INFO-2020-10

Informational Study Report

7/6/2021

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1.0 Summary

This report is an informational evaluation of a 325MW Solar PV plus Battery Energy Storage hybrid Generating Facility interconnection on the Pawnee – Missile Site 230kV line, at the POI where GI-2020-06 taps the line. The expected Commercial Operation Date of the Generating Facility is December 31, 2024 and requested was studied for NRIS.

The study did not identify any thermal or voltage violations or breaker duty limit violations. The study did not identify any impacts to the Affected Systems.

Network Resource Interconnection Service of INFO-2020-10 is 325MW.

The total estimated cost of the transmission system improvements to interconnect INFO-2020-10 for 325MW NRIS is $2.057 Million (Tables 7 and 8).

The COD of INFO-2020-10 is dependent of the construction of the GI-2020-06 230kV Switching Station, which is expected to require a CPCN. The total estimated time frame for regulatory activities (CPCN) and to site, design, procure and construct the switching station at the POI is approximately 36 months after authorization to proceed has been obtained.

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 325MW hybrid Generating Facility. The hybrid facility is composed of a 325MW PV Solar Photovoltaic (PV) Generating Facility and an 80MW Battery Energy Storage (BES) Generating Facility, with net output at the POI limited to 325MW at all times. The Point of Interconnection (POI) is the Pawnee – Missile Site 230kV line, at the tap point designed for GI-2020-06 in the DISIS-2020-001 cluster.

The proposed Commercial Operation Date (COD) of INFO-2020-10 is December 31, 2024.The geographical location of the Transmission System near the POI is shown in Figure 1 below.

The request is referred to as “INFO-2020-10” and requested Network Resource Interconnection Service (NRIS)[1].

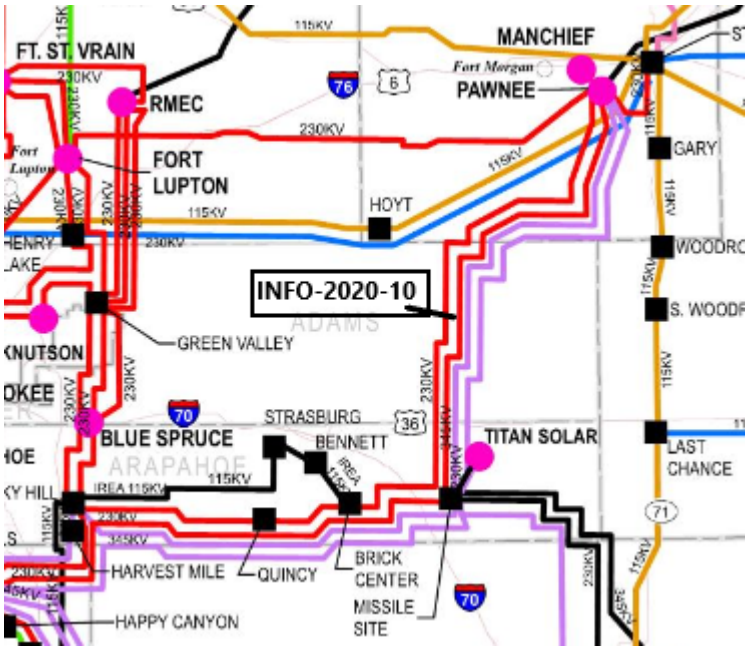

Figure 1 – INFO-2020-10 Point of Interconnection

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 reactive power analysis, power flow analysis to evaluate the steady state thermal and voltage limit violations, and short circuit analysis to identify breaker duty violations. Per the Study Request, the 325 MW rated output of INFO-2020-10 is assumed to be delivered to PSCo native load, so existing PSCo generation is used to sink the generator output.

[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

The study also evaluated the impact of the 80MW battery charging from the grid.

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 to 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 Determination

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

3.2 Study Criteria

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

P0 - System Intact conditions:

Thermal Loading: <=100% Normal facility rating

Voltage range: 0.95 to 1.05 per unit

P1 & P2-1 – Single Contingencies:

Thermal Loading: <=100% Normal facility rating

Voltage range: 0.90 to 1.10 per unit

Voltage deviation: <=8%

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

Thermal Loading: <=100% Emergency facility rating

Voltage range: 0.90 to 1.10 per unit

Voltage deviation: <=8%

3.3 Study Methodology

The steady state assessment is performed using PSSE V34 and the TARA AC tool.

3.3.1 Steady State Assessment methodology

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

Voltage violations are identified if a bus voltage has a further variation of 0.01p.u.

3.4 Study Area

The Study Area includes WECC designated zones 700, 704, and 706. The Affected System included in the analysis is the Tri-State Generation and Transmission Inc. (TSGT) system in the study area.

4.0 Modeling Assumptions

The study was performed using the 2023HS case.

4.1 Base Case Modeling

The Base Case was created from the 2023HS case by making the following modifications. The following approved transmission projects in the PSCo's 10-year transmission plan which are expected to be in-service before August 2023 are modeled:

- Cloverly 115kV Substation – ISD 2021
- Mirasol switching station 230kV – ISD 2022
- Tundra 345kV Switching Station – ISD 2022
- Bluestone Valley Phase 2 – ISD 2023
- Avery Substation – ISD 2022
- High Point Substation – ISD 2022
- Titan Substation – ISD 2023
- Dove Valley Substation – ISD 2023
- Greenwood – Arapahoe - Denver Terminal 230kV line – ISD 2022
- Monument – Flying Horse 115kV Series Reactor – ISD 2023
- Gilman – Avon 115kV line – ISD 2023
- Climax – Robinson Rack – Gilman 115kV – ISD 2023

- 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

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 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 existing PSCo generation resources and existing Affected System generation. In addition, the following generation with approved Transmission Service and higher-queued generation are modeled:

- GI-2014-7, GI-2018-24, 1RSC-2020-1, 1RSC-2020-2, 2RSC-2020-5, T-2021-2 and GI-2020-06 (DISIS-2020-001) in the PSCo queue
- TI-18-0809 and 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 INFO-2020-10 is studied in the Eastern Colorado study pocket.

5.1.1 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 interconnection 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:

PV: Pmax = 329.8MW, Pmin = 0, Qmax = 117MVAR, Qmin = -117MVAR.

BES: Pmax = 80MW, Pmin = 0, Qmax = 29.04MVAR, Qmin = -29.04MVAR.

Additionally, the Generating Facility includes a 4 x 13 MVAR shunt capacitor bank.

Since it is unknown how the PV and BES coordinate to control voltage or reactive power and both PV and BES have the same power factor capability, this study report analyzed reactive power capability with the PV generator at 325MW. 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% and 100%. However, the generator is not capable of meeting 0.95 leading power factor for 10% output level. The Generating Facility needs to install a 1.8Mvar shunt reactor to meet the 0.95pf leading power factor.

Table 1 – Reactive Capability Evaluation for INFO-2020-10

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
330MW / 117Mvar	On	1.06	0.99	325.0	125.2	0.934 (lag)	0.99	325.0	124.5	0.934 (lag)
330MW / -89.8Mvar	Off	0.90	0.94	325.1	-150.0	0.907 (lead)	0.95	325.0	-150.8	0.907 (lead)
33MW / 11.8Mvar	On	1.01	0.99	32.9	66.2	0.445 (lag)	0.99	32.9	66.3	0.446 (lag)
33MW / -11.8Mvar	Off	0.97	0.98	33	-9.3	0.963 (lead)	0.98	33.0	-9.2	0.963 (lead)
0MW / 0Mvar	Off	0.98	0.98	0	3.0	0	0.98	0	3.1	0 (supply)

5.2 Study Analysis – Generation Interconnection Service Benchmark Case Modeling

The Benchmark Case was created from the Base Case by changing the study pocket generation dispatch as shown in Table 2 below.

Table 2 – Generation Dispatch Used to Create the Benchmark Case (MW is Gross Capacity)

Bus Name	ID	Status	PGen (MW)
SPRUCE1 18.000	G1	0	0
SPRUCE2 18.000	G2	0	0
MANCHEF1 16.000	G1	1	136.1
MANCHEF2 16.000	G2	1	136.1
PAWNEE 22.000	C1	1	536
PTZLOGN1 34.500	W1	1	160.8
PTZLOGN2 34.500	W2	1	96
PTZLOGN3 34.500	W3	1	63.6
PTZLOGN4 34.500	W4	1	140
CEDARPOINT 34.500	W1	1	200
TITAN-PV 34.500	S1	1	42.5
CHEYRGE_W1 0.6900	W1	1	99.2
CHEYRGE_W2 0.6900	W2	1	100.8
CHEYRGW_W1 0.6900	W1	1	99.2
CHEYRGW_W2 0.6900	W2	1	100.8
LIMON1_W 34.500	W1	1	160.8
LIMON2_W 34.500	W2	1	160.8
LIMON3_W 34.500	W3	1	160.8
BRONCO_W1 0.6900	W1	1	240
RUSHCK_W1 34.500	W1	1	304
RUSHCK_W2 34.500	W2	1	176
KNUTSON1 13.800	G1	1	64.5
KNUTSON2 13.800	G2	1	64.5
CEDAR2_W1 0.6600	W1	1	31.5
CEDAR2_W2 0.6900	W2	1	5.25

Bus Name	ID	Status	PGen (MW)
CEDAR2_W3 0.6600	W3	1	25
CEDARCK_1A 34.500	W1	1	46.2
CEDARCK_1B 34.500	W2	1	16.8
GI-2020-6	S1	1	199

5.2.1 Study Case Modeling

A Study case was created from the Benchmark Case by modeling INFO-2020-10 at the GI-2020-6 230kV Switching Station. The 325MW NRIS output from the generator was balanced by reducing Comanche 1.

5.2.2 Steady State Analysis Results

The results of the single contingency analysis are shown in Table 3.

The addition of INFO-2020-10 caused an increase in the existing overload on the Pawnee – Story 230kV line from 107.2% to 120%. The benchmark overload will be mitigated by PSCo and it is expected that the benchmark mitigation will eliminate the Study Case overload, so this overload is not attributed to INFO-2020-10.

Xcel Energy

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 INFO-2020-10	Single Contingency Definition
				MVA Flow	% Line Loading	MVA Flow	% Line Loading		
Pawnee - Story 230kV	Line	PSCo	581	622.8	107.2%	698.9	120.3%	13.1%	Smoky Hill – Missile Site 345kV line

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

The study did not identify any single or multiple contingency 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 Study Case		Change due to INFO-2020-10	Multiple Contingency Definition
				MVA Flow	% Line Loading	MVA Flow	% Line Loading		
Capitol Hill – Denver terminal 115KV l	Line	PSCo	145	153.1	105.6%	157.6	108.7%	3.1%	Cherokee – Argo 115kV & Cheroke – Lacombe 230kV
Clark - Jordan 230KV	Line	PSCo	364	375.3	103.1%	396.0	108.8%	5.7%	Smoky – Sullivan 230kV & Smoky – Leetsdale 230kV
Beaver Creek Tri 230/115kV	Xfmr	TSGT	224	222.1	99.2%	233.2	104.1%	4.9%	Beaver Creek breaker failure

Beaver Creek - Beaver Creek Tri 115kV	Bus tie	TSGT	239	228.3	95.5%	239.5	100.2%	4.7%	Beaver Creek breaker failure

5.2.3 Short Circuit Analysis Results

The short circuit fault current values and Thevenin system equivalent impedances at the GI-2020-06 230kV Switching Station POI are shown in Table 5.

Table 5 – Short Circuit Parameters at the GI-2020-06 230kV Switching Station

	Before INFO-2020-10 Interconnection	After INFO-2020-10 Interconnection
Three Phase Current	12327A	12327A
Single Line to Ground Current	13866A	16116A
Positive Sequence Impedance	0.00184+j0.02056 ohms	0.00184+j0.02056 ohms
Negative Sequence Impedance	0.00184+j0.02056 ohms	0.00184+j0.02056 ohms
Zero Sequence Impedance	0.00202+j0.01626 ohms	0.00152+j0.0119 ohms

The preliminary breaker duty study did not identify any circuit breakers that became over-dutied[2] as a result of adding this generation

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

5.3 Study Analysis – BES Grid Charging Benchmark Case Modeling

The Benchmark Case was created from the Base Case described in Section 4.1 by changing the study pocket generation dispatch as shown in Table 6 below.

Table 6 – Generation Dispatch Used to Create the BES Grid Charging Benchmark Case (MW is Gross Capacity)

Bus Name	ID	Status	PGen (MW)
SPRUCE1 18.000	G1	1	145.8
SPRUCE2 18.000	G2	1	145.8
MANCHEF1 16.000	G1	1	136.2
MANCHEF2 16.000	G2	1	136.2
PAWNEE 22.000	C1	1	536
PTZLOGN1 34.500	W1	1	42.2
PTZLOGN2 34.500	W2	1	25.2
PTZLOGN3 34.500	W3	1	16.7
PTZLOGN4 34.500	W4	1	36.8
CEDARPOINT 34.500	W1	1	26.3
TITAN-PV 34.500	S1	0	0
CHEYRGE_W1 0.6900	W1	1	26
CHEYRGE_W2 0.6900	W2	1	26.5
CHEYRGW_W1 0.6900	W1	1	26
CHEYRGW_W2 0.6900	W2	1	26.5
LIMON1_W 34.500	W1	1	42.2
LIMON2_W 34.500	W2	1	42.2
LIMON3_W 34.500	W3	1	42.2
BRONCO_W1 0.6900	W1	1	240
RUSHCK_W1 34.500	W1	1	79.8
RUSHCK_W2 34.500	W2	1	46.2
KNUTSON1 13.800	G1	1	58.1
KNUTSON2 13.800	G2	1	58.1
CEDAR2_W1 0.6600	W1	1	26.25
CEDAR2_W2 0.6900	W2	1	21.2
CEDAR2_W3 0.6600	W3	1	5.3
CEDARCK_1A 34.500	W1	1	46.2

Bus Name	ID	Status	PGen (MW)
CEDARCK_1B 34.500	W2	1	16.8
GI-2020-6	S1	0	0

5.3.1 BESS Grid Charging Study Case Modeling

A Study case was created from the Battery Energy Storage System Grid Charging Benchmark Case by modeling INFO-2020-10 as a generator dispatched at -80MW.

5.3.2 BESS Grid Charging Analysis Results

The results of the single and multiple contingency analysis did not result in new thermal or voltage violations.

6.0 Cost Estimates and Assumptions

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.

The estimated total cost for the required upgrades is **$2.057 Million.**

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

The estimated total cost of the Transmission Provider's Interconnection Facilities and Station Network Upgrades are shown in Table 7 and Table 8 respectively. 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.
- INFO-2020-10 Generating Facility is not in PSCo's retail service territory. Therefore, no costs for retail load metering are included in these estimates.
- Line and substation outages will be necessary during the construction period. Outage availability could potentially be problematic and extend requested back feed date

- Customer will install two (2) separate fiber optics circuits into the Transmission provider's substation as part of its interconnection facilities construction scope.
- Power Quality Metering (PQM) will be required on the Customer's generation tie-line terminating into GI-2020-06 230kV Switching Station.
- The Customer will be required to design, procure, install, own, operate and maintain a Load Frequency/Automated Generation Control (LF/AGC) RTU at their Customer Substation. PSCo / Xcel will need indications, readings and data from the LFAGC RTU.
- PSCo (or it's Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- PSCo does not anticipate that a CPCN will be required for the interconnection facilities construction.
- The estimated time to permit, design, procure and construct the interconnection facilities is approximately 18 months after authorization to proceed has been obtained.

Table 7 – Transmission Provider's Interconnection Facilities

Element	Description	Cost Est. (Millions)
PSCO's proposed GI-2020-6 230kV Switching Station	Interconnect Customer to the GI-2020-06 230kV Switching Station POI. The new equipment includes: • Three(3) 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.	$1.002
	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	**$1.097**
Time Frame	**Site, design, procure and construct**	**18 Months**

Table 8 – Station Network Upgrades

Element	Description	Cost Est. (Millions)

PSCO's proposed GI-2020-6 230kV Switching Station	GI-2020-6 230kV Substation Expansion to accommodate INFO-2020-10. The new equipment includes: •Two (2) 230kV gang switches •One (1) 230kV circuit breakers •Associated bus, wiring and equipment •Associated foundations and structures •Associated transmission line communications, relaying and testing	$0.940
	Siting and Land Rights support for substation permitting and construction	$0.020
	Total Cost Estimate for Network Upgrades for Interconnection	**$0.960**
Time Frame	**Site, design, procure and construct**	**18 Months**

7.0 Summary of Informational Interconnection Study Results:

Network Resource Interconnection Service of INFO-2020-10 is 325MW.

The total estimated cost of the transmission system improvements to interconnect INFO-2020-10 for 325MW NRIS is $2.057 Million (Tables 7 and 8).

The COD of INFO-2020-10 is dependent of the construction of the GI-2020-06 230kV Switching Station, which is expected to require a CPCN. The total estimated time frame for regulatory activities (CPCN) and to site, design, procure and construct the switching station at the POI is approximately 36 months after authorization to proceed has been obtained.

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-2020-10 Interconnecting at the GI-2020-06 230kV Switching Station tapping the Pawnee – Missile 230kV line