

Draft
Feasibility Study Report
Request # GI-2007-7

Rocky Plains
300 MW Wind Generation Facility, near Akron, Colorado

PSCo Transmission Planning
December 20, 2007

Executive Summary

Public Service Company of Colorado (PSCo) Transmission received a generation request to determine the feasibility of interconnecting 300 MW of wind turbine generation at PSCo's owned Pawnee 230 kV substation. The Customer proposed commercial operation date is November 1, 2010 with a back feed date of June 1, 2010. This request was studied as both an Energy Resource and a Network Resource. The study was conducted primarily as a "stand-alone" project, but sensitivity analyses were performed to consider other higher queued projects namely GI-2006-2. The GI-2006-2 is an additional 200 MW of wind interconnecting into the existing 400 MW Peetz Logan Wind farm generation, which injects power into the Pawnee 230 kV bus. PSCo has determined that it is not feasible to interconnect at Pawnee and deliver the full 300 MW of firm power by the requested in service date. As part of Senate Bill 100 (SB100), PSCo has filed a CPCN to construct a new Pawnee – Smoky Hill 345 kV Transmission Project, which will be the network upgrades needed for GI-2007-7. Once a CPCN is granted, PSCo will advance to construction with the expected in service date of 2013.

Energy Resource

The ER portion of this study determined that the Customer could provide 0 MW without the construction of network reinforcements. Non-firm transmission capability may be available depending on marketing activities, dispatch patterns, generation levels, demand levels, TOT 3 levels, and the status of transmission facilities.

Network Resource

As an NR request, PSCo evaluated the network to determine the upgrades required to deliver the full 300 MW of the wind facility to PSCo native load customers. The estimated cost of the recommended system upgrades to accommodate the project is approximately **\$121.7¹ million** and includes:

¹ PSCo has filed on October 31st, 2007 a CPCN for the Pawnee – Smoky Hill 345 kV Transmission Project with a cost estimate of \$120.5 million, and if approved, the differential cost to deliver the full 300 MW would be \$1.20 million. The level of accuracy for the cost estimates in this study is considered to be ± 30%, which is typical for a project at this budgetary stage in the process. This estimate is based on cost per mile indicators of past projects,

- \$513,000 for Customer Funded PSCo Interconnection Facilities at Pawnee 230 kV substation. Refer to Figure 1 for the interconnection diagram at Pawnee.
- \$700,000 for PSCo Funded PSCo Interconnection Facilities at Pawnee 230 kV substation. Refer to Figure 1 for the interconnection diagram at Pawnee.
- \$120.5 million for PSCo Network Upgrades for Delivery. Refer to Figure 2 for the system upgrades diagram necessary for delivery. This project has been proposed as a CPCN as part of the SB100 filing.

The system upgrades can be described in three basic sections:

- Section 1 consists of approximately 79 miles of new 345 kV double circuit transmission line. The transmission would be built to allow for double-circuit capability when conditions warrant.
- Section 2 consists of rebuilding an approximately 15 – mile section of the existing 230 kV single circuit wood-pole Pawnee – Daniels Park (#5457) transmission line to double-circuit, 345 kV capable steel-pole transmission structures. One side of the double-circuit towers would carry the existing 230 kV circuit (a portion of the Pawnee – Daniels Park 230 kV (5457) line that runs from Pawnee to near Smoky Hill). The other side would carry this 15 – mile section of the newly created Pawnee – Smoky Hill 345 kV circuit.
- Section 3 involves constructing the last mile of the previously discussed new 345 kV transmission line into the Smoky Hill Substation, and consists of approximately one mile of new 345 kV transmission. This section would also be built to allow for double-circuit 345 kV capability, but only one circuit would be utilized.
- The Pawnee – Smoky Hill 345 kV transmission will connect to the Pawnee and Smoky Hill substations using two (2) 560 MVA 345/230 kV autotransformers at the Pawnee Substation and three (3) single phase plus one (1) spare 250 MVA 345/230 kV autotransformers at the Smoky Hill Substation.

Transmission study shows that the proposed 300 MW of wind generation at Rocky Plains does not supply the reactive power support necessary at the POI (Pawnee 230 kV bus) to control the +/- 0.95 p.f. across the full operating range. The preliminary study has indicated the Customer may need to supply approximately 170 MVAR of reactive power at the Customer generation site in order to meet the interconnection guidelines at the POI. This would be needed to make up for the relatively large reactive losses absorbed by the Customer's main 230-34.5 kV step-up transformers, transmission line reactance, and other Customer's 34.5 kV collector facilities. Importantly, the Customer's facility needs to be VAR neutral (0 MVAR, +/- 25 MVAR) at the

average unit costs, and 2007 overhead and labor rates. This estimate is in 2007-year dollars, and it includes all appropriate overheads including AFUDC. At this stage of the project, these are high level, scoping estimates, which are the best estimates that the Company is able to provide prior to detailed engineering of the Transmission Project.

POI across the full operating range (0 MW – 300 MW). More detailed studies will have to be performed by the Customer to determine the specific reactive (capacitive and inductive) CVAR, DVAR, SVC, or similar dynamic reactive equipment necessary to meet the requirements.

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

1. The conditions of the Large Generator Interconnection Guidelines (LGIG)² are met.
2. A single point of contact is given to Operations to manage the Transmission System reliably for all wind projects on the proposed radial line.
3. PSCo will require testing of the full range of 0 MW to 300 MW operational capabilities of the facility. These tests will include but not limited to p.f. control and VAR control as measured at the Pawnee 230 kV bus POI for various generation output levels (0 to 300 MW) of the Customer's wind generation facility. Specific commissioning and testing will be determined in the system impact studies (SIS).

The time required to engineer, permit, and construct all the required PSCo facilities for interconnection is estimated to be at least 12 months. The estimated time required to engineer, permit, and construct the Network Upgrade facilities for delivery is at least 60 months. According to the interconnection request, the Customer will engineer, permit, construct, and finance the 25-mile 230 kV transmission line to the proposed tap station.

Additional details of the studies can be found under the Power Flow Study Results section.

² Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater than 20 MW, version 3.0 12/31/06.

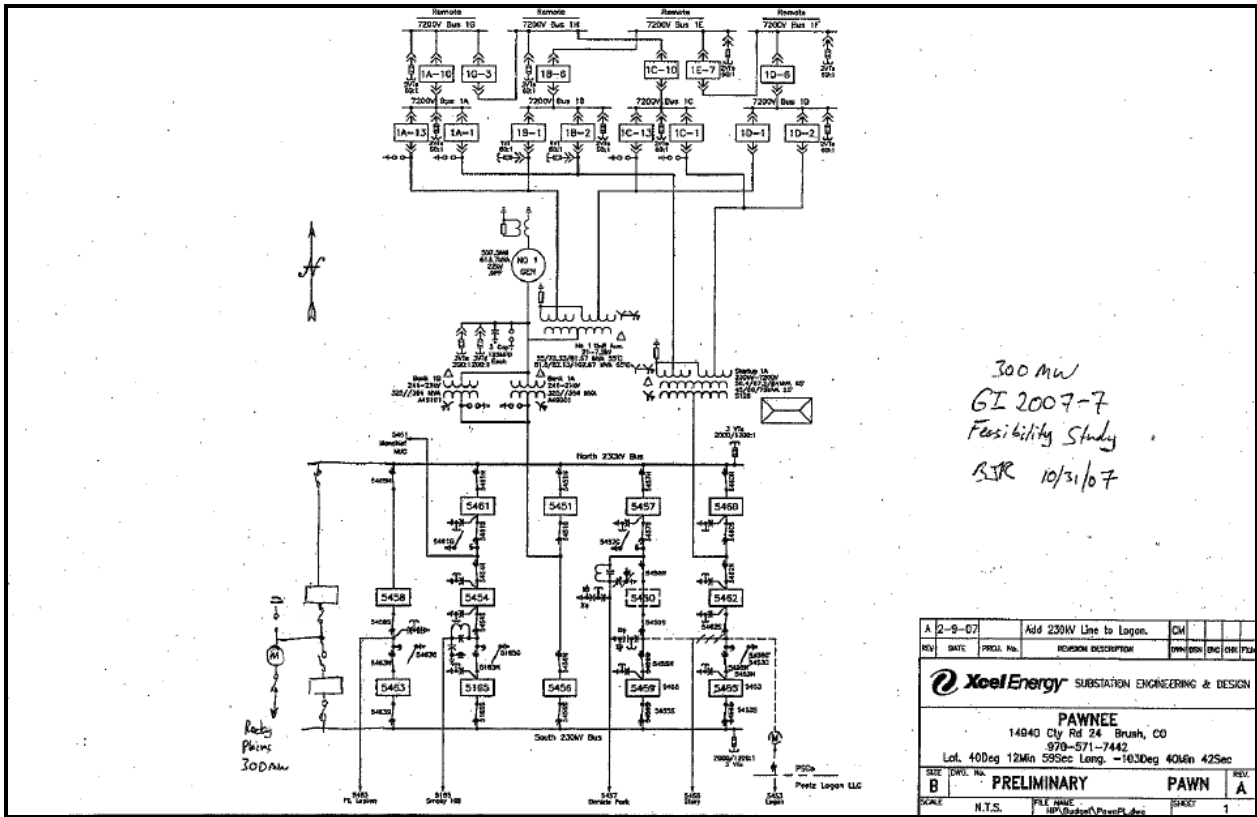


Figure 1: Rocky Plains interconnection into Pawnee 230 kV substation.

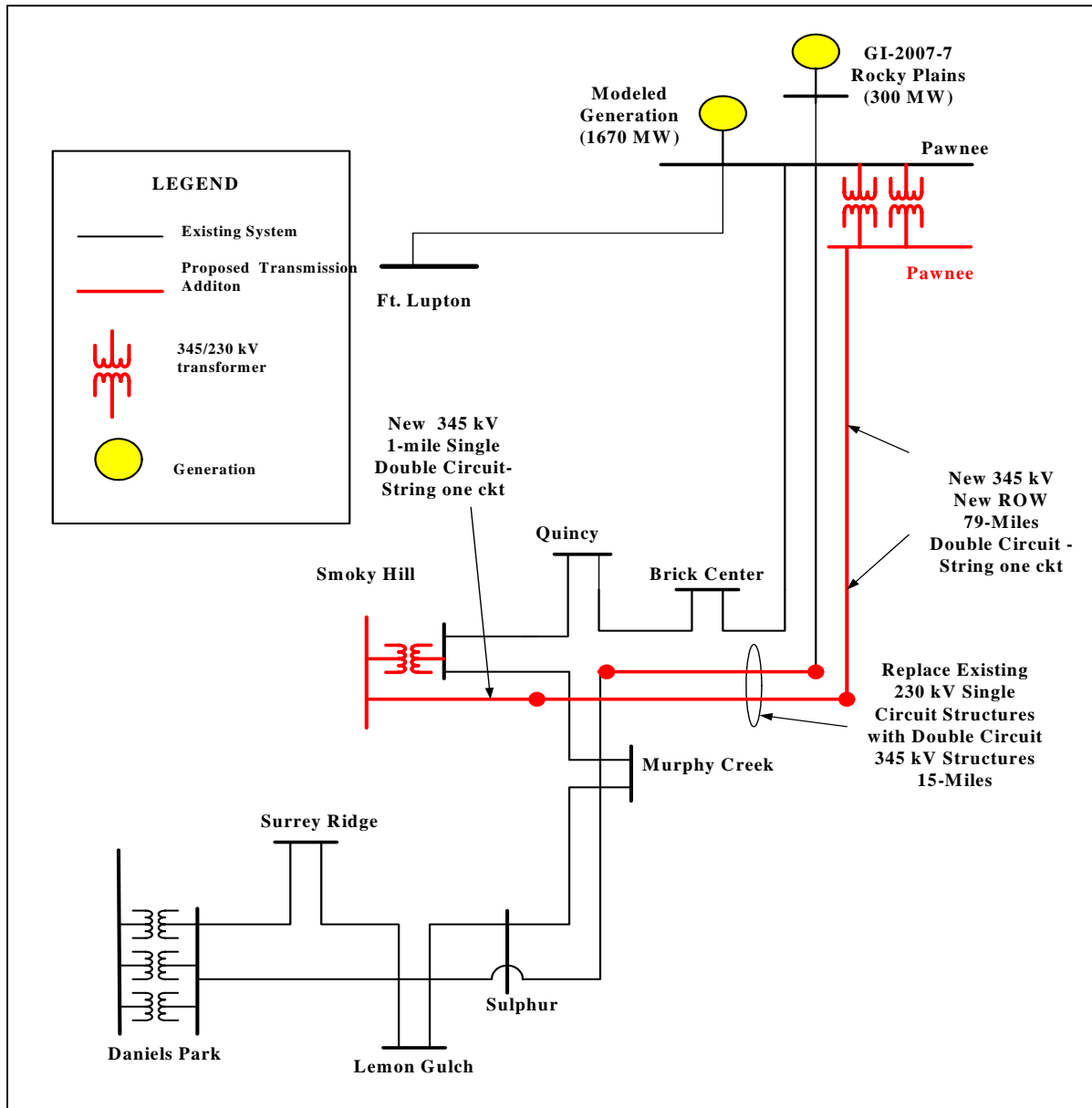


Figure 2: Pawnee – Smoky Hill 345 kV Transmission Project

Introduction

PSCo Transmission received a large generator interconnection request (GI-2007-7) to interconnect one hundred forty three (143) Suzlon S88 2.1 MW wind turbines, for a total of 300 MW generation, with a commercial operation date of November 1, 2010 and a back feed date of June 1, 2010. The proposed wind farm project would be located near Akron, Colorado and would interconnect into the PSCo transmission system via the planned Customer 25-mile radial 230 kV line terminating at the PSCo Pawnee Station. The Customer has requested that this Project be evaluated as a Network Resource (NR) and an Energy Resource (ER) with the energy going to PSCo customers.

Study Scope and Analysis

The Interconnection Feasibility Study evaluated the transmission requirements associated with the proposed interconnection to the PSCo Transmission System. It consisted of power flow and short circuit analyses. The power flow analysis provided a preliminary identification of any thermal or voltage limit violations resulting for the interconnection, and for a NR request, a preliminary identification of network upgrades required to deliver the proposed generation to PSCo loads. The short circuit analysis identified any circuit breaker 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 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.

Based on the results of other generator interconnection studies, impacts to TOT 3 and the neighboring utilities are considered minimal. For this project, affected parties include Western Area Power Administration (WAPA), and Intermountain Rural Electric (IREA). PSCo will notify and work with the affected parties during the system impact study (SIS) phase.

Power Flow Study Models

The power flow studies were based on a PSCo developed 2011 heavy summer base case that originated from the Western Electricity Coordinating Council (WECC) approved 2011 heavy summer base model. Generation was dispatched for relatively high north-to-south stressing (TOT 3 at 1272 MW), with further regional stressing created by modeling the Peetz Logan wind generation facility at 600 MW full 100% output (existing 400 MW, plus additional 200 MW for GI-2006-2), injecting into the Pawnee 230 kV bus. Other wind farm generation facilities are modeled at 10% output level, consistent with other study procedures.

The Customer’s Rocky Plains 300 MW wind farm was modeled as two lumped equivalent (2) x 150 MW, 34.5 kV conventional generators, operating at 1.0 p.f. (without any VAR capabilities), which the Customer has stated to be a summation of 143 Suzlon S88 2.1 MW wind turbines. The two 150 MW generators were tied to two separate 230-34.5 kV, 150 MVA main step-up transformers, with a 25-mile, 230 kV Customer transmission line connecting the Rock Plains facility to the Pawnee 230 kV bus POI. As discussed later on, the studies show that additional MVAR support will be required to enable the +/- 0.95 p.f. control capability at full rated injection (300 MW) at Customer’s facility, Rocky Plains 230 kV bus. For dispatching to the PSCo native loads, the Customer’s generation was scheduled (re-dispatched) to offset other PSCo generation in the southern PSCo system by reducing generation in that area.

Pertinent modeling adjustments:

- Other generation at Pawnee was modeled at full output.

Base Case	Generation Resources	Gross Output (MW)
2011 HS	Pawnee	530
	Manchief	280
	Brush	260
	Peetz Logan (includes new GI-2006-2 as a sensitivity analysis)	600
	Total Generation on-line at Pawnee:	1,670
	Colorado – Wyoming transfer	Level (MW)
	TOT 3	1,272

- Study models included a planned upgrade of the existing Pawnee to Smoky Hill and Pawnee to Daniels Park 230 kV line to 637 MVA. These upgrades are projected to be complete in 1st quarter of 2008.

The Point of Interconnection (POI) between the Customer and PSCo is assumed to be the point at which the Customer’s 25-mile, 230 kV transmission line connects to the Pawnee Substation bus. The 25-mile line was modeled per the Customer provided information:

- A single-circuit of 25-mile, using a Bittern 230 kV “Shielded H-frame” construction with a 1272 ACSR per phase rated at 462 MVA.

To evaluate the capabilities and system requirements for firm transfer levels, the powerflow model was modified to simulate TOT 3 path flows at approximately 1,272 MW. Efforts were made to include in the models all transmission projects expected to be in service for the 2011 heavy summer season. The studies assumed 2011 peak summer demand conditions in the PSCo system and in other utility systems.

Power Flow Study Results and Conclusions

Energy Resource (ER) Study Results

The ER portion of this study determined that the Customer could provide 0 MW without the construction of network reinforcements. This determination is based on existing limitations due to overloaded lines under single contingency. Refer to Appendix A for the contingency comparison table detailing the overloaded elements. Non-firm transmission capability may be available depending on marketing activities, dispatch patterns, TOT 3 levels, generation levels, demand levels and the status of transmission facilities.

Network Resource (NR) Study Results

The NR study determined the network upgrades that would be required to accept the full 300 MW from the proposed generating plant for the conditions studied. The study was conducted primarily as a “stand-alone” project, but sensitivity analyses were performed to consider other higher queued projects such as GI-2006-2. The GI-2006-2 is an additional 200 MW of wind interconnecting at Pawnee on top of the existing 400 MW of Peetz Logan Wind. At 300 MW of additional generation and 600 MW at Peetz Logan, there were numerous of overloaded elements. Appendix A shows the most significant contingencies and the associated overloads along with results from the benchmark case and with the Network Upgrades.

Studies indicated that if the proposed alternative for Network Upgrades for Delivery is implemented for this project, there are no significant impacts to the neighboring utilities or to the TOT 3 transmission path. All negative impacts to neighboring utilities as a result of this project will be assessed in a greater detail during the system impact study.

Voltage Control at the Point of Interconnection

Studies show that under certain conditions the Customer’s 300 MW wind turbine generators cannot by themselves meet the interconnection guidelines as mandated by PSCo in their Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater than 20 MW (Guidelines). Additional Customer designed / specified and supplied reactive control equipment (CVAR, DVAR, SVC, etc.) will likely be required to be installed in order to meet the following reactive control requirements. It is the responsibility of the Customer to specify, design, and install the reactive control facilities needed to meet these requirements. Voltage related issues will be addressed in further later dynamics studies, as part of the System Impact, and facilities studies.

- The Customer needs to demonstrate that the proposed facility is designed to be capable of providing or absorbing reactive power at the POI sufficient to control +/- 0.95 p.f. across the full operating range. Moreover, the Customer’s facility needs to be VAR neutral at the POI and control to (0 MVAR, +/- 25 MVAR) for all levels of generation.

In addition, PSCo requires the Customer to provide a single point of contact³ to coordinate compliance with the power factor/voltage regulation at the POI. The Customer will need to control the VAR flow on their line according to the Interconnection Guidelines. It is the responsibility of the Customer to determine what type of equipment (CVAR, added switched capacitors, SVC, reactors, etc.), the ratings (MVAR, voltage 34.5 kV, 230 kV), and the location are required to meet these reactive power controllability standard.

Short Circuit Study Results

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 faults currents at Pawnee are 22,980 Amps for a single-line to ground fault and 19,915 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 is **\$121.7 million**

The estimated costs shown are (+/-30%) estimates in 2007 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, 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 1: Transmission Provider Interconnection Facilities (Customer Funded)

Element	Description	Cost Est. (in millions)
Pawnee Station 230kV Switchyard	Interconnect Customer to tap at PSCo’s 230 kV Switchyard. The new equipment includes: <ul style="list-style-type: none"> • One 230 kV gang switch • Three 230 kV bidirectional metering units • Associated foundations and structures • Associated transmission line relaying and testing 	\$0.327
	Transmission – labor to install slack span into Pawnee. Materials furnished by Customer	\$0.018

³ The POI will provide a point of injection of wind generation from several different entities.

	Customer Generator Communication to and from Lookout	\$0.047
	Customer telemetry equipment and Generator Witness Testing	\$0.116
	Siting and Land Rights for required easements, reports, permits and licenses.	\$0.005
Total		\$0.513

Table 2: Transmission Provider Interconnection Facilities (PSCo Funded)

Element	Description	Cost Est. (in millions)
Pawnee Station 230kV Switchyard	Interconnect Customer to tap at PSCo's 230 kV Switchyard. The new equipment includes: <ul style="list-style-type: none"> • Two 230 kV, 40 kA circuit breakers • Four 230 kV gang switches • Electrical bus work • Associated foundations and structures 	\$0.700
Total		\$0.700
Time Frame		12 months

Table 3: PSCo Network Upgrades for Delivery

Facility	Description	Cost Est. (in millions)
Pawnee -Smoky Hill Substation 345kV Line	Construct approximately 95 miles of 345kV, double circuit transmission line (steel h-frame structure design) with bundled 2-1272 kcmil conductor, stringing one side (Pawnee-Brick Center); bundled 2-1272 kcmil conductor, stringing both sides (Brick Center-Smoky Hill)	\$ 76.027
Pawnee -Smoky Hill Substation 345kV Line	Siting and Lands Rights activities including siting and environmental studies, jurisdictional and community involvement, ROW and easement acquisition, obtaining temporary construction staging areas: <ul style="list-style-type: none"> • 79 miles of new 200 ft. 345kV transmission line ROW and easement from Pawnee to Brick Center Substation • permitting to build 16 miles of 345kV transmission line in existing corridor from Brick Center Substation to Smoky Hill Substation 	\$8.678
Pawnee 345kV Substation	Construction and upgrades for the Pawnee 345kV Substation: <ul style="list-style-type: none"> • Two 345-230kV, 560 MVA autotransformers • Three 345kV circuit breakers • Eight 345kV gang operated switches • Nine 345kV CCVT's • Three 230kV circuit breakers • Six 230kV gang operated switches • Three 230kV CCVT's • Two 230kV underground tie circuits • Associated relaying and communications • Associated equipment testing • Associated foundations and structures • Associated yard work 	\$15.720
Smoky Hill 345kV Substation	Construction and upgrades for the Smoky Hill 345kV Substation: <ul style="list-style-type: none"> • Four 345-230kV, 250 MVA autotransformers • Two 345kV circuit breakers • Ten 345kV gang operated switches • Six 345kV CCVT's • Two 230kV circuit breakers • Six 230kV gang operated switches 	\$20.050

Facility	Description	Cost Est. (in millions)
	<ul style="list-style-type: none"> • One 230kV CCVT's • Associated relaying and communications • Associated equipment testing • Associated foundations and structures • Associated yard work 	
Total		\$120.5
Time Frame	To site, engineer, procure and construct	60 months

Assumptions

- The cost estimates provided are “scoping estimates” with an accuracy of +/- 30%.
- Estimates are based on 2007 dollars.
- There is no contingency added to the estimates.
- Labor is estimated for straight time only – no overtime included.
- The Generator 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 for design and construction of PSCo network upgrades for interconnection is at least 60 months, and is completely independent of other queued projects and their respective ISD’s.
- PSCo has submitted a Certificate of Public Convenience and Necessity (CPCN) on October 31, 2007 with the CPUC for a new Pawnee to Smoky Hill 345 kV line. That process should take 6 months to complete. The estimated time frame for the CPCN process, siting, permitting, easement and right-of-way acquisition, design and construction for the PSCo network upgrades is at least 65 months. This time frame is also based on other identified assumptions for Siting and Land Rights, Substation Engineering and Transmission Engineering as listed below.
- 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.
- A siting study will be required on network upgrades for delivery. Extensive public involvement is anticipated. Permit applications and possible right-of-way acquisition will be required. Land use permits will be required from multiple local jurisdictions.

Appendix A

Contingency Results

Table 4: Contingency Comparison Table of Most Significant Contingencies

Overloaded Element										Case		Benchmark: Peetz Logan @ 400 MW, with Chambers proj., TOT 3 = 1281 MW		Stand-Along: Peetz Logan @ 400 MW + Rocky Plains @ 300 MW, TOT 3 = 1270 MW		Sensitivity: Peetz Logan @ 400 MW + GI-2006-2 (200 MW) + Rocky Plains @ 300 MW, TOT 3 = 1259 MW		Recommended Soln: Peetz Logan @ 400 MW + Rocky Plains @ 300 MW, SB100 345 kV Soln, TOT 3 = 1292 MW			List Of Contingencies
From Bus #	From --name--	kV	Area	To Bus #	To --name--	kV	Area	ID	Rating [MVA]	Pre-Cnt Load	Cnt Load	Pre-Cnt Load	Cnt Load	Pre-Cnt Load	Cnt Load	Pre-Cnt Load	Cnt Load	Δ Cnt Load			
70108	"CHEROKEE"	115	70	70126	"CONOCO"	115	70	1	135	0.76	1.00	0.78	1.02	0.79	1.04	0.76	0.99	-0.03	70108 CHEROKEE 115 TO 70277 MAPLETO2 115		
70395	"SMOKYHIL"	115	70	70416	"STRASBRG"	115	70	1	145	0.18	0.99	0.21	1.15	0.23	1.27	0.15	0.63	-0.52	70343 QUINCY 230 TO 70545 BRICKCTR 230		
70244	"LAFAYETT"	115	70	70444	"VALMONT"	115	70	1	135	0.22	0.99	0.21	1.00	0.20	1.01	0.24	0.98	-0.02	70191 FTLUPTON 115 TO 70192 FTLUPTON 230		
73023	"BIJOUTAP"	115	73	73379	"FMWEST"	115	73	1	80	0.58	0.94	0.67	1.07	0.74	1.16	0.43	0.72	-0.35	73020 BEAVERCK 115 TO 73464 ADENA 115		
70191	"FTLUPTON"	115	70	70192	"FTLUPTON"	115	70	T3	280	0.81	0.94	0.83	0.97	0.89	1.04	0.78	0.90	-0.07	70192 FTLUPTON 230 TO 70529 JLGREEN 230		
73305	"EFMORGTPT"	115	73	73379	"FMWEST"	115	73	1	121	0.69	0.92	0.75	1.01	0.79	1.07	0.59	0.78	-0.23	73020 BEAVERCK 115 TO 73464 ADENA 116		
70416	"STRASBRG"	115	70	70547	"BENNETT"	115	70	1	188	0.28	0.90	0.30	1.03	0.32	1.12	0.25	0.63	-0.40	70343 QUINCY 230 TO 70545 BRICKCTR 230		
70311	"PAWNEE"	230	70	70545	"BRICKCTR"	230	70	1	637	0.67	0.84	0.77	0.97	0.84	1.07	0.46	0.54	-0.43	70139 DANIELPK 230 TO 70311 PAWNEE 230		
70311	"PAWNEE"	230	70	70192	"FTLUPTON"	230	70	1	518	0.58	0.82	0.70	0.98	0.79	1.10	0.38	0.47	-0.51	70311 PAWNEE 230 TO 70545 BRICKCTR 230		
70311	"PAWNEE"	230	70	70139	"DANIELPK"	230	70	1	637	0.58	0.68	0.67	0.80	0.74	0.88	0.45	0.49	-0.31	70192 FTLUPTON 230 TO 70311 PAWNEE 230		

Line Rating	
Pawnee - Smoky - D.Pk = 667 MVA	
Pawnee - Ft. Lupton = 518 MVA	