Generation Interconnection System Impact Study Report
Request # GI-2007-13

Cedar Point Wind Energy 300 MW Project
PSCo Transmission Planning
October 20, 2008

A. Executive Summary

On January 28, 2008, Public Service Company of Colorado (PSCo) and a Customer signed an Interconnection System Impact Study request to determine the potential impacts of interconnecting a 300 MW wind powered generation plant at a new PSCo 230 kV switching station (Missile Site) on the PSCo Pawnee-Brick Center-Smoky Hill 230 kV line. The customer also requested that PSCo study an interconnection on the PSCo Pawnee-Daniels Park 230 kV line. The location of this new switching station is assumed to be adjacent to the Pawnee-Brick Center-Smoky Hill /Pawnee-Daniels Park 230 kV double circuit line approximately 57 miles from the Pawnee Substation. The Missile Site Switching Station would serve as the POI where the Customer's proposed new 40-mile, radial 230 kV line from their proposed new Cedar Point Wind Project location (GI-2007-13) would interconnect with the PSCo 230 kV system. The Customer requested that PSCo bypass the Feasibility Study and go immediately to the System Impact phase of the study.

The Customer initially proposed a 300 MW wind generation facility using one-hundred fifty 2.0 MW Gamesa Model G87-2.0 wind turbine generators lumped as two single 150 MW, 34.5 kV simple generators with associated dedicated 230-34.5 kV main step-up transformers. Subsequently, the Customer changed the turbine generator manufacturer from Gamesa to General Electric. The wind facilities considered for this study consisted of two hundred GE-1.5 WindRIDE-THRU LVRT-II (Low Voltage Ride Through) wind turbine generators that provide uninterrupted turbine operation through grid disturbances. The units were modeled with a +/- 0.95 power factor capability.

The study represented the facility as two wind generating facilities approximately 150 MW each, separated by 7.6 miles per request by the Customer. Each farm would require one hundred GE-1.5 MW wind turbine generators with associated 34.5 kV collector systems and transformers to step up the voltage from to 34.5 kV to 230 kV at the Customer wind generating facility sites. The distance from the POI to the first site (as provided by the Customer) would be 32.4 miles and the distance from the first site to the second site (provided by the Customer) would be 7.6 miles, for a total of 40 miles from the POI to the more remote site. The sites would connect to the POI with a 230 kV transmission line. Interconnecting to either the Pawnee-Brick Center-Smoky Hill 230 kV line or the Pawnee-Daniels Park 230 kV line would require the construction of a new PSCo 230 kV "Missile Site" Switching Station. Alternative 1 assumed an interconnection on the Pawnee-Brick Center-Smoky Hill 230 kV line and Alternative 2 assumed an interconnection on the Pawnee-Daniels Park 230 kV transmission line.

The Customer proposed commercial operation in-service date is December 1, 2009 with an assumed in-service date for back feed of June 30, 2009. The Customer was notified in previous

discussions that this was a very aggressive schedule. The ability to meet this schedule is addressed in the Study Report.

This request was studied as both a Network Resource (NR)[1], and as an Energy Resource (ER)[2]. This investigation included steady-state power flow studies, short-circuit analysis, and transient dynamic stability 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 LGIP queue, other than the generation projects that are already approved and planned to be in service by the summer of 2009.

PSCo Engineering and Siting and Land Rights conducted studies and determined that the time required to site, engineer, procure and construct the Missile Site Switching Station would be approximately 18 months from the Authorization to Proceed to the completion of the project. Based on this information, the required transmission upgrades would not be achievable by June 30, 2009, consistent with providing back-feed service prior to the requested commercial operation in-service date of December 1, 2009. PSCo Engineering and Siting and Land Rights indicated that if a CPCN were required for the project, then approximately 10 to 12 months would need to be added to the 18-month schedule assumed for this project. In July 2008, the Public Utilities Commission of the State of Colorado ruled that no Certificate of Public Convenience and Necessity (CPCN) would be required for the "Missile Site 230kV Switching Station (In-service May 31, 2010)" Project that PSCo submitted through the Rule 3206 annual filing process. Therefore, the 18-month schedule for the Missile Site 230kV Switching Station should still be valid. Based on these investigations, it was assumed that a more likely in-service date would be somewhere between 2010 and 2011. Therefore, a 2010 heavy summer base case was used for the study.

The purpose of this System Impact Study was to evaluate the potential impacts on the PSCo transmission infrastructure with an injection of the Customer's 300 MW into the new PSCo Missile Site 230 kV bus point of interconnection (POI), and deliver the additional generation to native PSCo loads. The project cost to install the transmission interconnection facilities (ER & NR), and transmission system infrastructure (NR) upgrades necessary to accommodate the added Customer generation has been evaluated by Engineering, with the details of these upgrades identified in the Power Flow Study Results and Conclusions.

Power flow studies show that interconnecting to the Pawnee-Brick Center-Smoky Hill 230 kV line would require system upgrades that an interconnection to the Pawnee-Daniels Park 230 kV line would not require. Therefore, an interconnection on the Pawnee-Daniels Park 230 kV line (Alternative 2) was selected as the preferred alternative. The results of the power flow studies are summarized in Table 2, titled "Summary Listing of Differentially Overloaded Elements".

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[1] **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.

[2] **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

Table 2 lists newly overloaded elements, or delta overloads greater than 5% of rating, due to a 300 MW Cedar Point generation injection at the POI as determined using the 2010 HS "CPnewgenPTZ400.sav" case.

The generator interconnection on the Pawnee-Daniels Park 230 kV line would require the construction of interconnection facilities from the Customer facilities to the PSCo bulk transmission system. The work required would consist of:

- A new PSCo 230 kV Missile Site Switching Station, three-breaker ring-bus breaker station, sectionalizing the Pawnee-Daniels Park 230 kV transmission line (Circuit No. 5457), approximately 57 miles from the Pawnee station, and 67 miles from the new Daniels Park Substation. (PSCo funded costs)
- Transmission line work associated with interconnecting the new Missile Site breaker station into the Pawnee– Daniels Park 230 kV transmission line. (PSCo funded costs)
- Revenue metering equipment (CT/VT metering instrument transformers, meters, recorder) and line termination equipment at the new Missile Site breaker station, associated with the Customer's Cedar Point–Missile Site 230 kV transmission line. (Customer funded costs)
- One transmission infrastructure upgrade required for delivery was identified. PSCo will replace the 1600 amp (637.4 MVA) line traps at Pawnee and Daniels Park. (Expected completion date: 4Q/2009). This upgrade will be facilitated through the PSCo Capital Construction Budget Process for FAC-009 Prioritization Projects.
- **The Estimated project cost to Interconnect to the PSCo Transmission System is $4.008 million consisting of**
  - $0.842 million for PSCo Owned and Customer-funded PSCo interconnection facilities, and
  - $3.166 million for PSCo-owned and PSCo-funded interconnection and delivery PSCo facilities, and
  - $0 for PSCo Network Upgrades for Delivery. Criteria violations will be resolved through the PSCo Capital Construction Budget Process for FAC-009 projects.

B. Stand Alone Study Results

The stand-alone results are based upon comparative studies with the Customer's new Cedar Point Wind Energy generation interconnecting at a new Missile Site Switching Station 230 kV bus (called "CP230TAP 230" in the study case) on the Pawnee-Daniels Park 230 kV line. The Customer generation was modeled in the power flow case either at a full output of approximately 300 MW, or off line at 0 MW output. The remaining PSCo balancing authority (Area 70) generation and loads in the power flow model reflect a heavy summer load, moderately heavy north-to-south stressed 2010 case. The 2010 heavy summer case was selected instead of a 2009 heavy summer case because it represents a transmission scenario that more closely matches the conditions when the wind generating facility would be interconnected.

1. Energy Resource Interconnection Service (ER)

Energy Resource Interconnection Service (ER) is 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.

The Feasibility Study determined that firm transmission capacity for the 300 MW wind generation facility 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.

2. Network Resource Interconnection Service (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.

Table 2 below is a list of the lines and autotransformers that incur new single contingency (N-1) overloading, or that become significantly overloaded as a result of adding 300 MW of new generation at the new Missile Site 230 kV bus POI. These results are for a power flow model for heavy summer 2010 system conditions, with the re-dispatched case for the maximum wind power generation at Peetz-Logan (400 MW), and new generation at FSV. Overloaded facilities that have a 3% or more differential loading between the case with the new Cedar Point generation at 300 MW vs. at 0 MW injection at Missile Site 230 kV are listed. The line ratings and limiting elements identified in Table 2 are based upon the base case ratings along with new project upgrades or additional that are already planned and budgeted for in the 2010 time frame.

Table 2 shows that with the Peetz Logan wind facility at 400 MW and the Cedar Point wind facility at 300 MW, a contingency overload of the Daniels Park-CP230TAP 230 kV line occurs at 101.2% of the 637 MVA rating[2]. The Pawnee-Daniels Park 230kV line is limited from 1600 amp (637.4 MVA) line traps at the Pawnee and Daniels Park substations. Replacing these with 2000 amp (796.7 MVA) line traps would mitigate the potential overload and the Pawnee-Daniels Park 230kV line rating could increase to 734 MVA. The 124-mile Pawnee-Daniels Park 230 kV line (Circuit No. 5457) is constructed with 2-636 kcmil conductors on 230 kV double circuit steel lattice structures.

[2] The Pawnee-Daniels Park 230kV rating was increased from 490 MVA to 637 MVA. The 490 MVA rating was based on 1-1272 kcmil aluminum jumpers at Pawnee and Daniels Park that limited the line rating to 490 MVA (summer normal rating of 1229 amps). PSCo Transmission Engineering has verified that this rating limitation has been mitigated and the present rating of the Pawnee-Daniels Park 230kV line is 637 MVA.

The System Impact Study determined that the NR Injection capability is 300 MW after network upgrades are completed. Network upgrades are additions, modifications, and upgrades to the Transmission Provider's Transmission System required at or beyond the point at which the Interconnection Facilities connect to the Transmission Provider's Transmission System to accommodate the interconnection of the Large Generating Facility to the Transmission Provider's Transmission System.

C. Study Scope and Analysis

This Interconnection System Impact Study evaluated the transmission impacts associated with the proposed interconnection of 300 MW of new Customer generation into the PSCo Transmission System at a new PSCo Missile Site 230 kV switching station. The Customer's proposed new 300 MW Cedar Point Wind Energy project would be located approximately 40 miles east of Denver in Elbert County, Colorado. The study assumed that the Customer's new 230 kV transmission line would be constructed for approximately 40 miles, from the Cedar Point Wind Project site to the PSCo 230 kV Pawnee–Daniels Park 230 kV line, interconnecting at a new PSCo 230 kV Missile Site switching station. Two alternatives were considered for the POI,

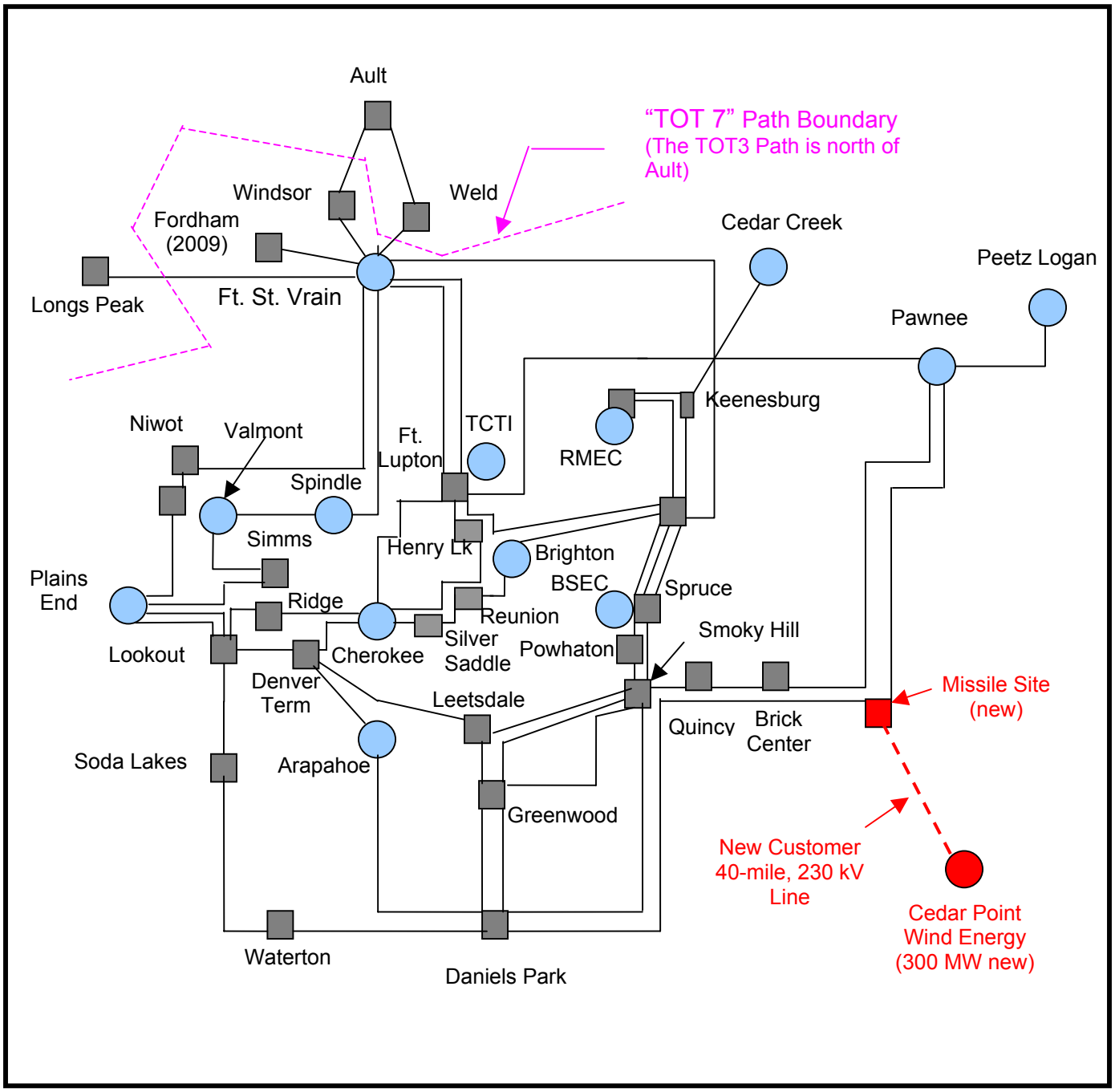
1) an interconnection on the Pawnee-Brick Center-Smoky Hill 230 kV line (Alternative 1)
2) an interconnection on the adjacent Pawnee–Daniels Park 230 kV line (Alternative 2)

This study consisted of steady-state power flow analysis, short-circuit analysis and transient stability studies. The power flow analysis provided a preliminary identification of any thermal or voltage limit violations resulting for the interconnection, and for an NR request, a preliminary identification of network upgrades required to deliver the proposed generation to PSCo loads. 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 of system nominal / normal conditions, and steady-state power flows within 1.0 per-unit of all elements' thermal (continuous current or MVA) ratings. Operationally, PSCo tries to maintain a transmission system voltage profile ranging from 1.02 per-unit or higher at generation buses, to 1.0 per-unit or higher at transmission load buses. 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 power flows within 1.0 per unit of the elements continuous thermal ratings.

D. Power Flow Study Models

PSCo utilized the 2010 heavy summer load / stressed case model to perform both the steady state power flow studies and the dynamics studies. The system around the Beaver Creek area

Figure 1: Study Area with the Proposed Wind Generating Facility



was modified to more closely reflect the expected system configuration. The new case was called “CPnewgenPTZ400.sav” and included the following local generation representation:

- The Cedar Point 300 MW Wind Project was modeled as interconnecting to the 230 kV bulk transmission system at either of two locations in the case - Alternative 1 (interconnection on the Pawnee-Brick Center-Smoky Hill 230 kV line) or Alternative 2 (interconnection on the Pawnee-Daniels Park 230 kV line) were developed.
- The increases in the Cedar Point 300 MW Wind Project facilities were re-dispatched among other PSCo generation facilities namely Comanche Unit 1 and Unit 2.
- The Peetz Logan 400 MW Wind Project was modeled at maximum output in the case.
- The Peetz Logen 200 MW Wind Expansion Project was not in the case.
- The Cedar Creek Wind 300 MW Wind Project (called “CEDARCK1” and “CEDARCK2” in the case) was scheduled at 37.6 MW out of 300 MW in the case. The Cedar Creek 300 MW Wind Project is represented as connected to the Keensburg 230 kV bus with an 800 MVA 230 kV transmission line. The interconnection point at Keensburg sufficiently distant from the Missile Site interconnection so that its impact on the alternatives is minimal.

Table 1 lists the generation schedules in Zone 706. Zone 706 represents a portion of the bulk transmission system in northeast Colorado. Table 1 does not list the Cedar Point 300 MW Wind Project generation schedules or the Peetz Logan 400 MW Wind Project generation schedules because these wind generating facilities have detailed representations in the load flow and transient stability representation in the case and these generators were not listed for conciseness.

Table 1 Zone 706 (N.E. Colorado) Generation Schedule – Case “CPnewgenPTZ400.sav”

Bus Number	Bus Name	Id	Code	In Service	Pgen (MW)	Pmax (MW)	Bus Number	Bus Name	Id	Code	In Service	Pgen (MW)	Pmax (MW)
70010	QF MNFRT 13.800	G1	-2	0	0.0	32.0	70499	QF B4-4T 13.800	G5	2	1	25.0	25.0
70188	FTLUP1-2 13.800	1	-2	0	0.0	50.0	70500	QF CPP1T 13.800	G1	2	1	20.0	24.0
70188	FTLUP1-2 13.800	2	-2	0	0.0	50.0	70500	QF CPP1T 13.800	G2	2	1	20.0	24.0
70310	PAWNEE 22.000	G1	2	1	505.0	530.0	70501	QF CPP3T 13.800	S1	2	1	27.0	27.0
70314	MANCHEF1 16.000	G1	2	1	120.0	140.0	70502	QF UNC 13.800	G1	2	1	29.0	29.0
70315	MANCHEF2 16.000	G2	2	1	120.0	140.0	70502	QF UNC 13.800	G2	2	1	29.0	29.0
70350	RAWHIDE 24.000	1	2	1	290.0	290.0	70502	QF UNC 13.800	G3	2	1	17.0	17.0
70351	RAWHIDEA 13.800	1	2	1	57.0	70.0	70556	QF B4D4T 12.500	S3	2	1	50.0	70.0
70487	QF TC-T4 13.800	G4	2	1	33.0	33.0	70561	RAWHIDEF 18.000	1	2	1	70.0	138.0
70487	QF TC-T4 13.800	G5	2	1	33.0	33.0	70567	RAWHIDED 13.800	1	2	1	58.0	70.0
70490	QF TC-T3 13.800	G3	2	1	33.0	33.0	70568	RAWHIDEB 13.800	1	2	1	57.0	70.0
70490	QF TC-T3 13.800	S2	2	1	50.0	51.0	70569	RAWHIDEC 13.800	1	2	1	57.0	70.0
70493	QF TI-T2 13.800	S1	-2	1	50.0	51.0	70721	SPRNGCAN 34.500	1	2	1	7.5	60.0
70495	QF TI-T1 13.800	G1	2	1	33.0	33.0	70822	CEDARCK1 34.500	1	2	1	18.8	150.0
70495	QF TI-T1 13.800	G2	2	1	33.0	33.0	70823	CEDARCK2 34.500	1	2	1	18.8	150.0
70498	QF BCP2T 13.800	G3	-2	0	0.0	30.0	70950	ST.VR_5 18.000	G5	-2	1	110.0	150.0
70498	QF BCP2T 13.800	S2	-2	0	0.0	36.0	70951	ST.VR_6 18.000	G6	-2	1	110.0	150.0
70499	QF B4-4T 13.800	G4	2	1	24.0	24.0	70932	WND_PLN 34.500	1	2	1	13.0	400.0

E. Power Flow Study Results and Conclusions

1. Power Flow Study

Various power flow case scenarios were created and evaluated for the studies. These include the following:

* Alternative 1 with Peetz Generation at 48 MW with Cedar Point Generation at 0 MW
* Alternative 1 with Peetz Generation at 48 MW with Cedar Point Generation at 300 MW
* Alternative 1 with Peetz Generation at 300 MW with Cedar Point Generation at 0 MW
* Alternative 1 with Peetz Generation at 300 MW with Cedar Point Generation at 300 MW
* Alternative 2 with Peetz Generation at 48 MW with Cedar Point Generation at 0 MW
* Alternative 2 with Peetz Generation at 48 MW with Cedar Point Generation at 300 MW
* Alternative 2 with Peetz Generation at 300 MW with Cedar Point Generation at 0 MW
* Alternative 2 with Peetz Generation at 300 MW with Cedar Point Generation at 300 MW

As the list demonstrates, a reference dispatch model was established without the additional 300 MW Cedar Point generation and a second model with the new 300 MW of generation included.

Automated contingency power flow studies were completed on all case models using PTI's MUST program routine, switching out single elements one at a time for all of the elements (lines and transformers) in balancing authorities 70 (PSCo) and 73 (WAPA-RM). Upon switching each element out, the program re-solves with all voltage taps and switched shunt devices locked, and balancing authority interchange adjustments disabled. These automated contingency studies were performed for both the Cedar Point 300, and the Cedar Point 0 models, and the results listing the overloaded elements (load flows in excess of their continuous rating) were compared. Table 2 below summarizes the contingency overloads noted from the power flow study.

Table 2: Summary Listing of Differentially Overloaded Elements

Branch Overloads Due to Addition of GI-2007-13 300 MW Generation							
		Contingent Loading-Percent of Rating					
	Element that is Overloaded	**Element Rating in the Base Case**	**Element Flow in the Base Case as a Percent of Rating**	**ALT1 - Tap Pawnee-Brick Center (Element Flow as a Percent of Rating)**	**ALT 2 - Tap Pawnee-Daniels Park (Element Flow as a Percent of Rating)**	**TDF for ALT2 - Tap on Pawnee-Daniels Park**	**Contingency**
Peetz Logan Generation at 48 MW							
	70047 BARRLAKE 230 70048 GREENVAL 230 1	159.0	150.8	157.8	<100%		70192 FTLUPTON 230 70529 JLGREEN 230 1
	70395 SMOKYHIL 115 70416 STRASBRG 115 1	144.6	<75%	122.7	<100%		70343 QUINCY 230 70545 BRICKCTR 230 1
	70545 BRICKCTR 230 70546 BRICKCTR 115 T1	200.0	<75%	107.2	<100%		70343 QUINCY 230 70545 BRICKCTR 230 1
	70060 BOONE 115 70061 BOONE 230 1	150.0	163.9	<100%	170.1	3.1%	70061 BOONE 230 70254 LAMAR CO 230 1
Peetz Logan Generation at 400 MW							
	70047 BARRLAKE 230 70048 GREENVAL 230 1	159.0	159.3	166.8	<100%		70192 FTLUPTON 230 70529 JLGREEN 230 1
	70060 BOONE 115 70061 BOONE 230 1	150.0	164.1	182.9	180.7	8.3%	70061 BOONE 230 70254 LAMAR CO 230 1
	70060 BOONE 115 70247 LAJUNTAT 115 1	109.0	154.7	167.3	165.5	3.9%	70061 BOONE 230 70254 LAMAR CO 230 1
	70060 BOONE 115 70249 LAJUNTAW 115 1	40.0	282.4	310.6	306.4	3.2%	70061 BOONE 230 70254 LAMAR CO 230 1
	70139 DANIELPK 230 70901 CP230TAP 230 1	637.0	79.8	<100%	101.2	45.4%	70311 PAWNEE 230 70545 BRICKCTR 230 1
	70192 FTLUPTON 230 70311 PAWNEE 230 1	478.0	104.0	109.4	102.7	-2.1%	70545 BRICKCTR 230 70901 CP230TAP 230 1[(1)]
	70343 QUINCY 230 70545 BRICKCTR 230 1	637.0	75.6	101.2	<100%		70139 DANIELPK 230 70311 PAWNEE 230 1
	70395 SMOKYHIL 115 70416 STRASBRG 115 1	144.6	96.6	142.9	105.1	4.1%	70343 QUINCY 230 70545 BRICKCTR 230 1
	70545 BRICKCTR 230 70546 BRICKCTR 115 T1	200.0	87.9	121.5	<100%		70343 QUINCY 230 70545 BRICKCTR 230 1
	70545 BRICKCTR 230 70901 CP230TAP 230 1	637.0	90.5	114.2	<100%		70139 DANIELPK 230 70311 PAWNEE 230 1
	73196 TERRY 115 73503 ERIE SW 115 1	109.0	98.6	<100%	107.7	3.3%	73502 DACONO 115 73503 ERIE SW 115 1
	Note for Column 7: TDF is the Transfer Distribution Factor. A distribution factor is the fraction of the flow on a line that is transferred to another line when the first line is opened.						

Table 2 shows newly overloaded elements, or delta overloads > 5% of rating, due to 300 MW Cedar Point generation injection at POI), 2010 HS (CPnewgenPTZ400.sav) case. It presents a comparison of Alternative 1 (a tap of the Pawnee-Brick Center 230 kV line) or Alternative 2 (a tap of the Pawnee-Daniels Park 230 kV line) against the benchmark case without the project. Based on the study results, Alternative 2 is the preferred alternative. It would result in fewer contingency overloads than Alternative 1 and fewer network upgrades for delivery than Alternative 1.

Table 2 demonstrates that most of the contingency overloads due to the addition of the Customer facility are within the 5% accommodation level. It should be noted that the rating of the Green Valley-Barr Lake 230 kV line (Circuit No. 5759) is 159 MVA in the base case; however, the actual rating of the branch is 506 MVA based on the FAC-009 facility rating method. Therefore, the contingency overloads of this element can be ignored.

Table 2 shows that for Alternative 2, an outage of the Pawnee-Brick Center 230kV line results in a contingency overload of the Daniels Park-CP230 Tap 230 kV line (part of Circuit No. 5457) at 101.2% of its 637 MVA rating[3]. The line rating is based on 1600 amp (637.4 MVA) line traps at the Pawnee and Daniels Park substations. Replacing these line traps with 2000 amp (796.7 MVA) line traps would mitigate the overload. The next limiting element would be the 2-636 kcmil conductor of the transmission line. It has a continuous thermal rating of 734 MVA. These circuit limitations will be eliminated through the PSCo Capital Construction Budget FAC-009 Prioritization Project that involves replacing the 1600 amps (637.4 MVA) line traps at Pawnee and Daniels Park. (Expected completion date: 4Q/2009)

Table 2 shows that for Alternative 2, a contingency overload of the Boone 230-115 kV transformer occurs after the addition of the Customer Project with Peetz Logan generation at 400 MW. The wind generating facility was dispatched by lowering generation at Comanche Unit 1 and Unit 2. Because of the proximity of the Boone Substation to the Comanche Substation, flows on the 115kV system in the vicinity of Boone and Lamar changed due to the addition of the wind generating facility; therefore, loading across the Boone transformer changed. Selecting other units in the PSCo system as being displaced by the wind generation would likely reduce the flow on the Boone 230-115kV transformer.

2. Reactive Power Capability Study

The case "CPnewgenPTZ400.sav" was utilized to determine the Customer's reactive generation (MVAR) capacities that may be necessary to meet the operational power factor and related reactive power (MVAR) requirements at the Missile Site 230 kV POI. The study results are listed in Table 3.

[3] The Pawnee-Daniels Park 230kV rating was increased from 490 MVA to 637 MVA. The 490 MVA rating was based on 1-1272 kcmil aluminum jumpers at Pawnee and Daniels Park that limited the line rating to 490 MVA (summer normal rating of 1229 amps). PSCo Transmission Engineering has verified that this rating limitation has been mitigated and the present rating of the Pawnee-Daniels Park 230kV line is 637 MVA.

Table 3: Reactive Power Results at the Missile Site POI

Power Flow Values from "CPnewgenPTZ400.sav"	Cedar Point Facility at Maximum of 300 MW	Cedar Point Facility at Minimum of 0 MW (Increase generation schedules in PSCo South Area)	Cedar Point Facility at Maximum of 300 MW	Cedar Point Facility at Minimum of 0 MW (Increase generation schedules in PSCo South Area)
	Pawnee Area Generation Near Maximum		Pawnee Generator O/S (increase generation schedules in PSCo South Area)	
Voltage at POI (CP230Tap)	1.003 p.u.	1.001 p.u.	1.003 p.u.	1.021 p.u.
Angle at POI (CP230Tap)	48.3 degrees	47.1 degrees	52.4 degrees	43.8 degrees
Real Flow into the POI (CP230Tap-CPSub2 230 kV Real Flow)	284.1 MW	0 MW	284.4 MW	0 MW
Reactive Flow into the POI (CP230Tap-CPSub2 230 kV Reactive Flow)	23.4 MVAR	11.9 MVAR	-36.7 MVAR	12.3 MVAR
Power Factor at the POI	0.997 lagging PF (current lags voltage by 4.7 degrees)	0.0 lagging PF (current lags voltage by 90 degrees)	0.992 leading PF (current leads voltage by 7.4 degrees)	0.0 lagging PF (current lags voltage by 90 degrees)

Four operating scenarios were studied – two scenarios with the Cedar Point wind facility at a maximum level with the Pawnee Area generation either near maximum levels or with the Pawnee generator out-of-service and two scenarios with the Cedar Point wind facility out-of-service with the Pawnee Area generation either at maximum levels or with the Pawnee generator out-of-service. The Comanche generators, Fountain Valley generators and Lamar DC Tie schedules were increased to account for the reduction in generation at the Cedar Point wind generating facility and the Pawnee generator. Table 3 describes the study results. Based on the scenarios considered, the wind generating facility appears to operate within the 0.95 lagging and 0.95 leading power factor range with the voltages at the POI remaining within criteria. The Rocky Mountain Area Voltage Coordination Guidelines (that were developed by the Voltage Coordination Guidelines Subcommittee (VCGS) of the Colorado Coordinated Planning Group) indicate that system should be operated in such a way that non-regulated 230 kV bus voltages in Northeast Colorado (such as the Missile Site 230 kV POI voltage) remain within an ideal voltage range from 1.0 p.u and 1.03 p.u. The study results would suggest that for the operating conditions simulated, the voltages at the POI remain within criteria. The study did not investigate all possible operating conditions including the NERC Reliability Standards TPL-002 and TPL-003. Further study work would be required by the Customer to determine the impact of the

proposed wind generating facility on the power factor and voltage at the POI. With the Cedar Point generating station out-of-service, the power factor at the POI increases to 0.0 lagging with approximately 12 MVAR injected into the POI due to the distributed capacitance of the Customer's 230 kV line (between the wind generation facility and the POI). PSCo requires that the customer remain "VAR neutral" at the POI under this scenario; therefore, it is expected that reactors would be needed to mitigate the reactive power injection into the POI during these conditions.

More detailed studies will have to be performed by the Customer to determine the specific reactive (capacitive and inductive) dynamic or static equipment that may be necessary to meet the requirements. The project costs do not reflect the addition of the reactive power requirements for interconnection. The Interconnection Agreement (IA) requires that certain conditions be met, as follows:

1) The conditions of the Large Generator Interconnection Guidelines (LGIG) are met.
2) PSCO will require testing of the full range of 0 MW to 300 MW operational capability of the facility. These tests will include, but not be limited to, power factor control, and VAR control as measured at the Missile Site 230 kV bus POI for various generation output levels (0 to 300 MW) of the Customer's wind generation facility.
3) A single point of contact needs to be provided to PSCo Operations to manage the transmission system reliably for all wind projects on the proposed line.

NOTE – It is the responsibility of the Customer to determine what type of equipment is required (CVAR, added switched capacitors, SVC, reactors, etc.) and at what final ratings (MVAR, voltage 34.5 kV, 230 kV) and location (Cedar Point or Missile Site POI) will be necessary to meet these reactive power controllability requirements. Furthermore, the actual voltage tap ratios used for the Customer's main 230 - 34.5 kV transformers will directly impact the operating voltages and related reactive capabilities for the Cedar Point facility. The Customer should review these issues in determining the final design requirements for this equipment (CVAR, transformer voltage tap ratios and MVA, etc.).

3. Transient Stability Analysis Results and Conclusions

The stability analysis consisted of 3-phase faults near the POI with 300 MW represented at Cedar Point, Normal fault clearing times were used in this study and consisted of 5-cycles for 230 kV facilities. Stuck breaker cases were not considered in this study. The wind generating facility (300 MW) was modeled at the 575-volt level connected through GSUs to 34.5kV with 34.5-kV feeders then connected to 34.5/230 kV transformer, using transformer information provided by the Customer for impedance and off-nominal tap settings. The representation of the 230 kV system on the Cedar Point wind generating facility used the impedance/line length information provided by the Customer. All faults simulated were 3-phase faults at the indicated location that were cleared by opening the indicated circuit segment. In three cases, the fault location was such that opening the appropriate branch(es) disconnects generation, either 150 or 300 MW of the wind project or the Pawnee unit. Outside of these generation losses, the results indicate that the system remains stable, no significant post disturbance voltage deviations, all observed oscillations are positively damped, and the LVRT criteria is met (no wind generation tripped). The information is summarized in Table 4 below.

Table 4: Summary of Transient Stability Study

#	Fault				Cleared Circuit 1							
	Location			Duration	Bus 1			Bus 2			Circuit	Results
	Name	kV	Number	(Cycles)	Name	kV	Number	Name	kV	Number		
1	Pawnee	230	70311	5	Daniel Park	230	70139	Pawnee	230	70311	1	Stable with positive damping, no wind units tripped.
2	Pawnee	230	70311	5	Ft.Lupton	230	70192	Pawnee	230	70311	1	Stable with positive damping, no wind units tripped.
3	Pawnee	230	70311	5	BrickCTR	230	70545	Pawnee	230	70311	1	Stable with positive damping, no wind units tripped.
4	Daniels Park	230	70139	5	Daniel Park	230	70139	Pawnee	230	70311	1	Stable with positive damping, no wind units tripped.
5	Ft.Lupton	230	70192	5	Ft.Lupton	230	70192	Pawnee	230	70311	1	Stable with positive damping, no wind units tripped.
6	Pawnee	230	70311	5	Pawnee	230	70311	Pawnee	22	70310	1A	Stable with positive damping, no wind units tripped.
7	Pawnee	230	70311	5	Trip Unit							Stable with positive damping, no wind units tripped.
8	Daniels Park	230	70139	5	Daniels Park	230	70139	Daniels Park	345	70601	1	Stable with positive damping, no wind units tripped.
9	Pawnee	230	70311	5	Pawnee	230	70311	Story	230	73192	1	Stable with positive damping, no wind units tripped.
10	CP230TAP	230	70901	5	CP230TAP	230	70901	CPSUB2	230	918	1	Stable with positive damping, no wind units tripped.
11	CPSUB2	230	918	5	CPSUB2	230	918	35KVBUS2	35	904	1	Stable with positive damping, no wind units tripped.
12	CP230TAP	230	70901	5	CP230TAP	230	70901	Daniel Park	230	70139		Stable with positive damping, no wind units tripped.
13	CP230TAP	230	70901	5	CP230TAP	230	70901	Pawnee	230	70311		Stable with positive damping, no wind units tripped.
14	Pawnee	230	70311	5	Pawnee	230	70311	CP230TAP	230	70901		Stable with positive damping, no wind units tripped.
15	Daniels Park	230	70139	5	Daniel Park	230	70139	CP230TAP	230	70901		Stable with positive damping, no wind units tripped.
	Note 1	For Fault #10, trip entire 300 MW Wind Farm										
	Note 2	For Fault #11, trip 150 MW of the Wind Farm										

F. Short Circuit Study Results

A short circuit study was conducted to determine the fault currents (single-line-to ground or three-phase) at the Missile Site Substation 230 kV bus. The study was conducted consistent with a 2010 study year assuming a December 2009 in-service date. The 300 MW wind generation facility was represented as a constant voltage behind a direct axis saturated sub-transient reactance. Table 5 summarizes the approximate fault currents at the Missile Site 230 kV Bus with the addition of the GI-2007-13 facility. Table 6 shows the approximate fault contribution from the proposed wind generation facility.

Table 5 Short-Circuit Study Results With the Proposed 300 MW Wind Generating Facility

System Condition	Three-phase (amps)	Thevenin System Equivalent Impedance (R,X) (ohms)	Single-line-to-ground (amps)	Thevenin System Equivalent Impedance (R,X) (ohms)
System Intact	I_1=7,677.3 I_2=I_0=0 I_A=I_B=I_C=7,677.3	Z1(pos)= 1.83079,17.1994 Z2(neg)=1.83611,17.2042 Z0(zero)=8.94664,38.7844	I_1=I_2=1,788.02 3I_0=5,364.05 I_A=1,788.02 I_B=I_C=0	Z1(pos)= 1.83079,17.1994 Z2(neg)=1.83611 ,17.2042 Z0(zero)=8.94664,38.7844

Table 6 Fault Contribution from the Proposed 300 MW Wind Generating Facility

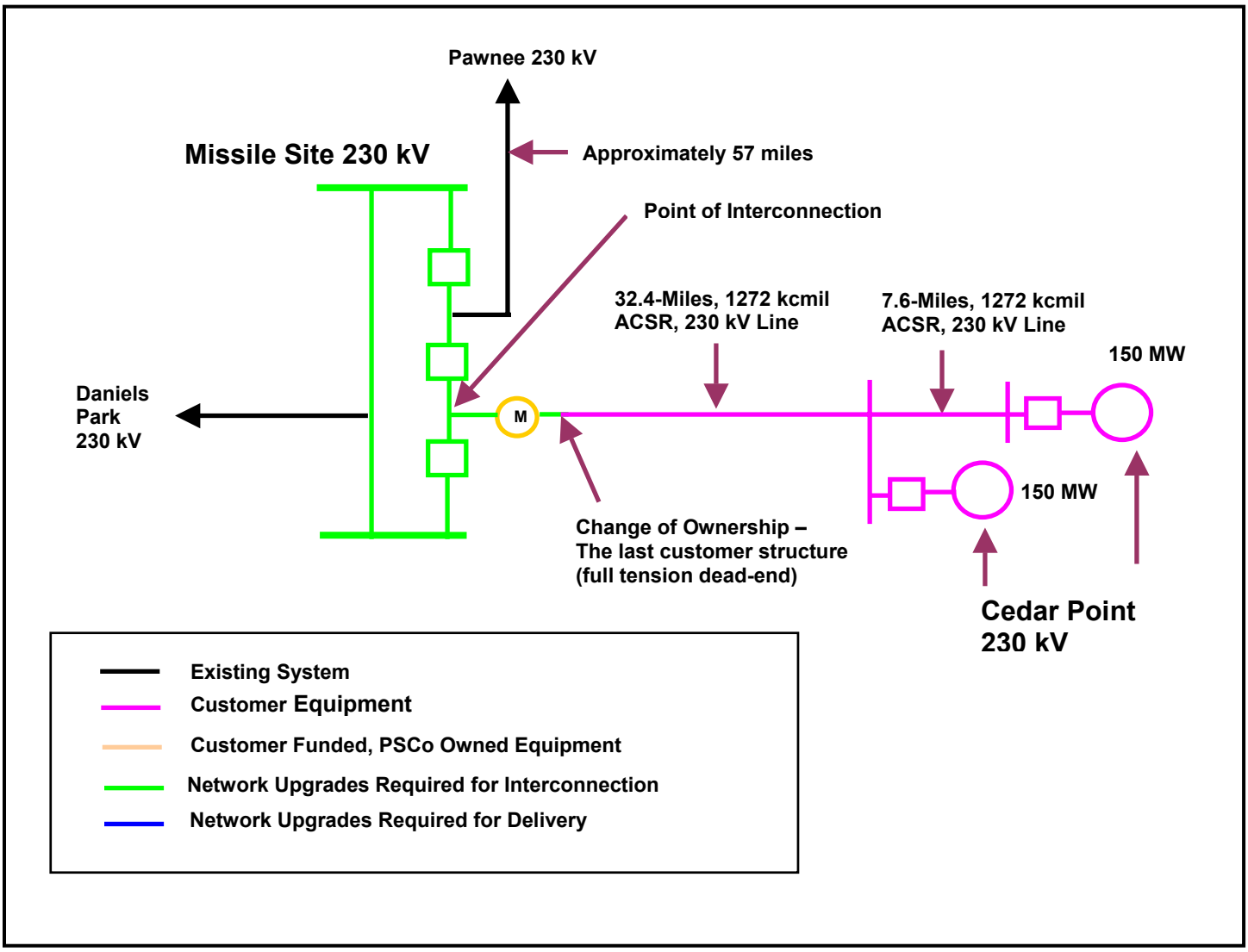
3Φ Bus Fault 230 kV (A)	S-L-G Bus Fault 230 kV (A)	Pos Seq Thev Equiv (230 kV Bus, PU)	Zero Seq Thev Equiv (230 kV, Bus PU)	Cedar Point 230 kV Line Contribution (3-ph Amps)	Cedar Point 230 kV Line Contribution (3I0 Amps)
7,677	5,364	0.00346 + j0.03251	0.01691 + j0.07332	1,042	1,632

PSCo Substation Engineering indicated that the addition of the 300 MW wind generating facility is not expected to necessitate the replacement of circuit breakers, switches or other substation equipment due to the increased fault current levels at the Missile Site Substation.

G. Costs Estimates and Assumptions

Scoping level cost estimates (+/- 30%) were determined by PSCo Engineering. The cost (+/- 30%) estimates are in 2008 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 estimated total cost for the required upgrades for is $ 4,008,000. Figure 2 below represents a conceptual one-line of the proposed interconnection at the Missile Site Substation..

Figure 2 Simplified One-Line of the Missile Site Substation and Proposed 300 MW Wind generating facility



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 generation output. 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 7 – PSCo Owned; Customer Funded Interconnection Facilities

Element	Description	Cost Est. (Millions)
Missile Site 230 kV Substation	Interconnect Customer to tap at PSCo's New Missile Site 230 kV Substation. The new equipment includes: • One 230 kV, 2000 amp gang switch • One bidirectional revenue meter & recorder • Three 230 kV combination CT/PT instrument transformers • Three 230 kV lightning arresters • Associated bus, wiring and equipment • Associated foundations and structures • Associated transmission line communications, relaying and testing.	**$0.464**
	Transmission line tap into substation. One double circuit steel pole, conductor, hardware and installation labor.	**$0.246**
	Customer LF/AGC and Generator Witness Testing. (Customer generation telemetry equipment, and witnessing the Customer generator commissioning testing).	**$0.122**
	Siting and Land Rights support for required easements, reports, permits and licenses.	**$0.010**
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	**$0.842**
Time Frame	**Site, engineer, procure and construct**	**12 Months**

Table 8: PSCo Owned; PSCo Funded Interconnection Facilities

Element	Description	Cost Estimate (Millions)
Missile Site 230 kV Substation	Interconnect Customer to tap at PSCo's New Missile Site 230 kV Substation. The new equipment includes: • Three 230 kV, 3000 amp circuit breakers • Eight 230 kV, 3000 amp gang switches • Six 230 kV CCVT's • One electric equipment enclosure • Associated communications, supervisory and SCADA equipment • Line relaying and testing • Associated bus, miscellaneous electrical equipment, cabling and wiring • Associated foundations and structures • Associated yard surfacing, landscaping, fencing and grounding	**$2.814**
Pawnee 230 kV Substation	Interconnection and substation upgrades required at PSCo's Pawnee Substation (relaying and testing).	**$0.096**
Daniels Park 230 kV Substation	Interconnection and substation upgrades required at PSCo's Daniels Park Substation (relaying and testing).	**$0.096**
	Siting, permitting and acquisition of a 35-acre substation site and associated transmission line tap.	**$0.160**
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	**$3.166**
Time Frame	**Site, engineer, procure and construct**	**18 Months**

Table 9 – PSCo Network Upgrades for Delivery

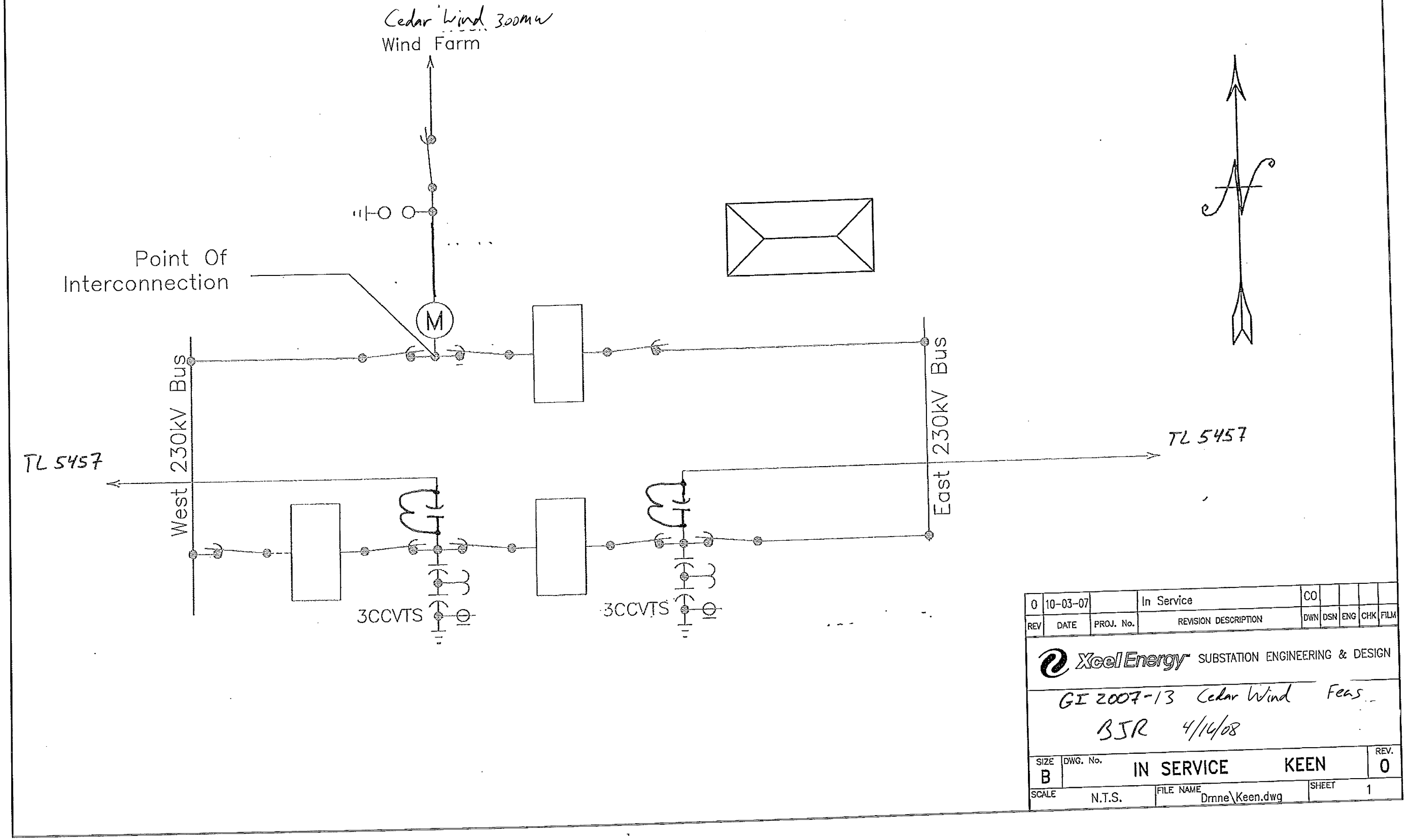
Element	Description	Cost Est. (Millions)
PSCo's Transmission Network	• FAC-009 Prioritization Project - Replace the 1600 amp (637.4 MVA) line traps at Pawnee and Daniels Park. (Expected completion date: 4Q/2009)	----------
	Total Cost Estimate for PSCo Network Upgrades for Delivery	----------
Time Frame	**Network Upgrades for Delivery – to be constructed via the PSCo Capital Budget Construction Process.**	----------
	Total Cost of Project	**$4.008**

Assumptions for Alternatives

- The cost estimates provided are "scoping estimates" with an accuracy of +/- 30%.
- Estimates are based on 2008 dollars (no escalation applied).
- There is no contingency or AFUDC included in the estimates.
- Labor is estimated for straight time only – no overtime included.
- The cost estimates for the PSCo network upgrades for delivery are not included as they are part of PSCo's Capital Budget Construction process.
- Lead times for materials were considered for the schedule.
- The Wind Generation Facility is not in PSCo's retail service territory. Therefore, no costs for retail load metering are included in these estimates.
- PSCo (or it's Contractor) crews will perform all construction and wiring associated with PSCo owned and maintained facilities.
- The estimated time to site, engineer, procure and construct the interconnection facilities is at least 12 months, The estimated time for PSCo to site, engineer, procure and construction the scope of work identified in Table 8 is 18 months after authorization to proceed has be obtained. This is completely independent of other queued projects and their respective ISD's.
- Customer will string OPGW fiber into substation as part of the transmission line construction scope.
- Contractor to construct the new substation, PSCo crews to perform checkout, relay panel construction and final commissioning.
- Acquisition of a new site this size eliminates the subdivision process.
- New site is adjacent to the existing transmission line corridor, most likely assumed to be on the north and / or west side of the existing 230 kV double-circuit transmission lines at this location (see Appendix). However, the specific details regarding the new Missile Site switching station layout, location, potential transmission line exits and line crossings, and detailed requirements necessary to meet both the initial station design / construction requirements, and still meet the ultimate expansion capabilities will need to be further reviewed in the later Facilities Study phase.

Appendix

A. Station One-Line Diagram (New PSCo Missile Site Switching Station)



REV	DATE	PROJ. No.	REVISION DESCRIPTION	DWN	DSN	ENG	CHK	FILM
0	10-03-07		In Service	CO				

Xcel Energy SUBSTATION ENGINEERING & DESIGN

GI 2007-13 Cedar Wind Feas.

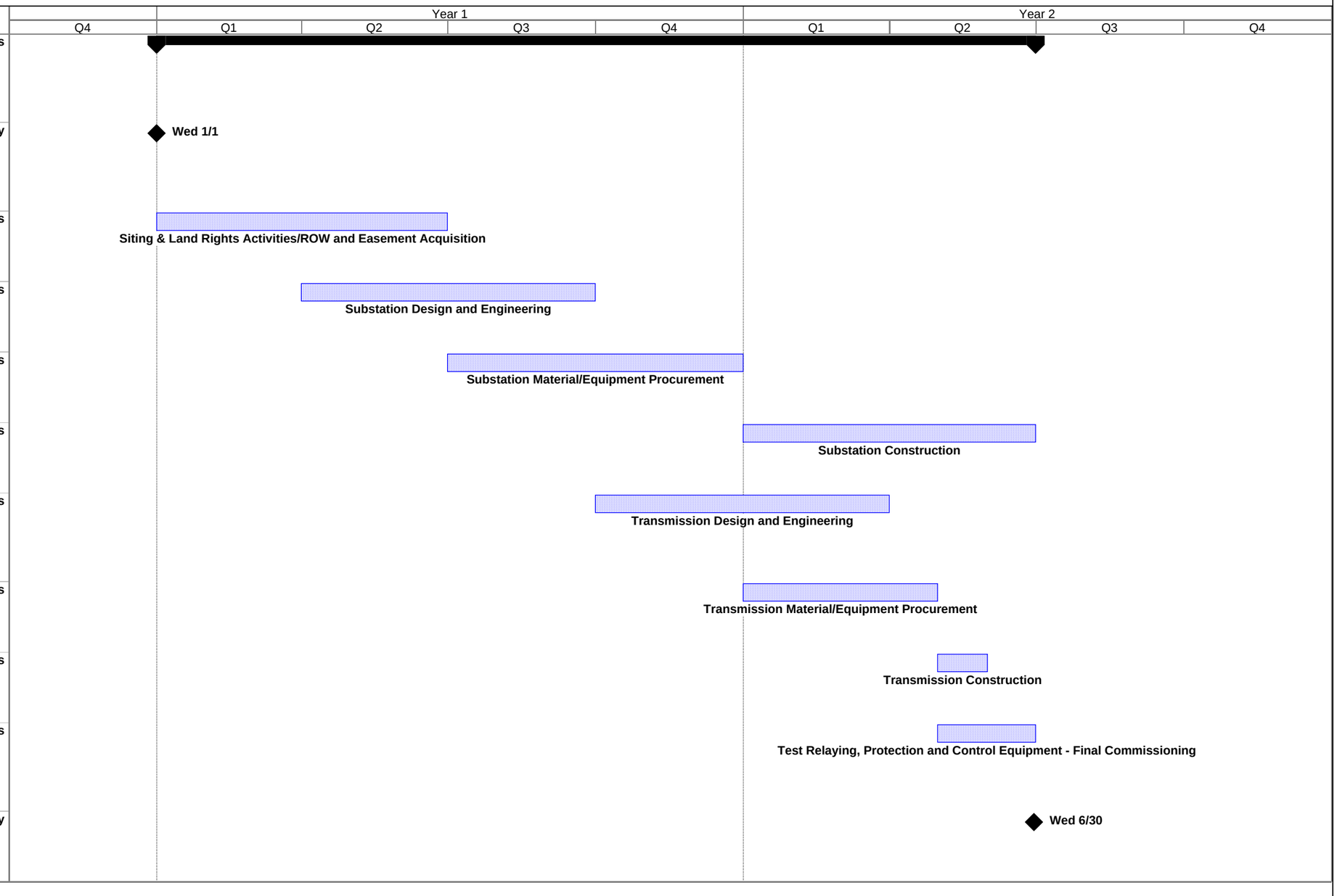
BJR 4/14/08

SIZE	DWG. No.		REV.
B	IN SERVICE	KEEN	0
SCALE N.T.S.	FILE NAME Drnne\Keen.dwg	SHEET 1	

B. Project Schedule

GI-2007-13 (Feasibility/SIS Report)
Cedar Point 300 MW Wind Energy Project

ID	Task Name	Duration
1	**GI-2007-13 (Feasibility/SIS Report) Cedar Point 300 MW Wind Energy Project**	**547 days**
2	**Authorization to Proceed - Day One Execution of Interconnection Agreement**	**1 day**
3	**Siting & Land Rights Activities/ROW and Easement Acquisition**	**181 days**
4	**Substation Design and Engineering**	**183 days**
5	**Substation Material/Equipment Procurement**	**184 days**
6	**Substation Construction**	**182 days**
7	**Transmission Design and Engineering**	**183 days**
8	**Transmission Material/Equipment Procurement**	**121 days**
9	**Transmission Construction**	**31 days**
10	**Test Relaying, Protection and Control Equipment - Final Commissioning**	**61 days**
11	**Completion Date**	**1 day**



Project: Schedule 10-07-08.mpp
Date: Tue 10/7/08

Task | Milestone | Rolled Up Task | Rolled Up Progress | External Tasks | Group By Summary
Progress | Summary | Rolled Up Milestone | Split | Project Summary