Interconnection Feasibility Study Report
Request # GI-2008-10

450 MW Wind Powered Generation Interconnecting at Pawnee Substation

PSCo Transmission Planning
October 27, 2009

Executive Summary

On September 8, 2008 Public Service Company of Colorado (PSCo) Transmission Planning received a generation interconnection request to determine the potential system impacts associated with interconnecting a 450-MW wind generation facility at the Pawnee Substation through a 110-mile transmission line. The 230-kV bus at Pawnee was considered to be the primary Point of Interconnection (POI), while the 345-kV bus at Pawnee was considered as a secondary POI. The customer requested a commercial operation date for the expansion of September 1, 2011, and a back-feed for site energization date of March 1, 2011. Based on projected equipment lead-times and other transmission project in-service dates, both the interconnection at the 230 kV bus and the commercial operation and back-feed dates requested by the Customer were not determined feasible; therefore, it is recommended that the Customer's POI ultimately be at the 345-kV bus at Pawnee. An earliest date the wind generation facility could become a network resource for PSCo would be after the completion of the Pawnee – Smoky Hill 345 kV line that is scheduled for May 2013. The study request indicated that the generation would be delivered to PSCo native load.

This request was studied as both an Energy Resource (ER)[1] and as a Network Resource (NR)[2]. These investigations included steady-state power flow and short-circuit studies. 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 the summer of 2011. The main purpose of this study was to evaluate the potential impact of GI-2008-10 on the PSCo transmission infrastructure as well as that of neighboring entities, when injecting

[1] **Energy Resource Interconnection Service (ER 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.

a total of 450 MW of wind turbine generation into Pawnee, and delivering the additional generation to native PSCo loads. The costs to interconnect the project with the transmission system at Pawnee Substation have been evaluated by PSCo Engineering. This study considered facilities that are part of the PSCo transmission system as well as monitoring other nearby entities' regional transmission systems.

Stand Alone Results

The stand-alone analysis consisted of a comparative study of the system behavior with the addition of the Customer's 450-MW project to the PSCo system compared with that associated with the existing PSCo system. The power flow model used in this study is a 2011 budget model with heavy summer load and moderately heavy stressed north-to-south (HSHN) flows. A 2015 power flow model was also used, recognizing the timing issues associated with the construction of certain transmission projects.

Energy Resource (ER)

The results of this feasibility study indicate that firm transmission capacity for the 450 MW wind generation facility expansion is not available due to existing overloads and firm transmission commitments and is not possible without the construction of network reinforcements. Non-firm transmission capability may be available depending on marketing activities, dispatch patterns, generation levels, demand levels, import path levels (TOT3, etc.) and the operational status of transmission facilities.

Network Resource (NR)

Network Resource Interconnection Service is 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. A Network Resource is any designated generating resource owned, purchased, or leased by a Network Customer under the Network Integration Transmission Service Tariff. Network Resources do not include any resource, or any portion thereof, that is committed for sale to third parties or otherwise cannot be called upon to meet the Network Customer's Network Load on a non-interruptible basis. Network Resource Interconnection Service in and of itself does not convey transmission service.

As a network request, a contingency analysis was performed to determine the network upgrades that would be required to deliver the entire output of the GI-2008-10 wind facility as provided at the POI to PSCo native load customers. **Interconnection at the 230-kV bus was not determined feasible; therefore it is recommended that the Customer's POI ultimately be at the 345-kV bus at Pawnee.** Under that condition, the estimated cost of the recommended system upgrades to accommodate the project is approximately **$30,551,000** and includes:

- ***$963,000 for PSCo-Owned, Customer-Funded Interconnection Facilities***
- ***$500,000 for PSCo-Owned, PSCo-Funded Network Upgrades for Interconnection***
- ***$29,088,000 for PSCo Network Upgrades for Delivery. This assumes that PSCo completes the network upgrade projects that have been identified and included in the PSCo Transmission Capital Budget.***

Based upon the steady-state analysis performed for the feasibility study, the full 450-MW generation output of the GI-2008-10 project could be provided to PSCo after reinforcements to the PSCo transmission system have been completed. PSCo will complete some of these reinforcements through its capital budget process for transmission upgrades, whereas others will be required as network upgrades.

The feasibility study indicates that approximately 30 - 75 MVAR of reactors will likely be required for the Customer's wind generating plant to maintain a power factor within the range of 0.95 leading to 0.95 lagging near minimum generation levels, measured at the POI. This would be needed whenever the Customer facilities are off-line or generating at very low levels while the Customer is connected to the POI. In addition, about 320 MVAR of switched capacitors will be needed to meet the voltage criteria at the POI near maximum generation. More detailed studies should be performed by the Customer to ensure that proposed wind generation facility will display acceptable performance during the commissioning testing. If the Customer advances the request to the system impact study phase, the results of the stability analysis may modify the nature of the reactive power support that may be required of the Customer for the project to meet relevant reliability criteria.

Interconnecting to the PSCo bulk transmission system requires the Customer to adhere to certain interconnection requirements. These requirements are contained in the Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater than 20 MW (Guidelines). The Guidelines make reference to interconnection requirements resulting from FERC Order 661A. FERC Order 661A describes the interconnection requirements for wind generation plants. In addition, PSCo System Operations conducts commissioning tests prior to the commercial in-service date for a Customer's facilities. Some of the requirements that the Customer must complete include the following:

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

2. The voltage at a POI shall be maintained in the ideal voltage range for the appropriate Colorado region and bus type (regulating[3] or non-regulating) as determined in the Rocky Mountain Area Voltage Coordination Guidelines[4]. The System Impact Study will investigate pertinent demand (on-peak or off-peak), season (summer or winter), dispatch, and outage scenarios based on the defined study area that includes the proposed POI. The study will conform to the NERC Transmission System Planning Performance Requirements (TPL standards).

3. The POI for a wind generating facility cannot be declared a regulating bus unless system studies demonstrate that the designation of the POI as a regulating bus is needed for system reliability or safety.

4. The impact of the wind generating facility on the reactive power schedules of nearby generating units may need to be mitigated by the Customer if system studies demonstrate that the proposed wind generating facility causes nearby generating units to generate or absorb reactive power for voltage control[5]. It is understood that sufficient reactive power reserve must be maintained on generating units to allow them to dynamically regulate voltage for extreme system conditions.

5. If a wind generating facility is interconnected to the bulk transmission system but is operating with its generation off-line and receiving power from the bulk transmission system for its station service requirements, that facility is acting as a load and will be required to maintain the power factor at the POI within 98% lagging or leading (when the station service load is greater than 85% of maximum) per the Xcel Energy document titled Interconnection Guidelines For Transmission Interconnected Customer Loads.

[3] A regulating bus is defined in the Rocky Mountain Area Voltage Coordination Guidelines as any transmission or generation bus with controllable VAR's. This implies that the bus has a voltage schedule that is being regulated by a generating facility. Generating facilities include Static VAR Compensators (SVC's), synchronous generators, or synchronous condensers that can supply fast-acting reactive power (VAR) compensation to dynamically regulate voltage at a power system bus. Switchable capacitors, switchable reactors, load tap changing transformers, etc. are not defined as generating facilities as they do not provide controllable dynamic VARs'.

[4] The Voltage Coordination Guidelines Subcommittee (VCGS) of the Colorado Coordinated Planning Group developed the guidelines. The subcommittee consisted of representatives from major Colorado utilities including Colorado Springs Utilities, Platte River Power Authority, Tri-State Generation and Transmission, Public Service Company of Colorado, and Western Area Power Administration-Rocky Mountain Region. Other major utilities outside of Colorado were also involved in the development of these guidelines.

[5] The Rocky Mountain Area Voltage Coordination Guidelines (July 2006), page 8 of 34, Item 6, states that "Static VAR sources (switched shunt capacitors, reactors) should be operated to control the voltage profile before relying on LTC or generator VAR output, and should be used in such a manner to keep LTC transformers near their nominal tap range and to keep reactive margin on generating equipment. The rationale for this goal is that the generator is a dynamic reactive source that can provide high-speed reactive support to the transmission system after a disturbance that results in low voltages, or conversely are in a position to reduce voltages after a contingency that results in high voltages. Keeping transformers near their mid-tap range also allows for maximum response to either boost or reduce voltages following a disturbance".

6. 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.

7. It is the responsibility of the Customer to determine what type of equipment (DVAR, added switched capacitors, SVC, reactors, etc.), the ratings, and the locations of those facilities that may be needed for acceptable performance during the commissioning testing.

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 end of the line near the POI will need to be controlled according to the Interconnection Guidelines.

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

1. The conditions of the Large Generator Interconnection Guidelines[6] (LGIG) are met.

2. A single point of contact is given to Operations to manage the transmission system reliably for all wind projects using the transmission facilities associated with GI-2008-10 that deliver power to the Pawnee POI, as indicated in the Interconnection Guidelines.

3. PSCo will require testing of the full range of 0 MW to 450 MW of the wind project. These tests will include, but not be limited to, power factor (pf) control, and voltage control as measured at the Pawnee POI for various generation output levels (0 to 450 MW) of the overall wind generation facility.

4. The Customer must show that the power factor at the POI is within the required +/-0.95 power factor range at all levels of generation and that the voltage levels and changes are within reliability criteria as measured at the POI for the full range of testing (including generator off-line conditions).

[6] Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater than 20 MW, version 3.0, 12/31/06

Figure 1 Simple Diagram of GI-2008-10, Point of Interconnection at 345 kV – 2013

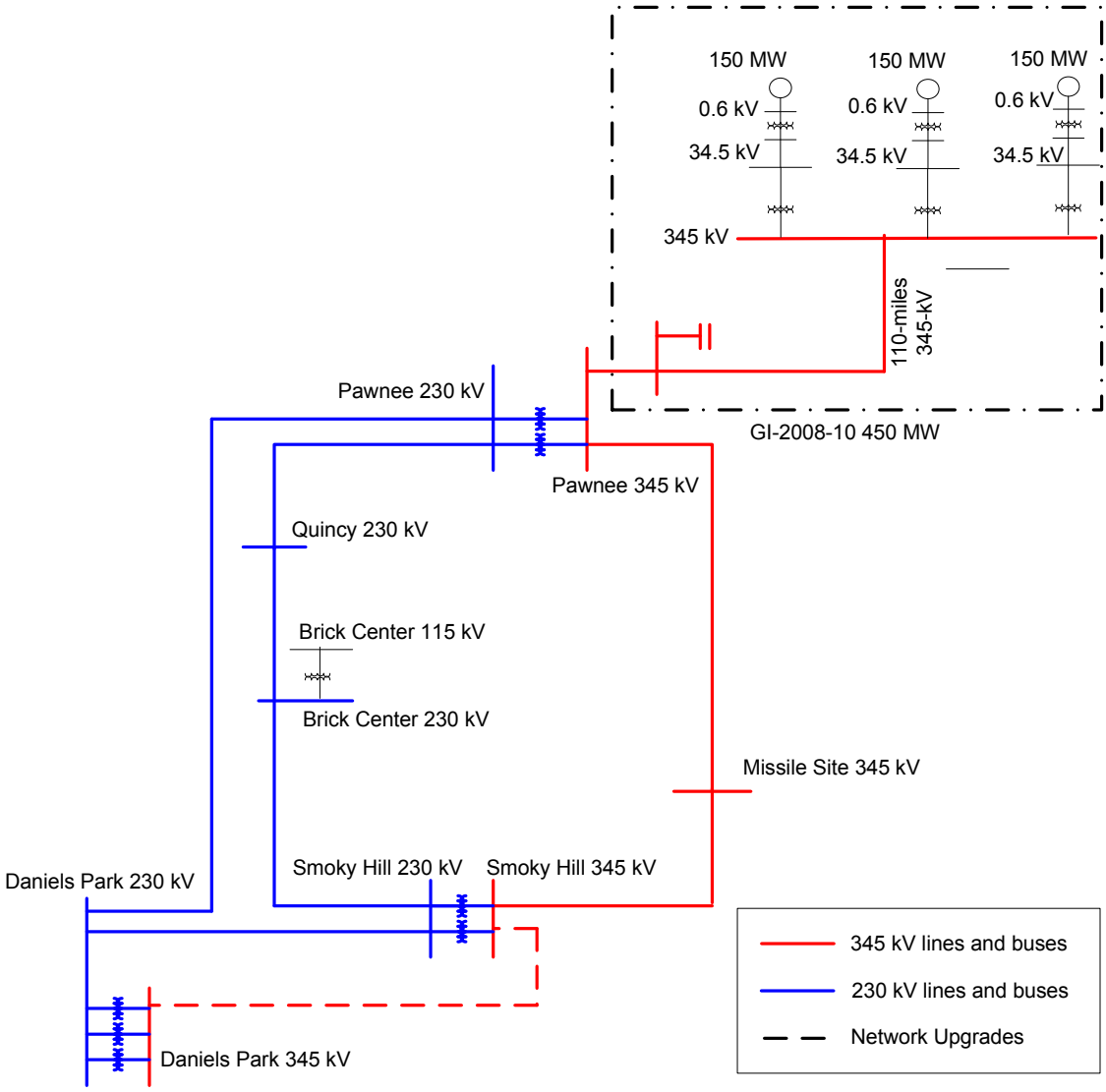


Figure 2 Preliminary One-Line of the Proposed GI-2008-10

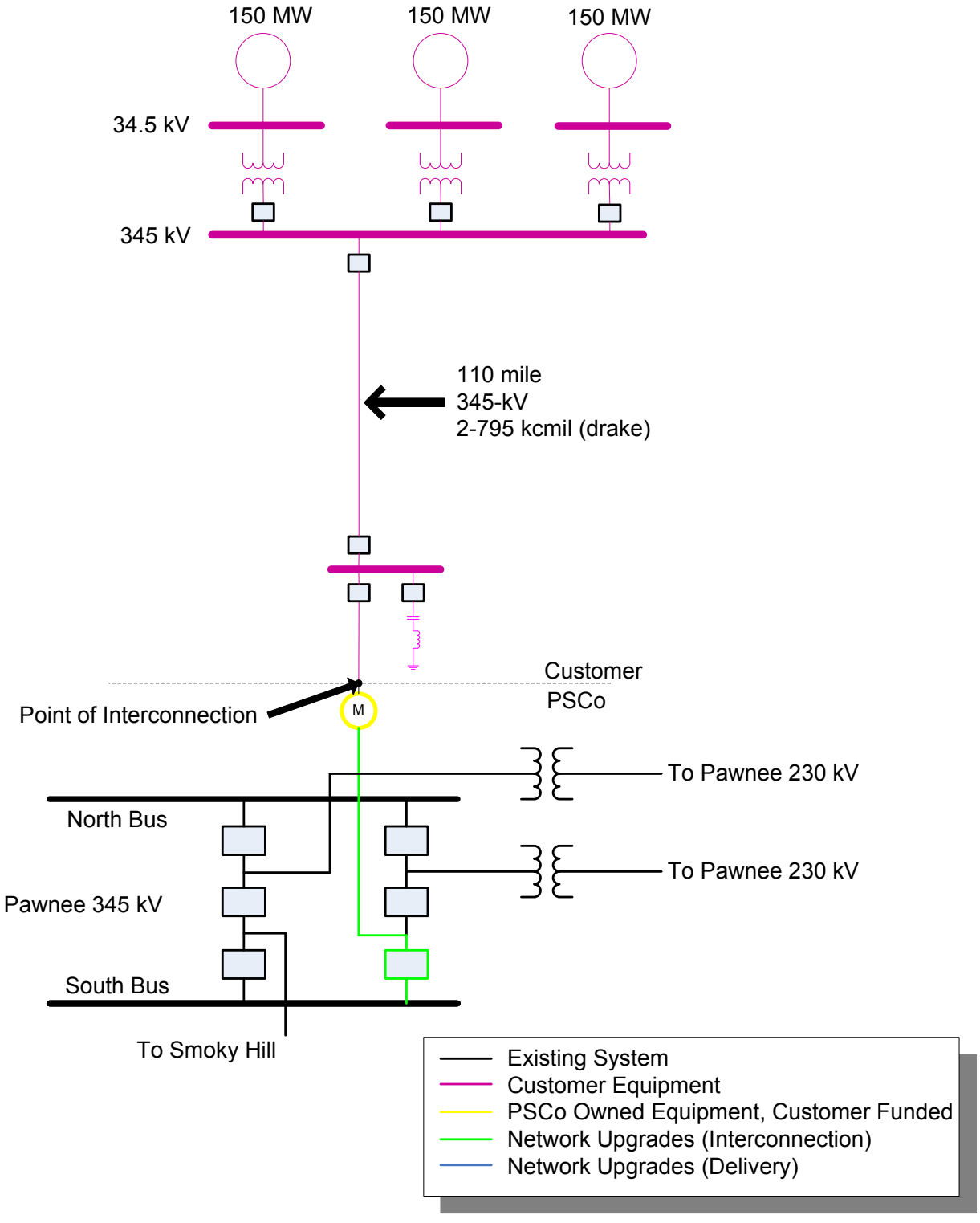
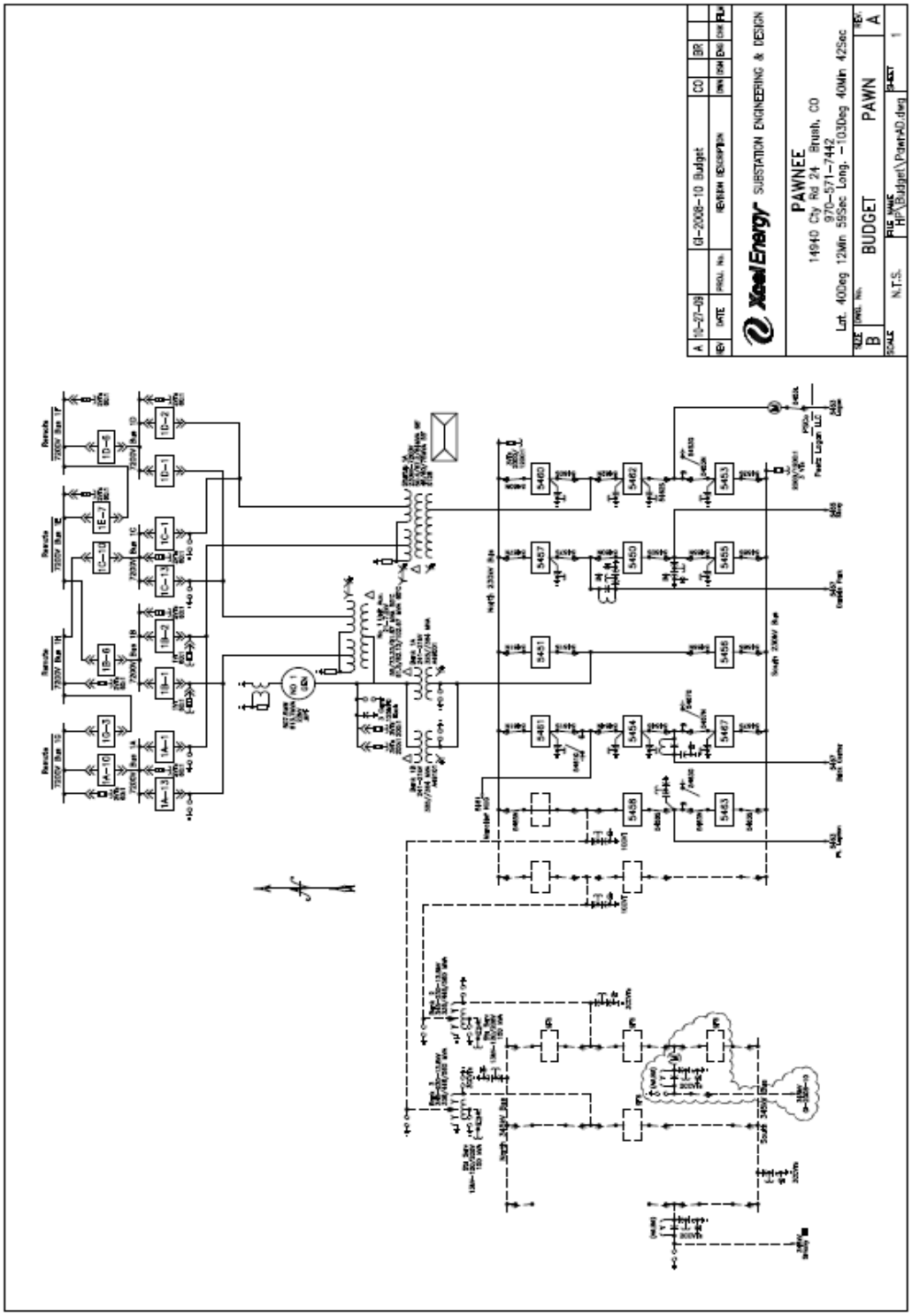


Figure 3 Preliminary One-Line of the Proposed GI-2008-10 at Pawnee



Introduction

Public Service Company of Colorado (PSCo) received a large generator interconnection request (GI-2008-10) to interconnect 300 GE 1.5 MW wind turbines, with a total generator nameplate capacity of 450 MW, a commercial operation date of September 1, 2011, and a back-feed for site energization date of March 1, 2011. The proposed project would be located in Kit Carson County, Colorado. The GI-2008-10 project would be connected with a new 110-mile transmission line to the Pawnee Substation. As per the customer's request, the 230-kV bus at Pawnee was considered to be the primary Point of Interconnection (POI), while the 345-kV bus at Pawnee was considered as a secondary POI. **While interconnection at the 230 kV bus was analyzed, the behavior of the system under contingency conditions indicate that the Customer's POI ultimately be at the 345-kV bus at Pawnee.** This request is evaluated as a stand-alone project with no other higher queued projects modeled.

The Customer has requested that this project be evaluated as a Network Resource (NR) and an Energy Resource (ER), with the energy delivered to PSCo native load customers.

Study Scope and Analysis

This feasibility study evaluates the feasibility of providing 450 MW of energy from GI-2008-10 through the point of interconnection at Pawnee to PSCo native loads. This request was studied both as an Energy Resource (ER) as well as a Network Resource (NR). This feasibility study consisted of both steady state power flow analysis and short circuit analysis. The power flow analysis provides a preliminary identification of any thermal or voltage limit violations resulting from the interconnection, and for an NR request, a preliminary identification of network upgrades required to deliver the proposed generation to PSCo loads. The short circuit analysis identifies any circuit breakers with short circuit capability limits exceeded as a result of the interconnection and for a NR request, the delivery of the proposed generation to PSCo loads.

PSCo adheres to NERC / WECC criteria as well as internal company criteria for planning studies. The following criteria were used for this study:

- For system intact conditions, transmission system bus voltages must be maintained between 0.95 and 1.05 per-unit of system nominal / normal conditions, and steady-state power flows must be maintained within 1.0 per-unit of all elements' thermal (continuous current or MVA) ratings.
- PSCO tries to maintain a transmission system voltage profile ranging from 1.02 per unit or higher at regulating buses, and 1.0 per unit or higher at transmission load buses.
- The ideal voltage range for the buses at the Pawnee substation is between 1.03 per unit to 1.04 per unit.

- 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 between 0.92 per-unit and 1.07 per-unit at load buses for PRPA), and power flows within 1.0 per-unit of the elements' continuous thermal ratings.

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

Power Flow Study Models

Western Electricity Coordinating Council (WECC) coordinates the preparation of regional power flow cases for transmission planning purposes. PSCo transmission developed a base case for the 2011 heavy summer peak load as a part of their annual five-year project identification process, from WECC approved models and modified for PSCo-approved projects and topology changes. In the 2011 case, the following generators in Area 70 (PSCo Transmission) were re-dispatched to simulate high north-to-south stressed system conditions.

- Wind generation at Peetz Logan was raised to its current maximum value of 400 MW.
- The generation at Pawnee and Manchief were raised to their maximum capacity.
- To accommodate these increases in generation, the generation at Comanche was decreased.

Implementation of these changes established the benchmark case used for this study. Comanche Unit 1 was designated as the slack bus for Area 70.

Using the 2011 benchmark case as the starting point, two power flow models were developed to reflect the GI-2008-10 project with the two potential transmission line alternatives and POIs, at 230-kV and 345-kV. The proposed wind generation facility consists of 300 General Electric (GE) 1.5 MW wind turbines. The turbines have a terminal voltage of 575 volts. For this feasibility study, the turbines have been represented as three equivalent generators, of 150 MW each, with a terminal voltage of 575 volts, which is stepped up to 34.5 kV.

The Customer has requested that the study consider both a 230-kV and 345-kV interconnection alternative at Pawnee. The wind generation facility would be connected to Pawnee substation by a radial transmission line, 110 miles long, at either the 230-kV or 345-kV bus. In the 2011 timeframe, there is no 345-kV bus at the Pawnee substation. Therefore, in the 2011 case for the Customer's 345-kV transmission line alternative, a 560-MVA 345/230-kV transformer has been assumed to be added to the PSCo transmission system at Pawnee. For the 230-kV interconnection, the following has been added to the benchmark power flow case for 2011:

1. The GI-2008-10 generation and a simplistic 34.5-kV collector system
2. Three 200-MVA 34.5/230-kV transformers at the wind farm site
3. 110-mile transmission line built for and operated at 230-kV

In the 345-kV interconnection alternative, the 2011 benchmark power flow case was modified to include:

1. The GI-2008-10 generation and 34.5-kV collector system
2. Three 230-MVA 34.5/345-kV transformers at the wind farm site
3. 110-mile transmission line built for and operated at 345-kV
4. One 560-MVA 345/230-kV transformer at Pawnee

A double-bundled 795-kcmil ACSR (Drake) conductor was used for the radial line connecting the proposed facility to PSCo system. The line impedance parameters for the 110-mile line were calculated for each voltage level using the PSS®E program TMLC. The new generation from GI-2008-10 was accommodated by decreasing generation at Comanche unit 3 and exporting power across the Lamar DC tie.

Power Flow Study Process

Automated contingency power flow studies were completed on all power flow models using the PSS®MUST program, switching out single elements one at a time for all of the elements (lines and transformers) in control areas 70 (PSCo) and 73 (WAPA RM). Upon switching each element out, the program re-solves the power flow model with all transformer taps and switched shunt devices locked, and control area interchange adjustments disabled.

Power Flow Results

Thermal Overloads – 2011 Case

When GI-2008-10 is modeled to deliver 450 MW to the 230-kV bus at Pawnee with all transmission facilities in service, the power flow case does not converge. With a 20 MVAR capacitor connected close to the POI, and another 15 MVAR capacitor connected close to the wind farm on the 110-mile radial line, the power flow case does converge with all transmission facilities in service. However, voltage collapse occurs for a number of single line contingencies, as described in Table 1.

Table 1. Contingencies Leading to Voltage Collapse
POI at the Pawnee 230-kV bus – 2011 Case

	Single Line Contingency
1	70192 FTLUPTON 230 70311 PAWNEE 230 1
2	70311 PAWNEE 230 70545 BRICKCTR 230 1
3	70311 PAWNEE 230 73192 STORY 230 1
4	73012 AULT 345 73108 LAR.RIVR 345 1

To address this issue, capacitor sizes were increased to 250 MVAR close to the POI and 70 MVAR close to the wind farm. No attempt has been made to optimize this configuration or evaluate other options. In addition, larger switched capacitors or other reactive power support will be required to meet reactive power requirements at the POI.

The results for the single line contingency analysis when 450 MW are connected to the Pawnee substation are shown in Table 2. Connecting the new wind generation facility to the 230-kV bus at Pawnee without any reinforcements causes several lines in PSCo's system as well as in TSG&T's system to overload. In comparing the results of the contingency analysis with the benchmark case for Area 70 (PSCo system), the 115/230-kV transformer at Ft. Lupton, the 115 kV lines around Smoky Hill and the 230 kV line from Washington to JL Green would be overloaded for certain single-line contingencies. For Area 73 (TSG&T), the 230-kV line from Story to Beaver Creek would be overloaded under certain contingencies.

The 230-kV line from Barr Lake to Green Valley is also overloaded. However, the thermal rating of this line has been revised from 159 MVA to 518 MVA as per the Substation/Transmission Facility Equipment Rating FAC-009 list. The rating of the 230-kV line from Cherokee to Lacombe has also been revised from 444 MVA to 859 MVA. Therefore these lines would not be overloaded due to their revised ratings.

Table 2. AC Contingency Analysis for the 2011 Base Case

** From bus ** ** To bus ** CKT	Branch Rating	Loading as % of Branch Rating			Contingency
		Bench-mark Case	POI @ 230kV	POI @ 345kV	
70047 BARRLAKE 230 70048 GREENVAL 230 1	159.0	161.0	170.2	170.9	70192 FTLUPTON 230 70529 JLGREEN 230 1
70107 CHEROKEE 230 70324 LACOMBE 230 1	444.0	101.6	111.3	111.9	70266 LOOKOUT 230 70480 WESTPS 230 1
70191 FTLUPTON 115 70192 FTLUPTON 230 T3	280.0	97.0	100.8	101.0	70447 VALMONT 230 70592 SPNDLE 230 1
70395 SMOKYHIL 115 70416 STRASBRG 115 1	97.6	115.8	143.9	145.9	70343 QUINCY 230 70545 BRICKCTR 230 1
70395 SMOKYHIL 115 70521 PEAKVIEW 115 1	133.5	98.3	109.3	110.0	70396 SMOKYHIL 230 70551 MURPHY 230 1
70416 STRASBRG 115 70547 BENNETT 115 1	133.5	95.2	115.8	117.2	70343 QUINCY 230 70545 BRICKCTR 230 1
70461 WASHINGT 230 70529 JLGREEN 230 1	413.0	105.6	113.4	113.9	70192 FTLUPTON 230 70605 HENRYLAK 230 1
73192 STORY 230 73537 BEAVERCK 230 1	413.0	134.6	163.3	165.0	73012 AULT 345 73108 LAR.RIVR 345 1

When GI-2008-10 is connected to the 345-kV bus at Pawnee, the power flow case converges without the need for reactive support in the case with all facilities and under single contingency conditions. All the lines that would be overloaded when Pawnee 230-kV bus is the POI are overloaded in this case as well. The loading on the lines is higher with the 345-kV POI under contingency conditions, due to lower losses on the Customer's transmission facilities.

Since several lines would be overloaded under contingency conditions when the GI-2008-10 facility is connected to the Pawnee substation, network upgrades are necessary to accommodate the injection of 450 MW at Pawnee. A necessary network upgrade to accommodate 450 MW at Pawnee is the Pawnee – Smoky Hill 345-kV line.

Recognizing that PSCo has recently received the CPCN necessary construct this transmission line, it is planned as a network upgrade in the PSCo capital budget. It is expected that the 345-kV line along with the necessary 345/230-kV autotransformers at Pawnee will not be operational prior to the May 2013 timeframe.

Power Flow Study Results for the 2015 Case

For this study, we have recognized the Pawnee – Smoky Hill 345-kV reinforcement and its timing by utilizing a second power flow model for 2015. The heavy summer peak load power flow model was developed by PSCo in a similar manner as the 2011 power flow model, and includes the 345-kV Pawnee – Smoky Hill line.

The 2015 power flow case without GI-2008-10 was used as the benchmark case and reflects the loads, generation, and transmission configuration that are expected to be in operation at that time. To this 2015 benchmark case the GI-2008-10 project was added, with two power flow cases created to analyze the 230-kV and 345-kV transmission line alternatives. The contingency analysis was then repeated using the 2015 cases to determine the adverse impacts to the PSCo system associated with the GI-2008-10 project.

When the proposed facility is interconnected at the 230-kV bus at Pawnee with all transmission facilities in service, the power flow case does not converge. With a 35 MVAR capacitor close to the Pawnee bus and a 40 MVAR capacitor close to the generation facility, the power flow case converges for normal system conditions. However, the solution process does not converge for several single-line contingencies that are listed in Table 3. The same approach used in the 2011 analysis was used again to establish some level of additional reactive power that would allow the cases to solve when the Customer's proposed transmission line was built for 230-kV. In this case, the capacitor sizes were necessary to resolve this issue were 230 MVAR close to the POI and 70 MVAR close to the proposed generating facility. No reactive support is required to get the power flow case to converge, when GI-2008-10 is interconnected at the 345-kV bus at Pawnee.

Table 3. Contingencies Leading to Voltage Collapse
POI at the Pawnee 230-kV bus - 2015

	Single Line Contingency
1	70139 DANIELPK 230 70311 PAWNEE 230 1
2	70192 FTLUPTON 230 70311 PAWNEE 230 1
3	70311 PAWNEE 230 70545 BRICKCTR 230 1
4	70397 B.CK PS 115 73020 BEAVERCK 115 1
5	70598 PAWNEE 345 70624 CORNER2 345 1
6	73012 AULT 345 73108 LAR.RIVR 345 1

An AC contingency analysis was performed for both the 230 and 345-kV POIs and the results were compared to the results of the AC contingency analysis of the 2015 benchmark case. The results of this comparison are given in Table 4.

The rating of the line from Ft. Lupton to JL Green has been revised as per the FAC-009 list from 478 MVA to 571 MVA and it is no longer overloaded. In addition, the ratings of the 230-kV lines from Buckley to Smoky Hill and Valmont to Spindle have also been revised as per FAC-009 from 479 MVA and 478 MVA to 506 MVA and 558 MVA, respectively. Therefore, these lines will not be overloaded. Furthermore, although the Clark to Jordan line still remains overloaded under contingency conditions, due to the fact the line is underground, the emergency line rating allows for the line to operate for more than 100 hours when overloaded at 9%. Finally, an automatic switching procedure has been established, preventing the 230/115-kV transformer at Brick Center from becoming overloaded for the loss of the 230-kV line form Quincy to Brick Center.

Table 4. AC Contingency Analysis for the 2015 Base Case, with Pawnee – Smoky Hill 345-kV

** From bus ** ** To bus ** CKT	Branch Rating	Loading as % Branch Rating			Contingency
		Bench-mark	POI @ 230kV	POI @ 345kV	
70067 BUCKLY12 230 70396 SMOKYHIL 230 1	479.0	91.4	115.2	106.2	70283 MEADOWHL 230 70396 SMOKYHIL 230 1
70112 CLARK 230 70241 JORDAN 230 1	398.0	87.5	106.9	109.3	70067 BUCKLY12 230 70396 SMOKYHIL 230 1
70192 FTLUPTON 230 70529 JLGREEN 230 1	478.0	95.1	100.4	101	70192 FTLUPTON 230 70605 HENRYLAK 230 1
70545 BRICKCTR 230 70546 BRICKCTR 115 T1	200.0	99.7	115.0	114	70343 QUINCY 230 70545 BRICKCTR 230 1
70447 VALMONT 230 70592 SPNDLE 230 1	478.0	97.5	101.5	*	70410 ST.VRAIN 230 70544 ISABELLE 230 1

* Note: Loadings less than 100% of rating, within acceptable operating criteria

Generation Sensitivity Analysis for Peetz Logan (Increase to 550 MW)

During the course of this study, the total generating capability at Peetz Logan was increased from 400 MW to 550 MW. This 150 MW increase in capacity represents a committed resource. The additional generation at Peetz Logan has been assumed to displace generation at Comanche. In addition, the Lamar DC tie was set to export 120 MW in this case. Both the 2011 and 2015 benchmark case and the corresponding cases with the proposed generation connected to Pawnee at either 230 or 345 kV were modified and AC contingency analysis was repeated.

Again, when the proposed generation facility is connected to the 230-kV bus at Pawnee, the power flow case does not converge. Therefore, a 200 MVAR capacitor close to the POI and another 60 MVAR capacitor close to the wind farm help resolve the issue. These values are slightly less than the values without the Peetz Logan expansion. No reactive support is required when GI-2008-10 is interconnected at the 345-kV bus at Pawnee.

The results of the contingency analysis for the cases were compared with those of the benchmark case, as shown in the following Table 5. As was the case when the Peetz Logan generation was studied at 400 MW, the branch loadings of PSCo facilities in the

2011 period are relatively independent of the transmission line voltage selected by the customer for the GI-2008-10 transmission line. The line loadings on a number of 230-kV circuits would be significantly over their ratings under contingency conditions. The proposed Pawnee – Smoky Hill 345-kV line would provide another outlet from Pawnee, reducing the flows on the Pawnee – Ft. Lupton, Pawnee – Story 230-kV, Pawnee – Brick Center 230-kV circuits, as well as in the Beaver Creek area.

Table 5. AC Contingency Analysis for the 2011 Base Case and Peetz Logan increased to 550 MW

** From bus ** ** To bus ** CKT	Branch Rating	Loading as % of Branch Rating			Contingency
		Bench-mark	POI @ 230kV	POI @ 345kV	
70047 BARRLAKE 230 70048 GREENVAL 230 1	159.0	164.2	173.1	174.5	70192 FTLUPTON 230 70529 JLGREEN 230 1
70192 FTLUPTON 230 70311 PAWNEE 230 1	478.0	77.6	108.8	114.5	70311 PAWNEE 230 73192 STORY 230 1
70192 FTLUPTON 230 70529 JLGREEN 230 1	478.0	95.4	101.8	102.8	70192 FTLUPTON 230 70605 HENRYLAK 230 1
70311 PAWNEE 230 70545 BRICKCTR 230 1	637.0	74.3	*	100.3	70311 PAWNEE 230 73192 STORY 230 1
70311 PAWNEE 230 73192 STORY 230 1	625.0	73.1	107.3	112.5	5165 Circuit
70395 SMOKYHIL 115 70416 STRASBRG 115 1	144.6	85.2	103.0	105.5	70343 QUINCY 230 70545 BRICKCTR 230 1
73020 BEAVERCK 115 73537 BEAVERCK 230 1	224.0	83.0	100.6	103.1	73192 STORY 230 73537 BEAVERCK 230 1
73192 STORY 230 73537 BEAVERCK 230 1	454.0	131.0	156.8	159.9	73012 AULT 345 73108 LAR.RIVR 345 1
73196 TERRY 115 73503 ERIE SW 115 1	109.0	86.3	103.8	106.7	73502 DACONO 115 73503 ERIE SW 115 1

* Note: Loadings less than 100% of rating, within acceptable operating criteria

The Pawnee – Smoky Hill 345-kV line will not be operational until May 2013. Therefore, this request was also studied for the 2015 time frame, which includes the Pawnee – Smoky Hill 345-kV line. The comparison of the AC contingency analysis for the 2015 cases shows that there are still overloaded elements in Areas 70 (PSCo transmission) and 73 (TSG&T), even with the addition of the Pawnee – Smoky Hill 345-kV circuit. The percent loading on the lines is greater in this case, as shown in Table 6, than when the generation at Peetz Logan was 400 MW. Thus, further network reinforcements would be required to deliver power from the proposed GI-2008-10 facility to PSCo system.

Table 6. AC Contingency Analysis for the 2015 Base Case with Pawnee – Smoky Hill 345-kV and Peetz Logan increased to 550 MW

** From bus ** ** To bus ** CKT	Branch Rating	Loading as % of Branch Rating			Contingency
		Bench -mark	POI @ 230kV	POI @ 345kV	
70067 BUCKLY12 230 70396 SMOKYHIL 230 1	479.0	95.7	108.4	110.4	70283 MEADOWHL 230 70396 SMOKYHIL 230 1
70067 BUCKLY12 230 70512 JEWELL1 230 1	439.0	86.3	100.1	102.3	70283 MEADOWHL 230 70396 SMOKYHIL 230 1
70112 CLARK 230 70241 JORDAN 230 1	398.0	93.8	112.2	115.4	70067 BUCKLY12 230 70396 SMOKYHIL 230 1
70396 SMOKYHIL 230 70599 SMOKYHIL 345 T1	750.0	81.5	*	102.5	70311 PAWNEE 230 70545 BRICKCTR 230 1
70461 WASHINGT 230 70529 JLGREEN 230 1	413 .0	111.7	118.3	118.5	70192 FTLUPTON 230 70605 HENRYLAK 230 1
70545 BRICKCTR 230 70546 BRICKCTR 115 T1	200.0	105.2	121.3	119.8	70343 QUINCY 230 70545 BRICKCTR 230 1
70192 FTLUPTON 230 70529 JLGREEN 230 1	478.0	97.0	102.7	102.9	70192 FTLUPTON 230 70605 HENRYLAK 230 1
70311 PAWNEE 230 70598 PAWNEE 345 T1	560.0	82.7	100.6	*	70311 PAWNEE 230 70598 PAWNEE 345 T2
70311 PAWNEE 230 70598 PAWNEE 345 T2	560.0	82.7	100.6	*	70311 PAWNEE 230 70598 PAWNEE 345 T1

* Note: Loadings less than 100% of rating, within acceptable operating criteria

As mentioned earlier the rating of the Ft. Lupton - JL Green 230-kV circuit from has been revised as per the FAC 009 list from 478 MVA to 571 MVA and it is no longer overloaded. Furthermore, emergency line ratings for underground lines allow the Clark to Jordan line to operate for over 100 hours when overloaded at 115.4% of its normal rating. Finally, an automatic switching procedure prevents the 230/115-kV transformer at Brick Center from overloading with the loss of the 230-kV line form Quincy to Brick Center.

Although the rating of the 230-kV circuit from Buckley to Smoky Hill has been revised from 479 MVA to 506 MVA, when the generation is connected at the 345-kV bus, the line is still overloaded. Other thermal overloads requiring network upgrades include the 230-kV line from Washington to JL Green, the 230/345-kV transformers at Pawnee, which are slightly overloaded when the proposed facility is connected to the 230-kV Pawnee bus, and the 230/345-kV Smoky Hill transformer, which gets overloaded when the 345-kV bus at Pawnee is the POI. Since these elements in the PSCo system are overloaded, network upgrades would be required to be able to inject 450 MW from GI-2008-10 at Pawnee.

According to an independent study conducted on the addition of the Pawnee – Smoky Hill 345-kV line, in order to prevent significant overloads on the PSCo transmission system without the addition of additional network upgrades, the maximum allowable amount of on-line generation at or near Pawnee is 1,970 MW. In this study, with the generating capability at Peetz Logan being increased from 400 MW to 550 MW, and the addition of the 450 MW from GI-2008-10, the total generation on-line at or near Pawnee would be 2,070 MW, resulting in the above mentioned overloads. In order to alleviate these overloads the following network reinforcements have been considered in the case:

Option 1: Additional 230-kV line from Pawnee to Daniels Park

Option 2: 345-kV line from Smoky Hill to Daniels Park

The results of the AC contingency analysis with the proposed reinforcements were compared with the benchmark case, as shown in Table 7. The automatic switching procedure prevents the 230/115-kV transformer at Brick Center from overloading in the loss of the 230-kV line form Quincy to Brick Center.

Table 7. AC Contingency Results for the 2015 Base Case Options with Pawnee – Smoky Hill 345-kV and Peetz Logan increased to 550 MW

		Loading as % of Branch Rating							
			POI - Pawnee 230 kV			POI - Pawnee 345 kV			
** From bus ** ** To bus ** CKT	Branch Rating	Bench-mark	No Upgrade	Option 1	Option 2	No Upgrade	Option 1	Option 2	Contingency
70067 BUCKLY12 230 70396 SMOKYHIL 230 1	479.0	95.7	108.4	*	*	110.4	*	*	70283 MEADOWHL 230 70396 SMOKYHIL 230 1
70067 BUCKLY12 230 70512 JEWELL1 230 1	439.0	86.3	100.1	*	*	102.3	*	*	70283 MEADOWHL 230 70396 SMOKYHIL 230 1
70112 CLARK 230 70241 JORDAN 230 1	398.0	93.8	112.2	*	*	115.4	*	*	70067 BUCKLY12 230 70396 SMOKYHIL 230 1
70396 SMOKYHIL 230 70599 SMOKYHIL 345 T1	750.0	81.5		*	*	102.5	*	*	70311 PAWNEE 230 70545 BRICKCTR 230 1

70461 WASHINGT 230 70529 JLGREEN 230 1	413.0	111.7	118.3	*	*	118.5	*	*	70192 FTLUPTON 230 70605 HENRYLAK 230 1
70545 BRICKCTR 230 70546 BRICKCTR 115 T1	200.0	105.2	121.3	*	117.5	119.8	*	115.6	70343 QUINCY 230 70545 BRICKCTR 230 1
70192 FTLUPTON 230 70529 JLGREEN 230 1	478.0	97.0	478.0	*	*	102.9	*	*	70192 FTLUPTON 230 70605 HENRYLAK 230 1
70311 PAWNEE 230 70598 PAWNEE 345 T1	560.0	82.7	100.6	*	*	*	*	*	70311 PAWNEE 230 70598 PAWNEE 345 T2
70311 PAWNEE 230 70598 PAWNEE 345 T2	560.0	82.7	100.6	*	*	*	*	*	70311 PAWNEE 230 70598 PAWNEE 345 T1

* Note: Loadings less than 100% of rating, within acceptable operating criteria

As indicated in Table 7, both Options 1 and 2 decrease the loading on critical elements below their normal rating. However, Option 2 is the preferred option since the total length of reinforcements required for Option 2 is less than Option 1. Since the 550-MW capability at Peetz Logan has been committed, the 345-kV Customer transmission alternative would be more effective in the long-term by reducing the transformation requirements necessary to deliver the large block of power associated with GI-2008-10. Therefore, it is recommended that the Customer pursue the 345-kV POI alternative.

These upgrades associated with option would be handled through the transmission upgrade projects in the PSCo Capital Construction Budget process. A CPCN may be required by the CPUC for the construction of Option 2, adding a minimum of one year to the date of service.

Voltage Criteria Violations

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). The Guidelines make reference to interconnection requirements from FERC Order 661A. FERC Order 661A describes the interconnection requirements for wind generation plants. In addition, PSCo System Operations conducts commissioning tests prior to the commercial in-service date for a Customer's facilities. Some of the requirements that the Customer must complete include the following:

1. A wind 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 System Impact Study will investigate pertinent demand, dispatch, and outage scenarios based on the defined study area that includes the proposed POI. The study will conform to the NERC Transmission System Planning Performance Requirements (TPL standards).
3. The results of the System Impact Study (mentioned in Item 1 and 2 above) do not absolve the Customer from its 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.
4. Reactive Power Control at the POI is the responsibility of the Customer. Additional Customer studies should be conducted by 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.

5. 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.
6. 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.
7. 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 end of 230-kV/345-kV line near the POI will need to be controlled according to the Interconnection Guidelines

According to WECC/NERC criteria, it is necessary to maintain voltages at all buses in the system between 0.95 per unit to 1.05 per unit under operating conditions. In the Rocky Mountain Voltage Coordination Guidelines that were developed by the Voltage Coordination Guideline Subcommittee of the Colorado Coordinated Planning Group, the ideal voltage range for the 230-kV bus voltage at Pawnee is 1.03 – 1.04 per unit.

From the 2011 analysis, the voltage at the 230-kV bus at Pawnee is 1.024 per unit with Peetz Logan generation at 400 MWin the benchmark case without GI-2008-10. When the proposed facility is connected to the 230-kV bus at Pawnee the power flow case does not solve. With a 290 MVAR capacitor connected close to the POI and a 70 MVAR capacitor connected close to the generating facility, the power flow case solves and the voltage at the 230-kV Pawnee bus is restored to benchmark levels. No reactive support is required to get the case to solve when GI-2008-10 is connected to the 345-kV Pawnee bus. However, the voltage at the 345-kV bus at Pawnee (POI) falls to 1.002 per unit. Table 8 shows that in order to restore the voltage at the Pawnee 230kV bus to benchmark levels, a 190 MVAR capacitor needs to be connected close to the POI. It is seen that the capacitor requirements for the 345-kV interconnection is lower than the requirements for the 230-kV interconnection. Similar voltage violations and reactive requirements are observed when the generation at Peetz Logan is raised from 400 MW to 550 MW.

Table 8. Reactive Power Requirements2011 Case

	400 MW - Peetz Logan		550 MW - Peetz Logan	
	POI – 230 kV Pawnee	POI – 345 kV Pawnee	POI – 230 kV Pawnee	POI – 345 kV Pawnee
Voltage at the Pawnee 230 kV bus in the benchmark case without GI-2008-10 (p.u.)	1.024	1.024	1.028	1.028
Voltage at the Pawnee 230 kV bus in the case with maximum GI-2008-10 generation (p.u.)*	Voltage collapse	1.013	Voltage collapse	1.015
Reactive power supplied from 230 kV Pawnee bus at maximum GI-2008-10 generation (MVAR)*	N/A	94.2	N/A	94.2
Reactive power supplied from 345 kV Pawnee bus at maximum GI-2008-10 generation (MVAR)*	N/A	65.7	N/A	65.7

Switched shunt capacitor size to maintain voltage at POI at full generation (MVAR)	360.0	190.0	350.0	190.0
Reactor size to maintain VAR neutrality at POI at minimal GI-2008-10 generation (MVAR)	-35.0	-80.0	-30.0	-75.0

* Note: Without the addition of shunt capacitors on Customer's facilities.

The analysis of the voltage levels and required reactive power support for the 2015 power flow cases yielded similar results. With the addition of the Pawnee-Smoky Hill 345-kV circuit, the shunt capacitor requirements for the GI-2008-10 project are about 50 MVAR lower than the requirements in 2011.

Table 9. Reactive Power Requirements 2015 Case

	400 MW - Peetz Logan		550 MW - Peetz Logan	
	POI – 230 kV Pawnee	POI – 345 kV Pawnee	POI – 230 kV Pawnee	POI – 345 kV Pawnee
Voltage at the POI bus in the benchmark case without GI-2008-10 (p.u.)	1.019	1.017	1.024	1.021
Voltage at the Pawnee 230-kV bus in the benchmark case without GI-2008-10 (p.u.)	1.019	1.019	1.024	1.024
Voltage at the Pawnee 230-kV bus in the case with maximum GI-2008-10 (p.u.)*	Voltage collapse	1.012	Voltage collapse	1.017
Reactive power drawn at the POI at maximum GI-2008-10 generation (MVAR)*	N/A	65.2	N/A	68.2
Switched shunt capacitor size to maintain voltage at POI at full generation (MVAR)	320.0	140.0	300.0	120.0
Reactor size to maintain VAR neutrality at POI at 0 MW GI-2008-10 generation (MVAR)	-30.0	-75.0	-30.0	-75.0

* Note: Without the addition of shunt capacitors on Customer's facilities.

During periods of minimal wind generation, line charging associated with the 110-mile lightly-loaded Customer transmission line results in the power factor at the POI to be outside the range of 0.95 leading to 0.95 lagging. In addition, with a Customer 345-kV line, voltages on the wind farm will likely rise above 1.07 per unit. To restore the power factor at the POI to near unity and minimize the potential of high voltage on the wind farm, either 30 MVAR or 75 MVAR of switched reactors would be needed, dependent upon the Customer's transmission line voltage, as indicated in Table 8.

The results of the steady state contingency analysis do not indicate high or low voltage violations or any voltage deviation criteria violations on the PSCo system as a result of the studied contingencies.

It is the responsibility of the Customer to determine what type of equipment (CVAR, added switched capacitors, STATCOM, SVC, reactors, etc.), at what overall ratings (MVAR, voltage-34.5 kV, 230 kV, 345 kV), and at what locations (at the wind farm, near the POI) will be added to meet these reactive power control requirements. The voltage-tap settings on the main power transformers that connect the 34.5-kV system to the Customer's transmission line will impact the operating voltages and related reactive power capabilities and requirements for the GI-2008-10 facility. This should also be

considered by the Customer in determining the final design equipment and parameters. If the Customer advances the request to the system impact study phase, the results of the stability analysis may modify the nature of the reactive power support, to provide more dynamic reactive power, that may be required of the Customer for the project to meet relevant reliability criteria. For the system impact study, especially for the stability analysis portion, technical details of the generators, collector system, transformers and transmission line will be necessary to proceed.

Energy Resource (ER):

The ER portion of this study indicates that the Customer could provide 0 MW without the construction of new transmission lines from Pawnee. Once the interconnection is made, at the 230 kV POI, non-firm transmission capability may be available depending upon marketing activities, dispatch patterns, generation levels, demand levels, import path flow levels (TOT3, etc.), and the operational status of the transmission facilities.

Network Resource (NR):

The results of this study indicate that the 450 MW GI-2008-10 generation project delivered to the Pawnee POI could result in the overloading of facilities in the PSCo regional transmission system. Therefore, the 450 MW NR value requested will require interconnection and Transmission Network Upgrades. After these upgrades are complete, the 450 MW generating facility could be considered a network resource with firm transmission capability for the entire output of the plant to be delivered to load.

Short Circuit Analysis

A short circuit study was conducted to determine if the fault currents (single line-to-ground or three-phase) exceed the interrupt ratings of any circuit breakers at the Pawnee substation. The duty study compared the short-circuit model with the proposed new generation injected at the Pawnee substation and the addition of the Pawnee – Smoky Hills 345 kV line to a model without the generation and network upgrade, and identified which breakers are within 5% of their fault interruption rating as a result of the added generation. Per PSCo policy, these breakers would require replacement and would be categorized as network upgrades. The approximate fault currents at Pawnee with the addition of the GI-2008-10 450 MW wind facility are summarized in Table 10.

Table 10. Short-Circuit Study Results With the Proposed GI-2008-10

System Condition	Three-phase (amps)	Thevenin System Equivalent Impedance (R,X) (ohms)	Single-line-to-ground (amps)	Thevenin System Equivalent Impedance (R,X) (ohms)
Pawnee 345 kV Bus **After** to the Addition of the Wind Generation Facility and Network Upgrades	I_1=12091.1 I_2=I_0=0 I_A=I_B=I_C=12091.1	Z1(pos)= 0.83594,16.4525 Z2(neg)= 0.85032,16.4754 Z0(zero)= 0.96731,15.2818	I_1=I_2=4125.41 3I_0=12376.2 I_A=12609.3 I_B=I_C=0	Z1(pos)= 0.83594,16.4525 Z2(neg)= 0.85032,16.4754 Z0(zero)= 0.96731,15.2818

The results of the short-circuit analysis faulted at the Pawnee 345 kV bus show that none of the circuit breaker's fault interruption ratings at the Pawnee substation would be exceeded as a result of the new generation.

The short circuit study results show that the fault current levels for all buses studied are within the interrupting ratings of the breakers; therefore, the Project and associated infrastructure will not cause fault current to exceed the circuit breaker ratings.

The fault currents at the Pawnee substation are 12376.2 amps for a single-line to ground fault and 12091.1 amps for a three-phase fault. These values assume little to no fault current contribution from the proposed wind facility.

Costs Estimates and Assumptions

The estimated total cost for the required upgrades for is **$ 30,551,000.**

The estimated costs shown are (+/-30%) estimates in 2009 dollars (no escalation applied) and are based upon typical construction costs for previously performed similar construction. These estimated costs include all applicable labor and overheads associated with the engineering, design, and construction of these new PSCo facilities. This estimate did not include the cost 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. The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines. System improvements are subject to change upon more detailed analysis.

Table 11: PSCo Owned; Customer Funded Interconnection Facilities

Element	Description	Cost Est. Millions
Pawnee Sub 345kV – 450MW Wind Interconnection	Interconnect Customer at Xcel Energy's Pawnee Substation. The new equipment includes a 345kV gang switch, metering unit transformer, T-line relay panel, T-line structures and associated equipment and material.	**$0.799**
	Load Frequency, Generation Control and Generator Witness Testing. Includes GE/Harris RTU, software, metering and telemetry cabinet and other necessary hardware.	**$0.154**
	Total Cost Estimate for Customer Interconnection Facilities	**$0.953**
Time Frame		**18 Months**

Table 12: Customer Costs for Programming Changes (O&M)

Element	Description	Cost
Lookout Center	• Programming changes required for wind farm interconnection	**$0.010**
Time Frame		**6 Months**

Table 13: PSCo Owned; PSCo Funded Interconnection Facilities

Element	Description	Cost
Pawnee Sub 345kV – 450MW Wind Interconnection	Interconnect Customer at Xcel Energy's Pawnee 345kV Substation. New 345kV line termination requiring the following equipment: • one 345kV 40kA, dead tank breaker • one 345kV gang switch • aluminum aerial cable • required steel and foundations • minor site work (station wiring, grounding)	**$0.500**
Time Frame		**9 Months**

Table 14: PSCo Network Upgrades for Delivery

Element	Description	Cost Est. Millions
Smoky Hills tap – Daniels Park D/C 345kV	New 345kV line requiring the following: • 26 miles new 345kV line – bundled 1272 Bittern • 190 structures • 165 tangents • 25 DE • D/C steel pole structures	**$25.803**
Smoky Hills - 345kV line termination	Terminate new 345kV transmission line into Smoky Hills Substation. New 345kV line termination requiring the following equipment: • 345kV, 40kA gas dead tank breakers • Comm line trap 2000A • 3 – 345kV 3000A gang switches • Steel structures • Other miscellaneous material and site work	**1.124**

Element	Description	Cost Est. Millions
Daniels Park – 345kV line termination	Terminate new 345kV transmission line into Daniels Park Substation. New 345kV line termination requiring the following equipment. • 345kV, 40kA dead tank gas breakers • 3 – 345kV 3000A gang switches • Comm line trap 2000A • Steel structures • Other miscellaneous material and site work	**$1.525**
	Total Cost Estimate for PSCo Network Upgrades for Delivery	**$28.452**
Siting and Permitting	Obtain necessary siting, permits, easements and ROW as required.	**$0.636**
Time Frame		**36 - 48 Months**

Total	Total Cost of Project	$30.551
Time Frame		**36 - 48 Months min**

Assumptions

- The cost estimates provided are "scoping estimates" with an accuracy of +/- 30%.
- Estimates are based on 2009 dollars (no escalation applied) for the customer responsibility costs and on 2008 dollars for the PSCo responsibility costs.
- A CPCN may be required for the Smoky Hill – Daniels Park option and may take in excess of 1 year to obtain.
- A 10% contingency has been added to the estimates.
- AFUDC is included for network upgrades, excluded in delivery upgrades.
- Labor is estimated for straight time only – no overtime included.
- PSCo (or its Contractor) crews will perform all construction and wiring associated with PSCo owned and maintained facilities.
- Project feasibility and ISD is contingent upon the completion of the Pawnee – Smoky Hill 345 kV Project: A 345 kV transmission line that will be installed between the Pawnee Substation and the Smoky Hill Substation with an approximate in service date of May 2013.
- Due to customer's transmission line length, dual power line carrier will be installed for relay communications.
- Addition of generation does not require any breakers to be replaced due to fault interruption rating.

- The Wind Site is not in PSCo's service territory. The local utility will provide station service power to the generator.
- Customer supplied GSU data for 230-34.5kV units; however, the interconnection is studied at 345kV. Assumed same impedance for 345-34.5kV GSUs.
- The estimated time for design and construction of PSCo network upgrades for interconnection is at least 36 - 48 months, and is completely independent of other queued projects and their respective ISD's.
- Implementation of the recommended infrastructure for delivery will require that existing facilities be taken out of service for sustained periods. In most cases, these outages cannot be taken during peak load periods due to operational constraints. As a result, the estimated time frame for implementation could be increased by 3-6 months.