Generator Interconnection
System Impact Study – Restudy 2
Request # GI-2007-12

250 MW Wind Turbine Generation
El Paso County, Colorado

Public Service Company of Colorado
Transmission Planning
February 20, 2014

A. Executive Summary

On November 5, 2007, Public Service Company of Colorado (PSCo) received a generator interconnection request (GI-2007-12) to examine the installation of a 250 MW wind turbine generator facility in El Paso County, Colorado. The proposed interconnection point is the Jackson Fuller 230 kV Substation near Colorado Springs, Colorado (see Figure 1 below). This substation is jointly owned by Colorado Springs Utilities (CSU), Tri-State Generation & Transmission (TSG&T), and PSCo. The original Interconnection Request was for 100 Clipper Liberty 2.5 MW wind turbine generators with a requested commercial operation date of December 31, 2010. The required transmission studies were completed and a Large Generator Interconnection Agreement (LGIA) was executed on January 12, 2012 which was placed into immediate suspension. In the LGIA, the projected COD was changed to December 31, 2014.

On May 1, 2012, the Customer sent PSCo a request to take the LGIA out of suspension. Subsequently, the Customer requested a new COD of June 1, 2015 and changed the wind turbine generator type to 147 GE 1.7 MW machines, for a total of 249.9 MW. After consideration of the changes in project scope and schedule as compared to that which was originally studied, PSCo determined that a new System Impact Study would be required. A System Impact Study Agreement was executed on October 7, 2013.

The new System Impact Study consisted of steady-state power flow analyses to examine the impact of the proposed wind plant on the thermal and voltage performance of the transmission grid. The power factor performance of the wind plant interconnection at the Jackson Fuller POI was also considered.

The GE 1.7 MW wind turbine generator is a doubly-fed induction generator that is asynchronous from the transmission system and has an inverter-connected rotor with automatic voltage control capability. Given this and the strong short circuit strength at Jackson Fuller, a transient stability study to assess impact on system stability was not deemed necessary. It is expected that these machines will have at least +/- 0.95 power factor capability and be operated in voltage control mode at all times.

This request was studied as a stand-alone project only, without including other new generation interconnection requests that may exist in the Large Generator Interconnection Request (LGIR) queue, but including the generation interconnection projects that are already planned to be in service by June 1, 2015. Given the Colorado PUC's recent decision regarding Xcel Energy's Energy Resource Plan filing, the study was performed assuming the existing generation at Fountain Valley in-service. PSCo signed a PPA for generation from this plant on January 27, 2014. This request was studied as a Network Resource Interconnection Service and an Energy Resource Interconnection Service. The analyses included both NERC Category B and NERC Category C contingencies.

The results of the Category B contingency power flow thermal studies for 2016 heavy summer showed contingency overloads of the summer normal ratings of Colorado Springs Utilities' Briar Gate – Cottonwood S 115 kV and Cottonwood N – Kettle Creek 115 kV lines following the installation of the proposed wind plant. The summer normal rating of the Briar Gate – Cottonwood S 115 kV circuit is also slightly exceeded in the benchmark case without the new generation. Also, the summer emergency rating of the Cottonwood N – Kettle Creek 115 kV line is also violated, but not that of the other line. The Customer will need to work with CSU to resolve these overload concerns. The Category B contingency voltage analysis showed no problems due to the wind plant.

The results of the PSCo Category C contingency thermal analysis showed overloads of the normal ratings of the Daniels Park – Jackson Fuller 230 kV (PSCo), Monument – Palmer Lake 115 kV (PSCo/CSU), Kettle Creek – Flying Horse 115 kV (CSU) and Monument – Flying Horse 115 kV (CSU) lines. Terminal equipment upgrades are required to address the overloads of the Daniels Park – Jackson Fuller 230 kV (PSCo) circuit and the PSCo portion of the Monument – Palmer Lake 115 kV (PSCo/CSU) circuit. The emergency rating of the CSU-owned portion of the Monument – Palmer Lake 115 kV circuit is also violated. The Customer will need to work with CSU to resolve these overload concerns. The Category C contingency voltage analysis showed no problems due to the wind plant.

The Energy Resource Interconnection Service analysis showed that during peak system conditions, the maximum allowable output of the proposed wind facility is 237 MW based on the Category B contingency analysis due to the loading concerns on CSU's Cottonwood N – Kettle Creek 115 kV line. This restriction will disappear following CSU upgrades to address the overloads with full wind plant output.

This study also examined the issue of wind plant reactive compensation. Results and recommendations can be found in the body of the report. Reactive compensation was found to be needed from -20 Mvar to +50 Mvar to compensate for wind plant line charging and reactive losses depending on wind plant output. The wind plant developer will need to perform further studies to determine the optimum equipment configuration for reactive support devices for this facility.

The short circuit analysis showed that no PSCo-owned circuit breakers are expected to experience short circuit duty problems due to the installation of the proposed wind farm. With the proposed wind plant in service, the short circuit duty level of the PSCo-owned breakers at the Jackson Fuller Station (5114, 5119 & 5129) was determined to be 52% of their capability. At the time of this study, PSCo did not have breaker capability data for the non-PSCo-owned breakers in the Jackson Fuller Station, nor any other non-PSCo-owned breakers. Therefore, the wind plant developer will need to confirm with CSU and TSG&T the level of impact their facility will have on their respective circuit breakers.

Based on all of these results, the Customer will need to confirm with CSU as to what upgrades will be required to address CSU transmission system impacts that are expected to result from installation of the proposed generation. A written agreement completed and approved by CSU pertaining to mitigation of Adverse System Impacts will be required. Because circuit breaker short circuit duty evaluations were not completed for non-PSCo-owned breakers, particularly the breakers at Jackson Fuller Station, the Customer will need to request that CSU and TSG&T complete their own breaker duty calculations to assess the potential impact of the proposed generation on their breakers. These requirements will be included in the amended LGIA Milestones.

Cost Estimates

The estimates for the required interconnection facilities at the Jackson Fuller Station and the associated mitigation strategies to address adversely impacted PSCo transmission facilities are summarized below. PSCo mitigation plans include upgrading termination equipment at Daniels Park and Palmer Lake.

The estimated costs and construction times for the transmission interconnection (in 2013 dollars) are as follows:

Transmission Proposal
The total estimated cost of the recommended system improvements to interconnect the project is approximately **$3.05 million** and includes:

- $ 1.16 million for PSCo-Owned, Customer-Funded Interconnection Facilities
- $ 1.62 million for PSCo-Owned, PSCo-Funded Network Upgrades for Interconnection
- $ 0.27 million for PSCo Network Upgrades for Delivery to PSCo Loads

PSCo Engineering estimates that it will require 18 months to complete the PSCo and Customer Funded interconnection facilities at Jackson Fuller Station. PSCo Engineering also estimates that it will require 18 months to complete the Network Upgrades for Delivery. Therefore, neither the assumed backfeed date of February 1, 2015 nor the requested commercial operation date of June 1, 2015 appears feasible at this time.

Figure 1 Jackson Fuller Station and Surrounding Transmission System (2016)

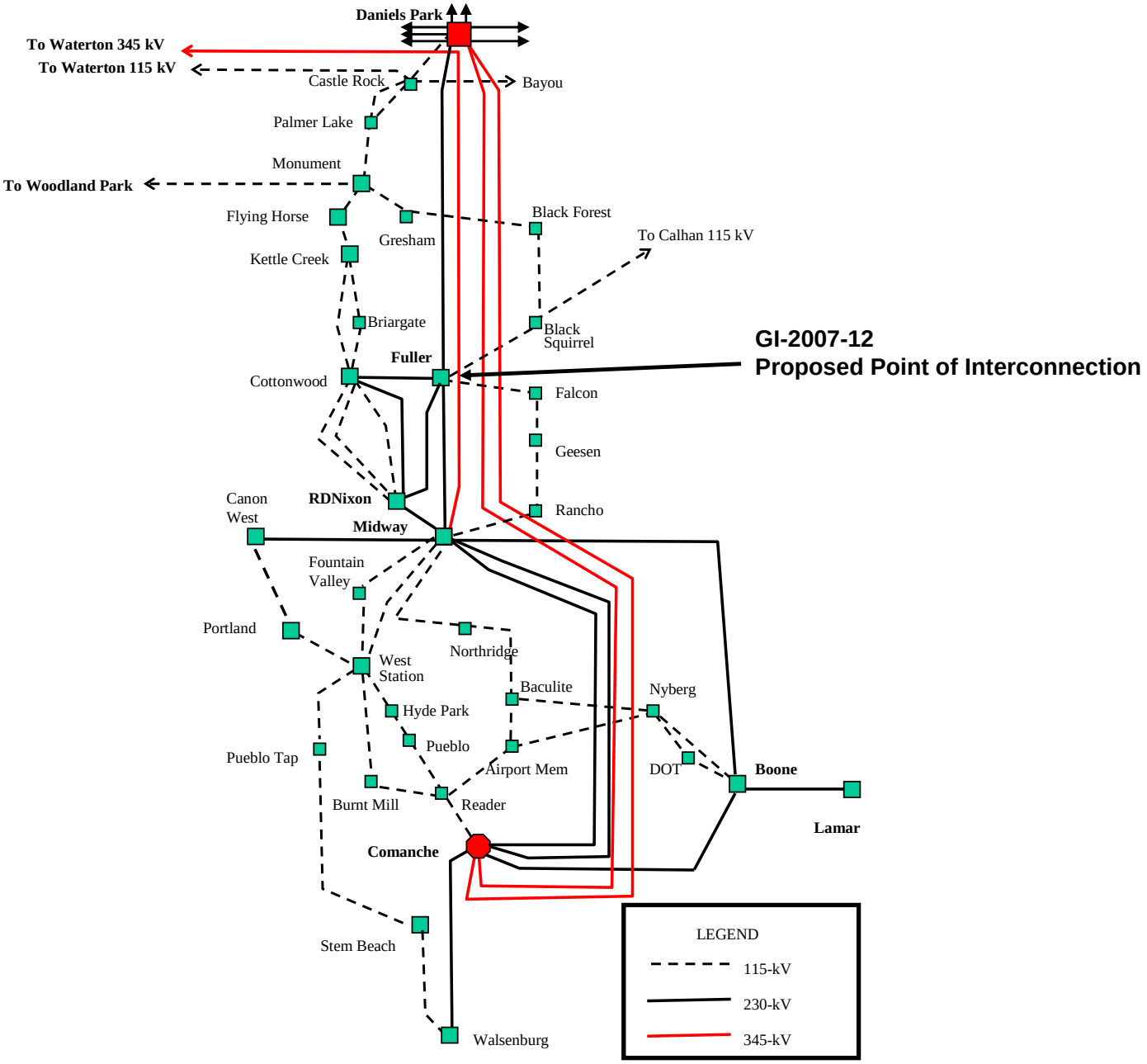
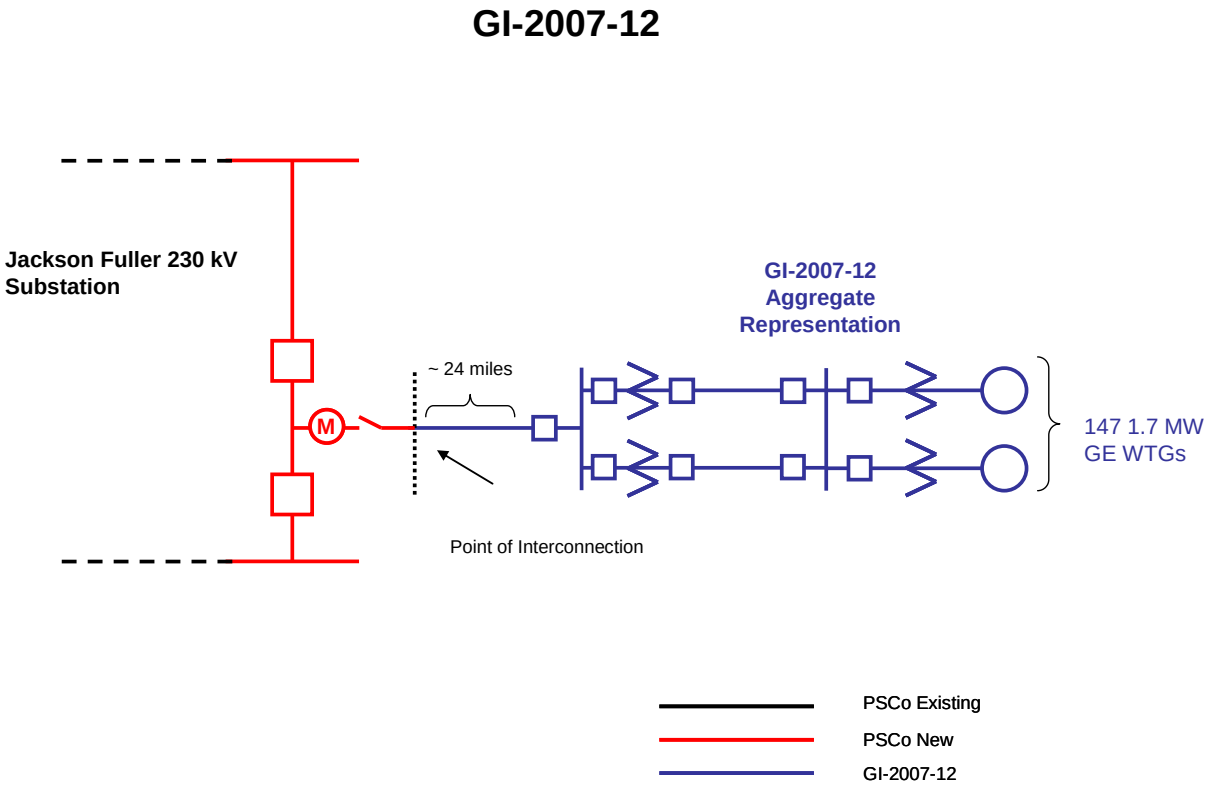


Figure 2: GI-207-12 Conceptual Diagram



B. Introduction

On November 5, 2007, Public Service Company of Colorado (PSCo) received a generator interconnection request (GI-2007-12) to examine the installation of a 250 MW wind turbine generator facility in El Paso County, Colorado. The proposed interconnection point is the Jackson Fuller 230 kV Substation near Colorado Springs, Colorado (see Figure 1 above). This substation is jointly owned by Colorado Springs Utilities (CSU), Tri-State Generation & Transmission (TSG&T), and PSCo. The wind generating facilities are located approximately 24 miles from the interconnection point and would be connected via a developer owned radial 230 kV line. The original Interconnection Request was for 100 Clipper Liberty 2.5 MW wind turbine generators with a requested commercial operation date of December 31, 2010. Feasibility, System Impact, and Facility Studies were all completed assessing the requirements for interconnecting the wind facility and a Large Generator Interconnection Agreement (LGIA) was executed on January 12, 2012, which was placed into immediate suspension. In the LGIA, the projected COD was changed to December 31, 2014.

On May 1, 2012, the Customer sent PSCo a request to take the LGIA out of suspension. Subsequently, the Customer requested a new COD of June 1, 2015 and changed the wind turbine generator type to 147 GE 1.7 MW machines. After consideration of the changes in project scope and schedule as compared to that which was studied originally, PSCo determined that a new System Impact Study would be required. A System Impact Study Agreement was executed on October 7, 2013.

The new System Impact Study consisted of steady-state power flow analyses to examine the impact of the proposed wind plant on the thermal and voltage performance of the transmission grid. The power factor performance of the wind plant interconnection at the Jackson Fuller POI was also considered.

The GE 1.7 MW wind turbine generator is a doubly-fed induction generator that is asynchronous from the transmission system and has an inverter-connected rotor with automatic voltage control capability. Given this and the strong short circuit strength at Jackson Fuller, a transient stability study to assess impact on system stability was not deemed necessary. It is expected that these machines will have at least +/- 0.95 power factor capability and be operated in voltage control mode at all times.

C. Study Scope and Analysis

The Feasibility/System Impact Study evaluated the transmission impacts associated with the proposed wind farm. It consisted of power flow and short circuit analyses.

The power flow analysis identified any steady-state thermal or voltage limit violations resulting from the installation of the proposed wind farm and an 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, and steady-state power flows below the thermal ratings of all facilities. Operationally, PSCo tries to maintain a transmission system voltage profile ranging from 1.02 per unit or higher at regulating (generation) buses to 1.0 per unit or higher at transmission load buses. Following a single contingency, transmission system steady state bus voltages must remain within 0.90 per unit to 1.05 per unit, and power flows within 100% of the facilities' continuous thermal ratings.

This interconnection request was studied both as a Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection Service (ERIS).

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 generating 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.

Energy Resource Interconnection Service shall mean 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.

For this project, potential Affected Parties were CSU, TSG&T and the Intermountain Rural Electric Association (IREA).

D. Power Flow Study Models

The power flow studies were based on the WECC approved 17HS1AP_r32 case. PSCo loads in the case were adjusted to reflect the most recent (April 2013) PSCo load forecast. IREA load was also adjusted to reflect IREA's latest load forecast (November 2013). The topology was also updated to reflect current project plans. Updates were included for the PSCo, IREA, CSU, TSG&T, WAPA, PRPA, BHE, and BEPC systems.

The PSCo updates included the addition of the new Cherokee combined cycle plant and associated transmission upgrades. The new IREA Happy Canyon distribution substation connected to the Crowfoot Valley – Daniels Park 115 kV circuit was also included. A significant CSU case update was the re-termination of the Nixon end of the Kelker – Nixon 230 kV line to Front Range.

Two main power flow generation dispatch scenarios were evaluated. One was created as a reference scenario and the other was created with the proposed generation connected to Jackson Fuller 230 kV.

To assess the impact of the proposed generation on the transmission system, the generation dispatch was adjusted to create a south to north flow stress through the Jackson Fuller area. This was accomplished by increasing the Colorado Green / Twin Buttes wind generation to 97.3 MW, the level at which loss of one of the 230/115 kV transformers at Lamar resulted in a 100% of normal rating loading level on the other 230/115 kV transformer at Lamar. The combustion turbines at Fountain Valley were also dispatched at 242 MW, due to the Colorado PUC's recent decision regarding Xcel Energy's Energy Resource Plan filing. PSCo signed a PPA for generation from this plant on January 27, 2014. Other PSCo thermal units were dispatched according to their relative generation costs. It should be noted that the Area 70 (Area PSCOLORADO) swing machine in the WECC load flow case was moved to Fort Saint Vrain Unit 1. The resulting PSCo generation dispatch can be found in Appendix B.

In the case with the proposed generation, the 249.9 MW of new wind turbine generation was added to the Jackson Fuller 230 kV bus using models provided by the customer. The wind plant model included the customer-owned 230 kV line, two 34.5/230 kV main step-up transformers, two equivalent 34.5 kV collector system branches, two equivalent 0.69/34.5 kV generator step-up transformers, and two equivalent wind turbine generators (73x1.7=124.1MW & 74x1.7=125.8MW). Each of the equivalent generators was modeled with a +/- 0.95 pf reactive capability. The main and generator step-up transformer high-side taps were each set to the 1.025 pu tap. The customer-provided model also included two 34.5 kV capacitor banks, each with two 16.5 Mvar steps, but locked on just one of the two steps (i.e., each set to 16.5 Mvar). The generation dispatch with the new wind farm can also be found in Appendix B.

E. Power Flow Study Process

Contingency power flow studies were completed on the reference model and the model with the proposed new generation using PTI's PSSE Ver. 32.1.0 & 33.4.0 program. Results from the two cases were compared and new overloads or overloads that increased significantly in the new generation case were noted. Voltage criteria violations were also recorded. The PSSE Ver. 33.4.0 ACCC contingency analysis activity was used to perform the load flow contingency analysis. The PSCo Category B & C analysis was performed using contingency definitions that reflect breaker to breaker outages. Single branch switching was also performed for branches in Zones 700, 704, 705, 709, 712, 752, 757, and 791. Single unit outages were also modeled for generators in Zones 700, 704, 705, 709, 712, 752, 757, 790, and 791. The facilities in Zones 700, 704, 705, 709, 712, 752, 757, and 791 were monitored for overloads and voltage problems.

F. Power Flow Thermal Results

Network Resource Interconnection Service

The results of the Network Resource contingency analysis are summarized in the tables in the Appendix. The results of the Category B contingency analyses (see Table 5) show two facilities with overloads that can be attributed to the proposed wind plant. Both are owned by Colorado Springs Utilities.

The first is the Briar Gate – Cottonwood S 115 kV circuit for the loss of the Cottonwood N – Kettle Creek 115 kV circuit. This circuit was found to be overloaded 112.4% of its 150 MVA summer normal rating. It was also overloaded at 100.3% in the benchmark case, representing a 12.1% increase. The corresponding emergency rating % loadings are 87.8% and 78.3% of the 192 MVA summer emergency rating, respectively. The Customer will need to confirm with CSU regarding the need for upgrades for this circuit.

The other is the Cottonwood N – Kettle Creek 115 kV circuit for the loss of the Briar Gate – Cottonwood S 115 kV circuit. This circuit was found to be overloaded 111.7% of its 162 MVA summer normal rating. The contingency loading was 98.9% in the benchmark case, representing a 12.8% increase. The corresponding emergency rating % loadings are 100.5% and 89.0% of the 180 MVA summer emergency rating, respectively. The Customer will need to confirm with CSU regarding the need for upgrades for this circuit.

The results of the Category C contingency analyses (see Table 6) showed four facilities with overloads that can be attributed to the proposed wind plant. One is owned by PSCo, one is jointly owned between PSCo and CSU, and the remaining two are owned by CSU. All of the overloads are for the double circuit tower outage of the two Comanche – Daniels Park 345 kV circuits (double circuit tower outage).

The first is the Daniels Park – Jackson Fuller 230 kV circuit. This circuit is owned by PSCo. This circuit was found to be overloaded 104.2% of its 478 MVA summer normal & emergency ratings. The contingency loading was 80.5% in the benchmark case, representing a 23.7% increase. This circuit will need to be upgraded. Upgrades include replacing a line trap and jumpers at Daniels Park.

The second is the Monument – Palmer Lake 115 kV circuit. This circuit is jointly owned by CSU & PSCo. This circuit was found to be overloaded 121.9% of its 120 MVA summer normal and emergency ratings. The contingency loading was 99.0% in the benchmark case, representing a 22.9% increase. The PSCo portion of this circuit will need to be upgraded. Upgrades include jumpers at Palmer Lake. Terminal equipment at CSU's end of the line is also overloaded. Therefore, the Customer will need to confirm with CSU the need for upgrades for this circuit.

The third is the Kettle Creek – Flying Horse 115 kV circuit. This CSU owned circuit was found to be overloaded 100.9% of its 162 MVA summer normal rating. The contingency loading was 83.6% in the benchmark case, representing a 17.3% increase. The corresponding emergency

rating % loadings are 90.8% and 75.2% of the 180 MVA summer emergency rating, respectively. The Customer will need to confirm with CSU regarding the need for upgrades for this circuit

The fourth is the Monument – Flying Horse 115 kV circuit. This CSU owned circuit was found to be overloaded 108.0% of its 142 MVA summer normal rating. The contingency loading was 88.2% in the benchmark case, representing a 19.8% increase. The corresponding emergency rating % loadings are 98.3% and 80.3% of the 156 MVA summer emergency rating, respectively. The Customer will need to confirm with CSU regarding the need for upgrades for this circuit

Energy Resource Interconnection Service

In addition to the Network Resource contingency analysis, the proposed generation was studied as an Energy Resource as well.

Based on Category B N-1 contingency analysis, it was found that the maximum output of the proposed generation to avoid an overload requiring upgrade is 237 MW. At this level, the contingency loss of CSU's Briar Gate-Cottonwood 115 kV line results in a loading level on CSU's Cottonwood-Kettle Creek 115 kV line of 99.9% of the 180 MVA emergency rating. According to our understanding of CSU policy, an overload of the emergency rating of one of their facilities is the loading level at which upgrades would be required.

Based on Category C contingency analysis, it was found that the maximum output of the proposed generation to avoid an overload requiring upgrade is 18 MW. At this level, the contingency loss of Comanche – Daniels Park 345 kV double circuit tower circuits results in a loading level on the Monument – Palmer Lake 115 kV circuit of 99.9% of the 120 MVA emergency rating.

G. Voltage Regulation and Reactive Power Capability

Interconnection Customers are required to interconnect their Large Generating Facilities with Public Service of Colorado's (PSCo) Transmission System in conformance to the *Xcel Energy Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater Than 20 MW* (available at http://www.xcelenergy.com/staticfiles/xe/Regulatory/Transmission-Interconnection-Guidelines-Great-20MW.pdf). Wind generating plant interconnections must also conform to the performance requirements in FERC Order 661-A. Accordingly, the following voltage regulation and reactive power capability requirements (at the POI) are applicable to this interconnection request:

- To ensure reliable operation, all Generating Facilities interconnected to the PSCo transmission system should adhere to the Rocky Mountain Area Voltage Coordination Guidelines. Accordingly, since the POI for this interconnection request is located within

Southeast Colorado Region 4; the applicable ideal transmission system voltage profile range is 1.02 – 1.03 per unit at regulated buses and 1.0 – 1.03 per unit at non-regulated buses.

- Xcel Energy's OATT requires all Interconnection Customers to have the reactive capability to achieve +/– 0.95 power factor at the POI, with the maximum "full output" reactive capability available at all output levels. Furthermore, Xcel Energy requires all Interconnection Customers to have dynamic voltage control and maintain the voltage specified by the Transmission Operator within the limitation of +/– 0.95 power factor at the POI, as long as the generating plant is on-line and producing power.
- It is the responsibility of the Interconnection Customer to determine the type (switched shunt capacitors and/or switched shunt reactors, etc.), the size (MVAR), and the locations (690 V, 34.5 kV or 230 kV bus) of any additional static reactive power equipment needed within the generating plant in order to have the reactive capability to meet the +/– 0.95 power factor and the 1.02 – 1.03 per unit voltage range standards at the POI. Further, for wind generating plants to meet the LVRT performance requirements specified in FERC Order 661-A, appropriately sized and located reactive power compensation devices (capacitor, DVAR, SVC, etc.) may need to be installed within the generating plant.
- The Interconnection Customer is required to demonstrate to the satisfaction of PSCo Transmission Operations prior to the commercial in-service date of the generating plant that it can safely and reliably operate within the required power factor and voltage ranges (noted above).

This study examined the ability of the proposed wind plant to adhere to the power factor and reactive power requirements of the interconnection guidelines. The analyses showed that with all facilities in service but 0 MW of generation from the wind generators, there are approximately 19.6 Mvars of line charging injected at the Jackson Fuller 230 kV point of interconnection (POI) with the voltage at 1.0185pu. Therefore, approximately 20 Mvars of reactive absorption capability must be provided at the Jackson Fuller wind farm facility in order to compensate for the line charging to obtain Unity Power Factor at the Jackson Fuller 230 kV POI.

With all facilities in service and 249.9 MW of generation from the wind generators, there are approximately 60.2 Mvars of reactive losses absorbed from the Jackson Fuller 230 kV point of interconnection (POI) with the voltage at 1.0105pu. This value was calculated with no available reactive support .within the GI-2007-12 wind farm model. However, the equivalent model provided by the Customer included two 34.5 kV 33 Mvar capacitor banks, each with two 16.5 Mvar steps. Also, the two equivalent machines were each modeled with a 95% power factor capability. The load flow base cases that include the equivalent models of the proposed generation showed that Unity Power Factor operation was entirely feasible with one 16.5 Mvar step of each capacitor bank along with each machine contributing 8-9 Mvar of additional reactive power injection for total reactive support of approximately 50 Mvar.

The Customer will need to perform additional studies to determine the capabilities, optimum location(s) and configuration(s) for the reactive compensation required to meet the +/– 0.95 power factor standard at the POI.

H. Dynamic Stability Analysis – Results

The GE 1.7 MW wind turbine generator is a doubly-fed induction generator that is asynchronous from the transmission system and has an inverter-connected rotor with automatic voltage control capability. Given this and the strong short circuit strength at Jackson Fuller, a transient stability study to assess impact on system stability was not deemed necessary. It is expected that these machines will have at least +/- 0.95 power factor capability and be operated in voltage control mode at all times.

I. Short Circuit

For the Customer proposed interconnection at the Jackson Fuller 230 kV POI, no PSCo-owned circuit breakers are expected to exceed their capabilities following installation of the new generation. Without the new generation, the PSCo Jackson Fuller breakers (5114, 5119 & 5129) each have short circuit duties of 43% of their interrupting capability. Following installation of the proposed generation, the short circuit duties of these breakers is expected to increase to 52% of their interrupting capability, leaving 48% additional margin. This assumes a fault current contribution from GI-2007-12 at the Jackson Fuller 230 kV Station of 1981.1 A. No other PSCo breakers were found to be overdutied as well.

At the time of this study, PSCo did not have breaker rating data for the other non-PSCo-owned breakers in the Jackson Fuller Station, or any other non-PSCo-owned breakers in the area. Therefore, the Customer will need to request that CSU and TSG&T complete their own breaker duty calculations to assess the potential impact of the proposed generation on their breakers.

The calculated short circuit levels and Thevenin system equivalent impedances for the POI at the Jackson Fuller 230 kV station are shown in Table 1 below.

Table 1 – Short Circuit Parameters at the Jackson Fuller 230 kV POI

System Condition	Three-Phase Fault Level (Amps)	Single-Line-to-Ground Fault Level (Amps)	Thevenin System Equivalent Impedance (R +j X) (ohms)
System Intact	17306.8	13712.7	Zpos = 0.77698 +j .63328 Zneg = 0.78659 +j 7.63233 Z0 = 2.90694 +j 13.4397
Fountain Valley Units Off	16704.1	13379.1	Zpos = 0.80791 +j 7.90844 Zneg = 0.81947 +j 7.90728 Z0 = 2.93934 +j 13.6754
Strongest Line Out - Jackson Fuller – Midway 230 kV Out	13707.0	11050.4	Zpos = 1.16312 +j 9.61772 Zneg = 1.17237 +j 9.61635 Z0 = 3.23950 +j 16.3825
Fountain Valley Units and Jackson Fuller – Midway 230 kV Out	13474.4	10912.7	Zpos = 1.17314 +j 9.78565 Zneg = 1.18383 +j 9.78417 Z0 = 3.25830 +j 16.5011

Costs Estimates and Assumptions
GI-2007-12 (System Impact Study Report)
Revised February 18, 2014

The Customer has requested a 250 MW Wind Generation Project interconnecting on the 230kV bus at Jackson Fuller Substation. A 230kV radial transmission line will connect the Customer's collector site with the PSCo transmission system at the Point of Interconnection. The estimated total cost for the required upgrades for is **$3,050,000.**

The estimated costs shown are (+/-30%) estimates in 2013 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, procurement and construction of these new PSCo facilities. This estimate does not include the cost for any other Customer owned equipment and associated design and engineering.

The following tables list the improvements required to accommodate the interconnection and the delivery of the Project. The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines. System improvements are subject to change upon more detailed analysis.

Table 1 – PSCo Owned; Customer Funded Interconnection Facilities

Element	Description	Cost Est. Millions
Jackson Fuller 230kV Substation	Interconnect Customer to tap the bus at the Jackson Fuller 230kV substation. The new equipment includes: • 230kV bidirectional metering • Three 230kV combination CT/PT instrument transformers • Associated foundations and structures • Associated transmission line communications, relaying and testing	**$0.760**
	Transmission – labor to install slack span into Jackson Fuller. Materials furnished by Customer.	**$0.100**
	Customer Generator Communication to Lookout.	**$0.010**
At Customer's Substation	Customer Load Frequency/Automated Generator Control and Generator Witness Testing.	**$0.280**
	Siting and Land Rights support for required easements, reports, permits and licenses.	**$0.010**
	Total Cost Estimate for Customer Interconnection Facilities	**$1.160**
Time Frame	**To site, design, procure and construct**	**18 Months**

Table 2: PSCo Owned; PSCo Funded Interconnection Facilities

Element	Description	Cost
Jackson Fuller 230kV Substation	Interconnect Customer to tap the bus at the Jackson Fuller 230kV substation. The new equipment includes: • Two 230kV, 3000 amp, gas circuit breakers • Five 230kV, 3000 amp gang switches • Three 230kV, arresters • Associated communications and SCADA equipment • Line relaying and testing • Electrical bus work • Associated foundations and structures • Associated yard surfacing, landscaping, fencing and grounding	**$1.610**
Jackson Fuller 230kV Substation	Siting and Land Rights support for required easements, reports, permits and licenses	**$0.010**
	Total Estimated Cost for PSCo Interconnection Facilities	**$1.620**
Time Frame	**To site, design, procure and construct**	**18 Months**

Table 3 – PSCo Network Upgrades for Delivery - PSCo Funded

Element	Description	Cost Est. Millions
Palmer Lake 115kV Substation	Replace jumpers to meet Palmer Lake-Monument 115kV line ratings	**0.160**
Daniels Park 230kV Substation	Replace line trap and jumpers to meet Daniels Park-Jackson Fuller 230kV line ratings	**0.110**
	Total Estimated Cost for PSCo Network Upgrades for Delivery	**$0.270**
Time Frame	To design, procure and construct	**18 Months**

Assumptions

- The cost estimates provided are “scoping estimates” with an accuracy of +/- 30%.
- Estimates are based on 2014 dollars.
- There is contingency and escalation included in the estimates. AFUDC is not included.
- Labor is estimated for straight time only – no overtime included.
- The Generator is not in PSCo’s retail service territory. Therefore no costs for retail load metering are included in these estimates.

- PSCo (or it's Contractor) crews will perform all construction and wiring associated with PSCo owned and maintained facilities.
- The estimated time to site, design, procure (long lead time materials) and construct the interconnection facilities is at least 18 months, and is completely independent of other queued projects and their respective ISD's.
- A CPCN will not be required for interconnection facility construction.
- Customer will string OPGW fiber into substation as part of the transmission line construction scope.
- PSCo crews to perform checkout, relay panel construction and final commissioning.
- No new substation land required. Substation work to be completed within existing property boundaries.

Xcel Energy

Appendix

GI-2007-12
Jackson Fuller 230 kV – 250 MW

A. Load Flow Thermal Results – 2016 Peak Summer Conditions
Colorado South-North Flow Stress - Lamar DC Tie – 101 MW Import
Colorado Green/Twin Buttes Wind – 97.3 MW
CPUC Resource Filing Unit Status - Fountain Valley – 242 MW
New Comanche & SLV PV Solar – 0 MW

Table 5 – Summary Listing of Overloaded Facilities[1] (Category B Contingencies)

				Branch Contingency Loading Without GI-2007-12		Branch Contingency Loading With GI-2007-12			
Monitored Facility (Line or Transformer)	**Type**	**Line Owner**	**Branch Rating MVA (Norm/Emer)**	**Cat B Flow in MVA (Current Equiv*)**	**Cat B Flow in % Current Equiv of Normal/Emer Rating**	**Cat B Flow in MVA (Current Equiv*)**	**Cat B Flow in % Current Equiv of Normal/Emer Rating**	**% Change**	**NERC Category B Contingency Outage**
Briar Gate – Cottonwood S 115 kV	LN	CSU	150 / 192	150.4	100.3 / 78.3	168.6	112.4 / 87.8	12.1 / 9.5	Cottonwood N – Kettle Creek 115 kV
Cottonwood N – Kettle Creek 115 kV	LN	CSU	162 / 180	160.2	98.9 / 89.0	181.0	111.7 / 100.5	12.8 / 11.5	Briar Gate – Cottonwood S 115 kV
Jackson Fuller 230/115 kV T1 (Informational)	TR	TSGT	100 / 100	87.0	87.0 / 87.0	96.0	96.0 / 96.0	9.0 / 9.0	Midway BR – Rancho 115 kV

*Current-corrected flows for transmission lines only.

Note – CSU has stated in the past that it is their policy to upgrade their system only when the contingency loading violates the Emergency Rating of a facility. The Customer will need to confirm this with CSU.

[1] Includes facilities with an Impact Factor of 2% or more of the proposed 249.9 MW generation.

B. Load Flow Thermal Results – 2016 Peak Summer Conditions
Colorado South-North Flow Stress - Lamar DC Tie – 101 MW Import
Colorado Green/Twin Buttes Wind – 97.3 MW
CPUC Resource Filing Unit Status - Fountain Valley – 242 MW
Comanche & New SLV PV Solar – 0 MW

Table 6 – Summary Listing of Overloaded Facilities[1] (Category C Contingencies)

				Branch Contingency Loading Without GI-2007-12		Branch Contingency Loading With GI-2007-12			
Monitored Facility (Line or Transformer)	**Type**	**Line Owner**	**Branch Rating MVA (Norm/Emer)**	**Cat C Flow in MVA (Current Equiv*)**	**Cat C Flow in % Current Equiv of Normal/Emer Rating**	**Cat C Flow in MVA (Current Equiv*)**	**Cat C Flow in % Current Equiv of Normal/Emer Rating**	**% Change**	**NERC Category C Contingency Outage**
Daniels Park – Jackson Fuller 230 kV	LN	PSCo	478 / 478	384.8	80.5 / 80.5	498.1	104.2 / 104.2	23.7 / 23.7	DCT Comanche – Daniels Park 345 kV 1 & 2
Monument – Palmer Lake 115 kV	LN	PSCo / CSU	120 / 120	118.8	99.0 / 99.0	146.3	121.9 / 121.9	22.9 / 22.9	DCT Comanche – Daniels Park 345 kV 1 & 2
Kettle Creek – Flying Horse 115 kV	LN	CSU	162 / 180	135.4	83.6 / 75.2	163.5	100.9 / 90.8	17.3 / 15.6	DCT Comanche – Daniels Park 345 kV 1 & 2
Monument – Flying Horse 115 kV	LN	CSU	142 / 156	125.2	88.2 / 80.3	153.3	108.0 / 98.3	19.8 / 18.0	DCT Comanche – Daniels Park 345 kV 1 & 2

*Current-corrected flows for transmission lines only.

Note – CSU has stated in the past that it is their policy to upgrade their system only when the contingency loading violates the Emergency Rating of a facility. The Customer will need to confirm this with CSU.

[1] Includes facilities with an Impact Factor of 2% or more of the proposed 249.9 MW generation.

C. Generation Dispatch

Case Description: 2016 HS, Colorado South to North Generation Flow Bias, Fountain Valley Units On at Maximum, based on WECC 17hs1ap.sav with updates from CCPG companies.

Benchmark Case – GI-2007-12

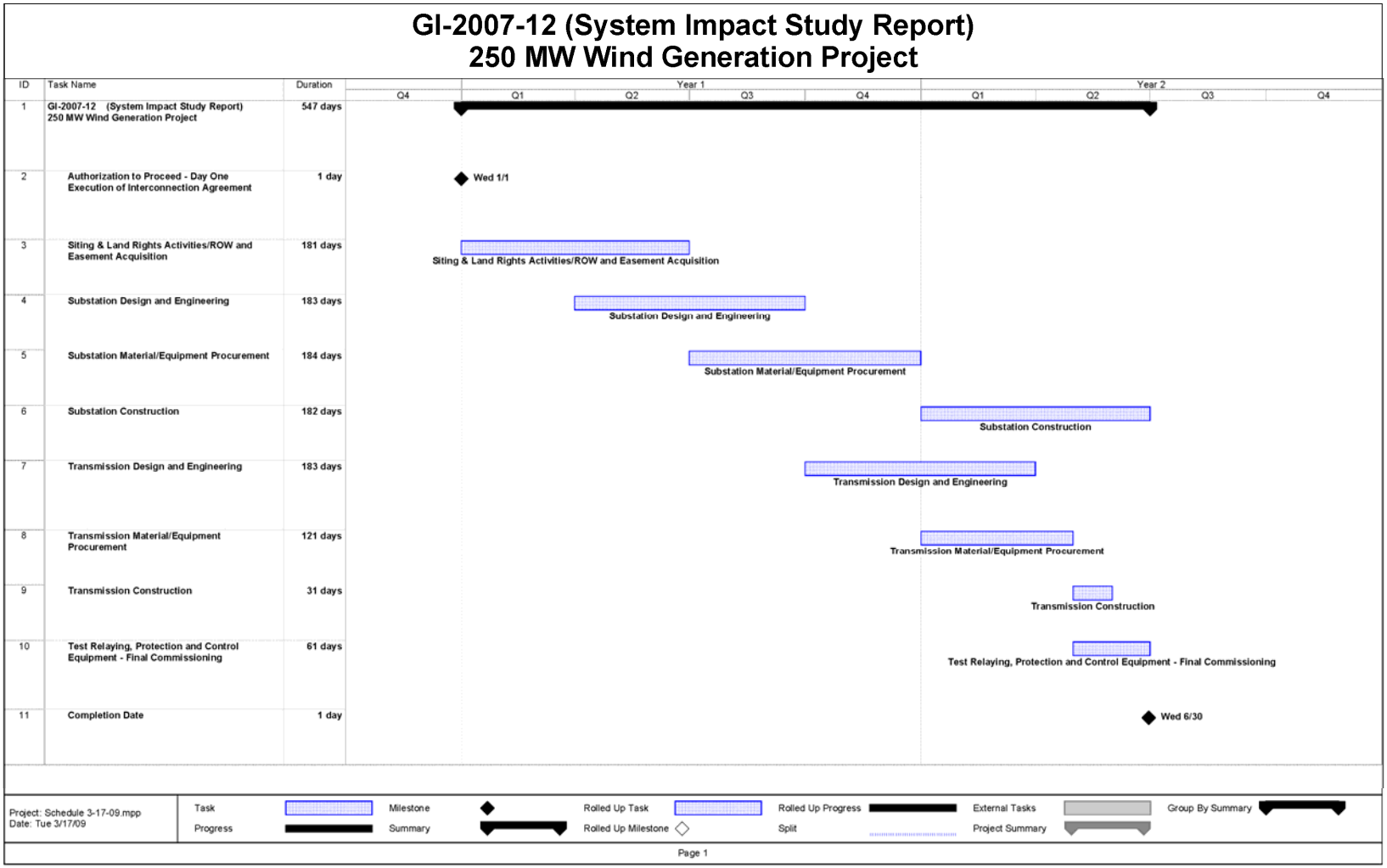
Arapahoe Unit 3 & 4	0 MW
Cabin Creek Units	210 MW
Cherokee Units 1 – 3	0 MW
Cherokee Unit 4	383 MW
Cherokee Unit 5-7	603.8 MW
Comanche Unit 1	360 MW
Comanche Unit 2	365 MW
Ft Lupton Units 1 & 2	0 MW
Pawnee Unit 1	536 MW
Manchief Units 1 & 2	0 MW
Ft St Vrain Units 1-4	700 MW
Valmont Unit 5	196 MW
Valmont Unit 6	0 MW
Alamosa Units 1 & 2	27 MW
QF Thermo – Ft Lup	266 MW
Brush Units 1, 3, & 4	0 MW
Brush Unit 2	0 MW
QF UNC	0 MW
Arapahoe Units 5-7	118 MW
Lamar DC Tie	101 MW Import from SPS
Spruce Units 1 & 2	0 MW
Brighton Units 1 & 2	85 MW
Fountain Valley Units	242 MW
Plains End Units	0 MW
RMEC Units 1-3	586 MW
Spindle Units 1 & 2	83.6 MW
Cedar Point Wind (MS 230 kV)	57.5 MW (23%)
Limon Wind (MS 345 kV)	138.1 MW (23%)
Peetz Logan 230 kV	132.4 MW (23%)
Comanche Unit 3	804 MW
Cedar Creek Wind	126.8 MW (23%)
San Luis Valley Solar	85.2 MW
Colorado Grn/Twin Buttes	97.3 MW
Ft St Vrain Units 5 & 6	295 MW
Lamar Units	0 MW (ARPA)
Baculite Mesa Plant	382 MW (BHE)

Busch Ranch Wind	28.8 MW (BHE)
Remaining BHE Gens	0 MW (BHE)
Birdsall	0 MW (CSU)
Nixon	224.8 MW (CSU)
Nixon CTs	0 MW (CSU)
Tesla	24.8 MW (CSU)
Drake	265.4 MW (CSU)
Front Range CC	404 MW (CSU)

GI-2007-12 Case Adjustments

GI-2007-12	249.9 MW
Spindle Units 1 & 2	0 MW
Ft St Vrain Units 5 & 6	134.5 MW

D. Proposed Project Schedule



E. Proposed Jackson Fuller Substation One-Line