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Interconnection Feasibility Study Report
Request # GI-2008-2

300 MW Wind Project

PSCo Transmission Planning
September 9, 2008

A. Executive Summary

The purpose of the Interconnection Feasibility Study is to provide a preliminary evaluation of the system impact and cost of interconnecting the Generating Facility to the Transmission Provider's Transmission System, the scope of which is described in the Standard Large Generator Interconnection Procedures.

On March 5, 2008, Public Service Company of Colorado (PSCo) received a generation interconnection request to determine the potential impacts of interconnecting a 300 MW wind-powered generation facility located in the Walsenburg area in southern Colorado to the Comanche 230 kV bus (or alternate bus). The Customer's project facility would consist of 144 Suzlon S-88 2.1-MW wind turbine generators, with an associated collector system to step up the voltage from 34.5 kV to 230 kV (or alternate voltage) at the Customer wind site.

The customer requested a primary Point of Interconnection (POI) on the 230 kV bus at the Comanche Substation with the 345 kV bus as an assumed secondary POI. PSCo Engineering reviewed the request and indicated that interconnecting at the 230 kV bus would be extremely difficult and expensive due to the location of existing transmission lines interconnecting in the 230 kV yard. Therefore, it was determined to study the interconnection at 345 kV and not at 230 kV.

The study was conducted assuming the wind generation facility would interconnect on the Comanche 345 kV bus by way of a Customer-Owned and Customer-constructed 46-mile, 345 kV transmission line. The Commercial Operation Date[1]

[1] **Commercial Operation Date** of a unit shall mean the date on which the Generating Facility commences Commercial Operation as agreed to by the Parties pursuant to Appendix E to the Standard Large Generator Interconnection Agreement.

requested by the Customer is July 1, 2009. The assumed In-Service Date[2] for back-feed is April 1, 2009.

The investigation included steady-state power flow studies and short-circuit analysis but did not include 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.

The transmission system study cases provide a representation of the transmission system as projected by the utilities in the study area for the year, season, and demand condition selected. Colorado Springs Utilities (CSU), a utility with transmission facilities in the study area, has conducted power flow studies that demonstrate that opening CSU's Monument-Palmer Lake 115 kV transmission line would mitigate potential contingency overloads on the CSU system. CSU made a recommendation to PSCo and Tri-State G&T, another utility with transmission facilities in the study area, to open the line to alleviate any potential overloads during outage conditions. Under an interim understanding with PSCo and Tri-State G&T, the utilities agreed to allow CSU to operate the line open for one year, after which the open or closed status of the line would be reevaluated. Because of the temporary nature of this operating condition, it was decided to study the system with the Monument-Palmer Lake 115 kV line closed. In addition, PSCo has studied the future replacement of the MidwayPS-Daniels Park 230 kV line with a MidwayPS-Waterton 345 kV line along with the addition of a 560 MVA 345-230 kV transformer at the MidwayPS Substation and the addition of a 560 MVA 345-230 kV transformer at the Waterton Substation. These projects were also represented in the study cases.

The request was studied as both a Network Resource (NR)[3], and as an Energy Resource (ER)[4]. The project costs to install the transmission interconnection

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[2] **In-Service Date** shall mean the date upon which the Interconnection Customer reasonably expects it will be ready to begin use of the Transmission Provider's Interconnection Facilities to obtain back-feed power.

[3] **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 generation 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.

[4] **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 Provier'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.

facilities (ER & NR) and transmission system infrastructure (NR) upgrades necessary to accommodate the added Customer generation have been evaluated by Engineering with the details of these upgrades identified in Section F of this report titled "Power Flow Study Results and Conclusions".

The engineering evaluation determined that from the time of the Authorization to Proceed until the In-Service Date[5] for back-feed would be approximately 18 months. PSCo is in the process of constructing the Comanche 345 kV yard with an expected completion date of May 2009. Based on this evaluation, the requested In-Service Date for back-feed of April 1, 2009 cannot be met. Additional time will be required for network service to deliver the full 300 MW on a firm basis. PSCo Engineering has indicated that replacing the Comanche 230-115 kV transformers (required for network service) will take at least 24 months to site, design, procure, and construct. This project assumes that a Certificate of Public Convenience and Necessity (CPCN) would not be needed. It will be up to the Colorado Public Utilities Commission (CPUC) to determine if a CPCN would be required through the CPUC Rule 3206 annual filing process. If a CPCN would be required, then approximately ten to twelve months would need to be added to the schedule assumed for this project.

The wind farm site would be located in the San Isabel Electric Association service territory and not in the PSCo retail service territory. San Isabel Electric Association is a rural electric cooperative and a Tri-State G&T member. If the Customer chooses to obtain the house power requirements for the site from San Isabel Electric Association, the Customer will need to coordinate this with San Isabel Electric Association.

The construction work required to interconnect at the Comanche 345 kV yard for back-feed would consist of the following:

- Construct an additional line position in the Comanche 345 kV bus. (PSCo-funded costs)
- Install revenue-metering equipment including CT/VT metering instrument and line termination equipment at the Comanche transformers, meters, recorder. (Customer-funded costs)
- Modify the substation associated with the Customer's 345 kV transmission line to Comanche. (Customer-funded costs)

The estimated project cost is: $ 3,388,000

[5] **In-Service Date** shall mean the date upon which the Interconnection Customer reasonably expects it will be ready to begin use of the Transmission Provider's Interconnection Facilities to obtain back-feed power.

The costs for the transmission interconnection required for back-feed are scoping level cost estimates (+/- 30%) in 2008 dollars (no escalation applied) and are based upon typical construction costs for previously performed similar construction.

The network upgrades required for delivery of the 300 MW output of the Wind facility would consist of the following:

- Upgrade the two Comanche 230-115 kV transformers to 280 MVA each (PSCo-funded costs)
- Add a Comanche-Reader 115 kV Line #2 (PSCo-funded costs)
- Uprate the Daniels Park - Prairie 230 kV line (PSCo-funded costs)
- Uprate the Prairie - Greenwood 230 kV line (PSCo-funded costs)

The transmission facility enhancements listed above will be completed through the PSCo Capital Budget Construction Process. The replacement of the MidwayPS-Daniels Park 230 kV line with the MidwayPS-Waterton 345 kV line will also be included in this process.

The studies identified that the 300 MW wind generation addition at the Comanche 345 kV bus could be delivered after modifications have been completed to the transmission system infrastructure as listed above. Based on the Feasibility Study results, the ER and NR capabilities are as follows:

- **Energy Resource (ER) injection capability = 0 MW**

Energy Resource Interconnection Service 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 the firm ER Injection capability is 0 MW. Firm capacity 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.

- **Network Resource (NR) injection capability = 300 MW (after the network upgrades are completed.**

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.

The Feasibility 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.

- **Reactive Power Capability**

The power flow models were also utilized to determine the Customer's MVAR generation capacities that may be necessary to meet the operational power factor and related MVAR requirements at the Comanche 345 kV POI. Customer data provided with the generation interconnection request indicated that the wind turbine generators would be compensated to be able to provide reactive power up to 0.95 power factor leading and lagging. With the Customer's generation at the full 300 MW output and at a 0.95 leading power factor, the reactive power losses in the project's main power transformers and the transmission line were noted. The transformer and line losses were compensated with the line charging capacitance such that the net reactive power loss was only one MVAR.

PSCo's interconnection requirements stipulate that the Customer must be VAR neutral throughout the entire operating range of the proposed facility, including minimum generating conditions and off-line conditions. A more detailed investigation will be conducted in the System Intact Study. It is the responsibility of the Customer to determine what type of equipment is required (CVAR, switched capacitors, SVC, reactors, etc.), the final ratings (MVAR, voltage 34.5 kV, 345 kV), and the location (project substation or Comanche POI) that will be necessary to meet the reactive power controllability requirements. Furthermore, the actual voltage tap ratios used for the Customer's main 34.5 - 345 kV transformers will directly impact the operating voltages and related reactive capabilities for the project facility. The Customer should review these studies to determine the final design requirements for this equipment (CVAR, transformer voltage tap ratios and MVA, etc.).

The Interconnection Customer's Interconnection Facilities costs are to be determined by the Customer. These include all facilities and equipment, as identified in the Standard Large Generator Interconnection Agreement, that are located between the Generating Facility and the Point of Change of Ownership, including any modifications, additions, or upgrades to such facilities and equipment necessary to physically and electrically interconnect the Generating Facility to the Transmission Provider's Transmission System. Interconnection Customer's Interconnection Facilities are sole use facilities.

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 Comanche 345 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.

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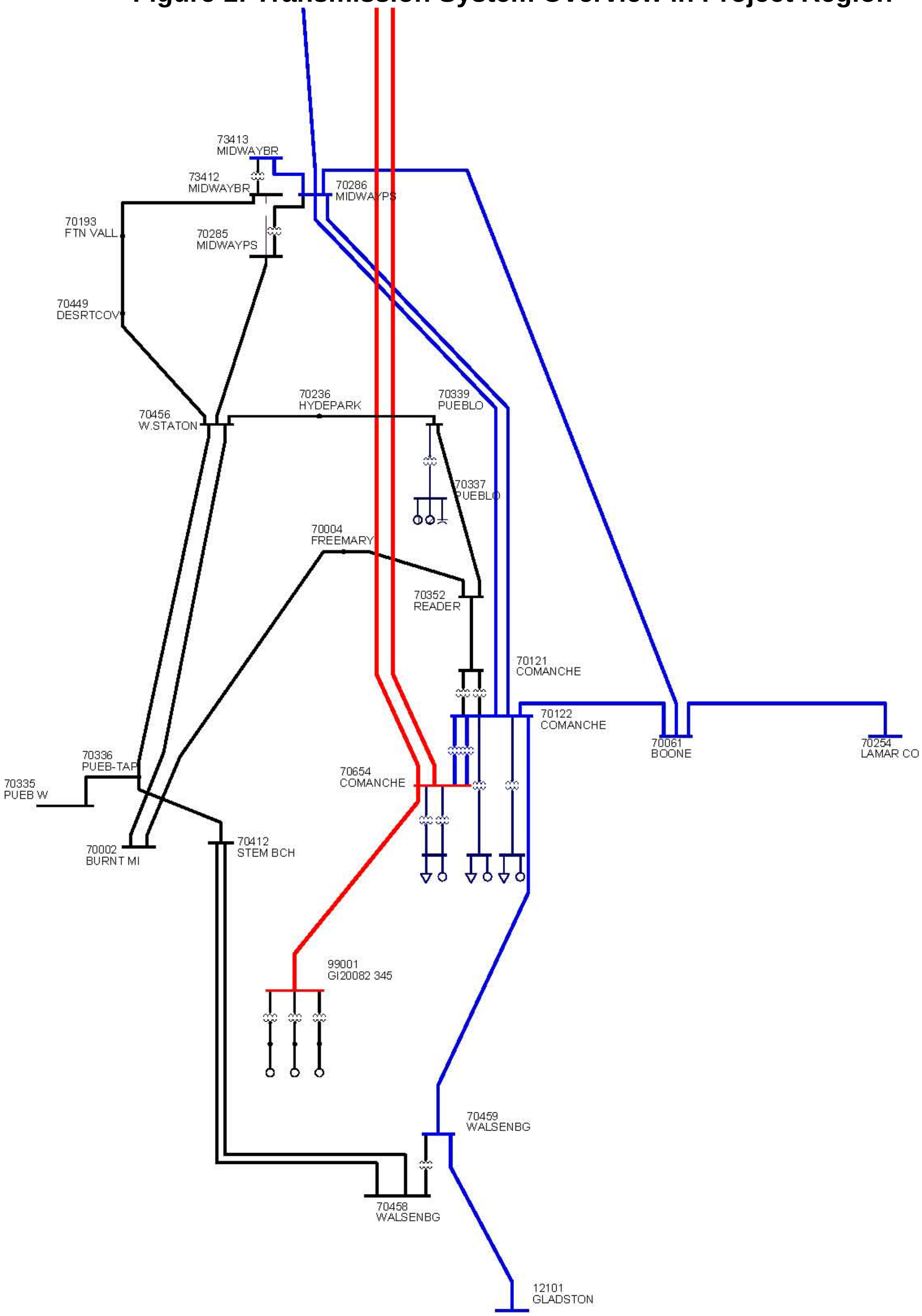
Figure 1: Transmission System Overview in Project Region



B. Introduction

The Interconnection Feasibility Study evaluated the transmission impacts associated with the proposed interconnection of 300 MW of new Customer generation into the PSCo Transmission System at the Comanche Substation 345 kV bus. The Customer's proposed new 300 MW wind project would be located approximately 15 miles northwest of Walsenburg, Colorado. The study assumed that the Customer's new interconnecting 345 kV transmission line would be constructed for 46 miles in a typical horizontal configuration on lattice-type structures using bundle 954 kcmil conductor. It was decided not to interconnect at 230 kV as originally planned by the Customer due to engineering considerations in the Comanche Substation. The Comanche 345 kV POI was the only interconnection point studied.

C. Study Scope and Analysis

This study consisted of steady-state power flow analysis and short-circuit analysis. The power flow analysis provided a preliminary identification of any thermal or voltage 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. 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 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 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.

For this project, potential affected parties include Black Hills Power, (service territory formerly the responsibility of Aquila, Inc), Tri-State G&T, and Colorado Springs Utilities. These parties will be contacted for involvement in the potential transmission facility overloads mentioned in this study and possible new projects that may be required as a result of this interconnection.

D. Power Flow Study Models

The power flow studies used PSCo's 2009 heavy summer budget case, which is based on the WECC 2009 heavy summer approved operating case. The PSCo case was modified to include some corrections and additions that were not already included in the case model. The cases were modeled with the Midway-Waterton 345 kV line in service. The Comanche Unit #3 was also included. The generation in the PSCo Balancing Authority (Area 70) was dispatched for a heavy south-to-north stressing, with the PSCo Balancing Authority (Area 70) swing bus moved to Cherokee #3 and generation levels in the south increased to maximum levels. Generation in the north was correspondingly decreased, and the Western-RMR Balancing Authority (Area 73) to PSCo Balancing Authority (Area 70) interchange was adjusted accordingly.

E. Power Flow Study Process

Two power flow case model generation dispatch scenarios were evaluated. A benchmark or base dispatch model (to establish a reference) was developed without the additional 300 MW generation ("Base Case"), and a second model was developed with the new 300 MW of generation included ("Gen Case"). The Gen Case was re-dispatched to lower other PSCo Balancing Authority (Area 70) generation by 230 MW in the north and reduce imports from the Western-RMR Balancing Authority (Area 73) by 70 MW also in the north. Reductions were made at locations that would maintain or maximize the south-to-north stress level in the case. The generation schedules of the Base Case and Gen Case are shown in Table 1.

Table 1: Case Generation Schedules

Station / Interface	Base Case (MW)	Gen Case (MW)
Pawnee	400	400
Manchief	0	0
Brush	156	106
Ft. Lupton	175	125
Ft. St. Vrain	360	230
Comanche	1475	1475
Ftn. Valley	240	240
Lamar DC (E-W)	210	210
Twin Buttes	9.7	9.7
CO Green	19.4	19.4
Peetz-Logan	39.8	39.8
Sidney DC (E-W)	20	0
Stegall DC (E-W)	10	0
Laramie River (MBPP)	1025	985
WY - CO (TOT3)	1101	1052

The Customer's facility was modeled as three 100 MW lumped-equivalent generators with associated 34.5-345 kV main transformers. The actual wind farm is to consist of 144 Suzlon S-88 2.1-MW wind turbine generators with an associated collector system to bring power back to the project substation where it is stepped up to 345 kV. The wind farm was further modeled as connecting into the PSCo 345 kV transmission system via a Customer Owned and -constructed 46-mile, 345 kV transmission line. Since the data provided by the customer was for a 230 kV transmission line, typical data for a horizontal configuration on lattice-type structures using bundled Cardinal (2-954 kcmil ASCR) conductors per phase was used to model the 345 kV interconnect line. Customer data provided with the generation interconnection request indicated that the wind turbine generators would be compensated to be able to provide reactive power up to 0.95 power factor leading and lagging. The three equivalent generators were each modeled with a maximum capacity of 100.8 MW (Pmax) / 33.1 MVAR (Qmax), or effectively 0.95 p.f. at the Customer 34.5 kV bus, with reactive power generation in the model adjusted to regulate the voltage on the 34.5 kV bus.

F. Power Flow Study Results and Conclusions

Automated contingency power flow studies were completed on both case models using the Siemens PTI PSS/E program, switching out single elements one at a time for all of the elements (lines and transformers) in the PSCo Balancing Authority (Area 70) and the Western-RMR Balancing Authority (Area 73). Upon switching each element out, the program re-solves with all voltage taps and switched shunt devices locked, and control area interchange adjustments disabled. Automated contingency studies were performed for both the Base Case and the Gen Case models, and the results are listed in Table 2 below.

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Table 2: Summary Listing of Differentially Overloaded Transmission Elements

Branch			FAC-9	Base	Gen		
From	To	Rating	Rating	Case (%)*	Case (%)*	Diff.	Contingency
70139 DANIELPK 230	70331 PRARIE12 230 1	275	490	98.5	115.9	17.4	None (N-0)
70236 HYDEPARK 115	70456 W.STATON 115 1	99		91.9	104.5	12.6	None (N-0)
70236 HYDEPARK 115	70339 PUEBLO 115 1	99		106.3	119.5	13.2	None (N-0)
70121 COMANCHE 115	70352 READER 115 1	239	218	94.6	102.3	7.7	None (N-0)
70122 COMANCHE 230	70459 WALSENBG 230 1	164	239	111.2	118.4	7.2	None (N-0)
70212 GREENWD 230	70331 PRARIE12 230 1	275	478	96.8	125.2	28.4	Daniels Park - Prairie3 230
70139 DANIELPK 230	70323 PRAIRIE3 230 1	275	490	135.1	162.5	27.4	Daniels Park - Prairie12 230
70139 DANIELPK 230	70331 PRARIE12 230 1	275	490	144	171.4	27.4	Daniels Park - Prairie3 230
70212 GREENWD 230	70323 PRAIRIE3 230 1	275	478	135.1	162.5	27.4	Daniels Park - Prairie12 230
70236 HYDEPARK 115	70339 PUEBLO 115 1	99		161.8	178.5	16.7	Burnt Mill - W. Station 115
70236 HYDEPARK 115	70456 W.STATON 115 1	99		146.5	163.2	16.7	Burnt Mill - W. Station 115
70002 BURNT MI 115	70456 W.STATON 115 1	99		107.5	121.2	13.7	Hyde Park - Pueblo 115
70002 BURNT MI 115	70004 FREEMARY 115 1	99		107.6	121.2	13.6	Hyde Park - Pueblo 115
70004 FREEMARY 115	70352 READER 115 1	99		107.6	121.2	13.6	Hyde Park - Pueblo 115
70121 COMANCHE 115	70352 READER 115 1	239	218	131.3	143.2	11.9	Comanche - Walsenburg 230 RAS
70121 COMANCHE 115	70122 COMANCHE 230 A1	176		116.7	127.3	10.6	Comanche 230 - Comanche 115 A2
70121 COMANCHE 115	70122 COMANCHE 230 A2	184		111.9	122	10.1	Comanche 230 - Comanche 115 A1
70122 COMANCHE 230	70459 WALSENBG 230 1	159	239	145.3	153.9	8.6	Comanche - Reader 115
70336 PUEB_TAP 115	70456 W.STATON 115 1	95		218.8	226.4	7.6	Comanche - Walsenburg 230 RAS
70063 BOONE TP 69	70235 HUERFANO 69 1	23		138	144.8	6.8	Comanche - Reader 115

Table 2 compares line flows on transmission facilities before and after the addition of the proposed 300 MW generating facility. If a transmission facility was not overloaded (either for system intact or outage conditions) prior to the addition of the proposed 300 MW generating facility, and the addition of the proposed 300 MW generation facility resulted in a new overload, the overloaded facility was listed in Table 2. In addition, if a transmission facility was overloaded prior to the addition of the proposed 300 MW generating facility, and the addition of the proposed 300 MW generating facility resulted in an increase in the magnitude of the overload (either for system intact or outage conditions) by greater than 5% of the rating of the transmission facility, the transmission facility is also listed in Table 2. The transmission facilities highlighted in Table 2 are on Black Hills Power's system. The percent loading is calculated in terms of the model rating, not the FAC-009[6] rating.

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[6] "FAC-009" is the Substation/Transmission Facility Equipment Ratings FAC-009 Listing that PSCo maintains for its transmission facilities.

These studies indicate that the additional 300 MW of Customer injection into the Comanche 345 kV bus POI could cause new and/or additional flows in excess of present or planned element ratings. No new voltage criteria violations resulted from the new generation. The following is a list of overloaded transmission facilities that are due to or made worse by the proposed 300 MW generating facility.

- **Comanche 115-230 kV Auto-transformers:** During the loss of one of the two 115 - 230 kV auto-transformers at Comanche, the other transformer becomes overloaded. These overloads occur in the base case but are worsened by 10% in the generation addition case. This issue can be resolved by completion of planned upgrades of the auto-transformers to units with 280 MVA ratings. PSCo Project Management is developing a new schedule to upgrade the auto-transformers at Comanche Substation.

- **Daniels Park-Prairie 230 kV and Prairie-Greenwood 230 kV:** During system-intact conditions, one of the Daniels Park - Prairie lines is overloaded in the generating case. Loading on that branch increases from 99% in the base case to 116% in generating addition case. For N-1 conditions, during the loss of one of the two Daniels Park - Prairie lines, the remaining intact branch (both Daniels Park - Prairie and Prairie - Greenwood) overloads. These contingency overloads occur in the base case but are worsened by 27% to 28% in the generation addition case. The issues are resolved with updated ratings in FAC-009.

- **Comanche-Walsenburg 230 kV:** During system-intact conditions, the Comanche - Walsenburg 230 kV line is overloaded. The base case loading is 111% and increases to 118% in the generation addition case. For N-1 conditions, during the loss of Comanche-Reader 115 kV line, the Comanche – Walsenburg line becomes overloaded. The overload occurs in the base case and is worsened by 8% in the generation addition case. The issue is resolved with the addition of a second Comanche - Reader line, which significantly reduces the impact of this N-1 contingency. PSCo Project Management is developing a new schedule to construct the second Comanche - Reader 115 kV line. The rating of the Comanche - Walsenburg line also increases to 239 MVA with FAC-009.

- **Comanche-Reader 115 kV:** During system-intact conditions the Comanche - Reader 115 kV line becomes overloaded in the generation addition case. The loading on this branch in the base case is 93%, and in the generation addition case, loading increases to 102%. For N-1 conditions, during the loss of Comanche - Walsenburg 230 kV and Walsenburg - Gladstone 230 kV, Comanche - Reader 115 kV is overloaded. The overload increases from 131% in the Base Case to

143% in the generation addition case. This issue will be resolved with the uprating of the existing Comanche - Reader 115 kV line and addition of a second Comanche - Reader 115 kV line. PSCo Project Management is developing a new schedule to construct the second Comanche - Reader 115 kV line.

- **Boone Tap-Huerfano 115 kV:** During the loss of Comanche - Reader 115 kV, this line becomes overloaded. The overload occurs in the base case but is worsened by 7% in the generation addition case. The issue is resolved with the addition of a second Comanche - Reader 115 kV line, which significantly reduces the impact of this N-1 contingency as mentioned above. PSCo Project Management is developing a new schedule to construct the second Comanche - Reader 115 kV line.

The following lines on the Black Hills Power system experience overloads for N-1 contingency conditions in both the base case and the generation addition case with more than 5% additional overload in the Gen Case:

- Hyde Park - Pueblo 115 kV (17% additional overload)
- Hyde Park - West Station 115 kV (17% additional overload)
- Burnt Mill - West Station 115 kV (14% additional overload)
- Burnt Mill - Freemary 115 kV (14% additional overload)
- Freemary - Reader 115 kV (14% additional overload)
- Pueblo Tap - West Station 115 kV (8% additional overload)

Future plans on the Black Hills Power system are yet to be determined, so it is possible that planned future upgrades will resolve these overloads. It is also possible that additional upgrades will be necessary. This situation will be addressed in conjunction with Black Hills Power in more detail in the System Impact Study.

Energy Resource (ER):

Due to existing overloads and firm transmission commitments, the ER portion of this study determined that the Customer could provide 0 MW of firm injection at the POI without 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.

ER = 0 MW (without any Network Upgrades)

Network Resource (NR):

Table 2 lists the lines and auto-transformers that either incur new single-contigency (N-1) overloading or that become significantly overloaded as a result of adding 300 MW of generation at the Comanche 345 kV bus POI. These results are for a power flow model for heavy summer 2009 system conditions, with the case re-dispatched for the maximum generation at Comanche and heavy south-to-north flows. Branch ratings that are expected to change as listed in the FAC-009 Facility Equipment Ratings (Rev. 6) are listed in the table.

NR = 300 MW (with required Network Upgrades)

Voltage Control at the Point of Interconnection:

The power flow models were utilized to determine the Customer's MVAR generation capacities that may be necessary to meet the operational power factor and related MVAR requirements at the Comanche 345 kV POI. Two basic operating scenarios were modeled. It should be noted that a simplified model was used for the Customer wind farm and that detailed models of the Customer's 34.5 kV collector and feeder systems and their associated reactive and capacitive characteristics have not been developed at this stage. The Customer will need to develop these models for further/future studies (e.g. dynamic System Impact Study, detailed Facilities Study) in order to ascertain the specific dynamic MVAR capacitive and inductive equipment (DVAR, CVAR, SVC, reactors, etc.) that would be required to meet both of the following operating scenarios.

The study determined the approximate MVAR generation levels that are required at full 300 MW rated output for supplying the typical MVAR losses that could be expected in the three project main transformers plus the Customer's 46-mile, 345 kV Project Substation-Comanche 345 kV transmission line while still meeting the 0.95 p.f. (300 MW +/- 33 MVAR) requirements. These transformer plus line losses (including line charging current) were determined to be approximately one MVAR with the project generation at 300 MW at 0.95 leading power factor. Therefore, the Customer-supplied dynamic power factor control equipment, such as may be provided by a separate CVAR reactive power management system, would not need to be capable of supplying additional reactive power to provide net 33 MVAR control capability at the Comanche 345 kV POI. The transmission system operating voltages at the POI and related voltage limits at the project buses will primarily determine the actual MVAR demands called on by the PSCo Operations. Specific MVAR controllability, capability testing, and commissioning requirements still need to be developed by PSCo and provided to the Customer prior to the facility designs being finalized by the Customer.

Commissioning testing for similar installations have included requirements to demonstrate the Customer facility's ability to operate in a controlled fashion across a specified controlled range of MVAR delivered and absorbed at specified power generation levels while operating within the voltage limitations achievable for the transmission system conditions in place at the time of testing.

The second study was performed using a model with the project generation at zero MW output and the Project Substation-Comanche 345 kV line energized. This model was used to determine the approximate reactive (MVAR) flow from the Project to the POI at Comanche due to line capacitance. PSCo requires that the Customer facilities have a near neutral (0 +/- 5 MVAR) reactive impact on the PSCo POI transmission bus with the Customer generation offline. This requirement helps ensure that the PSCo transmission system would not be burdened with absorbing unwanted reactive flows and potentially high voltages caused by this reactive power under typically light system loading conditions. The studies performed with a typical 46-mile, 345 kV line indicate that the reactive flow into the POI is approximately 40 MVAR with the project generation at 0 MW and the bus voltage near 1.02 per-unit at the Comanche 345 kV bus POI. Therefore it appears likely that shunt reactors or generator CVAR lagging power factor operation will be needed to operate within the 0 +/- 5 MVAR range requirement[7]. As previously stated, these models did not include any of the Customer's wind farm 34.5 kV collector feeders and cables, so the potential capacitive contribution of this 34.5 kV network has not been determined in this study. The reactive charging of the actual 345 kV line configuration used should also be taken into account in more detailed future studies.

G. <u>Short Circuit Study Results</u>

A short circuit study was conducted to determine the fault currents (single-line-to ground or three-phase) at the Comanche Substation 345 kV bus. The study was conducted without the addition of the proposed 300-MW wind farm as it is not expected to significantly increase the fault currents at the Comanche Substation. Table 3 summarizes the approximate fault currents at the Comanche 345 kV Bus with the addition of the GI-2008-2 facility.

[7] 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, 345 kV) and location (project substation or Comanche POI) will be necessary to meet the reactive power controllability requirements. Furthermore, the actual voltage tap ratios used for the Customer's main 34.5 - 345 kV transformers will directly impact the operating voltages and related reactive capabilities for the project facility. The Customer should review these studies in determining the final design requirements for this equipment (CVAR, transformer voltage tap ratios and MVA, etc.).

Table 3 Short-Circuit Study Results Without the Proposed 300 MW Wind Farm

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=15,063.2 I_2=I_0=0 I_A=I_B=I_C=15,063.2	Z1(pos)= 0.65620,13.2071 Z2(neg)=0.66313,13.2287 Z0(zero)=0.48046,8.25350	I_1=I_2=5,734.3 3I_0=17,202. I_A=17,202.9 I_B=I_C=0	Z1(pos)= 0.65620,13.2071 Z2(neg)=0.66313,13.2287 Z0(zero)=0.48046,8.25350

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

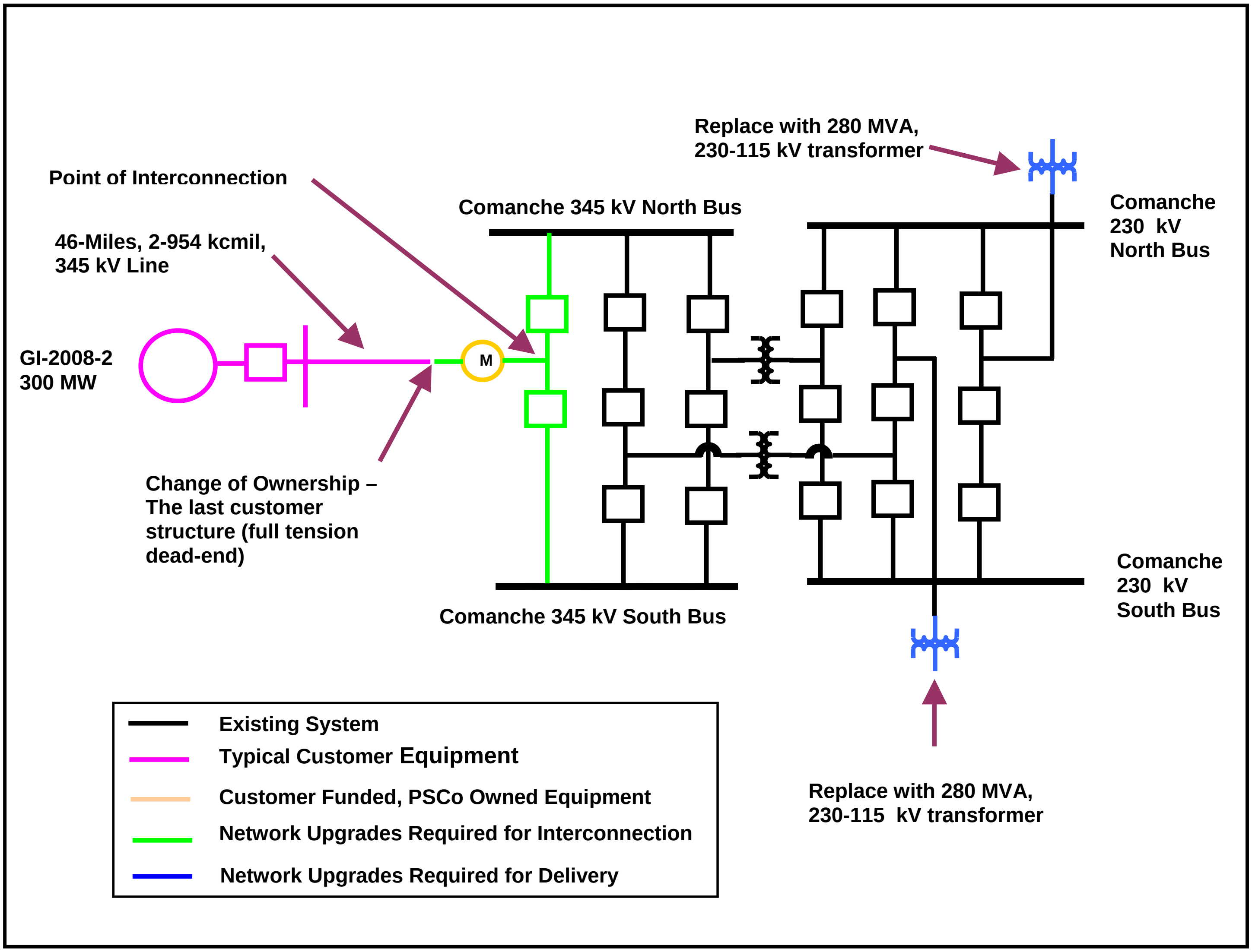
H. Costs Estimates and Assumptions

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 **$ 3,388,000**

Figure 2 below represents a conceptual one-line of the proposed interconnection at the Comanche Substation. The representation of the Comanche Substation is not a complete one-line diagram of the substation but was simplified to more clearly show the proposed interconnection. A detailed one-line is provided in the Appendix.

Figure 2 – Conceptual (Simplified) Diagram of the Comanche Sub (Please refer to the Appendix for the actual one-line)



H. Costs Estimates and Assumptions (continued)

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 4 – PSCo Owned; Customer Funded Interconnection Facilities

Element	Description	Cost Est. Millions
PSCo's Comanche 345 kV Substation	Interconnect Customer at Xcel's Comanche 345 kV Substation. The new equipment includes revenue metering and associated equipment and material.	**$0.165**
	Transmission tie line into substation.	**$0.200**
	Customer LF/ACG and Generator Witness Testing.	**$0.145**
	Siting and Land Rights for required easements, reports, permits and licenses.	**$0.010**
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	**$0.610**
Time Frame		**18 Months**

Table 5: PSCo Owned; PSCo Funded Interconnection Facilities

Element	Description	Cost
PSCo's Comanche 345 kV Substation	Interconnect Customer at Xcel's Comanche 345 kV Substation. New 345 kV line termination requiring the following equipment: • Two 345 kV breakers • Six 345 kV gang switches • Electrical bus work • Required steel and foundations • Minor site work (station wiring, grounding)	
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	**$2.778**
Time Frame		**18 Months**

Table 6 – PSCo Network Upgrades for Delivery

Element	Description	Cost Est. Millions
PSCo's Transmission Network	Upgrade the two Comanche 230-115 kV transformers to 280 MVA each.	PSCo-funded costs
	Add a Comanche-Reader 115 kV Line #2	PSCo-funded costs
	Uprate the Daniels Park-Prairie 230 kV line	PSCo-funded costs
	Uprate the Prairie-Greenwood 230 kV line	PSCo-funded costs
	Replace the MidwayPS-Daniels Park 230 kV line with the MidwayPS-Waterton 345 kV line. Install a 560 MVA 345-230 kV transformer at the MidwayPS Substation and a 560 MVA 345-230 kV transformer at the Waterton Substation.	PSCo-funded costs
	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.**	**These projects will not be in-service by the Customer's requested ISD.**
	Total Cost of Project	**$3.388**

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 added to the estimates.
- AFUDC is excluded.
- Labor is estimated for straight time only – no overtime included.
- PSCo (or it's Contractor) crews will perform all construction and wiring associated with PSCo owned and maintained facilities.
- The cost estimates for the PSCo network upgrades for delivery are not included as they are part of PSCo's Capital Budget Construction process.
- No additional land will be required at the Comanche Substation.
- A 230 kV interconnection was deemed not feasible, so those estimates are not included.

- This estimate and schedule is dependent on other projects at Comanche. If other projects at Comanche at the same time, that could slow down the schedule.
- Lead times for materials were considered for the schedule.

Appendix

A. Comanche Substation Proposed Budget One-Line

A revised one-line diagram of the Comanche Substation after the addition of the proposed wind farm is shown below.

B. Bay Addition at the Comanche Sub for the 300 MW Project