INFO-2020-7

Informational Interconnection Study Report

3/4/2021

Table of Contents

1.0 Summary

Customer has requested an informational evaluation of the interconnection of a 125MW Solar PV Generating Facility at the Comanche 230kV Substation. The expected Commercial Operation Date of the Generating Facility is December 31, 2024 and the request is evaluated for Energy Resource Interconnection Service.

The Customer requested two additional scenarios to be studied. The results of the analyses are as follows:

- *Base analysis:* The analysis identified generation dispatch conditions which eliminated the stressed condition single contingency overloads. There were no violations attributed to INFO-2020-7
- *Scenario-1 - Comanche 1 offline:* The study did not identify any violations
- *Scenario-2 - Comanche 1 offline and stress third party system:* This scenario was not studied as the modeling assumptions for Scenario-1 and Scenario-2 are similar

Energy Resource Interconnection Service of INFO-2020-7 before Network Upgrades is 125MW

Energy Resource Interconnection Service of INFO-2020-7 is: 125MW

The total estimated cost of the transmission system improvements to interconnect INFO-2020-7 are: $5.46 Million (Tables 5 and 6).

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

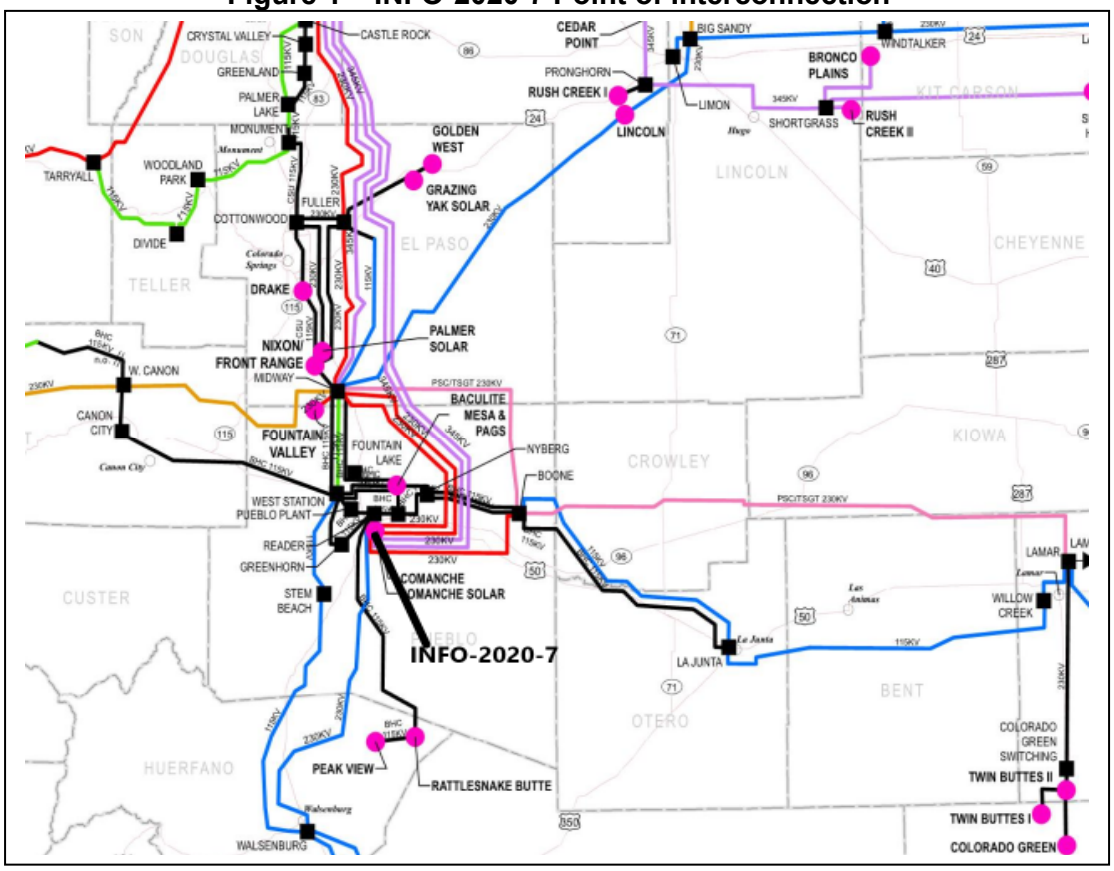
Note – This report is an informational study and does not grant any Interconnection Service or Transmission Service. The results are based on the modeling assumptions and study scope specified by the Customer, which may or may not reflect the standard modeling assumptions followed for the LGIP studies.

2.0 Introduction

This report is the informational study for a 125MW Solar Photovoltaic (PV) Generating Facility with a Point of Interconnection (POI) at the Comanche 230kV Substation. The request is referred to as "INFO-2020-7" and studied for Energy Resource Interconnection Service (ERIS)[1].

The proposed Commercial Operation Date (COD) of INFO-2020-7 is December 31, 2024.The geographical location of the Transmission System near the POI is shown in Figure 1 below.

Figure 1 – INFO-2020-7 Point of Interconnection



[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

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-2020-7 for ERIS at the Comanche 230kV Substation. 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.

In addition, the Customer has requested the following two additional Scenarios:

- Scenario-1 - Comanche 1 offline
- Scenario-2 - Comanche 1 offline and stress third party system

All the Comanche area generation was stressed in the Scenario-1 and there were no additional Affected System generation to be stressed. The modeling assumptions for Scenario-1 and Scenario-2 would be the same, so Scenario-2 was not studied.

3.1 Study Pocket Determination

As shown in Figure 1, the POI of the request is located in the “Southern Colorado” study pocket. Hence the study analysis is based on the Southern 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% of pre-contingency voltage

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% of pre-contingency voltage

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 Pocket GIR cluster 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 for Southern Colorado study pocket includes WECC designated zones 704, 710, and 712. The Affected Systems included in the analysis include Tri-State Generation and Transmission Inc. (TSGT), Black Hills Energy (BHE), Colorado Spring Utilities (CSU), Intermountain Rural Electric Association (IREA) and Western Area Power Administration (WAPA) systems in the study area.

4.0 Modeling Assumptions

The study was performed using the 2023HS case developed for the 2019 Colorado Coordinated Planning Group TPL1-4 studies.

4.1 Base Case Modeling

The Base Case is created from the 2023HS 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 August 2023 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

All transmission facilities are modeled at their expected ratings for 2023 Summer season. 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, future resources with approved Transmission Service, Affected System's existing resources and Affected System's future resources with approved Transmission Service. In addition, the following additional generation were modeled per the modeling requirements specified by the Customer:

- TI-18-0809, 100MW ERIS/ERIS Solar, Walsenburg-Gladstone 230kV line
- TI-19-1016, 40MW ERIS/ERIS Solar, Walsenburg-Gladstone 230kV line
- BHCT-G29, 200MW NRIS Solar, Pueblo West – Canon City 115kV line

5.0 Study Analysis

The INFO-2020-7 is studied in the Southern Colorado study pocket.

5.1 Southern Colorado Study Pocket Analysis

5.1.1 Benchmark Case Modeling

The Benchmark Case was created from the Base Case by changing the Study Pocket generation dispatch to reflect a heavy south to north flow on the Comanche – Midway – Jackson Fuller – Daniels Park transmission system. This was accomplished by adopting the generation dispatch in Table 1.

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

Bus Name	ID	Benchmark PGen (MW)	PMax (MW)
COMAN_1 24.000	C1	360	360
COMAN_2 24.000	C2	365	365
COMAN_3 27.000	C3	869	869
COMAN_PV 34.500	S1	104	122.5
CO_GRN_E 34.500	W1	64.8	81
CO_GRN_W 34.500	W2	64.8	81
FTNVL1&2 13.800	G1	36	40
FTNVL1&2 13.800	G2	36	40
FTNVL3&4 13.800	G3	36	40
FTNVL3&4 13.800	G4	36	40
FTNVL5&6 13.800	G5	36	40
FTNVL5&6 13.800	G6	36	40
JKFULGEN 0.6900	W1	199.5	250
LAMAR_DC 230.00	DC	0	210
TWNBUTTE 34.500	W1	60	75
SI_GEN 0.6000	1	25.5	30
TBII_GEN 0.6900	W	60	75
TI-18-0809 0.6300	PV	85	100
TI-19-1016 0.6300	PV	0	40
GI-2018-24 34.500	S1	212.5	250
PI-2020-2	S1	170	200
APT_DSLS 4.1600	G1	0	10
BAC_MSA GEN113.800	G1	0	90
BAC_MSA GEN213.800	G1	0	90
BAC_MSA GEN413.800	G1	25	40
BAC_MSA GEN413.800	G2	25	40
BAC_MSA GEN413.800	S1	20	24.8
BAC_MSA GEN513.800	G1	20	40
BAC_MSA GEN513.800	G2	30	40
BAC_MSA GEN513.800	S1	14	24.8
BAC_MSA GEN613.800	G1	0	40
BUSCHRNCH_LO0.7000	W1	30	59.4
BUSCHRWTG1 0.7000	G1	14	28.8
PEAKVIEWLO 0.7000	G1	22	60
PUB_DSLS 4.1600	G1	0	8

Bus Name	ID	Benchmark PGen (MW)	PMax (MW)
R.F.DSLS 4.1600	G1	0	10
BHCT-G29	PV	200	200

5.1.2 Study Case Modeling

A Study case was created from the Benchmark Case by modeling INFO-2020-7 at the Comanche 230kV Substation. The 125MW ERIS output from the generator was sunk to Pawnee.

5.1.3 Scenario-1 Case Modeling

The Scenario-1 Benchmark Case was created from the Benchmark case described in Section 5.1.1 by modeling Comanche 1 offline.

The Scenario-1 Study case was created from the Scenario-1 Benchmark case by modeling INFO-2020-7 at the Comanche 230kV Substation. The 125MW ERIS output from the generator was sunk to Pawnee.

5.1.4 Base Study Results

The results of the single contingency analysis are given in Table 2. The study identified generation dispatch conditions which eliminated the stressed condition single contingency overloads. There were no violations attributed to INFO-2020-7.

The results of the multiple contingency analysis are given in Table 3. Per TPL1-4, the multiple contingency overloads can be mitigated using system adjustments, including generation redispatch and/or operator actions. PSCo is in the process of identifying system mitigations which may include automatic generation adjustments schemes for the multiple contingencies between Comanche – Tundra – Daniels park Substations. These future mitigations will address existing and new overloads, and all GIRs in the Southern Colorado study pocket may become part of the mitigations and may be subject to automatic generation adjustments.

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

Xcel Energy

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-2020-7	Single Contingency Definition	Type of Overload	OPF Identified
				MVA Flow	% Line Loading	MVA Flow	% Line Loading				
Daniels Park – Prairie3 230kV	Line	PSCo	576	572.5	99.4%	587.5	102.0%	2.6%	Daniels park – Prairie1 230kV line	Beyond POI Sub	Yes
Daniels park – Prairie1 230kV line	Line	PSCo	576	578.3	100.4%	593.3	103.0%	2.6%	Daniels Park – Prairie3 230kV	Beyond POI Sub	Yes
West Canyon – Hogback 115kV	Line	BHE	120	123.8	103.2%	128.4	107.0%	3.8%	MidwayBR – West Canon 230kV line	Beyond POI Sub	Yes
West Canyon 230/115kv	Line	BHE	100	98.3	98.3%	102.8	102.8%	4.5%	MidwayBR – West Canon 230kV line	Beyond POI Sub	Yes

Table 3 – Overloads identified in Multiple Contingency Analysis

Overloaded Facility	Type	Owner	Facility Emergency Rating (MVA)	Facility Loading in Benchmark Case		Facility Loading in NRIS Study Case		% Change due to INFO-2020-7	Multiple Contingency Definition
				MVA Flow	% Line Loading	MVA Flow	% Line Loading		
Daniels Park – Fuller 230kV #1	Line	PSCo	478	631.4	132.1%	677.8	141.8%	9.7%	Comanche – Daniels Park 345kV #1 & Daniels Park – Tundra 345kV #1
MidwayPS – MidwayBR 230kV #1	Line	PSCo/ WAPA	525	578.0	110.1%	631.6	120.3%	10.2%	Comanche – Daniels Park 345kV #1 & Daniels Park – Tundra 345kV #1
MidwayPS – Fuller 230kV #1	Line	PSCo	382.4	426.4	111.5%	451.2	118.0%	6.5%	Comanche – Daniels Park 345kV #1 & Daniels Park – Tundra 345kV #1
Vollmer – Black Squirrel 115kV # 1	Line	TSGT	173	168.3	97.3%	177	102.3%	5.0%	Comanche – Daniels Park 345kV #1 & Daniels Park – Tundra 345kV #1
Vollmer – Fuller 115kV # 1	Line	TSGT	173	168.5	97.4%	177	102.3%	4.9%	Comanche – Daniels Park 345kV #1 & Daniels Park – Tundra 345kV #1

Overloaded Facility	Type	Owner	Facility Emergency Rating (MVA)	Facility Loading in Benchmark Case		Facility Loading in NRIS Study Case		% Change due to INFO-2020-7	Multiple Contingency Definition
				MVA Flow	% Line Loading	MVA Flow	% Line Loading		
Black Forest Tap – Black Squirrel MV 115kV # 1	Line	TSGT	143	139	97.2%	147.1	102.9%	5.7%	Comanche – Daniels Park 345kV #1 & Daniels Park – Tundra 345kV #1

5.1.5 Scenario-1 – Comanche 1 off Study Results

The single contingency analysis did not result in any violations. The results of the multiple contingency analysis are given in Table 4. Per TPL1-4, the multiple contingency overloads can be mitigated using system adjustments, including generation redispatch and/or operator actions. PSCo is in the process of identifying system mitigations which may include automatic generation adjustments schemes for the multiple contingencies between Comanche – Tundra – Daniels park Substations. These future mitigations will address existing and new overloads, and all GIRs in the Southern Colorado study pocket may become part of the mitigations and may be subject to automatic generation adjustments. The study did not identify any impacts to the Affected Systems.

Table 4 – Overloads identified in Multiple Contingency Analysis

Overloaded Facility	Type	Owner	Facility Emergency Rating (MVA)	Facility Loading in Benchmark Case		Facility Loading in NRIS Study Case		% Change due to INFO-2020-7	Multiple Contingency Definition
				MVA Flow	% Line Loading	MVA Flow	% Line Loading		
Daniels Park – Fuller 230kV #1	Line	PSCo	478	517.2	108.2%	561.6	117.5%	9.3%	Comanche – Daniels Park 345kV #1 & Daniels Park – Tundra 345kV #1
Midway – Fuller 230kV #1	Line	PSCo	382.4	365.6	95.6%	390	102.0%	6.4%	Comanche – Daniels Park 345kV #1 & Daniels Park – Tundra 345kV #1

6.0 Cost Estimates and Assumptions

The PSCo Engineering has developed cost estimates (with no accuracy) for Interconnection Facilities and Network/Infrastructure Upgrades required for the interconnection of INFO-2020-7 at the Comanche 230kV Substation. The cost estimates are based on 2021 dollars with escalation and contingencies applied. Allowances for Funds Used During Construction (AFUDC) is not included. These 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-2020-7 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 due.
- 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 the Comanche 230kV Substation.
- 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.

Figure 2 is a conceptual one-line of INFO-2020-7 POI at the Comanche 230kV Substation.

The estimated total cost of the Transmission Provider's Interconnection Facilities identified in the study are shown in Table 5.

Table 5 – Transmission Provider's Interconnection Facilities

Element	Description	Cost Est. (Millions)
PSCo's Comanche 230kV Substation	Interconnect Customer to connect to the 230kV bus at the Comanche Substation. The new equipment includes: - three (3) arresters 230 kV - one (1) switch gang 230 kV - equipment foundations - station wiring - one tower deadend	$1.02

	- three (3) transformer instrument CPVC	
	Transmission line tap into substation.	$0.050
	Siting and Land Rights support for siting studies, land and ROW acquisition and construction	$0.020
	Total Cost Estimate for Transmission Provider's Interconnection Facilities	**$1.09**
Time Frame	**Site, design, procure and construct**	**18 Months**

Table 6 – Station Network Upgrades

Element	**Description**	**Cost Est. (Millions)**
PSCo's Comanche 230kV Substation	The purpose of this project is to interconnect 125MW solar facility to Comanche substation at the 230kV Bus. The new equipment includes: - two (2) circuit breaker 230kV - five (5) switch gang 230 kV - equipment foundations - structures for Bus and Distribution - one (1) new EEE - one (1) Battery Storage & Charger - two (2) Tower Deadend - two (2) Transformer Special Voltage - Station Controls	$3.750
	Substation Communications Upgrades/Additions	$0.600
	Siting and Land Rights support for substation construction	$0.020
	Total Cost Estimate for Network Upgrades for ERIS	**$4.370**
Time Frame	**Site, design, procure and construct**	**18 Months**

7.0 Summary of Informational Interconnection Study Results:

Energy Resource Interconnection of INFO-2020-7 before Network Upgrades is 125MW

Energy Resource Interconnection Service of INFO-2020-7 is: 125MW

The total estimated cost of the transmission system improvements to interconnect INFO-2020-7 are: $5.46 Million (Tables 5 and 6)

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-2020-7 Interconnecting at the Comanche 230kV Substation