Provisional Interconnection Study Report for GI-2021-1

200MW at Comanche 230kV

(in 3DISIS-2021-001)

7/9/2021

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1.0 Executive Summary

The “PI-2021-1” is the Provisional Interconnection request for Generation Interconnection Request GI-2021-1 in the 3DISIS-2021-001 Cluster.

The GI-2021-1 is a new 200MW Solar Photovoltaic Generating Facility with POI at the Comanche 230kV Substation.

The total estimated cost of the transmission system improvements required for GI-2021-1 to qualify for Provisional Interconnection Service is $2.398 Million (Tables 6 and 7).

The Provisional Interconnection Service of GI-2021-1 is 200MW.

Security: As stated in the study agreement, assuming GI-2021-1 in 3DISIS-2021-001 selects Energy Resource Interconnection Service (ERIS), the security associated with the Network Upgrades that might be identified at the conclusion of the GI-2021-1 Large Generation Interconnection Procedure (LGIP) in the 3DISIS-2021-001 cluster is estimated to be approximately $5 Million.

The Interconnection Customer assumes all risk and liabilities with respect to changes between the PLGIA and the LGIA, including changes in output limits and Interconnection Facilities, Network Upgrades, Distribution Upgrades, and/or System Protection Facilities cost responsibility.

It is expected that the Interconnection of GI-2021-1 at the Comanche 230kV Substation will require a CPCN. The estimated time for CPCN approval is expected to be 18 months. The estimated time for the construction of transmission system improvements required to accommodate the interconnection is expected to be 18 months after receiving all approvals, including CPCN.

Note: Provisional Interconnection Service in and of itself, does not convey transmission service.

2.0 Introduction

The PI-2021-1 is the Provisional Interconnection Service[1] request for GI-2021-1 (GI) in the 3DISIS-2021-001 Cluster.

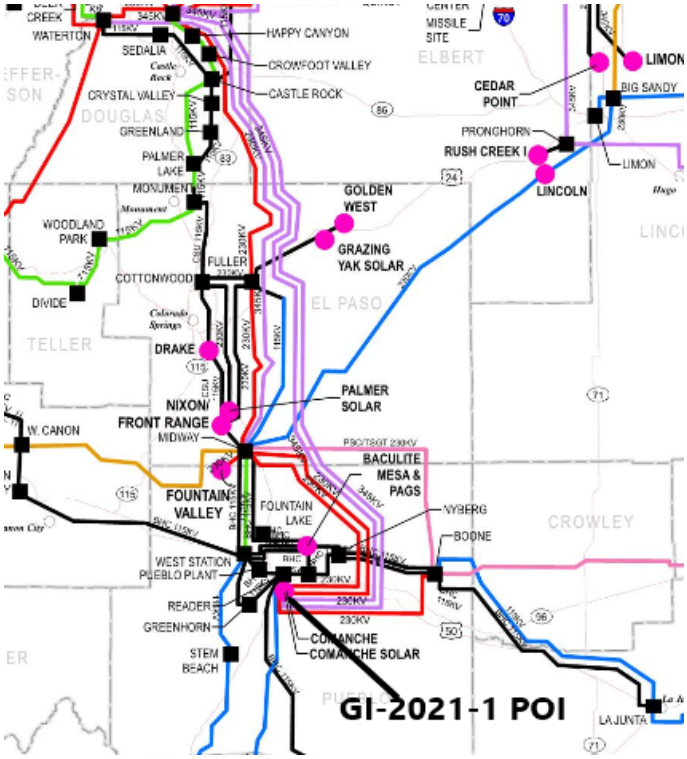
The GI-2021-1 is a 200MW Solar Photovoltaic (PV) Generating Facility composed of fifty-eight (58) SMA4200 inverters rated at 3.8458MVA and 0.908pf, each with its own 630V/34.5kV, 4MVA, Z=6% and X/R=40 pad-mount transformer. The 34.5kV collector system will interface with one (1) 230/34.5/13.8kV, 135/180/225 MVA wye-grounded/Wye-grounded/Delta, Z=8.5% and X/R=47.1 main step-up transformer which will use a 0.05mi 230kV generation tie-line to connect to the PSCo's Comanche 230kV Substation located in Pueblo County, Colorado. The Generating Facility will also install a 15Mvar, 34.5kV shunt capacitor bank.

The proposed Commercial Operation Date (COD) of the GI is December 31, 2022. The back-feed date is assumed to be June 30, 2022, approximately 6 months before the COD.

The geographical location of the transmission system near the POI is shown in Figure 1.

[1] [1] **Provisional Interconnection Service** shall mean an Interconnection Service provided by Transmission Provider associated with interconnecting the Interconnection Customer's Generating Facility to Transmission Provider's Transmission System and enabling that Transmission System to receive electric energy and capacity from the Generating Facility at the Point of Interconnection, pursuant to the terms of the Provisional Large Generator Interconnection Agreement and, if applicable, the Tariff

Figure 1 – Point of Interconnection of GI-2021-1



3.0 Study Scope

The purpose of this study is to determine the impacts to the PSCo system and the Affected Systems from interconnecting GI-2021-1 for Provisional Service. As stated in the PI-2021-1 study agreement, the Provisional Service assumes GI-2021-1 selects Energy Resource Interconnection Service (ERIS)[2].

The scope of this report includes steady state (thermal and voltage) analysis, transient stability analysis, short circuit analysis, and cost estimates for Interconnection Facilities and Station Network Upgrades. The study also identifies the estimated Security[3] and Contingent Facilities associated with the Provisional Service.

3.1 Study Criteria

3.1.1 Steady State Criteria

[2] **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] **Security** estimates the risk associated with the Network Upgrades and Interconnection Facilities that could be identified in the corresponding LGIA.

The following Criteria is used for the reliability analysis of the PSCo system and Neighboring Utility systems.

The steady state analysis criteria are as follows:

P0 - System Intact conditions:

Thermal Loading: <=100% of the 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

3.1.2 Transient Stability Criteria

The transient voltage stability criteria are as follows:

a. Following fault clearing, the voltage shall recover to 80% of the pre-contingency voltage within 20 seconds of the initiating event for all P1 through P7 events for each applicable Bulk Electric System (BES) bus serving load.
b. Following fault clearing and voltage recovery above 80%, voltage at each applicable BES bus serving load shall neither dip below 70% of pre-contingency voltage for more than 30 cycles nor remain below 80% of pre-contingency voltage for more than two seconds, for all P1 through P7 events.
c. For Contingencies without a fault (P2.1 category event), voltage dips at each applicable BES bus serving load shall neither dip below 70% of pre-contingency voltage for more than 30 cycles nor remain below 80% of pre-contingency voltage for more than two seconds.

The transient angular stability criteria are as follows:

a. P1 – No generating unit shall pull out of synchronism. A generator being disconnected from the system by fault clearing action or by a special Protection System is not considered an angular instability.
b. P2-P7 – One or more generators may pull out of synchronism, provided the resulting apparent impedance swings shall not result in the tripping of any other generation facilities.
c. P1-P7 – The relative rotor angle (power) oscillations are characterized by positive damping (i.e. amplitude reduction of successive peaks) > 5% within 30 seconds.

3.1.2 Breaker Duty Analysis Criteria

Fault Current after PI addition should not exceed 100% of the Breaker Duty rating. PSCo can only perform breaker duty analysis on the PSCo system. Before the PI goes in-service the Affected Systems may choose to perform a breaker duty analysis to identify breaker duty violations on their system.

3.2 Study Methodology

The steady state assessment is performed using PSSE V35 and the ACCC tool. The transient stability assessment is performed using GE PSLF DYTOOLs. The short circuit analysis is performed using CAPE.

3.2.1 Steady State Assessment Methodology

For PSCo and non-PSCo facilities, thermal violations attributed to the request include all new facility overloads with a thermal loading >100% and increased by 1% or more from the benchmark case overload post the GI addition.

The voltage violations assigned to the request include new voltage violations which resulted in a further variation of 0.01 per unit.

Since the request is for Provisional Service, if thermal or voltage violations are seen, the maximum permissible Provisional Interconnection before violations is identified. For voltage violations caused by reactive power deficiency at the POI, voltage upgrades are identified.

3.2.2 Transient Stability Study Methodology

The Provisional Interconnection request should meet the Transient stability criteria as stated in 3.1. If the addition of the GI causes any violations, the maximum permissible Provisional Interconnection Service before violations is identified.

3.3 Contingency Analysis

The transmission system on which steady state contingency analysis is run includes the WECC designated areas 70 and 73.

The transient stability analysis is performed for the following worst-case contingencies:

- Three-phase fault at Boone 230kV, trip Boone-Lamar 230kV and all generation connected at Lamar
- Three-phase fault at Boone 230kV, trip Boone-Comanche 230kV

- Three-phase fault at Boone 230kV, trip Boone-Midway 230kV
- Three-phase fault Comanche 345kV, trip Comanche #3 generator
- Three-phase fault at Midway 230kV, trip Fountain Valley Generation
- Three-phase fault at Midway 230kV bus tie breaker, loss of MidwayPS and Midway WAPA facilities.
- Three-phase fault at Midway 345kV, loss of Midway-Waterton 345kV
- Three-phase fault at Comanche 345kV, P7 loss of Comanche-Daniels Park 345kV and Comanche-Tundra 345kV
- Three-phase fault at Daniels Park 345kV, loss of Daniels Park-Comanche 345kV and Daniels Park-Tundra 345kV

3.4 Study Area

The study area or monitored area is the electrical system consisting of PSCo's transmission system and the neighboring transmission systems that may be impacted by the Provisional Interconnection.

The study area includes WECC designated zones 700, 710, 712, 751, 757 and 785. The neighboring utilities included in the analysis include Colorado Springs Utilities (CSU), Tri-State Generation and Transmission Inc. (TSGT), Intermountain Rural Electric Association (IREA), Black Hills Energy (BHE) and Western Area Power Administration (WAPA) systems in the study area.

4.0 Base Case Modeling Assumptions

The study was performed using the 2023HS2 WECC base case released on May 14, 2021.

Consistent with the COD of the GI, the following planned transmission projects with ISD before December 2022 are modeled in the Base Case:

- Cloverly 115kV Substation – ISD 2021
- Mirasol switching station 230kV – ISD 2022
- Tundra 345kV Switching Station – ISD 2022
- Avery Substation – ISD 2022
- High Point Substation – ISD 2022
- Greenwood – Arapahoe - Denver Terminal 230kV line – ISD 2022
- Rebuild Villa Grove – Poncha 69kV Line to 73MVA – ISD 2021
- Upgrade Poncha – Sargent – San Luis Valley 115kV line to 120MVA – ISD 2022
- Rebuild San Luis Valley – Mosca 69kV line to 143MVA – ISD 2022

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 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

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

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 Base Case model includes existing PSCo generation resources and existing Affected System generation. In addition, the following generation with approved Transmission Service and their associated Network Upgrades are modeled:

- GI-2018-24, 1RSC-2020-1, 1RSC-2020-2, 2RSC-2020-5 in the PSCo queue
- T-2021-2, 200MW at Comanche 230kV in the PSCo queue
- T-2021-3, 100MW at Midway 115kV Substation. Midway 230/115kV, 280MVA xfmr replacement project identified in T-2021-3
- TI-18-0809 and TI-19-1016 in the TSGT queue
- Victory Solar, Pioneer Solar, Hunter Solar and Kiowa Solar in the IREA system

5.0 Provisional Interconnection Service Analysis

5.1 Voltage and Reactive Power Capability Evaluation

The following voltage regulation and reactive power capability requirements at the POI are

applicable to the generator:

- Xcel Energy's OATT requires all non-synchronous Generator Interconnection Customers to provide dynamic reactive power within the power factor range of 0.95 leading to 0.95 lagging at the high side of the generator substation. Furthermore, Xcel Energy requires every Generating Facility to have dynamic voltage control capability to assist in maintaining the POI voltage schedule specified by the Transmission Operator.
- It is the responsibility of the Interconnection Customer to determine the type (switched shunt capacitors and/or switched shunt reactors, etc.), the size (MVAR), and the locations (on the Interconnection Customer's facility) of any additional static reactive power compensation needed within the generating plant in order to have adequate reactive capability to meet the +/- 0.95 power factor at the high side of the main step up transformer. Finally, it is the responsibility of the Interconnection Customer to compensate their generation tie-line to ensure minimal reactive power flow under no load conditions.

The reactive power analysis performed in this report is an indicator of the generic reactive power requirements at the POI and the capability of the generator to meet those requirements. All generators are required to design the Generating Facility to meet the POI voltage control requirements that will be specified by the Transmission Operator. The Interconnection Customer is required to demonstrate to the satisfaction of PSCo Transmission Operations prior to the commercial in-service date of the generating plant that it can safely and reliably operate within the required power factor and the regulating voltage of the POI.

According to the modeling data provided by the Customer, the generator model is as follows: Pmax = 202.66 MW, Pmin = 0 MW, Qmax = 93.1780 MVAR, Qmin = -93.1780 MVAR.

Additionally, the Generating Facility includes a 15 MVAR shunt capacitor bank.

The results of the reactive capability analysis are given in Table 1. The INFO-2020-10 is capable of maintaining ±0.95pf at the high side of the main step-up transformer for generation levels of 0% 10% and 100%.

Table 1 – Reactive Capability Evaluation

Gen MW / Mvar	52 MVAR Cap bank status	Gen Voltage (p.u.)	Main Step-up Transformer High Side				POI			
			Voltage (p.u.)	MW	Mvar	Power Factor	Voltage (p.u.)	MW	Mvar	Power Factor
202.7MW / 93.2Mvar	On	1.044	1.018	199.9	68.5	0.946 (lag)	1.018	199.9	68.5	0.946 (lag)
202.7MW / 93.2Mvar	Off	1.045	1.017	199.9	54.9	0.964 (lag)	1.017	199.9	54.9	0.964 (lag)
202MW / -35.2Mvar	Off	1.01	1.01	199.5	-69.5	0.944 (lead)	1.01	199.5	-69.5	0.944 (lead)
20.7MW / 7.6Mvar	Off	1.012	1.016	20.7	8.8	0.920 (lag)	1.015	20.7	8.8	0.920 (lag)
20.7MW / -9.2Mvar	Off	0.996	1.015	20.7	-8.1	0.931 (lead)	1.015	20.7	-8.1	0.931 (lead)
0 MW / 0 Mvar	Off	1.018	1.017	0	-1.6	NA	1.017	0	-1.6	NA

5.2 Benchmark Case Modeling

The Benchmark Case was created from Base Case described in Section 4.0 by changing the study pocket generation dispatch to reflect a heavy south to north flow. This was accomplished by adopting the generation dispatch given in Table 2.

Table 2 – Generation Dispatch Used to Stress the Benchmark Case

(MW is Gross Capacity)

Bus Name	ID	Status	PGen (MW)
COMAN_1 24.000	C1	1	360
COMAN_2 24.000	C2	1	365
COMAN_3 27.000	C3	1	804
COMAN_S1 0.4180	S1	1	106
TWNBUTTE 34.500	W1	1	60
TBII_GEN 0.6900	W	1	60
LAMAR_DC 230.00	DC	1	0
FTNVL1&2 13.800	G1	1	36
FTNVL1&2 13.800	G2	1	36
FTNVL3&4 13.800	G3	1	36
FTNVL3&4 13.800	G4	1	36
FTNVL5&6 13.800	G5	1	36
FTNVL5&6 13.800	G6	1	36
GLDNWST_W1 0.6900	W1	1	99.3

Bus Name	ID	Status	PGen (MW)
GLDNWST_W2 0.6900	W2	1	100
CO_GRN_E 34.500	W1	1	65
CO_GRN_W 34.500	W2	1	65
GI-2018-24_PV 0.6600	PV	1	212.5
GI-2018-24_ES 0.4800	BES	0	0
2RSC20-5_PV 0.6600	PV	1	170
2RSC20-5_BAT0.4800	BES	0	0
GI-2014-6	PV	1	85
GI-2014-6	BES	0	0
GI-2019-6	PV	1	204
SPANPKS2_GEN0.6300	PV	1	85

5.0 Study Case Modeling

A Study case was created from the Benchmark Case by modeling the GI using the modeling data provided with the request. The 200MW output of the GI to Ft. St. Vrain.

5.1 Steady State Analysis

The results of the single contingency analysis are given in Table 3. The Optimum Power Flow (OPF) solution identified generation redispatch scenarios that mitigated each of the overloads shown in Table 3.

Per TPL1-4, multiple contingency overloads are mitigated using system adjustments, including generation redispatch and/or operator actions. Since the GI under study can be redispatched to mitigate any impact of the study generator, the multiple contingencies are not impacted by the study generator.

Additionally, PSCo is in the process of identifying system mitigations which may include automatic generation adjustment schemes for the Comanche – Daniels Park P7 outage. These future mitigations will address the existing and new overloads, and all the generation in southern Colorado may become part of the automatic generation adjustment scheme.

Table 3 - 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 PI-2021-1	Single Contingency Definition
				MVA Flow	% Line Loading	MVA Flow	% Line Loading		
Leetsdale - MonroePS 230.00	Line	PSCo	398	382.8	96.18	422.6	106.17	9.99	Daniels Park – SantaFe 230kV
Greenwood - Monaco 230.00	Line	PSCo	560	523.0	93.4	560.8	100.14	6.74	Buckley – Smokyhill 230kV
Daniels Park – Prairie1 230.00	Line	PSCo	561	553.3	98.63	589.1	105	6.37	Daniels Park – Prairie3 230kV

5.0 Transient Stability Results

The following results were obtained for the disturbances shown in Table 5. The transient stability plots are shown in Appendix A to this report.

- ✓ No machines lost synchronism with the system
- ✓ No transient voltage drop violations were observed
- ✓ Machine rotor angles displayed positive damping

Table 5 – Transient Stability Analysis Results

#	Fault Location	Fault Type	Facility Tripped	Clearing Time (cycles)	Post-Fault Voltage Recovery	Angular Stability
0	No disturbance	NA	NA	NA	stable	stable
1	Boone 230kV	3ph	Boone-Lamar 230kV and all the generation at Lamar	5.0	Maximum transient voltage dips within criteria	Stable with positive damping
2	Comanche 230kV	3ph	Boone-Comanche 230kV	5.0	Maximum transient voltage dips within criteria	Stable with positive damping
3	Boone 230kV	3ph	Boone-Midway 230kV	5.0	Maximum transient voltage dips within criteria	Stable with positive damping
4	Comanche 345kV	3ph	Lose Comanche #3 Unit	4.0	Maximum transient voltage dips within criteria	Stable with positive damping
5	Midway 230kV	3ph	All Fountain Valley generation	5.0	Maximum transient voltage dips within criteria	Stable with positive damping
6	Midway 230kV	3ph	Lose MidwayPS – Fuller, Midway 230kV bus tie, all Midway_WA 115kV and Midway_WA 230kV lines	5.0	Maximum transient voltage dips within criteria	Stable with positive damping
7	Midway 345kV	3ph	Midway-Waterton 345kV	4.0	Maximum transient voltage dips within criteria	Stable with positive damping

However, the following two faults did not result in satisfactory stability results for voltage and angular stability. It was identified that the stability issue exists pre GI. Based on the inverter settings that demonstrate full control capability for fault ride through and recovery, PI-2021-1 is considered to not contribute to the stability issue.

- Three-phase fault at Comanche 345kV, P7 loss of Comanche-Daniels Park 345kV and Comanche-Tundra 345kV
- Three-phase fault at Daniels Park 345kV, P7 loss of Daniels Park-Comanche 345kV and Daniels Park-Tundra 345kV

5.1 Short Circuit and Breaker Duty Analysis Results

The short circuit fault current values and Thevenin system equivalent impedances at the Comanche 230kV Substation POI are shown in Table 5.

Table 5 – Short Circuit Parameters at the Comanche 230kV Substation POI

	Before GI-2021-1 Interconnection	After GI-2021-1 Interconnection
Three Phase Current	23592A	23592A
Single Line to Ground Current	28442A	29402A
Positive Sequence Impedance	0.00067+j0.01069 ohms	0.00067+j0.01069 ohms
Negative Sequence Impedance	0.0007+j0.01073 ohms	0.0007+j0.01073 ohms
Zero Sequence Impedance	0.0003+j0.00532 ohms	0.00028+j0.00532 ohms

The preliminary breaker duty study did not identify any circuit breakers that became over-dutied[4] as a result of adding this generation.

5.2 Contingent Facilities

The following is the list of the unbuilt Interconnection Facilities and Network Upgrades upon which the GI-2021-1 request's costs, timing, and study findings are dependent, and if delayed or not built, could cause a need for re-studies of the Interconnection Request or a reassessment of the Interconnection Facilities and/or Network Upgrades and/or costs and timing.

- Greenwood – Arapahoe - Denver Terminal 230kV line – ISD 2022
- 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

[4] "Over-dutied" circuit breaker: A circuit breaker whose short circuit current (SCC) rating is less than the available SCC at the bus.

- 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 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
- Fuller – Vollmer – Black Squirrel 115kV line modeled at 173MVA – ISD 2022
- Midway 230/115kV, 280MVA xfmr replacement project identified in T-2021-3

5.8 Cost Estimates

The cost estimates are in 2021 dollars with escalation and contingencies applied. Allowance 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.

The estimated total cost for the transmission system improvements is $2.398 Million.

Figure 2 is a conceptual one-line of the proposed interconnection at the Comanche Substation 230kV bus.

Table 6 and Table 7 list the Transmission Provider Interconnection Faciliteis and Station Network Upgrades respectively, to accommodate the interconnection of GI-2021-1 for Provisional Interconnection Service. The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines. System improvements are subject to revision as a more detailed and refined design is produced.

Table 6 –Transmission Provider's Interconnection Facilities

Element	Description	Cost Est. (Millions)
PSCo's Comanche Substation 230kV bus	Interconnect Customer at the Comanche Substation 230kV bus. The new equipment includes: • Three (3) 230kV deadend structures • Three (3) 230kV arresters • One (1) 230kV 3000A 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.	$1.064
	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	**$1.139**
Time Frame	**Site, design, procure and construct**	**36 Months**

Table 7 –Station Network Upgrades

Element	**Description**	**Cost Est. (Millions)**
PSCo's Comanche 230kV Substation	Interconnect GI-2021-1 at an existing bay at the Comanche 230kV bus. The new equipment includes: • One (1) 230kV, 3000A Circuit Breakers • One (1) 230kV 3000A Switches • Station controls and wiring • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures	$1.239
	Siting and Land Rights support for substation site acquisition, permitting, and construction	$0.020
	Total Cost Estimate for Substation Network Upgrades for Interconnection	**$1.259**
Time Frame	**Site, design, procure and construct**	**36 Months**

- Labor is estimated for straight time only – no overtime included.
- Lead times for materials were considered for the schedule.
- The Solar Generation Facility is not in PSCo's retail service territory. Therefore, no costs for retail load metering are included in these estimates.
- PSCo (or it's Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- PSCO anticipates that a CPCN may be required for the interconnection facilities construction.
- It is expected that CPCN processing and approval may take upto 18 months. The estimated time to permit, design, procure and construct the interconnection facilities is approximately 18 months after authorization to proceed and CPCN are obtained.
- Customer will install two (2) redundant fiber optics circuits into the Transmission provider's substation
- Power Quality Metering (PQM) will be required on the Customer's 345kV line terminating into the PSCo / Xcel 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

6.0 Summary of Provisional Interconnection Service Analysis

The total estimated cost of the PSCo transmission system improvements required for GI-2021-1 in 3DISIS-2021-001 to qualify for Provisional Interconnection Service is: $2.398 Million (Tables 6 and 7).

The Provisional Interconnection Service of GI-2021-1 is 200MW

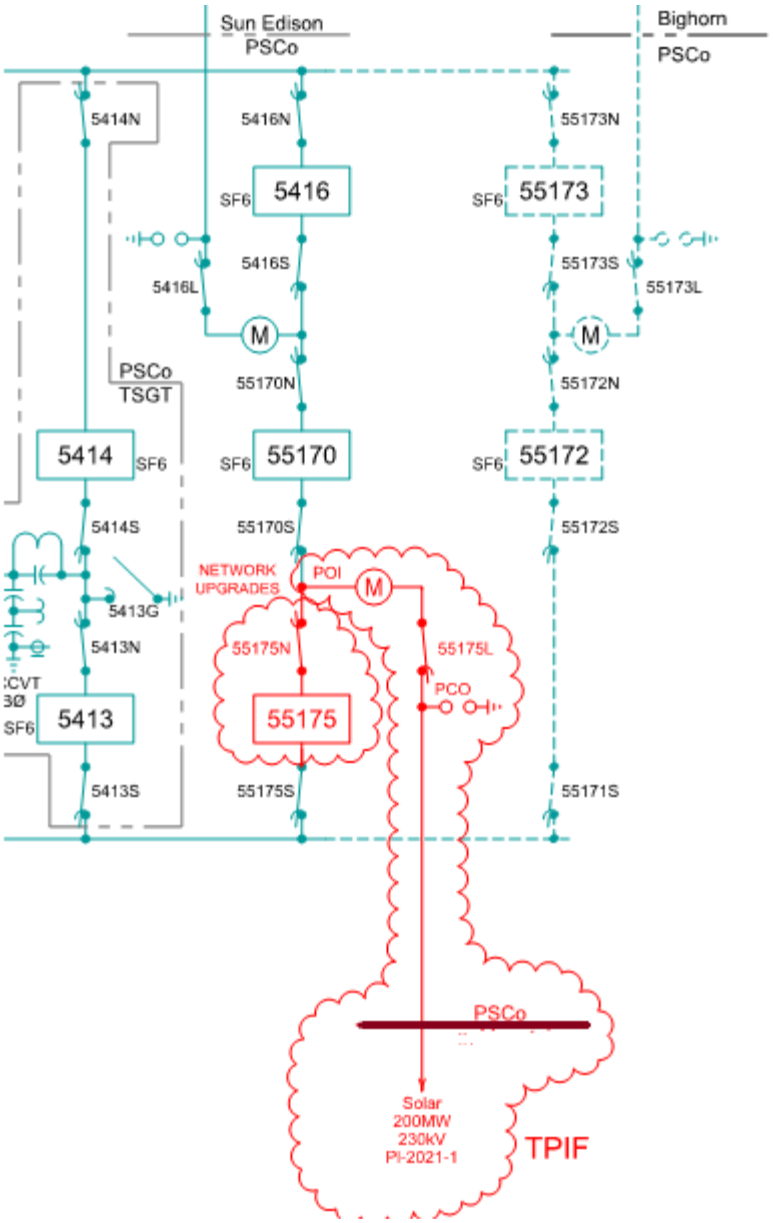
Security: As stated in the study agreement, assuming GI-2021-1 in 3DISIS-2021-001 selects Energy Resource Interconnection Service (ERIS), the security associated with the Network Upgrades that might be identified at the conclusion of the GI-2021-1 Large Generation Interconnection Procedure (LGIP) in the 3DISIS-2021-001 cluster is estimated to be approximately $5 Million.

The Interconnection Customer assumes all risk and liabilities with respect to changes between the PLGIA and the LGIA, including changes in output limits and Interconnection Facilities, Network Upgrades, Distribution Upgrades, and/or System Protection Facilities cost responsibility.

It is expected that the Interconnection of GI-2021-1 at the Comanche 230kV Substation will require a CPCN. The estimated time for CPCN approval is expected to be 18 months. The estimated time for the construction of transmission system improvements required to accommodate the interconnection is expected to be 18 months after receiving all approvals, including CPCN.

Note: Provisional Interconnection Service in and of itself, does not convey transmission service

Figure 2 Preliminary one-line of GI-2021-1 Provisional Interconnection Service POI at the Comanche 230kV Substation



Appendix A - Transient Stability Plots