Generator Interconnection
System Impact Study – Restudy 2
Request # GI-2007-12
Revision 1

250 MW Wind Turbine Generation
El Paso County, Colorado

Public Service Company of Colorado
Transmission Planning
April 29, 2014

A. Executive Summary

[This revision of the original report is being published to incorporate updated and additional contingency results requested by the Developer and an Affected Party (CSU). The revision also clarifies the application of the ER results that were reported previously. It also adds additional language to Section H on dynamic stability.]

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 (COD) 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 point of interconnection (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 two of Colorado Springs Utilities' (CSU's) circuits. The summer normal rating of CSU's Briar Gate – Cottonwood S 115 kV circuit is overloaded in the case with the proposed wind plant and also slightly overloaded in the benchmark case. The summer normal rating of CSU's Cottonwood N – Kettle Creek 115 kV circuit is also overloaded in the case with the proposed wind plant, but not in the benchmark case. This circuit's emergency rating is also violated. PSCo will 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. PSCo will work with CSU to resolve these overload concerns. The Category C contingency voltage analysis showed no problems due to the wind plant.

Energy Resource Interconnection Service allows the Customer to deliver a 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. Because it was included in the original 2007 Interconnection Request, this study identified the amount of Energy Resource (ER) capacity available for the modeled 2016 peak summer conditions for both Category B and Category C contingencies. However, the actual amount of ER firm or non-firm capacity that will be available at any particular point in time in the future will vary depending on actual system conditions, such as generation dispatch levels, demand levels, import path levels, and the operational status of transmission facilities.

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 the contingency analysis results, PSCo will confirm with CSU the need for upgrades and will work with them on mitigation strategies, as 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.

Additional Contingency Analysis Requested by Developer and CSU

During the review meeting on March 3, 2014 for the initial version of this report, the Developer and one of the Affected Parties, CSU, requested additional contingency analysis. The Developer requested the additional analysis to evaluate the impact of increasing the reactive capability of the wind turbine generators to 90% power factor. The results are in Tables 7-8 in Section E in the Appendix. Those analyses showed no significant difference in the results.

CSU requested PSCo perform additional studies to examine the impact of adding a phase-shifting transformer into the Monument – Palmer Lake 115 kV circuit at Monument. PSCo performed these studies, as well as additional studies to examine the impacts of replacing the phase-shifting transformer at Monument with a series reactor or operating the Monument – Palmer Lake 115 kV normally open. The results are in Tables 9-23 in Section E in the Appendix. While the majority of these alternatives were found to eliminate the CSU overload impacts found in the original studies, some other overload and voltage impacts were noted on the PSCo, IREA, Tri-State G&T and CSU systems. Plans are already in place for the PSCo overload impacts, but some additional upgrades may be required by IREA, TSGT & CSU depending on alternative and associated operational strategy.

Please note that CSU Transmission Operations also requested transient stability studies. Those studies are ongoing.

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

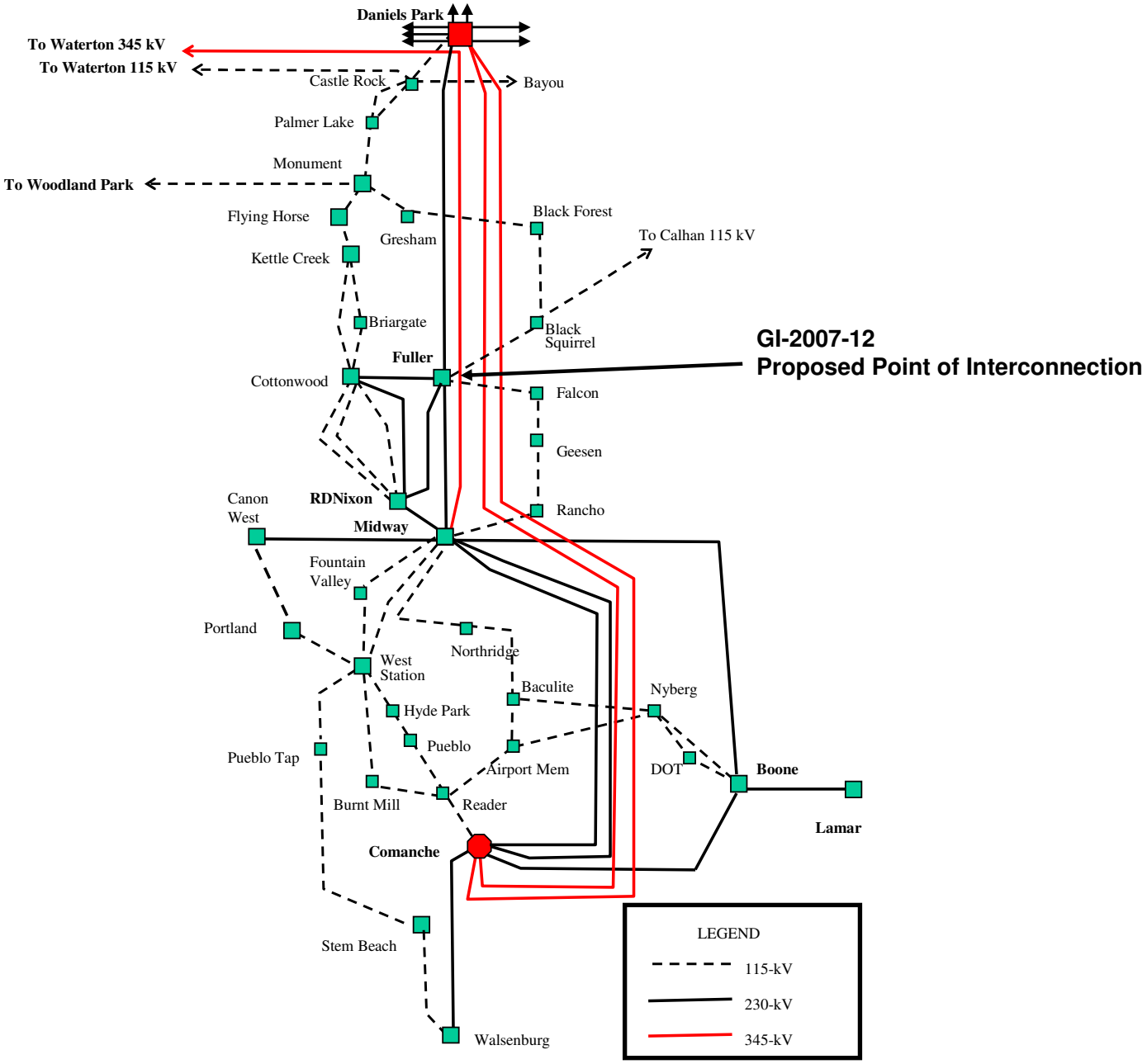
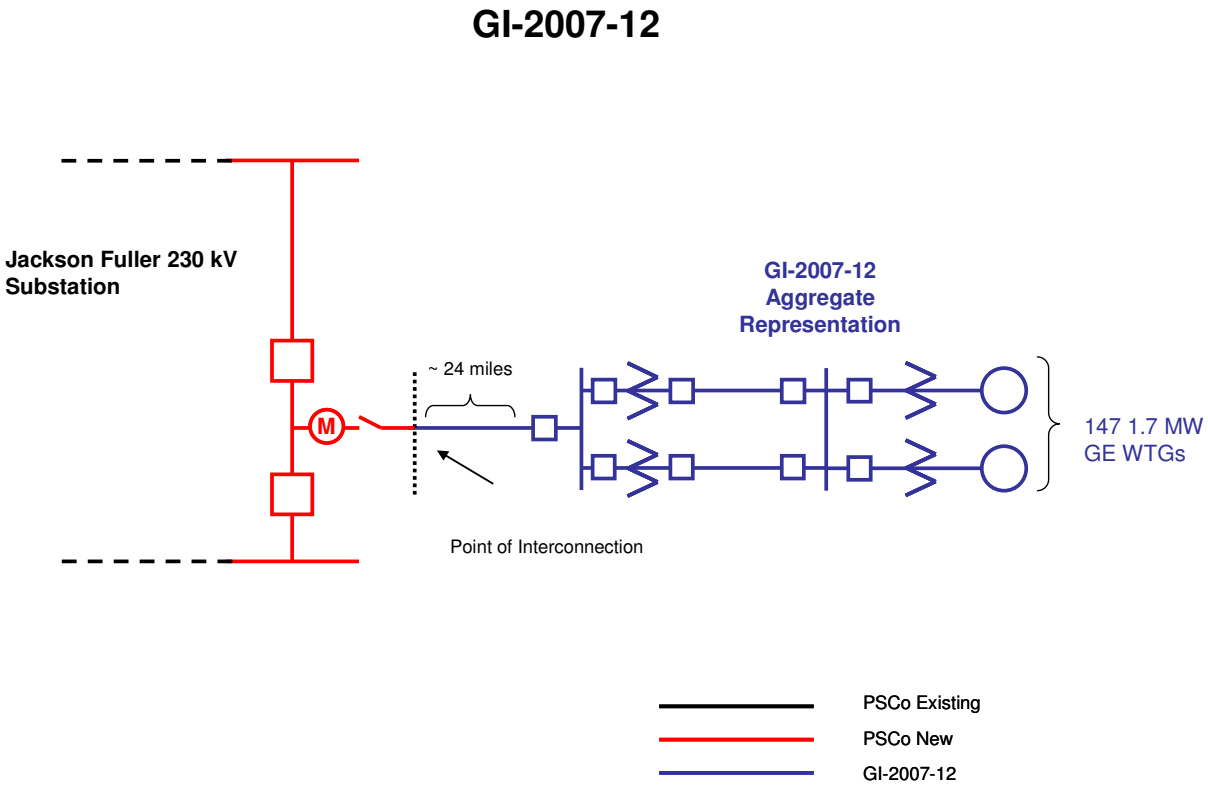


Figure 2: GI-207-12 Conceptual Diagram



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 Section 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 Section 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 Section A of 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. Since this circuit is already overloaded in the benchmark case, and there is no new overload of the emergency rating, mitigation of this overload due to the proposed generation is not required.

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. PSCo will confirm with CSU the need for upgrades for this circuit and will work with them on mitigation, as required.

In the previous System Impact Study for this project dated June 15, 2009, TSG&T's Jackson Fuller 230/115 kV transformer was found to be significantly overloaded. In this study, the Jackson Fuller 230/115 kV transformer was not found to be overloaded in the Category B contingency analysis.

The results of the Category C contingency analyses (see Table 6) showed seven facilities with overloads or substantial increases in overloads that can be attributed to the proposed wind plant. One is owned by PSCo, one is jointly owned between PSCo and CSU, four are owned by CSU and one is owned by TSGT.

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 due to the double circuit tower loss of the Comanche – Daniels Park 345 kV #1 & 2 circuits. 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 135.0% of its 120 MVA summer normal and emergency ratings due to the double circuit tower loss of the Midway – Waterton 345 kV and Daniels Park – Jackson Fuller 230 kV circuits. The maximum contingency loading in the

benchmark case was 99.0% due to the double circuit tower loss of the Comanche – Daniels Park 345 kV #1 & 2 circuits, representing a 36.0% 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. PSCo will confirm with CSU the need for upgrades for this circuit and will work with them on mitigation, as required.

The third is the Briar Gate – Cottonwood S 115 kV circuit. This CSU owned circuit was found to be overloaded 113.4% of its 150 MVA summer normal rating for a bus fault on the Cottonwood 115 kV N bus. The contingency loading was 102.0% in the benchmark case, representing an 11.4% increase. The corresponding emergency rating % loadings are 88.6% and 79.7% of the 192 MVA summer emergency rating, respectively. Since this circuit is already overloaded in the benchmark case, and there is no new overload of the emergency rating, mitigation of this overload due to the proposed generation is not required.

The fourth is the Cottonwood N – Kettle Creek 115 kV circuit. This CSU owned circuit was found to be overloaded 102.1% of its 162 MVA summer normal rating for a bus fault on the Cottonwood 115 kV S bus. The contingency loading was 89.9% in the benchmark case, representing a 12.2% increase. The corresponding emergency rating % loadings are 91.9% and 80.9% of the 180 MVA summer emergency rating, respectively. PSCo will confirm with CSU the need for upgrades for this circuit and will work with them on mitigation, as required.

The fifth is the Kettle Creek – Flying Horse 115 kV circuit. This CSU owned circuit was found to be overloaded 113.2% of its 162 MVA summer normal rating due to the double circuit tower loss of the Midway – Waterton 345 kV and Daniels Park – Jackson Fuller 230 kV circuits. The maximum contingency loading in the benchmark case was 83.6% due to the double circuit tower loss of the Comanche – Daniels Park 345 kV #1 & 2 circuits, representing a 29.6% increase. The corresponding emergency rating % loadings are 101.9% and 75.2% of the 180 MVA summer emergency rating, respectively. PSCo will confirm with CSU the need for upgrades for this circuit and will work with them on mitigation, as required.

The sixth is the Monument – Flying Horse 115 kV circuit. This CSU owned circuit was found to be overloaded 122.1% of its 142 MVA summer normal rating due to the double circuit tower loss of the Midway – Waterton 345 kV and Daniels Park – Jackson Fuller 230 kV circuits. The maximum contingency loading in the benchmark case was 99.5% in the benchmark case due to a circuit breaker failure (fault) of the Cottonwood 115 kV station bus tie breaker, representing a 26.6% increase. The corresponding emergency rating % loadings are 111.2% and 86.9% of the 156 MVA summer emergency rating, respectively. PSCo will confirm with CSU the need for upgrades for this circuit and will work with them on mitigation as required.

The last is the Jackson Fuller 230/115 kV transformer due to a circuit breaker failure (fault) of the Cottonwood 115 kV station bus tie breaker. This TSGT owned transformer was found to be overloaded 128.1% of its 100 MVA summer normal & emergency rating. It was also overloaded at 110.8% in the benchmark case, representing a 17.3% increase. Since this element is already overloaded in the benchmark case, and there is no new overload of the emergency rating, mitigation of this overload due to the proposed generation is not required.

Energy Resource Interconnection Service

The original 2007 Interconnection Request included requests for both Network Resource Interconnection Service and Energy Resource Interconnection Service. Therefore, in addition to the Network Resource contingency analysis, the proposed generation was studied as an Energy Resource as well. As defined in Section C above, Energy Resource Interconnection Service allows the Customer to deliver a 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. The ER analyses were performed using the same 2016 peak summer load flow cases as were used for the Network Resource contingency analyses.

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.

Please note that since these results were based on 2016 summer peak conditions, the actual amount of ER firm or non-firm capacity that will be available at any particular point in time in the future will vary depending on actual system conditions, such as generation dispatch levels, demand levels, import path levels, and the operational status of transmission facilities.

Additional Contingency Analyses

During the review meeting on March 3, 2014 for the initial version of this report, the Developer and one of the Affected Parties, CSU, requested additional contingency analysis. The Developer requested the additional analysis to evaluate the impact of increasing the reactive capability of the wind turbine generators to 90% power factor. CSU requested PSCo perform additional studies to examine the impact of adding a phase-shifting transformer into the Monument – Palmer Lake 115 kV circuit at Monument. PSCo performed these studies, as well as additional studies to examine the impacts of replacing the phase-shifting transformer at Monument with a series reactor or operating the Monument – Palmer Lake 115 kV normally open. The results are in Tables 7-23 in Section E in the Appendix. Please note that CSU Transmission Operations also requested transient stability studies. Those studies are ongoing.

The results of the contingency analysis with the increased reactive capability showed no change. The results can be found in Tables 7 & 8.

The contingency analysis with the phase-shifting transformer was performed with Phase Shifting Transformer Adjustments turned off. The results depend on the MW control setpoint. They are contained in Tables 9-14. For a setting of 25 MW north, the CSU system overloads were eliminated but the Category C contingency overload of the Daniels Park – Jackson Fuller 230 kV line increased to 111.5% of its summer normal & emergency rating of 478 MVA. The planned upgrades to the terminal equipment at Daniels Park 230 kV will still be sufficient to mitigate this overload. The Smoky Hill – Peakview 115 kV circuit was also found to be overloaded at 100.5% of it summer normal & emergency rating of 159 MVA for the double-circuit tower outage of the Parker – Sulphur 115 kV 1 & 2 circuits. This is an IREA-owned line but the terminal equipment at Smoky Hill is owned by PSCo. This circuit is limited by the PSCo-owned terminal equipment. This equipment has been added to PSCo's FAC-008/009 terminal equipment upgrade program. For this alternative, confirmation with IREA will be required to verify the need for upgrades on their portion of the line.

For a setting of 0 MW, the CSU system overloads were also eliminated. However, the Daniels Park – Happy Canyon 115 kV circuit was overloaded 104.8% to 105.4% of the 120 MVA summer normal & emergency rating for the Category B contingency loss of the Bayou – Parker PS 115 kV line, and 105.3% to 105.9% for the Category C loss of the Bayou – Parker PS 115 kV line and the IREA load at Parker. The limiting terminal equipment at Daniels Park 115 kV has been added to PSCo's FAC-008/009 terminal equipment upgrade program. Also, the Category C contingency overload of the Daniels Park – Jackson Fuller 230 kV line increased to 113.7%. The planned upgrades to the terminal equipment at Daniels Park 230 kV will still be sufficient to mitigate this overload. The Smoky Hill – Peakview 115 kV IREA circuit was also found to be overloaded at 101.6% to 103.5%. The PSCo-owned limiting terminal equipment at Smoky Hill has been added to PSCo's FAC-008/009 terminal equipment upgrade program but confirmation with IREA will be required to verify the need for upgrades on their portion of the line. In addition, the Emil Anderson – Forest Lake 115 kV line owned by Tri-State G&T (TSGT) is also overloaded at 103.1% of its 58 MVA summer normal & emergency rating. For this alternative and operational setting, PSCo will need to coordinate with TSGT regarding the need for upgrades on this circuit.

As a sensitivity, contingency analysis was also performed with a phase-shifter setting of 25 MW South. The same circuit overloads listed for the 0 MW setting were also overloaded for the 25 MW South setpoint, although at slightly higher levels. These can be seen in Table 13-14. The planned upgrades for the PSCo-owned facilities are still sufficient to mitigate these overloads. this alternative and operational setting, PSCo would still need to coordinate with IREA regarding the need for upgrades of the Smoky Hill – Peakview 115 kV circuit and TSGT regarding the need for upgrades of the Emil Anderson – Forest Lake 115 kV line. However, this was just a sensitivity case – this operational mode is less likely under the heavy south to north flow conditions.

Two scenarios were examined with the series reactor alternative instead of the phase-shifting transformer. In one case, the size of the series reactor was chosen to result in 25 MW flow in the case with the proposed generation at Jackson Fuller. The reactance of this reactor was 32.5% on 100 MVA. The other case was a sensitivity with the Series Reactor sized at 20%. The results of the series reactor contingency analysis can be found in Tables 15-20.

For the reactor X=32.5% contingency analysis, the same circuit overloads listed for the phase-shifter 0 MW & 25 MW South setpoints were also overloaded at similar levels. For this mitigation alternative, the planned upgrades for the PSCo-owned facilities are still sufficient to mitigate the PSCo overloads and PSCo will still need to coordinate with IREA regarding the need for upgrades of the Smoky Hill – Peakview 115 kV circuit and TSGT regarding the need for upgrades of the Emil Anderson – Forest Lake 115 kV line. An additional overload is the Black Squirrel – Jackson Fuller 115 kV circuit. This circuit is also owned by TSGT. This circuit is overloaded at 106.8% of its 144 MVA summer normal & emergency rating due to the Category C breaker failure outage of the Cottonwood 115 kV Tie breaker which takes out the entire Cottonwood 115 kV Station. PSCo will also need to coordinate with TSGT regarding the need for upgrades for this circuit.

The contingency voltage results for the series reactor sized to X=32.5% scenario are in Table 17. Following the Category C loss of the Cottonwood 115 kV Tie breaker, two CSU buses experienced a voltage drop to below 90% – Briar Gate 115 kV & Kettle Creek 115 kV. The voltage range was 88.9% to 89.8%. For this mitigation alternative, PSCo would need to coordinate with CSU regarding the need for mitigation of these contingency low voltages.

For the sensitivity case with the series reactor sized to X=20%, the overload levels for the circuits listed in the X=32.5% case were lower or non-existent. However, the Briar Gate – Cottonwood S 115 kV circuit was overloaded with the new generation at 100.2% of the 150 MVA summer normal rating for the Category B loss of the Cottonwood N – Kettle Creek 115 kV circuit and 102.1% of the summer normal rating for a Category C bus fault at the Cottonwood 115 kV North bus. For these outages, the corresponding contingency loading levels are 78.3% & 79.7% of the 192 MVA summer emergency rating.

The contingency voltage results for the series reactor sized to X=20% scenario are in Table 20. Following the Category C loss of the Cottonwood 115 kV Tie breaker, one CSU bus experienced a voltage drop to below 90% – Briar Gate 115 kV. The voltages were 88.6% to 89.9% for the cases with and without the proposed generation at Jackson Fuller. For this mitigation alternative, PSCo would need to coordinate with CSU regarding the need for mitigation of these contingency low voltages.

The results of the Monument – Palmer Lake 115 kV Normally Open contingency analysis can be found in Tables 21-23. In this case, the same circuit overloads listed for the series reactor sized to X=32.5 % case were also overloaded, although at higher levels. For this mitigation alternative, the planned upgrades for the PSCo-owned facilities are still sufficient to mitigate the PSCo overloads and PSCo will still need to coordinate with IREA regarding the need for upgrades of the Smoky Hill – Peakview 115 kV circuit and TSGT regarding the need for

upgrades of the Emil Anderson – Forest Lake 115 kV and Black Squirrel – Jackson Fuller 115 kV circuits. However, for this alternative, with the proposed generation at Jackson Fuller, the CSU-owned Monument – Flying Horse 115 kV circuit is also overloaded 103.8% of the 142 MVA summer normal rating for the Category C breaker failure outage of the Cottonwood 115 kV Tie breaker. This contingency loading level is 94.5% of the 156 MVA emergency rating. The corresponding normal & emergency loading levels without the Jackson Fuller generation are 103.6% & 94.3%, respectively.

The contingency voltage results for the Monument – Palmer Lake 115 kV Normally Open scenario are in Table 23. Following the Category C loss of the Cottonwood 115 kV Tie breaker, six buses experienced voltage drops to levels below 90% – three CSU buses (Briar Gate 115 kV, Kettle Creek 115 kV & Flying Horse 115 kV), two TSGT buses (Emil Anderson 115 kV & Forest Lake 115 kV) and a bus that is jointly owned between CSU & TSGT (Monument 115 kV). The voltage range was 86.1% to 89.9%. For this mitigation alternative, PSCo would need to coordinate with CSU & TSGT regarding the need for mitigation of these contingency low voltages.

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. Also, stability studies performed previously for the GI-2007-10 and original GI-2007-12 wind turbine generator interconnection studies showed no stability performance concerns. It is expected that the GE

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 (40 kA). 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.

An estimated 18 month project schedule can be found in Appendix Section C. the proposed Jackson Fuller Station one-line can be found in Appendix Section D.

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 its 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 ISDs.
- 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.

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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 – GI-2007-12 Summary Listing of Worst Case 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.

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

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Table 6 – GI-2007-12 Summary Listing of Worst Case 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%	Double-Circuit Tower Comanche – Daniels Park 345 kV 1 & 2
Monument – Palmer Lake 115 kV	LN	PSCo / CSU	120 / 120	113.7	94.7% / 94.7%	162.0	135.0% / 135.0%	40.3% / 40.3%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
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%	Double-Circuit Tower Comanche – Daniels Park 345 kV 1 & 2
Briar Gate – Cottonwood S 115 kV	LN	CSU	150 / 192	153.0	102.0% / 79.7%	170.0	113.4% / 88.6%	11.4% / 8.9%	Bus Fault Cottonwood 115 kV N bus
Cottonwood N – Kettle Creek 115 kV	LN	CSU	162 / 180	145.6	89.9% / 80.9%	165.3	102.1% / 91.9%	12.2% / 11.0%	Bus Fault Cottonwood 115 kV S bus
Kettle Creek – Flying Horse 115 kV	LN	CSU	162 / 180	133.6	82.5% / 74.2%	183.4	113.2% / 101.9%	30.7% / 27.7%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
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%	Double-Circuit Tower Comanche – Daniels Park 345 kV 1 & 2
Monument – Flying Horse 115 kV	LN	CSU	142 / 156	123.7	87.1% / 79.3%	173.4	122.1% / 111.2%	35.0% / 31.9%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Monument – Flying Horse 115 kV	LN	CSU	142 / 156	135.6	95.5% / 86.9%	135.7	95.5% / 87.0%	0.0% / 0.1%	Breaker Failure Cottonwood 115 kV Tie Breaker
Jackson Fuller 230/115 kV T1	TR	TSGT	100 / 100	110.8	110.8% / 110.8%	128.1	128.1% / 128.1%	17.3% / 17.3%	Breaker Failure Cottonwood 115 kV Tie Breaker

*Current-corrected flows for transmission lines only.

[1] Includes facilities with an Impact Factor of 2% or more of the proposed 249.9 MW generation (except Monument – Flying Horse 115 kV benchmark overload).

B. 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

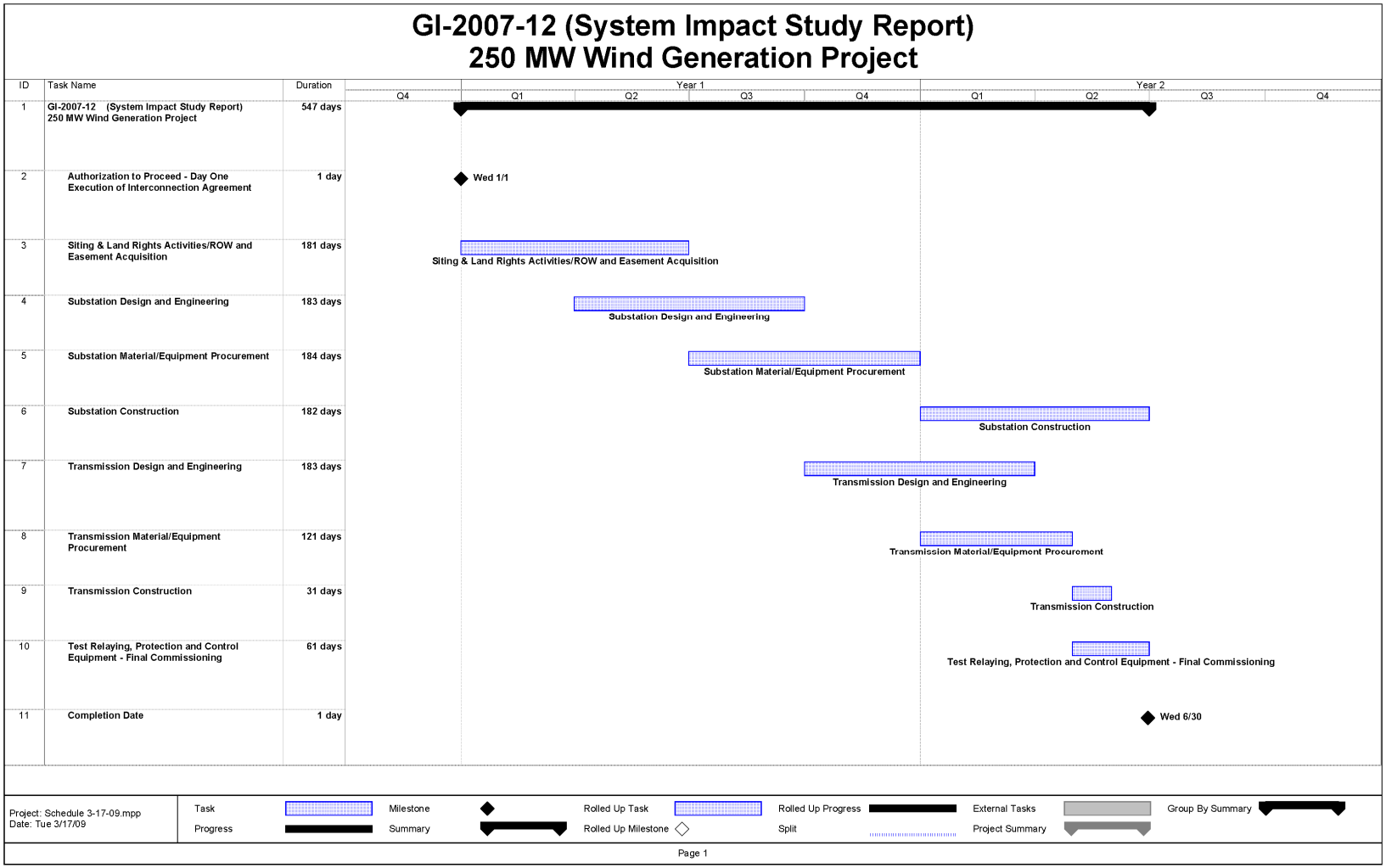
Arapahoe Unit 3 & 4	0 MW
Cabin Creek Units	210 MW
Cherokee Units 1 – 3	0 MW
Cherokee Unit 4	383 MW
Cherokee Unit 5-7	603.8 MW
Comanche Unit 1	360 MW
Comanche Unit 2	365 MW
Ft Lupton Units 1 & 2	0 MW
Pawnee Unit 1	536 MW
Manchief Units 1 & 2	0 MW
Ft St Vrain Units 1-4	700 MW
Valmont Unit 5	196 MW
Valmont 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)

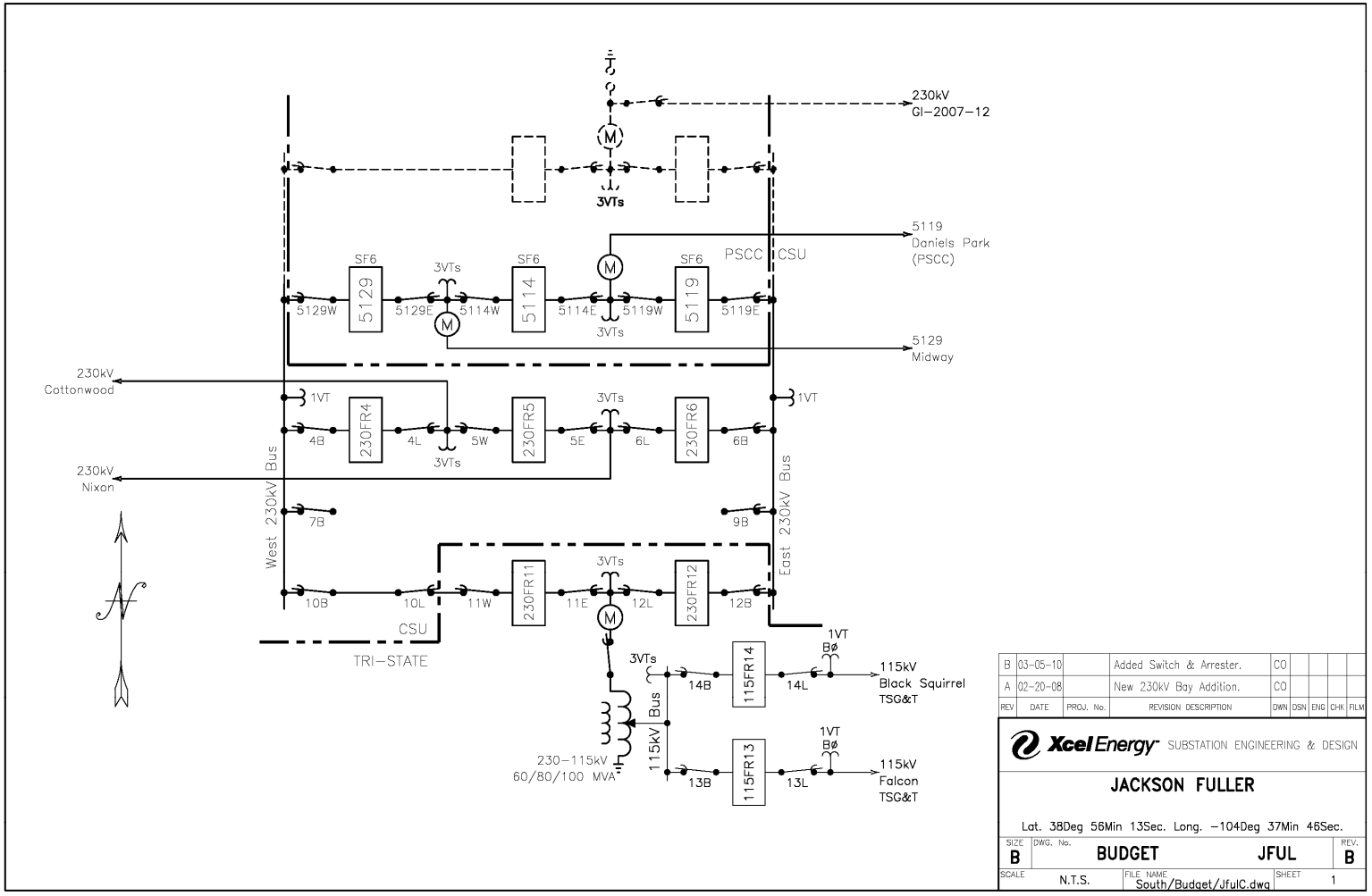
GI-2007-12 Case Adjustments

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

C. Proposed Project Schedule



D. Proposed Jackson Fuller Substation One-Line



E. Additional Contingency Analysis Load Flow Thermal Results

Wind Turbine Generator Reactive Capability – 90% PF

Table 7 – GI-2007-12 Summary Listing of Worst Case Overloaded Facilities[3] (Category B Contingencies)

				Branch Contingency Loading Without GI-2007-12		Branch Contingency Loading With GI-2007-12 WTG RC = 90% PF			
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.

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

Table 8 – GI-2007-12 Summary Listing of Worst Case Overloaded Facilities[4] (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%	Double-Circuit Tower Comanche – Daniels Park 345 kV 1 & 2
Monument – Palmer Lake 115 kV	LN	PSCo / CSU	120 / 120	113.7	94.7% / 94.7%	162.0	135.0% / 135.0%	40.3% / 40.3%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
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%	Double-Circuit Tower Comanche – Daniels Park 345 kV 1 & 2
Briar Gate – Cottonwood S 115 kV	LN	CSU	150 / 192	153.0	102.0% / 79.7%	170.0	113.4% / 88.6%	11.4% / 8.9%	Bus Fault Cottonwood 115 kV N bus
Cottonwood N – Kettle Creek 115 kV	LN	CSU	162 / 180	145.6	89.9% / 80.9%	165.3	102.1% / 91.9%	12.2% / 11.0%	Bus Fault Cottonwood 115 kV S bus
Kettle Creek – Flying Horse 115 kV	LN	CSU	162 / 180	133.6	82.5% / 74.2%	183.4	113.2% / 101.9%	30.7% / 27.7%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
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%	Double-Circuit Tower Comanche – Daniels Park 345 kV 1 & 2
Monument – Flying Horse 115 kV	LN	CSU	142 / 156	123.7	87.1% / 79.3%	173.4	122.1% / 111.2%	35.0% / 31.9%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Monument – Flying Horse 115 kV	LN	CSU	142 / 156	135.6	95.5% / 86.9%	135.7	95.5% / 87.0%	0.0% / 0.1%	Breaker Failure Cottonwood 115 kV Tie Breaker
Jackson Fuller 230/115 kV T1 (Informational)	TR	TSGT	100 / 100	110.8	110.8% / 110.8%	128.1	128.1% / 128.1%	17.3% / 17.3%	Breaker Failure Cottonwood 115 kV Tie Breaker

* Current-corrected flows for transmission lines only.

[4] Includes facilities with an Impact Factor of 2% or more of the proposed 249.9 MW generation (except Monument – Flying Horse 115 kV benchmark overload).

Table 9 – GI-2007-12 Summary Listing of Worst Case Overloaded Facilities (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	138.4	92.3% / 72.1%	145.2	96.8% / 75.6%	4.5% / 3.5%	Cottonwood N – Kettle Creek 115 kV
Cottonwood N – Kettle Creek 115 kV	LN	CSU	162 / 180	145.9	90.0% / 81.0%	153.5	94.7% / 85.3%	4.4% / 4.3%	Briar Gate – Cottonwood S 115 kV
Jackson Fuller 230/115 kV T1 (Informational)	TR	TSGT	100 / 100	82.7	82.7% / 82.7%	87.7	87.7% / 87.7%	4.3% / 4.3%	Midway BR – Rancho 115 kV

*Current-corrected flows for transmission lines only.

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Phase-Shifting Transformer Added in the Monument-Palmer Lake 115 kV Line at Monument – Regulating to 25 MW North

Table 10 – GI-2007-12 Summary Listing of Worst Case Overloaded Facilities (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	408.5	85.5% / 85.5%	532.8	111.5% / 111.5%	26.0% / 26.0	Double-Circuit Tower Comanche – Daniels Park 345 kV 1 & 2
Monument – Palmer Lake 115 kV**	LN	PSCo / CSU	120 / 120	66.9	55.7% / 55.7%	84.8	70.6% / 70.6%	14.9% / 14.9%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Monument – Palmer Lake 115 kV**	LN	PSCo / CSU	120 / 120	67.1	55.9% / 55.9%	71.0	59.2%/ 59.2%	3.3% / 3.3%	Double-Circuit Tower Comanche – Daniels Park 345 kV 1 & 2
Smoky Hill – Peakview 115 kV	LN	IREA	159 / 159	159.7	100.5% / 100.5%	156.8	98.6% / 98.6%	-1.9% / -1.9%	Double-Circuit Tower Parker – Sulphur 115 kV 1 & 2
Briar Gate – Cottonwood S 115 kV	LN	CSU	150 / 192	141.9	94.6% / 73.9%	147.8	98.5% / 77.0%	3.9% / 3.1%	Bus Fault Cottonwood 115 kV N bus
Cottonwood N – Kettle Creek 115 kV	LN	CSU	162 / 180	134.1	82.8% / 74.5%	141.5	87.4% / 78.6%	4.6% / 4.1%	Bus Fault Cottonwood 115 kV S bus
Emil Anderson – Forest Lake 115 kV	LN	TSGT	58 / 58	35.5	61.1% / 61.1%	55.8	96.1% / 96.1%	35.0% / 35.0%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Emil Anderson – Forest Lake 115 kV	LN	TSGT	58 / 58	48.6	83.7% / 83.7%	43.6	75.2% / 75.2%	-8.5% / -8.5%	Breaker Failure Cottonwood 115 kV Tie Breaker
Kettle Creek – Flying Horse 115 kV	LN	CSU	162 / 180	104.9	64.8% / 58.3%	136.2	84.1% / 75.7%	19.3% / 17.4%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Kettle Creek – Flying Horse 115 kV	LN	CSU	162 / 180	127.2	78.5% / 70.7%	127.3	78.6% / 70.7%	0.1% / 0.0%	Breaker Failure Cottonwood 115 kV Tie Breaker
Monument – Flying Horse 115 kV	LN	CSU	142 / 156	137.6	96.9% / 88.2%	137.6	96.9% / 88.2%	0.0% / 0.0%	Breaker Failure Cottonwood 115 kV Tie Breaker
Jackson Fuller 230/115 kV T1 (Informational)	TR	TSGT	100 / 100	116.2	116.2% / 116.2%	127.5	127.5% / 127.5%	11.3% / 11.3%	Breaker Failure Cottonwood 115 kV Tie Breaker

*Current-corrected flows for transmission lines only.
**Phase-shifting adjustments were turned off in the contingency analysis.

Phase-Shifting Transformer Added in the Monument-Palmer Lake 115 kV Line at Monument – Regulating to 0 MW

Table 11 – GI-2007-12 Summary Listing of Worst Case Overloaded Facilities (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**
Daniels Park – Happy Canyon 115 kV	LN	PSCo	120 / 120	125.8	104.8% / 104.8%	126.5	105.4% / 105.4%	0.6% / 0.6%	Bayou – Parker PS 115 kV
Briar Gate – Cottonwood S 115 kV	LN	CSU	150 / 192	125.2	83.5% / 65.2%	132.1	88.1% / 68.8%	4.6% / 3.6%	Cottonwood N – Kettle Creek 115 kV
Cottonwood N – Kettle Creek 115 kV	LN	CSU	162 / 180	131.0	80.9% / 72.8%	138.9	85.7% / 77.1%	4.8% / 4.3%	Briar Gate – Cottonwood S 115 kV
Jackson Fuller 230/115 kV T1 (Informational)	TR	TSGT	100 / 100	78.2	78.2% / 78.2%	83.2	83.2% / 83.2%	5.0% / 5.0%	Midway BR – Rancho 115 kV

*Current-corrected flows for transmission lines only.

Table 12 – GI-2007-12 Summary Listing of Worst Case Overloaded Facilities (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 – Happy Canyon 115 kV	LN	PSCo	120 / 120	126.4	105.3% / 105.3%	127.1	105.9% / 105.9%	0.6% / 0.6%	Breaker Failure Bayou – Parker PS 115 kV Parker PS 115 kV Load
Daniels Park – Jackson Fuller 230 kV	LN	PSCo	478 / 478	419.3	87.7% / 87.7%	543.7	113.7% / 113.7%	26.0% / 26.0%	Double-Circuit Tower Comanche – Daniels Park 345 kV 1 & 2
Monument – Palmer Lake 115 kV**	LN	PSCo / CSU	120 / 120	44.5	37.1% / 37.1%	62.4	52.0% / 52.0%	14.9% / 14.9%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Monument – Palmer Lake 115 kV**	LN	PSCo / CSU	120 / 120	50.0	41.6% / 41.6%	51.9	43.3% / 43.3%	1.7% / 1.7%	Breaker Failure Cottonwood 115 kV Tie Breaker
Smoky Hill – Peakview 115 kV	LN	IREA	159 / 159	164.6	103.5% / 103.5%	161.5	101.6% / 101.6%	-1.9% / -1.9%	Double-Circuit Tower Parker – Sulphur 115 kV 1 & 2
Briar Gate – Cottonwood S 115 kV	LN	CSU	150 / 192	128.8	85.9% / 67.1%	135.0	90.0% / 70.3%	4.1% / 3.2%	Bus Fault Cottonwood 115 kV N bus
Cottonwood N – Kettle Creek 115 kV	LN	CSU	162 / 180	120.1	74.2% / 66.7%	127.8	78.9% / 71.0%	4.7% / 4.3%	Bus Fault Cottonwood 115 kV S bus
Emil Anderson – Forest Lake 115 kV	LN	TSGT	58 / 58	39.1	67.4% / 67.4%	59.8	103.1% / 103.1%	35.7% / 35.7%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Emil Anderson – Forest Lake 115 kV	LN	TSGT	58 / 58	43.9	75.8% / 75.8%	40.1	69.1% / 69.1%	-6.7% / -6.7%	Breaker Failure Cottonwood 115 kV Tie Breaker
Kettle Creek – Flying Horse 115 kV	LN	CSU	162 / 180	126.5	78.1% / 70.3%	126.7	78.2% / 70.4%	0.1% / 0.1%	Breaker Failure Cottonwood 115 kV Tie Breaker
Monument – Flying Horse 115 kV	LN	CSU	142 / 156	136.9	96.4% / 87.8%	137.0	96.5% / 87.8%	0.1% / 0.0%	Breaker Failure Cottonwood 115 kV Tie Breaker
Jackson Fuller 230/115 kV T1 (Informational)	TR	TSGT	100 / 100	108.0	108.0% / 108.0%	119.4	119.4% / 119.4%	11.4% / 11.4%	Breaker Failure Cottonwood 115 kV Tie Breaker

*Current-corrected flows for transmission lines only.
**Phase-shifting adjustments were turned off in the contingency analysis.

Xcel Energy

Phase-Shifting Transformer Added in the Monument-Palmer Lake 115 kV Line at Monument – Regulating to 25 MW South

Table 13 – GI-2007-12 Summary Listing of Worst Case Overloaded Facilities (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**
Daniels Park – Happy Canyon 115 kV	LN	PSCo	120 / 120	139.6	116.3% / 116.3%	140.5	117.1% / 117.1%	0.8% / 0.8%	Bayou – Parker PS 115 kV
Briar Gate – Cottonwood S 115 kV	LN	CSU	150 / 192	112.6	75.0% / 58.6%	119.3	79.5% / 62.1%	4.5% / 3.5%	Cottonwood N – Kettle Creek 115 kV
Cottonwood N – Kettle Creek 115 kV	LN	CSU	162 / 180	116.9	72.2% / 64.9%	124.5	76.8% / 69.1%	4.6% / 4.2%	Briar Gate – Cottonwood S 115 kV
Jackson Fuller 230/115 kV T1 (Informational)	TR	TSGT	100 / 100	73.8	73.8% / 73.8%	78.7	78.7% / 78.7%	4.9% / 4.9%	Midway BR – Rancho 115 kV

*Current-corrected flows for transmission lines only.

Xcel Energy

Phase-Shifting Transformer Added in the Monument-Palmer Lake 115 kV Line at Monument – Regulating to 25 MW South

Table 14 – GI-2007-12 Summary Listing of Worst Case Overloaded Facilities (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 – Happy Canyon 115 kV	LN	PSCo	120 / 120	140.2	116.8% / 116.8%	141.1	117.6% / 117.6%	0.8% / 0.8%	Breaker Failure Bayou – Parker PS 115 kV Parker PS 115 kV Load
Daniels Park – Jackson Fuller 230 kV	LN	PSCo	478 / 478	430.4	90.0% / 90.0%	554.8	116.1% / 116.1%	26.1% / 26.1%	Double-Circuit Tower Comanche – Daniels Park 345 kV 1 & 2
Monument – Palmer Lake 115 kV**	LN	PSCo / CSU	120 / 120	68.4	57.0% / 57.0%	70.7	58.9% / 58.9%	1.9% / 1.9%	Breaker Failure Cottonwood 115 kV Tie Breaker
Smoky Hill – Peakview 115 kV	LN	IREA	159 / 159	169.9	106.8% / 106.8%	166.8	104.9% / 104.9%	-1.9% / -1.9%	Double-Circuit Tower Parker – Sulphur 115 kV 1 & 2
Briar Gate – Cottonwood S 115 kV	LN	CSU	150 / 192	116.4	77.6% / 60.6%	122.3	81.6% / 63.7%	4.0% / 3.1%	Bus Fault Cottonwood 115 kV N bus
Cottonwood N – Kettle Creek 115 kV	LN	CSU	162 / 180	93.6	57.8% / 52.0%	114.3	70.5% / 63.5%	12.7% / 11.5%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Cottonwood N – Kettle Creek 115 kV	LN	CSU	162 / 180	106.7	65.9% / 59.3%	114.1	70.4% / 63.4%	4.5% / 4.1%	Bus Fault Cottonwood 115 kV S bus
Emil Anderson – Forest Lake 115 kV	LN	TSGT	58 / 58	43.1	74.2% / 74.2%	64.1	110.5% / 110.5%	36.3% / 36.3%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Kettle Creek – Flying Horse 115 kV	LN	CSU	162 / 180	126.2	77.9% / 70.1%	126.3	78.0% / 70.2%	0.1% / 0.1%	Breaker Failure Cottonwood 115 kV Tie Breaker
Monument – Flying Horse 115 kV	LN	CSU	142 / 156	136.6	96.2% / 87.5%	136.6	96.2% / 87.6%	0.0% / 0.1%	Breaker Failure Cottonwood 115 kV Tie Breaker
Jackson Fuller 230/115 kV T1 (Informational)	TR	TSGT	100 / 100	100.3	100.3% / 100.3%	111.4	111.4% / 111.4%	11.1% / 11.1%	Breaker Failure Cottonwood 115 kV Tie Breaker

*Current-corrected flows for transmission lines only.

**Phase-shifting adjustments were turned off in the contingency analysis.

Xcel Energy

Series Reactor (X = 32.5%) Added in the Monument-Palmer Lake 115 kV Line at Monument – Sized for 25 MW Flow in Case with GI-2007-12 Generation

Table 15 – GI-2007-12 Summary Listing of Worst Case Overloaded Facilities (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**
Daniels Park – Happy Canyon 115 kV	LN	PSCo	120 / 120	120.8	100.7% / 100.7%	117.6	98.0% / 98.0%	-2.7% / -2.7%	Bayou – Parker PS 115 kV
Briar Gate – Cottonwood S 115 kV	LN	CSU	150 / 192	134.9	89.9% / 70.2%	146.0	97.4% / 76.1%	7.5% / 5.9%	Cottonwood N – Kettle Creek 115 kV
Cottonwood N – Kettle Creek 115 kV	LN	CSU	162 / 180	141.4	87.3% / 78.6%	153.9	95.0% / 85.5%	7.7% / 6.9%	Briar Gate – Cottonwood S 115 kV
Jackson Fuller 230/115 kV T1 (Informational)	TR	TSGT	100 / 100	81.4	81.4% / 81.4%	87.8	87.8% / 87.8%	6.4% / 6.4%	Midway BR – Rancho 115 kV

*Current-corrected flows for transmission lines only.

Xcel Energy

Series Reactor (X = 32.5%) Added in the Monument-Palmer Lake 115 kV Line at Monument – Sized for 25 MW Flow in Case with GI-2007-12

Table 16 – GI-2007-12 Summary Listing of Worst Case Overloaded Facilities (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 – Happy Canyon 115 kV	LN	PSCo	120 / 120	121.1	101.0% / 101.0%	117.9	98.3% / 98.3%	-2.7% / -2.7%	Breaker Failure Bayou – Parker PS 115 kV Parker PS 115 kV Load
Daniels Park – Jackson Fuller 230 kV	LN	PSCo	478 / 478	419.7	87.8% / 87.8%	541.5	113.3% / 113.3%	25.5% / 25.5%	Double-Circuit Tower Comanche – Daniels Park 345 kV 1 & 2
Monument – Palmer Lake 115 kV	LN	PSCo / CSU	120 / 120	43.3	36.0% / 36.0%	61.5	51.2% / 51.2%	15.2% / 15.2%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Smoky Hill – Peakview 115 kV	LN	IREA	159 / 159	162.7	102.3% / 102.3%	158.2	99.5% / 99.5%	-2.8% / -2.8%	Double-Circuit Tower Parker – Sulphur 115 kV 1 & 2
Briar Gate – Cottonwood S 115 kV	LN	CSU	150 / 192	138.8	92.5% / 72.3%	149.1	99.4% / 77.7%	6.9% / 5.4%	Bus Fault Cottonwood 115 kV N bus
Cottonwood N – Kettle Creek 115 kV	LN	CSU	162 / 180	131.1	80.9% / 72.8%	143.0	88.3% / 79.5%	7.4% / 6.7%	Bus Fault Cottonwood 115 kV S bus
Emil Anderson – Forest Lake 115 kV	LN	TSGT	58 / 58	39.0	67.3% / 67.3%	60.0	103.5% / 103.5%	36.2% / 36.2%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Emil Anderson – Forest Lake 115 kV	LN	TSGT	58 / 58	54.0	93.2% / 93.2%	50.8	87.5% / 87.5%	-5.7% / -5.7%	Breaker Failure Cottonwood 115 kV Tie Breaker
Kettle Creek – Flying Horse 115 kV	LN	CSU	162 / 180	129.6	80.0% / 72.0%	130.0	80.2% / 72.2%	0.2% / 0.2%	Breaker Failure Cottonwood 115 kV Tie Breaker
Monument – Flying Horse 115 kV	LN	CSU	142 / 156	140.1	98.7% / 89.8%	140.6	99.0% / 90.1%	0.3% / 0.3%	Breaker Failure Cottonwood 115 kV Tie Breaker
Black Squirrel – Jackson Fuller 115 kV	LN	TSGT	144 / 144	142.2	98.8% / 98.8%	153.8	106.8% / 106.8%	8.0% / 8.0%	Breaker Failure Cottonwood 115 kV Tie Breaker
Jackson Fuller 230/115 kV T1 (Informational)	TR	TSGT	100 / 100	123.6	123.6% / 123.6%	138.2	138.2% / 138.2%	14.6% / 14.6%	Breaker Failure Cottonwood 115 kV Tie Breaker

*Current-corrected flows for transmission lines only.

Series Reactor (X = 32.5%) Added in the Monument-Palmer Lake 115 kV Line at Monument – Sized for 25 MW Flow in Case with GI-2007-12

Table 17 – GI-2007-12 Summary Listing of Worst Case Low Voltages[5] (Category C Contingencies)

		Bus Voltage Without GI-2007-12	Bus Voltage With GI-2007-12		
Monitored Facility (Station or Bus)	**Station or Bus Owner**	**% Voltage**	**% Voltage**	**% Change**	**NERC Category C Contingency Outage**
Briar Gate 115 kV	CSU	89.1%	88.9%	-0.2%	Breaker Failure Cottonwood 115 kV Tie Breaker
Kettle Creek 115 kV	CSU	89.8%	89.5%	-0.3%	Breaker Failure Cottonwood 115 kV Tie Breaker

[5]Contingency low voltages that fall below 90.0%.

Xcel Energy

Series Reactor (X = 20.0%) Added in the Monument-Palmer Lake 115 kV Line at Monument – Sensitivity

Table 18 – GI-2007-12 Summary Listing of Worst Case Overloaded Facilities (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**
Daniels Park – Happy Canyon 115 kV	LN	PSCo	120 / 120	115.7	96.4% / 96.4%	111.2	92.7% / 92.7%	-3.7% / -3.7%	Bayou – Parker PS 115 kV
Briar Gate – Cottonwood S 115 kV	LN	CSU	150 / 192	137.8	91.9% / 71.8%	150.3	100.2% / 78.3%	8.3% / 6.5%	Cottonwood N – Kettle Creek 115 kV
Cottonwood N – Kettle Creek 115 kV	LN	CSU	162 / 180	144.9	89.4% / 80.5%	158.9	98.1% / 88.3%	8.7% / 7.8%	Briar Gate – Cottonwood S 115 kV
Jackson Fuller 230/115 kV T1 (Informational)	TR	TSGT	100 / 100	82.4	82.4% / 82.4%	89.3	89.3% / 89.3%	6.9% / 6.9%	Midway BR – Rancho 115 kV

*Current-corrected flows for transmission lines only.

Xcel Energy

Series Reactor (X = 20.0%) Added in the Monument-Palmer Lake 115 kV Line at Monument – Sensitivity

Table 19 – GI-2007-12 Summary Listing of Worst Case Overloaded Facilities (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 – Happy Canyon 115 kV	LN	PSCo	120 / 120	116.1	96.8% / 96.8%	111.6	93.0% / 93.0%	-3.8% / -3.8%	Breaker Failure Bayou – Parker PS 115 kV Parker PS 115 kV Load
Daniels Park – Jackson Fuller 230 kV	LN	PSCo	478 / 478	413.2	86.5% / 86.5%	533.5	111.6% / 111.6%	25.1% / 25.1%	Double-Circuit Tower Comanche – Daniels Park 345 kV 1 & 2
Monument – Palmer Lake 115 kV	LN	PSCo / CSU	120 / 120	56.9	47.4% / 47.4%	80.9	67.4% / 67.4%	20.0% / 20.0%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Smoky Hill – Peakview 115 kV	LN	IREA	159 / 159	160.8	101.1% / 101.1%	155.9	98.0% / 98.0%	-3.1% / -3.1%	Double-Circuit Tower Parker – Sulphur 115 kV 1 & 2
Briar Gate – Cottonwood S 115 kV	LN	CSU	150 / 192	141.4	94.3% / 73.7%	153.1	102.1% / 79.7%	7.8% / 6.0%	Bus Fault Cottonwood 115 kV N bus
Cottonwood N – Kettle Creek 115 kV	LN	CSU	162 / 180	133.8	82.6% / 74.3%	147.2	90.9% / 81.8%	8.3% / 7.5%	Bus Fault Cottonwood 115 kV S bus
Emil Anderson – Forest Lake 115 kV	LN	TSGT	58 / 58	37.0	63.8% / 63.8%	56.6	97.6% / 97.6%	33.8% / 33.8%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Emil Anderson – Forest Lake 115 kV	LN	TSGT	58 / 58	51.6	89.0% / 89.0%	48.7	84.0% / 84.0%	-5.0% / -5.0%	Breaker Failure Cottonwood 115 kV Tie Breaker
Kettle Creek – Flying Horse 115 kV	LN	CSU	162 / 180	98.7	60.9% / 54.8%	133.7	82.5% / 74.3%	21.6% / 19.5%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Kettle Creek – Flying Horse 115 kV	LN	CSU	162 / 180	128.2	79.2% / 71.2%	128.8	79.5% / 71.6%	0.3% / 0.4%	Breaker Failure Cottonwood 115 kV Tie Breaker
Monument – Flying Horse 115 kV	LN	CSU	142 / 156	138.7	97.7% / 88.9%	139.3	98.1% / 89.3%	0.4% / 0.4%	Breaker Failure Cottonwood 115 kV Tie Breaker
Black Squirrel – Jackson Fuller 115 kV	LN	TSGT	144 / 144	138.0	95.8% / 95.8%	150.5	104.5% / 104.5%	8.7% / 8.7%	Breaker Failure Cottonwood 115 kV Tie Breaker
Jackson Fuller 230/115 kV T1 (Informational)	TR	TSGT	100 / 100	120.6	120.6% / 120.6%	135.8	135.8% / 135.8%	15.2% / 15.2%	Breaker Failure Cottonwood 115 kV Tie Breaker

*Current-corrected flows for transmission lines only.

Series Reactor (X = 20.0%) Added in the Monument-Palmer Lake 115 kV Line at Monument – Sensitivity

Table 20 – GI-2007-12 Summary Listing of Worst Case Low Voltages[6] (Category C Contingencies)

		Bus Voltage Without GI-2007-12	Bus Voltage With GI-2007-12		
Monitored Facility (Station or Bus)	Station/Bus Owner	% Voltage	% Voltage	% Change	NERC Category C Contingency Outage
Briar Gate 115 kV	CSU	89.9%	88.6%	-0.3%	Breaker Failure Cottonwood 115 kV Tie Breaker

[6]Contingency low voltages that fall below 90.0%.

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Monument-Palmer Lake 115 kV Line Prior Outage

Table 21 – GI-2007-12 Summary Listing of Worst Case Overloaded Facilities (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**
Daniels Park – Happy Canyon 115 kV	LN	PSCo	120 / 120	138.3	115.3% / 115.3%	139.2	116.0% / 116.0%	0.7% / 0.7%	Bayou – Parker PS 115 kV
Briar Gate – Cottonwood S 115 kV	LN	CSU	150 / 192	126.0	84.0% / 65.65	132.9	88.6% / 69.2%	4.6% / 3.6%	Cottonwood N – Kettle Creek 115 kV
Cottonwood N – Kettle Creek 115 kV	LN	CSU	162 / 180	131.0	80.9% / 72.8%	138.6	85.6% / 77.0%	4.7% / 4.2%	Briar Gate – Cottonwood S 115 kV
Jackson Fuller 230/115 kV T1 (Informational)	TR	TSGT	100 / 100	78.4	78.4% / 78.4%	83.3	83.3% / 83.3%	4.9% / 4.9%	Midway BR – Rancho 115 kV

*Current-corrected flows for transmission lines only.

Xcel Energy

Monument-Palmer Lake 115 kV Line Prior Outage

Table 22 – GI-2007-12 Summary Listing of Worst Case Overloaded Facilities (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 – Happy Canyon 115 kV	LN	PSCo	120 / 120	138.4	115.4% / 115.4%	139.3	116.1% / 116.1%	0.7% / 0.7%	Breaker Failure Bayou – Parker PS 115 kV Parker PS – Grandview 115 kV
Daniels Park – Jackson Fuller 230 kV	LN	PSCo	478 / 478	438.9	91.8% / 91.8%	565.4	118.3% / 118.3%	26.5% / 26.5%	Double-Circuit Tower Comanche – Daniels Park 345 kV 1 & 2
Smoky Hill – Peakview 115 kV	LN	IREA	159 / 159	167.8	105.5% / 105.5%	166.4	103.7% / 103.7%	-1.8% / -1.8%	Double-Circuit Tower Parker – Sulphur 115 kV 1 & 2
Briar Gate – Cottonwood S 115 kV	LN	CSU	150 / 192	130.6	87.1% / 68.0%	136.9	91.3% / 71.3%	4.2% / 3.3%	Bus Fault Cottonwood 115 kV N bus
Cottonwood N – Kettle Creek 115 kV	LN	CSU	162 / 180	122.6	75.7% / 68.1%	130.1	80.3% / 72.3%	4.6% / 4.2%	Bus Fault Cottonwood 115 kV S bus
Emil Anderson – Forest Lake 115 kV	LN	TSGT	58 / 58	45.5	78.4% / 78.4%	70.5	121.6% / 121.6%	43.2% / 43.2%	Double-Circuit Tower Midway – Waterton 345 kV Daniels Park – Jackson Fuller 230 kV
Emil Anderson – Forest Lake 115 kV	LN	TSGT	58 / 58	64.4	111.1% / 111.1%	60.0	103.4% / 103.4%	-7.7% / -7.7%	Breaker Failure Cottonwood 115 kV Tie Breaker
Kettle Creek – Flying Horse 115 kV	LN	CSU	162 / 180	136.0	84.0% / 75.6%	136.4	84.2% / 75.8%	0.2% / 0.2%	Breaker Failure Cottonwood 115 kV Tie Breaker
Monument – Flying Horse 115 kV	LN	CSU	142 / 156	147.1	103.6% / 94.3%	147.4	103.8% / 94.5%	0.2% / 0.2%	Breaker Failure Cottonwood 115 kV Tie Breaker
Black Squirrel – Jackson Fuller 115 kV	LN	TSGT	144 / 144	160.0	111.1% / 111.1%	168.0	116.7% / 116.7%	5.6% / 5.6%	Breaker Failure Cottonwood 115 kV Tie Breaker
Jackson Fuller 230/115 kV T1 (Informational)	TR	TSGT	100 / 100	136.4	136.4%/ 136.4%	148.4	148.4% / 148.4%	12.0% / 12.0%	Breaker Failure Cottonwood 115 kV Tie Breaker

*Current-corrected flows for transmission lines only.

Monument-Palmer Lake 115 kV Line Prior Outage

Table 23 – GI-2007-12 Summary Listing of Worst Case Low Voltages[7] (Category C Contingencies)

		Bus Voltage Without GI-2007-12	Bus Voltage With GI-2007-12		
Monitored Facility (Station or Bus)	Station/Bus Owner	% Voltage	% Voltage	% Change	NERC Category C Contingency Outage
Briar Gate 115 kV	CSU	89.9%	88.6%	-0.3%	Breaker Failure Cottonwood 115 kV Tie Breaker
Emil Anderson 115 kV	TSGT	89.4	89.4	0.0%	Breaker Failure Cottonwood 115 kV Tie Breaker
Kettle Creek 115 kV	CSU	86.1	86.1	0.0%	Breaker Failure Cottonwood 115 kV Tie Breaker
Monument 115 kV	TSGT/CSU	88.6	88.5	-0.1%	Breaker Failure Cottonwood 115 kV Tie Breaker
Forest Lake 115 kV	TSGT	89.7	89.7	0.0%	Breaker Failure Cottonwood 115 kV Tie Breaker
Flying Horse 115 kV	CSU	87.2	87.2	0.0%	Breaker Failure Cottonwood 115 kV Tie Breaker

[7]Contingency low voltages that fall below 90.0%.