DRAFT

GENERATION INTERCONNECTION

REQUEST # GI-2010-11

ADDENDUM TO SYSTEM IMPACT STUDY REPORT

52 MW PV SOLAR, ALAMOSA COUNTY, COLORADO

Performed by: TranServ International, Inc.

Reviewed by: PSCo Transmission Planning

XCEL ENERGY SERVICES - TRANSMISSION PLANNING WEST

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Executive Summary

PSCo received an interconnection request (GI-2010-11) for a 52 MW PV solar generation interconnection using 34 SMA 1.5 MW CPs ("Kodiak") inverters and 1 SMA 1.0 MW inverter, each connected to a 34.5 kV feeder through a 2200 kVA, .27/34.5 kV step-up transformer. The primary point of interconnection to be studied will be located at the San Luis Valley 230 kV substation.

This is a joint Supplement to the System Impact Study (SIS) report by PSCo and TranServ. PSCo determined the required mitigation, provided the scoping level cost estimates and performed all analyses except the stability analyses. The stability analyses were performed by TranServ under PSCo's direction.

This Supplemental SIS evaluated the impact of the newly proposed inverters ("the Plant") on the transmission system performance. The scope of the SIS is limited to identifying mitigation for injection constraints that likely would limit the ability of the Plant to interconnect. In accordance with PSCo SIS practices, this study only identified impacts that would be required to be mitigated in order for this Plant to interconnect at the requested Point of Interconnection (POI).

In conclusion, as referenced in Figures 2a and 2b, the power output of the PV inverters goes to zero for a short amount of time (3.5-17 seconds as shown in Figure 2a). From Figure 2a, PSCo concludes that the updated model still does not meet the "Low Voltage Ride Through" criteria and it is not an acceptable generator output performance. The trip of the GI-2010-11 generation and the transient voltage criteria violation following the Disturbance 1s are criteria violations which must be mitigated.

As mentioned in the SIS report meeting on July 15th, 2014, PSCo Planning and Operations notified the Customer that they would prefer them to operate the photovoltaic inverters in voltage control mode which is QVAR mode #3. The SIS report has demonstrated that the QVAR mode #3, voltage control mode, has positive effect on the bulk electric system and will enable the Plant to ride through some of the most critical faults in the San Luis Valley area.

In addition, the Customer will need to confirm the future existence of the ± 6 MVAR dynamic reactive power device as referenced in the model data sheet, but was not in the dynamic PSSE file. Results show that the dynamic reactive power device modeled the transient voltage dip% is within WECC criteria for all the buses shown. However, without the dynamic reactive power device modeled the transient voltage dip% exceeds 25% at one of the buses which is a clear violation of the WECC criterion.

Dynamic Analysis

The original modeling information provided by the Customer included a ± 6 MVAR dynamic reactive power device. Thus the GI-2010-11 SIS modeling included this dynamic reactive power device. Subsequent to the completion of the GI-2010-11 SIS, the Customer provided updated modeling. However, the updated modeling, as shown in Figure 1a, provided by the Customer did not include a dynamic reactive power device.

Original Modeling Information Provided by the Customer:

Plant Reactive Power Compensation.
Provide the following information for plant-level reactive compensation, if applicable:
a) Individual fixed shunt reactive device type: _____
    - Size of each: 1×6 MVA
b) Dynamic reactive control device (e.g., SVC, STATCOM): _____
c) Control range at rated MW output: 6 Mvar (lead and lag)
d) Control mode (e.g., voltage, power factor, reactive power): _____
e) Regulation point: _____
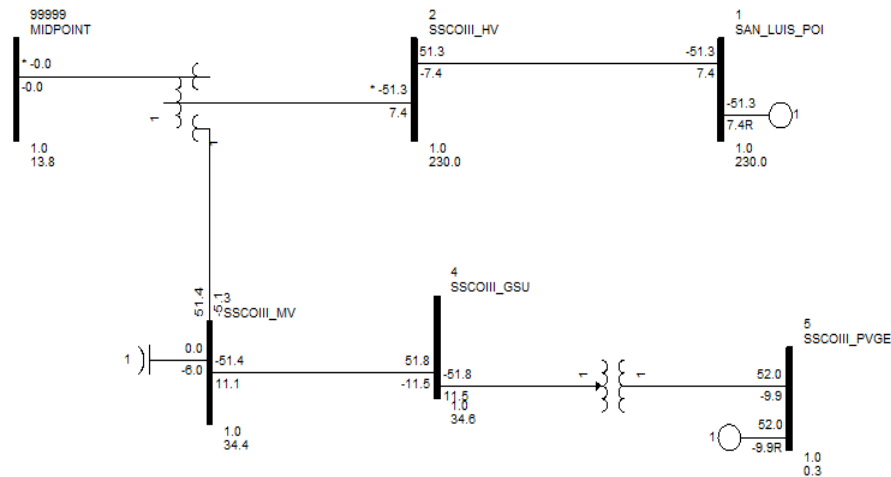
Updated Modeling Information Provided by the Customer:

Fig 1a: Updated Topology

Given the uncertainty of the Customer's intention regarding the inclusion of a dynamic reactive power device in the project design, TranServ tested the two disturbances which were found to be most severe in

the GI-2010-11 SIS scenarios both with and without the dynamic reactive power device modeled. The disturbance descriptions are listed below:

- **01s:** 3 phase Fault on the San Luis Valley - Poncha 230 kV line at San Luis 230 kV: clear the fault by tripping the San Luis Valley - Poncha 230 kV line.
- **02s:** 3 phase Fault on the Poncha - San Luis Valley 230 kV line at Poncha 230 kV: clear the fault by tripping the Poncha - San Luis Valley 230 kV line.

It should be noted that the remaining disturbances which were tested in the GI-2010-11 SIS were not tested without the dynamic reactive power device modeled. Thus if the project design does not include the dynamic reactive power device which was modeled in the SIS, the remaining disturbances will also need to be tested without the dynamic reactive power device modeled.

Disturbance 01s:

Figures 2a and 2b respectively, illustrate the Disturbance 1s results both with and without the dynamic reactive power device modeled.
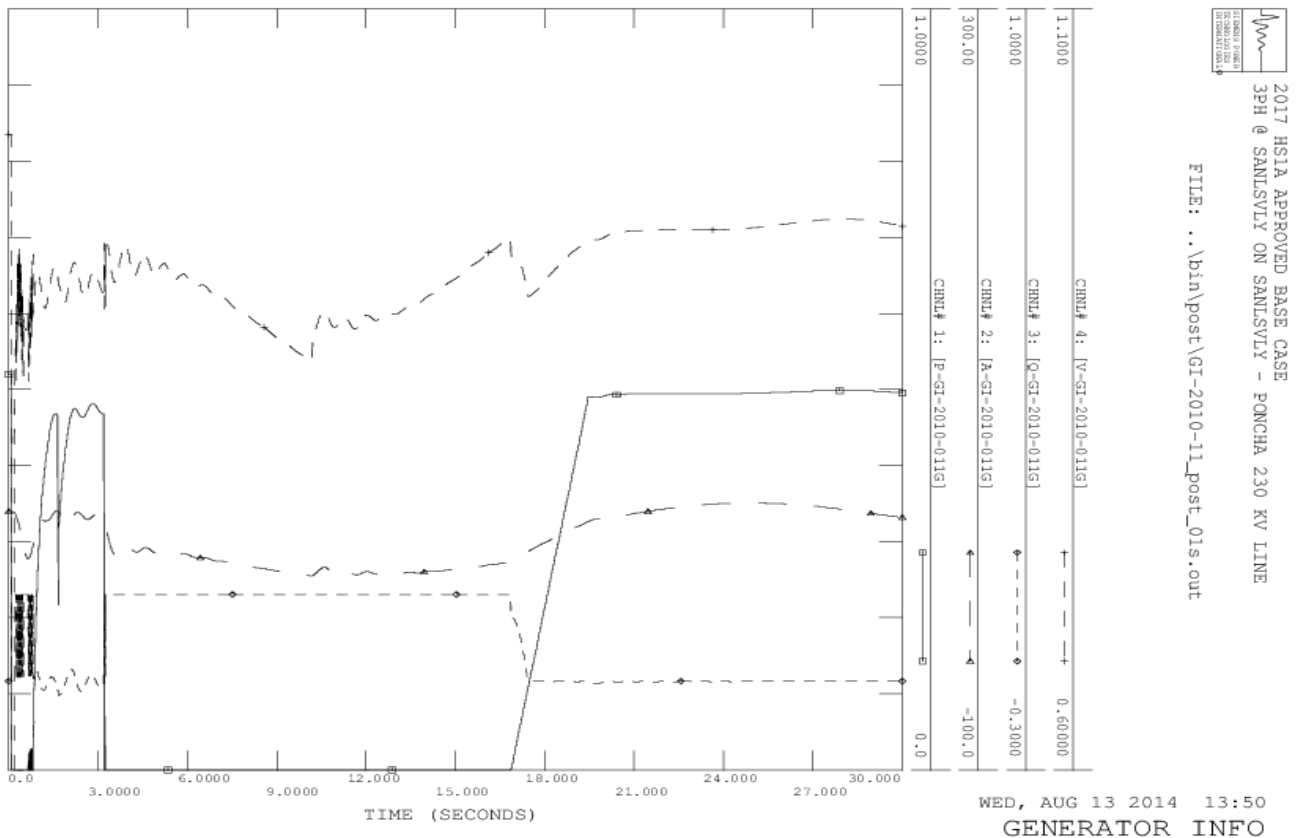
Fig 2a: Plot with Dynamic Reactive Power Device Modeled

As seen in Fig 2a, with the dynamic reactive power device modeled, the power output of the PV inverters goes to zero from approximately 3.5 to 17 sec and then recovers for the 01s disturbance simulation. PSCo should determine if this generation output performance is acceptable for a new generator seeking interconnection to the PSCo transmission system. No other potential criteria violations were identified.
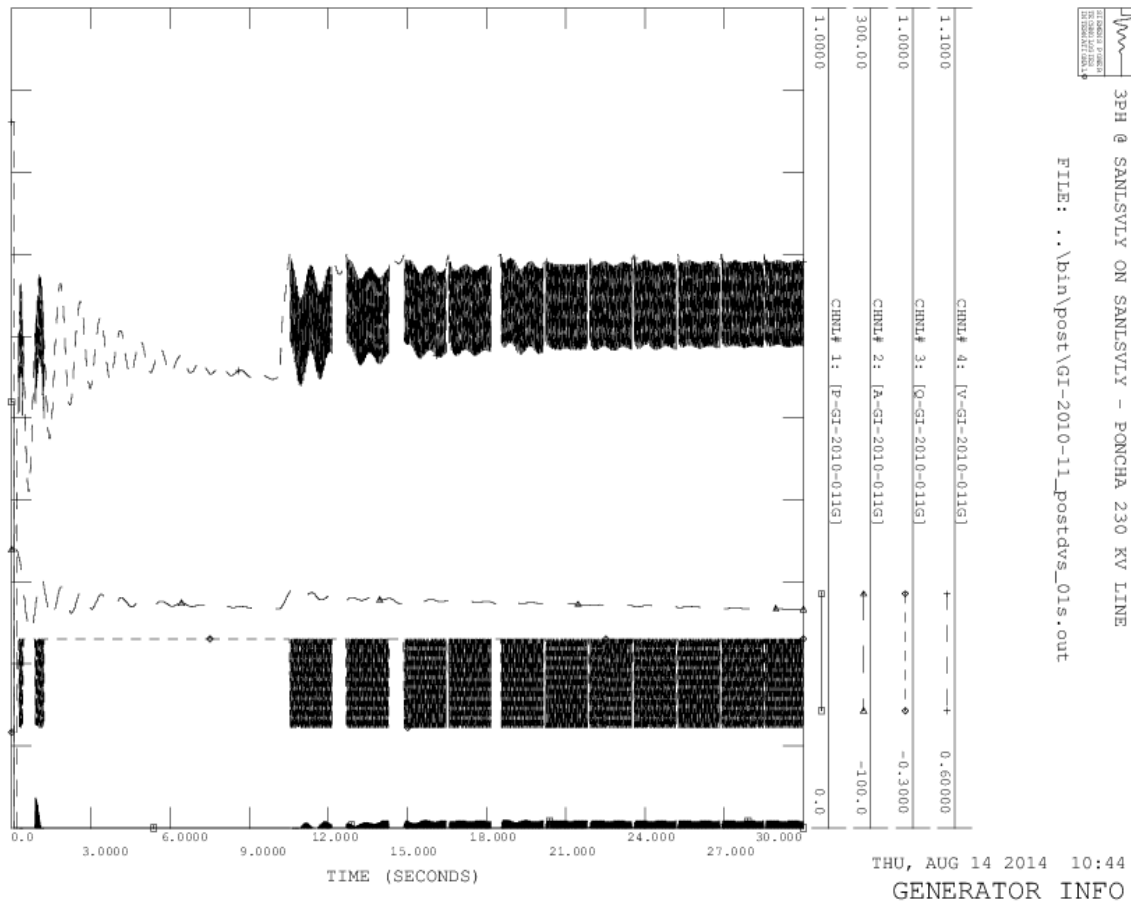

Fig 2b: Plot without Dynamic Reactive Power Device Modeled

As seen in Fig 2b, without the dynamic reactive power device modeled, the power output of the PV inverters goes to zero and does not recover within 30 seconds. Thus the GI-2010-11 generation trips following the Disturbance 1s if the dynamic reactive power device is not modeled. In addition the table below shows that a transient voltage criteria violation also occurs following the Disturbance 1s if the dynamic reactive power device is not modeled. The trip of the GI-2010-11 generation and the transient voltage criteria violation following the Disturbance 1s are criteria violations, which must be mitigated.

The table below shows the Disturbance 1s minimum load bus transient voltages observed both with and without the dynamic reactive power device modeled.

Load Buses	Steady State Post Project Voltage with DVS	Post Minimum Voltage with DVS	Post Deviation Voltage with DVS	Transient Voltage dip with DVS%	Steady State Post Project Voltage without DVS	Post Minimum Voltage without DVS	Post Deviation Voltage without DVS	Transient Voltage dip without DVS%	No of cycles below WECC criterion
FTGARLND 69	0.9574	0.7785	0.1789	18.68	0.9670	0.7241	0.2429	25.11	Violation
ANTONITO 69	0.9717	0.7919	0.1798	18.50	0.9812	0.7371	0.2441	24.87	16.2
ROMEO 69	0.9751	0.7953	0.1798	18.43	0.9846	0.7405	0.2441	24.77	16.2

*DVS: Dynamic Var Support

It can be seen that with the dynamic reactive power device modeled the transient voltage dip% is well within WECC criteria for all the buses shown. Without the dynamic reactive power device modeled the transient voltage dip% exceeds 25% at the FT GARLAND 69 kV bus, which is a clear violation of the WECC criterion.

Disturbance 02s:

Figures 3a and 3b respectively, illustrate the Disturbance 2s results both with and without the dynamic reactive power device modeled.
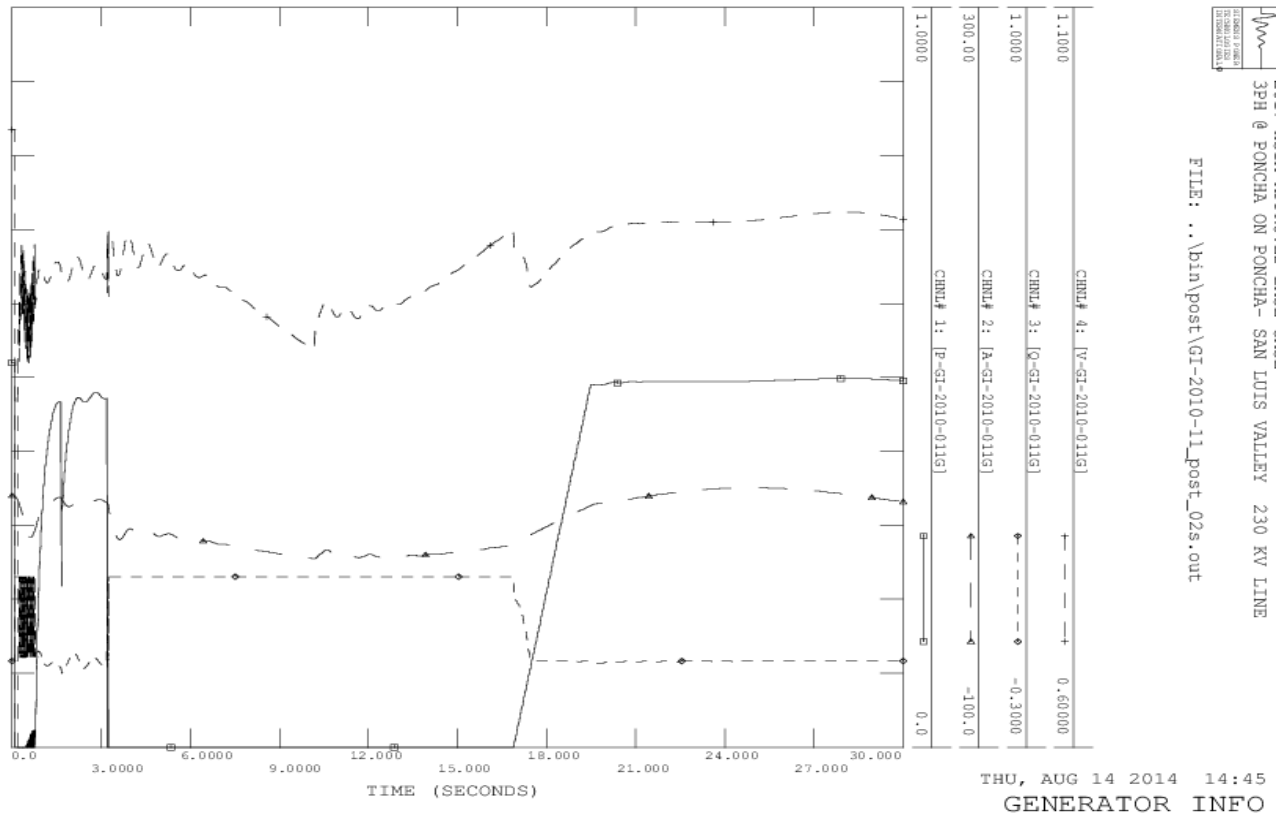
Fig 3a: Plot with Dynamic Reactive Power Device Modeled

As seen in Fig 3a, with the dynamic reactive power device modeled, the power output of the PV inverters goes to zero from approximately 3.5 to 17 sec and then recovers for the 02s disturbance simulation. PSCo should determine if this generation output performance is acceptable for a new generator seeking interconnection to the PSCo transmission system. No other potential criteria violations were identified.
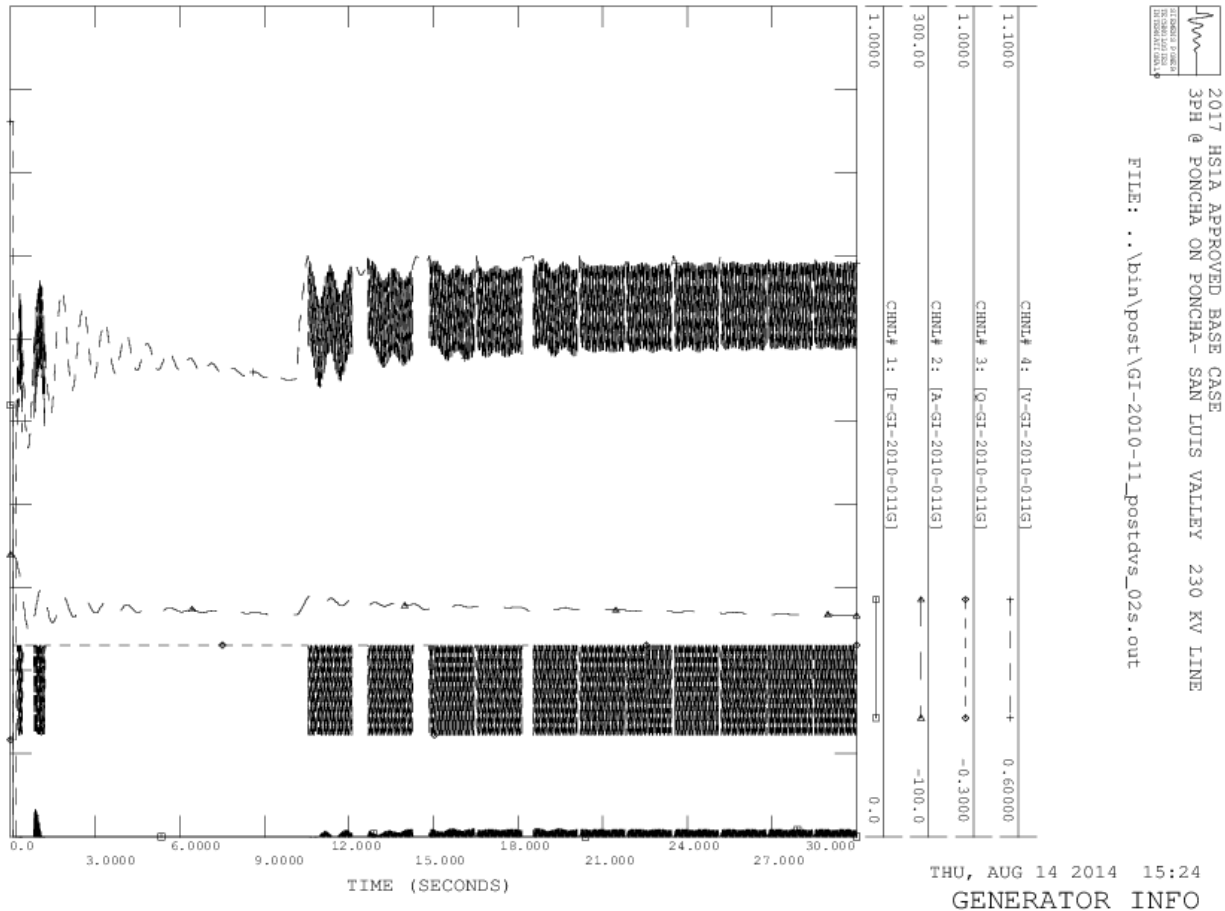
Fig 3b: Plot without Dynamic Reactive Power Device Modeled

As seen in Fig 3b, without the dynamic reactive power device modeled, the power output of the PV inverters goes to zero and does not recover within 30 seconds. Thus the GI-2010-11 generation trips following the Disturbance 2s if the dynamic reactive power device is not modeled. Also shown in Figure 3b, significant oscillations result if the dynamic reactive power device is not modeled. The trip of the GI-2010-11 generation and the oscillations following the Disturbance 2s are criteria violations, which must be mitigated. No other potential criteria violations were identified.

The table below shows the Disturbance 2s minimum load bus transient voltages observed both with and without the dynamic reactive power device modeled.

Load Buses	Steady State Post Project Voltage with DVS	Post Minimum Voltage with DVS	Post Deviation Voltage with DVS	Transient Voltage dip with DVS%	Steady State Post Project Voltage without DVS	Post Minimum Voltage without DVS	Post Deviation Voltage without DVS	Transient Voltage dip without DVS%	No of cycles below WECC criterion
FTGARLND 69	0.9576	0.7794	0.1782	18.60	0.9673	0.7541	0.2132	22.04	11
ANTONITO 69	0.9720	0.7928	0.1792	18.43	0.9815	0.7672	0.2143	21.83	11
ROMEO 69	0.9754	0.7963	0.1791	18.36	0.9849	0.7706	0.2143	21.75	11

*DVS: Dynamic Var Support

From the table above it can be seen the transient voltage dip% following the Disturbance 2s is well within WECC criteria for all the buses shown regardless of the inclusion of the dynamic reactive power device.