Interconnection Feasibility Study Report
Request # GI-2011-04

587 MW Combined Cycle 2x1 Generators
Cherokee Station, Denver, Colorado

Public Service Company of Colorado
Transmission Asset Management
September 24, 2012

A. Executive Summary

Public Service Company of Colorado (PSCo) received an interconnection request (GI-2011-04) for a 587 MW 2x1 combined cycle generation facility to be connected to the PSCo transmission system in Denver, Colorado. The interconnection request was received April 7, 2011.

The proposed generation facility will consist of two (2) gas-fired 218 MVA combustion turbine generators and a 300 MVA steam turbine generator connected in a combined cycle configuration. This facility is proposed to interconnect with the PSCo Cherokee 115 kV substation (the Point Of Interconnection) via three (3) separate generator step-up transformers (see Figure 1 below). The requested in-service date was June 30, 2015. However, in a plan filed by the Customer with the Colorado Public Utilities Commission, the plant is required to be placed in service by December 31, 2015. Therefore, the studies examined system performance for 2016 peak summer conditions.

The 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 December 31, 2015. The main purpose of this Feasibility Study was to evaluate the potential impact on the PSCo transmission infrastructure as well as that of neighboring utilities when injecting the additional 587 MW of generation at the existing Cherokee 115 kV substation, and delivering the additional generation to native PSCo loads.

This request was studied as a Network Resource Interconnection Service. These investigations included both power flow and short circuit studies. The power flow analysis included both NERC Category B and NERC Category C contingencies.

With the proposed combined cycle generators in-service at the Cherokee 115 kV Station, the thermal loading results show six (6) new facility overloads of their normal ratings due to Category B contingencies and eight (8) new overloads of their normal ratings due to Category C contingencies. The thermal results can be found in Tables 7 & 8 in Appendix A. Also, the short circuit studies found 29 115 kV circuit breakers that could be required to interrupt short circuit currents that exceed their 63 kA capability following installation of the proposed generation. Based

these results, PSCo Engineering developed a set of mitigation strategies to address the line overload and circuit breaker over-duty problems associated with the installation of the proposed generation. The mitigation strategies and associated total estimated costs are summarized below and described in detail in Tables 4 – 6 in the cost estimates section of this report. **Following implementation of the proposed mitigation upgrade plans, the proposed generation should be able to provide the full 587 MW of generation without restriction.**

Cost Estimates

The estimates for the required Interconnection Facilities and the associated mitigation strategies to address adversely impacted transmission facilities are summarized below. The mitigation strategies include splitting the Cherokee 115 kV Station into separate Cherokee North and South Stations, re-terminating the Cherokee 230/115 kV T2 transformer & Cherokee-Semper 115 kV circuit at the Cherokee North Station, re-conductoring certain transmission lines, and upgrading terminal equipment.

The estimated costs and construction times for the transmission interconnection (in 2012 dollars) are as follows:

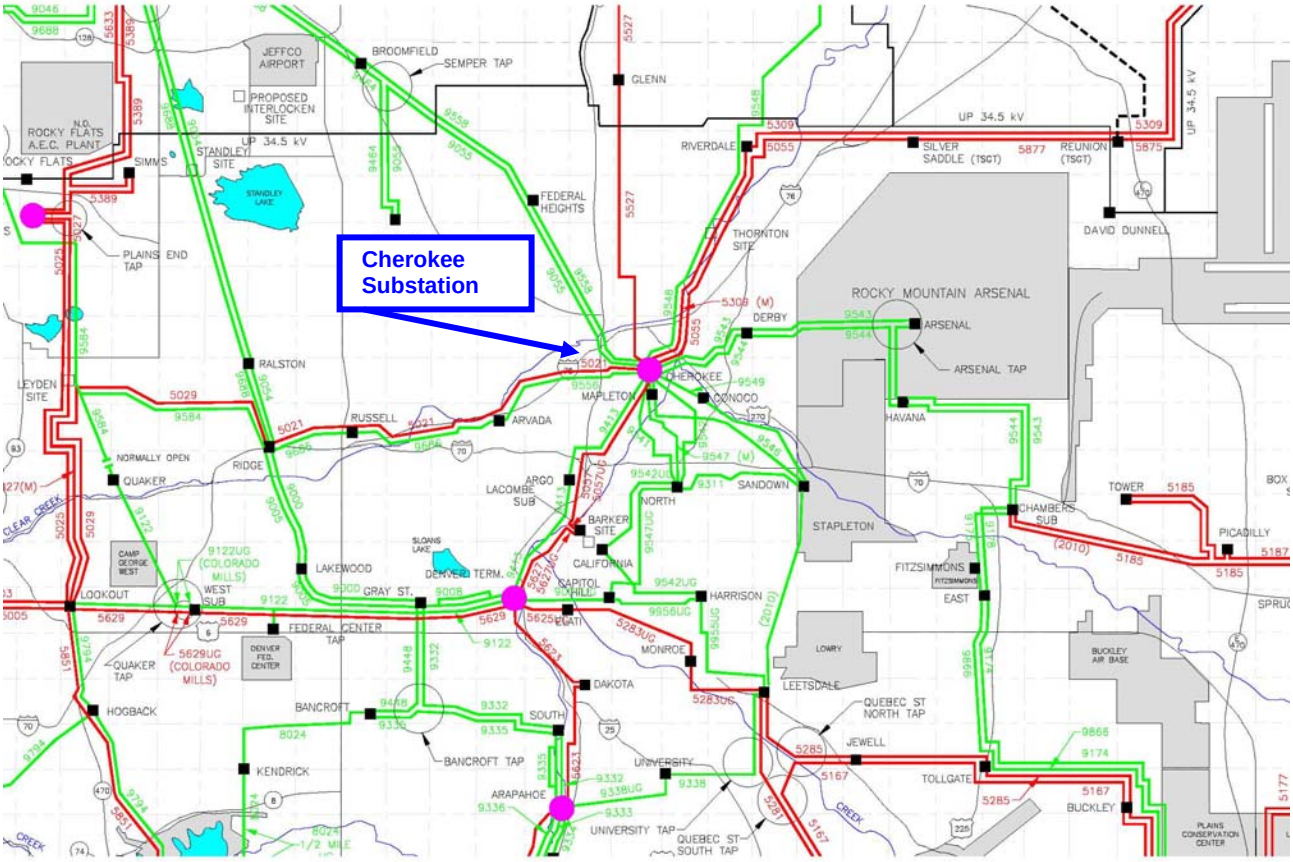
Transmission Proposal
The total estimated cost of the recommended system improvements to interconnect the project is approximately **$10.412 million** and includes:

- $ 2.167 million for PSCo-Owned, Customer-Funded Interconnection Facilities (18 months)
- $ 1.730 million for PSCo-Owned, PSCo-Funded Network Upgrades for Interconnection (18 months)
- $ 6.515 million for PSCo Network Upgrades for Delivery to PSCo Loads (24 months)

PSCo Engineering estimates that it will require 18 months to complete the PSCo and Customer Funded Interconnection Facilities at Cherokee Station. PSCo Engineering estimates it will also require up to 24 months to complete the Network Upgrades for Delivery (please see Estimate Section below).

Please note that some of the listed upgrades and system changes are already underway per Colorado Public Utilities Decision No. C10-1328 associated with Docket No. 10M-245E. This decision was issued in response to PSCo's compliance filing with the CPUC with regard to the Colorado House Bill 10-1365, "Clean Air – Clean Jobs Act". As a result, PSCo anticipates that the required transmission system upgrades will be in-service by the initially requested June 15, 2015 date.

Figure 1 Cherokee Substation and Surrounding Transmission System



B. Introduction

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The proposed generation facility will consist of two (2) gas-fired 218 MVA combustion turbine generators and a 300 MVA steam turbine generator connected in a combined cycle configuration. This facility is proposed to interconnect with the PSCo Cherokee 115 kV substation (the Point Of Interconnection) via three (3) separate generator step-up transformers (see Figure 1 above). The requested in-service date was June 30, 2015. However, in a plan filed by the Customer with the Colorado Public Utilities Commission, the plant is required to be placed in service by December 31, 2015. Therefore, the studies examined system performance for 2016 peak summer conditions.

C. Study Scope and Analysis

The Feasibility Study evaluated the transmission impacts associated with the proposed 587 MW combined cycle plant. It consisted of power flow and short circuit analyses.

The power flow analysis was performed to identify any steady-state thermal or voltage limit violations resulting from the installation of the proposed generation and an identification of network upgrades required to deliver the proposed generation to PSCo loads. The short circuit analysis identified short circuit levels and determined short circuit impacts on area circuit breakers due to the installation of the proposed generation.

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 1.00 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 as a Network Resource Interconnection Service (NRIS). 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.

D. Power Flow Study Models

In this Feasibility study, two main power flow generation dispatch scenarios were evaluated. One was created as a reference benchmark scenario and the other was created with the proposed generation. The power flow studies were based on the WECC approved 17HS1AP case. The Colorado Coordinated Planning Group (CCPG) portion of the case was adjusted to 2016 peak summer conditions using load, topology and generation dispatch updates from the PSCo, IREA, CSU, TSG&T, WAPA, PRPA, BHE, and BEPC systems. PSCo loads in the case were adjusted to reflect the most recent (September 2011) PSCo load forecast. IREA load was also adjusted to reflect IREA's latest load forecast.

Some of the PSCo upgrades that were included in the transmission system models were system upgrades that were developed as a result of studies PSCo performed in compliance with the Colorado Clean Air Clean Jobs Act (CACJA). These upgrades and their associated cost estimates are described in CPUC Decision No. C10-1328, Docket No. 10M-245 concerning PSCo's CACJA compliance filing.

The CACJA upgrades that were implemented in all load flow cases include the following:

1. Cherokee Unit 2 conversion to a synchronous condenser (currently in service)
2. Arapahoe Unit 3 Retirement (planned for 2013)
3. Arapahoe Unit 4 Conversion to Natural Gas (this was planned for 2014 but PSCo recently decided to retire the unit in favor of signing a PPA with Southwest Generation for power from Arapahoe Units 5, 6, & 7. They are similarly sized units/plants with similar economic cost)
4. Cherokee Unit 3 Retirement (planned for 2015)
5. 90 Mvar Capacitor bank installation at the Cherokee 115 kV South Station (planned for 2013)
6. 90 Mvar Capacitor bank installation at the Arapahoe 115 kV Station (planned for 2013)

Additional CPUC CACJA Order system changes that were only included in the load flow model with the proposed Cherokee 2x1 generation were the following:

1. Split the Cherokee 115 kV North and South station (to alleviate short circuit problems)
2. Re-terminate the Cherokee 230/115 kV T-2 transformer at the Cherokee North 115 kV station.
3. Re-terminate the Cherokee-Semper 115 kV line at the Cherokee North 115 kV station.

Since the Cherokee 115 kV Station split and the line re-terminations were directly related to the installation of the Cherokee 2x1 combined cycle units, estimates for these upgrades are included in the Estimate Section below.

As part of the load flow model preparation, the existing and planned PSCo-connected wind turbine generation levels were increased to a level (21% of max) that represents the approximate average output of these wind plants during historical summer peak periods. These wind plants include Peetz Logan, Cedar Creek, Cedar Point and Limon.

The PSCo thermal units were dispatched according to their relative average maximum MW generation costs. Also, the Area 70 (Area PSCOLORADO) swing machine in the WECC load flow case was moved to Comanche Unit 1. The resulting PSCo generation dispatch can be found in Appendix B.

In the case with the proposed generation, the 587 MW of new combined cycle generation was added to the Cherokee 115 kV South bus using modeling information provided by the customer. Based on information received from the Customer, the generator load flow modeling parameters for the Feasibility Study are included in the following table:

	MW	Mvar Limits	GSU Tap Setting
Combustion Turbine Gen #1	168.6	+133.0 to -69.0	115.0/17.7 kV
Combustion Turbine Gen #2	168.6	+133.0 to -69.0	115.0/17.7 kV
Steam Turbine Gen	249.5	+155.0 to -100.0	115.0/18.0 kV

Also, 8.8 MW of auxiliary load was modeled connected to each of the combustion turbine generator buses for a total of 17.6 MW of auxiliary load. The three generator step-up transformers for each of the three units were modeled set to the center tap (115/xx.x kV). However, the actual GSU transformer tap settings to optimize the reactive capability of these units may be different than those modeled in this study. Additional studies will be required after the transformers and their test reports are received to determine the recommended tap settings.

The generation dispatch adjustments with the new combined cycle plant can also be found in Appendix B. Please note that because of the anticipated higher cost of Arapahoe Unit 4 generation after fuel-switching to natural gas, the generator was modeled out of service in the cases with the proposed generation.

E. Power Flow Study Process

Contingency power flow studies were completed on the benchmark model and the model with the proposed new generation using PTI's PSSE Ver. 32.1.0 and MUST Ver. 10.2.1 programs. Results from the two cases were compared and new overloads in the new generation case were noted. Voltage criteria violations were also recorded. MUST's contingency analysis activities were 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 and around the Denver Metro Area. Single unit outages were also modeled for generators in PSCo's control area. Single unit outages were also modeled in the CSU and Foothills area. The transmission facilities in and around the Denver Metro Area were monitored for overloads and voltage problems.

F. Power Flow Thermal Results

The results of the Category B contingency analyses can be found in Table 7 in Appendix A. A majority of the Category B contingency branch overloads involves terminal equipment only and do not include the transmission line conductor. However, the Leetsdale – University 115 kV line (#9338) is limited by the 191 MVA rating of the 0.28 miles of 1-636 26/7 ACSR line conductor. This line section will be re-conductored with higher capacity 1-636 26/7 ACSS.

The results of the Category C contingency analyses can be found in Table 8 in Appendix A. A majority of the Category C contingency branch overloads also involves terminal equipment only and do not include the transmission line conductor. However, the following three branch overloads do involve transmission line conductors:

California – Cherokee 115 kV (#9542) – this line is limited by the 137 MVA rating of the 2.69 miles of 1-1250 kcmil 91 strand copper underground cable. Seven (7) total Category C contingencies cause overloads on this circuit. Transmission Line Engineering reviewed the emergency ratings for this circuit and found that it could be loaded to 1040 A (207 MVA) for up to 8 hours assuming a pre-contingency loading of 524 A (104 MVA). This is 151.2% of the 137 MVA continuous rating. The pre-contingency loading in the load flow case with the new generation was 105 MVA. Therefore, the indicated 8 hour 207 MVA emergency rating should be satisfactory and we are not recommending cable replacement for this line at this time.. However, this approach will be revisited in the System Impact Study and/or Facility Study.

Besides overloading the underground cable, the contingency also causes the loading on the substation jumpers at California to exceed their normal rating. The jumper conductor is 795 kcmil AL and has normal and 30 minute emergency ratings of 763 A / 901 A (152 MVA / 180 MVA). The cost to upgrade these jumpers is small compared to the cost of replacing the underground cable. Therefore, we recommend that these jumpers be upgraded with 1-1272 kcmil AL. A cost estimate is included in the Estimates Section.

Cherokee – Conoco 115 kV (#9549) - this line is limited by the 159 MVA rating of the 1.95 miles of 1-477 26/7 ACSR line conductor. Seven (7) total Category C contingencies cause overloads on this circuit. This line section will be re-conductored with higher capacity 1-477 26/7 ACSS. Also, some terminal equipment at Cherokee will need to be upgraded.

Conoco – Sandown 115 kV (#9549) - this line is limited by the 159 MVA rating of the 3.94 miles of 1-477 26/7 ACSR line conductor. The contingency loading of this line is just 100.1% of the normal rating of 159 MVA. There is only one Category C contingency that causes an overload for this circuit. Since the contingency loading is less than the 30 minute emergency rating of 175 MVA, PSCo Transmission Operations should have time to make system adjustments to mitigate the overload. Therefore, no upgrades are required on this line at this time.

In the case with the new generation, Arapahoe Unit 4 was modeled out of service for cost reasons. Sensitivity studies were performed to check the effect of dispatching that unit at full output. All of the overloads in the previous studies were lessened or eliminated with Arapahoe Unit 4 in service,

and there were no new overloads. Therefore, modeling this unit out of service was the worst case with the new Cherokee 2x1 generation.

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). 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 Metro-Denver-Boulder-Ft Lupton Region 8; 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 for the 115kV and 230 kV systems.
- 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.
- 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 impact of the proposed Cherokee 587 MW plant on area transmission system voltages. No problems were found that could be attributed to the proposed generation.

H. Short Circuit

A circuit breaker short circuit duty study was performed to assess the impact of the proposed generation on the ability of the area circuit breakers to safely and successfully interrupt fault current. The single line to ground fault levels were found to be most limiting. The study determined that 29 115 kV circuit breakers at the Cherokee 115 kV station are expected to exceed their capabilities following installation of the new generation. Therefore, additional studies were performed to develop a station reconfiguration plan that would mitigate the circuit breaker short circuit over-duty problem. The configurations are identified on each line in the Tables 1 & 2 below.

Scenario #1 represents the benchmark station configuration without the proposed 2x1 generation and the existing Cherokee Station configuration. Scenario #2 includes the proposed 2x1 generation and the existing Station configuration but excludes Cherokee Unit 3. This unit is scheduled for retirement in 2015. The breakers at the Cherokee 115 kV Station all have a symmetrical rating of 63 kA. Therefore, without any other station adjustments, 29 of the breakers at Cherokee 115 kV Station could experience a short circuit over-duty event presenting a serious safety risk.

Scenarios 3 – 8 represent different alternative Cherokee Station configurations that were tested to evaluate and improve the Station short circuit performance with the proposed generation. Please note that based on previous studies related to the Colorado Clean Air Clean Jobs Act that were separate from this study, PSCo decided to move the terminations of the Cherokee 230/115 kV T2 transformer and the Cherokee-Semper 115 kV from the Cherokee South 115 kV station to the North Station for thermal overload reasons. The short circuit performance with the facility re-terminations was found to improve.

The configuration specified for Scenario #5 was found to satisfactorily mitigate the breaker over-duty problem while allowing an adequate safety margin. The calculated short circuit levels for the Cherokee 115 kV & 230 kV stations are shown in Tables 1 & 2 below. Besides the facility re-terminations, Scenario #5 includes a separation of the Cherokee North and South 115 kV Stations.

Please note that Scenarios 6 – 8 include Cherokee Unit 3 modeled in-service. This information was included for information only since Unit 3 is planned for retirement in 2015.

Table 3 below shows the Thevenin System Impedances for the original and recommended Cherokee Station configurations.

Table 1 – Single Line to Ground Short Circuit Parameters at the Cherokee 115 kV & 230 kV Substations

Scenario #	GI-2011-04 Project Status	North-South 115kV Bus-Tie Status	Cherokee Unit 3 Status	Cherokee 230/115 kV T2 Low-Side Termination	Cherokee – Semper 115 kV Line 9055 Termination	North 115kV Bus Fault (SLG-Amps)	South 115kV Bus Fault (SLG-Amps)	230kV Bus Fault (SLG-Amps)	Num. BKRs needing to be replaced 230kV/115kV
1	Off-Line	Closed	On	115kV South Bus	115kV South Bus	62.2	62.2	33.6	0/0
2	On-Line	Closed	Off	115kV South Bus	115kV South Bus	73.9	73.9	34.7	0/29
3	On-Line	Open	Off	115kV South Bus	115kV South Bus	31.2	61.2	34.2	0/0
4	On-Line	Open	Off	115kV North Bus	115kV South Bus	37.9	57.3	34.7	0/0
5	On-Line	Open	Off	115kV North Bus	115kV North Bus	37.7	55.4	34.7	0/0
6	On-Line	Open	On	115kV South Bus	115kV South Bus	31.4	65.9	34.6	0/19
7	On-Line	Open	On	115kV North Bus	115kV South Bus	38.2	62.0	35.0	0/0
8	On-Line	Open	On	115kV North Bus	115kV North Bus	37.8	60.0	35.0	0/0

Table 2 – Three Phase Short Circuit Parameters at the Cherokee 115 kV & 230 kV Substations

Scenario #	GI-2011-04 Project Status	North-South 115kV Bus-Tie Status	Cherokee Unit 3 Status	Cherokee 230/115 kV T2 Low-Side Termination	Cherokee – Semper 115 kV Line 9055 Termination	North 115kV Bus Fault (3PH-kA)	South 115kV Bus Fault (3PH-kA)	230kV Bus Fault (3PH-kA)
1	Off-Line	Closed	On	115kV South Bus	115kV South Bus	59.9	59.9	31.9
2	On-Line	Closed	Off	115kV South Bus	115kV South Bus	68.7	68.7	33.4
3	On-Line	Open	Off	115kV South Bus	115kV South Bus	31.0	58.2	32.6
4	On-Line	Open	Off	115kV North Bus	115kV South Bus	39.4	54.2	33.4
5	On-Line	Open	Off	115kV North Bus	115kV North Bus	40.0	52.4	33.4
6	On-Line	Open	On	115kV South Bus	115kV South Bus	31.1	61.3	33.2
7	On-Line	Open	On	115kV North Bus	115kV South Bus	39.7	57.3	33.8
8	On-Line	Open	On	115kV North Bus	115kV North Bus	40.3	55.5	33.8

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The yellow highlighted lines show the short circuit levels with GI-2011-04 connected and Cherokee Unit 3 retired. These levels exceed the interrupting ratings of the breakers
The blue highlighted lines show the short circuit levels with the new generation and Unit 3 retired, as well as the station split and the Semper line & T2 autotransformer re-terminated. These short circuit levels are satisfactory.

Table 3 – Thevenin System Impedances at the Cherokee 115 kV & 230 kV Substations for Studies 1 & 5

Scenario #	GI-2011-04 Project Status	North-South 115kV Bus-Tie Status	Cherokee Unit 3 Status	Cherokee 230/115 kV T2 Low-Side Termination	Cherokee – Semper 115 kV Line 9055 Termination	North 115kV Bus R +j X (Ohms)	South 115kV Bus R +j X (Ohms)	230kV Bus R +j X (Ohms)
1	Off-Line	Closed	On	115kV South Bus	115kV South Bus	+ 0.09362 +j 1.10404 – 0.09641 +j 1.09738 0 0.09536 +j 0.98928	+ 0.09362 +j 1.10404 – 0.09641 +j 1.09738 0 0.09536 +j 0.98928	+ 0.34583 +j 4.14888 – 0.36128 +j 4.13399 0 0.36529 +j 3.53929
5	On-Line	Open	Off	115kV North Bus	115kV North Bus	+ 0.17814 +j 1.64745 – 0.18276 +j 1.64524 0 0.17600 +j 1.96952	+ 0.11160 +j 1.26253 – 0.12182 +j 1.25398 0 0.10272 +j 1.06473	+ 0.31736 +j 3.96792 – 0.33772 +j 3.95515 0 0.36768 +j 3.52716

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Costs Estimates and Assumptions
GI-2011-4 (Report)
September 20, 2012

Scoping level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by Xcel Energy/PSCo Engineering. The cost estimates are in 2012 dollars with escalation and contingencies applied (AFUDC is not included) and are based upon typical construction costs for previously performed similar construction. These estimated costs include all applicable labor and overheads associated with the siting support, engineering, design, material/equipment 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 estimated total cost for the required upgrades for is **$11,437,000.** Figure 2 below represents a conceptual one-line of the proposed expansion/interconnection at the Cherokee Terminal 115kV Substation. These estimates do not include costs 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 generation output. The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines. System improvements are subject to change upon a more detailed and refined design.

Figure 2 Cherokee Station One-Line with GI-2011-04 and Station Upgrades

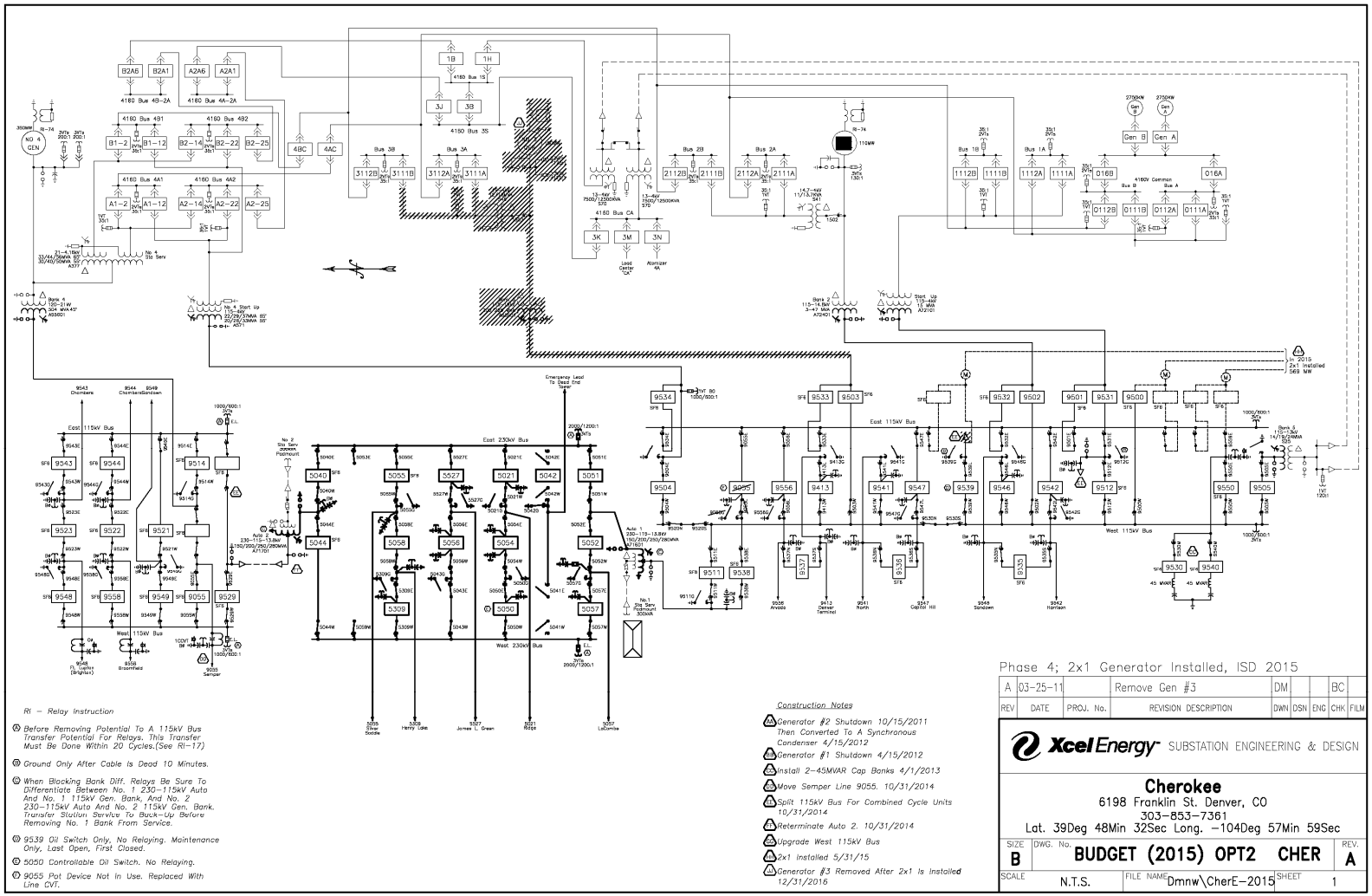

Table 4 – PSCo Owned; Customer Funded Transmission Provider Interconnection Facilities

Element	Description	Cost Est. (Millions)
PSCo's Cherokee Terminal 115kV Transmission Substation	Interconnect Customer to the 115kV bus at the Cherokee Terminal Substation. The new equipment and assumptions includes: • (3) 115kV DE Tower • (3) 115kV Metering Units • (3) Relay Panels • Primary metering for Load Frequency/Automated Generation Control • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures • Associated transmission line communications, fiber, relaying and testing.	**$0.657**
Cherokee plant – Cherokee Sub 115kV Transmission Line	Transmission line interconnecting the Cherokee Plant sub to the Cherokee Transmission Terminal 115 kV • Assumes all two terminations will be overhead and third termination will be underground	**$1.5**
	Siting and Land Rights and Project Management support	**$0.010**
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	**$2.167**
Time Frame	**Site, design, procure and construct**	**18 Months**

Table 5: PSCo Owned; PSCo Funded Interconnection Network Facilities

Element	Description	Cost Estimate (Millions)
PSCo's Cherokee Terminal 115kV Transmission Substation	Interconnect Customer to the 115kV bus at the Cherokee Terminal Substation. The new equipment includes: • (4) 115kV Breakers • (3) 115kV switches • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures • Associated transmission line communications, fiber, relaying and testing.	**$1.730**
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	**$1.730**
Time Frame	**Site, design, procure and construct**	**18 Months**

Table 6 – PSCo Network Upgrades for Delivery

Element	Description	Cost Est. (Millions)
PSCo's East Terminal 115kV Transmission Substation (Line #9175)	Replace disconnect switches 9175L and 9175M with new 1200 amp 115 kV disconnect switches	**$0.10**
PSCo's Arvada Terminal 115 kV Transmission Substation (Line #9556)	Replace Breakers 9556 and 9686 with new 3000 amp 115kV breakers Replace disconnect switches 9556L and 9556M with new 1200 amp 115 kV disconnect switches Replace existing 500 Cu jumpers with new 1272 aluminum ACSR conductor	**$0.38**
PSCo's Cherokee Terminal 115 kV Transmission Substation	Major equipment for 115kV bus split, moving Semper 9055 and Autotransformer #2 move to north 115kV: • West Bus Upgrade to 5" Aluminum Bus • (1) Line Trap and CCVT • (2) 115kV Breakers • (4) 115kV Switches • (2) Relay Panels • (1) 115kV DE Tower • Replace termination jumpers for 9549 Cherokee to	**$4.71**

Element	Description	Cost Est. (Millions)
	Conoco, 9556 Arvada to Cherokee, and 9547 Cherokee to Mapleton at the Cherokee Substation	
PSCo's Capitol Hill Terminal 115kV Transmission Substation (Line #9547)	Replace existing 1-795 AL termination jumpers with new bundled 795 ACSR conductor	**$0.20**
PSCo's California Terminal 115kV Transmission Substation (Line #9542)	Replace existing 1-795 AL termination jumpers with new 1-1272 AL conductor	**$0.15**
PSCo's Line 9549 Cherokee to Conoco Transmission Line	Re-Conductor 1.95 miles of existing 1-477 ACSR Hawk Transmission line with 477 ACSS Hawk conductor to uprate line rating	**$0.60**
PSCo's Line 9338 Leetsdale to University Transmission Line	Re-Conductor 0.28 miles of existing 1-636 ACSR Grosbeak Transmission line with 1-636 ACSS Grosbeak conductor to uprate line rating	**$0.125**
	Siting and Land Rights and Project Management support	**$0.25**
	Total Cost Estimate for PSCo Network Upgrades for Delivery	**$6.515**
Time Frame	**Site, design, procure and construct**	**24 months**
	Total Project Estimate	**$10.412**

Cost Estimate Assumptions

- Scoping level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by Xcel Energy/PSCo Engineering.

- Estimates are based on 2012 dollars (appropriate contingency and escalation applied).
- AFUDC has been excluded.
- Engineering will be completed with PSCo' engineers.
- Lead times for materials were considered for the schedule.
- PSCo (or it's Contractor) crews will perform all construction, wiring; testing and commissioning for PSCo owned and maintained facilities.
- Construction labor is estimated for straight time only – no overtime included.
- The estimated time to site (support), design, procure and construct the interconnection facilities is approximately 18 months after authorization to proceed has been obtained.
- This project is completely independent of other queued projects and their respective ISD's.
- A CPCN will not be required for the interconnection facilities construction.
- Line and substation bus outages will be authorized during the construction period to meet requested backfeed dates.

- Xcel Crews will perform all work.
- All new relaying being installed.
- Trench/Duct space is available.
- Existing bus ratings are adequate for the addition. (Planning should complete load flows based on bus ratings to verify.) This needs to be done.
- The North and South 115kV bus needs to be split to reduce the fault current.
- Existing switch stands can be reused
- Semper Line needs to be moved to the north 115kV yard.
- Auto #2 reterminated to the North 115kV yard.
- Operations will need to take transformers off line to reduce fault current. This only needs to be done when crews are using personal grounds for protection. Fault current need to be lower than 50kA. Delays in project for this reason have not been estimated.

Appendix

GI-2011-04
Cherokee 115 kV – 587 MW

A. Load Flow Thermal Results (2016HS) –

Table 7 – Summary Listing of Differentially Overloaded Facilities (Category B Contingencies)[1]

					Benchmark Case Branch Contingency Loading Without GI-2011-04 Cherokee 115 Intact		Branch Contingency Loading With GI-2011-04 Cherokee 115 kV Split Arapahoe 4 Off Semper Line Re-terminated			
Overloaded Monitored Facility (Line or Transformer)	**Type**	**Line Owner**	**FAC 009 Branch Rating MVA**	**Line Cond Rating MVA**	**MVA Flow**	**% of Rating**	**MVA Flow**	**% of Rating**	**Total # Overloads**	**Worst NERC Category B Contingency Outage**
Arvada – Cherokee 115 kV #9556	LN	PSCo	120	253	95.0	79.2%	129.3	107.8%	3	Denver Terminal – Gray Street 115 kV #9008
Cherokee – Mapleton 115 kV #1 #9547	LN	PSCo	159	241	-	< 75.0%	168.6	106.0%	1	Cherokee – Denver Terminal 115 kV #9413
Cherokee – Conoco 115 kV #9549	LN	PSCo	159	189	-	<75%	173.0	108.8%	5	Cherokee Unit 5 or 6 Trip + 1/2 Unit 7 ST MW
Cherokee – Conoco 115 kV #9549	LN	PSCo	159	189	-	<75%	161.9	101.8%		Broomfield – Cherokee 115 kV #9558
Cherokee – Federal Heights 115 kV #9558	LN	PSCo	139	187	120.3	86.6%	147.4	106.1%	3	Valmont – Spindle 230 kV #9385
Leetsdale – University 115 kV #9338	LN	PSCo	191	191	-	<75%	191.1	100.0%	1	Arapahoe 115/230 kV T5

[1] **Newly overloaded elements due to proposed 587 MW generation increase at POI.**

Table 8 – Summary Listing of Differentially Overloaded Facilities (Category C Contingencies)[2]

					Benchmark Branch Contingency Loading Without GI-2011-04 Cherokee 115 Intact		Branch Contingency Loading With GI-2011-04 Cherokee 115 kV Split Arapahoe 4 Off Semper Line Re-terminated			
Overloaded Monitored Facility (Line or Transformer)	**Type**	**Line Owner**	**FAC 009 Branch Rating MVA**	**Line Cond Rating MVA**	**MVA Flow**	**% of Rating**	**MVA Flow**	**% of Rating**	**Total # Overloads**	**Worst NERC Category C Contingency Outage BF = Breaker Failure DCT = Double Circuit Tower**
Arvada – Cherokee 115 kV #9556	LN	PSCo	120	253	126.3	105.3%	157.0	130.8%	19	BF Valmont 115 kV Station
California – Cherokee 115 kV #9542	LN	PSCo	137	137	-	< 75.0%	157.1	114.7%	7	DCT Cherokee – Sandown 115 kV Cherokee – Capitol Hill 115 kV #9546 & 9547
Capitol Hill – Mapleton 115 kV #1 #9547	LN	PSCo	152	182	-	< 75.0%	174.6	114.9%	3	BF Cherokee – Arvada 115 kV Cherokee – Denver Term 115 kV #9556 & 9413
Cherokee – Mapleton 115 kV #1 #9547	LN	PSCo	159	241	-	< 75.0%	202.7	127.5%	6	BF Cherokee – Arvada 115 kV Cherokee – Denver Term 115 kV #9556 & 9413
Cherokee – Conoco 115 kV #9549	LN	PSCo	159	189	-	< 75.0%	195.6	123.0%	7	DCT Cherokee – Semper 115 kV Cherokee – Broomfield 115 kV #9055 & 9558
Cherokee – Federal Heights 115 kV #9558	LN	PSCo	139	187	173.2	124.6%	172.3	123.9%	9	BF Valmont 115 kV Station
Conoco – Sandown 115 kV #9549	LN	PSCo	159	159	-	< 75.0%	159.1	100.1%	1	DCT Cherokee – Semper 115 kV Cherokee – Broomfield 115 kV #9055 & 9558
East – Chambers 115 kV #9175	LN	PSCo	120	159	104.8	87.4%	124.2	103.5%	1	DCT Spruce – Smoky Hill 230 kV 1 Spruce – Smoky Hill 230 kV 2 #5171 & 5177

[2] **Newly overloaded elements due to proposed 587 MW generation increase at POI & facilities also overloaded for Category B.**

B. Generation Dispatch

Case: 2016 HS; based on WECC 17HS1AP including updates from CCPG companies.

Benchmark Case

Arapahoe Unit 4	118 MW
Cabin Creek Units	210 MW
Cherokee Unit 2 SC	0 MW
Cherokee Unit 4	383 MW
Comanche Unit 1	359.9 MW
Comanche Unit 2	365 MW
Ft Lupton Units 1 & 2	13.4 MW
Pawnee Unit 1	536 MW
Manchief Units 1 & 2	259.5 MW
FSV Units 1-4	700 MW
Valmont Unit 5	196 MW
Valmont Unit 6	0 MW
QF Thermo	256 MW
Brush Unit 2	66 MW
Brush Units 1, 3, & 4	104 MW
QF UNC	0 MW
Arapahoe Units 5-7	0 MW
Valmont Units 7 & 8	0 MW
Lamar DC Tie	101 MW Import from SPS
Spruce Units 1 & 2	268 MW
Brighton Units 1 & 2	86.6 MW
Fountain Valley Units	0 MW
Plains End Units	227.6 MW
RMEC Units 1-3	586 MW
Spindle Units 1 & 2	278 MW
Missile Site 230 kV	52.5 MW
Missile Site 345 kV	84.0 MW
Peetz Logan 230 kV	120.9 MW
Cedar Creek Wind	116.0 MW
Comanche Unit 3	804.0 MW
Ft St Vrain Unit 5 & 6	295.0 MW
Ft St Vrain Unit 7	0 MW
Rawhide Plant	535.5 MW (PRPA)
Baculite Mesa Plant	478.0 MW (BHE)

GI-2011-04 Case Adjustments

GI-2011-04 CT #1	168.6 MW
GI-2011-04 CT #2	168.6 MW
GI-2011-04 ST	249.5 MW
Arapahoe Unit 4	0 MW
Ft Lupton Units 1 & 2	0 MW
Manchief Units 1 & 2	0 MW
Brush Unit 4	0 MW
Plains End Units	137.3 MW