



Interconnection Feasibility Study Report Request # GI-2014-7

42 MW Increase to Hydro Pumping Generating Facility
Cabin Creek 230 kV Station, Colorado

Public Service Company of Colorado
Transmission Planning
November 14, 2014

DRAFT

Executive Summary

Public Service Company of Colorado (PSCo) received an interconnection request for a 42 MW increase at Cabin Creek pumping hydro generating facility for a new total capacity of 366 MW on July 31, 2014 that was assigned GI-2014-7 as the queue number. The proposed increase will be located at the existing facility near PSCo's Cabin Creek 230/115 kV Station. The primary point of interconnection (POI) requested for GI-2014-7 is the Cabin Creek 230 kV bus and the generating facility will interconnect to the POI using the existing customer owned 230 kV transmission lines. There is no alternate POI requested for this study. The in-service date (ISD) requested for GI-2014-7 generating facility is May 26, 2019 for Unit A (183 MW) and May 26, 2020 for Unit B (183 MW), and the request will be studied as a Network Resource.

This request was studied as a stand-alone generator interconnection that excluded any other new generation requests existing in the PSCo Generator Interconnection Request queue, except for the generator interconnection projects that are already planned to be in-service by the summer of 2020. The main purpose of this Feasibility Study was to evaluate the potential impact on the interconnected transmission system of PSCo and its neighboring utilities (the affected parties) due to an additional 42 MW of generation injected into the Cabin Creek 230 kV bus. It should be noted that PSCo evaluated the capacity adequacy of the transmission system beyond the POI – the Interconnection Customer is responsible for ensuring that the 230 kV tie lines and transformers to the POI are adequately rated for the total proposed 366 MW generation.

There are no facilities belonging to other entities in the immediate vicinity of the interconnection and the studies indicated that there were no adverse impacts to other systems.

Network Resource (NR)

At the primary POI (Cabin Creek 230 kV bus), the 42 MW injection from the proposed generation resulted in an increased Category B contingency loading on the following



PSCo transmission facilities: Cabin Creek-Lookout 230 kV Line and Idaho Springs-Lookout 230 kV Line by 6.4% and Woodland Park-Forest Lake 115 kV Line by 1.4%. Since these transmission facilities are overloaded prior to GI-2014-7 and have existing operating practices for mitigation the Network Resource Interconnection Service (NRIS) for the proposed generation is as follows:

At Cabin Creek 230 kV POI:

NRIS = 42 MW

Short Circuit

The short circuit study results showed no new circuit breakers are overdutied due to the proposed solar generation facility.

Cost Estimates

There is no transmission facility upgrades required to increase Cabin Creek generating output by 42 MW. Therefore total estimated cost to interconnect GI-2014-7 is **\$0**.

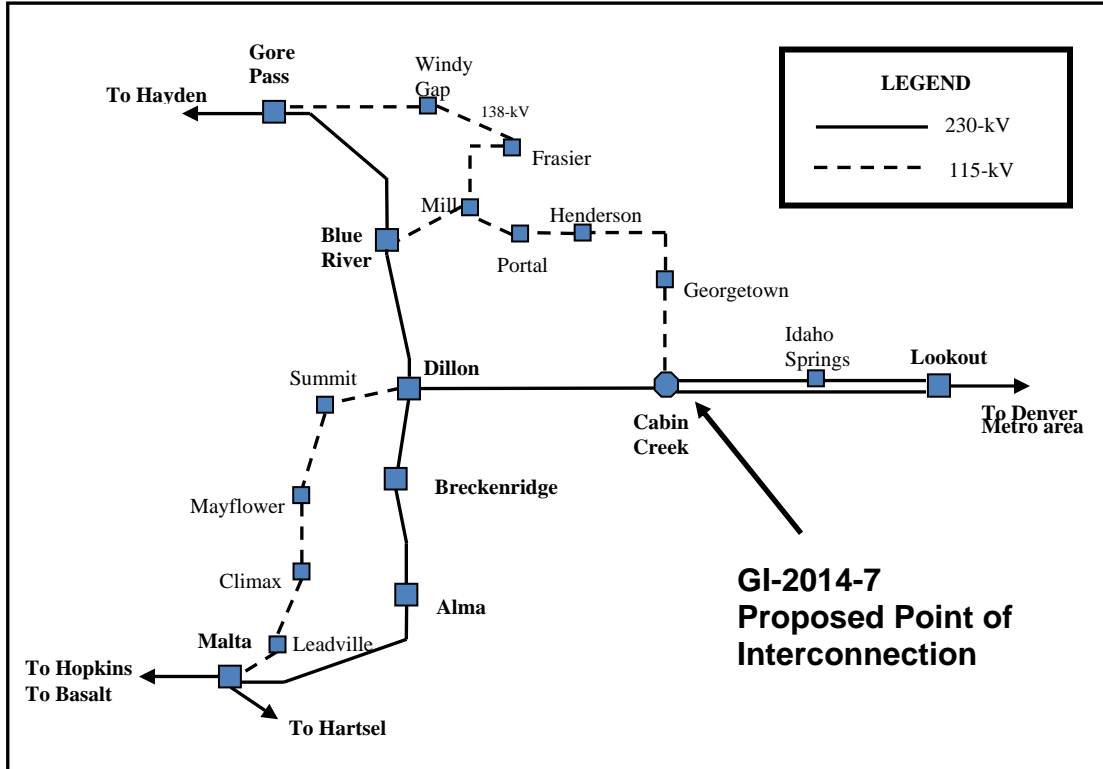


Figure 1: Cabin Creek Station and Surrounding Transmission System



Introduction

Public Service Company of Colorado (PSCo) received an interconnection request for a 42 MW increase for a new total capacity of 366 MW of the Cabin Creek hydro pumping generating facility on July 31, 2014 that was assigned GI-2014-7 as the queue number. The proposed increase will be located at the existing facility near PSCo's Cabin Creek 230/115 kV Station. The primary point of interconnection (POI) requested for GI-2014-7 is the Cabin Creek 230 kV bus and the generating facility will interconnect to the POI using the existing customer owned 230 kV transmission lines. There is no alternate POI requested for this study. The in-service date (ISD) requested for GI-2014-7 generating facility is May 26, 2019 for Unit A (183 MW) and May 26, 2020 for Unit B (183 MW), and the request will be studied as a Network Resource.

Study Scope and Analysis

The Feasibility Study evaluated the transmission impacts associated with the proposed solar generation facility. The study consists of power flow and short circuit analyses. The power flow analysis identified thermal and 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 any new circuit breakers overdutied due to the proposed generation and the short circuit levels at the primary 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 attempts 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 1.10 per unit, and power flows within 100% of the facilities' continuous thermal ratings. Also, voltage deviations should not exceed 5%.

The project was studied as a Network Resource. 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 generation facilities to serve native load customers; or (2) in an TRO 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.

There are no facilities belonging to other entities in the immediate vicinity of the interconnection and the studies indicated that there were no adverse impacts to other systems.



Power Flow Study Models

The power flow studies were based on the WECC approved 2020 Heavy Summer (20HS2AP) case. The 2020 case sufficiently models the system after the in-service date for Unit B of GI-2014-7. The case was updated to output Cabin Creek hydro at its full present capacity of 324 MW. Two power flow cases were created for evaluating the impact of the proposed generator – the reference case and the study case. The study case includes the 42 MW increased generation dispatch at Cabin Creek 230 kV bus due to the proposed generator interconnection.

To assess the impact of the proposed generation during stressed conditions of the western slope of Colorado, an additional reference case and study case were created to model the TOT5 transmission path at 1400 MW flow west-to-east. High TOT5 flow level directly impacts the Cabin Creek 230 kV flow into Metro Denver. The stressed condition was accomplished by reducing generation in the Denver Metro Area as well as along the Front Range and increasing generation in Arizona, Idaho, and the Pacific Northwest.

Power Flow Study Process

Contingency power flow studies were completed on the reference models and the models with the proposed new generation using PTI's PSSE Ver. 33.4.0 program. Results from each of the four cases were compared and new overloads or overloads that increased significantly in the new generation case were noted. Voltage criteria violations were also recorded. PSSE's ACCC activity was used to perform the load flow contingency analysis for PSCo Category B & C contingencies. Powerflow areas 70 and 73 were used for contingency files (single branches and tielines). Monitored elements included branches in ties in powerflow zones 700, 703, 704, 705, 706, 710, 752, 753, 754, and 757.

Power Flow Results

The results of the Network Resource contingency analysis are summarized in the tables in the Appendix. The analysis did not find any thermal loading or voltage issues in the pre and post GI-2014-7 study cases for the summer peak demand scenario. The analysis did, however, find thermal loading issues in the stressed TOT5 (1400 MW west-to-east) study cases which are shown in the tables in the Appendix. The results of the Category A analysis show normal thermal overloads of the two generator step-up (GSU) transformers at Cabin Creek. These transformers are rated at 195 MVA and with the increased Cabin Creek hydro pumping output due to GI-2014-7, Units A and B can produce slightly more than 195 MVA when fully over excited. These transformers are behind the Cabin Creek 230 kV bus POI and therefore are the responsibility of the customer to ensure adequate capacity and are not included as associated network upgrades for this study. Overloads of these transformers are also seen in the Category B contingency analysis and will not be discussed further.



The results of the Category B contingency analysis, displayed in Table 6, show three transmission facilities with thermal overloads owned by PSCo including the Cabin Creek-Lookout and Idaho Springs-Lookout 230 kV lines and the Woodland Park-Forest Lake 115 kV line. Since these transmission facilities are overloaded prior to the GI-2014-7 interconnection, none of these thermal overloads can be attributed to the proposed 42 MW increased injection at Cabin Creek by GI-2014-7. The mitigation approach for these facilities is accomplished by established operating practices for high TOT5 flow. To mitigate overloads of the Cabin Creek-Lookout or Idaho Springs-Lookout 230 kV lines the action is to reduce Cabin Creek generation. The generation reduction amount may increase due to the higher capacity of GI-2014-7 under these conditions. To mitigate overload of the Woodland Park-Forest Lake 115 kV line the action is to reduce Mt Elbert generation which is similar to the action for mitigating overload of the Malta-Poncha 230 kV Line.

The results of the Category C contingency analysis, displayed in Table 7, found thermal overloads of the Cabin Creek-Lookout 230 kV line due to several N-1-1 contingency events. This again cannot be attributed to GI-2014-7 due to the preexisting condition. To mitigate the overload the established operating practice is to reduce Cabin Creek generation following the first contingency. The generation reduction amount may increase due to the higher capacity of GI-2014-7.

No new violations of the voltage limit criteria (0.9 - 1.05 pu) or the voltage deviation criteria (< 5%) were caused in PSCo's interconnected transmission system due to the addition of GI-2014-7 generating facility.

Network Resource (NR)

At the primary POI (Cabin Creek 230 kV bus), the 42 MW injection from the proposed generation resulted in an increased Category B contingency loading on the following PSCo transmission facilities: Cabin Creek-Lookout 230 kV Line and Idaho Springs-Lookout 230 kV Line by 6.4% and Woodland Park-Forest Lake 115 kV Line by 1.4%. Since these transmission facilities are overloaded prior to GI-2014-7 and have existing operating practices for mitigation the Network Resource Interconnection Service (NRIS) for the proposed generation is as follows:

At Cabin Creek 230 kV POI:

NRIS = 42 MW

Short Circuit Analysis

The short circuit study results showed no new circuit breakers are overdutied due to the proposed solar generation facility. The study found the single-line-to-ground (SLG) and 3-phase fault duty at Cabin Creek 230 kV bus (including GI-2014-7) shown in Table 1 below.

Table 1 - Short Circuit Levels at the Cabin Creek 230 kV POI

System Condition	Three-Phase Fault Level (Amps)	Single-Line-to-Ground Fault Level (Amps)	Thevenin System Equivalent Impedance (R + jX) (Ohms)
System Intact	14,492	14,072	Z1(pos)= 0.87423 +j 9.12120 Z2(neg)= 0.83029 +j 8.71366 Z0(zero)= 0.74506 +j 10.3673



Costs Estimates and Assumptions

GI-2014-7 (Feasibility Study Report)

There are no transmission facility upgrades required to increase Cabin Creek generating output by 42 MW. Therefore total estimated cost to interconnect GI-2014-7 is \$0. The existing facilities at Cabin Creek are adequate to accommodate 460 Amps from each 163 MW unit.

Table 2: PSCo Owned; Customer Funded Transmission Provider Interconnection Facilities

Element	Description	Cost Est. (Millions)
	N/A	

Table 3: PSCo Network Upgrades for Delivery

Element	Description	Cost Est. (Millions)
	N/A	

Table 4: PSCo Network Upgrades for Delivery

Element	Description	Cost Est. (Millions)
	N/A	

Appendix

Power Flow Contingency Analysis Results

Table 5: N-0 Differentially Overloaded Facilities¹ for Stressed TOT5 Conditions (1400 MW west-to-east)

Monitored Facility (Line or Transformer)	Type	Owner	Facility Rating MVA (Norm)	Normal Branch Loading Before GI-2014-7		Normal Branch Loading After GI-2014-7		Differential % Impact
				Flow in MVA	Flow in % of Rating (Norm)	Flow in MVA	Flow in % of Rating (Norm)	
Cabin Creek 230/13.8 kV Tran. A	Tfrmr	PSCo	195	175.7	92.0%	196	100.8%	8.8%
Cabin Creek 230/13.8 kV Tran. B	Tfrmr	PSCo	195	176.4	92.0%	197	101.1%	9.1%

Table 6: N-1 Differentially Overloaded Facilities¹ for Stressed TOT5 Conditions (1400 MW west-to-east)

Monitored Facility (Line or Transformer)	Type	Owner	Facility Rating MVA (Norm)	Branch N-1 Loading Before GI-2014-7		Branch N-1 Loading After GI-2014-7		Differential % Impact	NERC Category B Contingency Outage
				N-1 Flow in MVA	N-1 Flow in % of Rating (Norm)	N-1 Flow in MVA	N-1 Flow in % of Rating (Norm/Emer)		
Cabin Creek 230/13.8 kV Tran. A	Tfrmr	PSCo	195	181.6	95.0%	202	103.6%	8.6%	Hayden-North Park 230 kV Line
Cabin Creek 230/13.8 kV Tran. B	Tfrmr	PSCo	195	182.4	95.0%	203	104.1%	9.1%	Hayden-North Park 230 kV Line
Cabin Creek-Lookout 230 kV	Line	PSCo	478	713	152.3%	741	158.7%	6.4%	Cabin Creek-Idaho Springs 230 kV Line
Idaho Springs-Lookout 230 kV	Line	PSCo	478	690	148.3%	718	154.7%	6.4%	Cabin Creek-Lookout 230 kV Line
Woodland Park-Forest Lake 115 kV	Line	PSCo	120	119	102.8%	121	104.2%	1.4%	Tarryall-Waterton 230 kV Line

¹ Due to proposed 42 MW generation increase at Cabin Creek 230 kV Station



Table 7: N-1-1 Differentially Overloaded Facilities² for Stressed TOT5 Conditions (1400 MW west-to-east)

Monitored Facility (Line or Transformer)	Type	Owner	Facility Rating MVA (Norm)	Branch N-1 Loading Before GI-2014-7		Branch N-1 Loading After GI-2014-7		Differential % Impact	NERC Category C Contingency Outage
				N-1 Flow in MVA	N-1 Flow in % of Rating	N-1 Flow in MVA	N-1 Flow in % of Rating		
Cabin Creek-Lookout 230 kV	Line	PSCo	478	730	156.7%	760	163.5%	6.8%	Cabin Creek-Lookout 230 kV Line & McKenzie-Stillwater Tap 69 kV Line
Cabin Creek-Lookout 230 kV	Line	PSCo	478	723	154.7%	752	161.3%	6.6%	Cabin Creek-Idaho Springs 230 kV Line & Otero Tap-Twin Lake Tap 115 kV Line

² Due to proposed 42 MW generation increase at Cabin Creek 230 kV Station