INFO-2021-1

Informational Interconnection Study Report

9/9/2021

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1.0 Summary

The report is an informational evaluation for interconnecting INFO-2021-1 for NRIS at the Green Valley 230kV Substation. The report studied INFO-2021-1 for 500MW NRIS and 1000MW NRIS.

500MW results:

The overloads and the corresponding mitigations identified in the study are given in Section 5.3.2 of this report.

The study identified TSGT as an impacted Affected System.

The total estimated cost of the transmission system improvements to interconnect INFO-2021-1 for 500MW NRIS is $115.935 Million (Tables 6, 7 and 8).

Network Resource Interconnection Service of INFO-2021-1 is 500MW.

1000MW results:

The overloads and the corresponding mitigations identified in the study are given in Section 5.3.1 of this report.

The study identified TSGT as an impacted Affected System.

The total estimated cost of the transmission system improvements to interconnect INFO-2021-1 for 1000MW NRIS is $197.735 Million (Tables 6, 7 and 9).

Network Resource Interconnection Service of INFO-2021-1 is 1000MW.

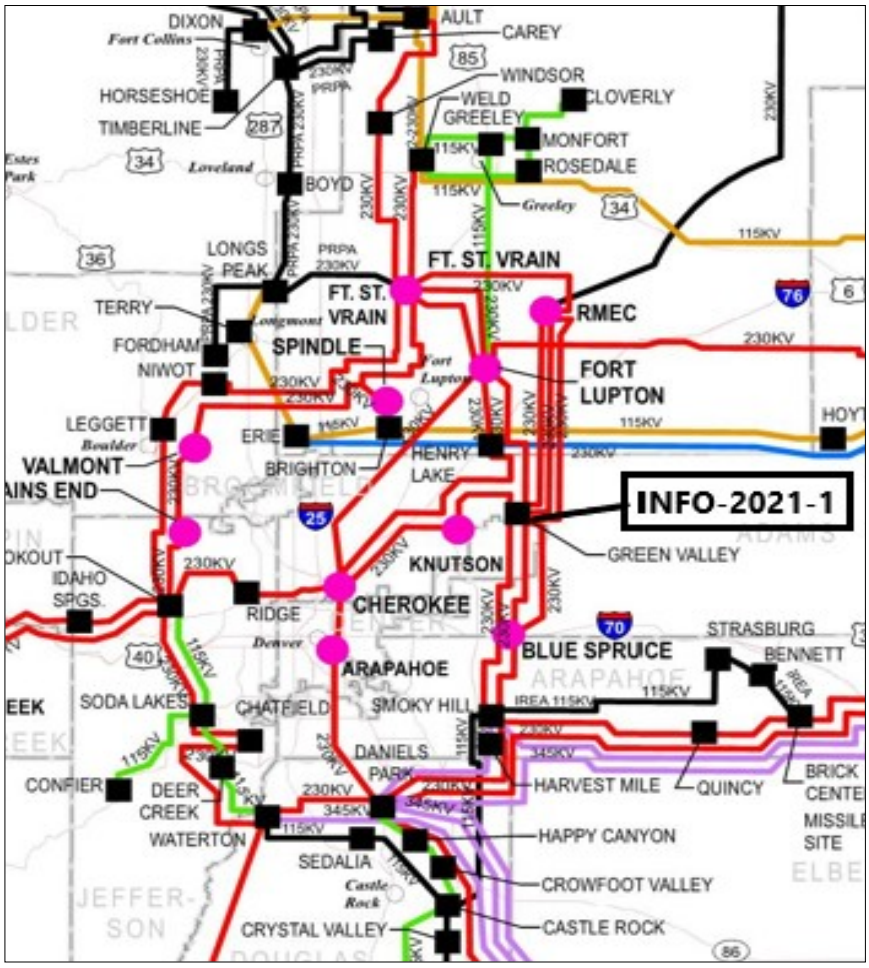
Note – This report is an informational study and does not grant any Interconnection Service or Transmission Service. The results are based on the modeling assumptions and study scope specified by the Customer, which may or may not reflect the standard modeling assumptions followed for the LGIP studies.

2.0 Introduction

INFO-2021-1 is a Hybrid Generating Facility composed of a 500MW Solar Photovoltaic (PV) facility plus a 500MW Battery Energy Storage (BES) facility. The study request included

evaluation INFO-2021-1 for a net 500MW Network Resource Interconnection Service (NRIS)[1] and a net 1000MW NRIS. The Point of Interconnection (POI) requested is the Green Valley 230kV Substation. The proposed Commercial Operation Date (COD) of INFO-2021-1 is May 1, 2023.The geographical location of the Transmission System near the POI is shown in Figure 1.

Figure 1 – Approximate Location of INFO-2021-1 POI



[1] 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.

3.0 Study Scope

The study was performed using the modeling assumptions specified by the Interconnection Customer. The study scope identified by the Customer includes power flow analysis to evaluate the steady state thermal and voltage limit violations. Per the Study Request, the 500MW and the 1000MW rated output of INFO-2021-1 is assumed to be delivered to PSCo native load, so existing PSCo generation is used to sink the generator output.

This report also provides cost estimates for Interconnection Facilities, Station Upgrades and Network Upgrades.

The study analyzed impacts to the PSCo Transmission System and the Affected Systems, while mitigations for PSCo system impacts are identified and costs are included in this report, Affected System impacts are identified but mitigations are not identified.

3.1 Study Pocket

The study analysis is based on the northern 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 System.

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 V34 and the TARA AC tool.

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 0.01p.u.

The Affected System included in the analysis is the Tri-State Generation and Transmission Inc. (TSGT) system in the study area.

4.0 Base Case Modeling Assumptions

Per the Customer's request, the Base Case was modeled per the standard Definitive Interconnection System Impact Study modeling assumptions. The study was performed using the 2023HS case.

The following approved transmission projects in PSCo's 10-year transmission plan, with in-service date before summer 2023 were modeled in the Base Case: (http://www.oasis.oati.com/woa/docs/PSCO/PSCOdocs/FERC_890_Q1_2021_Transmission_Plan_Presentation.pdf)

- Cloverly 115kV Substation – ISD 2021
- Graham Creek 115kV Substation – ISD 2022
- Husky 230/115kV Substation – ISD 2022
- Mirasol 230kV Substation – ISD 2022
- Avery Substation – ISD 2021
- Barker Substation – Bank1 ISD: 2021, Bank 2 ISD: 2022
- High Point Substation – ISD 2022
- Titan Substation – ISD 2022
- Dove Valley Substation – ISD 2023
- Monument – Flying Horse 115kV Series Reactor – ISD 2022
- Ault – Husky 230kV line – ISD 2022
- Husky – Graham Creek – Cloverly 115kV line – ISD 2022

- Gilman – Avon 115kV line – ISD 2022
- Climax – Robinson Rack – Gilman 115kV – ISD 2022
- Greenwood – Arapahoe – Denver Terminal 230kV – ISD 2022
- Upgrade Villa Grove – Poncha 69kV Line to 73MVA – ISD 2021
- Upgrade Poncha – Sargent - San Luis Valley 115kV line to 120MVA – ISD 2021
- Upgrade Antonito – Romeo – Old40Tap – Alamosa Terminal – Alamosa Switchyard 69kV line to 143MVA – ISD 2022/2023

All transmission facilities were modeled at their expected ratings for 2023 Summer season. Also, the following facility uprate projects were 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 756MVA – ISD to be determined
- Upgrade Greenwood – Priarie1 230kV line to 576MVA – ISD 2021
- Upgrade Daniels Park – Priarie3 230kV line to 756MVA – ISD to be determined
- 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 115 kV line modeled at 173 MVA – ISD 2022
- Fuller 230/115kV, 100MVA #2 transformer – ISD 2023

The following additional changes were made to the 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 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 South 115/230kV transformer project tapping the Cottonwood – Fuller 230kV line – ISD 2023

The Base Case model includes the existing PSCo generation resources and all Affected System's existing resources.

In addition, the following higher-queued generation from PSCo's queue were modeled in the Base Case: GI-2014-6, GI-2014-9, GI-2014-13, GI-2016-15, Transitional Cluster (GI-2018-24 , GI-2018-25, and GI-2019-6), 1RSC-2020 (1RSC-2020-1 and 1RSC-2020-2), DISIS-2020-001 (GI-2020-1, GI-2020-3, GI-2020-4, GI-2020-5, GI-2020-6, GI-2020-7, and GI-2020-10), 2RSC-2020 (2RSC-2020-5), DISIS-2020-002 (GI-2020-12, GI-2020-13, GI-2020-14, GI-2020-15 and GI-2020-16) and GI-2021-6 (3DISIS-2021-001[2]). While the higher-queued NRIS requests were dispatched at 100%, the higher-queued ERIS requests were modeled offline.

The following future generation connected to the Affected Systems are modeled in the Base Case:

IREA:

- 80MW Pioneer Solar PV Generating Facility interconnecting on the Victory – Brick Center 115kV line – COD 12/31/2020
- 45MW Hunter Solar PV Generating Facility interconnecting at Brick Center 115kV Substation – COD 2/1/2022
- 54.5MW Kiowa Solar PV Generating Facility interconnecting at Victory 115kV Substation – COD 4/1/2023

TSGT:

- TI-18-0809, 100MW NRIS/ERIS Solar, Walsenburg-Gladstone 230kV line

[2] The 3DISIS-2021-001 Phase 1 studies are ongoing at the time of this study, Since GI-2021-6 impacts INFO-2021-1, the GI is modeled in the study. The other GIs in 3DISIS-2021-001 were not expected to impact INFO-2021-1.

- TI-19-1016, 40MW NRIS/ERIS Solar, Walsenburg-Gladstone 230kV line

5.0 Study Analysis

The INFO-2021-1 is studied in the Northern Colorado study pocket.

5.1 Benchmark Case Modeling

The Benchmark Case was created from the Base Case by changing the study pocket generation dispatch as shown in Table 1.

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

Bus Name	ID	Status	PGen (MW)
CEDAR2_W1 0.66	W1	1	100
CEDAR2_W2 0.69	W2	1	80.6
CEDAR2_W3 0.66	W3	1	20
CEDARCK_1A 34.50	W1	1	176
CEDARCK_1B 34.50	W2	1	64
FTLUP1-2 13.80	G1	1	45
FTLUP1-2 13.80	G2	1	45
JMSHAFR1 13.80	G1	1	32.2
JMSHAFR1 13.80	G2	1	31.5
JMSHAFR2 13.80	ST	1	45.6
JMSHAFR3 13.80	G3	1	32.5
JMSHAFR3 13.80	ST	1	45
JMSHAFR4 13.80	G4	1	31.3
JMSHAFR4 13.80	G5	1	29.7
KNUTSON1 13.80	G1	1	58.1
KNUTSON2 13.80	G2	1	58.1
PAWNEE 22.00	C1	1	535
MANCHEF1 16.00	G1	0	0
MANCHEF2 16.00	G2	0	0
PLNENDG1_1 13.80	G0	1	4.9
PLNENDG1_1 13.80	G1	1	4.9
PLNENDG1_1 13.80	G2	1	4.9

Bus Name	ID	Status	PGen (MW)
PLNENDG1_1 13.80	G3	1	4.9
PLNENDG1_1 13.80	G4	1	4.9
PLNENDG1_1 13.80	G5	1	4.9
PLNENDG1_1 13.80	G6	1	4.9
PLNENDG1_1 13.80	G7	1	4.9
PLNENDG1_1 13.80	G8	1	4.9
PLNENDG1_1 13.80	G9	1	4.9
PLNENDG1_2 13.80	G0	1	4.9
PLNENDG1_2 13.80	G1	1	4.9
PLNENDG1_2 13.80	G2	1	4.9
PLNENDG1_2 13.80	G3	1	4.9
PLNENDG1_2 13.80	G4	1	4.9
PLNENDG1_2 13.80	G5	1	4.9
PLNENDG1_2 13.80	G6	1	4.9
PLNENDG1_2 13.80	G7	1	4.9
PLNENDG1_2 13.80	G8	1	4.9
PLNENDG1_2 13.80	G9	1	4.9
PLNENDG2_1 13.80	G1	1	7.3
PLNENDG2_1 13.80	G2	1	7.3
PLNENDG2_1 13.80	G3	1	7.3
PLNENDG2_1 13.80	G4	1	7.3
PLNENDG2_1 13.80	G5	1	7.3
PLNENDG2_1 13.80	G6	1	7.3
PLNENDG2_1 13.80	G7	1	7.3
PLNENDG2_2 13.80	G1	1	7.3
PLNENDG2_2 13.80	G2	1	7.3
PLNENDG2_2 13.80	G3	1	7.3
PLNENDG2_2 13.80	G4	1	7.3
PLNENDG2_2 13.80	G5	1	7.3
PLNENDG2_2 13.80	G6	1	7.3
PLNENDG2_2 13.80	G7	1	7.3
PLNENDG2_2 13.80	G1	1	7.3
RMEC1 15.00	G1	1	143.1
RMEC2 15.00	G2	1	143.1

Bus Name	ID	Status	PGen (MW)
RMEC3 23.00	ST	1	284.4
SPNDLE1 18.00	G1	1	141.3
SPNDLE2 18.00	G2	1	141.3
SPRUCE1 18.000	G1	1	145.8
SPRUCE2 18.000	G2	1	145.8
ST.VRAIN 22.00	ST	1	279
ST.VR_2 18.00	G2	1	121.4
ST.VR_3 18.00	G3	1	133.2
ST.VR_4 18.00	G4	1	137.7
ST.VR_5 18.00	G5	1	164.7
ST.VR_6 18.00	G6	1	164.7
VALMONT6 13.80	G6	0	0
VALMNT7 13.80	G7	0	0
VALMNT8 13.80	G8	0	0
MTNBRZ_W1 34.50	W1	1	135.2

5.2 Study Case Modeling

A Study case was created from the Benchmark Case by modeling INFO-2021-1 at the Green Valley 230kV Substation. The INFO-2021-1 output was balanced by reducing Comanche 2 in the 500MW Study Case, and reducing Comanche 2 & 3 in the 1000MW Study Case.

5.3 Steady State Analysis Results

5.3.1 INFO-2021-1 at 1000MW:

The results of the single contingency analysis are shown in Table 2. The 1000MW output of INFO-2021-1 caused several new overloads, and also increased the Benchmark Case pre-existing overloads on the California – Cherokee 115kV line, Capitol Hill – Denver Terminal 115kV and Cherokee 115/230kV transformer. The mitigations to the pre-existing overloads are expected to be adequate to mitigate the Study Case overloads, so the pre-existing overloads are not attributed to INFO-2021-1.

The following overloads and mitigations are attributed to INFO-2021-1:

- Bancroft – Gray St 115kV line overload for the loss of Allison – Soda Lakes 115kV line. Mitigation is to increase the Bancroft – Gray St 115kV line rating by reconductoring the line
- BarrLake – Reunion 230kV line overload for the loss of Green Valley – Imboden 230kV line. Mitigation is to increase the BarrLake – Reunion 230kV line rating by reconductoring the line
- Green Valley – Imboden 230kV line overload for the loss of Green Valley – Spruce 230kV line. Mitigation is to increase the Green Valley – Imboden 230kV line rating to by fixing FAC8 terminal equipment and reconductoring the underground portion of the line
- Capitol Hill – Mapleton 115kV line overload for the loss of Argo – Cherokee S 115kV line. Mitigation is to reconductor the underground portion of the line that is limiting the line rating.
- Cherokee – Lacombe 230kV line overload for the loss of Lookout – WestPS 230kV line. Mitigation is to increase the Cherokee – Lacombe 230kV line rating by fixing FAC8 terminal equipment
- Cherokee – SilverSaddle 230kV line overload for the loss of Fort Lupton – J L Green 230kV line. Mitigation is to increase the Cherokee – SilverSaddle 230kV line rating by reconductoring the line
- Clark – Jordan 230kV line overload for the loss of Buckley1 – Smoky Hill 230kV line #2. Mitigation is to reconductor the Clark – Jordan 230kV line to increase the line rating
- East – Chambers 115kV line overload for the loss of Fitzsmmonis – Chambers 115kV line. Mitigation is to reconductor the East – Chambers 115kV line to increase the line rating
- Meadows – Smoky Hill 230kV line overload for the loss of Buckley1 – Smoky Hill 230kV line #2. Mitigation is to increase the Meadows – Smoky Hill 230kV line rating by fixing FAC8 terminal equipment
- SkyRanch – Spruce 230kV line overload for the loss of Green Valley – Imboden 230kV line. Mitigation is to reconductor the SkyRanch – Spruce 230kV line and increase the line rating
- SkyRanch – GI-2021-6 230kV line overload for the loss of Green Valley – Imboden 230kV line. Mitigation is to reconductor the SkyRanch – GI-2021-6 230kV line and increase the line rating

- SmokyHill – Spruce 230kV line overload for the loss of Spruce - Powhaton 230kV line. Mitigation is to increase the SmokyHill – Spruce 230kV line rating by reconductoring the line
- SmokyHill – Powhaton 230kV line overload for the loss of SmokyHill – Spruce 230kV line. Mitigation is to increase the SmokyHill – Powhaton 230kV line rating by reconductoring the line
- Valmont 115/230kV # T7 overload for the loss of Valmont 115/230kV # T8. Since this overload is insignificant, it is not attributed to INFO-2021-1
- Valmont 115/230kV # T8 overload for the loss of Valmont 115/230kV # T7. Since this overload is insignificant, it is not attributed to INFO-2021-1
- Spruce – Powhaton 230kV line overload for the loss of SmokyHill – Spruce 230kV line. Mitigation is to reconductor the Spruce – Powhaton 230kV line to increase the line rating
- Fitzsmmonis – Chambers 115kV line overload for the loss of East – Chambers 115kV line. Mitigation is to increase the Fitzsmmonis – Chambers 115kV line rating by reconductoring the line
- HenryLake 115/230kV # T1 overload is attributed to INFO-2021-1. This is a facility owned by TSGT and identifying mitigations to Affected System violations is outside the scope of this study. TSGT has been identified as an impacted Affected System

Table 2 – Overloads identified in Single Contingency Analysis. INFO-2021-1 at 1000MW

Overloaded Facility	Type	Owner	Facility Normal Rating (MVA)	Facility Loading in Benchmark Case		Facility Loading in Study Case		% Change due to INFO-2021-1	Single Contingency Definition
				MVA Flow	% Line Loading	MVA Flow	% Line Loading		
Bancroft - Gray St 115kV	Line	PSCo	193	188.0	97.4%	195.0	101.1%	3.7%	Allison – Soda Lake 115kV Line
BarrLake - Reunion 230kV	Line	PSCo	478	455.5	95.3%	617.7	129.2%	33.9%	Green Valley – Imboden 230kV Line
Green Valley - Imboden 230kV	Line	PSCo	567	439.4	77.5%	735.7	129.8%	52.3%	Green Valley - Spruce 230kV Line

Overloaded Facility	Type	Owner	Facility Normal Rating (MVA)	Facility Loading in Benchmark Case		Facility Loading in Study Case		% Change due to INFO-2021-1	Single Contingency Definition
				MVA Flow	% Line Loading	MVA Flow	% Line Loading		
California - Cherokee 115kV	Line	PSCo	137	143.9	105.0%	153.3	111.9%	6.9%	Cherokee - Mapleton Line#2
Capitol Hill - Denver Terminal 115kV	Line	PSCo	131	135.9	103.8%	147.2	112.4%	8.6%	Argo - Cherokee S 115kV Line
Capitol Hill - Mapleton 115kV	Line	PSCo	182	171.8	94.4%	183.8	101.0%	6.6%	Argo - Cherokee S 115kV Line
Cherokee - Lacombe 230kV	Line	PSCo	435	390.3	89.7%	539.6	124.1%	34.4%	Lookout - West PS 230kV
Cherokee – Silver Saddle 230kV	Line	PSCo	478	382.5	80.0%	525.6	110.0%	30%	Ft. Lupton - JLGreen 230kV Line
Cherokee 115/230kV Transformer #1	Xfmr	PSCo	280	285.1	101.8%	315.5	112.7%	10.9%	Cherokee - Lacombe 230kV
Clark - Jordan 230kV	Line	PSCo	331	308.7	93.3%	415.6	125.6%	32.3%	Buckley1 – Smoky Hill 230kV Line#2
East - Chambers 115kV	Line	PSCo	159	137.3	86.3%	166.1	104.4%	18.1%	Fitzmonis - Chambers 115kV Line
Meadow Hill – Smoky Hill 230kV	Line	PSCo	564	470.9	83.5%	578.9	102.6%	19.1%	Buckley1 – Smoky Hill 230kV Line#2
Sky Ranch - Spruce 230kV	Line	PSCo	484	385.5	79.7%	594.7	122.9%	43.2%	Green Valley - Imboden 230kV
SkY Ranch - GI-2021-6 230kV	Line	PSCo	484	407.1	84.1%	617.4	127.6%	43.5%	Green Valley - Imboden 230kV
Smoky Hill - Spruce 230kV	Line	PSCo	717	624.9	87.2%	1054.6	147.1%	59.9%	Spruce - Powhaton 230kV
Smoky Hill - Powhaton 230kV	Line	PSCo	740	614.6	83.1%	1043.4	141.0%	57.9%	Smoky Hill - Spruce 230kV
Valmont 115/230kV #T7	Xfmr	PSCo	280	279.3	99.8%	283.0	101.1%	1.3%	Valmont 115/230kV Transfer #8
Valmont 115/230kV #T8	Xfmr	PSCo	280	279.3	99.8%	283.0	101.1%	1.3%	Valmont 115/230kV Transformer #7
Spruce - Powhaton 230kV	Line	PSCo	717	626.1	87.3%	1055.1	147.2%	59.9%	Smoky Hill - Spruce 230kV Line
Fitzmonis - Chambers 115kV Line	Line	PSCo	159	138.1	86.9%	166.3	104.6%	17.7%	East - Chambers 115kV Line
Henry Lake 115/230kV #T1	Xfmr	TSGT	100	100	100%	109.4	109.4%	9.4%	Barr Lake - Reunion 230 kV

The results of the multiple contingency analysis are given in Table 3. Per TPL1-4, multiple contingency overloads on the PSCo facilities and Affected System facilities will be mitigated using system adjustments, including generation redispatch (including the GI under study) and/or operator actions.

Table 3 – Overloads identified in Multiple Contingency Analysis. INFO-2021-1 at 1000MW

Overloaded Facility	Type	Owner	Facility Emerge-ncy Rating (MVA)	Facility Loading in Benchmark Case		Facility Loading in Study Case		% Change due to INFO-2021-1	Multiple Contingency Definition
				MVA Flow	% Line Loading	MVA Flow	% Line Loading		
Allison – Soda Lake 115kV Line	Line	PSCo	174	244.4	140.5%	246.5	141.7%	1.2%	Gray St - Bancroft 115kV & Bancroft - South 1 115kV & South 1 - Arap B 115kV
Barr Lake - Green Valley 230kV	Line	PSCo	478	289.8	60.6%	536.6	112.3%	51.7%	SmokyHill - Spruce 230kV & SmokyHill - Powhaton 230kV & Spruce - Powathon 230kV
Barr Lake - Reunion 230kV	Line	PSCo	478	584.7	122.3%	838.9	175.5%	53.2%	SmokyHill - Spruce 230kV & SmokyHill - Powhaton 230kV & Spruce - Powathon 230kV
Green Valley - Imboden 230kV	Line	PSCo	624	425.6	68.2%	723.9	116.0%	47.8%	Green Valley - Keenesburg Line #2 230kV & Green Valley - Spruce 230kV
Green Valley -Spruce 230kV	Line	PSCo	717	625.5	87.2%	1026.1	143.1%	55.9%	Skyranch - Spruce 230kV & Skyranch - High Pt. 230kV & High Pt. - Imboden 230kV & Green Valley - Imboden 230kV
Green Valley - GI-2021-6 230kV	Line	PSCo	555	391.3	70.5%	752	135.5%	65.0%	Green Valley - Keenesburg Line #1 230kV & Green Valley - Imboden 230kV & Imboden - High Pt 230kV & High Pt - Green Valley 230kV
California - Cherokee 115kV	Line	PSCo	151	159.5	105.6%	177	117.2%	11.6%	Cherokee - Lacombe 230kV & Argo - Cherokee S 115kV
Capitol Hill - Denver Terminal 115kV	Line	PSCo	145	165.4	114.0%	190.3	131.2%	17.2%	Cherokee - Lacombe 230kV & Argo - Cherokee S 115kV
Capitol Hill - Mapleton 115kV	Line	PSCo	200	202.1	101.1%	228.2	114.1%	13.0%	Cherokee - Lacombe 230kV & Argo - Cherokee S 115kV

Overloaded Facility	Type	Owner	Facility Emerge-ncy Rating (MVA)	Facility Loading in Benchmark Case		Facility Loading in Study Case		% Change due to INFO-2021-1	Multiple Contingency Definition
				MVA Flow	% Line Loading	MVA Flow	% Line Loading		
Cherokee - Lacombe 230kV	Line	PSCo	506	549.1	108.5%	863.3	170.6%	62.1%	SmokyHill - Spruce 230kV & SmokyHill - Powhaton 230kV & Spruce - Powhaton 230kV
Cherokee – Silver Saddle 230kV	Line	PSCo	478	489.6	102.4%	737.1	154.2%	51.8%	SmokyHill - Spruce 230kV & SmokyHill - Powhaton 230kV & Spruce - Powhaton 230kV
Cherokee 115/230kV #1	Xfmr	PSCo	317	292	92.1%	323.4	102.0%	9.9%	Denver Terminal - Lacombe 230kV & Denver Terminal - West PS - Lookout 230kV
Cherokee - Mapleton 115kV #2	Line	PSCo	239	234.9	98.3%	261.6	109.4%	11.1%	Cherokee - Lacombe 230kV & Argo - Cherokee S 115kV
Cherokee - Conoco 115kV	Line	PSCo	213	165.7	77.8%	221.3	103.9%	26.1%	SmokyHill - Spruce 230kV & SmokyHill - Powhaton 230kV & Spruce - Powhaton 230kV
Clark - Jordan 230kV	Line	PSCo	364	376.7	103.5%	491.9	135.1%	31.6%	Leetsdale - Jewell2 - Tolgate - Buckley 2 -SmokyHill 230kV & SmokyHill - Buckley1 - Jewell1 - Sullivan 230kV
Denver Terminal - Gray St 115kV	Line	PSCo	239	254.9	106.7%	265.3	111.0%	4.3%	Isabelle - Ft St Vrain 230kV & Valmont - Spindle 230kV
Denver Terminal - Lacombe 230kV	Line	PSCo	568	459.9	80.9%	769.1	135.4%	54.5%	SmokyHill - Spruce 230kV & SmokyHill - Powhaton 230kV & Spruce - Powathon 230kV
East – Smoky Hill 115kV	Line	PSCo	145	68.4	47.2%	138.5	115.5%	68.3%	SmokyHill - Spruce 230kV & SmokyHill - Powhaton 230kV & Spruce - Powhaton 230kV
East - Fitzmonis 115kV	Line	PSCo	145	93.1	64.2%	159.1	109.7%	45.5%	SmokyHill - Spruce 230kV & SmokyHill - Powhaton 230kV & Spruce - Powathon 230kV
East - Chambers 115kV	Line	PSCo	175	151.5	86.6%	227.5	130.0%	43.4%	SmokyHill - Spruce 230kV & SmokyHill - Powhaton 230kV & Spruce - Powhaton 230kV
Havana1 - Chambers 115kV	Line	PSCo	175	127.2	72.7%	176.3	100.8%	28.1%	SmokyHill - Spruce 230kV & SmokyHill - Powhaton 230kV & Spruce - Powhaton 230kV

Overloaded Facility	Type	Owner	Facility Emerge-ncy Rating (MVA)	Facility Loading in Benchmark Case		Facility Loading in Study Case		% Change due to INFO-2021-1	Multiple Contingency Definition
				MVA Flow	% Line Loading	MVA Flow	% Line Loading		
Meadow Hill – Smoky Hill 230kV	Line	PSCo	621	537.8	86.6%	653.8	105.3%	18.7%	Leetsdale - Jewell2 - Tolgate - Buckley 2 -SmokyHill 230kV & SmokyHill - Buckley1 - Jewell1 - Sullivan 230kV
Sky Ranch - Spruce 230kV	Line	PSCo	555	569.3	102.6%	921.3	166.0%	63.4%	Green Valley - Keenesburg Line #1 230kV & Green Valley - Imboden 230kV & Imboden - High Pt 230kV & High Pt - Green Valley 230kV
Sky Ranch - GI-2021-6 230kV	Line	PSCo	555	591	106.5%	943.8	170.1%	63.6%	Green Valley - Keenesburg Line #1 230kV & Green Valley - Imboden 230kV & Imboden - High Pt 230kV & High Pt - Green Valley 230kV
Smoky Hill - Spruce 230kV	Line	PSCo	717	512.6	71.5%	790.4	110.2%	38.7%	Spruce - Chambers 230kV & Spruce - Picadilly - Tower - Chambers 230kV
Fitzsmmonis - Chambers 115kV Line	Line	PSCo	175	155.5	88.9%	222.4	127.1%	38.3%	SmokyHill - Spruce 230kV & SmokyHill - Powhaton 230kV & Spruce - Powhaton 230kV
Chambers 115/230kV T1	Xfmr	PSCo	319	280.1	87.8%	396	124.1%	36.3%	SmokyHill - Spruce 230kV & SmokyHill - Powhaton 230kV & Spruce - Powhaton 230kV
Chambers 115/230kV T2	Xfmr	PSCo	319	280.1	87.8%	396	124.1%	36.3%	SmokyHill - Spruce 230kV & SmokyHill - Powhaton 230kV & Spruce - Powhaton 230kV
Henry Lake 115/230 T1	Xfmr	TSGT	100	115.5	115.5%	127.3	127.3%	11.9%	Cherokee - Henry Lake 230kV & Barr Lake - Reunion 230kV
Silver Saddle - Reunion 230kV	Line	PSCo	648	524.2	80.9%	772.5	119.2%	38.3%	SmokyHill - Spruce 230kV & SmokyHill - Powhaton 230kV & Spruce - Powhaton 230kV

5.3.2 INFO-2021-1 at 500MW:

The results of the single contingency analysis are shown in Table 4.

Addition of INFO-2021-1 at 500MW caused several new overloads and increased the Benchmark Case pre-existing overloads on the California – Cherokee 115kV line, Capitol Hill – Denver Terminal 115kV and Cherokee 115/230kV transformer. The mitigations to the pre-existing overloads are expected to be adequate to mitigate the Study Case overloads, so the pre-existing overloads are not attributed to INFO-2021-1.

The following overloads and mitigations are attributed to INFO-2021-1:

- BarrLake – Reunion 230kV line overload for the loss of Green Valley – Imboden 230kV line. Mitigation is to increase the BarrLake – Reunion 230kV line rating by reconductoring the line
- Green Valley – Imboden 230kV line overload for the loss of Green Valley – Spruce 230kV line. Mitigation is to increase the Green Valley – Imboden 230kV line rating to by fixing FAC8 terminal equipment and reconductoring the underground portion of the line
- Cherokee – Lacombe 230kV line overload for the loss of Lookout – WestPS 230kV line. Mitigation is to increase the Cherokee – Lacombe 230kV line rating by fixing FAC8 terminal equipment
- Clark – Jordan 230kV line overload for the loss of Buckley1 – Smoky Hill 230kV line #2. Mitigation is to reconductor the Clark – Jordan 230kV line to increase the line rating
- SkyRanch – Spruce 230kV line overload for the loss of Green Valley – Imboden 230kV line. Mitigation is to reconductor the SkyRanch – Spruce 230kV line and increase the line rating
- SkyRanch – GI-2021-6 230kV line overload for the loss of Green Valley – Imboden 230kV line. Mitigation is to reconductor the SkyRanch – GI-2021-6 230kV line and increase the line rating
- SmokyHill – Spruce 230kV line overload for the loss of Spruce - Powhaton 230kV line. Mitigation is to increase the SmokyHill – Spruce 230kV line rating by reconductoring the line
- SmokyHill – Powhaton 230kV line overload for the loss of SmokyHill – Spruce 230kV line. Mitigation is to increase the SmokyHill – Powhaton 230kV line rating by fixing terminal equipment limitations

- Spruce – Powhaton 230kV line overload for the loss of SmokyHill – Spruce 230kV line. Mitigation is to increase the SmokyHill – Powhaton 230kV line rating by fixing terminal equipment limitations
- HenryLake 115/230kV # T1 overload is attributed to INFO-2021-1. This is a facility owned by TSGT and identifying mitigations to Affected System violations is outside the scope of this study. TSGT has been identified as an impacted Affected System

Table 4 – Overloads identified in Single Contingency Analysis. INFO-2021-1 at 500MW

Overloaded Facility	Type	Owner	Facility Normal Rating (MVA)	Facility Loading in Benchmark Case		Facility Loading in Study Case		% Change due to INFO-2021-1	Single Contingency Definition
				MVA Flow	% Line Loading	MVA Flow	% Line Loading		
BarrLake - Reunion 230 kV	Line	PSCo	478	464.8	97.2%	537.4	112.4%	15.2%	Ft. Lupton - JLGreen 230kV Line
Green Valley - Imboden 230kV	Line	PSCo	567	439.4	77.5%	587.3	103.6%	26.1%	Green Valley - Spruce 230kV Line
California - Cherokee 115kV	Line	PSCo	137	143.9	105.0%	148.4	108.3%	3.3%	Cherokee - Mapleton Line#2
Capitol Hill - Denver Terminal 115kV	Line	PSCo	131	135.9	103.8%	144.3	110.1%	6.3%	Cherokee - Lacombe 230kV Line
Cherokee - Lacombe 230kV	Line	PSCo	435	390.3	89.7%	464.1	106.7%	17.0%	Lookout - West PS 230kV
Cherokee 115/230kV #1	Line	PSCo	280	285.1	101.8%	292.4	104.4%	2.6%	Cherokee - Lacombe 230kV Line
Clark - Jordan 230kV	Line	PSCo	331	308.7	93.3%	362.3	109.4%	16.1%	Buckley1 – Smoky Hill 230kV Line#2
Denver Terminal - Gray St 115kV	Line	PSCo	239	206.4	99.7%	250.7	104.9%	5.2%	Leetsdale 1 - University 115kV Line#1
Sky Ranch - Spruce 230kV	Line	PSCo	484	385.5	79.7%	489	101.0%	21.3%	Green Valley - Imboden 230kV
Sky Ranch - GI-2021-6 230kV	Line	PSCo	484	407.1	84.1%	511.3	105.6%	21.5%	Green Valley - Imboden 230kV
Smoky Hill - Spruce 230kV	Line	PSCo	717	624.9	87.2%	839.1	117.0%	29.8%	Spruce - Powhaton 230kV
Smoky Hill - Powhaton 230kV	Line	PSCo	740	614.6	83.1%	828.3	111.9%	28.8%	Smoky Hill - Spruce 230kV
Spruce - Powhaton 230kV	Line	PSCo	717	626.1	87.3%	839.9	117.1%	29.8%	Smoky Hill - Spruce 230kV Line
Henry Lake 115/230 # T1	Line	TSGT	100	100	100%	105.1	105.1%	5.1%	Barr Lake - Reunion 230 kV

The results of the multiple contingency analysis are given in Table 5. Per TPL1-4, multiple contingency overloads on the PSCo facilities and Affected System facilities will be mitigated using system adjustments, including generation redispatch (including the GI under study) and/or operator actions

Table 5 – Overloads identified in Multiple Contingency Analysis. INFO-2021-1 at 500MW

Overloaded Facility	Type	Owner	Facility Emerge-ncy Rating (MVA)	Facility Loading in Benchmark Case		Facility Loading in Study Case		% Change due to INFO-2021-1	Multiple Contingency Definition
				MVA Flow	% Line Loading	MVA Flow	% Line Loading		
Barr Lake - Reunion 230kV	Line	PSCo	478	584.7	122.3%	710.4	148.6%	26.3%	Smokyhill - Spruce 230kV & Smokyhill - Powhaton 230kV & Spruce - Powathon 230kV
Green Valley -Spruce 230kV	Line	PSCo	717	625.5	87.2%	824.6	115.0%	27.8%	Skyranch - Spruce 230kV & Skyranch - High Pt. 230kV & High Pt. - Imboden 230kV & Green Valley - Imboden 230kV
Green Valley - GI-2021-6 230kV	Line	PSCo	555	391.3	70.5%	571.0	102.9%	32.4%	Green Valley - Keenesburg Line #1 230kV & Green Valley - Imboden 230kV & Imboden - High Pt 230kV & High Pt - Green Valley 230kV
California - Cherokee 115kV	Line	PSCo	151	159.5	105.6%	167.2	110.7%	5.1%	Cherokee - Lacombe 230kV & Argo - Cherokee S 115kV
Capitol Hill - Denver Terminal 115kV	Line	PSCo	145	165.4	114.0%	179.8	124.0%	10.0%	Cherokee - Lacombe 230kV & Argo - Cherokee S 115kV
Capitol Hill - Mapleton 115kV	Line	PSCo	200	202.1	101.1%	215.2	107.6%	6.5%	Cherokee - Lacombe 230kV & Argo - Cherokee S 115kV
Cherokee - Lacombe 230kV	Line	PSCo	506	549.1	108.5%	703.5	139.0%	30.5%	Smokyhill - Spruce 230kV & Smokyhill - Powhaton 230kV & Spruce - Powathon 230kV
Cherokee – Silver Saddle 230kV	Line	PSCo	478	489.6	102.4%	611.9	128.0%	25.6%	Smokyhill - Spruce 230kV & Smokyhill - Powhaton 230kV & Spruce - Powathon 230kV

Overloaded Facility	Type	Owner	Facility Emerge-ncy Rating (MVA)	Facility Loading in Benchmark Case		Facility Loading in Study Case		% Change due to INFO-2021-1	Multiple Contingency Definition
				MVA Flow	% Line Loading	MVA Flow	% Line Loading		
Cherokee - Mapleton 115kV #2	Line	PSCo	239	234.9	98.3%	247.8	103.7%	5.4%	Cherokee - Lacombe 230kV & Argo - Cherokee S 115kV
Clark - Jordan 230kV	Line	PSCo	364	376.7	103.5%	434.5	119.4%	15.9%	Leetsdale - Jewell2 - Tolgate - Buckley 2 - Smokyhill 230kV & Smokyhill -Buckley1 - Jewell1 - Sullivan 230kV
Denver Terminal - Gray St 115kV	Line	PSCo	239	254.9	106.7%	258.8	108.3%	1.6%	Isabelle - Ft St Vrain 230kV & Valmont - Spindle 230kV
Denver Terminal - Lacombe 230kV	Line	PSCo	568	459.9	80.9%	611.0	107.6%	26.7%	Smokyhill - Spruce 230kV & Smokyhill - Powhaton 230kV & Spruce - Powathon 230kV
East - Chambers 115kV	Line	PSCo	175	151.5	86.6%	188.5	107.7%	21.1%	Smokyhill - Spruce 230kV & Smokyhill - Powhaton 230kV & Spruce - Powathon 230kV
Sky Ranch - Spruce 230kV	Line	PSCo	555	569.3	102.6%	743.7	134.0%	31.4%	Green Valley - Keenesburg Line #1 230kV & Green Valley - Imboden 230kV & Imboden - High Pt 230kV & High Pt - Green Valley 230kV
Sky Ranch - GI-2021-6 230kV	Line	PSCo	555	591.0	106.5%	765.9	138.0%	31.5%	Green Valley - Keenesburg Line #1 230kV & Green Valley - Imboden 230kV & Imboden - High Pt 230kV & High Pt - Green Valley 230kV
Fitzsmmonis - Chambers 115kV Line	Line	PSCo	175	155.5	88.9%	187.9	107.4%	18.5%	Smokyhill - Spruce 230kV & Smokyhill - Powhaton 230kV & Spruce - Powathon 230kV
Chambers 115/230kV T1	Xfmr	PSCo	319	280.1	87.8%	339.1	106.3%	18.5%	Smokyhill - Spruce 230kV & Smokyhill - Powhaton 230kV & Spruce - Powathon 230kV
Chambers 115/230kV T2	Xfmr	PSCo	319	280.1	87.8%	339.1	106.3%	18.5%	Smokyhill - Spruce 230kV & Smokyhill - Powhaton 230kV & Spruce - Powathon 230kV
Henry Lake 115/230 T1	Xfmr	TSGT	100	115.5	115.5%	121.4	121.4%	5.9%	Cherokee - Henry Lake 230kV & Barr Lake - Reunion 230kV

6.0 Cost Estimates and Assumptions

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.

The estimated total cost for the required upgrades to interconnect 500MW NRIS of INFO-2021-1 is **$115.935 Million.**

The estimated total cost for the required upgrades to interconnect 1000MW NRIS of INFO-2021-1 is **$197.735 Million.**

Figure 1 below is a conceptual one-line of the POI.

The total cost of the Transmission Provider's Interconnection Facilities and Station Network Upgrades are shown in Table 6 and Table 7 respectively.

The total cost of Transmission Network Upgrades (beyond POI) for the 500MW NRIS and 1000MW NRIS are given in Table 8 and Table 9 respectively.

The cost responsibilities associated with these facilities shall be handled as per current FERC guideline. System improvements are subject to revision as a more detailed and refined design is produced.

- Labor is estimated for straight time only – no overtime included.
- Lead times for materials were considered for the schedule.
- 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 Green Valley 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.
- 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, but a CPCN may be required for the Transmission Upgrades identified in Table 8 and Table 9. It is anticipated that the CPCN approval may take 18 months and the construction timeframe following the CPCN and all regulatory approvals is expected to take 36 months, resulting in total 48 month estimate shown in the tables.

Table 6 – Transmission Provider's Interconnection Facilities

Element	Description	Cost Est. (Millions)
PSCo's Green Valley 230kV Substation	Interconnect INFO-2021-1 at the Green Valley Substation 230kV bus. The new equipment includes: • Three (2) 230kV deadend structures • Three (3) 230kV arresters • One (1) 230kV Switch • One set (of three) high side metering units • Fiber communication equipment • Station controls • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures • Associated transmission line communications, fiber, relaying and testing.	$1.042
	Transmission line tap into substation.	$0.075
	Siting and Land Rights support for permitting and construction.	$0.020
	Total Cost Estimate for Transmission Providers Interconnection Facilities	**$1.137**
Time Frame	**Site, design, procure and construct**	**18 Months**

Table 7 – Station Network Upgrades

Element	Description	Cost Est. (Millions)
PSCo's Green Valley 230kV Substation	Expand the Green Valley 230kV Substation to interconnect INFO-2021-1. The new equipment includes: •Five (5) 230kV gang switches •Two (2) 230kV circuit breakers •Associated bus, wiring and equipment •Associated foundations and structures •Associated transmission line communications, relaying and testing	$2.178
	Siting and Land Rights support for permitting, and construction	$0.020
	Total Cost Estimate for Network Upgrades for Interconnection	**$2.198**
Time Frame	**Site, design, procure and construct**	**18 Months**

Table 8 – Transmission Network Upgrades – INFO-2021-1 at 500MW

Element	Description	Cost Est. (Millions)

Barr Lake - Reunion 230 kV L5875	Reconductor line and replace deadends/angles and 10 tangents.	$6.100
Green Valley - Imboden 230kV L5277	Replace Station jumpers.	$0.100
Green Valley - Imboden 230kV L9547	Reconductor UG line	$40.000
Cherokee - Lacombe 230kV L5057	Replace Station jumpers.	$0.100
Clark - Jordan 230kV L5435	Reconductor UG line	$43.000
Sky Ranch - Spruce 230kV L5735	Replace Station jumpers.	$0.100
Sky Ranch - GI-2021-6 230kV L5275	Reconductor UG line. Replace Station jumpers.	$1.500
Smoky Hill - Spruce 230kV L5177	Reconductor line and replace 12 deadends/angles and 50 tangents. Replace Station bus, relays and 230kV breaker.	$16.700
Smoky Hill – Powhaton – Spruce 230kV L5171	Replace Station bus, relays and 230kV breaker.	$5.000
	Total Cost Estimate for Network Upgrades for Interconnection	**$112.6000**
Time Frame	**Site, design, procure and construct**	**48 Months**

Table 9 – Transmission Network Upgrades – INFO-2021-1 at 1000MW

Element	Description	Cost Est. (Millions)
Bancroft - Gray St 115kV L9448	Reconductor line and replace all deadends/angles and 3 tangents. Replace Station jumpers.	$4.100
Barr Lake - Reunion 230 kV L5875	Reconductor line and replace deadends/angles and 10 tangents. Replace Station bus, relays and add new 230kV breaker.	$7.100
Green Valley - Imboden 230kV L5277	Replace Station bus and relays.	$0.300
Green Valley - Imboden 230kV L9547	Reconductor UG line	$40.000
Cherokee - Lacombe 230kV L5057	Replace Station jumpers.	$0.400
Cherokee - SILVSADL 230kV L5055	Reconductor line and replace deadends/angles and tangents. Replace Station bus and relays.	$2.600
Cap Hill - Mapleton 115kV L9547	Reconductor UG line	$40.000
Clark - Jordan 230kV L5435	Reconductor UG line	$44.000
East - Chambers 115kV L9175	Reconductor line and replace deadends/angles and 2 tangents.	$2.2000
Meadow Hills – Smoky Hill 230kV L5169	Replace Station jumpers.	$0.100
Sky Ranch - Spruce 230kV L5735	Reconductor line and replace 2 deadends/angles. Replace Station jumpers and bus.	$0.900
Sky Ranch - GI-2021-6 230kV L5275	Reconductor line and replace 3 deadends/angles and 2 tangents. Replace Station jumpers and bus.	$1.600
Smoky Hill - Spruce 230kV L5177	Reconductor line and replace 12 deadends/angles and 50 tangents. Replace Station bus, relays and 230kV breakers.	$16.700
Smoky Hill - Powhaton 230kV L5171	Reconductor line and replace 10 deadends/angles and 17 tangents.	$6.900

Spruce - Powhaton 230kV L5171	Reconductor line and replace 10 deadends/angles and 17 tangents. Replace Station bus, relays and 230kV breakers	$10.500
Fitzsimons - Chambers 115kV L9178	Reconductor line and replace 3 deadends/angles and 2 tangents.	$1.000
Chambers T1	Replace Bank T1 and low and high side breakers.	$8.000
Chambers T2	Replace Bank T2 and low and high side breakers.	$8.000
	Total Cost Estimate for Network Upgrades for Interconnection	**$194.400**
Time Frame	**Site, design, procure and construct**	**48 Months**

7.0 Summary of Informational Interconnection Study Results:

500MW results:

The study identified TSGT as an impacted Affected System. Identifying mitigations to Affected System violations are not within the scope of the study.

The total estimated cost of the transmission system improvements to interconnect INFO-2021-1 for 500MW NRIS is $115.935 Million (Tables 6, 7 and 8).

Network Resource Interconnection Service of INFO-2021-1 is 500MW.

Construction of the Transmission Network Upgrades is expected to require a CPCN

1000MW results:

The study identified TSGT as an impacted Affected System. Identifying mitigations to Affected System violations are not within the scope of the study.

The total estimated cost of the transmission system improvements to interconnect INFO-2021-1 for 1000MW NRIS is $197.735 Million (Tables 6, 7 and 9).

Network Resource Interconnection Service of INFO-2021-1 is 1000MW.

Construction of the Transmission Network Upgrades is expected to require a CPCN

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.

Figure 2 – Preliminary One-line of INFO-2021-1 POI at the Green Valley 230kV substation.