

Provisional Interconnection Study Report for GI-2021-2

38MW Summer/49MW Winter Incremental Capacity at
Fort Saint Vrain #2
(in 3DISIS-2021-001)

8/9/2021



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1.0 Executive Summary

The “PI-2021-2” is the Provisional Interconnection request for Generation Interconnection Request GI-2021-2 in the 3DISIS-2021-001 Cluster which is an Affiliate request.

The GI-2021-2 is a 38MW(Summer)/49MW(Winter) incremental capacity in the output of the existing Fort Saint Vrain #2 Combustion Turbine Generating Facility.

The total estimated cost of the transmission system improvements required for GI-2021-2 to qualify for Provisional Interconnection Service is \$0.05 Million (Tables 4 and 5).

The Provisional Interconnection Service of GI-2021-2 is 49MW.

Security: As stated in the study agreement, assuming GI-2021-2 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-2021-2 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.

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

2.0 Introduction

The PI-2021-2 is the Provisional Interconnection Service¹ request for GI-2021-2 in the 3DISIS-2021-001 Cluster which is an Affiliate request.

The GI-2021-2 is a request for 38MW(Summer)/49MW(Winter) incremental capacity in the output of the existing Fort Saint Vrain#2 Combustion Turbine generator located in Weld County,

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.

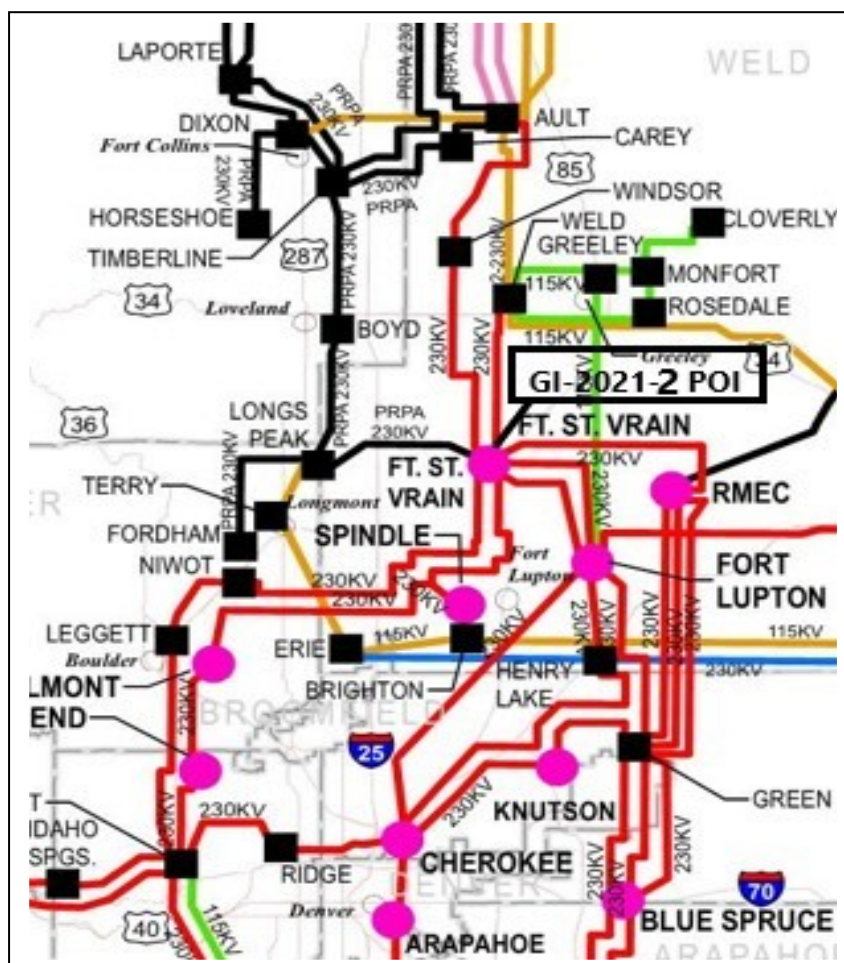
Colorado. The incremental output is driven by turbine prime mover changes being performed as part of maintenance and modernizing the equipment and no changes to the electrical generator set are anticipated. The net generating capacity of Fort Saint Vrain#2 after the Provisional Interconnection will be 165MW(Summer)/187MW(Winter).

The POI of the incremental capacity is the existing Fort Saint Vrain Substation where Fort Saint Vrain#2 is currently interconnected.

The proposed Commercial Operation Date (COD) of GI-2021-2 is April 1, 2022. Since POI is existing, a back-feed date is not applicable.

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

Figure 1 – Point of Interconnection of GI-2021-2



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-2021-2 for Provisional Service. As stated in the PI-2021-2 study agreement, the Provisional Service assumes GI-2021-2 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 Security³ and Contingent Facilities associated with the Provisional Service.

3.1 Study Criteria

3.1.1 Steady State Criteria

The following Steady State Criteria are used for the reliability analysis of the PSCo system 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 – 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

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.

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

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.

The Provisional Interconnection request should meet the Transient stability criteria stated in Section 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 Ft. St. Vrain 230kV, trip Ft. St. Vrain #5 & #6 units
- Three-phase fault at Ft. St. Vrain 230kV, trip Ft. Lupton-Ft. St. Vrain 230kV #1 & 2
- Three-phase fault at Rocky Mountain Energy Center (RMEC), trip all RMEC units
- Three-phase fault at Pawnee 230kV, trip Pawnee generation
- Three-phase fault at Pawnee 230kV, trip Pawnee-Ft. Lupton 230kV

3.4 Study Area

The study area includes WECC designated zones 700, 703 and 706. The Affected Systems included in the analysis include Tri-State Generation and Transmission Inc. (TSGT) system 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. The following planned transmission projects 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

4.1 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 north to south flow. This was accomplished by adopting the stressed generation dispatch given in Table 1.

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

Bus Number	Bus Name	ID	PGen (MW)	PMax (MW)	Owner
70825	CEDAR2_W1 0.66	W1	100	125	PSCO
70826	CEDAR2_W2 0.69	W2	80.6	100.8	PSCO
70827	CEDAR2_W3 0.66	W3	20	25	PSCO
70823	CEDARCK_1A 34.50	W1	176	220	PSCO
70824	CEDARCK_1B 34.50	W2	64	80	PSCO
70106	CHEROK4 22.00	G4	0	383	PSCO
70188	FTLUP1-2 13.80	G1	45	50	PSCO
70188	FTLUP1-2 13.80	G2	45	50	PSCO
70495	JMSHAFR1 13.80	G1	32.2	35.8	TSGT
70495	JMSHAFR1 13.80	G2	31.5	35	TSGT
70493	JMSHAFR2 13.80	ST	45.6	50.7	TSGT
70490	JMSHAFR3 13.80	G3	32.5	36.1	TSGT
70490	JMSHAFR3 13.80	ST	45	50	TSGT
70487	JMSHAFR4 13.80	G4	31.3	34.8	TSGT
70487	JMSHAFR4 13.80	G5	29.7	33	TSGT
70565	KNUTSON1 13.80	G1	65.3	72.5	TSGT
70566	KNUTSON2 13.80	G2	65.3	72.5	TSGT
70310	PAWNEE 22.00	C1	535	535	PSCO

Bus Number	Bus Name	ID	PGen (MW)	PMax (MW)	Owner
70314	MANCHEF1 16.00	G1	0	140	PSCO
70315	MANCHEF2 16.00	G2	0	140	PSCO
70580	PLNENDG1_1 13.80	G0	4.9	5.4	PSCO
70580	PLNENDG1_1 13.80	G1	4.9	5.4	PSCO
70580	PLNENDG1_1 13.80	G2	4.9	5.4	PSCO
70580	PLNENDG1_1 13.80	G3	4.9	5.4	PSCO
70580	PLNENDG1_1 13.80	G4	4.9	5.4	PSCO
70580	PLNENDG1_1 13.80	G5	4.9	5.4	PSCO
70580	PLNENDG1_1 13.80	G6	4.9	5.4	PSCO
70580	PLNENDG1_1 13.80	G7	4.9	5.4	PSCO
70580	PLNENDG1_1 13.80	G8	4.9	5.4	PSCO
70580	PLNENDG1_1 13.80	G9	4.9	5.4	PSCO
70587	PLNENDG1_2 13.80	G0	4.9	5.4	PSCO
70587	PLNENDG1_2 13.80	G1	4.9	5.4	PSCO
70587	PLNENDG1_2 13.80	G2	4.9	5.4	PSCO
70587	PLNENDG1_2 13.80	G3	4.9	5.4	PSCO
70587	PLNENDG1_2 13.80	G4	4.9	5.4	PSCO
70587	PLNENDG1_2 13.80	G5	4.9	5.4	PSCO
70587	PLNENDG1_2 13.80	G6	4.9	5.4	PSCO
70587	PLNENDG1_2 13.80	G7	4.9	5.4	PSCO
70587	PLNENDG1_2 13.80	G8	4.9	5.4	PSCO
70587	PLNENDG1_2 13.80	G9	4.9	5.4	PSCO
70585	PLNENDG2_1 13.80	G1	7.3	8.1	PSCO
70585	PLNENDG2_1 13.80	G2	7.3	8.1	PSCO
70585	PLNENDG2_1 13.80	G3	7.3	8.1	PSCO
70585	PLNENDG2_1 13.80	G4	7.3	8.1	PSCO
70585	PLNENDG2_1 13.80	G5	7.3	8.1	PSCO
70585	PLNENDG2_1 13.80	G6	7.3	8.1	PSCO
70585	PLNENDG2_1 13.80	G7	7.3	8.1	PSCO
70586	PLNENDG2_2 13.80	G1	7.3	8.1	PSCO
70586	PLNENDG2_2 13.80	G2	7.3	8.1	PSCO
70586	PLNENDG2_2 13.80	G3	7.3	8.1	PSCO

Bus Number	Bus Name	ID	PGen (MW)	PMax (MW)	Owner
70586	PLNENDG2_2 13.80	G4	7.3	8.1	PSCO
70586	PLNENDG2_2 13.80	G5	7.3	8.1	PSCO
70586	PLNENDG2_2 13.80	G6	7.3	8.1	PSCO
70586	PLNENDG2_2 13.80	G7	7.3	8.1	PSCO
70586	PLNENDG2_2 13.80	G1	7.3	8.1	PSCO
70588	RMEC1 15.00	G1	139.5	155	PSCO
70589	RMEC2 15.00	G2	139.5	155	PSCO
70591	RMEC3 23.00	ST	309.6	344	PSCO
70593	SPNDLE1 18.00	G1	141.3	157	PSCO
70594	SPNDLE2 18.00	G2	141.3	157	PSCO
70409	ST.VRAIN 22.00	ST	279	310	PSCO
70406	ST.VR_2 18.00	G2	146	146	PSCO
70407	ST.VR_3 18.00	G3	133.2	148	PSCO
70408	ST.VR_4 18.00	G4	137.7	153	PSCO
70950	ST.VR_5 18.00	G5	164.7	183	PSCO
70951	ST.VR_6 18.00	G6	164.7	183	PSCO
70448	VALMONT6 13.80	G6	0	53	PSCO
70557	VALMNT7 13.80	G7	0	44.3	PSCO
70558	VALMNT8 13.80	G8	0	44.3	PSCO
70818	MTNBRZ_W1 34.50	W1	135.2	169	PSCO

4.2 Study Case Modeling

Since the difference between the summer and winter incremental capacities of GI-2021-2 is minimal, the study was performed using the 49MW winter capacity. A Study case was created from the Benchmark Case by proportionally increasing Fort Saint Vrain#2 by 49MW. The additional 49MW output from PI-2021-2 was sunk to Comanche 3.

5.0 Provisional Interconnection Service Analysis

5.1 Voltage and Reactive Power Capability Evaluation

Xcel Energy's OATT requires all synchronous Generator Interconnection Customers to provide dynamic reactive power within the power factor range of 0.95 leading to 0.95 lagging at the POI.

See the Interconnection guidelines for Generators greater than 20MW for additional details - <https://www.transmission.xcelenergy.com/staticfiles/microsites/Transmission/Files/PDF/Interconnection/Interconnections-POL-TransmissionInterconnectionGuidelineGreat20MW.pdf>

The Fort Saint Vrain #2 generator is currently capable of voltage control at the POI, since the reactive capability curve of the generator is not expected to change due to the prime mover modifications, the Provisional Interconnection is modeled by increasing the Qmax and Qmin values pro-rata for the 49MW increase in Fort Saint Vrain #2 capacity. The analysis indicates that the Provisional Interconnection Service is capable of meeting +/-0.95 power factor at the POI.

Table 2 – Reactive capability evaluation of GI-2021-2

Gen MW/Mvar	Gen Terminal Voltage (p.u.)	POI Voltage (p.u.)	POI MW	POI MVar	POI power Factor
187MW / 111.5Mvar	1.04	1.02	182.5	-80.8	0.898 (lag)
187MW / -69.0Mvar	0.95	1.01	182.6	91.4	0.894 (lead)

5.2 Steady State Analysis

The single contingency analysis (P1 and P2-1) and multiple contingency analysis (P4 and P7) did not result in any new thermal or voltage violations after the additional of the 49MW Provisional Interconnection at Fort Saint Vrain#2.

5.3 Transient Stability Results

The following results were obtained for the disturbances analysed:

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

The results of the contingency analysis are shown in Table 3. The transient stability plots are shown in Appendix A to this report.

Table 3 – Transient Stability Analysis Results

Stability Scenarios						
#	Fault Location	Fault Type	Facility Tripped	Clearing Time (cycles)	Post-Fault Voltage Recovery	Angular Stability
1	Ft. St. Vrain 230kV	3ph	Ft. St. Vrain #5 & #6	5	Maximum transient voltage dips within criteria	Stable with positive damping
2	Ft. St. Vrain 230kV	3ph	Ft. Lupton-Ft. St. Vrain 230kV #1 & 2	5	Maximum transient voltage dips within criteria	Stable with positive damping
3	RMEC	3ph	All RMEC units	5	Maximum transient voltage dips within criteria	Stable with positive damping
4	Pawnee 230kV	3ph	Pawnee Generation	5	Maximum transient voltage dips within criteria	Stable with positive damping
5	Pawnee 230kV	3ph	Pawnee-Ft. Lupton 230kV	5	Maximum transient voltage dips within criteria	Stable with positive damping

5.4 Short Circuit and Breaker Duty Analysis Results

Since there are no changes to the Fort Saint Vrain#4 electrical characteristics, there is no short circuit current contribution due to the incremental output.

6.0 Cost Estimates

The POI is existing, and the Provisional Interconnection study did not identify any new Interconnection Facilities or Station Network Upgrades required to accommodate the 38MW (Summer)/49MW (Winter) incremental output at Fort Saint Vrain#2.

The total cost of the required Upgrades for GI-2021-2 to interconnect for Provisional Service at the Fort Saint Vrain Substation is **\$50,000**.

- **The cost of Transmission Provider's Interconnection Facilities is \$50,000**
- **The cost of Station Network Upgrades is \$0**

The list of improvements required to accommodate the Provisional Interconnection of GI-2021-2 (in 3DISIS-2021-001) are given in Tables 4 and 5. The work needed to interconnect the Provisional Interconnection only includes testing of fibre, communication and relaying installed to accommodate the incremental 49MW output. Since the POI is existing, a CPCN will not be required to accommodate the interconnection.

Table 4 –Transmission Provider’s Interconnection Facilities

Element	Description	Cost Est. (Millions)
Existing Fort Saint Vrain Substation POI	Interconnect PI-2021-2 Generating Facility. The new equipment includes: • testing of communications, relays	\$0.05
	Transmission line tap into substation:	0
	Siting and Land Rights support for siting studies, land and ROW acquisition and construction	0
	Total Cost Estimate for Transmission Providers Interconnection Facilities	\$0.05
Time Frame	Site, design, procure and construct	12 Months

Table 5 –Station Network Upgrades

Element	Description	Cost Est. (Millions)
N/A	N/A	0
	Siting and Land Rights support for substation construction	0
	Total Cost Estimate for Network Upgrades for Interconnection	0
Time Frame	Site, design, procure and construct	N/A

The PSCo Engineering has developed cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades required for the interconnection of GI-2021-2 for Provisional Service. The cost estimates are in 2021 dollars with escalation and contingencies applied. Allowances for Funds Used During Construction (AFUDC) is not included. These estimated costs include all applicable labor and overheads associated with the siting, engineering, design, and

construction of these new PSCo facilities. This estimate does not include the cost for any Customer owned equipment and associated design and engineering.

- Labor is estimated for straight time only – no overtime included.
- The POI is existing and metered, so 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.
- Breaker duty study determined that no breaker replacements are needed.
- Existing Power Quality Metering (PQM) is adequate.
- Existing Load Frequency/Automated Generation Control (LF/AGC) RTU is adequate

7.0 Summary of Provisional Interconnection Service Analysis

The total estimated cost of the PSCo transmission system improvements required for GI-2021-2 in 3DISIS-2021-001 to qualify for Provisional Interconnection Service is: \$0.05 Million.

The Provisional Interconnection Service allotted to the Generating Facility is 49MW.

Security: As stated in the study agreement, assuming GI-2021-2 in 3DISIS-2021-001 selects ERIS, the security associated with the Network Upgrades that might be identified at the conclusion of the GI-2021-2 Large Generation Interconnection Procedure (LGIP) in the 3DISIS-2021-001 cluster is estimated to be approximately \$5 Million.

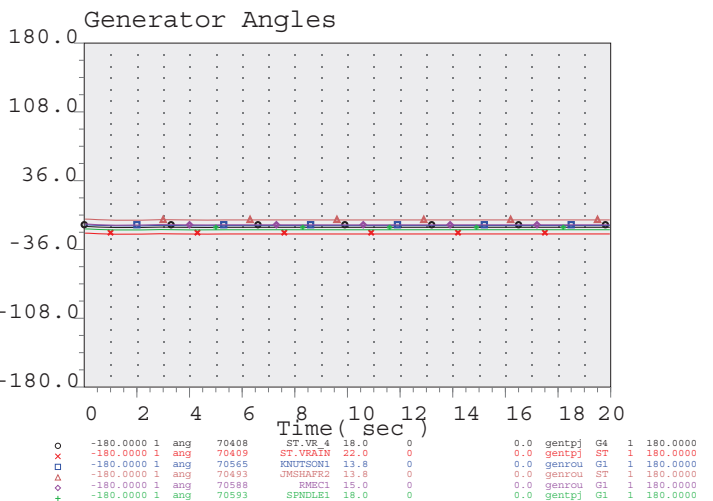
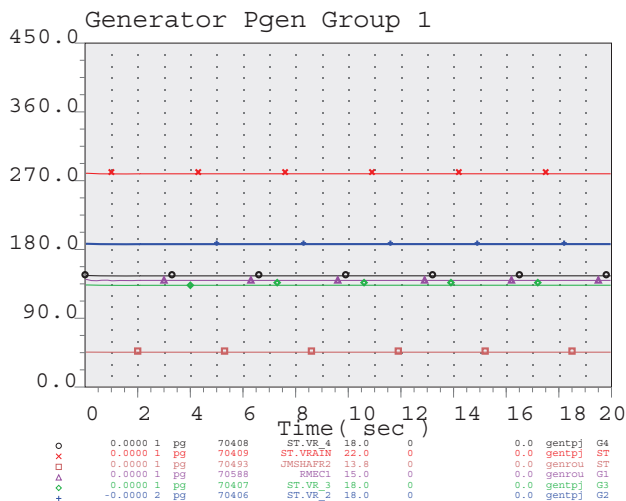
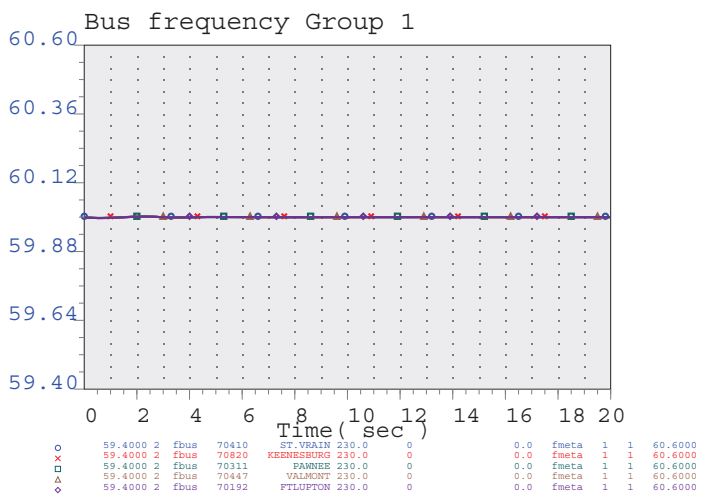
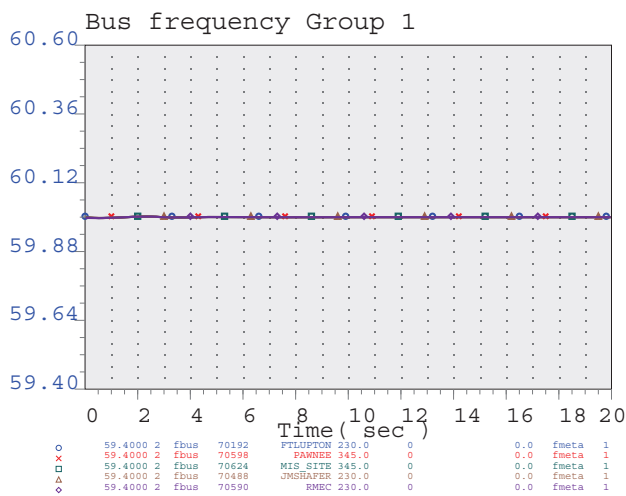
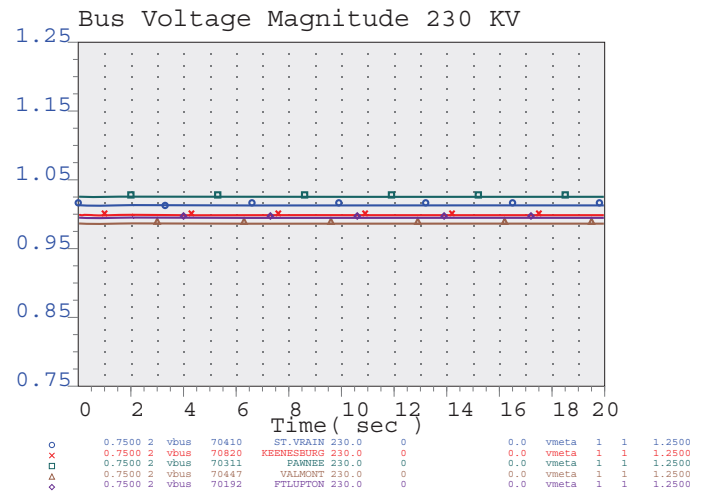
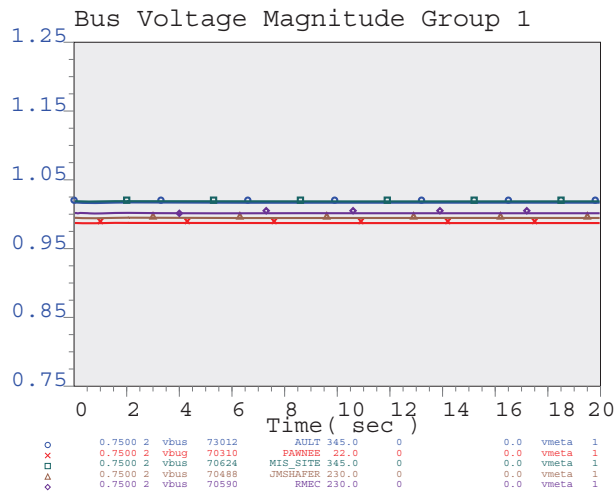
The Interconnection Customer assumes all risk and liabilities with respect to changes between the PLGIA and the LGIA, including changes in output limits and Interconnection Facilities, Network Upgrades, Distribution Upgrades, and/or System Protection Facilities cost responsibility.

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

8.0 Contingent Facilities

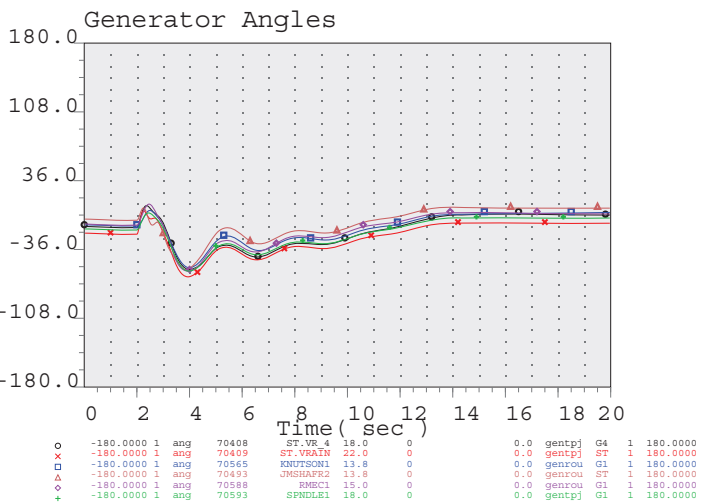
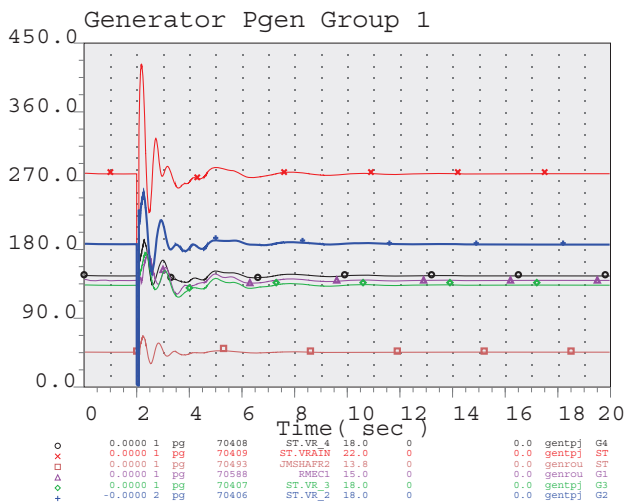
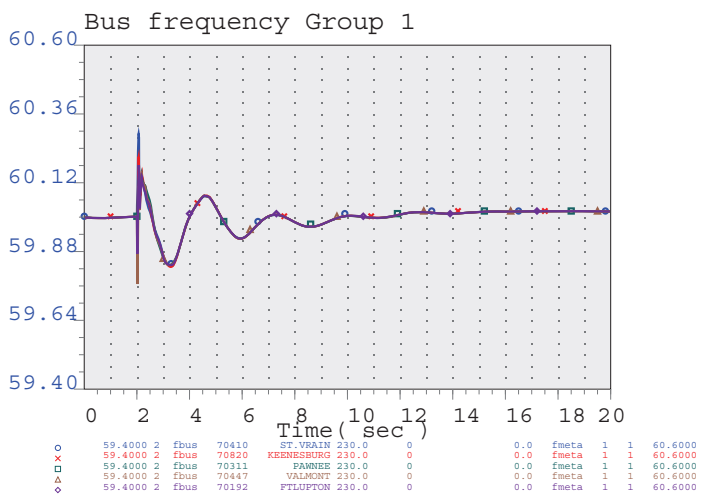
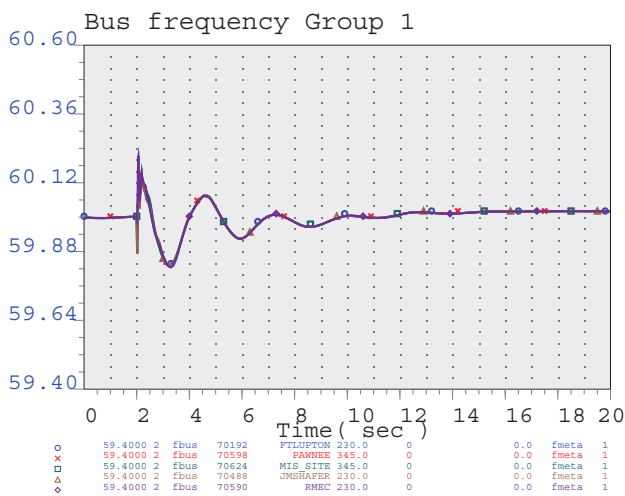
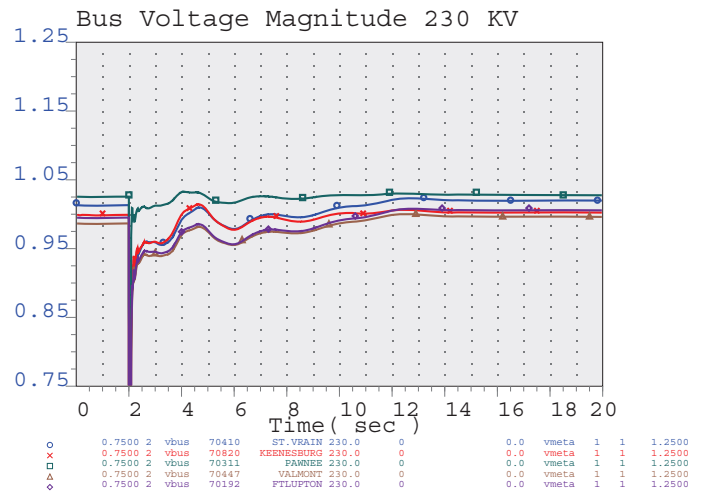
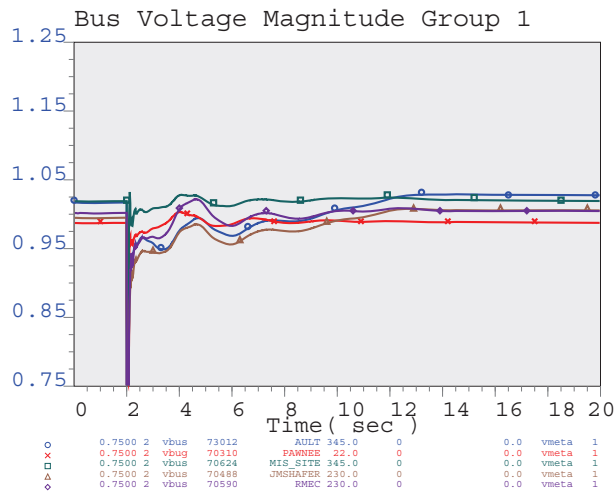
There are no new transmission projects planned in the study area and there were no Interconnection Facilities or Station Network Upgrades identified for PI-2021-2. So, there are no Contingent Facilities identified.

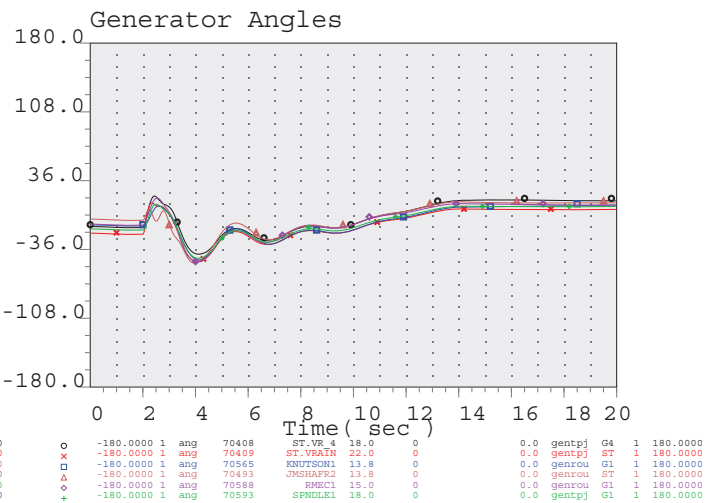
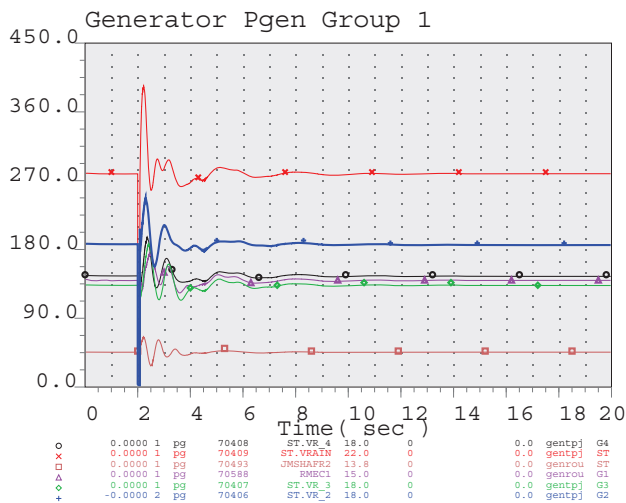
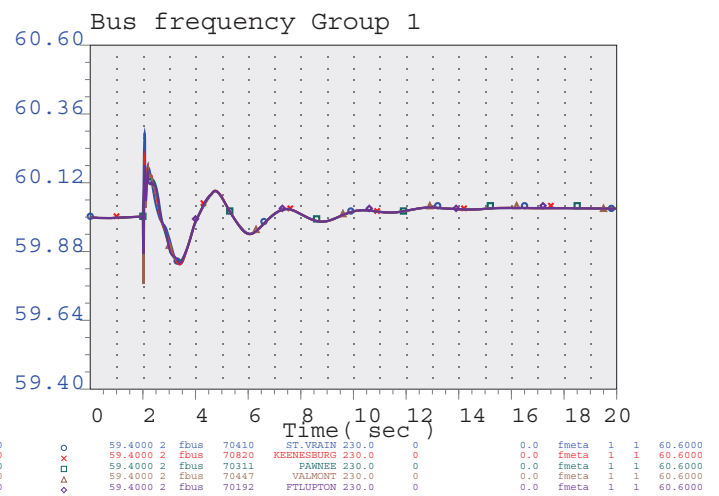
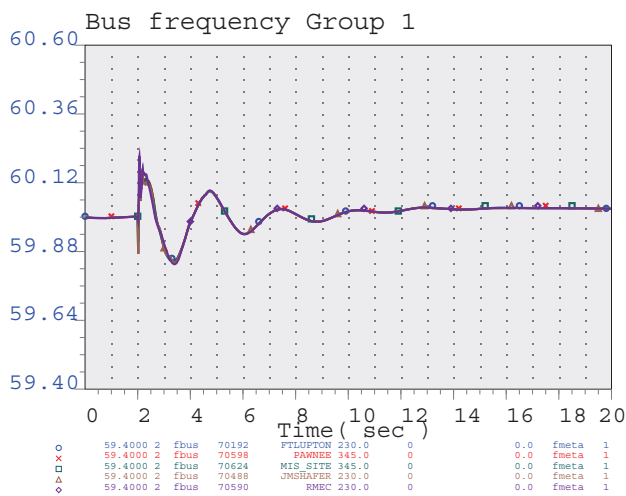
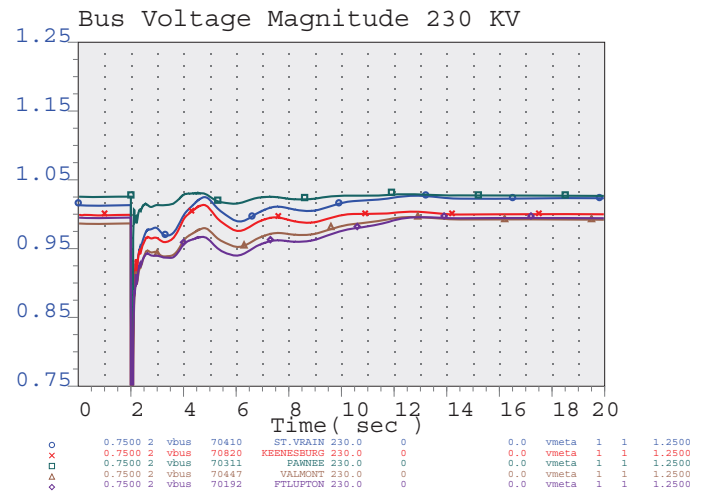
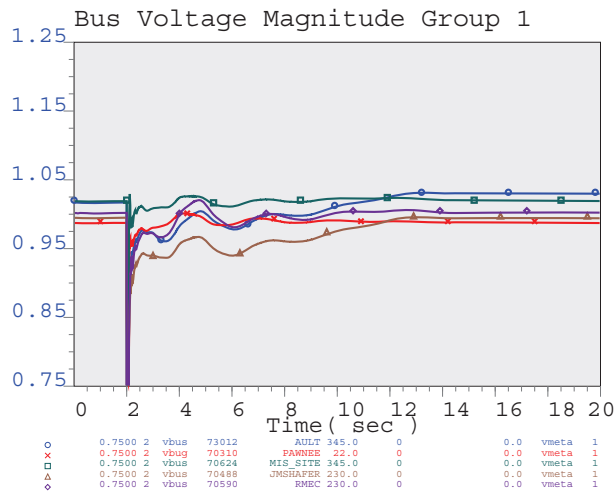
Appendix A - Transient Stability Plots



PI-2021-2 Pre-Project Case

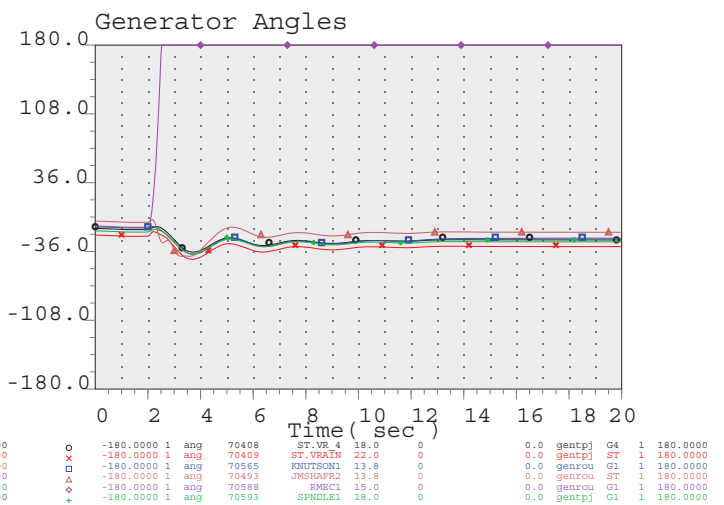
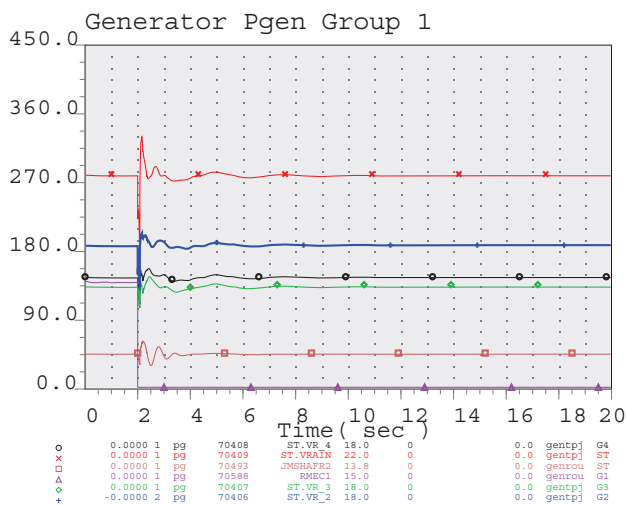
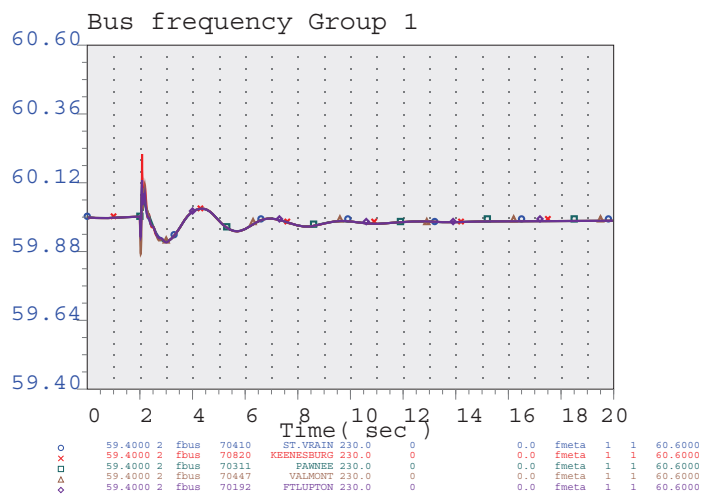
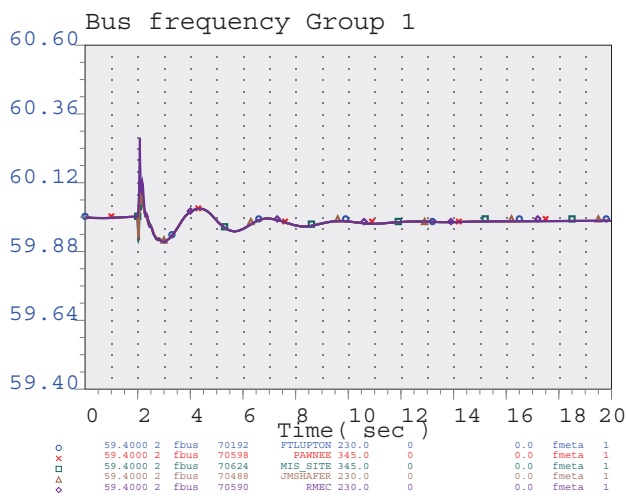
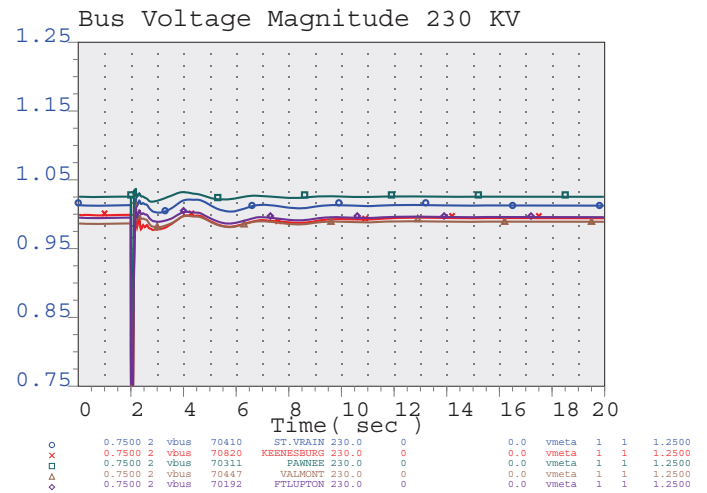
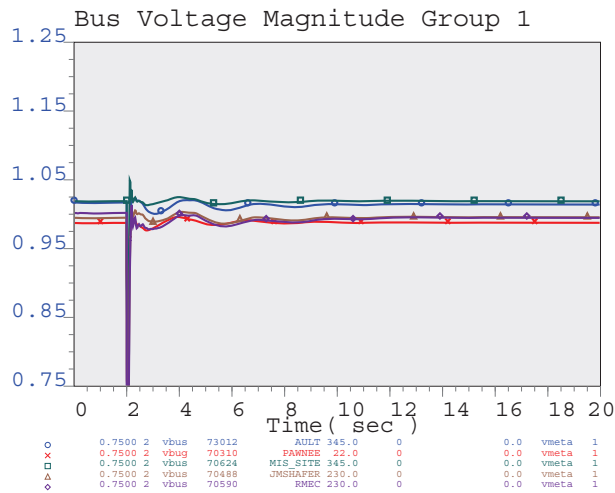






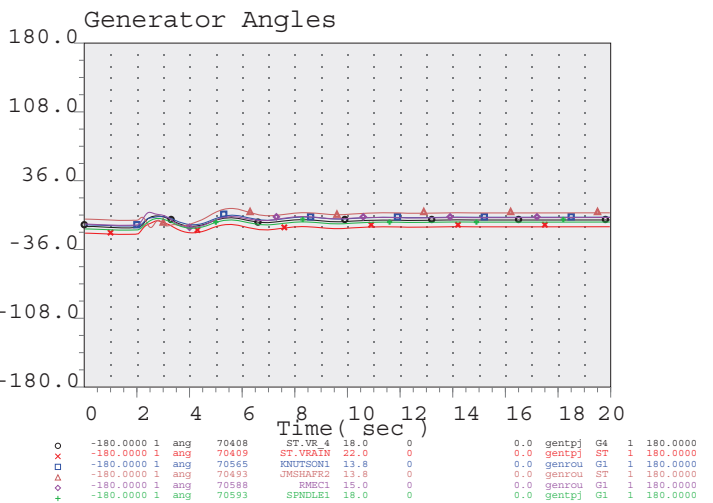
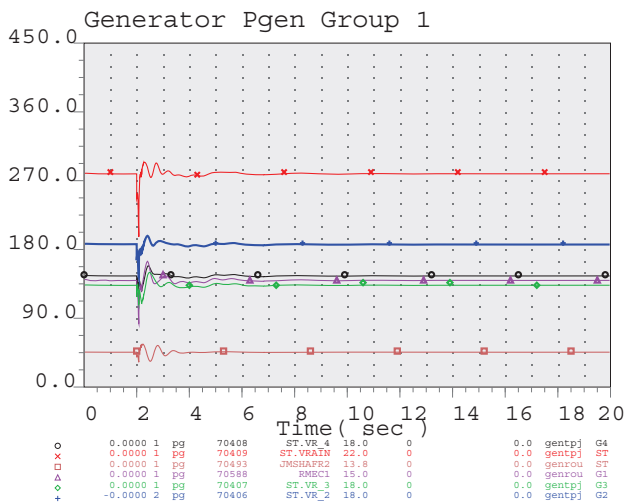
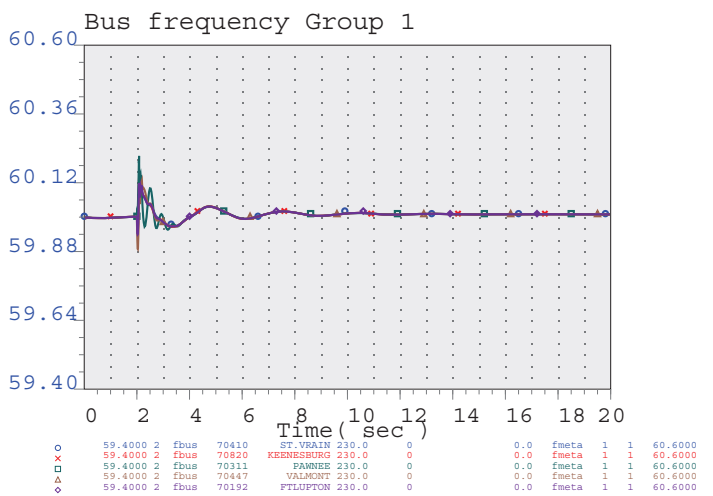
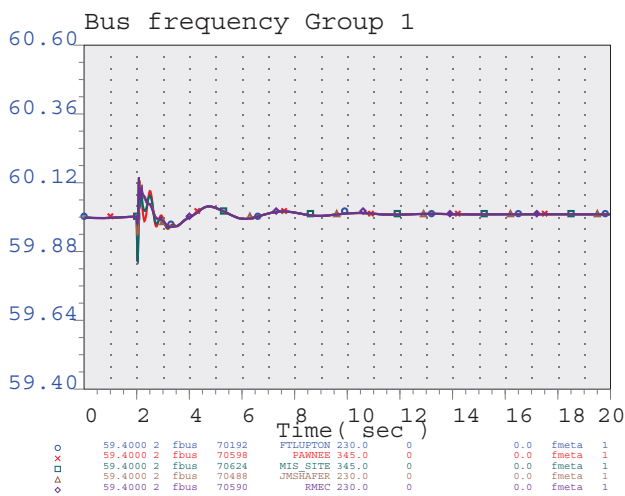
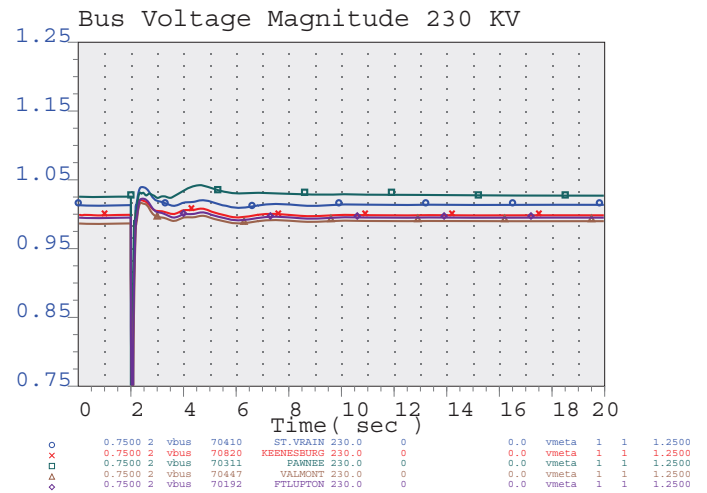
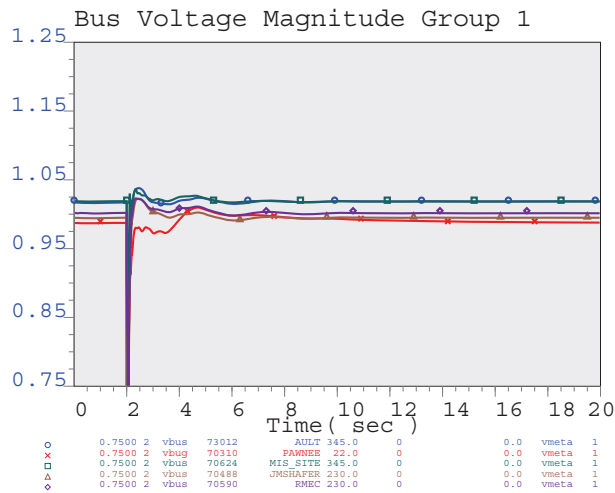
PI-2021-2 Pre-Project Case





PI-2021-2 Pre-Project Case





PI-2021-2 Pre-Project Case

