GI-2020-18

System Impact Study Report

4.5MW Hydro Generating Facility

Vineland 69kV Substation

05/17/2021

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1.0 Summary

GI-2020-18 is a 4.5MW Hydroelectric Generating Facility interconnection at the Vineland 69kV Substation. The Generating Facility is and expansion of the existing 3MW Hydroelectric Generating Facility connected on the Vineland distribution feeder and requested ERIS.

The study did not identify any impacts to the PSCo facilities or the Affected System facilities.

Energy Resource Interconnection Service of GI-2020-18 before Network Upgrades is 4.5MW.

Energy Resource Interconnection Service of GI-2020-18 is 4.5MW.

The total estimated cost of the transmission system improvements required for GI-2020-18 is 4.315 Million (Tables 4 and 5).

2.0 Introduction

GI-2020-18 is a 4.5MW Hydroelectric Generating Facility interconnection at the Vineland 69kV Substation. The request is a modification of the existing hydro facility connected on the Vineland distribution feeder, resulting in an increase in the capacity from 3MW to 4.5MW and change in the Point of Interconnection (POI) from the distribution feeder to the Vineland 69kV Substation. The Generating Facility will be located in Mesa County, Colorado and requested Energy Resource Interconnection Service (ERIS)[1] evaluation.

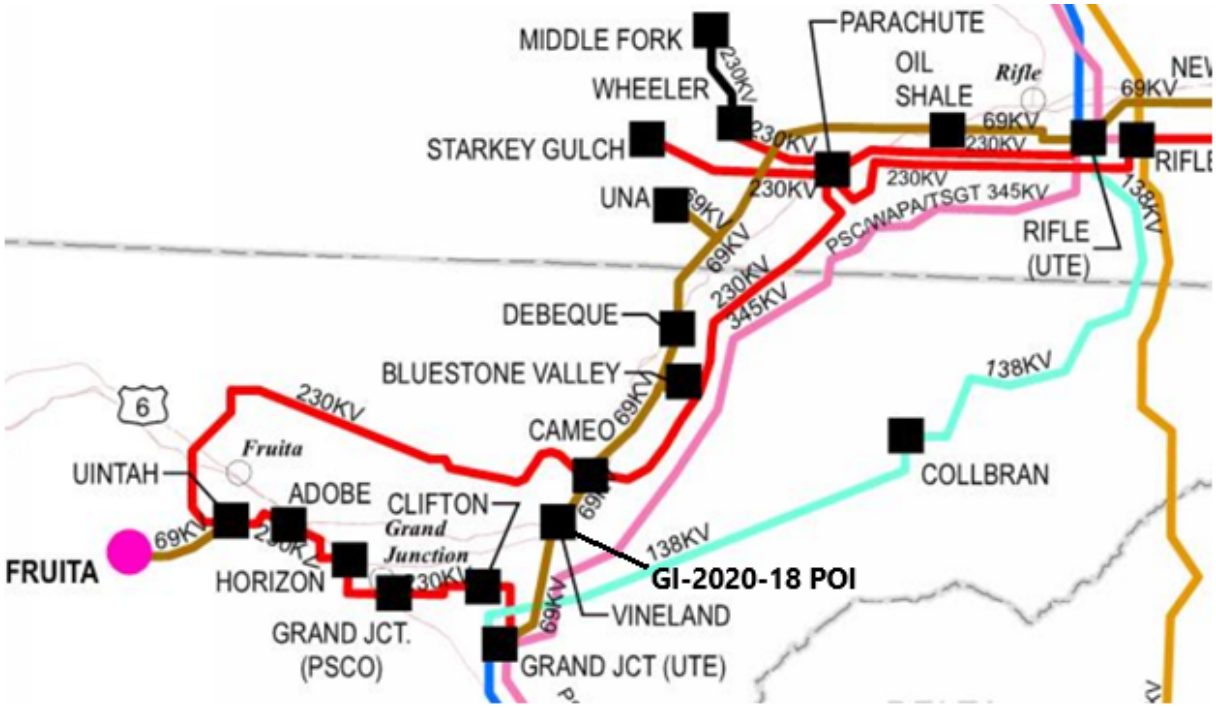
The geographical location of the Transmission System near the POI is shown in Figure 1.

GI-20201-8 Hydroelectric Generating Facility is a Synchronous machine with a proposed 4.5MW generation size and a power factor capability of +/- 0.9. The Generating Facility will connect to one (1) 4.16/69kV, 5MVA, X/R = 10 delta/grounded-wye three-phase main step-up transformer which in turn will connect to the Vineland Substation via a 0.38mile generation tie-line.

The proposed Commercial Operating date (COD) of GI-2020-18 is June 2022. Per the standard interconnection practices, the backfeed date is assumed to be approximately six months before the COD, i.e., December 2021.

[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 – GI-2020-18 Point of Interconnection



3.0 Study Scope

The purpose of the study is to determine the system impact of interconnecting GI-2020-18 for ERIS.

The scope of the study includes steady state thermal and voltage analysis, short circuit analysis, and cost estimates for Interconnection Facilities and Network Upgrades.

Since the request is a minimal increase in the overall existing capacity of the hydro plant, transient stability analysis is waived.

The steady state analysis identifies thermal and voltage violations on the PSCo system and the neighbouring systems due to the addition of GI-2020-18.

The short circuit analysis determines the maximum available fault current at the POI and identifies if any circuit breaker(s) within the PSCo station(s) exceed their breaker duty ratings.

3.1 Steady State Analysis Criteria

The following criteria are used to identify the thermal and voltage violations for the transmission system evaluation of the PSCo and affected systems:

P0 - System Intact conditions:

Thermal Loading: <=100% of the normal facility rating

Voltage Range: 0.95 to 1.05 per unit

P1 & P2-1 & P6 – Single Contingencies:

Thermal Loading: <=100% of the normal facility rating

Voltage Range: 0.90 to 1.1 per unit

Voltage deviation: <=8% of pre-contingency voltage

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

Thermal Loading: <=100% of the normal facility rating

Voltage Range: 0.90 to 1.1 per unit

Voltage deviation: <=8% of pre-contingency voltage

3.2 Breaker Duty Analysis Criteria

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

3.3 Study Methodology

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

The short circuit analysis is performed using CAPE.

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 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) 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, Affected System's existing generation and future resources with approved Transmission Service.

The following requests in PSCo's Generation Interconnection queue are modeled: 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, DISIS-2020-002 and GI-2020-17.

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)

Note – GI-2020-17 represents the same Generating Facility as GI-2020-18, so GI-2020-17 is considered offline to avoid duplication of the Interconnection Service.

The following approved resources from the Affected Systems queue are modeled:

- 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

5.0 Study Analysis

The GI-2020-18 is studied in the Western Colorado study pocket.

5.1 Benchmark Case Modeling

The Benchmark Case for evaluating GI-2020-18 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

Generation	Pgen MW
Hayden 1	202
Hayden 2	285
Bonanza	490
MBPP-1	221
MBPP-2	150
Cabincreek A	160
Cabincreek B	160
Blue Mesa 1	40
Blue Mesa 2	40
Morrow 1	72
Morrow 2	72
Elbert-1	90
Elbert-2	90

5.2 Study Case Modeling

A Study case was created from the Benchmark Case by modeling GI-2020-18 at the Vineland 69kV Substation. The 4.5MW output from the generator was sunk to Pawnee. The study generator is modeled using the following information:

- Generator – 4.5 MW generation size of a vertical Synchronous machine with a power factor capability of +/- 0.9 with a generation voltage of 4.16kV and 5MVA rated capacity
- Transformer – one (1) 4.16/69kV, 5MVA/100MVA, X/R = 10 delta/grounded wye three-phase main step-up transformer
- Generation tie- line – a 0.38mile generation tie-line with positive impedance equals Z1=.45+j.89

6.0 Voltage and Reactive Power Capability Evaluation

The following voltage regulation and reactive power capability requirements are applicable to the GI-2020-18:

- Xcel Energy OATT requires all synchronous GIRs to meet +/-0.95 pf at the POI while maintain the system operating voltage at the POI.

The reactive power analysis is only an indicator of the reactive power requirements at the POI and the reactive Power capabilities of the generator. All GIRs are required to design their interconnection to meet the POI voltage control requirements that will be specified by the Transmission Operator.

The results of the reactive power capability analysis are shown in Table 2. The reactive power capability analysis shows that GI-2020-18 meets the reactive power capability requirements.

Table 2 - Reactive capability evaluation of GI-2020-18

Gen MW / Mvar (Hydro)	Gen Voltage (p.u.) (Hydro)	Main Step-up Transformer High Side				POI			
		Voltage (p.u.)	MW	Mvar	Power Factor	Voltage (p.u.)	MW	Mvar	Power Factor
4.5MW / 2.2Mvar	1.029	1.027	4.5	2.2	0.90 (lag)	1.27	4.5	2.2	0.90 (lag)
4.5MW /-2.2Mvar	1.019	1.02	4.5	-2.2	0.90 (lead)	1.09	4.5	-2.2	0.90 (lead)
0.45MW / 0.22Mvar	1.023	1.023	0.45	0.23	0.90 (lag)	1.023	0.45	0.22	0.90 (lag)
0.45MW /-0.22Mvar	1.022	1.022	0.45	-0.23	0.90 (lead)	1.022	0.45	-0.23	0.90 (lead)
0MW /-2.2Mvar	1.017	1.019	0	-2.2	N/A	1.019	-0.0	-2.2	N/A

7.0 Study Results

7.1 Steady State Analysis Results

The study did not identify any thermal or voltage violations due to the addition of GI-2020-18.

No Affected System impacts were identified.

7.2 Short Circuit and Breaker Duty Analysis Results

A breaker duty study on the PSCo transmission system did not identify any circuit breakers that became over-dutied"[2] as a result of adding GI-2020-18.

Table 3 – Short Circuit Parameters at the Vineland 69kV Substation

	Before the Southern Colorado Cluster addition	After Southern Colorado Cluster addition
Three Phase Current	5146A	5149A
Single Line to Ground Current	4325A	4659A
Positive Sequence Impedance	1.358+j7.621 ohms	1.356+j7.617 ohms

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

Negative Sequence Impedance	1.362+j7.616 ohms	1.361+j7.613 ohms
Zero Sequence Impedance	2.472+j11.907 ohms	1.936+j9.996 ohms

8.0 Cost Estimates and Assumptions

PSCo Engineering has developed cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades required for the interconnection of GI-2020-18 at the Vineland 69kV Substation. 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.
- Costs for retail load metering are not included in these estimates.
- Line and substation outages will be necessary during the construction period.
- 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 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.

Figure 2 is a conceptual one-line of GI-2020-18 POI at the Vineland 69kV Substation.

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)
PSCO's Vineland Substation 69kV bus	Interconnect Customer to tap the Substation 69kV bus. The new equipment includes: • Deadend and structures • One (1) 69kV 3000A Circuit Breaker • Two (2) 69kV 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.	$0.887
	Transmission line tap into substation.	$0.155
	Siting and Land Rights support for permitting and construction.	$0.020
	Total Cost Estimate for Transmission Providers Interconnection Facilities	**$1.062**
Time Frame	**Site, design, procure and construct**	**18 Months**

Table 5 – Station Network Upgrades

Element	Description	Cost Est. (Millions)
PSCO's Vineland Substation 69kV bus	Reconfigure Vineland substation to accommodate GI-2020-18 interconnection. The new equipment includes: • Two (2) 69kV 3000A circuit breakers • Four (4) 69kV 3000A disconnect switches • Station controls and wiring • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures • Associated transmission line communications, fiber, relaying and testing.	$3.233
	Siting and Land Rights support for substation site acquisition, permitting, and construction	$0.020
	Total Cost Estimate for Substation Network Upgrades for Interconnection	**$3.253**
Time Frame	**Site, design, procure and construct**	**18 Months**

9.0 Summary of Interconnection Service

Energy Resource Interconnection of GI-2020-18 before Network Upgrades is 4.5MW.

Energy Resource Interconnection Service of GI-2020-18 is 4.5MW.

The total estimated cost of the transmission system improvements to interconnect GI-2020-18 is $4.315 (Tables 4 and 5).

Figure 2 – Preliminary One-line of GI-2020-18 Interconnection at Vineland 69kV Substation