Generator Interconnection
Feasibility Study
Request # GI-2010-05

149.5 MW Wind Turbine Generation
Logan County, Colorado

Xcel Energy Services
Transmission Planning – West
August 19, 2014

A. Executive Summary

Public Service Company of Colorado (PSCo) received an Interconnection Request (GI-2010-05) for a 149.5 MW wind turbine generation facility in Logan County, Colorado. The Interconnection Request was received March 5, 2010. The wind generation facility will consist of 65 Siemens 2.3 MW wind turbine generators. This facility will be an expansion of the existing Peetz Logan wind farm complex and will use the existing Peetz Logan – Pawnee 230 kV line for the interconnection (see Figures 1 & 2 below). The original requested in-service date was June 1, 2011. This date was subsequently revised to December 31, 2015.

The Feasibility Study consisted of steady-state power flow analyses to examine the impact of the proposed wind plant on the thermal and voltage performance of the transmission grid. The reactive power performance of the wind plant interconnection at the Pawnee 230 kV point of interconnection (POI) was also considered. A 2017 peak summer power flow base case was used for the studies, although the PSCo generation dispatch represented expected 2016 peak summer conditions. The short circuit impact of the proposed wind plant was also considered.

This request was studied as a Network Resource and an Energy Resource. 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 2016, consistent with the modeled system conditions. The main purpose of this Feasibility Study was to evaluate the potential impact on the PSCo transmission infrastructure as well as that of neighboring utilities when injecting the additional 149.5 MW of generation at the Pawnee 230 kV substation, and delivering the additional generation to native PSCo loads.

The results of the Network Resource NERC Category B & C contingency analyses show that there are several facilities that experience significant overloads, or overload increases, as a result of the addition of the proposed generation. Of greatest significance, in the results of the Category B contingency analysis for one of the studied scenarios, the emergency ratings of each of the two 345/230 kV transformers at Smoky Hill were found to be overloaded in the

benchmark case for the contingency loss of the parallel Smoky Hill 345/230 kV transformer. The overloads were significantly higher with the proposed generation.

PSCo already has budgeted plans to implement transmission reinforcements that are expected to alleviate previously projected contingency overloads of the Smoky Hill 345/230 kV transformers. These system reinforcements are included in the Pawnee-Daniels Park 345 kV project, which has a planned in-service date of May 2019.

The amount of Energy Resource Interconnection Service available at any particular point in time varies depending on actual system conditions. For one of the studied scenarios, there is no ERIS because of the benchmark contingency overloads of the Smoky Hill 345/230 kV transformers. However, some firm or non-firm transmission capability may be available for other system scenarios depending upon actual generation dispatch levels, demand levels, WECC Major Path import levels (TOT 3, TOT 7, etc.) and the operational status of transmission facilities.

This study also examined the need for additional reactive power compensation at the Peetz Logan wind farm. With the Peetz Logan generation at 100% of nameplate, the study found that the proposed expansion of the Peetz Logan wind farm will substantially increase the amount of reactive power losses as seen at the Pawnee 230 kV POI, requiring substantial additional reactive support from local PSCo reactive support equipment to compensate in order to maintain the Pawnee 230 kV scheduled voltage. This significantly reduces the available reactive capability for voltage control from the existing sources and needs to be mitigated. Additional capacitors at the Pawnee/Peetz Logan Capacitor Station totaling 109 Mvar were found to be an effective means of returning the reactive power injection to pre-project levels. Also, with the proposed wind facilities energized but generating 0 MW, the study also found that 6 Mvar of additional line charging was introduced, which would require compensation for the low/no-wind generation scenario. The wind plant developer will need to perform further studies to determine the optimum equipment configuration and locations for reactive power compensation devices to allow this facility to meet PSCo reactive power requirements.

The short circuit analysis showed that no PSCo-owned circuit breakers are expected to experience short circuit duty problems due to the installation of the proposed wind farm. Calculated short circuit levels can be found in the body of the report.

Cost Estimates

This study found that the proposed generation cannot be accommodated without the installation of the **Pawnee-Daniels Park 345 kV Project**. The estimated cost of this project is **$177.8 M**. The current planned in-service date is **May 2019**. This project will not be in-service by the current requested in-service date of the proposed generation of December 2015.

Figure 1 Pawnee Substation and Surrounding Transmission System

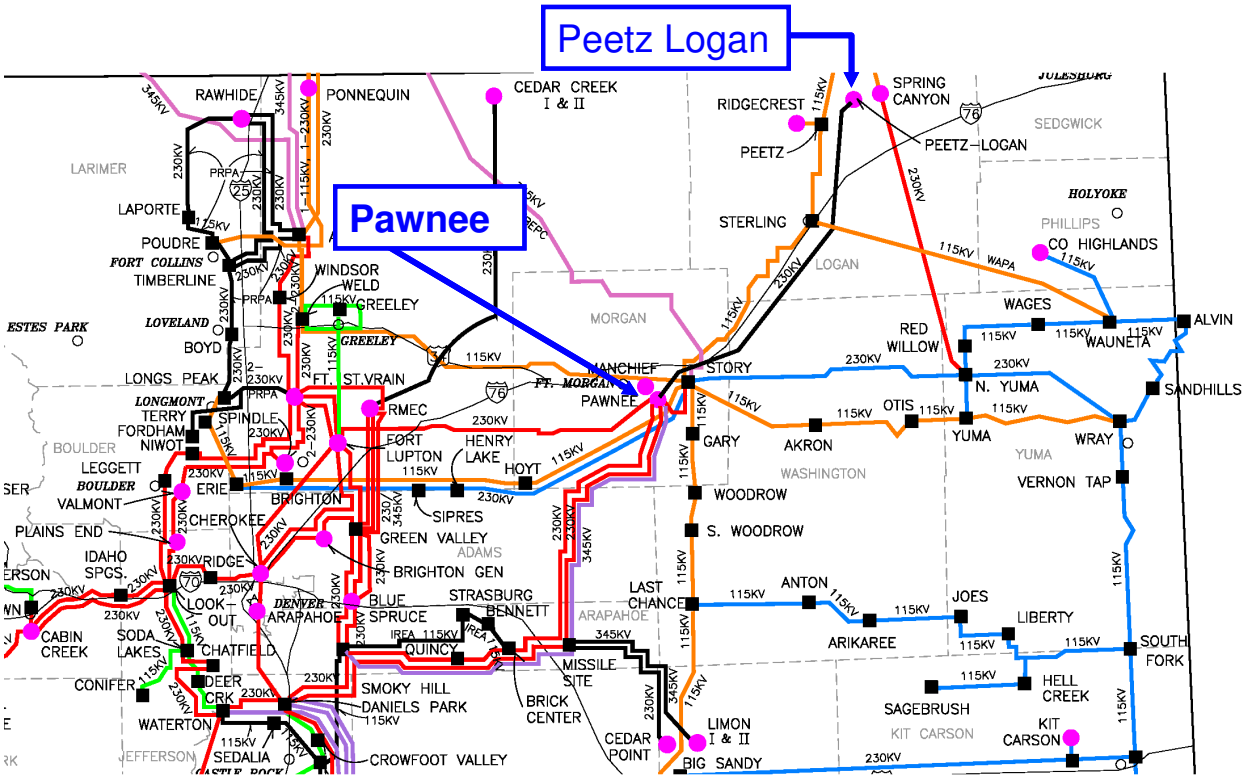
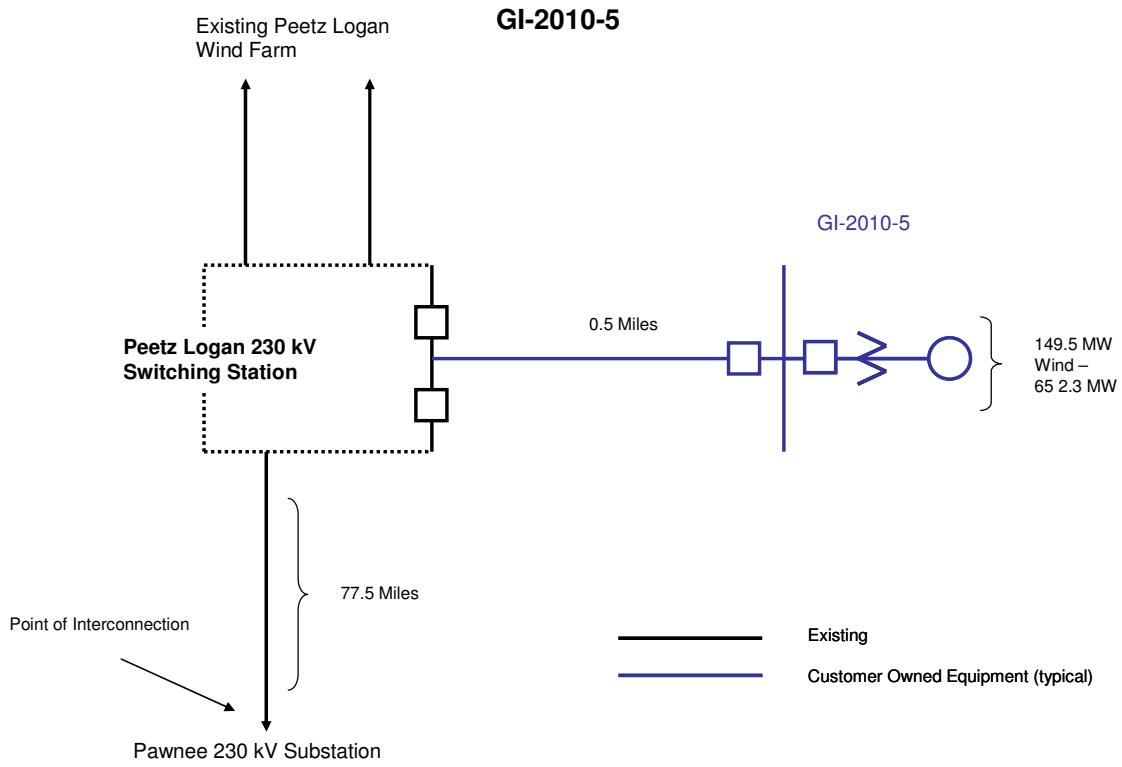


Figure 2: GI-2010-05 Conceptual Diagram



B. Introduction

Public Service Company of Colorado (PSCo) received an interconnection request (GI-2010-05) for a 149.5 MW wind turbine generation facility in Logan County, Colorado. The interconnection request was received March 5, 2010. The wind generation facility will consist of 65 Siemens 2.3 MW wind turbine generators. This facility will be an expansion of the existing Peetz Logan wind farm complex and will use the existing Peetz Logan – Pawnee 230 kV line for the interconnection (see Figures 1 & 2 below). The original requested in-service date was June 1, 2011. This date was subsequently revised to December 31, 2015.

C. Study Scope and Analysis

The Feasibility Study consisted of steady-state power flow analyses to examine the impact of the proposed wind plant on the thermal and voltage performance of the transmission grid. The power factor performance of the wind plant interconnection at the Pawnee 230 kV point of interconnection (POI) was also considered. A 2017 peak summer power flow base case was used for the studies, although the PSCo generation dispatch represented expected 2016 peak summer conditions. The short circuit impact of the proposed wind plant was also considered. The results of these studies were used to identify network upgrades required to deliver the proposed generation to PSCo loads. They also identified the need for additional reactive power correction associated with the proposed addition to the Peetz Logan wind farm.

PSCo adheres to NERC & WECC Reliability Criteria, as well as internal Company criteria for planning studies. During system intact conditions, criteria are to maintain transmission system bus voltages between 0.95 and 1.05 per unit (pu) of nominal and steady-state power flows below the continuous thermal ratings of all facilities. Based on the recommendations in the Colorado Coordinated Planning Group's (CCPG) Rocky Mountain Area Voltage Coordination Guidelines, in the area surrounding the Pawnee POI, PSCo tries to maintain a transmission system voltage profile ranging from 1.02 per unit to 1.03 per unit at regulating (generation) buses and 1.0 per unit to 1.03 per unit at transmission load buses. However, at the Pawnee 230 kV bus, the voltage target is normally 1.03 per unit to 1.04 per unit. Following a single contingency, transmission system steady state bus voltages must remain within 0.90 per unit to 1.05 per unit, power flows on transmission lines must remain within 100% of their continuous thermal ratings, and transformer flows must remain within their 8 hour emergency thermal ratings. Following a NERC Category C contingency, transmission system steady state bus voltages must remain within 0.90 per unit to 1.05 per unit, and power flows on transmission lines and transformers within 100% of their 30 minute emergency thermal ratings.

This interconnection request was evaluated for both Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection Service (ERIS).

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.

Energy Resource Interconnection Service shall mean an Interconnection Service that allows the Interconnection Customer to connect its Generating Facility to the Transmission Provider's Transmission System to be eligible to deliver the Generating Facility's electric output using the existing firm or non-firm capacity of the Transmission Provider's Transmission System on an as available basis. Energy Resource Interconnection Service in and of itself does not convey transmission service.

For this project, potential Affected Parties were Tri-State Generation & Transmission (TSG&T), Westeran Area Power Administration (WAPA) and the Intermountain Rural Electric Association (IREA).

D. Power Flow Study Models

The power flow studies were based on the WECC approved 19HS2A1_R335 case. This case was modified to represent 2017 peak summer conditions in the Colorado Coordinated Planning Group area, although the PSCo generation dispatch was adjusted to represent expected 2016 peak summer conditions. PSCo loads in the case were adjusted to reflect the most recent PSCo load forecast available by the end of January 2014. IREA load was also adjusted to reflect IREA's latest load forecast (November 2013). The topology was also updated to reflect current project plans. Updates and adjustments were included for the PSCo, Intermountain REA (IREA), Colorado Springs Utilities (CSU), Tri-State G&T (TSG&T), Western Area Power Authority (WAPA), Platte River Power Authority (PRPA), Black Hills Energy (BHE), and Basin Electric Power Cooperative (BEPC) systems.

Four main power flow generation dispatch scenarios were evaluated. Two were created as reference scenarios with the wind generation at either Missile Site Substation or Keenesburg Substation at 79% of nameplate. The other was modeled at 23% of nameplate. The 79% generation level represents the historical summertime collective maximum of PSCo-connected wind generation from 2008-2010 for the highest 100 summer PSCo load hours. The 23% generation level represents the historical summertime collective average of PSCo-connected wind generation for the same load hours. In both cases, other wind in the area around the Pawnee Substation was dispatched at 79% (Spring Canyon – 2x47.6 MW and Ridgecrest – 23.5 MW). All of the existing or planned PV solar (by 2016 summer) was dispatched at 100% and the remaining PSCo thermal generation was dispatched according to their relative generation costs. At the POI at Pawnee, the existing wind generation at Peetz Logan was modeled at 100% of nameplate. The Pawnee coal generation and Manchief Combustion Turbines (CTs) were also modeled in service and at 100% of summer nameplate. These cases were then modified to create separate cases that include the proposed 149.5 MW of wind generation connected to the Peetz

Logan 230 kV switching station. The resulting PSCo generation dispatches can be found in Appendix Section C.

In the case with the proposed generation, the 149.5 MW of new wind turbine generation was added to the Peetz Logan Wind Farm complex using models provided by the Developer. The wind plant model included a developer-owned 230 kV line, one 34.5/230 kV main step-up transformer, an equivalent 34.5 kV collector system branch, one equivalent 0.69/34.5 kV generator step-up transformer, and one equivalent wind turbine generator (65x2.3=149.5). The equivalent generator was modeled with a +/- 0.90 power factor (pf) reactive capability. The main step-up transformer high-side tap was set to the 1.000 pu tap. The generator step-up transformer high-side tap was set to the 1.025 pu tap. The generation dispatch with the new wind farm can also be found in Appendix Section C.

Please note that in an email dated 1/27/2012 from the Developer, the rating of the Developer's Peetz Logan to Pawnee 230 kV line was given as 1418 A or 565 MVA. With the proposed Peetz Logan wind farm addition, this line is overloaded in the base case at 125% of 565 MVA. The same email mentions the Developer's intent to use a dynamic line rating strategy, but during the modeled summer peak conditions, this may not yield much additional thermal capability. It is also notable that of the combined total of 725 MW of Peetz Logan wind generation, only about 660 MW are injected at the Pawnee 230 kV POI because of wind farm transmission line MW losses.

E. Power Flow Study Process

Contingency power flow studies were completed on the reference models and the models with the proposed new generation using PTI's PSSE Ver. 33.4.0 program. Results from each of the cases were compared and new overloads or overloads that increased significantly in the new generation case were noted. Voltage criteria violations were also recorded. The PSSE Ver. 33.4.0 ACCC contingency analysis activity was used to perform the power flow contingency analysis. The PSCo Category B & C analyses were performed using contingency definitions that reflect breaker to breaker outages. Single branch switching was also performed for branches in Areas 70 & 73 to capture contingencies for which breaker to breaker outage definitions were not available. Single unit outages were also modeled for generators in Areas 70 & 73. The facilities in Zones 700, 703, 704, 705, 706, 752, 753, 754, 756, 757, 505, 506, 707, 713 and 770 were monitored for overloads and voltage problems.

F. Power Flow Thermal Results

Network Resource Interconnection Service

The results of the Network Resource NERC Category B & C contingency analyses are summarized in Tables 5-8 in Sections A & B of the Appendix. As the results show, there are several facilities that experience significant overloads, or overload increases, as a result of the

addition of the proposed 149.5 MW generation at the Peetz Logan wind farm. Of greatest significance, in the results of the Category B contingency analyses with the wind generation at Missile Site at 79% of nameplate, the 8 hour emergency ratings of each of the two Smoky Hill 345/230 kV transformers were found to be overloaded in the benchmark case for the contingency loss of the other Smoky Hill 345/230 kV transformer (see Table 5). The overloads for each were 102.5% of the 644 MVA emergency rating. This overload increased to 106.1% with the proposed generation.

PSCo already has budgeted plans to implement transmission reinforcements that are expected to alleviate previously projected contingency overloads of the Smoky Hill 345/230 kV transformers. Other facility overloads in the contingency results are also expected to be alleviated. These plans involve the construction of the **Pawnee-Daniels Park 345 kV Project**. This project includes construction of the Pawnee-Daniels Park 345 kV circuit, the Daniels Park-Smoky Hill 345 kV circuit and the Harvest Mile 345/230 kV substation. The Harvest Mile substation is essentially a bus extension of the Smoky Hill 345/230 kV substation and is intended to facilitate the addition of more transformation in parallel with the two Smoky Hill 345/230 kV transformers. The Pawnee-Daniels Park 345 kV project has a planned in-service date of May 2019. Further information about this project can be found in PSCo's Colorado Public Utilities Commission Rule 3627 10 Year Plan filing under Proceeding 14M-0110E. More information about this project can also be found at – http://sb100transmission.com/projects/pawnee-daniels-park/index.asp.

Energy Resource Interconnection Service

In addition to the Network Resource contingency analysis, the Energy Resource status of the proposed generation was also considered. As defined in Section C above, Energy Resource Interconnection Service allows the Customer to deliver a 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. For the 2017 peak summer conditions studied with the Missile Site wind generation at 79% of nameplate, there is no ERIS available. This is primarily due to the benchmark case overloads of the two Smoky Hill 345/230 kV transformers. However, for other system scenarios, some firm or non-firm transmission capability may be available depending upon actual generation dispatch levels, demand levels, WECC Major Path import levels (TOT 3, TOT 7, etc.) and the operational status of transmission facilities.

G. Voltage Regulation and Reactive Power Capability

Interconnection Customers are required to interconnect their Large Generating Facilities with Public Service of Colorado's (PSCo) Transmission System in conformance to the *Xcel Energy Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater Than 20 MW* (available at http://www.xcelenergy.com/staticfiles/xe/Regulatory/Transmission-Interconnection-Guidelines-Great-20MW.pdf). Wind generating plant interconnections must also conform to the performance requirements in FERC Order 661-A. Accordingly, the following voltage regulation

and reactive power capability requirements (at the POI) are applicable to this interconnection request:

- To ensure reliable operation, all Generating Facilities interconnected to the PSCo transmission system should adhere to the CCPG Rocky Mountain Area Voltage Coordination Guidelines. These can be found by clicking on the • Reports link at http://www.westconnect.com/planning_ccpg_voltage_coord.php. Accordingly, since the POI for this interconnection request is located within Northeast Colorado Region 7; the applicable ideal transmission system voltage profile range is 1.02 – 1.03 per unit at regulated buses (except Pawnee 230 kV) and 1.0 – 1.03 per unit at non-regulated buses. Also, a voltage schedule of 1.03 to 1.04 per unit is ideal for the Pawnee 230 kV bus.
- Xcel Energy's OATT requires all Interconnection Customers to have the reactive capability to achieve +/– 0.95 power factor at the POI, with the maximum "full output" reactive capability available at all output levels. Furthermore, Xcel Energy requires all Interconnection Customers to have dynamic voltage control and maintain the voltage specified by the Transmission Operator within the limitation of +/– 0.95 power factor at the POI, as long as the generating plant is on-line and producing power.
- The *Xcel Energy Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater Than 20 MW* also specify that Generators generally must provide for their own reactive power needs, including the reactive power needs of their Generator Step-Up transformer (GSU).
- It is the responsibility of the Interconnection Customer to determine the actual type (switched shunt capacitors and/or switched shunt reactors, etc.), size (MVAR), and locations (690 V, 34.5 kV or 230 kV bus) of any additional static reactive power equipment needed within the generating plant in order to have the reactive capability to meet the +/– 0.95 power factor and the 1.03 – 1.04 per unit voltage range standards at the Pawnee 230 kV POI. Further, for wind generating plants to meet the Low Voltage Ride Through (LVRT) performance requirements specified in FERC Order 661-A, appropriately sized and located reactive power compensation devices (capacitor, DVAR, SVC, etc.) may need to be installed within the generating plant.
- The Interconnection Customer is required to demonstrate to the satisfaction of PSCo Transmission Operations prior to the commercial in-service date of the generating plant that it can safely and reliably operate within the required power factor and voltage ranges (noted above).

This study examined the ability of the proposed wind plant to adhere to the power factor and reactive power requirements of the interconnection guidelines. With the existing Peetz Logan wind generation at maximum output and all facilities in service, the Peetz Logan wind farm is injecting 33.6 Mvar into the Pawnee 230 kV point of interconnection (POI) with the voltage there at 1.030pu. With the 149.5 MW of additional proposed generation, the Peetz Logan wind farm is absorbing 82.3 Mvar, demonstrating an increase in reactive power losses of 115.9 Mvars. This value was calculated with no additional reactive support at the Pawnee/Peetz Logan 230 kV capacitor station, which currently has 200 Mvar of existing capacitors. These values, along with

the associated reactive power injections from the local generation at Pawnee, are shown in Table 1 below.

Table 1 – Reactive Power Injections at Pawnee with and without GI-2010-05

Reactive Power Injection Source	Missile Site Wind @ 79% Keenesburg Wind @ 23%		Missile Site Wind @ 79% Keenesburg Wind @ 23%	
	Benchmark	With GI-2010-05	Benchmark	With GI-2010-05
	Mvars	Mvars	Mvars	Mvars
Peetz Logan Wind Farm (injected at Pawnee 230 kV)	+33.6	-82.3	+33.6	-82.3
Pawnee Unit 1 (gen gross)	+104.8	+181.5	+91.8	+170.2
Manchief Unit 1 (gen gross)	+41.2	+71.3	+36.1	+66.9
Manchief Unit 2 (gen gross)	+41.2	+71.3	+36.1	+66.9

As can be seen, the additional reactive losses required substantial increases in reactive support from local reactive power sources to compensate in order to maintain the Pawnee 230 kV scheduled voltage. This significantly reduces the available reactive capability for voltage control from the existing sources and needs to be mitigated. The addition of an additional 109 Mvar of capacitor banks at that location restored the amount of reactive power flow at Pawnee/Peetz Logan 230 kV to within 0.2 Mvar of the pre-project flow.

The analyses also showed that with all facilities in service but 0 MW of generation from the proposed wind generators, there are approximately 6 Mvars of line charging injected from the new facilities with a voltage of 1.0238pu at the Peetz Logan 230 kV Switching Station. For this wind generation scenario, the wind farm additional reactive power injection would need to be compensated.

The Developer will need to perform additional studies to determine the capabilities, optimum location(s) and configuration(s) for the reactive compensation required to meet the reactive power requirements at the Pawnee 230 kV POI.

H. Short Circuit

For the Developer's proposed wind farm addition at the Peetz Logan wind farm complex, no PSCo-owned circuit breakers are expected to exceed their capabilities following installation of the new generation. The calculated short circuit levels and Thevenin system equivalent impedances for the POI at the Pawnee 230 kV station are shown in Tables 2 & 3 below.

Table 2 – Short Circuit Parameters at the Pawnee 230 kV POI – Without GI-2010-05

System Condition	Three-Phase Fault Level (Amps)	Single-Line-to-Ground Fault Level (Amps)	Thevenin System Equivalent Impedance (R +j X) (ohms)
System Intact	29911.4	33559.6	Zpos 0.28152 +j 4.43053 Zneg = 0.28611 +j 4.43615 Z0 = 0.19753 +j 2.97920
Strongest Generation Source Out – Pawnee Unit 1	23699.3	28052.1	Zpos 0.43710 +j 5.58607 Zneg = 0.44467 +j 5.59479 Z0 = 0.19753 +j 2.97920
Strongest Transmission Source Out – One Pawnee 345/230 kV Tr.	28472.2	31635.6	Zpos 0.29673 +j 4.65443 Zneg = 0.30124 +j 4.66072 Z0 = 0.23549 +j 3.24976

Table 3 – Short Circuit Parameters at the Pawnee 230 kV POI – With GI-2010-05

System Condition	Three-Phase Fault Level (Amps)	Single-Line-to-Ground Fault Level (Amps)	Thevenin System Equivalent Impedance (R +j X) (ohms)
System Intact	30143.6	33768.3	Zpos = 0.28120 +j 4.39628 Zneg = 0.28572 +j 4.40180 Z0 = 0.19827 +j 2.97429
Strongest Generation Source Out – Pawnee Unit 1	23931.7	28278.8	Zpos 0.43498 +j 5.53166 Zneg = 0.44242 +j 5.54021 Z0 = 0.19827 +j 2.97429
Strongest Transmission Source Out – One Pawnee 345/230 kV Tr.	28704.4	31841.3	Zpos 0.29635 +j 4.61664 Zneg = 0.30080 +j 4.62283 Z0 = 0.23630 +j 3.24391

I. Costs Estimates and Assumptions

GI-2010-05 (Feasibility Study Report)

The Developer has requested a 149.5 MW Wind Generation Project addition to the Peetz Logan wind farm complex that interconnects via an existing Developer-owned 230 kV line to the 230kV bus at the Pawnee Substation. The Feasibility Study has determined that this project cannot be accommodated without the addition of the Pawnee-Daniels Park 345 kV Project. The estimated total cost for this project is **$177,800,000.** It is not planned to be in service until May 2019.

The estimated project costs shown in the Table 4 below are (+/-30%) estimates in 2014 dollars 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, procurement and construction of these new PSCo facilities.

Table 4 – Pawnee-Daniels Park 345 kV Project

Element	Sub Cost (Millions)	Cost Est. (Millions)
Siting and Land Rights Permitting / Acquisition		**$ 6.1**
Substation Costs		**$ 52.8**
Pawnee Substaton	$ 5.8	
Smoky Hill Substation	$ 5.4	
Daniels Park Substation	$ 6.9	
Harvest Mile Substation	$27.7	
Missile Site Substaton	$ 7.0	
Transmission Line Costs		**$118.9**
Pawnee – Daniels Park		**$118.9**
Time Frame to site, design, procure and construct		**48 months**
Total Project Estimate		**$177.8**

Appendix

GI-2010-05
Pawnee/Peetz Logan 230 kV – 149.5 MW

A. Power flow Thermal Results – 2017 Peak Summer Conditions
Missile Site Wind @ 79% (673.1 MW) of nameplate
Keenesburg Wind @ 23% (126.5 MW) of nameplate

Table 5 – GI-2010-05 Summary Listing of Worst Case Overloaded Facilities[1] (Category B Contingencies)

				Branch Contingency Loading Without GI-2010-05		Branch Contingency Loading With GI-2010-05			
Monitored Facility (Line or Transformer)	**Type**	**Facility Owner**	**Branch Rating MVA (Norm/Emer)**	**Cat B Flow in MVA (Current Equiv[2])**	**Cat B Flow in % Current Equiv of Normal/Emer Rating**	**Cat B Flow in MVA (Current Equiv[2])**	**Cat B Flow in % Current Equiv of Normal/Emer Rating**	**% Change**	**NERC Category B Contingency Outage**
Smoky Hill 345/230 kV T4	Xfmr	PSCo	560 / 644	660.0	117.9% **/ 102.5%**	683.5	122.1% **/ 106.1%**	4.2% / 3.6%	Smoky Hill 345/230 kV T5
Smoky Hill 345/230 kV T5	Xfmr	PSCo	560 / 644	660.0	117.9% **/ 102.5%**	683.5	122.1% **/ 106.1%**	4.2% / 3.6%	Smoky Hill 345/230 kV T4
Archer/Arrow 345/230 kV T1	Xfmr	WAPA	500 / 500	596.8	**119.4% / 119.4%**	610.9	**122.2% / 122.2%**	2.8% / 2.8%	Ault – Laramie River 345 kV

[1] Includes facilities with an Impact Factor of 2% or more of the proposed 149.5 MW generation.
[2] Current-corrected flows for transmission lines only

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Table 6 – GI-2010-05 Summary Listing of Worst Case Overloaded Facilities[1] (Category C Contingencies)

				Branch Contingency Loading Without GI-2010-05		Branch Contingency Loading With GI-2010-05			
Monitored Facility (Line or Transformer)	**Type**	**Facility Owner**	**Branch Rating MVA (Norm/Emer)**	**Cat C Flow in MVA (Current Equiv[2])**	**Cat C Flow in % Current Equiv of Normal/Emer Rating**	**Cat C Flow in MVA (Current Equiv[2])**	**Cat C Flow in % Current Equiv of Normal/Emer Rating**	**% Change**	**NERC Category C Contingency Outage**
Clark – Jordan 230 kV	Line	PSCo	331 / 331	369.5	111.6% **/ 111.6%**	377.1	113.9% **/ 113.9%**	2.3% / 2.3%	DCT Smoky Hill – Sullivan 230 kV Smoky Hill – Leetsdale 230 kV
Pawnee – Ft Lupton 230 kV	Line	PSCo	481 / 529	499.7	103.9% **/ 94.5%**	544.7[3]	113.3% **/ 103.0%**	9.4% / 8.5%	DCT Missile Site – Daniels Park 230 kV Missile Site – Smoky Hill 345 kV
Pawnee – Story 230 kV	Line	PSCo / TSGT	648 / 648	836.9	**129.2% / 129.2%**	927.0[4]	**143.1% / 143.1%**	13.9% / 13.9%	DCT Missile Site – Daniels Park 230 kV Missile Site – Smoky Hill 345 kV
Archer/Arrow 345/230 kV T1	Xfmr	WAPA	500 / 500	596.7	**119.4% / 119.4%**	611.0	**122.2% / 122.2%**	2.8% / 2.8%	Breaker Failure Ault – Laramie River 345 kV Ault 345/230 kV KU1B

[1] Includes facilities with an Impact Factor of 2% or more of the proposed 149.5 MW generation.
[2] Current-corrected flows for transmission lines only
[3] This overload decreases to 539.0 MVA (112.1%/101.9%) following the addition of 109 Mvar of capacitor banks at the Pawnee-Peetz Logan 230 kV capacitor station.
[4] This overload decreases to 910.7 MVA (140.5%/140.5%) following the addition of 109 Mvar of capacitor banks at the Pawnee-Peetz Logan 230 kV capacitor station.

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Appendix

GI-2010-05
Pawnee/Peetz Logan 230 kV – 149.5 MW

B. Power flow Thermal Results – 2017 Peak Summer Conditions
Missile Site Wind @ 23% (196.1 MW) of nameplate
Keenesburg Wind @ 79% (434.5 MW) of nameplate

Table 7 – GI-2010-05 Summary Listing of Worst Case Overloaded Facilities[1] (Category B Contingencies)

				Branch Contingency Loading Without GI-2010-05		Branch Contingency Loading With GI-2010-05			
Monitored Facility (Line or Transformer)	**Type**	**Facility Owner**	**Branch Rating MVA (Norm/Emer)**	**Cat B Flow in MVA (Current Equiv[2])**	**Cat B Flow in % Current Equiv of Normal/Emer Rating**	**Cat B Flow in MVA (Current Equiv[2])**	**Cat B Flow in % Current Equiv of Normal/Emer Rating**	**% Change**	**NERC Category B Contingency Outage**
California – Cherokee 115 kV	Line	PSCo	137 / 137	148.3	**108.3% / 108.3%**	151.9	**110.8% / 110.8%**	2.5% / 2.5%	Capitol Hill – Cherokee 115 kV
Capitol Hill – Mapleton 1 115 kV	Line	PSCo	152 / 179	172.5	**113.5% / 96.4%**	177.0	**116.4% / 98.9%**	2.9% / 2.5%	Cherokee – Denver Terminal 115 kV
Leetsdale 1 – University 115 kV	Line	PSCo	181 / 210	137.7	**76.1% / 65.6%**	183.5	**101.4% / 87.4%**	25.3% / 21.8%	Arapahoe 230/115 kV T5
Henry Lake 230/115 kV	Xfmr	TSGT	100 / 100	118.6	**118.6% / 118.6%**	122.1	**122.1% / 122.1%**	3.5% / 3.5%	Barr Lake – Green Valley 230 kV
Prairie Center – Reunion 115 kV	Line	TSGT	60 / 60	69.8	**116.4% / 116.4%**	73.3	**122.1% / 122.1%**	5.7% / 5.7%	Barr Lake – Green Valley 230 kV
Archer/Arrow 345/230 kV T1	Xfmr	WAPA	500 / 500	569.0	**113.8% / 113.8%**	580.7	**116.1% / 116.1%**	2.3% / 2.3%	Ault – Laramie River 345 kV

[1] Includes facilities with an Impact Factor of 2% or more of the proposed 149.5 MW generation.
[2] Current-corrected flows for transmission lines only

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Table 8 – GI-2010-05 Summary Listing of Worst Case Overloaded Facilities[1] (Category C Contingencies)

				Branch Contingency Loading Without GI-2010-05		Branch Contingency Loading With GI-2010-05			
Monitored Facility (Line or Transformer)	**Type**	**Facility Owner**	**Branch Rating MVA (Norm/Emer)**	**Cat C Flow in MVA (Current Equiv[2])**	**Cat C Flow in % Current Equiv of Normal/Emer Rating**	**Cat C Flow in MVA (Current Equiv[2])**	**Cat C Flow in % Current Equiv of Normal/Emer Rating**	**% Change**	**NERC Category C Contingency Outage**
California – Cherokee 115 kV	Line	PSCo	137 / 137	173.6	126.7% / **126.7%**	177.2	129.3% / **129.3%**	2.6% / 2.6%	DCT Cherokee – Sandown 115 kV Cherokee – Capitol Hill 230 kV
Capitol Hill – Denver Terminal 115 kV	Line	PSCo	131 / 131	152.8	116.7% / **116.7%**	156.2	119.3% / **119.3%**	2.6% / 2.6%	DCT Cherokee – Denver Terminal 115 kV Cherokee – Lacombe 230 kV
Capitol Hill – Mapleton 1 115 kV	Line	PSCo	152 / 179	196.8	129.5% / **110.0%**	202.3	133.1% / **113.0%**	3.6% / 3.0%	DCT Cherokee – Denver Terminal 115 kV Cherokee – Lacombe 230 kV
Clark – Jordan 230 kV	Line	PSCo	331 / 331	332.9	100.5% / **100.5%**	356.0	107.6% / **107.6%**	7.1% / 7.1%	DCT Smoky Hill – Sullivan 230 kV Smoky Hill – Leetsdale 230 kV
Coors Recycling – Ft Lupton 115 kV	Line	PSCo	120 / 144	122.4	102.0% / **85.0%**	125.7	104.8% / **87.3%**	2.8% / 2.3%	DCT Fort St Vrain – Isabelle 230 kV Fort St Vrain – Spindle 230 kV
Leetsdale 1 – University 115 kV	Line	PSCo	181 / 210	137.0	75.7% / **65.2%**	182.6	100.9% / **87.0%**	25.2% / 21.8%	Breaker Failure Arapahoe – Daniels Park 230 kV Arapahoe – Denver Terminal 230 kV
Pawnee – Story 230 kV	Line	PSCo / TSGT	648 / 648	595.8	**91.9% / 91.9%**	660.2	**101.9% / 101.9%**	10.0% / 10.0%	DCT Missile Site – Daniels Park 230 kV Missile Site – Smoky Hill 345 kV
Henry Lake 230/115 kV T1	Xfmr	TSGT	100 / 100	142.8	**142.8% / 142.8%**	147.8	**147.8% / 147.8%**	5.0% / 5.0%	DCT Cherokee – Henry Lake 230 kV Barr Lake – Reunion 230 kV
Prairie Center – Reunion 115 kV	Line	TSGT	60 / 60	93.3	**155.5% / 155.5%**	98.2	**163.6% / 163.6%**	8.1% / 8.1%	DCT Cherokee – Henry Lake 230 kV Barr Lake – Reunion 230 kV
Archer/Arrow 345/230 kV T1	Xfmr	WAPA	500 / 500	569.0	**113.8% / 113.8%**	580.8	**116.2% / 116.2%**	2.4% / 2.4%	Breaker Failure Ault – Laramie River 345 kV Ault 345/230 kV KU1B

[1] Includes facilities with an Impact Factor of 2% or more of the proposed 149.5 MW generation.
[2] Current-corrected flows for transmission lines only

C. Generation Dispatch

Case Description: 2017 Peak Summer, Missile Site Wind @ 79% of nameplate, Keenesburg Wind @ 23% of nameplate, based on WECC 17hs1ap.sav with updates from CCPG companies.

Benchmark Case – GI-2010-05

Arapahoe Unit 3 & 4	0 MW
Cabin Creek Units	210 MW
Cherokee Units 1 – 3	0 MW
Cherokee Unit 4	383 MW
Cherokee Unit 5-7	603.8 MW
Comanche Unit 1	360 MW
Comanche Unit 2	365 MW
Ft Lupton Units 1 & 2	0 MW
Pawnee Unit 1	536 MW
Manchief Units 1 & 2	259.5 MW
Ft St Vrain Units 1-4	700 MW
Valmont Unit 5	196 MW
Valmont Unit 6	0 MW
Alamosa Units 1 & 2	0 MW
JM Shaffer – Ft Lup	279.8 MW
Brush Units 1, 3, & 4	0 MW
Brush Unit 2	0 MW
QF UNC	0 MW
Arapahoe Units 5-7	0 MW
Lamar DC Tie	0 MW but regulating voltage
Spruce Units 1 & 2	0 MW
Knutson Units 1 & 2	0 MW
Fountain Valley Units	0 MW
Plains End Units	0 MW
RMEC Units 1-3	586 MW
Spindle Units 1 & 2	0 MW
Comanche Unit 3	788 MW
Ft St Vrain Units 5 & 6	0 MW
Jackson Fuller Wind	57.5 MW (23%)
Colorado Grn/Twin Buttes	54.5 MW (23%)
Spring Canyon Wind	94.8 MW (79%)
Ridgecrest Wind	23.5 MW (79%)
Cedar Point Wind (MS 230 kV)	197.7 MW (79%)
Limon Wind (MS 345 kV)	474.5 MW (79%)
Peetz Logan 230 kV	575.5 MW (100%)
Cedar Creek Wind	126.8 MW (23%)
Comanche Solar	120 MW
San Luis Valley Solar	85.2 MW

GI-2010-05 Case Adjustments

GI-2010-05	149.5 MW
Ft St Vrain Units 1-4	674.8 MW
JM Shaffer – Ft Lup	181.7 MW

Case Description: 2017 Peak Summer, Missile Site Wind @ 23% of nameplate, Keenesburg Wind @ 79% of nameplate, based on WECC 17hs1ap.sav with updates from CCPG companies.

Benchmark Case – GI-2010-05

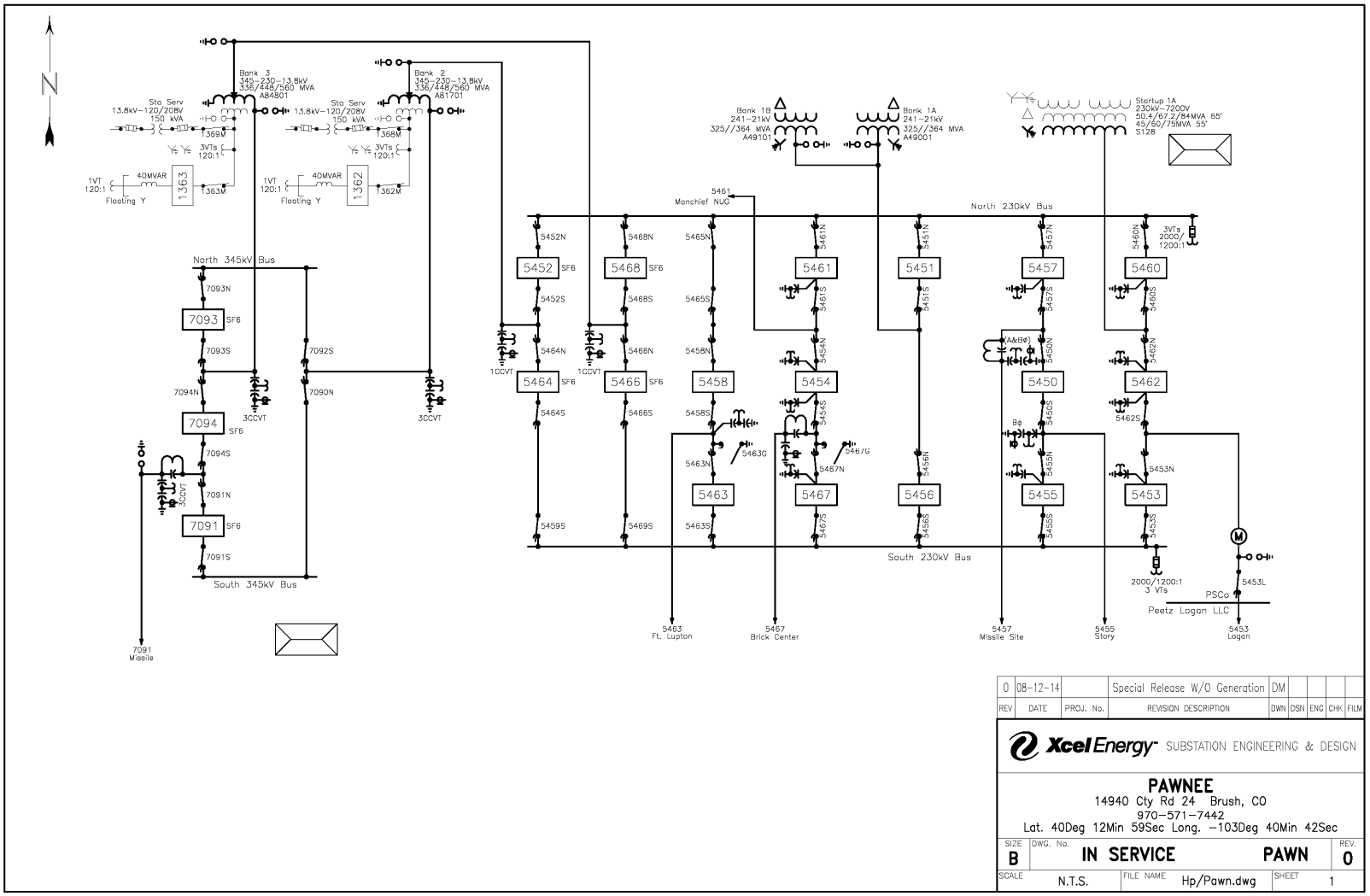
Arapahoe Unit 3 & 4	0 MW
Cabin Creek Units	210 MW
Cherokee Units 1 – 3	0 MW
Cherokee Unit 4	383 MW
Cherokee Unit 5-7	603.8 MW
Comanche Unit 1	360 MW
Comanche Unit 2	365 MW
Ft Lupton Units 1 & 2	0 MW
Pawnee Unit 1	536 MW
Manchief Units 1 & 2	259.5 MW
Ft St Vrain Units 1-4	700 MW
Valmont Unit 5	196 MW
Valmont Unit 6	0 MW
Alamosa Units 1 & 2	0 MW
JM Shaffer – Ft Lup	310.9 MW
Brush Units 1, 3, & 4	0 MW
Brush Unit 2	0 MW
QF UNC	0 MW
Arapahoe Units 5-7	118 MW
Lamar DC Tie	0 MW but regulating voltage
Spruce Units 1 & 2	0 MW
Knutson Units 1 & 2	0 MW
Fountain Valley Units	0 MW
Plains End Units	25.3 MW
RMEC Units 1-3	586 MW
Spindle Units 1 & 2	0 MW
Comanche Unit 3	788 MW
Ft St Vrain Units 5 & 6	0 MW
Jackson Fuller Wind	57.5 MW (23%)
Colorado Grn/Twin Buttes	54.5 MW (23%)
Spring Canyon Wind	94.8 MW (79%)
Ridgecrest Wind	23.5 MW (79%)
Cedar Point Wind (MS 230 kV)	57.5 MW (23%)

Limon Wind (MS 345 kV)	138.1 MW (23%)
Peetz Logan 230 kV	575.5 MW (100%)
Cedar Creek Wind	436.3 MW (79%)
Comanche Solar	120 MW
San Luis Valley Solar	85.2 MW

GI-2010-05 Case Adjustments

GI-2010-05	149.5 MW
Arapahoe Units 5-7	0 MW
Plains End Units	17.3 MW

D. Pawnee Substation One-Line



REV	DATE	PROJ. No.	REVISION DESCRIPTION	DWN	DSN	ENG	CHK	FILM
0	08-12-14		Special Release W/O Generation	DM				

Xcel Energy SUBSTATION ENGINEERING & DESIGN

PAWNEE
14940 Cty Rd 24 Brush, CO
970-571-7442
Lat. 40Deg 12Min 59Sec Long. -103Deg 40Min 42Sec

SIZE	DWG. No.		REV.
B	IN SERVICE	PAWN	0
SCALE	N.T.S.	FILE NAME Hp/Pawn.dwg	SHEET 1