

# **Interconnection System Impact Study Report Request # GI-2006-2 - Second Restudy Dynamics Study to Verify Compliance with FERC Order 661-A**

175 MW Wind Expansion of Peetz Logan, near Peetz, Colorado

Public Service Company of Colorado Transmission Planning  
February 25, 2009

## **Executive Summary**

PSCo transmission finalized the System Impact Study (SIS) for request GI-2006-4 for a total of 800 MW at Peetz- Logan on February 5<sup>th</sup>, 2008. In the process of conducting that SIS for GI-2006-4 (200 MW) at Peetz Logan for a total of 800 MW it was determined that the original GI-2006-2 SIS dated April 2007 would need to be reevaluated. Transmission Planning studies for GI-2006-4 indicated that the proposed 200 MW Developer's Large Generation Facility expansion does not meet the FERC Order 661-A guidelines for Low Voltage Ride Through (LVRT)<sup>1</sup> and therefore it is not feasible to expand the Developer's Large Generation Facility to a total of 800 MW. In addition, during the evaluation of the LVRT requirements in this present study GI-2006-2, it was determined that the Developer does not meet the FERC Order 661-A guidelines for Low Voltage Ride Through (LVRT) for a previous request evaluated in GI-2006-2<sup>2</sup>. PSCo Transmission Planning and the Developer agreed to a restudy of the GI-2006-2 system impact study based on a more detailed representation of the wind collector system. The results of that restudy were presented in a report issued June 25, 2008. Subsequently, after discussions with the developer concerning that report, a request was received by PSCo concerning a change in turbine provider( Siemens 2.3 MW) and a reduction in the size of the GI-2006-2 request to 175 MW. Additionally, the developer submitted a detailed steady state and dynamics report to PSCo in January 2009 for their evaluation of the revised GI-2006-2 project. PSCo has reviewed that January 2009 report and has issued this restudy system impact study dated February 2009.

**The results of this restudy concluded that based upon the information provided by the developer, the addition of a reduced GI-2006-2 project to 175 MW would not adversely impact the PSCo transmission system. With the nameplate capability of the entire Peetz Logan wind facility totaling 575 MW and the use of Siemens 2.3 MW wind turbines for the 175 MW GI-2006-2, the low-voltage ride-through criteria will be met.**

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<sup>1</sup> <http://www.ferc.gov>

<sup>2</sup> The System Impact Study GI-2006-2 was issued to the Customer on April 4, 2007. The Facility Study GI-2006-2 was issued to the Customer on December 19, 2007.

## **Power Flow Case Set-up**

The power flow cases used in this re-study started from the 2012 HS2A Approved Case modified for 2010, i.e., the 2010HS Budget case. From this case, two cases were developed, one with generation at the Peetz Logan wind farm increased to 400 MW (benchmark case), and a second case with that 400 MW plus an additional 175 MW for the reduced GI-2006-2 project. This generation was assumed to displace power from resources in southeastern Colorado, resulting in a stressed system near the point of interconnection (POI.)

The wind farm was modeled in significant detail, based upon the 34.5-kV collector system data provided by the developer, for both the initial 400 MW as well as the proposed 175 MW expansion as GI-2006-2. Each individual wind turbine generator was modeled with voltage schedules and with individual step-up transformers, along with the full power flow representation of the 34.5 kV collector system, the four 230/34.5 kV transformers and the 230-kV line from the wind farm to Pawnee. This detail was provided by the developer for the entire 575-MW facility and has been used as presented.

In the data provided by the developer, 200 MVAR of switched shunt capacitors for GI-2006-2 were added to PSCo's Pawnee 230-kV bus. For this restudy analysis, these capacitors were moved to a tap on the developer's 230-kV transmission line, about 5% of the distance from Pawnee to the Peetz Logan Switching Station. This change is not a material change, but reflects that the developer's facilities would be outside of the PSCo substation.

The resultant power flow model reflected the desired Pawnee 230 kV bus voltage at 1.030 pu with the Manchief and Pawnee controlling their respective generator buses.

## **Steady State Results: Reactive Power Requirements**

The Interconnection Agreement (IA) requires that certain conditions be met, as follows:

- 1 The conditions of the Large Generator Interconnection Guidelines (LGIG) are met.
- 2 PSCo will require testing of the full range of 0 MW to 575 MW operational capability of the facility. These tests will include, but not be limited to, power factor control, and VAR control as measured at the Pawnee 230 kV bus POI for various generation output levels (0 to 575 MW) of the Customer's wind generation facility.
- 3 A single point of contact needs to be provided to PSCo Operations to manage the transmission system reliably for all wind projects on the proposed line.

As previously discussed, a switched capacitor bank was located on the long Pawnee – Peetz Logan 230-kV circuit, close to Pawnee. At 200 MVAR, it will provide close to unity power factor at 575 MW. This value was used for power flow and stability analyses with the proposed GI-2006-2 expansion at Peetz Logan, but not included for the benchmark case with 400 MW of wind turbine capacity installed at Peetz Logan. With generation at the terminals of all the wind turbines at Peetz Logan totaling 575 MW, approximately 532 MW are delivered to the POI, with transmission and distribution losses amounting to about 43 MW.

No contingency analysis was performed for this study effort, since there was no material change in the power delivered to the POI for this re-study. PSCo has recently performed a cursory steady state evaluation under N-1 conditions in addition to the analysis in the Feasibility Study dated November 2006. The results indicated all associated facilities were within reliability criteria limits.

### **Dynamic Stability Results**

Based upon information provided by the developer, the wind turbines for the existing 400 MW wind farm are GE 1.5sle units. The revised plan for the proposed expansion, GI-2006-2, consists of 76 Siemens SWT-2.3-93 wind turbines with a total nameplate capability of 175 MW. Dynamic models have been provided for the Siemens turbines. For the existing turbines, the voltage protection scheme is based upon GE's LVRTII package.

In the dynamics analysis, the 2010 heavy summer case has been used, that reflected the expected transmission system configuration at that time. A total of seven contingencies were studied, which reflected 3-phase faults on the 230-kV system that would be cleared in 5 cycles. For six of the seven fault conditions studied, the fault was assumed to be at the Pawnee end of the circuit, as indicated in the following table, and subsequently cleared by opening the indicated branch. The remaining fault contingency reflected a fault on one of the 230-kV circuits at Peetz Logan that would result in the disconnection of 400 MW of wind generation when the fault was cleared.

**Table 1: Transient Stability Results – Benchmark Case with 400 MW and 175 MW Addition for GI-2006-2**

<u>No.</u>	<u>Faulted End</u>	<u>From Bus</u>	<u>To Bus</u>	<u>Benchmark 400 MW</u>	<u>GI-2006-2 575 MW</u>
1	Pawnee	Pawnee 230 kV	Ft. Lupton 230 kV	Stable	Stable
2	Pawnee	Pawnee 230 kV	Brick Center 230 kV	Stable	Stable
3	Pawnee	Pawnee 230 kV	Story 230 kV	Stable	Stable
4	Pawnee	Pawnee 230 kV	Peetz Capacitor 230 kV	Stable	Stable
5	Pawnee	Pawnee 230 kV	Pawnee 22 kV	Stable	Stable
6	Pawnee	Pawnee 230 kV	Daniels Park 230	Stable	Stable
7	Peetz Switch 230 kV	Peetz Switching 230 kV	Peetz No. & So. 230 kV	Stable	Stable

For all of the faults studied, the PSCo system remained stable with all oscillations positively damped, for both the existing 400 MW facility as well as the proposed 575 MW facility. Two of the contingencies, numbers 4 and 7, will result in the expected loss of generation through disconnection, but no other adverse impacts were observed. Except for those two contingencies, all of the wind turbines at the Peetz Logan facilities remain online, with all oscillations positively damped. With the addition of 175 MW of new generation for GI-2006-2, the voltage recovery at the Pawnee 230 kV bus and throughout the Peetz Logan wind farm 34.5-kV and 230-kV transmission system is slower after a major system disturbance than in the 400 MW benchmark case, consistent with the results observed in the earlier restudy effort with 575 MW.

In conclusion, based upon the information provided by the developer, the addition of a reduced GI-2006-2 project at 175 MW and using Siemens 2.3 MW wind turbines would not adversely impact the PSCo transmission system. With the nameplate capability of the entire Peetz Logan wind facility totaling 575 MW, the low-voltage ride-through criteria will be met.