



Interconnection Feasibility Study Report (Re-Study) Request # GI-2004-6

250 MW Wind Facility, near Akron, Colorado

Xcel Energy Transmission Planning
March, 2005

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 a new PSCo switching station adjacent to the existing Story Substation, which is owned by Tri-State Generation and Transmission (TSGT). This report documents a re-study of the GI-2004-6 Feasibility Study completed in November, 2004. The Customer requested to move the point of interconnection from the PSCo Pawnee Station to a tap on the Story-Pawnee 230 kV line near Story Substation.

The Customer proposed commercial operation date is December 31, 2006 with an assumed 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 queue¹, but some sensitivity analysis was also performed to consider some higher queued projects.

Energy Resource:

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. The total estimated cost of the recommended upgrades required for interconnection of the project for non-firm transmission service is **\$2.97 million** and includes:

- \$0.37 million for Customer Interconnection Facilities
- \$2.60 million for PSCo Network Upgrades for Interconnection

The time required to engineer, permit, and construct the facilities required for interconnection is estimated to be at least **20** months. A diagram of the regional system is shown in Figure No. 1. A one-line diagram of the network upgrades required for interconnection is shown in Figure No. 2.

¹ www.rmao.com

Network Resource:

As an NR request, PSCo evaluated the network upgrades required to deliver the full 250 MW of the wind facility to PSCo native load customers. As a stand-alone project the total estimated cost of the recommended system upgrades to accommodate the project is approximately **\$119.5** million and includes:

- \$116.5 million for PSCo Network Upgrades for Delivery

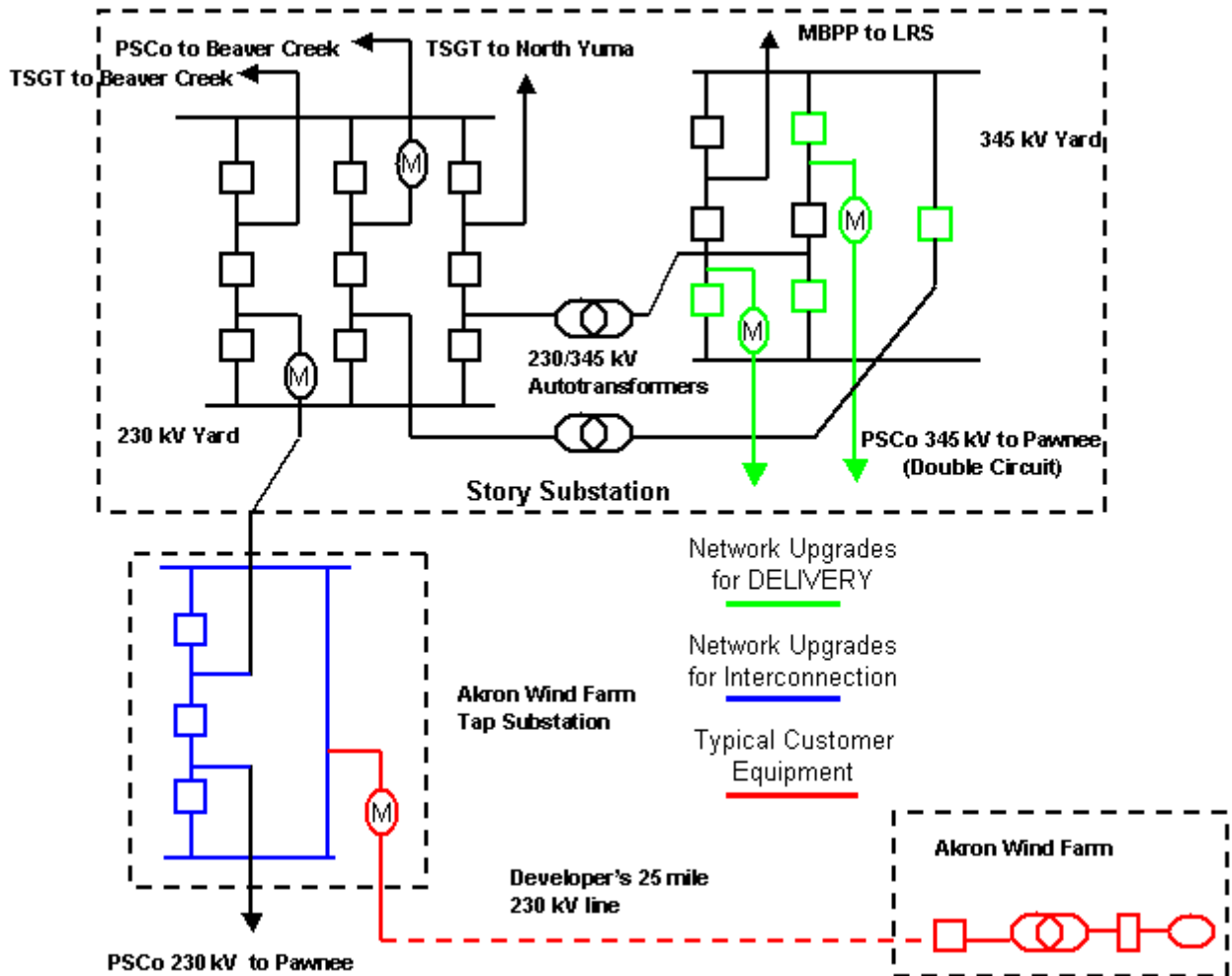
The time required to engineer, permit, and construct the facilities required for interconnection is estimated to be at least **60** months. Therefore, it is not feasible to implant the network upgrades for delivery of firm output by the proposed in-service date. As a stand-alone project, the basic upgrades would consist of:

- Tap the existing Story-Pawnee 230 kV line near story and build a new 230 kV, three-breaker ring station to interconnect the project.
- Construct a new 9-mile 345 kV, double-circuit, 1200 MVA per circuit transmission line from Story Substation to Pawnee Station.
- Construct a new 345 kV switchyard at Pawnee Station with one 345-230 kV 560 MVA autotransformer.
- Construct a new 345 kV switchyard at Smoky Hill Substation with one 345-230 kV 560 MVA autotransformer.
- Construct a new 345 kV switchyard at Daniels Park Substation with one 345-230 kV 560 MVA autotransformer.
- Reconductor and re-insulate the 59-mile, single-circuit 230 kV line from Pawnee to Corner Point for 345 kV operation.
- Construct 35 miles of double-circuit, 345 kV structures from Corner Point to Smoky Hill.
- Relocate the existing Quincy-Smoky Hill 230 kV line to the new double-circuit structures to serve Quincy Substation.
- Construct a new 23-mile, 345 kV line from Smoky Hill to Daniels Park using double circuit structures.
- Upgrade the 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.

According to the interconnection request, the Customer will engineer, permit, construct, and finance the 19-mile 230 kV transmission line to the proposed tap station.

If some other higher queued projects in the region are considered to be in place, other studies indicate that those projects would result in requiring the Pawnee-Ft. Lupton network upgrades for delivery described above. If this project (GI-2004-6) was implemented in addition to the higher queued projects, sensitivity studies indicate that additional upgrades would be required between Pawnee and Denver Metro Area to supply the total 250 MW from the Project. The extent and cost of the additional upgrades was not evaluated.

Figure 2 – PSCo Story Substation One-line with GI-2004-6



Introduction

Following the completion of the original feasibility study for GI-2004-6 in November 2004, the Customer requested that re-study be performed to evaluate a different point of interconnection. The original study, evaluated the point of interconnection at the PSCo Pawnee Station. This re-study evaluates the project at a point of interconnection near the existing Story Substation, which is owned and operated by Tri-State Generation and Transmission. The restudy evaluates the interconnection at a new PSCo-owned substation that would tap the existing Story-Pawnee 230 kV transmission line.

PSCo Transmission received a large generator interconnection request (GI-2004-6) to interconnect one hundred sixty-seven 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 19 mile radial 230 kV line terminating at a new switching station adjacent to the Story Substation. 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).

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 19-mile transmission line meets the new switching station. The 19-mile line was modeled per the Customer provided information:

- A single-circuit 19-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 the point of interconnection; 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 basic recommended network upgrades to alleviate the overloads and accommodate the generation include the following:

- Tap the existing Story-Pawnee 230 kV line near story and build a new 230 kV, three-breaker ring station to interconnect the project.
- Construct a new 9-mile 345 kV, double-circuit, 1200 MVA per circuit transmission line from Story Substation to Pawnee Station.
- Construct a new 345 kV switchyard at Pawnee Station with one 345-230 kV 560 MVA autotransformer.
- Construct a new 345 kV switchyard at Smoky Hill Substation with one 345-230 kV 560 MVA autotransformer.
- Construct a new 345 kV switchyard at Daniels Park Substation with one 345-230 kV 560 MVA autotransformer.
- Reconductor and re-insulate the 59-mile, single-circuit 230 kV line from Pawnee to Corner Point for 345 kV operation.
- Construct 35 miles of double-circuit, 345 kV structures from Corner Point to Smoky Hill.
- Relocate the existing Quincy-Smoky Hill 230 kV line to the new double-circuit structures to serve Quincy Substation.
- Construct a new 23-mile, 345 kV line from Smoky Hill to Daniels Park using double circuit structures.
- Upgrade the 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.

The total estimated cost for the recommended upgrades is \$116.5 million. The facility costs are described in more detail in the Cost Estimates and Assumptions section.

If some other higher queued projects in the region are considered to be in place, other studies indicate that those projects would result in requiring the Pawnee-Ft. Lupton network upgrades for delivery described above. If this project (GI-2004-6) was implemented in addition to the higher queued projects, sensitivity studies indicate that additional upgrades would be required between Pawnee and Denver Metro Area to supply the total 250 MW from the Project. The extent and cost of the additional upgrades was not evaluated.

Short Circuit Study Results

Based on previous studies, the project is not expected to cause fault currents to exceed existing circuit breaker ratings. Short circuit analysis will need to be studied in more detail during the System Impact Study.

Costs Estimates and Assumptions

The estimated total cost for the required upgrades is \$119,512,000

The estimated costs shown are “indicative”, or “scoping” (+/-30%) estimates in 2006 dollars and is 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 Tables 1 and 2. Table 3 details the cost for delivery. The customer is responsible for the construction of the 19-mile transmission line from the wind project location to the point of interconnection; this cost to the Customer has not been estimated by PSCo.

Table 1 – Customer Interconnection Facilities

Substation	Description	Cost Est.
Story (PSCo)	Interconnect Customer to tap 230 kV bus. The new equipment includes 230 kV bi-directional transformer metering, relaying and associated equipment and material.	\$311k
	Transmission tie line into Story Substation.	\$38k
	Siting and Land Rights for required easements, reports, permits and licenses.	\$20k
	Total Cost Estimate for Customer Interconnection Facilities	\$369k

Table 2 – PSCo Network Upgrades for Interconnection

Substation	Description	Cost Est.
Story (PSCo)	Construct new 3-breaker ring substation to interconnect Customer's 230 kV line, which will tap the existing Story-Pawnee 230 kV transmission line at Story. The new equipment required includes: <ul style="list-style-type: none"> • three 230kV, 3000 amp gas circuit breakers • eight 230kV, 3000 amp gang switches • site grading and landscaping • new electric equipment enclosure and protective relaying • supporting bus, steel structures and foundations • misc. building wiring, grounding and materials 	\$2,598k
	Total Cost Estimate for PSCo Network Upgrades for Interconnection	\$2,598k
Time Frame		20 months

Table 3 – PSCo Network Upgrades for Delivery

Substation	Description	Cost Est.
Story (Tri-State)	Build out the existing Story 345 kV ring bus to two breaker-and-a-half bays to accommodate the new double-circuit Story-Pawnee 345 kV line. Major equipment requirements include: <ul style="list-style-type: none"> • four 345 kV dead tank gas circuit breakers • seven 345 kV, 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 	\$2,704k
Pawnee	Construct a new 345 kV Pawnee	\$8,292k

Substation	Description	Cost Est.
Station	Substation with one 345kV/230kV autotransformer tying to the 230 kV yard, and bays for 345 kV transmission to Story and Smoky Hill Substations. Construct a new 230 kV Line terminal to Ft. Lupton. Major equipment required includes: <ul style="list-style-type: none"> • one 345kV/230kV autotransformer • four 345kV dead tank gas circuit breakers • ten 345kV, 2000 amp gang switches • two 230kV, 3000 Amp, 50 kA circuit breakers • four 230kV, 3000 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 	
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: <ul style="list-style-type: none"> • 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 	\$1,280k

Substation	Description	Cost Est.
Daniels Park	Construct a new 345kV switching station with one 345kV/230kV autotransformer tying to the 230kV yard. Major equipment required includes: <ul style="list-style-type: none"> • one 345kV/230kV autotransformer • two 345kV dead tank gas circuit breakers • six 345kV, 2000 amp gang switches • two 230kV, 3000 amp gas circuit breaker • four 230kV, 3000 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 	\$7,693k
Smoky Hill	Construct a new 345kV Smoky Hill Switching Station with one 345/230kV autotransformer, one 345kV line to Pawnee Station, and one 345kV line to one 345kV line to Daniels Park Sub. Major equipment required includes: <ul style="list-style-type: none"> • one 345/230kV autotransformer • three 345kV dead tank gas circuit breakers • eight 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 	\$8,128k

Substation	Description	Cost Est.
Transmission	Construct a new 10-mile Pawnee-Story double circuit 345 kV line. Bundled 954 conductor.	\$6,292k
	Convert the existing Pawnee-Smoky Hill 230kV line to 345kV. Reconductor and reinsulate existing structures from Pawnee to Corner Point (59 miles).	\$6,687k
	Construct a new 345kV line from Smoky Hill to Daniels Park (23 miles). Bundled 954 conductor, double circuit structures for future expansion.	\$10,865k
	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.	\$43,415k
	Construct new double circuit, 345kV structures from Corner Point to Smoky Hill (35 miles). Bundled 954 conductor.	\$18,625k
Siting and Permitting	Siting and Land Rights for required easements, reports, permits and licenses.	\$2,564k
	Total Cost Estimate for PSCo Network Upgrades for Delivery	\$116,545
	Total Cost of Project	\$119,512
Time Frame		60 months

Assumptions

Estimate for Interconnection

- The estimated costs provided are “Scoping Estimates” with an accuracy of $\pm 30\%$.
- All applicable overheads are included. AFUDC has been removed.

- Estimates were escalated at 3% through 2006.
- Back-feed 10 months after receiving authorization to proceed, which is anticipated to correspond to back-feed service available for commencing on-line commissioning testing.
- A Certificate of Public Convenience and Necessity (CPCN) will not be required from the Colorado Public Utility Commission (CPUC) for the PSCo Network Upgrades for Interconnection.
- A CPCN will be required for all transmission line construction and upgrades required for Delivery
- Permitting cost estimates include PSCo responsibility to conduct all Siting and land Rights activities associated with transmission and substation construction, obtain all required reports, permits and easements. It is anticipated that this project will be very difficult to permit, particularly near and in the Metro Denver Area. Strong political and public involvement is planned.
- PSCo (or its Contractor) crews will perform all construction and wiring associated with PSCo-owned and maintained equipment.
- PSCo will design, engineer, procure, construct, own and maintain all switching station facilities.
- PSCo needs a minimum of one month to witness testing of Customer's protection and control equipment associated with interconnection. This to be done in accordance with PSCo and Western requirements of Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater Than 20 MW. A majority of the testing can be performed in parallel with the 9-month to back-feed schedule.
- The estimated time for design, procurement and construction for the PSCo network upgrades required for the interconnection is at approximately 10 months after authorization to proceed.
- All required transmission outages necessary to support construction will be obtained as needed.
- PSCo meters will be four quadrant, bi-directional meters with recorders. Meters and recorders will be equipped such that they can be accessed remotely through a phone circuit.

- Controls and protection scheme details will be designed to PSCo standards.

Substation Interconnection Assumptions

- The point of interconnection will be a new (3) breaker ring substation just south of Tri-State's Story substation (see one line).
- The new substation will intersect the 230 kV transmission line from Pawnee to Tri-State's Story substation.
- The customer is responsible for constructing the transmission line (approx. 25 miles) from the wind farm to the point of interconnection.

Substation Estimates for Delivery

Pawnee Estimate Assumptions

- Enough land is available to accommodate a 345kV switching yard.
- A new 345kV switching yard is required with (1) 345/230/13.8kV 560 MVA autotransformer tying to the 230kV yard, (2) new 345kV lines to Story Sub, and (1) 345kV line to Smoky Hill (see one lines).
- The existing 230kV transmission line to Tri-State's Story sub will now terminate at the new Akron Wind substation.
- The existing 230kV transmission line to Smoky Hill (5165) will move over to the new 345kV yard and the vacated position will be used for the autotransformer.
- 230kV single transmission line to Ft. Lupton will be rebuilt as double circuit 834MVA capacity lines.
- A new bay will be constructed to accommodate the additional 230kV transmission line to Ft. Lupton.
- The connection between the autotransformer and the 230kV yard will be underground.

Ft. Lupton Estimate Assumptions

- See comments above about line rebuild.
- An additional bay will be built to accommodate the new line to Pawnee (see one-lines).
- The 5047 line to Henry Lake and the 5525 line to Green Valley will be relocated one bay east and the vacated position will be for the new line to Pawnee.
- The location of the modified line termination(s) is dictated by transmission constraints.
- Breaker 5463 will be replaced due to a low continuous current rating (1600A).
- Same comment applies in regards to limiting the transmission line capacity. Breaker(s) 5522, 5524, and 5525 are good for 2000A continuous current.
- All gang switches in the existing 5183 line & 5463 line bay will be replaced due to a low continuous current rating (1600A). This replacement is needed because of the 5463 line uprating to 800 MVA.

Smoky Hill Estimate Assumptions

- A new 345kV switching yard is required with (1) 345kV line to Pawnee, (1) 345kV line to Daniels Park, and (1) 345/230/13.8kV 560 MVA autotransformer (see one lines).
- The existing 230kV transmission line to Pawnee will move over to the new 345kV yard and the vacated position will be used for the new autotransformer.
- Replace existing Strain bus with 5" aluminum tube bus. With a bus fault on either bus the shift in load current to the unfaulted bus exceeds the single 1272 rating by a substantial amount.
- Enough land is available to accommodate a 345kV switching yard.

Daniels Park Estimate Assumptions

- A new 345kV switching yard is required with (1) 345kV line to Smoky Hill, and (1) 345/230/13.8kV 560 MVA autotransformer (see one lines).
- A new 230kV bay west of the Waterton/Arapahoe bay will be built to accommodate the new autotransformer termination.
- The 230kV line to Arapahoe (5107) will be swung to a new line position in the new adjacent bay to the west and the vacated position will tie in the autotransformer.
- The connection between the autotransformer and the 230kV yard will be underground.

Tri-State Story Assumptions

- Existing 230kV transmission line to Pawnee will terminate into new Akron Wind substation
- (2) new 345 kV transmission lines to Pawnee will terminate into existing 345kV yard (see one line).
- Tri-State has no immediate plans (less than 5 years) for 345kV expansion at Story sub.
- (4) additional 345kV breakers, associated gang switches, (2) sets of bus PT's, and metering units will be needed to terminate the Pawnee lines in Tri-State's 345kV yard.
- A new Electrical Equipment Enclosure (EEE) will be required for the additional relay, SCADA, and/or metering equipment. The existing control building has insufficient space.