INFO-2020-3

Informational Study Report

5/4/2021

Table of Contents

1.0 Summary

Customer has requested an informational evaluation of the interconnection of a 150MW Solar PV Generating Facility interconnection on the Hartsel – Tarryall 230kV line (same POI as 1RSC-2020-1). The expected Commercial Operation Date of the Generating Facility is December 31, 2024 and requested an evaluation for Energy Resource Interconnection Service.

Energy Resource Interconnection Service of INFO-2020-3 before Network Upgrades is 150MW.

Energy Resource Interconnection Service of INFO-2020-3 is 150MW.

The total estimated cost of the transmission system improvements to interconnect INFO-2020-3 is $2.651 Million (Tables 4 and 5).

The study did not identify any impacts to the Affected Systems.

Note – This report is an informational study and does not grant any Interconnection Service or Transmission Service. The results are based on the modeling assumptions and study scope specified by the Customer, which may or may not reflect the standard modeling assumptions followed for the LGIP studies.

2.0 Introduction

This report is the informational study for a 150MW Solar Photovoltaic (PV) Generating Facility with a Point of Interconnection (POI) on the Hartsel – Tarryall 230kV line. The request is referred to as "INFO-2020-3" and studied for Energy Resource Interconnection Service (ERIS)[1].

The proposed Commercial Operation Date (COD) of INFO-2020-3 is December 31, 2024.The geographical location of the Transmission System near the POI is shown in Figure 1.

[1]**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

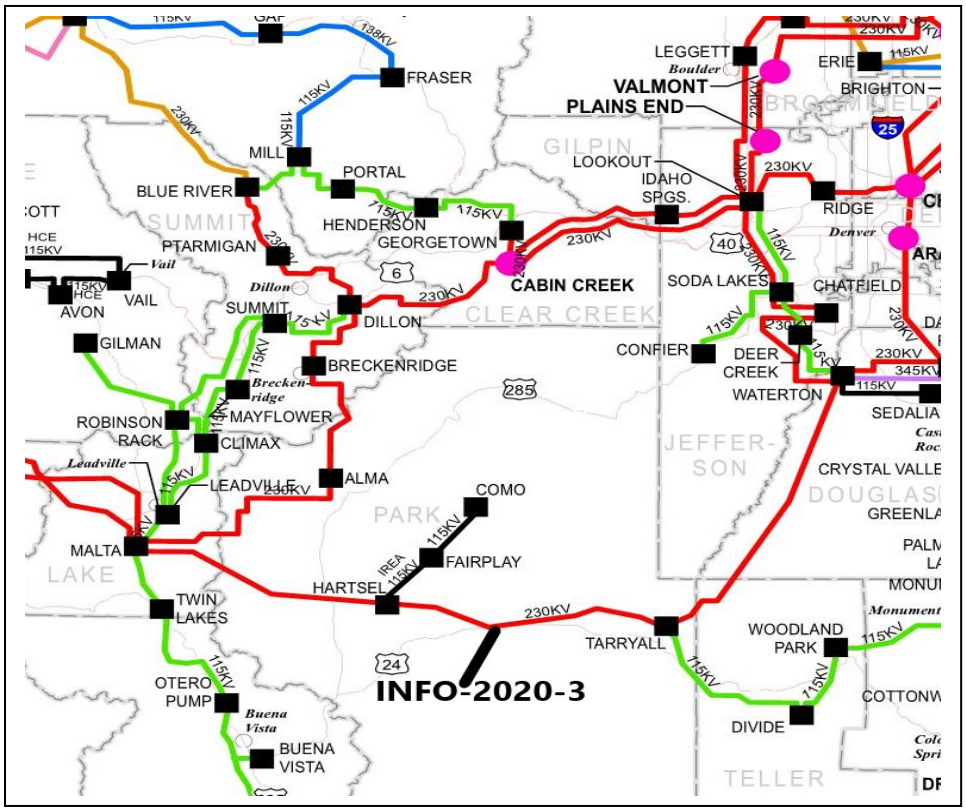

Figure 1 – INFO-2020-3 Point of Interconnection

3.0 Study Scope

The study was performed using the modeling assumptions specified by the Interconnection Customer. The scope of the study only includes power flow analysis to evaluate the steady-state thermal and voltage limit violations in the PSCo Transmission System and Affected Systems resulting from the addition of INFO-2020-3 for ERIS on the Tarryall – Hartsel 230kV line, at the switching station built for 1RSC-2020-1. The study identified the maximum allowable ERIS before upgrades, and upgrades required to allow full ERIS. The scope of this report also includes cost estimates for Interconnection Facilities, Station Upgrades and Network Upgrades.

3.1 Study Pocket Determination

As shown in Figure 1, the POI of the request is located in Western Colorado. Hence the study analysis is based on the western colorado study pocket analysis.

3.2 Study Criteria

The following steady state Criteria is used to identify violations on the PSCo system and the Affected Systems.

P0 - System Intact conditions:

Thermal Loading: <=100% Normal facility rating

Voltage range: 0.95 to 1.05 per unit

P1 & P2-1 – Single Contingencies:

Thermal Loading: <=100% Normal facility rating

Voltage range: 0.90 to 1.10 per unit

Voltage deviation: <=8%

P2 (except P2-1), P4, P5 & P7 – Multiple Contingencies:

Thermal Loading: <=100% Emergency facility rating

Voltage range: 0.90 to 1.10 per unit

Voltage deviation: <=8%

3.3 Study Methodology

The steady state assessment is performed using PSSE V33 and the TARA AC tool.

3.3.1 Steady State Assessment methodology

Thermal violations are identified if a facility (i) resulted in a thermal loading >100% in the Study Case after the study generator addition and (ii) contributed to an incremental loading increase of 1% or more to the benchmark case loading.

Voltage violations are identified if a bus voltage has a further variation of 0.1p.u.

3.4 Study Area

The Study Area includes WECC designated zones 700, 703, 704, 705, 708, 709, 790 and 791. The neighboring utilities included in the analysis include Tri-State Generation and Transmission Inc. (TSGT), Intermountain Rural Electric Association (IREA) and Western Area Power Administration (WAPA) systems in the study area.

4.0 Modeling Assumptions

The study is performed using the WECC 2026HW2 case released on July 31, 2020.

4.1 Base Case Modeling

The Base Case is created from the 2026HW2 case by making the following modifications. The following approved transmission projects in PSCo's 10-year transmission plan which are expected to be in-service before December 2025 are modeled:

- Cloverly 115kV Substation – ISD 2021
- Graham Creek 115kV Substation – ISD 2022
- Husky 230/115kV Substation – ISD 2022
- Ault – Husky 230kV line – ISD 2022
- Husky – Graham Creek – Cloverly 115kV line – ISD 2022
- Monument – Flying Horse 115kV Series Reactor – ISD 2022
- Avery Substation – ISD 2021
- Barker Substation (Bank1: 2021, Bank 2: 2022) – ISD 2021/2022
- High Point Substation – ISD 2022
- Titan Substation – ISD 2022
- Gilman – Avon 115kV line – ISD 2022
- Upgrade Villa Grove – Poncha 69kV Line to 73MVA – ISD 2021
- Upgrade Poncha – Sargent – San Luis Valley 115kV line to 120MVA – ISD 2021
- Climax – Robinson Rack – Gilman 115kV – ISD 2023
- Greenwood – Arapahoe - Denver Terminal 230kV line – ISD 2022
- Bluestone Valley Phase 2 – ISD 2023

Also, the following facility uprate projects are modeled at their planned future ratings:

- Upgrade Allison – SodaLakes 115kV line to 318MVA – ISD 2021
- Upgrade Buckley34 – Smokyhill 230kV line to 506MVA – ISD 2021
- Upgrade Daniels Park – Priarie1 230kV line to 576MVA – ISD 2021
- Upgrade Greenwood – Priarie1 230kV line to 576MVA – ISD 2021
- Upgrade Daniels Park – Priarie3 230kV line to 576MVA – ISD 2021
- Upgrade Greenwood – Priarie3 230kV line to 576MVA – ISD 2021

- Upgrade Midway 230kV bus tie to 576MVA – ISD 2023
- Upgrade Waterton – Martin2 tap 115kV line to 189MVA – ISD 2021
- Upgrade Daniels Park 345/230kV # T4 to 560MVA – ISD 2021
- Upgrade Leetsdale – Monaco 230kV line to 560MVA – ISD 2021
- Upgrade Greenwood – Monaco 230kV line to 560MVA – ISD 2021
- Upgrade Waterton – Martin1 tap 115kV line to 189MVA – ISD 2023

The following additional changes were made to the TSGT model in the Base Case per further review and comment from TSGT:

- Fuller – Vollmer – Black Squirrel 115kV line modeled at 173MVA – ISD 2022
- Fuller 230/115kV, 100MVA #2 transformer – ISD 2023

The following additional changes were made to the Black Hills Energy (BHE) model in the Base Case per further review and comment from BHE:

- Pueblo West substation – ISD 4/13/2021
- Pueblo Reservoir – Burnt Mill 115kV Rebuild – ISD 8/31/2021
- Boone - South Fowler 115kV Project – ISD 10/1/2021
- North Penrose Substation – ISD 1/31/2022
- West Station – Pueblo Res 115kV Rebuild – ISD 1/31/2022

The following additional changes were made to the Colorado Springs Utilities (CSU) model in the Base Case per further review and comment from CSU:

- The Cottonwood – Tesla 34.5kV line is modeled open and Kettle Creek – Tesla 34.5kV line is modeled closed on the CSU system – ISD 2023
- Briargate S 115/230kV transformer project tapping the Cottonwood – Fuller 230kV line – ISD 2023

The Base Case model includes the existing PSCo generation resources and future resources with approved Transmission Service, and, Affected System's existing resources and future resources with approved Transmission Service. In addition, the following additional generation were modeled per the modeling requirements specified by the Customer:

- GI-2014-13, GI-2014-6, GI-2014-7, GI-2014-9, GI-2016-15, GI-2017-12, Transitional Cluster, 1RSC-2020, DISIS-2020-001, 2RSC-2020 and DISIS-2020-002 in the PSCo queue

- TI-18-0809, TI-19-1016 in the TSGT queue
- BHCT-G29 in the BHE queue
- Victory Solar, Pioneer Solar, Hunter Solar and Kiowa Solar in the IREA system

The following upgrades identified in the PSCo Generation interconnection queue studies are also modeled:

- Upgrade Daniels Park – Prairie 230kV # 1 line to 756MVA (DISIS-2020-001)
- Upgrade Daniels Park – Prairie 230kV # 3 line to 756MVA (DISIS-2020-001)
- Install a second Waterton 345/230kV, 560MVA xfmr (DISIS-2020-002)
- Loop Comanche – Daniels Park 345kV line into GI-2020-12/GI-2020-14 345kV Switching Station (DISIS-2020-002)
- Uprate Boone – GI-2020-13 Switching Station segment to 394MVA (DISIS-2020-002)

5.0 Study Analysis

The INFO-2020-3 is studied in the western colorado study pocket.

5.1.1 Benchmark Case Modeling

The Benchmark Case for evaluating INFO-2020-3 was developed from the Base Case described in Section 4.1 by changing the generation dispatch in the Western part of Colorado to reflect a West to East flows across TOT5. The study modeled the TOT5 path at a maximum of 1,680MW by adopting the generation dispatch in Table 1.

Table 1 – Generation Dispatch Used to Create the Benchmark Case (MW is Gross Capacity)

Generation	Pgen MW
Craig 1	470
Craig 2	470
Craig 3	478
Hayden 1	202
Hayden 2	285
Bonanza	490
MBPP-1	221
MBPP-2	150
Cabincreek A	160
Cabincreek B	160

Generation	Pgen MW
Blue Mesa 1	40
Blue Mesa 2	40
Morrow 1	72
Morrow 2	72
Elbert-1	90
Elbert-2	90

5.1.2 Study Case Modeling

A Study case was created from the Benchmark Case by modeling INFO-2020-3 at the 1RSC-2020-1 POI tapping the Hartsel – Tarryall 230kV line. The 150MW output from the generator was sunk to Pawnee.

5.1.3 Steady State Analysis Results

The results of the single contingency analysis are given in Table 2. The addition of INFO-2020-3 caused several overloads on the PSCo system. The facility overloads impacted by the addition of INFO-2020-3 are as follows:

- Cabin Creek - Idaho Springs 230 KV #1 line loading increased from 95.1% to 100.4% (PSCo facility). The Optimum Power Flow (OPF) tool identified a generation redispatch scenario which mitigated the Study Case overload, no Network Upgrades were identified to mitigate this overload
- Cabin Creek - Lookout 230 KV #1 line loading increased from 109.8% to 115.9% (PSCo facility). The Benchmark Case overload is mitigated by existing Operating Procedure (See Table 3), and OPF identified a generation redispatch scenario which mitigated the Study Case overload, no Network Upgrades were identified to mitigate this overload
- Climax – Leadville1 115kV #1 line loading increased from 116.4% to 122.9% (PSCo facility). This facility overload exists in the benchmark case and the benchmark case overload would be mitigated by PSCo. The Optimum Power Flow (OPF) tool identified a generation redispatch scenario which mitigated the Study Case overload, no Network Upgrades were identified to mitigate this overload
- Climax – Mayflower 115kV #1 line loading increased from 109.8% to 133.0% (PSCo facility). This facility overload exists in the benchmark case and the benchmark case

- overload would be mitigated by PSCo. The Optimum Power Flow (OPF) tool identified a generation redispatch scenario which mitigated the Study Case overload, no Network Upgrades were identified to mitigate this overload
- Idaho Springs - Lookout 230 KV line loading increased from 124.0% to 125.8% (PSCo facility). The Benchmark Case overload was mitigated by existing Operating Procedure (See Table 3), and OPF identified a generation redispatch scenario which mitigated the Study Case overload, so no Network Upgrades were identified to mitigate this overload
- Tarryall – Lake Geroge115kV #1 line loading increased from 92% to 116.3% (PSCo facility). The Optimum Power Flow (OPF) tool identified a generation redispatch scenario which mitigated the Study Case overload, so no Network Upgrades were identified to mitigate this overload
- Tarryall 230/115kV transformer loading increased from 91.5% to 105.7% (PSCo facility). The Optimum Power Flow (OPF) tool identified a generation redispatch scenario which mitigated the Study Case overload, so no Network Upgrades were identified to mitigate this overload

Table 2 – Overloads identified in Single Contingency Analysis

Overloaded Facility	Type	Owner	Facility Normal Rating (MVA)	Facility Loading in Benchmark Case		Facility Loading in Study Case		% Change due to INFO-2020-3	Single Contingency Definition	Type of Overload	OPF Identified
				MVA Flow	% Line Loading	MVA Flow	% Line Loading				
Cabin Creek – IdahoSprings 230kV # 1	Line	PSCo	473	449.8	95.1%	474.9	100.4%	5.3%	Cabin Creek – Lookout 230kV Line # 1	Beyond POI	Yes
Cabin Creek – Lookout 230kV # 1	Line	PSCo	478	524.8	109.8%	554	115.9%	6.1%	Cabin Creek – IdahoSprings 230kV # 1	Beyond POI	Yes
Climax – Leadville1 115kV #1	Line	PSCo	57	66.3	116.4%	70	122.9%	6.5%	Malta – Leadville2 115kV # 1	Beyond POI	Yes
Climax – Mayflower 115kV #1	Line	PSCo	46	50.5	109.8%	61.2	133.0%	23.2%	Alma – Malta 230kV #1	Beyond POI	Yes

Idaho Springs – Lookout 230kV # 1	Line	PSCo	473	501.8	106.1%	531.2	112.3%	6.2%	Cabin Creek – Lookout 230kV Line # 1	Beyond POI	Yes
Lake George – Tarryall 115kV	Line	PSCo	120	110.4	92%	139.6	116.3%	24.3%	Tarryall – Waterton 230kV Line # 1	Beyond POI	Yes
Tarryall 230/115kV # T1	xfmr	PSCo	100	110.9	110.9%	141.5	141.5%	30.6%	Tarryall – Waterton 230kV Line # 1	Beyond POI	Yes

Table 3 – TOT5 Mitigation Measures to Address Criteria Violations

Monitored Facility (Line or Transformer)	NERC Single Contingency	Mitigation Measure
Cabin Creek – Lookout 230kV Line	Cabin Creek – Idaho Springs 230kV Line	Reduce Cabin Creek generation (Existing TOT5 Operating Practice)
Idaho Springs – Lookout 230kV Line	Cabin Creek – Lookout 230kV Line	Reduce Cabin Creek generation (Existing TOT5 Operating Practice)

As the Western Slope study analysis models very high TOT5 flow, running multiple contingency analysis on such a stressed case may result in unrealistic overloads. Hence, only single contingency analysis is performed

The study did not identify any impacts to the Affected Systems

6.0 Cost Estimates and Assumptions

PSCo Engineering has developed cost estimates (with no accuracy) for Interconnection Facilities and Network/Infrastructure Upgrades required for the interconnection of INFO-2020-3 at the 1RSC-2020-1 POI tapping the Tarryall – Hartsel 230kV line. The cost estimates are based on 2021 dollars with escalation and contingencies applied. Allowance for Funds Used During Construction (AFUDC) is not included. The estimated costs include all applicable labor and overheads associated with the siting, engineering, design, and construction of these new PSCo facilities. This estimate does not include the cost for any Customer owned equipment and associated design and engineering.

- Labor is estimated for straight time only – no overtime included.
- Lead times for materials were considered for the schedule.
- INFO-2020-3 Generating Facility is not in PSCo's retail service territory. Therefore, no costs for retail load metering are included in these estimates.
- Line and substation outages will be necessary during the construction period. Outage availability could potentially be problematic and extend requested back feed date
- Customer will install two (2) separate fiber optics circuits into the Transmission provider's substation as part of its interconnection facilities construction scope.
- Power Quality Metering (PQM) will be required on the Customer's generation tie-line terminating into 1RSC-2020-1 Switching Station.
- The Customer will be required to design, procure, install, own, operate and maintain a Load Frequency/Automated Generation Control (LF/AGC) RTU at their Customer Substation. PSCo / Xcel will need indications, readings and data from the LFAGC RTU.
- PSCo (or it's Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- PSCO does not anticipate that a CPCN will be required for the interconnection facilities construction.
- The estimated time to permit, design, procure and construct the interconnection facilities is approximately 18 months after authorization to proceed has been obtained.

Figure 2 is a conceptual one-line of INFO-2020-3 POI on 1RSC-2020-1 Switching Station tapping the Tarryall – Hartsel 230kV line.

The estimated total cost of the Transmission Provider's Interconnection Facilities and Station Network Upgrades are shown in Table 4 and Table 5 respectively. System improvements are subject to revision as a more detailed and refined design is produced.

Table 4 – Transmission Provider's Interconnection Facilities

Element	Description	Cost Est. (Millions)
1RSC-2020-1 230kV Switching Station	Interconnect Customer to tap at the 1RSC-2020-1 2330kV Switching Station tapping the Tarryall – Hartsel 230kV line. The new equipment includes: • The new equipment includes: • Deadend and structures • Three (3) 230kV arresters • One 230kV 2000A Switch • One set (of three) high side metering units	$1.36

	• Fiber communication equipment • Station controls • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures • Associated transmission line communications, fiber, relaying and testing.	
	Transmission line tap into substation.	$0.055
	Siting and Land Rights support for permitting and construction	$0.020
	Total Cost Estimate for Transmission Providers Interconnection Facilities	**$1.435**
Time Frame	**Site, design, procure and construct**	**18 Months**

Table 5 – Station Network Upgrades

Element	**Description**	**Cost Est. (Millions)**
1RSC-2020-1 230kV Switching Station	1RSC-2020-1 Switching Station Expansion to accommodate INFO-2020-3. The new equipment includes: • One (1) 230kV 3000A circuit breakers • Two (2) 230kV 3000A disconnect switches • Station controls and wiring • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures	$1.196
	Siting and Land Rights support for substation site acquisition, permitting, and construction	$0.020
	Total Cost Estimate for Network Upgrades for Interconnection	**$1.216**
Time Frame	**Site, design, procure and construct**	**18 Months**

7.0 Summary of Informational Interconnection Study Results:

Energy Resource Interconnection of INFO-2020-3 before Network Upgrades is 150MW.

Energy Resource Interconnection Service of INFO-2020-3 is: 150MW.

The total estimated cost of the transmission system improvements to interconnect INFO-2020-3 is $2.651 (Tables 4 and 5).

Note – This report is only an informational study and does not grant any Interconnection Service or Transmission Service. The results are based on the modeling assumptions and study scope specified by the Customer, which may or may not reflect the standard modeling assumptions followed for the LGIP studies.

Figure 2 – Preliminary One-line of INFO-2020-3 Interconnecting at 1RSC-2020-1 Switching Station, tapping the Tarryall – Hartsel 230kV line