



Interconnection Feasibility Study Report Request # GI-2013-1

200 MW Wind Generator
Comanche 230 kV Substation, Colorado

Public Service Company of Colorado
Transmission Planning
May 6, 2014

Executive Summary

Public Service Company of Colorado (PSCo) received an interconnection request (GI-2013-1) for a 200 MW wind facility on February 4, 2013 and the feasibility study agreement was executed on May 6, 2013. The proposed GI-2013-1 will consist of eighty seven Siemens SWT-2.3-113 wind turbines. GI-2013-1 will be located 43 miles from the Comanche Substation and is proposed to interconnect to the 230 kV bus at Comanche Substation. The Customer has not requested a secondary Point of Interconnection (POI).

The proposed facility is planned to be in-service in December 2015 with a back feed date of June 2015. The GI was requested to be studied as an Energy Resource only. Studies were performed using a 2016 heavy summer power flow case. The study included steady state power flow and short circuit analyses. The power flow case has been stressed to simulate heavy South - North flows in the system.

This request was studied as a stand-alone project only, with no evaluations made of other potential new generation requests that may exist in the Generator Interconnection Request queue, other than the generation projects that are already approved and planned to be in service by July 2016. 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 an additional 200 MW of generation is injected into the Comanche 230 kV Substation, and delivering the additional generation to native PSCo loads. The affected parties for this study are Colorado Springs Utilities (CSU) and Black Hills Energy (BHE).

Energy Resource (ER)

N-1 Analysis:

The study was performed by modeling the Lamar DC tie at 101MW import capacity. Detailed single contingency study results can be found in Table 1. Addition of GI-2013-1



caused increase in the existing thermal overloads on various transmission facilities in the CSU system.

Also, overloads on the Briargate – Cottonwood South 115 kV line, Cottonwood North – Kettle Creek 115 kV line, Kelker North 230/115 kV transformer and Kelker South 230/115 kV transformer are pre-existing, before the addition of the generation proposed in GI-2013-1. The existing system with the expected generation additions already in plan before 2016 summer cannot support any generation additions at Comanche 230 kV bus.

Per the FERC LGIP process, 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.

Any upgrades to fix the existing overloads on the CSU system are preliminary developments at this stage and will not be in-service before the proposed GI is planned to be in-service (December, 2015), so the ER capacity of the proposed GI is 0 MW

ER = 0 MW (at Comanche 230 kV POI)

Short Circuit

ER = 0 for the proposed GI, so no short circuit data is provided.

Cost Estimates

Not applicable as ER = 0

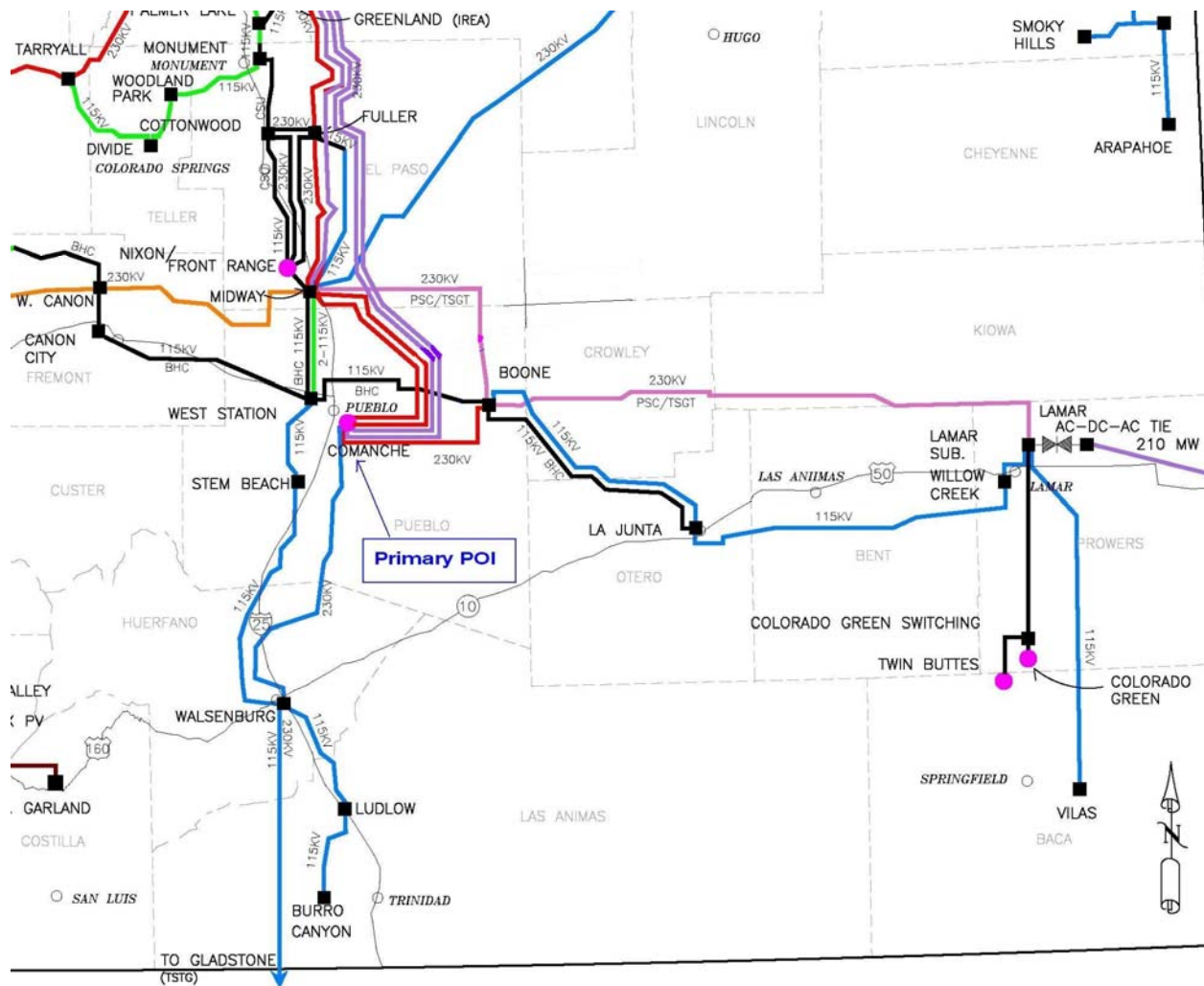


Figure 1 Comanche Transmission System

Introduction

Public Service Company of Colorado (PSCo) received an interconnection request (GI-2013-1) for a 200 MW wind generation facility near Comanche 230 kV Substation in Colorado. The generation facility will be located approximately 43 miles from the Comanche Substation and will interconnect to the 230 kV bus at the Comanche Substation using a Customer owned tie line. The Customer has not requested a secondary POI.

The proposed POI is shown in Figure 1 above. The proposed facility has a planned in-service date of December 2015 with an estimated back feed date of June 2015.

Study Scope and Analysis

The Feasibility Study evaluated the potential impacts on the PSCo transmission infrastructure as well as that of neighboring utilities when an additional 200 MW of generation is injected into the Comanche 230 kV bus, and delivering the additional generation to native PSCo loads. It consisted of power flow and short circuit analyses. The power flow analysis identified any thermal or voltage limit violations resulting from the installation of the proposed generation. Several single and double contingencies were studied. The short circuit analysis identified any new circuit breakers overdutied due to the proposed generation and the short circuit current levels at the POI.

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 1.02-1.03 per unit at regulating (generator) buses and 1.0-1.03 per unit at transmission load buses in the study area. Following a single or double contingency, transmission system steady state bus voltages must remain within 0.90 - 1.05 per unit, and power flows must remain within 100% of the facility's continuous thermal ratings. Also, voltage deviations should not exceed 5%.

The proposed facility was requested to be studied as an Energy Resource only. 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.

Network Resource Interconnection Service shall mean an Interconnection Service that allows the Interconnecting 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. This facility was not studied as a Network Resource.

The affected parties for this study are CSU and BHE.

Power Flow Study Models

The proposed facility interconnection was studied using 2016 heavy summer loading conditions. The 2016HS case was built using the WECC approved 2017HS1 base case. PSCo loads in the case were adjusted to reflect the most recent (March 2013) load forecast for Summer 2016. The topology was also updated to reflect current project plans and rating updates. Updates were included for CSU, TSGT, BHE, WAPA per the review comments received from the utilities.

The power flow case was stressed to create heavy South - North flows in the system. PSCo updates included addition of 250 MW of wind generation at Jackson Fuller which was dispatched at 40% of the rated capacity, and 120 MW of PV solar addition at Comanche 230 kV bus which is dispatched at 100% of the rated capacity. Colorado Green wind was dispatched at 40% of the rated capacity. The Jackson Fuller wind facility is a planned facility so its output levels are assumed to be the same as that of Colorado Green wind farm in order to maintain consistent wind generation levels in the southeast Colorado. The study simulated stressed South – North flows in the system while dispatching the wind generation in the area at a reasonable capacity. Because the 120 MW PV is interconnecting at the same POI as GI-2013-1, it is dispatched at full capacity.

Generation increase due to the proposed GI addition was sunk at Fort Saint Vrain. Fort Saint Vrain # 5 capacity changed from 147 MW to 0 MW, Fort Saint Vrain # 3 capacity changed from 132 MW to 100 MW and Fort Saint Vrain # 4 capacity changed from 132 MW to 100 MW. Typically two dispatch scenarios would be studied for any generation interconnection study in the Comanche area, one with DC tie importing at 101MW and a second scenario with DC tie exporting at 210 MW. The scenario with DC tie importing stresses the flows along the CSU system, and the scenario with DC tie exporting stresses the BHE system.

Power Flow Study Process

Contingency power flow studies were completed on the reference power flow case (benchmark) and the power flow case with GI 2013-1 using PTI's PSSE Ver. 32.1.0 program. Results from each of the two cases were compared and new overloads or existing overloads which increased by at least 1% in the case with the GI were noted. Any new voltage range violations or voltage deviations that increased by 5% or more



are also noted. PSSE's ACCC activity was used to perform the study. Contingencies were run on both areas 70 and 73, breaker-breaker outages were run in PSCo system, bus-bus contingencies were run for all other utilities in area 70 and area 73; Zones 700,704,705,706,709,710,712 and 757 were monitored for thermal and voltage violations.

Power Flow Results

N-1 analysis: The power flow case was studied with and without the proposed GI. The case without the GI-2013-1 addition, which is the expected system model in 2016, showed overloads on the Briar Gate – Cottonwood South 115 kV (110.2% of the 150 MVA normal rating of the line for the loss of Cotton Wood North – Kettle creek 115 kV line), Cotton Wood North – Kettle creek 115 kV line (109.3% of the 162 MVA normal rating of the line for the loss of Briar Gate – Cotton Wood South 115 kV), Kelker North 230/115 kV transformer (101.9% of the 280 MVA normal rating of the transformer for the loss of Kelker South 230/115 kV transformer) and Kelker South 230/115 kV transformer (101.9% of the 280 MVA normal rating of the transformer for the loss of Kelker North 230/115 kV transformer). Since GI-2013-1 was requested to be studied as an ER request, normal ratings of the facilities were considered. The overload on the Alamosa Terminal 115/69 kV # T1 is due to Mvar flow change on the transformer and is not related to the addition of GI-2013-1. The overload on the Cherokee – Federal heights 115 kV line is due to decreased generation at Fort Saint Vrain Substation which is used as a sink for the generation addition due to GI-2013-1.

The existing CSU transmission system is overloaded with the expected generation by summer 2016. Per the definition of an ER request, the generation addition should be evaluated based on the existing firm and non-firm capacity. Since the existing system cannot support any more generation additions without upgrades to relieve the existing overloads, the ER capacity of GI-2013-1 is 0 MW.

Due to the ER capacity being 0 MW with the DC tie importing at 101 MW, no further study analysis have been completed to analyze the DC tie exporting at 210 MW or N-2 contingencies.

ER = 0 MW (at Comanche 230 kV POI)

Short Circuit

Not provided as the ER capacity of GI-2013-1 is 0 MW

Costs Estimates and Assumptions

Not applicable as ER = 0 MW



GI-2013-1

A. Load Flow Thermal Results

Table 1 – Summary Listing of Differentially Overloaded Facilities DC Tie Importing at 101 MW (Comanche 230 kV Substation POI)¹

				Branch N-1 Loading Without GI-2013-1		Branch N-1 Loading With GI-2013-1			
Monitored Facility (Line or Transformer)	Type	Owner	Branch Rating MVA	N-1 Flow in MVA	N-1 Flow in % of Rating	N-1 Flow in MVA	N-1 Flow in % of Rating	% Change	N-1 Contingency Outage
Alamosa Terminal 115/69 kV # T1	Xfmr	PSCo	25	31.3	125.2	31.6	126.4	1.2	San Luis Valley – Blanca Peak 115 kV
Cherokee – Federal Ht 115 kV	Line	PSCo	139	155.2	111.7	158.8	114.3	2.6	Cherokee – Federal heights - Semper 115 kV
Briar Gate – Cottonwood S 115 kV	Line	CSU	150	165.3	110.2	172.9	115.3	5.1	Cottonwood – Kettle Creek 115 kV
Cotton wood N – Kettle Creek 115 kV	Line	CSU	162	177.1	109.3	185.8	114.7	5.4	Briar Gate – Cottonwood S 115 kV
Kelker North 230/115 kV	Xfmr	CSU	280	285.3	101.9	290.3	103.7	1.8	Kelker South 230/115 kV
Kelker South 230/115 kV	Xfmr	CSU	280	284.9	101.7	290.3	103.5	1.8	Kelker North 230/115 kV

¹ Detailed thermal violations due to the proposed 200 MW generation increase at Comanche 230 kV Substation

Table 2- Generation Dispatch of Major Generating Units in the Vicinity of GI-2013-1

PSCo:

<u>Bus</u>	<u>LF ID</u>	<u>MW</u>
Comanche	C1	325
Comanche	C2	335
Comanche	C3	766
Lamar DC Tie	DC	101.0 Import
Fountain Valley	G1	40
Fountain Valley	G2	40
Fountain Valley	G3	40
Fountain Valley	G4	40
Fountain Valley	G5	40
Fountain Valley	G6	40
Colorado Green	1	33.2
Colorado Green	2	33.2
Twin Butte	1	30.8
Jackson Fuller	W1	102.5
Comanche PV	S1	120
ST Vrain	G1	276
ST Vrain	G2	127
ST Vrain	G3	132
ST Vrain	G4	132
ST Vrain	G5	147
ST Vrain	G6	0

Arkansas River Power Authority:

<u>Bus</u>	<u>LF ID</u>	<u>MW</u>
City of Lamar	G1	0
City of Lamar	G2	0

BHE:

<u>Bus</u>	<u>LF ID</u>	<u>MW</u>
BUSCHWRTG1	G1	28.8
BUSCHWRTG2	G2	28.8
E Canon	G1	0
PP_MINE	G1	0
Pueblo Diesels	G1	0
Pueblo Plant	G1	0
Pueblo Plant	G2	0.0
R.F. Diesels	G1	0.0



Airport Diesels	G1	0.0
Canyon City	C1	0
Canyon City	C1	0
Baculite 1	G1	90
Baculite 2	G1	90
Baculite 3	G1	40.0
Baculite 3	G2	40.0
Baculite 3	S1	21
Baculite 4	G1	40.0
Baculite 4	G2	40.0
Baculite 4	S1	21

CSU:

<u>Bus</u>	<u>LF ID</u>	<u>MW</u>
Birdsale	1	0.0
Birdsale 2	1	0.0
Birdsale 3	1	0.0
Nixon	1	225
Tesla	1	24.8
Drake 5	1	49
Drake 6	1	80.3
Drake 7	1	136.1
Nixon CT 1	1	0.0
Nixon CT 2	1	0.0
Front Range CC 1	1	131
Front Range CC 2	1	131
Front Range CC 3	1	142