124	97	56	44	147	115	PCABKR3
PONCHA-SARGENT 115 kV	128	6	4	65	51	38	29	124	97	56	44	147	115	PCABKR2
PONCHA-SARGENT 115 kV	128	6	4	66	51	38	29	124	97	56	44	147	115	SLV-PONCHA230
SANLSVLY-SARGENT 115 kV	159	22	14	87	55	42	27	125	78	56	35	140	88	PCABKR1
SANLSVLY-SARGENT 115 kV	159	22	14	87	54	42	26	124	78	54	34	139	87	PCABKR3
SANLSVLY-SARGENT 115 kV	159	23	14	87	55	42	26	124	78	54	34	139	87	PCABKR2
SANLSVLY-SARGENT 115 kV	159	22	14	87	55	42	26	124	78	54	34	139	87	SLV-PONCHA230
SANLSVLY-PONCHA 230 kV	180	64	36	68	38	23	13	124	69	36	20	147	82	PONCHA-SARGENT115
SANLSVLY-PONCHA 230 kV	180	47	26	73	41	21	12	118	65	34	19	134	75	SLV-SARGENT115
SANLSVLY-PONCHA 230 kV	180	40	22	76	42	18	10	116	65	34	19	132	73	SLV-WAVERLY115
SANLSVLY-PONCHA 230 kV	180	42	23	72	40	20	11	114	64	34	19	130	72	SLV-STANLEY115
SANLSVLY-PONCHA 230 kV	180	47	26	67	37	20	11	111	62	33	18	128	71	RAMON-STANLEY115
SANLSVLY-PONCHA 230 kV	180	52	29	63	35	18	10	112	62	30	16	126	70	System Intact

As can be seen from Table 2, the Poncha – Sargent 115 kV line loads beyond acceptable levels with the addition of the GI-2010-10 generation. This loading is a constraint to interconnection service. No additional thermal constraints were identified.

Table 6 – Voltage Impacts of Interest

BUS/NAME		KV	Zone	HS Pre Project	HS Post Project	HS Delta Volt %	HSP Pre Project	HSP Post Project	HSP Delta Volt %	WI Pre Project	WI Post Project	WI Delta Volt %	Contingency
70187	FTGARLND	69	710	0.97	0.97	1%	0.90	0.99	9%	0.92	0.99	8%	PCABKR1
70025	ALMSA_TM	115	710	0.99	1.01	2%	0.92	1.01	9%	0.94	1.00	6%	PCABKR1
70029	ANTONITO	69	710	0.98	0.99	1%	0.91	1.00	9%	0.92	1.00	8%	PCABKR1
70367	ROMEO	69	710	0.98	0.99	1%	0.92	1.00	9%	0.92	1.00	8%	PCABKR1
70552	REATAP	69	710	0.99	1.00	1%	0.92	1.00	8%	0.93	1.00	8%	PCABKR1
70506	SAGUACHE	69	710	0.98	0.99	1%	0.92	1.01	8%	0.93	1.01	8%	PCABKR1
70375	SANLSVLY	230	710	0.92	1.03	11%	0.95	1.03	8%	0.98	1.03	5%	PCABKR1
70505	MIRGEJCT	69	710	0.99	0.99	1%	0.93	1.01	8%	0.93	1.01	7%	PCABKR1
70186	OLD16TAP	69	710	1.02	1.02	1%	0.94	1.02	8%	0.94	1.01	7%	PCABKR1
70289	MOFFAT	69	710	0.99	1.00	1%	0.93	1.01	8%	0.93	1.01	7%	PCABKR1
70024	ALMSA_ST	69	710	1.02	1.02	1%	0.94	1.02	8%	0.94	1.01	7%	PCABKR1
70511	OLD40TAP	69	710	1.02	1.03	1%	0.94	1.02	8%	0.94	1.01	7%	PCABKR1
70026	ALMSA_TM	69	710	1.02	1.03	1%	0.94	1.02	8%	0.94	1.01	7%	PCABKR1
70376	SANLSVLY	69	710	1.02	1.03	1%	0.94	1.02	8%	0.94	1.01	7%	PCABKR1
70228	HOMELAKE	69	710	1.01	1.01	0%	0.93	1.01	8%	0.93	1.00	7%	PCABKR1

The results listed in Table 3 are the voltages most impacted by the GI-2010-10 generation. As can be seen from Table 3, all of the listed voltages are within criterion. Under various load and capacitor/inductor modeling variations the GI-2010-10 generation was found to minimally impact some already outside of criteria voltages. PSCo realizes that there are voltage issues (both high and low) in the San Luis Valley under varying loading conditions and are working to resolve these issues. Since no new voltage issues were identified after capacitor and inductor modeling was appropriately adjusted and these issues were not significantly impacted by the GI-2010 generation, these pre-existing impacts were not considered constraints to interconnection service by PSCo. Thus no voltage constraints were identified.

The Poncha Breaker Failure Contingencies are defined as follows:

- PCABKR1 implies loss of
  - San Luis Valley – Poncha 230 kV line
  - Poncha 230-115 kV Transformer

- PCABKR2 implies loss of
  - San Luis Valley – Poncha 230 kV line
  - Poncha – W Cannon 230 kV line

- PCABKR3 implies loss of
  - San Luis Valley – Poncha 230 kV line
  - Poncha – Curecanti 230 kV line

- PCABKR4 implies loss of
  - Poncha 230-115 kV Transformer
  - Poncha – W Cannon 230 kV line

- PCABKR5 implies loss of
  - Poncha 230-115 kV Transformer
  - Poncha – Curecanti 230 kV line

- PCABKR6 implies loss of
  - Poncha – W Cannon 230 kV line
  - Poncha – Curecanti 230 kV line

It should be noted that not all of these contingencies will be valid. However the Poncha 230 kV breaker arrangement after the addition of the 230-115 kV transformer was unknown at the time that this analysis was performed, thus the validity of these breaker failure contingencies was undetermined. Once the ultimate Poncha 230 kV breaker arrangement is known the results due to any invalid conditions can be dismissed.

GI-2010-10

Appendix B - Generation Dispatch

Pre GI-2010-10 Dispatch of All Generating Units in the Immediate Vicinity of GI-2010-10 (Zone 710)

Bus	kV	LF Id	Maximum Generation MW	2015 Heavy Summer MW	2015 Heavy Spring MW	2015 Winter MW
G-SANDHIL_PV	34.5	S1	16	16	16	16
IBERDROLA_PV	34.5	S2	30	30	30	30
COGENTRIX_PV	34.5	1	30	30	30	30
ALMSACT1	13.8	G1	17	Off-line	Off-line	Off-line
ALMSACT2	13.8	G2	19	Off-line	Off-line	Off-line
SLV_SOLAR	34.5	1	130	Off-line (GI-2010-10)	Off-line (GI-2010-10)	Off-line (GI-2010-10)
SLV_SOLAR	34.5	2	70	Off-line	Off-line	Off-line
MOSCA	69.0	NT	4.95	4.95	4.95	4.95

Post GI-2010-10 Dispatch of All Generating Units in the Immediate Vicinity of GI-2010-10 (Zone 710)

Bus	kV	LF Id	Maximum Generation MW	2015 Heavy Summer MW	2015 Heavy Spring MW	2015 Winter MW
G-SANDHIL_PV	34.5	S1	16	16	16	16
IBERDROLA_PV	34.5	S2	30	30	30	30
COGENTRIX_PV	34.5	1	30	30	30	30
ALMSACT1	13.8	G1	17	Off-line	Off-line	Off-line
ALMSACT2	13.8	G2	19	Off-line	Off-line	Off-line
SLV_SOLAR	34.5	1	130	130	130	130
SLV_SOLAR	34.5	2	70	Off-line	Off-line	Off-line
MOSCA	69.0	NT	4.95	4.95	4.95	4.95

Pre GI-2010-10 Dispatch of Major Generating Units (Pmax > 75 MW) in the Study Area

(Areas 70 and 73)

Bus	kV	LF Id	Maximum Generation MW	2015 Heavy Summer MW	2015 Heavy Spring MW	2015 Winter MW
ARAP4	13.8	C4	118	Off-line	Off-line	Off-line
BAC_MSAGEN1	13.8	G1	100	95	95	95
BAC_MSAGEN2	13.8	G1	100	95	95	95
BAC_MSAGEN5	13.8	G1	100	90	90	90
BHPLPLAN	13.8	1	100	99	99	99
CABCRKA	13.8	HA	162	160	160	160
CABCRKB	13.8	HB	162	160	160	160
CEDARCK1	34.5	W1	150	32	32	32
CEDARCK2	34.5	W2	150	32	32	32
CEDARCK3	34.5	W3	250	53	53	53
CHEROK3	20	C3	165	162	160	162
CHEROK4	22	C4	383	371	314	290
CHEROKEE5	18	G5	210	170	170	170
CHEROKEE6	18	G6	210	170	170	170
CHEROKEE7	18	G7	255	230	230	230
CO_GRN_E	34.5	W1	81	17	17	17
CO_GRN_W	34.5	W2	81	17	17	17
COMAN_1	24	C1	360	355	355	355
COMAN_2	24	C2	365	360	360	360
COMAN_3	27	C1	805	750	750	750
CRAIG1	22	1	458	451	451	451
CRAIG2	22	1	458	451	451	451
CRAIG3	22	1	470	470	470	470
DRAKE6	13.8	1	90	81	81	81
DRAKE7	13.8	1	150	137	137	137
DRYFRK1	19	1	420	420	420	420
ELBERT-1	12.5	1	100	100	100	100
ELBERT-2	12.5	1	100	100	100	100
FTRNG1CC	18	1	158	88	88	88
FTRNG2CC	18	1	158	88	88	88
FTRNG3CC	21	1	180	108	108	108
HAYDEN1	18	1	212	210	210	210
HAYDEN2	22	1	286	283	283	283
LAMAR_DC	230	DC	210	101	101	101
MANCHEF1	16	G1	140	Off-line	Off-line	Off-line
MANCHEF2	16	G2	140	Off-line	Off-line	Off-line
MBPP-1	24	1	585	556	557	557

Bus	kV	LF Id	Maximum Generation MW	2015 Heavy Summer MW	2015 Heavy Spring MW	2015 Winter MW
MBPP-2	24	1	585	585	585	585
MIS_SITE	34.5	W1	250	53	53	53
MORRO1-2	12.5	1	80	80	80	80
MORRO1-2	12.5	2	80	80	80	80
NSS2	13.8	2	90	90	90	90
PAWNEE	22	C1	530	530	530	530
PTZLOGN1	34.5	W1	201	42	42	42
PTZLOGN2	34.5	W2	120	25	25	25
PTZLOGN3	34.5	W3	79.5	17	17	17
PTZLOGN4	34.5	W4	150	32	32	32
RAWHIDE	24	C1	304	300	300	300
RAWHIDEF	18	GF	138	135	135	135
RCDCW	230	1	200	-115	-115	-115
RD_NIXON	20	1	230	221	221	221
RMEC1	15	G1	142	125	125	125
RMEC2	15	G2	141	125	125	125
RMEC3	23	G3	322	300	300	300
SIDNEYDC	230	1	200	200	200	200
SLV_SOLAR	34.5	1	130	Off-line (GI-2010-10)	Off-line (GI-2010-10)	Off-line (GI-2010-10)
SPNDLE1	18	G1	134	134	134	134
SPNDLE2	18	G2	134	134	134	134
SPRUCE1	18	G1	140	135	135	135
SPRUCE2	18	G2	140	135	135	135
ST.VR_2	18	G2	130	Off-line	Off-line	Off-line
ST.VR_3	18	G3	130	100	100	100
ST.VR_4	18	G4	130	100	100	100
ST.VR_5	18	G5	150	Off-line	Off-line	Off-line
ST.VR_6	18	G6	150	Off-line	Off-line	Off-line
ST.VRAIN	22	G1	342	280	280	280
STEGALDC	230	1	100	60	60	60
TWNBUTTE	34.5	W1	75	16	16	16
VALMONT	20	C5	196	186	186	186
WYGEN	13.8	1	100	97	97	97
WYGEN2	13.8	1	100	98	98	98
WYGEN3	13.8	1	100	99	99	99

Post GI-2010-10 Dispatch of Major Generating Units (Pmax > 75 MW) in the Study Area

(Areas 70 and 73)

Bus	kV	LF Id	Maximum Generation MW	2015 Heavy Summer MW	2015 Heavy Spring MW	2015 Winter MW
ARAP4	13.8	C4	118	Off-line	Off-line	Off-line
BAC_MSAGEN1	13.8	G1	100	95	95	95
BAC_MSAGEN2	13.8	G1	100	95	95	95
BAC_MSAGEN5	13.8	G1	100	90	90	90
BHPLPLAN	13.8	1	100	99	99	99
CABCRKA	13.8	HA	162	160	160	160
CABCRKB	13.8	HB	162	160	160	160
CEDARCK1	34.5	W1	150	32	32	32
CEDARCK2	34.5	W2	150	32	32	32
CEDARCK3	34.5	W3	250	53	53	53
CHEROK3	20	C3	165	50	50	50
CHEROK4	22	C4	383	355	299	275
CHEROKEE5	18	G5	210	170	170	170
CHEROKEE6	18	G6	210	170	170	170
CHEROKEE7	18	G7	255	230	230	230
CO_GRN_E	34.5	W1	81	17	17	17
CO_GRN_W	34.5	W2	81	17	17	17
COMAN_1	24	C1	360	355	355	355
COMAN_2	24	C2	365	360	360	360
COMAN_3	27	C1	805	750	750	750
CRAIG1	22	1	458	451	451	451
CRAIG2	22	1	458	451	451	451
CRAIG3	22	1	470	470	470	470
DRAKE6	13.8	1	90	81	81	81
DRAKE7	13.8	1	150	137	137	137
DRYFRK1	19	1	420	420	420	420
ELBERT-1	12.5	1	100	100	100	100
ELBERT-2	12.5	1	100	100	100	100
FTRNG1CC	18	1	158	88	88	88
FTRNG2CC	18	1	158	88	88	88
FTRNG3CC	21	1	180	108	108	108
HAYDEN1	18	1	212	210	210	210
HAYDEN2	22	1	286	283	283	283
LAMAR_DC	230	DC	210	101	101	101
MANCHEF1	16	G1	140	Off-line	Off-line	Off-line
MANCHEF2	16	G2	140	Off-line	Off-line	Off-line
MBPP-1	24	1	585	556	557	557

Bus	kV	LF Id	Maximum Generation MW	2015 Heavy Summer MW	2015 Heavy Spring MW	2015 Winter MW
MBPP-2	24	1	585	585	585	585
MIS_SITE	34.5	W1	250	53	53	53
MORRO1-2	12.5	1	80	80	80	80
MORRO1-2	12.5	2	80	80	80	80
NSS2	13.8	2	90	90	90	90
PAWNEE	22	C1	530	530	530	530
PTZLOGN1	34.5	W1	201	42	42	42
PTZLOGN2	34.5	W2	120	25	25	25
PTZLOGN3	34.5	W3	79.5	17	17	17
PTZLOGN4	34.5	W4	150	32	32	32
RAWHIDE	24	C1	304	300	300	300
RAWHIDEF	18	GF	138	135	135	135
RCDCW	230	1	200	-115	-115	-115
RD_NIXON	20	1	230	221	221	221
RMEC1	15	G1	142	125	125	125
RMEC2	15	G2	141	125	125	125
RMEC3	23	G3	322	300	300	300
SIDNEYDC	230	1	200	200	200	200
SLV_SOLAR	34.5	1	130	130	130	130
SPNDLE1	18	G1	134	134	134	134
SPNDLE2	18	G2	134	134	134	134
SPRUCE1	18	G1	140	135	135	135
SPRUCE2	18	G2	140	135	135	135
ST.VR_2	18	G2	130	Off-line	Off-line	Off-line
ST.VR_3	18	G3	130	100	100	100
ST.VR_4	18	G4	130	100	100	100
ST.VR_5	18	G5	150	Off-line	Off-line	Off-line
ST.VR_6	18	G6	150	Off-line	Off-line	Off-line
ST.VRAIN	22	G1	342	280	280	280
STEGALDC	230	1	100	60	60	60
TWNBUTTE	34.5	W1	75	16	16	16
VALMONT	20	C5	196	186	186	186
WYGEN	13.8	1	100	97	97	97
WYGEN2	13.8	1	100	98	98	98
WYGEN3	13.8	1	100	99	99	99