Interconnection Feasibility Study Report
Request # GI-2004-6

250 MW Wind Facility, near Akron, Colorado

Xcel Energy Transmission Planning
November, 2004

Executive Summary

PSCo Transmission received a generation request to determine the feasibility of interconnecting 250 MW of new Customer wind turbine generation into the PSCo transmission system at the Pawnee Station 230 kV bus. The Customer proposed commercial operation date is December 31, 2006 with a back feed date of June 1, 2006. This request was studied as both an Energy Resource (ER) and a Network Resource (NR). The request was studied primarily as a "stand-alone" project, without considering other projects in the Rocky Mountain Area OASIS queue[1], but some sensitivity analysis was also performed to consider some higher queued projects.

The ER portion of this study determined that the Customer could not provide any firm energy without the construction of network reinforcements. This determination is based on existing limitations due to the TOT3 transfer path. Non-firm transmission capability may be available depending on marketing activities, dispatch patterns, demand levels and the status of transmission facilities.

As an NR request, PSCo evaluated the network to determine the upgrades required to deliver the full 250 MW of the wind facility to PSCo native load customers. The total estimated cost of the recommended system upgrades to accommodate the project is approximately **$45.4** million and includes:

- $0.395 million for Customer Interconnection Facilities at Pawnee Station
- $0.325 million for PSCo Network Upgrades for Interconnection
- $44.685 million for PSCo Network Upgrades for Delivery

As a stand-alone project, the basic upgrades would consist of:

- Uprate the 94 mile PSCo 230 kV line from Pawnee Station to Quincy and Smoky Hill Substations from 500 MVA to 800 MVA.
- Upgrade the PSCo 64 mile 230 kV line from Pawnee Station to Ft. Lupton Station to a 230 kV double circuit, 800 MVA per circuit rated transmission line.
- Uprate the existing 230 kV line from Story to Pawnee Station from 576 MVA to 650 MVA.
- Uprate the existing 230 kV line from Ft. Lupton Station to Henry Lake Substation to Riverdale Substation to Cherokee Station from 435 MVA to 475 MVA.

[1] www.rmao.com

The regional transmission system is shown in Figure 1 along with the recommended upgrades. A partial one-line of Pawnee Station can be found in Figure 2.

The time required to engineer, permit, and construct all the required PSCo facilities for interconnection is estimated to be at least 9 months. The estimated time required to engineer, permit, and construct the Network Upgrade facilities for delivery is at least 27 months. According to the interconnection request, the Customer will engineer, permit, construct, and finance the 28-mile 230 kV transmission line to the proposed tap station.

If some other higher queued projects and associated system upgrades are considered to be in place, sensitivity studies indicate that the total estimated cost of the recommended system upgrades to accommodate the project would be approximately **$135.8** million and include:

- $0.395 million for Customer Interconnection Facilities at Pawnee Station
- $1.120 million for PSCo Network Upgrades for Interconnection
- $134.4 million for PSCo Network Upgrades for Delivery

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

Introduction

PSCo Transmission received a large generator interconnection request (GI-2004-6) to interconnect one hundred sixty-seven (167) 1.5 MW, GE doubly fed induction generator (DFIG) wind turbines, for a total of 250 MW generation, with a commercial operation date of December 31, 2006, and a back feed date of June 1, 2006. The proposed wind farm (Project) would be located near Akron, Colorado and would interconnect into the PSCo transmission system via a 28 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 TOT3 and the neighboring utilities are considered minimal. Should the Customer continue this request and move on to the System Impact Study, more detailed impacts may be identified. For this project, potentially affected parties could include Western Area Power Administration (WAPA), and Tri-State Generation and Transmission (TSGT).

Figure 1 - Regional Transmission Network with Recommended Upgrades

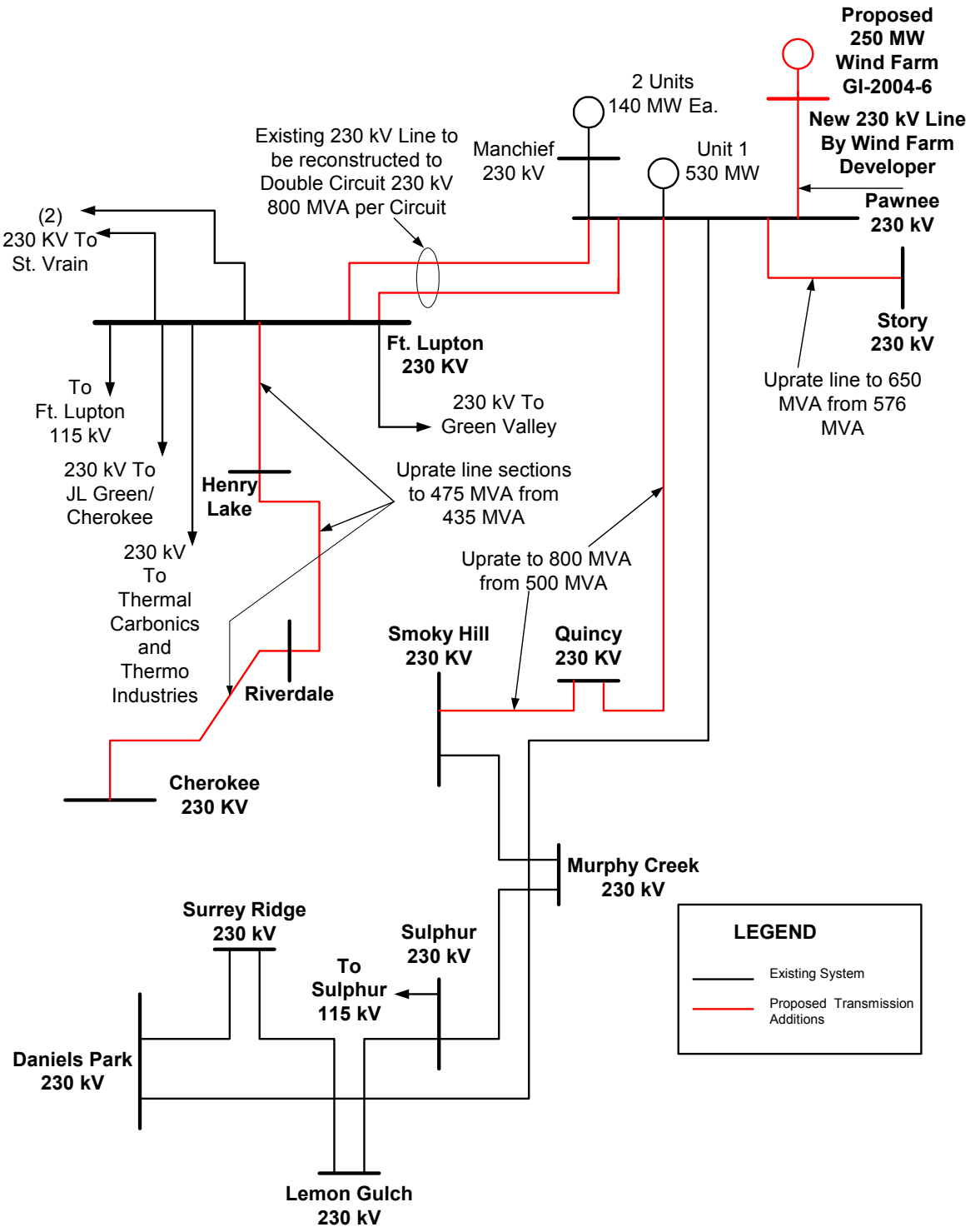
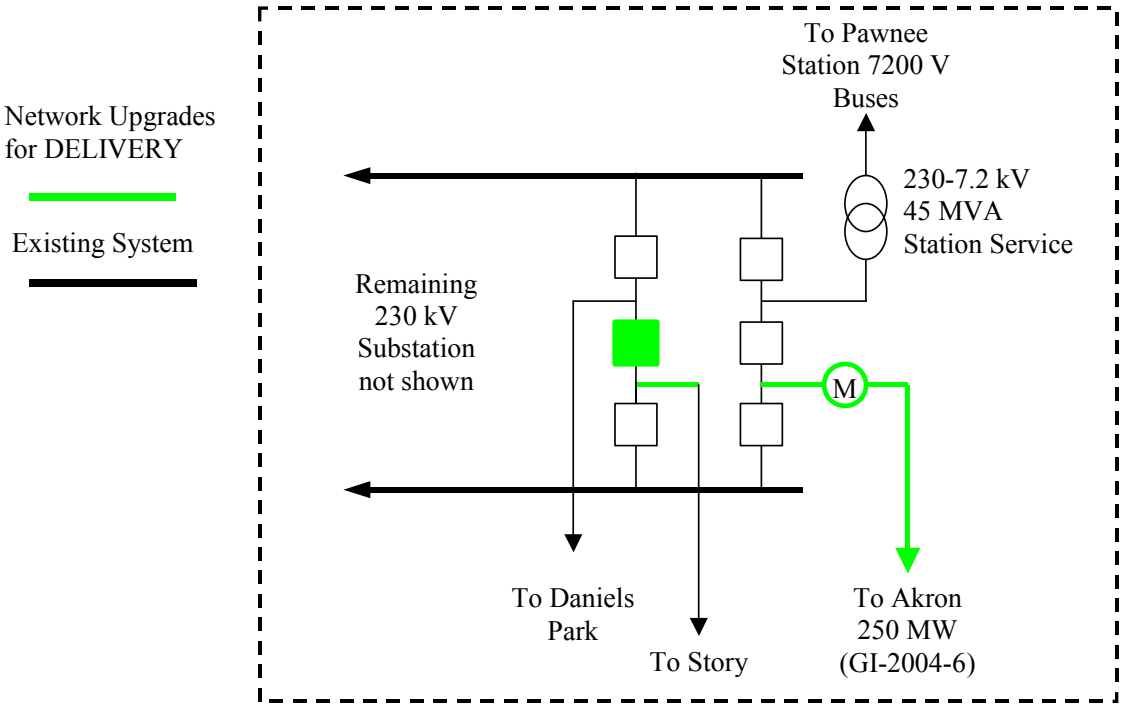


Figure 2 - Pawnee Station One-line with GI-2004-6



Power Flow Study Models

The power flow studies were based on a Western Electricity Coordinating Council (WECC) 2007 heavy summer base model. The studies were performed using the General Electric (GE) PSLF program. The 250 MW wind farm was modeled as two 125 MW conventional generators with a 0.95 per unit (p.u.) lagging power factor (overexcited) and a 0.90 p.u. leading power factor (under-excited) capability to simulate the VAR requirements of the generators, assumed to be GE 1.5 MW DFIG turbines. The project generation was scheduled to the southern PSCo system by reducing generation in that area.

The Point of Interconnection (POI) between the Customer and PSCo is assumed to be the point at which the 28-mile transmission line meets the Pawnee Substation bus. The 28-mile line was modeled per the Customer provided information:

- A single-circuit 28-mile, 230 kV line using conventional 230 kV “H-frame” wood pole construction with a single 954 ACSR conductor per phase, with a 281 MVA rating.
- One 230-34.5 kV, 225/300 MVA Customer GSU transformer, located at the Customer collector site.

To evaluate the capabilities and system requirements for firm transfer levels, the powerflow model was modified to simulate high TOT3 path flows. Efforts were made to include in the models all transmission projects expected to be in service for the 2007

heavy summer season. The studies assumed 2007 peak summer demand conditions in the PSCo system and in other utility systems. The TOT3 flow in the case was 1488 MW.

Power Flow Study Results and Conclusions

Energy Resource (ER) Study Results

The results of the ER study indicate that with the existing system and with existing firm reservations across TOT3, there is no available capacity at Pawnee Station; therefore the ER is zero MW. Non-firm transmission capability may be available depending on marketing activities, dispatch patterns, 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 250 MW from the proposed wind farm for the conditions studied. For the study, the project generation was scheduled to the southern PSCo system by reducing generation in that area. At 250 MW of generation, there were numerous contingency overloads.

The Customer's interconnection request is similar to previously studied interconnection requests at Pawnee Substation. The upgrades were determined to be comparable with the network upgrades identified for GI-2003-1. The basic recommended network upgrades to alleviate the overloads and accommodate the generation include the following:

- Between Pawnee Station and Smoky Hill Substation, uprate the existing 230 kV line from 500 MVA to 800 MVA by using phase raisers to raise 15 transmission structures.
- From Pawnee Station to Ft. Lupton Station rebuild the existing 64 mile 230 kV 413 MVA rated line to a double circuit 230 kV, 800 MVA per circuit configuration.
- Uprate the existing 230 kV line from Story to Pawnee Station from 576 MVA to 650 MVA by adjusting the rating methodology for that line to allow for a higher conductor temperature.
- Uprate the existing 230 kV line from Ft. Lupton Station to Henry Lake Substation to Riverdale Substation to Cherokee Station from 435 MVA to 475 MVA. This can be accomplished by replacing transmission line and equipment jumpers at Riverdale and Cherokee. The 230 kV main buses at Cherokee must also be replaced with 5-inch aluminum bus tube from the existing 1272 kCMIL ACSR.

The total estimated cost for the recommended upgrades is $45.4 million. The facility costs are described in more detail in the Cost Estimates and Assumptions section.

Sensitivity Results for Higher Queued Projects

The Project was also evaluated taking into consideration relevant projects ahead in the queue. The projects considered included:

- GI-2003-1: 300 MW interconnected at Pawnee 230kV station.
- GI-2004-1: 150 MW wind generation interconnected at Pawnee 230kV station
- GI-2004-5: 402 MW wind generation interconnected on the RMEC – Green Valley 230kV lines.

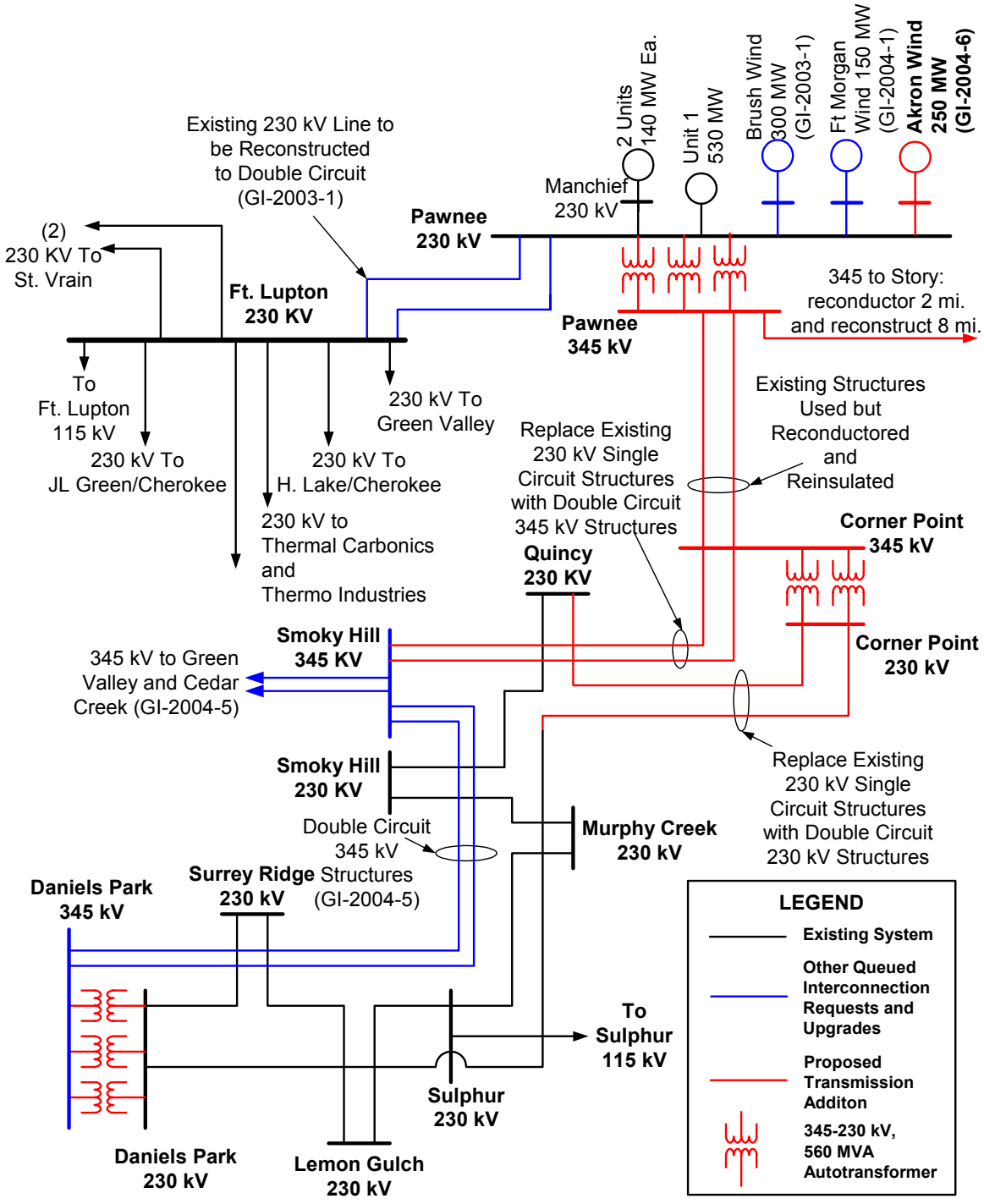
The associated network upgrades for each of the queued projects were also included in the studies. The details of the upgrades for those projects can be seen in their associated studies on the RMAO web page www.rmao.com.

With the addition of the Customer's generation at the full 250 MW, numerous contingency overloads were observed. The network upgrades are summarized below, and illustrated in Figure 3.

- Construct a new 345 kV substation at Pawnee including three 345 kV – 230 kV autotransformers.
- Rebuild the 10 mile Pawnee – Story 230 kV line to 345 kV.
- Construct a new Corner Point 230 kV substation 40 miles east of Smoky Hill and tap the Pawnee – Daniels Park 230 kV line at Corner Point. Note that this item is identified for GI-2003-2; however, this project (GI-2004-6) has an earlier in-service date.
- Replace the two existing 42 miles of single-circuit structures from Corner Point to Quincy with double-circuit 230 kV structures.
- Construct a new Corner Point 345 kV Substation including two 345 kV – 230 kV autotransformers.
- Reconductor and re-insulate the two 54-mile, single-circuit 230 kV lines from Pawnee to Corner Point for 345 kV operation.
- Construct a new 345 kV switching station at Smoky Hill to tap the double-circuit 345 kV lines added by GI-2004-5.
- Rebuild 42 miles of single-circuit 230 kV to double-circuit 345 kV from Corner Point to Smoky Hill 345 kV.
- Add a third 345 kV – 230 kV autotransformer at Daniels Park Substation.

Taking into account the projects ahead in the queue that also interconnect at Pawnee, the total estimated cost of upgrades would be approximately $135 million and include $1,455,000 for interconnection and $134 million for delivery. The time frame for construction is estimated to be at least 54 months.

Figure 3 - Recommended Upgrades with Queued Projects



Short Circuit Study Results

The short circuit study results are contained in Table 1. 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.

For all of the fault cases studied, the wind turbines for Akron were modeled as conventional synchronous generators. A more accurate short circuit model is not currently available for such short circuit programs as Aspen or CAPE. This study was performed on CAPE. More detailed short circuit models, and associated possible Customer generation fault contribution will need to be addressed in later studies, such as the Interconnection System Impact Study (SIS) and the following Interconnection Facilities Study (IFS).

Table 1 - Short Circuit Study Results

Case[1]	Wind Gen[2] (MW)	Fault Location[3]	Fault Type[4]	Fault Current[5] (A)
Existing	0	230kV Ft. Lupton	3 phase	27,944
Existing	0	230kV Ft. Lupton	SLG	23,756
Existing	0	230kV Pawnee	3 phase	19,298
Existing	0	230kV Pawnee	SLG	22,213
Existing	0	230kV Quincy	3 phase	15,481
Existing	0	230kV Quincy	SLG	10,656
Delivery	0	230kV Ft. Lupton	3 phase	31,451
Delivery	0	230kV Ft. Lupton	SLG	25,676
Delivery	0	230kV Corner Point	3 phase	19,163
Delivery	0	230kV Corner Point	SLG	19,536
Delivery	0	230kV Quincy	3 phase	17,491
Delivery	0	230kV Quincy	SLG	12,711
Delivery	0	230kV Smoky Hill	3 phase	28,325
Delivery	0	230kV Smoky Hill	SLG	25,817
Delivery	0	345kV Corner Point	3 phase	16,089
Delivery	0	345kV Corner Point	SLG	13,171
Delivery	0	345kV Pawnee	3 phase	17,042
Delivery	0	345kV Pawnee	SLG	17,672
Delivery	0	345kV Story	3 phase	10,216
Delivery	0	345kV Story	SLG	9,518

[1] Existing case is for current Xcel Energy system configuration. Interconnect case is for connecting customer only, without infrastructure upgrades. Delivery case is for customer interconnected and infrastructure upgrades in service.
[2] Initial cases were studied with the wind generators offline. Wind generation only introduced after infrastructure upgrades in service.
[3] Pawnee Sub is the location where the wind generation from the customer ties into the Xcel Energy system (see one-lines).
[4] SLG stands for single line to ground fault.
[5] Fault current for 3 phase faults is represented as positive sequence current. Fault current for single line to ground faults is represented as 3Io (where Io is zero sequence current). These fault studies were performed assuming all customers higher in the queue have been placed in-service.

Case[1]	Wind Gen[2] (MW)	Fault Location[3]	Fault Type[4]	Fault Current[5] (A)
Delivery	250	230kV Akron Wind	3 phase	10,230
Delivery	250	230kV Akron Wind	SLG	8,120
Delivery	250	230kV Corner Point	3 phase	19,386
Delivery	250	230kV Corner Point	SLG	16,642
Delivery	250	230kV Quincy	3 phase	17,579
Delivery	250	230kV Quincy	SLG	12,732
Delivery	250	230kV Ft. Lupton	3 phase	31,763
Delivery	250	230kV Ft. Lupton	SLG	25,771
Delivery	250	230kV Pawnee	3 phase	30,438
Delivery	250	230kV Pawnee	SLG	33,924
Delivery	250	345kV Corner Point	3 phase	16,385
Delivery	250	345kV Corner Point	SLG	13,262
Delivery	250	345kV Pawnee	3 phase	18,138
Delivery	250	345kV Pawnee	SLG	18,198
Delivery	250	345kV Story	3 phase	10,438
Delivery	250	345kV Story	SLG	9,606

Costs Estimates and Assumptions

The estimated total cost for the required upgrades is **$45,405,000.**

The estimated costs shown are “indicative”, or “scoping” (+/-30%) estimates in 2006 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 does not include any costs for any Customer-owned, supplied, and installed equipment and associated design and engineering. This estimate also does not include any costs that may be required for other entities’ systems.

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.

The estimated costs for interconnection are detailed in Table 2 and Table 3. The customer is responsible for the construction of the 28 mile transmission line from the wind project location to the point of interconnection at Pawnee Station; this cost to the Customer has not been estimated by PSCo.

Table 2 – Customer Interconnection Facilities

Substation	Description	Cost Est.
Pawnee Station	Interconnect Customer to tap PSCo's 230kV bus. The new equipment includes 230kV bi-directional transformer metering, relaying and associated equipment and material.	$335k
	Transmission tie line into Pawnee Station.	$40k
	Siting and Land Rights for required easements, reports, permits and licenses.	$20k
	Total Cost Estimate for Customer Interconnection Facilities	**$395k**

Table 3 – PSCo Network Upgrades for Interconnection

Substation	Description	Cost Est.
Pawnee Station	Interconnect Customer's 230 kV line, which will require the relocation of the existing Pawnee to Story 230 kV line to one bay west to allow the new Customer owned line to terminate in this position. The new equipment required includes: • a new 230 kV 3000 A, 50 kA circuit breaker • two 230 kV switches • required steel supporting structures	$325k
	Total Cost Estimate for PSCo Network Upgrades for Interconnection	**$325k**

Table 4 – PSCo Network Upgrades for Delivery

Element	Description	Cost
Pawnee Station	New 230 kV Line terminal to Ft. Lupton requiring the following equipment: • one new 230 kV breaker and half bay on the west side of the 230 kV switch yard • (2) 3000 Amp, 50 kA circuit breakers • (4) 230 kV switches • associated steel • electrical bus work • associated metering, control, and relaying Uprate the 230 kV line from Pawnee to Story requires the following: • replace four 230 kV 1600 Amp switches with 3000 Amp switches Uprate the Pawnee to Smoky Hill 230 kV line requires the following: • replace six (6) 1600 Amp switches with 3000 Amp switches • replace 1200 Amp Line trap with 2000 Amp Line Trap	$1,430k

Ft. Lupton Station	New 230 kV 2000 Amp Line Terminal to Pawnee which will require rearranging of the existing line terminations for the Henry Lake and Green Valley lines. The following equipment will be required: • a new 230 kV breaker and a half bay on the east side of the station • three (3) 230 kV 3000 Amp 50 kA circuit breakers that includes replacing one 1600 Amp breaker • ten (10) 230 kV switches that includes four (4) new and six (6) replacements from 1600 Amp to 3000 Amp • misc. supporting steel • electrical bus work • associated metering control and relaying	$1,400k
Smoky Hill Substation	Upgrade existing facilities on the Pawnee 230 kV line terminal which includes the following: • replace two (2) underrated 230 kV 1600 Amp circuit breakers with new 3000 Amp 50 kA circuit breakers • replace four (4) 1600 Amp switches with 3000 Amp switches • replace 1200 Amp Line trap with 2000 Amp Line Trap • replace existing east and west main 1272 kCMIL strain buses with 5” aluminum tube bus • associated metering, control, and relaying	$1,060k
Riverdale	Replace equipment jumpers and transmission line jumpers.	$65k
Quincy Substation	Replace existing 1200 Amp line-rupters with 2000 Amp line rupters	$310k
Cherokee	• Replace existing equipment jumpers and transmission line jumpers with (2) 1272 kCMIL ACSR, • Replace existing north and south 1272 kCMIL ACSR strain bus with 5” aluminum tube bus • Replace one 1600 Amp circuit breaker with a 3000 Amp 50 kA breaker	$720k
Transmission	Rebuild existing 413 MVA 230 kV line from Pawnee to Ft. Lupton with new double circuit 230 kV 834 MVA transmission utilizing existing ROW as much as possible	$38,700k
	Uprate the existing Pawnee to Quincy/Smoky Hill 230kV Line to 800 MVA from 500 MVA by installing approximately 15 phase raisers.	$210k
	Uprate Ft. Lupton to Henry Lake to Riverdale to Cherokee 230 kV line from 435 MVA to 475 MVA. Need an aerial survey to determine current ground clearances.	$190k
	Uprate Story to Pawnee 230 kV line from 576 MVA to 650 MVA	$0
Siting and Permitting	Obtain necessary siting, permits, and ROW as required	$610k
	Total Cost Estimate for PSCo Network Upgrades for Delivery	**$44,685k**
	Total Cost of Project	**$45,415k**
Time Frame		**27 Months**

Assumptions

- The cost estimates provided are “scoping estimates” with an accuracy of +/- 30%.
- Estimates are based on 2006 dollars.
- 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 at the Pawnee Station is at least 9 months, and is completely independent of other queued projects and their respective ISD’s.
- It is anticipated that in order to construct the PSCo network upgrades for delivery, a Certificate of Public Convenience and Necessity (CPCN) will be required by the Colorado Public Utilities Commission (CPUC). The application for a CPCN will not be submitted until the Interconnection Agreement is fully executed. 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 27 months from the time the Interconnection Agreement is fully executed. This time frame is also based on other identified assumptions for Siting and Land Rights, Substation Engineering and Transmission Engineering as listed below.
- The Customer will be responsible for funding and constructing approximately 28 miles of transmission line from the wind farm to the point of interconnection (Pawnee Station).
- The last span into Pawnee Station from the Customer owned 230 kV line will be a slack span between the PSCo substation dead-end and the Customer’s last structure, which is assumed to be a dead-end tangent structure.
- A siting study will not be required if network upgrades for delivery (transmission line construction) is in existing right-of-way. Extensive public involvement is anticipated. Permit applications and possible minor right-of-way acquisition will be required. Land use permits will be required from multiple local jurisdictions.

The following tables list the estimated incremental costs for interconnection and delivery of the Project, taking into consideration the projects GI-2003-1, GI-2004-1, and GI-2004-5. The network upgrades are illustrated in Figure 3.

Table 5 - Customer Interconnection Facilities

Substation	Description	Cost Est.
Pawnee Station	Interconnect Customer to tap PSCo's 230kV bus. The new equipment includes 230kV bi-directional transformer metering, relaying and associated equipment and material.	$335k
	Transmission tie line into Pawnee Station.	$40k
	Siting and Land Rights for required easements, reports, permits and licenses.	$20k
	Total Cost Estimate for Customer Interconnection Facilities	**$395k**

Table 6 - PSCo Network Upgrades for Interconnection

Substation	Description	Cost Est.
Pawnee Station	Interconnect Customer's 230 kV line, which will connect to a new bay at the Pawnee Station. The new equipment required includes: • two 230kV, 3000 amp gas circuit breakers • four 230kV, 3000 amp gang switches • supporting bus, steel structures and foundations • misc. building wiring, grounding and materials	$1,060k
	Total Cost Estimate for PSCo Network Upgrades for Interconnection	**$1,060k**

Table 7 - PSCo Network Upgrades for Delivery

Substation	Description	Cost Est.
Pawnee Station	Construct a new 345kV Pawnee Switching Station with three 345kV/230kV autotransformers tying to the 230kV yard, one 345kV line to Story Sub and two 345kV lines to Corner Point Sub. Major equipment required includes: • three 345kV/230kV autotransformers • nine 345kV dead tank gas circuit breakers • one 230kV, 3000 amp gas circuit breaker • two 230kV, 3000 amp gang switches • 18-345kV, 2000 amp gang switches • relaying, controls and communication additions/upgrades • supporting bus, steel structures and foundations	$20,000k

	• miscellaneous building wiring, grounding and materials • fence, earthwork and yard surfacing	
Daniels Park	Install one new 345kV/230kV autotransformer tying to the 230kV yard. Major equipment required includes: • one 345kV/230kV autotransformer • four 345kV dead tank gas circuit breakers • one 230kV, 3000 amp gas circuit breaker • two 230kV, 3000 amp gang switches • six 345kV, 2000 amp gang switches • relaying, controls and communication additions/upgrades • supporting bus, steel structures and foundations • miscellaneous building wiring, grounding and materials • fence, earthwork and yard surfacing	$7,850k
Smoky Hill	Construct a new 345kV Smoky Hill Switching Station with two 345kV lines to Corner Point Sub, two 345kV lines to Green Valley Sub and two 345kV lines to Daniels Park Sub. Major equipment required includes: • nine 345kV dead tank gas circuit breakers • 18 345kV, 2000 amp gang switches • new electric equipment enclosure • relaying, controls and communication additions/upgrades • supporting bus, steel structures and foundations • miscellaneous building wiring, grounding and materials • fence, earthwork and yard surfacing	$10,300k
Corner Point	Construct a new 345kV/230kV Corner Point Switching Station with two 345kV/230kV autotransformers tying to the 230kV yard, one 230kV line to Smoky Hill Sub, one 230kV line to Daniels Park Sub and two 345kV lines to Smoky Hill Sub. Major equipment required includes: • two 345kV/230kV autotransformer • nine 345kV dead tank gas circuit breakers • four 230kV, 3000 amp gas circuit breaker • ten 230kV, 3000 amp gang switches • 18 345kV, 2000 amp gang switches • new electric equipment enclosure • relaying, controls and communication additions/upgrades • supporting bus, steel structures and foundations • miscellaneous building wiring, grounding and materials • fence, earthwork and yard surfacing	$21,900k
Story (Tri-State)	Move the Pawnee Station line over to the 345kV	$950k

	yard and upgrade equipment for 345kV operation. Major equipment requirements include: • two 345kV, 2000 amp gang switches • one 345kV dead tank gas circuit breaker • relaying, controls and communication additions/upgrades • supporting bus, steel structures and foundations • miscellaneous building wiring, grounding and materials	
Transmission	Convert the existing 54 miles of the Pawnee-Daniels Park 230kV line to 345kV. Bundled 954 conductor and two new dead-ends.	$6,550k
	Convert the existing 54 miles of the Pawnee-Smoky Hill 230kV line to 345kV. Bundled 954 conductor, two new dead-ends and replace transposition structures with steel structures.	$6,670k
	Construct 42 miles of new 230kV line from Smoky Hill to Corner Point. Bundled 954 conductor, 285 steel pole structures.	$25,200k
	Construct 42 miles of new 345kV line from Smoky Hill to Corner Point. Bundled 954 conductor, 285 D/C Illinois structures.	$30,560k
	Convert the existing Pawnee-Story 230kV line to 345kV. Reconductor two miles of line and rebuild eight miles of line.	$3,110k
Siting and Permitting	Siting and Land Rights for required easements, reports, permits and licenses.	$1,270k
	Total Cost Estimate for PSCo Network Upgrades for Delivery	**$134,360k**
	Total Cost of Project	**$135,815k**
Time Frame		**54 months**

Assumptions:

- The cost estimates provided are “scoping estimates” with an accuracy of +/- 30%.
- Estimates are based on 2006 dollars.
- 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 at the Pawnee Station is at least 9 months and is completely independent of GI-2004-5.

- It is anticipated that in order to construct the PSCo network upgrades for delivery, a Certificate of Public Convenience and Necessity (CPCN) will be required by the Colorado Public Utilities Commission (CPUC). The application for a CPCN will not be submitted until the Interconnection Agreement is fully executed. 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 54 months from the time the Interconnection Agreement is fully executed. This time frame is also based on other identified assumptions for Siting and Land Rights, Substation Engineering and Transmission Engineering as listed below.
- Infrastructure associated with Interconnection Request GI-2004-5 is assumed to be constructed (see previous description) and it was determined that these network upgrades required a minimum of 56 months to complete following the execution of an Interconnection Agreement. The feasibility study report for GI-2004-5 is available via RMAO.com.
- The Customer will be responsible for funding and constructing approximately 28 miles of transmission line from the wind farm to the point of interconnection (Pawnee Station).
- The last span into Pawnee Station from the Customer owned 230 kV line will be a slack span between the PSCo substation dead-end and the Customer's last structure, which is assumed to be a dead-end tangent structure.
- A siting study will not be required if network upgrades for delivery (transmission line construction) is in existing right-of-way. Extensive public involvement is anticipated. Permit applications and possible minor right-of-way acquisition will be required. Land use permits will be required from multiple local jurisdictions.
- For all of the fault cases studied, the wind turbines for the Akron Wind Project were modeled as conventional synchronous generators. A more accurate model is not currently available for such short circuit programs as Aspen or CAPE. This study was performed using CAPE.

<u>Pawnee Station</u>

- Enough land is available to accommodate a 345kV switching yard.
- A new 345kV switching yard is required with three 345/230/13.8kV 560 MVA autotransformers tying to the 230kV yard, one 345kV line to Story Substation, and two 345kV lines to Corner Point Substation.
- The existing 230kV transmission line to Tri-State's Story Substation will move over to the new 345kV yard. At Story Substation, the existing 230kV line will move over to their 345kV yard.
- The existing 230kV transmission lines to Smoky Hill Substation (5165) and Daniels Park Substation (5457) will move over to the new 345kV yard and the vacated positions will be used for two of the autotransformers. The remote ends of these lines will terminate at the new Corner Point Substation.
- An additional 230kV breaker and switch are needed to tie in the third autotransformer.

Corner Point Substation

- A new 230/345kV switching yard is required with two 345/230/13.8kV 560 MVA autotransformers tying to the 230kV yard, one 230kV line to Smoky Hill Substation, one 230kV line to Daniels Park Substation and two 345kV lines to Smoky Hill Substation.
- Site terrain is unknown. Cost estimates are included for a significant amount of grading.
- See comments above about transmission lines to the Pawnee Station.

Smoky Hill Substation

- A new 345kV switching yard is required with two 345kV lines to Corner Point Substation, two 345kV lines to Green Valley Substation and two 345kV lines to Daniels Park Substation.
- Enough land is available to accommodate a 345kV switching yard.
- The new 345kV yard will not tie into the existing 230/115kV yard.
- The new 345kV yard will sectionalize the two new 345kV lines from Green Valley Substation to Daniels Park Substation added as part of the delivery upgrades in GI-2004-5

Daniels Park Substation

- A new 345/230/13.8kV 560 MVA autotransformer tying to the 230kV yard will be required.
- The new autotransformer will require the 230kV line to Arapahoe Station (5107) to be swung to a new line position in the adjacent bay to the west and the 345kV line to Smoky Hill Substation (was Green Valley Substation) to be swung to a new bay to the east.
- Four 345kV breakers, six 345kV gang switches, one 230kV breaker, and two 230kV gang switches are needed to accommodate the new autotransformer.
- This estimate assumes all work part of GI-2004-5 has been completed at Daniels Park Substation and only the new third autotransformer and associated breakers and switches are required.
- See comments above about transmission lines to Smoky Hill Substation (old Green Valley Substation).
- The connection between the autotransformer and the 230kV yard will be underground.

Story Substation (Tri-State)

- See comments above about 345kV line swing.
- General arrangements were not available at this time. The estimates for moving the Pawnee Station line over to the 345kV yard assume that adequate space is available.
- An additional 345kV breaker and associated gang switches will be needed to terminate the Pawnee Station line in Tri-State's 345kV yard.
- Enough space is available in the control building to accommodate a new 345kV transmission line relaying panel.