Interconnection System Impact Study Report
REQUEST # GI-2003-4

30 MW Wind Generation Test Facility at Ponnequin

Xcel Energy Transmission Planning
July 2004

Executive Summary:

This Interconnection Impact Study ("Study") Report summarizes the analysis performed by the Transmission Planning group of Public Service Company of Colorado (PSCo), in a coordinated effort with Western Area Power Administration (Western), to determine the transmission system impacts of interconnecting a Customer-proposed wind turbine generation (WTG) test facility into the PSCo Ponnequin 115kV Substation. The proposed new Customer WTG test facility would be sited just north of the Colorado – Wyoming border, and would tie into PSCo's Ponnequin Substation, located just south of this border. PSCo's Ponnequin Substation connects into Western's 115kV Cheyenne – Rockport transmission line. The maximum net output of this new Customer generation facility would be 30 MW, with the expected output typically less than this. This unique generation facility would serve as the USA's first installation to test and establish modeling data for new WTG designs, making the modeling of this facility a "best guess" approach for this Study. The original Customer proposed in-service date was mid-2004. However, based upon the results of this Study, the in-service date is now estimated as 4th Quarter 2005. At the request of the Customer, the Project was evaluated as both a Network Resource (NR), and as an Energy Resource (ER) with the energy delivered to PSCo customer load. Figure 1 depicts the regional transmission system.

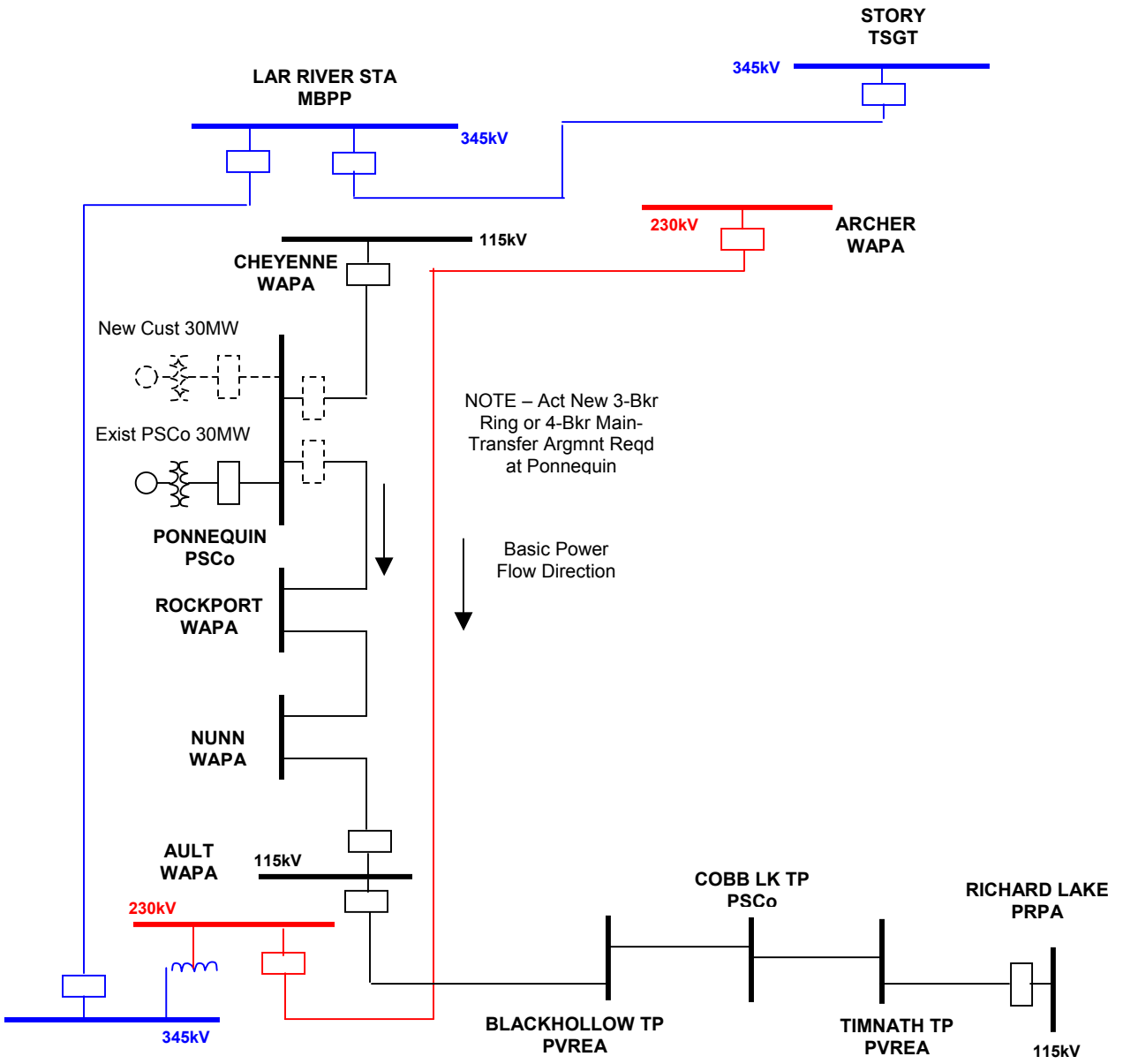
Energy Resource (ER):

As an ER, an interconnected generator is evaluated for its ability to deliver energy on an "as available" basis, using the capacity of the existing transmission system. The total estimated cost for the Network Upgrades ranges from $ 2.3 million to $ 2.5 million, depending upon 115kV bus configuration at Ponnequin Substation. Included in these total costs is $ 275k for the required Customer Interconnection Facilities (Table 4), and $ 2,049k to $ 2,245k for the Network Upgrades Required for Interconnection to the PSCo / Western transmission systems (Table 5). The Study indicates that the Customer facility could normally generate the full 30 MW as an ER. However, Western's TOT3 path studies indicate that this may be subject to possible operating schemes to reduce Customer generation levels under certain extreme operating conditions. The time frame to get the interconnection constructed for the generation addition is estimated to be 12 months after authorization to proceed has been obtained.

Network Resource (NR):

For the project to be considered an NR, an interconnected generator is evaluated for its ability to deliver energy to PSCo load on a fully dispatched basis, and determine any modifications of the existing transmission system required to accommodate the full requested generation injection. Since the full 30 MW Customer generation can be accommodated with the Network Upgrades associated with the interconnection, no additional PSCo Network Upgrades for Delivery to PSCo are required. However, Western's studies indicate that the full output of the Customer facility may, under certain conditions, impact the TOT 3 transfer limit. Western has indicated that in order to maintain reliable operation of their system for those particular conditions, an operational scheme may be required to reduce Customer generation at the Ponnequin facility. Western has stated a preference to impose a generation reduction scheme, rather than upgrading any of Western's existing affected 115kV lines in this region. This conclusion is based upon the anticipated low possibility that this Customer test facility generation levels will actually approach the 30 MW maximum level, in combination with the highly stressed transmission system conditions used for this model.

Figure 1:



Introduction

On November 11, 2003 Xcel Energy Transmission Planning received a request to interconnect a wind turbine generation test facility, with a total installed net output capacity not to exceed 30MW. PSCo completed an Interconnection Feasibility Study, and the report was issued and posted on the Rocky Mountain Area OASIS (RMAO) web site in February 2004. An Interconnection System Impact Study Agreement was executed with the Customer on or around March 15, 2004. The original Customer proposed Commercial Operation In-Service Date (ISD) was summer 2004.

As indicated by the information supplied by the Customer in this request, this wind farm will consist of generators and collector facilities in Wyoming, and an approximate 2-mile, 34.5kV underground (UG) distribution line to the existing PSCo Ponnequin Substation located just inside the northern Colorado border. The proposed facility would interconnect with the PSCo system using a new 34.5 – 115kV main transformer at Ponnequin Substation. The Customer has requested that this Project be evaluated as an NR and an ER with the energy going to PSCo customers.

Study Scope and Analysis

The Interconnection System Impact Study evaluated the transmission requirements associated with the proposed interconnection to PSCo's Ponnequin Substation. As per section 7.3 of the FERC LGIP, the Study considered the Base Case as well as all Generating Facilities (and with respect to (iii), any identified Network Upgrades) that exist on the date the Interconnection Feasibility Study was commenced:

(i) are directly interconnected to the Transmission System;
(ii) are interconnected to Affected Systems and may have an impact on the Interconnection Request;
(iii) have a pending higher queued Interconnection Request to interconnect to the Transmission System; and
(iv) have no Queue Position but have executed an LGIA or requested that an unexecuted LGIA be filed with FERC.

The Study consisted of power flow, short circuit, and dynamic stability analyses. The power flow analysis identified any thermal or voltage limit violations resulting for the interconnection; and for an NR request, identified 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. The dynamic stability analysis verified that there were no limitations due to angular instability of the system for regional disturbances.

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. NERC/WECC Planning Standards criteria applicable to Category B (N-1 outages) for transient voltage dip are not to exceed 25% at load buses, or 30% at non-load buses, less than 20% for 20 cycles at load buses.

Western also does not allow for the non-load bus voltage level to drop below 0.70 per-unit during these conditions, regardless of initial bus voltage. The associated NERC/WECC standard for a minimum transient frequency of 59.6 Hz for a duration of not more than 6 cycles at load buses.

Any new major generation or transmission additions have the potential to impact other regional entities. Western was considered an Affected System, and participated with PSCo in this Study.

Power Flow and Stability Study Models:

This Study used a 2005 heavy summer load flow case; based upon the WECC-approved 2004HS Operating Case, and updated for 2005 PSCo and Western load forecasts. The generation dispatch conditions used for this Study correspond to one of the several possible scenarios, specifically for the system intact (N-0) TOT3 power flow transfers near or above 1500 MW (see Appendix B for TOT3 details). TOT3 sensitivities were studied by changing the output of the Pawnee, Brush, and Laramie River generating stations, and included a model of the full 30 MW output of the proposed Customer wind test facility, in addition to the 30 MW total output of the existing PSCo Ponnequin generation facility.

As an NR request, the proposed new Customer 30 MW generation was scheduled to the Denver Metro Area and/or Southeast Colorado peaking units, and single contingency outages performed. As there were no significant new overloaded transmission lines identified for the maximum 30 MW Customer generation, plus 30 MW PSCo generation injection at Ponnequin cases, the ER and NR studies were identical.

For the steady state power flow studies, the 30 MW Customer wind farm was modeled as a single 30 MW, 34.5kV equivalent generator, with a +/- 0.90 per-unit power factor capability (+/-14.6 MVAR total). The leading p.f. (14.6 MVAR into the generator) condition was assumed to maximize the potential impact on the 115kV transmission system. For the more detailed stability study models, very little generator modeling information was made available by the Customer with this request. Therefore, stability modeling was done based upon available WTG model data for recently installed industry-standard generators. Western was contracted by PSCo to perform the stability studies, and obtained the generator model data from the Shaw / PTI User Support Group site for both a modern “double fed” design GE 1.5 WTG, and an older induction machine design GE/Vestas V47 660 kW. To compensate for the VAR requirements of the generators, and consistent with Western’s system operational criteria, switched capacitors were modeled on the Customer’s 34.5kV collector bus. Customer specified 34.5kV UG cable was modeled from the collector site to the Ponnequin Substation, and a Customer 34.5-115kV, 100 MVA step-up transformer was added at the PSCo Ponnequin Sub 115kV bus.

The existing PSCo Ponnequin Substation equipment was also included in the Study models, and included: a single lumped equivalent 30 MW, -6.1 MVAR (0.98 pf lead), 26.1kV generator (GE/Vestas V47 for stability model), 115-26.1kV, 33.6 MVA transformer, and 5 x 3 MVAR, 26.1kV switched capacitors.

There are three other Interconnection Requests with higher position in the Queue than this Study request: GI-2003-1, -2, and –3 (see the Rocky Mountain Area OASIS web site www.rmao.com, and Appendix A). For this Study, it was assumed that only GI-2003-1 (300MW generator interconnection in Morgan County, CO, ISD 12/2006) has a potential for impact on/by this Study. The other two IRs were considered to be electrically far remote from the Ponnequin area, and therefore were not considered relevant to this Study. The 2006 case model used for the GI-2003-1 study was updated to include the new Customer 30 MW generation injection at PSCo Ponnequin Substation. It was found that the Ponnequin generation had no impact on the GI-2003-1 study results.

Study Results:

Power Flow Analysis:

Single contingency outage runs were performed for cases with the proposed new Customer Ponnequin generation at levels of 0 MW, and repeated for generation at 30 MW / -14.5 MVAR (0.90 pf lead). The existing PSCo Ponnequin wind generation was fixed at 30 MW / -6.1MVAR (0.98 pf lead) for all runs. The power flow results were examined for differences between the listed elements with the new Customer generation off (0 MW) versus on (30 MW).

Closer investigations of the possible TOT3 rating impacts were done in this Study for the LRS – Ault 345kV, and LRS – Story 345kV line outage cases. The flows on TOT3 decreased as generation was increased at Ponnequin. The resulting power flows on most of the 345kV transmission lines that comprise the TOT3 path were either unchanged or slightly reduced. PSCo and Western power flow studies indicate that the injection of the proposed new 30 MW Customer wind generation into the transmission system at PSCo Ponnequin Substation will result in increased power flows on the Western 115kV transmission lines south of the Ponnequin interconnection point.

When combined with the 30 MW of maximum PSCo generation at Ponnequin, the added 30 MW of Customer generation at Ponnequin does result in contingency power flows approaching the Western-specified 109 MVA thermal ratings on these 115kV Western line sections south of Ponnequin. Western has indicated that these flows are within acceptable thermal line ratings, and do not justify any line upgrades as a result of the proposed new Customer 30 MW generation. However, when necessary, operating procedures involving reducing the new Customer generation output at Ponnequin would be required. Western has indicated a preference that these

operating procedures be implemented through an automatic reduction scheme when the follows on the Cheyenne – Ponnequin – Ault 115kV line exceed thermal ratings. Western states that this would be an acceptable means to regain TOT3 transfer ratings. Specific details of these operating procedures will need to be further investigated and discussed between PSCo, Western, and the Customer in the following Facility Study phase.

The results of PSCo's single contingency analysis indicated that there were no relevant new thermal overloads of PSCo transmission system elements resulting from the added 30 MW of Customer generation at Ponnequin. Note that existing contingency overloads were not investigated as part of this Study.

Table 1: PSCo Transmission Planning Power Flow Contingency Results:

Owner	Transmission Line	Rating (MVA/Amps)	Outage (N-1)	Flow % Rate (Amps) (Cust. 0MW)	Flow % Rate (Amps) (Cust. 30MW)
Western (73)	Archer – Cheyenne 115	80.0 (402)	Archer – Crow Creek 115	128% (515A)	111% (446A)
Western (73)	Cheyenne – Ponnequi 115	110 (552)	Ault – LRS 345	62% (345A)	52% (285A)
Western (73)	Ponnequi – RockprtTp 115	110 (552)	Ault – LRS 345	94% (519A)	100% (552A)
Western (73)	RockprtTp – Nunn 115	110 (552)	Ault – LRS 345	93% (515A)	99% (549A)
Western (73)	Nunn – Ault 115	*109 (547)	Ault – LRS 345	93% (511A)	99% (544A)
Western (73)	Ault - BlkHlwTp 115	*109 (547)	Ault – LRS 345	93% (509A)	99% (543A)
Western (73)	BlkHlwTp – CobbLkTp 115	*109 (547)	Ault – LRS 345	91% (497A)	97% (530A)
Western (73)	CobbLkTp - TimnthTp 115	*109 (547)	Ault – LRS 345	86% (473A)	90% (494A)
*Note: MVA Rate in WECC Case 85.1 MVA (427A); WAPA rev. rating is 109 MVA (547A) (128% of 427A rate).					

Western's TOT3 power flow studies indicated similar results, but had slightly higher load flows on the 115kV lines south of Ponnequin. This was likely due to adjustments made in the case, as later modified and used by Western for their studies. These modifications pertained mainly to reducing Western's Area 73 loads, adding and some necessary generation re-dispatch.

Comparisons of the voltage range violations listings indicated essentially no differences between either of the cases in the number or magnitudes of violations for the Customer generation on versus off.

Short Circuit Study Results:

The short circuit analysis at Ponnequin Sub consisted of applying faults at the 115kV bus at Ponnequin and recording values for 3-phase and single line-to-ground faults. All fault values are for present (2004 - 2005) system normal conditions, and do not include any fault current contribution from the proposed additional Customer wind generation at Ponnequin (see Table 2).

Table 2: Short Circuit Study Results:

Fault Type	Estimated Fault Current (Total Amps @ Ponnequin 115kV Bus)	
	No Gens on at Ponnequin	Existing PSCo 30MW Gen On
3-phase 115kV Bus Fault	5,870 A	6,010 A
Single Line-to-Ground 115kV Bus Fault (3I0, SLG)	4,050 A	4,090 A

Based upon investigations made with various consultants and manufacturers, the actual fault current contribution from the wind generation, or lack thereof, would have to be determined from additional, more detailed studies, using small signal analysis, assuming that detailed wind generator model data would be made available. However, a reasonable estimation of the fault current contribution for the existing PSCo Ponnequin older induction machine WTGs was used. The approach used was to model them as conventional non-synchronous induction machines, using a traditional short-circuit modeling program. PSCo Substation Engineering utilized the CAPE short-circuit program to estimate the maximum contribution from the PSCo Ponnequin generation, and shown in Table 3. Note that as was illustrated in the stability studies, these WTGs would quickly trip off line for faults at or near the Ponnequin 115kV bus.

The fault contribution for the new Customer WTGs would depend upon their design. A review of technical publications on this subject, assuming that these are similar to the GE 1.5 or other “double-fed” designs, with voltage ride-through / VAR control capability, indicates that the approximate fault contribution could possibly be on the order of 2 to 4 multiples of full-load rated amps, for a duration of several cycles. Due to the lack of established model data and proper computation tools being unavailable for a WTG facility like this, short-circuit current contribution can not be predicted at this time.

Stability Study Results and Conclusions:

Western was contracted by PSCo to perform the transient stability studies for this Study. A copy of the Stability Study Report (July 2004) provided by Western to PSCo is available upon request. The transient system stability studies indicate that the new Customer generation would have minimal impact on the transmission system and generation in the region around Ponnequin, including TOT3. The studies indicate that the Ponnequin wind generation will likely trip off-line for transmission faults near the Ponnequin 115kV bus. This result would be expected for the older induction machine designs presently existing at Ponnequin, and may also occur for the new Customer test generators, depending upon their specific design parameters. Faults were also applied at major 345kV buses in the region, and associated transmission lines tripped to clear the fault, with regional bus voltages, and generator voltages, power, and rotor angle monitored for several seconds. The study plots indicated that with the exception of the Ponnequin generators, the generators in this region recovered to a stable

operating condition (rotor angles, power output) following the clearing of the faults, with bus voltage swings within acceptable limits (see Table 3).

With respect to the sensitivity of the wind turbine generation at Ponnequin, the results of stability studies indicate that the older induction generator Vestas design modeled for the existing PSCo Ponnequin wind farm are subject to tripping off line for system faults near the Ponnequin 115kV bus. This is as would be expected for these types of units. The existing PSCo wind farm generators do not appear to be significantly impacted by the operation of the new Customer WTGs installed at Ponnequin, with some isolation being provided by the 115-26.1kV PSCo transformer, and the 115-34.5kV Customer transformer.

For the proposed Customer test facility generators, the older induction generator Vestas model are subject to tripping off line for system faults near the Ponnequin 115kV bus, while the newer design GE 1.5 model is more likely able to stay on line. There appears to be some interaction, and possible instability between the older Vestas and newer GE models. It should be noted that previous industry studies have indicated that many of these older WTG designs may significantly impact VAR flows into the generators during transient conditions. This could have significant influence on bus voltages. Due to the nature of this Customer WTG test facility having a wide variety of yet to be determined generator designs, some type of active voltage control / VAR compensation equipment (SVC, etc) may be necessary to be included in the Customer facilities at the Ponnequin site. This level of detailed requirements will need to be addressed in the later Facility Study.

Table 3: Transient Stability Study Results:

Case name	Fault Location	Element(s) Lost	Results
	Ponnequin 115kV	Ponnequin – Cheyenne 115kV Line (3-phase, 6-cycles)	Regional PSCo and Western Gens Stable and Damped; Bus Voltage Swings within Acceptable Limits.
	Ponnequin 115kV	Ponnequin – Ault 115kV Line (3-phase, 6-cycles)	Regional PSCo and Western Gens Stable and Damped; Bus Voltage Swings within Acceptable Limits.
	Ault 345kV	LRS – Ault 345kV Line (3-phase, 4-cycles)	Regional PSCo and Western Gens Stable and Damped; Bus Voltage Swings within Acceptable Limits.
	Ault 230kV	Ault – Rawhide 230kV Line & Ault – Weld#2 230kV Line (3-phase, 5-cycles)	Regional PSCo and Western Gens Stable and Damped; Bus Voltage Swings within Acceptable Limits.
	LRS 345kV	LRS – Ault 345kV Line (SLG, 12-cycles)	Regional PSCo and Western Gens Stable and Damped; Bus Voltage Swings within Acceptable Limits.
	LRS 345kV	LRS – Ault 345kV Line (3-phase, 4-cycles)	Difficulty in successful solution, but not related to Customer generation at Ponnequin.

Costs Estimates and Assumptions:

The estimated costs shown are "scoping" (+/-30%) budgetary estimates in 2004 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. The estimates do not include any costs for any Customer-owned, supplied, and installed equipment and associated design and engineering. Unless otherwise indicated, estimates also do not include any costs that may, or may not be required for other entities' systems.

Based upon these studies, in order for PSCo to provide an interconnection for the Customer requested generation interconnection at PSCo Ponnequin Substation, transmission system improvements must be made at the PSCo Ponnequin Substation.

Customer Interconnection Facilities:

Table 4 describes the improvements assumed necessary to be performed by PSCo, dedicated at PSCo Ponnequin Substation for the new Customer interconnection. It does not include all of the costs required for full delivery of the generation. Those costs are identified in Table 5. Note that estimates are provided for two different possible 115kV bus arrangements: Ring Bus, and Main-and-Transfer. It is assumed that all of the Customer owned, supplied, and operated equipment, both installed at Ponnequin Substation, and equipment installed between and at the Customer Wind TG Test facility site, will be designed, and installed by the Customer, or its contractors (such as the main 115 – 34.5kV transformer, 115kV fault interrupter, and other associated Customer–owned substation equipment). The costs of these Customer owned / operated facilities have not been estimated for by PSCo.

Table 4: Customer Interconnection Facilities:

Element	Description of Work	Estimated Cost
PSCo Ponnequin 115kV Substation	• (1) 115kV 3-phase disconnect switch for the Customer step-up transformer tap	$ 275k
	• (3) 115kV CT/VT combination metering units, and associated revenue metering equipment (electronic meter, recorder, and possible telemetry equipment)	
	• (1) Power Quality Monitor	
TOTAL	**Total Cost**	**$ 275k**
Time Frame		**12 months**

Network Upgrades Required for Interconnection:

Table 5 lists the costs associated with developing the transmission system in order to deliver the full 30MW of Customer generation into the PSCo and Western transmission systems at Ponnequin.

Table 5: Network Upgrades Required for Interconnection:

Element	Description of Work	Estimated Cost
PSCo Ponnequin 115kV Substation	• Relocate and replace the existing 115kV transmission line dead-end structures located outside of Ponnequin Sub, and the conductor spans into to the dead-end structures inside Ponnequin Sub.	$ 212k
	• (9) 115kV 3-phase gang disconnect switches (Ring), or • (11) 115kV 3-phase gang disconnect switches (Main-and-Transfer); • (3) 115kV breakers (Ring), or • (4) 115kV breakers (Main-and-Transfer); • 115kV CCVTs for buses and line terminations; • (1 lot) 115kV buswork, and associated structures, foundations, etc.; • (1 lot) protective relaying, for (2) 115kV line terms, 115kV buses; • (1 lot) communication equipment, microwave, for pri relay channels, SCADA, metering; • (1 lot) fencing addition, site work, etc. associated with sub site expansion required for breaker station conversion.	$ 1,774k (Ring Bus) to $ 1,970k (Main-and-Transfer)
	• Siting & Land Rights activities to amend existing Land Use Permit.	$ 63k
TOTAL	**Total Cost**	**$ 2,049k (Ring Bus) to $ 2,245k (Main-and-Transfer)**
Time Frame		**12 months**

Major Assumptions for Cost Estimates:

Ponnequin Substation Design / Construction Modifications:

- The demarcation point between PSCo and the Customer will be between PSCo's 115kV metering units and the Customer's high-side 115kV fault interrupting device (Circuit Switcher, breaker, or equivalent).
- Transmission system and substation modifications required primarily by Western at Ponnequin Substation include the conversion of Ponnequin Substation into a 115kV breaker station, with associated line breakers, line and bus protective relaying, relay channel / communications equipment, etc. This breaker station conversion will be performed in association with the Customer generation interconnection. This requirement is the main driver of the schedule for the PSCo and Western design and construction associated this generation interconnection request. Specific design details for the PSCo and Western facilities, as well as the review of the interconnection-related Customer facility designs, would be performed during the following Facilities Study. However, two basic bus configuration designs, Ring Bus, and Main-and-Transfer, were considered and estimated for this Study.
- Since the Customer facility generation will be connected into PSCo's Ponnequin Substation, in-turn connected directly into Western's 115kV Cheyenne – Rockport transmission line, the Customer will have to meet Western's protection and operational requirements for interconnection into Western's transmission system.

A cooperative effort will be undertaken between Western and PSCo for the following detailed Facilities Study associated with engineering reviews of the Customer generation and associated equipment designs, and control designs associated with the Customer – PSCo – Western interconnection.

- Scoping cost estimates are supplied by PSCo for this Study based upon PSCo (or its contractor) crews performing all construction and wiring associated with PSCo and/or Western-owned and maintained equipment. It is assumed that these are within +/- 30% accuracy, regardless of whether PSCo or Western crews ultimately perform the necessary work, details of which are yet to be determined.
- The estimated time for design and construction for the PSCo and Western additions at Ponnequin Substation is 12 months after authorization to proceed has been received, and based upon other identified assumptions for Siting and Land Rights, and Transmission (see below).

Transmission Engineering and Line Construction:

There will likely be some transmission engineering and line construction required by PSCo and/or Western to accommodate the breaker and associated additions / modifications at the PSCo Ponnequin Substation. This work may include Western's relocation and possible replacement of the existing 115kV transmission line dead-end structures located outside of Ponnequin Sub, and the conductor spans into the dead-end structures inside Ponnequin Sub. PSCo's and Western's Transmission and Substation Engineering groups will need to work together in the design and construction specific details in the following Facilities Study phase.

Siting and Land Rights:

Based upon the new scope of work identified for this SIS, the Siting and Land Rights group would be involved in providing any support necessary in order to acquire the additional permits, and easements, associated with a PSCo Ponnequin Substation site expansion for a new breaker station layout. Preliminary investigations indicate that an amendment to the existing PSCo Ponnequin land use permit would be required. It is not believed that there would be any new land purchase costs required for the estimated Ponnequin Substation site expansion, based upon PSCo's existing easement agreement.

APPENDIX A

PSCo Generation Interconnection Request Queue

GENERATION INTERCONNECTION REQUESTS

July 8, 2004 (RMAO)

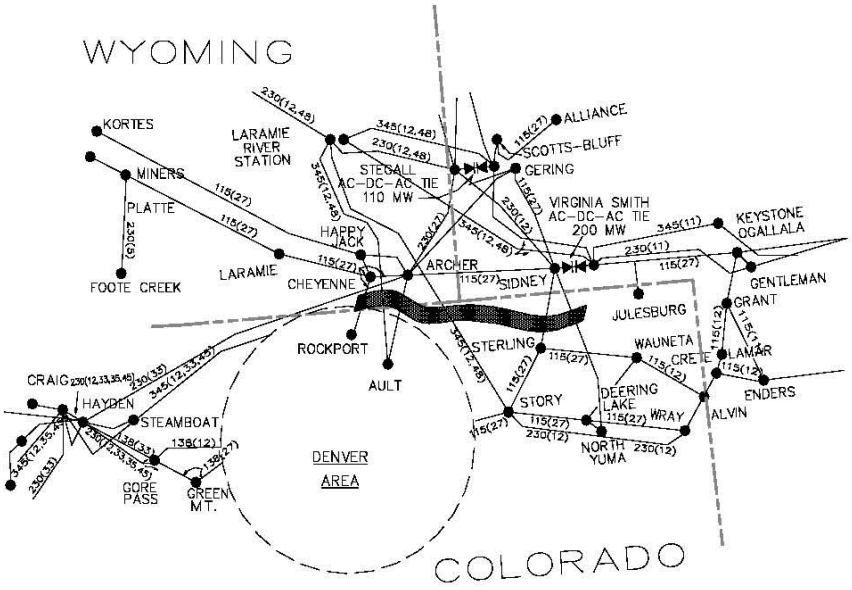
Queue Number	Date Received	Generation Type	Service Type	Location County/State	Interconnection Point Station or Line	Net Plant Max MW Sum	Win	In-Service Date	Comments/Status/Reason not Completed
GI-2003-1	10/21/2003	Wind	Network Resource	Morgan Co., CO	Pawnee Substation	300	300	12/1/2006	Feasibility Study complete System Impact Study underway
GI-2003-2	11/3/2003	Coal	Network +Energy Resource	Elbert Co., CO	Smokey Hill-Pawnee 230kV line	500	500	6/1/2008	Feasibility Study complete System Impact Study complete
GI-2003-3	11/7/2003	Coal	Network Resource	Pueblo Co., CO	Comanche Substation	750	750	10/1/2009	Feasibility Study complete System Impact Study complete
GI-2003-4	11/11/2003	Wind	Network +Energy Resource	Laramie Co., WY	Ponnequin Substation	30	30	Q2:2004	Feasibility Study complete System Impact Study underway
GI-2003-5	12/29/2003	Coal	Network Resource	Morgan Co., CO	Pawnee Substation	750	750	10/1/2009	Request withdrawn 2/20/04
GI-2004-1	1/19/2004	Wind	Network +Energy Resource	Morgan Co., CO	Story Substation	150	150	12/31/2005	Feasibility Study complete
GI-2004-2	2/9/2004	Wind	Network +Energy Resource	Baca Co., CO	Lamar Substation	238	238	9/31/2005	Feasibility Study complete

APPENDIX B

TOT 3 DETAILS

Revised February 2003

36. TOT 3



Revised February 2003

36. TOT 3

Accepted Rating ☒
Existing Rating ☐
Other ☐

Location:	Border between Northeast Colorado and Southeast Wyoming
Definition:	Sum of the flows on the following transmission lines: Line — Metered End Archer-Ault 230 kV — Archer Laramie River-Ault 345 kV — Laramie River Laramie River-Story 345 kV — Laramie River Cheyenne-Rockport 115 kV — Cheyenne Sidney-Sterling 115 kV — Sidney Sidney-N. Yuma 230 kV — Sidney
Transfer Limit:	North to South: 1605 MW (Maximum) South to North: Not defined Depending on local generation levels, DC tie levels and direction, the real-time rating can range between a maximum of 1605 W and a minimum of 843 MW. Typically, the real-time rating is calculated dynamically and updated every minute based on Table 1B.
Critical Disturbance that limits the transfer capability:	The critical disturbances and limiting elements vary with the various scenarios. Reference Table 1B for further information.
When:	Rating was first established in 1981. The current rating was established in July 1999 with publication of the "Comprehensive Progress Report for the Revised Rating of the TOT 3 Transfer Path." The study was conducted by Western and the revised rating was jointly proposed by: Western Area Power Administration (WAPA) - Loveland Tri-State Generation & Transmission Association, Inc. (TSGT) Public Service Company of Colorado (PSC) Basin Electric Power Cooperative (BEPC)
System Conditions:	This rating is independent of transfer levels between major areas of WECC. The transfer limit is impacted by local area generation and the direction and magnitude of DC tie flows. Historically, the flows have all been north to south across the path. Under certain operating conditions when TOT 3 is loaded to its limit, the TOT 5 capability cannot be used since additional schedule on TOT 5 will overload TOT 3.

Revised February 2000

Study Criteria:	(Summary) System intact: • Per unit voltages between 0.95 p.u. and 1.05 p.u. • All lines and transformers loaded to less than continuous rating. Single contingency outage conditions: • Per unit voltages between 0.90 p.u. and 1.10 p.u. • All lines loaded to less than 15-minute emergency ratings. • All transformers loaded to less than 30-minute emergency ratings. • Transient voltage swings down to 0.7 p.u. permitted.
Remedial Actions Required:	Remedial actions are required to achieve the rated transfer capability. Following an outage, all overloaded lines and transformers must have their loadings reduced to continuous ratings within 15 minutes. This is accomplished by reducing schedules and adjusting generation.
Formal Operating Procedure:	There is a formal operating procedure dated November 1999. WAPA-Loveland is the operating agent and uses real-time flows to monitor the path.
Allocation:	The transfer capability of the path is divided between WAPA, Missouri Basin Power Project (MBPP), Public Service Company of Colorado (PSC), and Tri-State Generation & Transmission (TSGT). TSGT and BEPC are members of MBPP.
Interaction w/Other Transfer Paths:	None
Contact Person:	Thu-Hong Tran Western Area Power Administration Rocky Mountain Region P. O. Box 3700 Loveland, CO 80539-3003 (970) 461-7404 (970) 461-7213 - fax trant@wapa.gov