Provisional Interconnection Study Report
Provisional Interconnection Request for GI-2018-25 (PI-2019-4)

200 MW Solar Photovoltaic and Battery Energy Storage Generating Facility
Badger Hills 230kV Substation

Pueblo County, Colorado

Xcel Energy - Transmission Planning West
November 13, 2019

Executive Summary

The PI-2019-4 (PI) is the Provisional Interconnection Service Request for the NRIS request GI-2018-25 (GI). The Generating Facility is a 200MW net rated Solar Photovoltaic (PV) plus Battery Energy Storage (BES) hybrid Generating Facility that will be located in Pueblo County, Colorado. This hybrid Generating Facility will consist of two distinct facility groups – 200MW Solar PV facility and 100MW BES facility. The proposed Point of interconnection (POI) of the PI will require building a new 230kV switching station – Badger Hills 230kV Substation. A Certificate of Public Need and Benefit (CPCN) is required to build the Badger Hills 230kV Substation.

The PI-2019-4 is an AC-Coupled hybrid PV and BES Generation Facility. The expected operating modes of the Generating Facility are:

i. 200MW rated generation output at the Point of Interconnection (POI) via combination of PV and BES ("Generation mode")
ii. 100MW rated load at the POI for a maximum of 4 hours when PV output is 0MW. The BES facility will not charge from the grid, i.e., act as a load during the first five (5) years and three (3) months beyond the stated Commercial Operation Date (COD), but it may act as a load and charge from the grid after that period ("Load mode")

The proposed COD of the PI facility is December 31, 2022. Accordingly, based on the standard construction schedules, the back-feed date is assumed to be June 30, 2022, approximately six (6) months before the COD. The backfeed and COD of the PI are dependent on Badger Hills being in-service.

The study evaluates the system impact due to Generation Mode and Load Mode of operation independently. The Provisional Interconnection Service evaluation is based on the Generation Mode results only.

The Load Mode study results are used to evaluate the system impacts of operating in this mode in the future.

PI-2019-4 was studied for Provisional Interconnection Service and the 200 MW rated output of the GI was assumed to be delivered to Public Service Company of Colorado (PSCo) native load, so existing PSCo generation was used as its sink.

The power flow analysis included steady state analysis with Comanche Unit #1 online and after its planned retirement. The study with Comanche Unit #1 online identified one new overload on the CSU system. The power flow analysis with the Comanche Unit #1 retirement modeled did not identify any thermal violations attributable to the PI.

The evaluation performed to evaluate the 100MW interconnection in the Load Mode, i.e., charging from the grid, did not identify any system violations.

The short-circuit and breaker duty analysis determined that no breaker replacements are needed at the POI station and/or in neighboring PSCo stations.

The total estimated cost of the PSCo transmission system improvements required for PI-2019-4 to qualify for Provisional Interconnection Service is:

- **$11.106 Million (Tables 6 and 7)**

For PI-2019-4 interconnection:

Provisional Interconnection Service (after the retirement of Comanche#1) = 200MW

In case the Comanche Unit #1 retirement is delayed for any reason, the maximum output of PI-2019-4 may be limited based on generation dispatch and available firm or non-firm capacity on the transmission system.

The Provisional Interconnection Service results above are contingent upon the transmission system improvements identified in Attachment 1.

Security: As the GI-2018-25 request is NRIS, the security associated with the Network Upgrades that might be identified at the conclusion of the GI-2018-25 LGIP is expected to be around $300 million. Security amount for PI-2019-4 is $300 million.

The net generation output of the hybrid facility at the POI will not exceed 200MW at any time, which will be monitored by PSCo and limited by the Plant Controller at all times.

The Interconnection Customer assumes all risk and liabilities with respect to changes between the Provisional Large Generator Interconnection Agreement and the Large Generator Interconnection Agreement, 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.

Introduction

The PI-2019-4 (PI) is the Provisional Interconnection Service Request for GI-2018-25 (GI). The Generating Facility is a 200MW net rated Solar Photovoltaic (PV) plus Battery Energy Storage (BES) hybrid Generating Facility that will be located in Pueblo County, Colorado. This hybrid Generating Facility will consist of two distinct facility groups – 200MW Solar PV facility and 100MW BES facility. The 200MW Solar PV facility will consist of ninety-seven (97) GE 2.3MVA, ±0.90 PF inverters, each with its own 600V/34.5kV, 2.3MVA, Z=6.3% pad-mounted step-up transformer. The 100MW BES facility will consist of forty-six (46) Parker 2.2MVA, 1.0 (unity) PF inverters, each with its own 480V/34.5kV, 2.2MVA, Z=5.75% pad-mounted step-up transformer. The Customer has confirmed that the Parker inverters are capable of ±0.95 PF even though the manufacturer data sheets specify 1.0 (unity) PF. The 34.5kV collector system will connect to one 34.5/230kV, 201/268/335MVA, Z=8.5% main step-up transformer which in turn will connect to Comanche – MidwayPS 230kV line via a 0.1 mile generation tie-line. The 230kV tap position on the Comanche – MidwayPS line will require building a new switching station – "Badger Hills Substation". A Certificate of Public Need and Benefit (CPCN) is required to build the Badger Hills 230kV Substation.

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

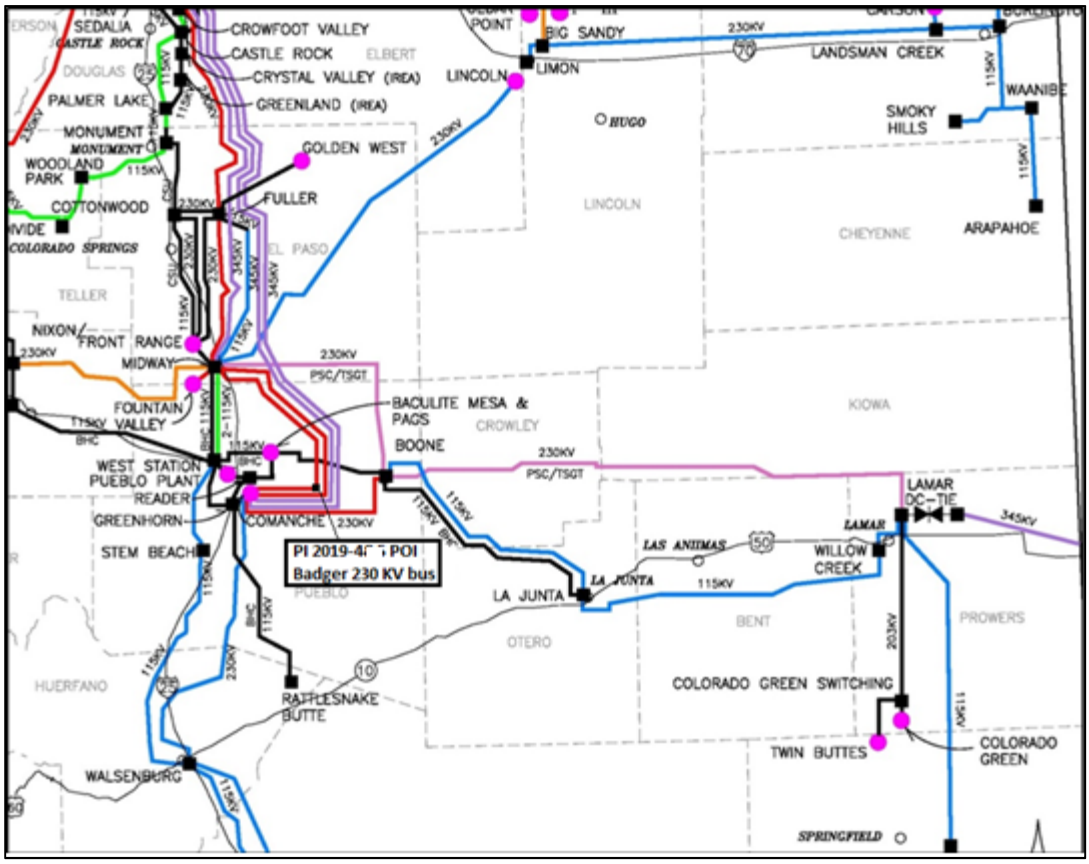


Figure 1- PI-2019-4 Point of Interconnection and Study Area

The PI-2019-4 is an AC-Coupled hybrid PV and BES Generation Facility. The expected operating modes of the Generating Facility are:

I. 200MW rated generation output at the POI via combination of PV and BES ("Generation Mode")
II. 100MW rated load at the POI for a maximum of four (4) hours when PV output is 0MW. The BES facility will not charge from the grid, i.e., act as a load during the first five (5) years and three (3) months following the COD stated in this report, but it may charge from the grid, i.e., operated as a load on the transmission system after that period ("Load Mode")

The proposed Commercial Operation Date (COD) of the PI facility is December 31, 2022. Accordingly, based on the typical construction timeframes for similar projects, the back-feed date is assumed to be June 30, 2022, approximately six (6) months before the COD. The backfeed and COD of the PI are dependent on Badger Hills being in-service.

The main purpose of this study is to determine the system impact of interconnecting 200MW of combined PV and BES generation at the Badger Hills 230kV Substation. Per the Provisional Interconnection Study Request, PI-2019-4 is studied for Provisional Interconnection Service[1] only. As stated in the PI-2019-4 study agreement, the study assumed GI-2018-25 selects Network Resource Interconnection Service (NRIS)[2]. For this evaluation, the 200 MW rated output of PI-2019-4 is assumed to be delivered to PSCo native load, so existing PSCo generation is used to sink the PI output.

This study report also evaluated the system impacts of operating in load mode in the future.

Study Scope and Analysis Criteria

The scope of this report includes steady state (power flow) analysis, transient stability analysis, short circuit analysis, and appropriation level cost estimates (+/- 20% accuracy). The report also identifies the estimated Security[3] for the Provisional Interconnection. The power flow analysis identifies thermal and voltage violations in the PSCo system and the neighboring systems as a result of the interconnection of the GI for Provisional Interconnection Service (Generation mode only). Several single contingencies are studied.

[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.

[2] **Network Resource Interconnection Service** shall mean an Interconnection Service that allows the Interconnection Customer to integrate its Large Generating Facility with the Transmission Provider's Transmission system (1) in a manner comparable to that in which the Transmission Provider integrates its generating facilities to serve native load customers; or (2) in an RTO or ISO with market based congestion management, in the same manner as all other Network Resources. Network Resource Interconnection Service in and of itself does not convey transmission service.

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

The transient stability analysis verifies that all generating units within the PSCo transmission system and the neighboring systems remain stable (in synchronism), have positive damping, and satisfy acceptable dynamic performance criteria. 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 and need to be replaced.

The system impact analysis criteria are as follows:
PSCo adheres to applicable NERC Reliability Standards and WECC Reliability Criteria, as well as its internal transmission planning criteria for studies. 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

The same list of contingencies was run on the benchmark case and the study case, and the results were compared.

For PSCo facilities, thermal violations attributable to the PI included any facilities without a pre-existing thermal violation that (i) resulted in a thermal loading >100% post the GI addition (ii) contributed to an incremental loading increase of 2% or more to the benchmark case loading. For non-PSCo facilities, thermal violations attributed to the GI include all new facility overloads with a thermal loading of >100% and existing thermal overloads that increased by 1% or more from the benchmark case overload post the GI addition.

The voltage violations assigned to the PI include new voltage violations or existing voltage violations which resulted in a further variation of 0.1 per unit.

Transient stability criteria require that all generating machines remain in synchronism and all power swings should be well damped following a contingency event. Also, transient voltage performance should meet the following WECC Disturbance-Performance criteria:

- Following fault clearing, the voltage shall recover to 80% of the pre-contingency voltage within 20 seconds for all contingencies
- For all contingencies, 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 contingencies without a fault, 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 study area is the electrical system consisting of PSCo's transmission system and the neighboring transmission systems that are impacted by or that will impact interconnection of the PI. The study area for PI-2019-4 includes WECC designated zones 121, 700, 703, 704, 705, 709, 710, 712, 752 and 757.

The study evaluates the system impact due to Generation Mode and Load Mode of operation independently. The Provisional Interconnection Service evaluation is based on the Generation Mode results only.

The Load Mode study results are used to evaluate the system impacts of operating in this mode in the future.

System Impact Study Power Flow Case Creation

The Base Case used for the power flow analysis originated from the 2023HS case built for the 2018 TPL1 Work Group of the Colorado Coordinated Planning Group (CCPG). As part of the case build efforts for the TPL1 work group, the case was reviewed by PSCo and neighboring utilities within the CCPG foot print.

All transmission planned projects in PSCo's 10 year transmission plan that are expected to be in-service before July 2023 are modeled in the Base Case, consistent with the case season and year. These projects are described at:
(http://www.oasis.oati.com/woa/docs/PSCO/PSCOdocs/Q1_2019_Transmission_Plan.pdf)

The PSCo projects added to the Base Case include the following:

- Shortgrass 345kV Switching Station – ISD 2020
- Shortgrass – Cheyenne Ridge 345kV line – ISD 2020
- Graham Creek 115kV Substation – ISD 2021
- Husky 230/115kV Substation – ISD 2021
- Cloverly 115kV Substation – ISD 2021
- Ault – Husky 230kV line – ISD 2021
- Husky – Graham Creek – Cloverly 115kV line – ISD 2021
- Monument – Flying Horse 115kV Series Reactor – ISD 2021
- 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
- Increase Waterton – Martin1 tap 115kV line to 159MVA – ISD 2022

The Base Case also modeled PSCo's Poncha - Smeltertown 115kV line open.

The following additional changes were made to the Tri-State Generation and Transmission (TSGT) model in the Base Case per further review and comment from TSGT:

- 30MW San Isabel Solar tapping Ludlo Tap – Pinon Canyon 115kV line
- 80MW TSGT_0809 solar facility tapping Gladstone – Walsenburg 230kV line
- 100MW TSGT_STEM_PV solar facility at Stem Beach 115kV bus was removed from the model
- Fuller – Vollmer – Black Squirrel 115 kV line modeled at 173 MVA
- Fuller 230/115kV, 100MVA #2 transformer

The following additional changes were made to the Black Hills Energy (BHE) model in the Base Case per further review and comment from BHE:

- Fountain Valley – DesertCove 115kV line was modeled at 222MVA. Planned upgrade project in 1/2021
- Fountain Valley – MidwayBR 115kV line was modeled at 222MVA. Planned upgrade project in 1/2021
- Pueblo West Substation – ISD 1/2021
- Skyline Ranch Substation – ISD 10/2021
- West Station – Greenhorn 115kV line Rebuild – ISD 9/2022

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
- Grazing Yak Solar – ISD 2020
- Cottonwood 230/115kV auto-transformer replacement – ISD 2019
- Nixon – Kelker 230kV line upgrade – ISD 2019

The Base Case model includes the existing PSCo generation resources. The higher-queued Provisional Interconnection requests modeled in the Base Case are PI-2019-2. There were no other higher-queued generators in the Provisional Interconnection queue with POI in the same generation pocket and no higher-queued generation in the Generation Interconnection queue which have a Power Purchase Agreement or have received the state approval in the Electric Resource Plan which qualified for inclusion in the Base Case.

Provisional Interconnection Capacity Evaluation

Benchmark Case Creation:

The Benchmark Case for evaluating the system impact of PI-2019-4 generation output was created from the Base Case by changing the generation dispatch to reflect a heavy south to north flow on the Comanche – Midway – Jackson Fuller – Daniels Park transmission system. This was accomplished by adopting the generation dispatch given in Table 1 below. The generation dispatch of the neighboring systems was provided by the neighboring utilities.

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

Bus Name	ID	Status	PGen (MW)	PMax (MW)	Owner
APT_DSLS 4.1600	G1	0	0	10	BHE
BAC_MSA GEN1 13.800	G1	1	59.4	90	BHE
BAC_MSA GEN2 13.800	G1	1	59.4	90	BHE
BAC_MSA GEN4 13.800	G1	1	26.4	40	BHE
BAC_MSA GEN4 13.800	G2	1	26.4	40	BHE
BAC_MSA GEN4 13.800	S1	1	16.4	24.8	BHE
BAC_MSA GEN5 13.800	G1	1	26.4	40	BHE
BAC_MSA GEN5 13.800	G2	1	26.4	40	BHE
BAC_MSA GEN5 13.800	S1	1	16.4	24.8	BHE
BAC_MSA GEN6 13.800	G1	1	26.4	40	BHE
BUSCHRNCH_LO0.7000	1	1	35.2	60	BHE
BUSCHRWTG1 0.7000	G1	1	16.9	28.8	BHE
E_CANON 69.000	G1	0	5.3	8	BHE
PP_MINE 69.000	G1	0	2	3	BHE
PUB_DSLS 4.1600	G1	0	6.6	10	BHE
R.F.DSLS 4.1600	G1	0	6.6	10	BHE
RTLSNKWNDLO 0.7000	G1	1	35.2	60	BHE
ALMSACT1 13.800	G1	0	0	17	PSCo
ALMSACT2 13.800	G2	0	0	14	PSCO
COGENTRIX_PV 34.500	S3	1	19.5	30	PSCO
COMAN_1 24.000	C1	0	360	360	PSCO
COMAN_2 24.000	C2	1	365	365	PSCO
COMAN_3 27.000	C3	1	788	788	PSCO
COMAN_PV 34.500	S1	1	102	120	PSCO
CO_GRN_E 34.500	W1	1	64.8	81	PSCo
CO_GRN_W 34.500	W2	1	64.8	81	PSCo
FTNVL1&2 13.800	G1	1	36	40	PSCO
FTNVL1&2 13.800	G2	1	36	40	PSCO
FTNVL3&4 13.800	G3	1	36	40	PSCO
FTNVL3&4 13.800	G4	1	36	40	PSCO
FTNVL5&6 13.800	G5	1	36	40	PSCO
FTNVL5&6 13.800	G6	1	36	40	PSCO
GSANDHIL_PV 34.500	S1	1	12.4	19	PSCO
JKFULGEN 0.6900	W1	1	199.5	249.4	PSCO
LAMAR_DC 230.00	DC	0	0	210	PSCO
SOLAR_GE 34.500	S2	1	19.5	30	PSCO
SUNPOWER 34.500	S1	1	33.8	52	PSCO

TWNBUTTE 34.500	W1	1	60	75	PSCO
SI_GEN 0.6000	1	1	24	30	TSGT
TBII_GEN 0.6900	W	1	60	76	TSGT
TSGT_0809 0.6200	PV	1	80	100	TSGT
GI-2018-24&25	PV+BES	0	0	325	--

To analyze the impact of the planned retirement of Comanche #1 generator in 2022, a scenario Benchmark Case was created from the Benchmark Case described above by modeling Comanche #1 offline.

A Study case and a scenario study case were created from the Benchmark Case and Scenario Benchmark Case, respectively, by adding the PI-2019-4 interconnection facility at the proposed Point of Interconnection. The 200MW output from PI-2019-4 was sunk pro-rata to the PSCo units outside the study area. The PI-2019-4 facility was modeled using the power flow modeling data provided by the Generation Interconnection Customer. The power flow analysis modeled the PI output at 200MW, as a combination of 100MW PV and 100MW BES. The dynamic data representing the inverters of the solar PV and BES models have different "reec" models and are expected to have different voltage behavior, so the stability analysis studied the PI for

- 100MW PV and 100MW BES
- 200MW PV only
- 100MW BES only.

A power flow analysis was performed, and the results of the Benchmark Case vs Study Case, and the Scenario Benchmark Case vs Scenario Study Case were compared to determine the impacts of the interconnection of the PI and the Provisional Interconnection Service capacity of PI-2019-4.

The steady state analysis was performed using PTI's PSSE Ver. 33.5.0 program and the ACCC contingency analysis tool.

The transient stability analysis was performed using General Electric's PSLF Ver.21.0_07 program. Three phase faults were simulated for selected single and multiple contingencies using standard clearing times. The voltage and frequency of transmission buses in the study area, and the relative rotor angle of generators in the study area were recorded and analyzed. PSLF's DYTOOLS EPCL program was used to simulate the disturbances.

Power Flow Analysis Results

Table 2 Power Flow Analysis Results of PI-2019-4 – 200MW generation

Note – Thermal overloads for single contingencies are calculated using the normal rating of the facility. All overloads are in red.

Summary of Power Flows from Single Contingency Analysis 2023 Heavy Summer Case									
				Facility Loading Without PI-2019-4		Facility Loading With PI-2019-4			
Monitored Facility (Line or Transformer)	Type	Owner	Branch Rating MVA (Norm)	N-1 Flow MVA (Norm)	N-1 Flow % of Rating (Norm)	N-1 Flow MVA (Norm)	N-1 Flow % of Rating (Norm)	% Change	NERC Single Contingency
Briargate S – Cottonwood S 115kV	Line	CSU	150.0	147.9	98.6%	153.2	101.4%	2.8%	Cottonwood N – KettleCreek S 115 KV Line

The results of the single contingency analysis (P1 and P2-1) for the case with Comanche Unit #1 online are given in Table 2. The addition of PI-2019-4 caused one new overload on the CSU system. The facility overloads impacted by the addition of PI-2019-4 are as follows:

- Briargate S – Cottonwood S 115kV line loading increased from 98.6% to 101.4% (CSU facility)

The scenario with Comanche Unit #1 retirement modeled did not result in any thermal or voltage violations.

Hence, in case the Comanche Unit #1 retirement is delayed for any reason, the maximum output PI-2019-4 may be limited based on generation dispatch and available firm or non-firm capacity on the transmission system.

If Comanche Unit #1 is retired as planned, the maximum Provisional Interconnection Service capacity of PI-2019-4 is 200MW.

The Customer is required to design and build the Generating Facility such that there are no control or operational interaction conflicts with neighboring inverter based Generating Facility(ies).

Voltage Regulation and Reactive Power Capability

The Interconnection Customer is required to interconnect its Large Generating Facility with PSCo's Transmission System in accordance with the *Xcel Energy Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater Than 20 MW* (available at:

http://www.transmission.xcelenergy.com/staticfiles/microsites/Transmission/Files/PDF/Interconnection/Interconnections-POL-TransmissionInterconnectionGuidelineGreat20MW.pdf).

Accordingly, the following voltage regulation and reactive power capability requirements at the POI are applicable to this interconnection request:

- To ensure reliable operation, all Generating Facilities interconnected to the PSCo transmission system are expected to adhere to the *Rocky Mountain Area Voltage Coordination Guidelines (RMAVCG)*. Accordingly, since the POI for this interconnection request is located within Southeast Colorado - Region 4 defined in the *RMAVCG*; the applicable ideal transmission system voltage profile range is 1.02 – 1.03 per unit at regulated buses and 1.0 – 1.03 per unit at non-regulated buses.
- Xcel Energy's OATT (Attachment N effective 10/14/2016) 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 as long as the Generating Facility does not have to operate outside its 0.95 lag – 0.95 lead dynamic power factor range capability.
- 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 (34.5kV or 230kV bus) 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 and the 1.0 – 1.03 per unit voltage range standards at the POI. 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 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 voltage ranges (noted above).

According to the modeling data provided by the Customer, PI-2019-4 generator has the following modeling parameters:

- Solar PV: Pmax =200MW, Pmin =0, Qmax = 97.25Mvar, Qmin = -97.25Mvar
- BES: Pmax =100MW, Pmin=-100MW, Qmax=48.43Mvar, Qmin=-48.43Mvar

Table 3 - Reactive Capability Evaluation

Gen MW(PV/BESS)/Mvar (PV/BESS)	Gen Voltage (p.u.) - (PV/BESS)	High Side Main Station Transformer Voltage (p.u.)	High Side MW	High Side Mvar	High Side Power Factor	Lead / lag	POI Voltage (p.u.)	POI MW	POI MVar	POI Power Factor
200MW / -48.6Mvar	1.005/1.001	1.028	198	-65	0.950	lead	1.028	198	-67.1	0.947
200MW /89.4Mvar	0.908/0.908	1.0505	198.1	65	0.95	lag	1.0505	196.5	-190.8	0.717
100MW / -23.8Mvar (BES only)	0/1.016	1.033	98.9	-32.5	0.95	lead	1.0333	98.9	-31.9	0.952
100MW / 40.6Mvar (BES only)	0/1.087	1.0441	99	32.5	0.95	lag	1.0441	99	31.5	0.953
20MW / -7.8Mvar	1.034/1.033	1.037	20	-6.6	0.95	lead	1.037	20	-6.3	0.954
20MW /6.8Mvar	1.043/1.044	1.0392	20	6.6	0.95	lag	1.0392	20	6.6	0.95
200MW / 145.6Mvar	1.139/1.143	1.059	197.8	118.1	0.859	lag	1.059	197.8	118.1	0.859
200MW / -145.6Mvar	0.908/0.908	1	196.5	-190.8	0.717	lead	1	196.5	-190.8	0.717
200MW /97.3Mvar (PV only)	1.118/1.085	1.051	197.3	71.6	0.94	lag	1.051	197.3	71.6	0.94
200MW/-97.3(PV only)	0.948/0.966	1.016	196.3	-133.8	0.826	Lead	1.016	196.3	-133.8	0.826
100MW/48.4Mvar (BES only)	1.063/1.097	1.046	98.9	39.9	0.927	Lag	1.046	98.9	39.9	0.927
100MW/-48.4 (BES only)	1.006/0.985	1.029	98.7	-59.5	0.856	Lead	1.029	98.7	-59.5	0.856
0MW/-145.6Mvar	0.908/0.912	1	-1.2	-159.5	N/A	N/A	1	-1.2	-159.5	N/A

From the analysis in Table 3, the Generating Facility is capable of meeting 0.95 PF at the high side of the main step-up transformer, while maintaining at least nominal voltage at the POI.

Transient Stability Study Results

Table 4 Transient Stability Analysis Results

Stability Scenarios						
#	Fault Location	Fault Type	Facility Tripped	Clearing Time (cycles)	Post-Fault Voltage Recovery	Angular Stability
1	Boone 230kV	3ph	Boone 230/115kV Transformer	5.0	Maximum transient voltage dips within criteria	Stable with positive damping
2	Boone 230kV	3ph	Lamar – Boone 230kV line and all generation at Lamar	5.0	Maximum transient voltage dips within criteria	Stable with positive damping
3	Boone 230kV	3ph	Boone – Comanche 230kV	5.0	Maximum transient voltage dips within criteria	Stable with positive damping
4	Boone 230kV	3ph	Boone – Midway 230kV	5.0	Maximum transient voltage dips within criteria	Stable with positive damping
5	Comanche 345 kV	3ph	Comanche#3 generator	4.0	Maximum transient voltage dips within criteria	Stable with positive damping
6	Lamar 230kV	3ph	Lamar – Boone 230kV line and all generation at Lamar	5.0	Maximum transient voltage dips within criteria	Stable with positive damping
7	MidwayPS 230kV	3ph	All Fountain Valley gas units	5.0	Maximum transient voltage dips within criteria	Stable with positive damping
8	MidwayPS 345kV	3ph	MidwayPS – Waterton 345kV line & Midway 230/345kV xfmr	4.0	Maximum transient voltage dips within criteria	Stable with positive damping
9	Comanche 345kV	3ph	Comanche – Daniels Park 345kV line # 1&2 and Comanche – PI-2019-2 Switching Station 345 KV line	4.0	Maximum transient voltage dips within criteria	Stable with positive damping

The results of the transient stability analysis are given in Table 4. It is determined that the interconnection of PI-2019-4 produced no adverse system stability impact. The following results were obtained for every case and disturbance analyzed:

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

Transient stability plots showing surrounding bus voltages, bus frequencies, generator terminal voltages, generator relative angles, generator speeds, and generator power output for each of the disturbances runs for each study scenario have been created and documented in Appendix B. Furthermore, it is the responsibility of the Interconnection Customer to ensure that its generating facility is capable of meeting the voltage ride-through and frequency ride-through (VRT and FRT) performance specified in the NERC Reliability Standard PRC-024.

Short Circuit and Breaker Duty Analysis

The calculated short circuit levels and Thevenin system equivalent impedances at the Badger Hills 230kV Substation are shown in Table 5.

Table 5 – Short Circuit Parameters at the PI-2019-4 at POI

	Before PI-2019-4 Interconnection	After PI-2019-4 Interconnection
Three Phase Current	11,821A	12,053A
Single Line to Ground Current	9,275A	10,748A
Positive Sequence Impedance	1.164+j11.190 ohms	1.164+j11.184 ohms
Negative Sequence Impedance	1.179+j11.202 ohms	1.179+j11.196 ohms
Zero Sequence Impedance	11.951+j41.023 ohms	8.930+j15.956 ohms

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

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

Cost Estimates and Assumptions

PSCo Engineering has developed Appropriations level cost estimates (AE) for Interconnection Facilities and Network/Infrastructure Upgrades required for the interconnection of the Interconnection Customer's proposed generation facility. The cost estimates are in 2019 dollars with escalation and contingencies applied. 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 required upgrades is $11,106,000.

Figure 2 below is a conceptual one-line of the proposed interconnection. The Point of Interconnection will be a terminal on the new Badger Hill 230kV bus.

Tables 6 and 7 list the improvements required to accommodate the interconnection and the delivery of the customer's 200 MW Solar PV and BES generation facility generation output. 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.

The Transmission Provider has specified and estimated the cost of the equipment, engineering, procurement and construction work needed to interconnect PI-2019-4. The results of the engineering analysis for facilities owned by the Transmission Provider are appropriation level estimates and are summarized in Tables 6 and 7.

> Table 6: "Transmission Provider's Interconnection Facilities" includes the nature and estimated cost of the Transmission Provider's Interconnection Facilities and an estimate of the time required to complete the construction and installation of such facilities.
>
> Table 7: "Network Upgrades Required for Interconnection includes the nature and estimated cost of the Transmission Provider's Network Upgrades necessary to accomplish the interconnection and an estimate of the time required to complete the installation of such facilities.

Upgrades identified in Tables 6 and 7 are illustrated in Figure 2 in the Appendix which shows the physical and electrical connection of the Interconnection Customer's Generating Facility to the Transmission Provider's Transmission System. The one-line diagram also identifies the electrical switching configuration of the interconnection equipment, including, without limitation: the transformer, switchgear, meters, and other station equipment.

Conclusion:

The total estimated cost of the PSCo transmission system improvements required for PI-2019-4 to qualify for Provisional Interconnection Service is:

- **$11.106 Million (Tables 6 and7)**

For PI-2019-4 interconnection:

Provisional Interconnection Service (after the retirement of Comanche#1) = 200MW

In case the Comanche Unit #1 retirement is delayed for any reason, the maximum output PI-2019-4 may be limited based on generation dispatch and available firm or non-firm capacity on the transmission system.

The Provisional Interconnection Service results above are contingent upon the transmission system improvements identified in Attachment 1.

The net generation output of the hybrid facility at the POI shall not exceed 200MW at any time, which will be monitored by PSCo and limited by the Plant Controller at all times.

Security: *As stated in the study agreement, assuming GI-2018-25 request selects NRIS, the security associated with the Network Upgrades that might be identified at the conclusion of the GI-2018-25 LGIP is expected to be approximately $300 million.*
The Interconnection Customer assumes all risk and liabilities with respect to changes between the Provisional Large Generator Interconnection Agreement and the Large Generator Interconnection Agreement, 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.

Table 6 – Transmission Provider's Interconnection Facilities

Element	Description	Cost Est. (Millions)
PSCO's Badger Hill 230kV Bus (New switching station)	Interconnect Customer to tap at the Badger Hill switching station 230kV bus. The new equipment includes: • One 230kV deadend and one girder • Three 230kV arresters • One 230kV 2000A 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.	$0.870
	Transmission line tap into substation:	$0.055
	Siting and Land Rights support for siting studies, land and ROW acquisition and construction	$0.020

	Total Cost Estimate for Transmission Providers Interconnection Facilities	$0.020
Time Frame	**Site, design, procure and construct**	**$0.945**
Time Frame	**Site, design, procure and construct**	**36 Months**

Table 7 - Network Upgrades for Interconnection (ERIS)

Element	**Description**	**Cost Est. (Millions)**
PSCO's Badger Hill 230kV Bus (New switching station)	Install a new three position ring bus switching station on the 230kV Comanche-Midway line. The new equipment includes: • Three 230kV 3000A circuit breakers • Nine 230kV 2000A disconnect switches (assume all switch stands will be installed) • Six 230kV CCVTs • Two Line Traps • Six 230kV Surge Arresters • Four Deadends / 2 DE Girder • One Electrical Equipment Enclosure • Station controls and wiring • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures	$7.043
PSCO's Badger Hill 230kV Bus (New switching station)	Install required communications in the EEE at the new switching station	$0.321
PSCo's Comanche 230kV Bus	Update line relaying on line to Badger Hill. Install one wave trap, three CCVTs.	$1.030
PSCo's Midway 230kV Bus	Update line relaying on line to Badger Hill. Install one wave trap, three CCVTs.	$1.030
PSCO's Comanche-Midway 230kV Bus (New switching station)	Reterminate the tranmission line into the new switching station	$0.717
	Siting and Land Rights support for substation construction	$0.020
	Total Cost Estimate for Network Upgrades for Interconnection	**$10.161**
Time Frame	**Site, design, procure and construct**	**36 Months**

Cost Estimate Assumptions

- Appropriation level project cost estimates (AE) for Interconnection Facilities were developed by PSCo Engineering. A level of accuracy of ±20% is specified for AE's.
- Estimates are based on 2019 dollars (appropriate contingency and escalation applied).
- "Allowance for Funds Used during Construction" (AFUDC) has been excluded.

- Labor is estimated for straight time only – no overtime included.
- Lead times for materials were considered for the schedule.
- The Generation Facility is not in PSCo's retail service territory. Therefore, no costs for retail load metering are included in these estimates.
- PSCo (or its Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- The estimated time to design, procure and construct the interconnection facilities is approximately 36 months after authorization to proceed has been obtained.
- A Certification of Public Convenience and Need (CPCN) will be required for the interconnection facilities construction.
- Customer will string OPGW fiber into substation as part of the transmission line construction scope.
- Breaker duty study determined that no breaker replacements are needed in neighboring substations.
- Line and substation bus outages will be necessary during the construction period. Outage availability could potentially be problematic and extend requested backfeed date.
- Power Quality Metering (PQM) will be required on the Customer's 230kV line terminating into Badger Hills 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.

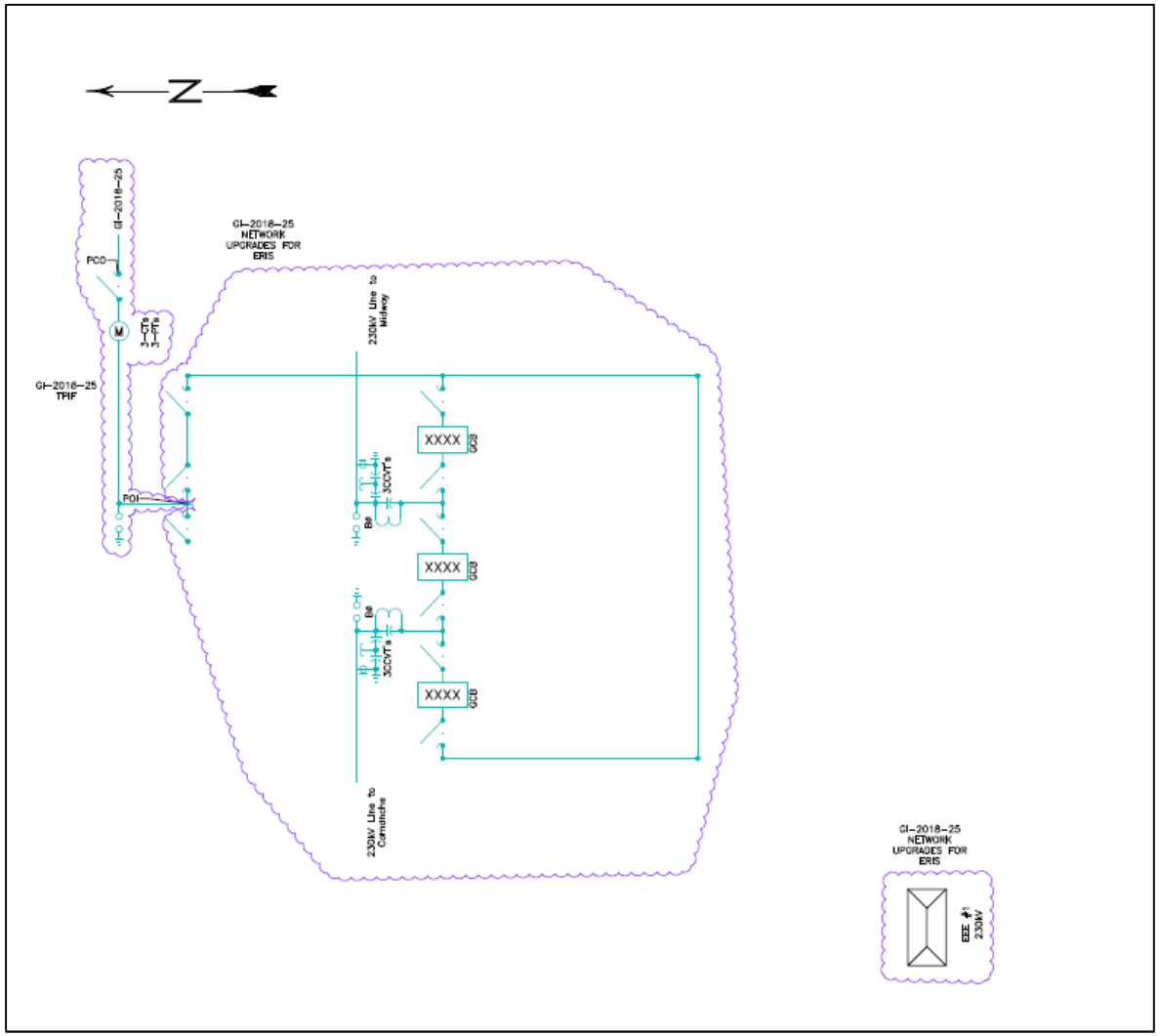


Figure 2 – Preliminary one-line of PI-2019-4 POI

Attachment 1 – Contingent Facilities Assigned to PI-2019-4

The following is the list of the unbuilt Interconnection Facilities and Network Upgrades upon which the PI-2019-4 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. PI-2019-4's maximum allowable output may be decreased if these Contingent Facilities are not in-service.

1. The following unbuilt transmission projects modeled in the Base Case
   - Monument – Flying Horse 115kV Series Reactor – ISD 2021
   - Upgrade Villa Grove – Poncha 69kV Line to 73MVA – ISD 2021
   - Upgrade Poncha - Sargent - San Luis Valley 115kV line to 120MVA – ISD 2021
   - Increase Waterton – Martin1 tap 115kV line to 159MVA – ISD 2022
   - TSGT's planned project to uprate the Fuller – Vollmer – Black Squirrel 115 kV line to 173 MVA
   - TSGT's planned project - Fuller 230/115kV, 100MVA #2 transformer
   - BHE's planed project to uprate the Fountain Valley – DesertCove 115kV line to 171MVA
   - BHE's planned project to uprate the Fountain Valley – MidwayBR 115kV line to 171MVA
   - BHE's Pueblo West Substation
   - BHE's Skyline Ranch Substation
   - BHE's West Station – Greenhorn 115kV line Rebuild project
   - CSU's project to close Tesla - Cottonwood 34.5kV line and open the Kettle Creek – Tesla 34.5kV line
   - CSU's new Cottonwood 230/115kV auto-transformer replacement
   - CSU's Nixon – Kelker 230kV line uprate project
2. Network Upgrades for Interconnection assigned to PI-2019-4 (refer to Tables 6 and 7 of this report)

Appendix – A: Load Impact Evaluation

Load Mode Benchmark Case:

The Benchmark Case for evaluating the system impact of PI-2019-4 operating in grid charging mode i.e., acting as a load on the transmission system was created from the PI-2019-4 Base Case (see System Impact Study Power Flow Case Creation section) by adopting the generation dispatch given in Table 8 below.

Table 8 – Generation Dispatch Used to Stress the Benchmark Case for Storage Charging Evaluation (MW is Gross Capacity)

Bus Name	ID	Status	PGen (MW)	PMax (MW)	Owner
APT_DSLS 4.1600	G1	0	0	10	BHE
BAC_MSA GEN1 13.800	G1	1	59.4	90	BHE
BAC_MSA GEN2 13.800	G1	1	59.4	90	BHE
BAC_MSA GEN4 13.800	G1	1	26.4	40	BHE
BAC_MSA GEN4 13.800	G2	1	26.4	40	BHE
BAC_MSA GEN4 13.800	S1	1	16.4	24.8	BHE
BAC_MSA GEN5 13.800	G1	1	26.4	40	BHE
BAC_MSA GEN5 13.800	G2	1	26.4	40	BHE
BAC_MSA GEN5 13.800	S1	1	16.4	24.8	BHE
BAC_MSA GEN6 13.800	G1	1	26.4	40	BHE
BUSCHRNCH_LO0.7000	1	1	12.6	60	BHE
BUSCHRWTG1 0.7000	G1	1	6	28.8	BHE
E_CANON 69.000	G1	0	0	8	BHE
PP_MINE 69.000	G1	0	0	3	BHE
PUB_DSLS 4.1600	G1	0	0	10	BHE
R.F.DSLS 4.1600	G1	0	0	10	BHE
RTLSNKWNDLO 0.7000	G1	1	35.2	60	BHE
ALMSACT1 13.800	G1	0	0	17	PSCo
ALMSACT2 13.800	G2	0	0	14	PSCO
COGENTRIX_PV 34.500	S3	1	0	30	PSCO
COMAN_1 24.000	C1	0	360	360	PSCO
COMAN_2 24.000	C2	0	365	365	PSCO
COMAN_3 27.000	C3	1	788	788	PSCO
COMAN_PV 34.500	S1	1	0	120	PSCO
CO_GRN_E 34.500	W1	1	17	81	PSCo

CO_GRN_W 34.500	W2	1	17	81	PSCo
FTNVL1&2 13.800	G1	1	0	40	PSCO
FTNVL1&2 13.800	G2	1	0	40	PSCO
FTNVL3&4 13.800	G3	1	0	40	PSCO
FTNVL3&4 13.800	G4	1	0	40	PSCO
FTNVL5&6 13.800	G5	1	0	40	PSCO
FTNVL5&6 13.800	G6	1	0	40	PSCO
GSANDHIL_PV 34.500	S1	1	0	19	PSCO
JKFULGEN 0.6900	W1	1	199.5	249.4	PSCO
LAMAR_DC 230.00	DC	0	0	210	PSCO
SOLAR_GE 34.500	S2	1	0	30	PSCO
SUNPOWER 34.500	S1	1	0	52	PSCO
TWNBUTTE 34.500	W1	1	15.8	75	PSCO
SI_GEN 0.6000	1	1	0	30	TSGT
STEM_PV 0.4800	PV	1	0	100	TSGT
TBII_GEN 0.6900	W	1	16	76	TSGT
TSGT_0809 0.6200	PV	1	0	100	TSGT
PI-2019-2	PV+BES	1	0	250	---

Per the interconnection request, the Generating Facility may operate in the grid charging mode only five (5) years and three (3) months post COD given in this report. To analyze the impact of the planned retirement of Comanche #1 in 2022 and Comanche #2 in 2025, the Benchmark Case modeled Comanche #1 & #2 offline.

A Study case was created from the Benchmark Case by adding the PI-2019-4 interconnection facility at the Badger Hills 230kV POI. The PI-2019-4 was modeled using the power flow modeling data provided by the Generation Interconnection Customer. The solar PV generator was modeled offline and the BES generator output was set to '-100MW'. The BES generator was modeled with the same reactive capability (Qmax and Qmin) as the discharging mode as the Customer indicated the inverter will operate in "grid following mode" and will have the same voltage control capabilities as the discharging mode.

A power flow analysis was performed, and the results of the Benchmark Case vs Study Case, were compared to determine the impacts of the Generating Facility operating in the charging mode.

The steady state analysis was performed using PTI's PSSE Ver. 33.5.0 program and the ACCC contingency analysis tool.

The transient stability analysis was performed using General Electric's PSLF Ver.21.0_07 program. Three phase faults were simulated for selected single and multiple contingencies using standard clearing times. The voltage and frequency of transmission busses in the study area, and the relative rotor angle of generators in the study area were recorded and analyzed. PSLF's DYTOOLS EPCL program was used to simulate the disturbances.

Power Flow Analysis Results

The power flow analysis did not result in any thermal or voltage violations due to the 100MW load.

Voltage Regulation and Reactive Power Capability

Per the reactive capability curve provided by the Customer, the BES inverter is capable of voltage control in the charging mode. The generator would be required to regulate the voltage in order to meet the requirements specified under "Voltage Regulation and Reactive Power Capability" on page 12.

Transient Stability Study Results

Table 10 Transient Stability Analysis Results

Stability Scenarios						
#	Fault Location	Fault Type	Facility Tripped	Clearing Time (cycles)	Post-Fault Voltage Recovery	Angular Stability
1	Boone 230kV	3ph	Boone 230/115kV Transformer	Primary (5.0)	Maximum transient voltage dips within criteria	Stable with positive damping
2	Boone 230kV	3ph	Lamar – Boone 230kV line and all generation at Lamar	Primary (5.0)	Maximum transient voltage dips within criteria	Stable with positive damping
3	Boone 230kV	3ph	Boone – Comanche 230kV	Primary (5.0)	Maximum transient voltage dips within criteria	Stable with positive damping
4	Boone 230kV	3ph	Boone – Midway 230kV	Primary (5.0)	Maximum transient voltage dips within criteria	Stable with positive damping
5	Comanche 345 kV	3ph	Comanche#3 generator	Primary (4.0)	Maximum transient voltage dips within criteria	Stable with positive damping
6	Lamar 230kV	3ph	Lamar – Boone 230kV line and all generation at Lamar	Primary (5.0)	Maximum transient voltage dips within criteria	Stable with positive damping
7	MidwayPS 230kV	3ph	All Fountain Valley gas units	Primary (5.0)	Maximum transient voltage dips within criteria	Stable with positive damping
8	MidwayPS 345kV	3ph	MidwayPS – Waterton 345kV line & Midway	Primary (4.0)	Maximum transient voltage dips within	Stable with positive

			230/345kV xfmr		criteria	damping
9	Comanche 345kV	3ph	Comanche – Daniels Park 345kV line #2 and Comanche – PI-2019-2 Switching Station 345 KV line	Primary (4.0)	Maximum transient voltage dips within criteria	Stable with positive damping
10	Comanche 345kV	3ph	Comanche – Daniels Park 345kV line #2 and Daniels Park – PI_2019_2 Switching Station 45 KV line	Primary (4.0)	Maximum transient voltage dips within criteria	Stable with positive damping

As shown in Table 10, the transient stability analysis simulated ten disturbances in the Study Case. It is determined that the interconnection of the 100 MW BES in charging mode produced no adverse system stability impact. The following results were obtained for every case and disturbance analyzed:

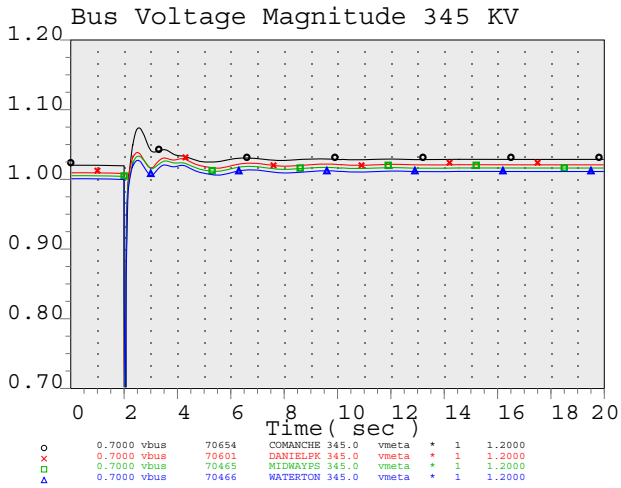
- ✓ No machines lost synchronism with the system
- ✓ No transient voltage drop violations were observed
- ✓ Machine rotor angles displayed positive damping

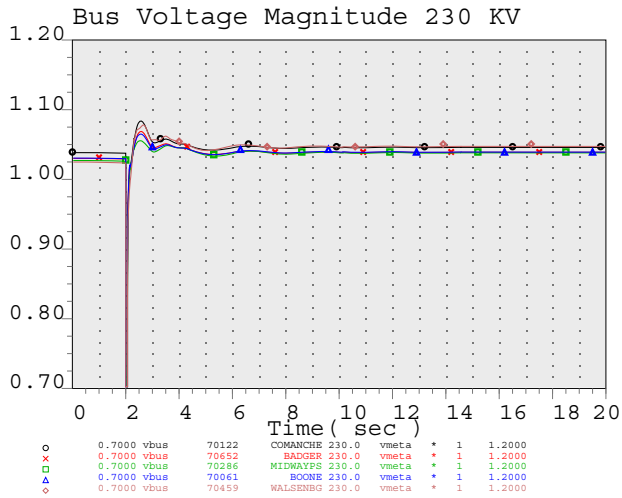
Costs Estimates and Assumptions: No additional transmission improvements were identified for the Load (charging) Mode.

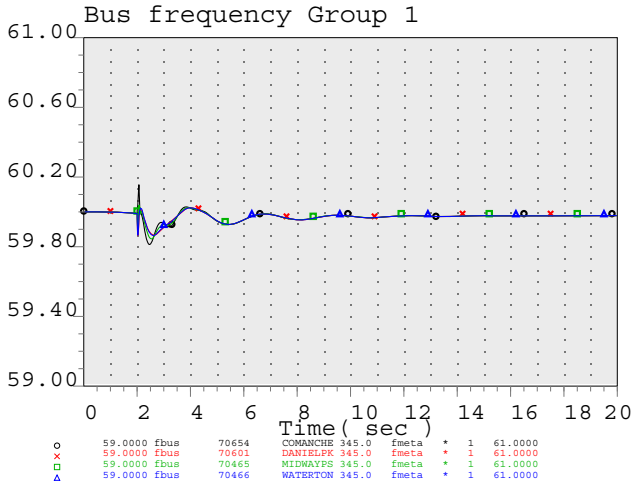
Conclusion:

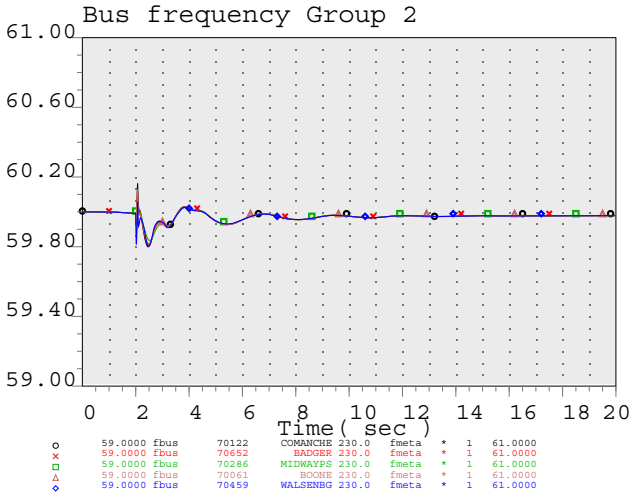
Studies indicate that the Load Mode of operation does not contribute to any system impact when PI-2019-4 is the only request operating in the charging mode.

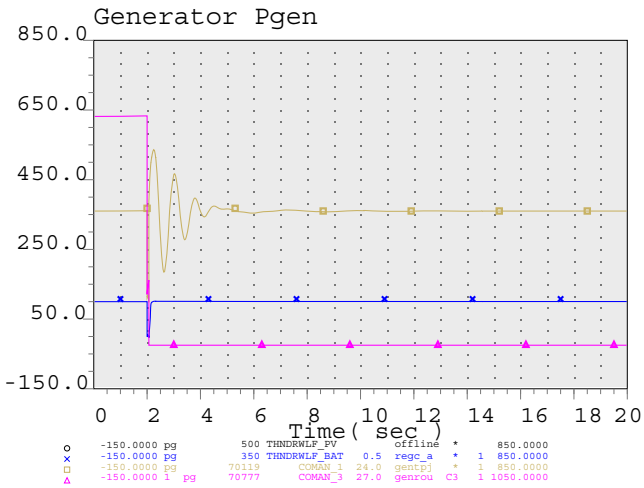
PSCo is further evaluating the load interconnection service of the Storage Facility and how it can be served based on various retail/wholesale/transmission service options. The Load Interconnection Service results above are preliminary and may change depending on the service under which the load could be served.

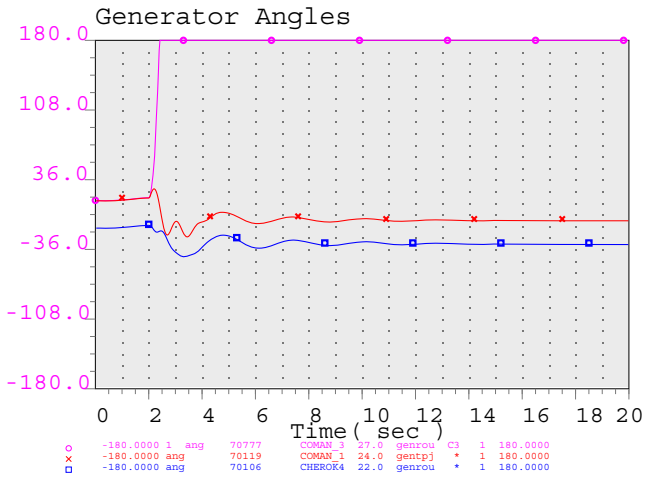






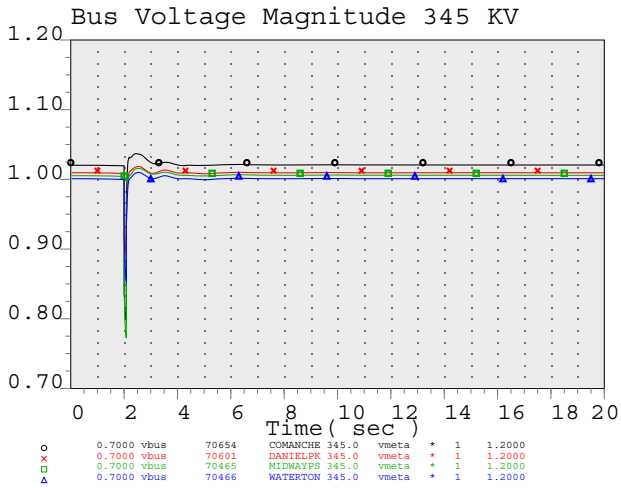


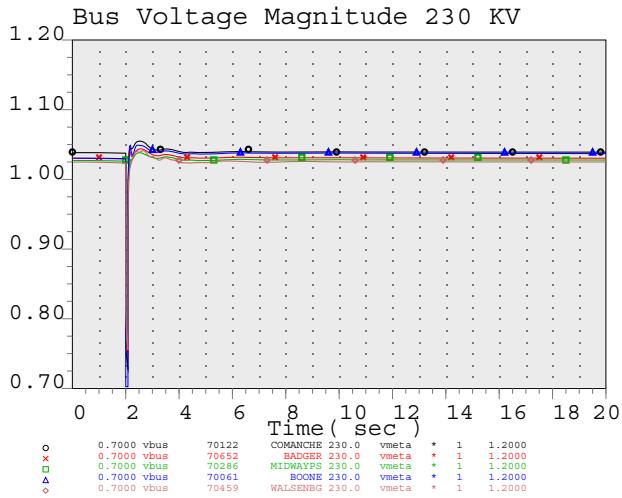


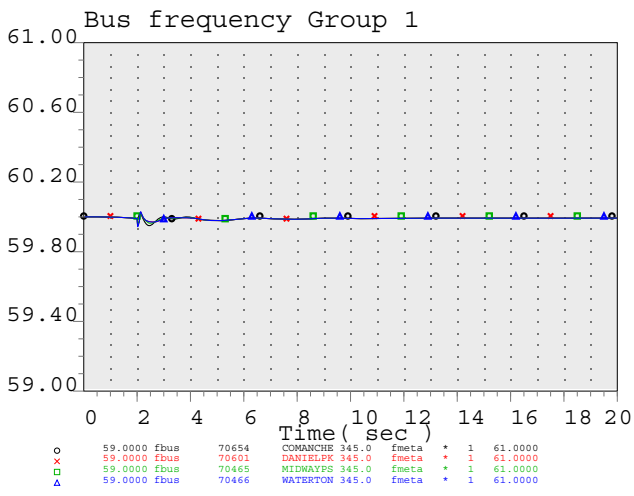


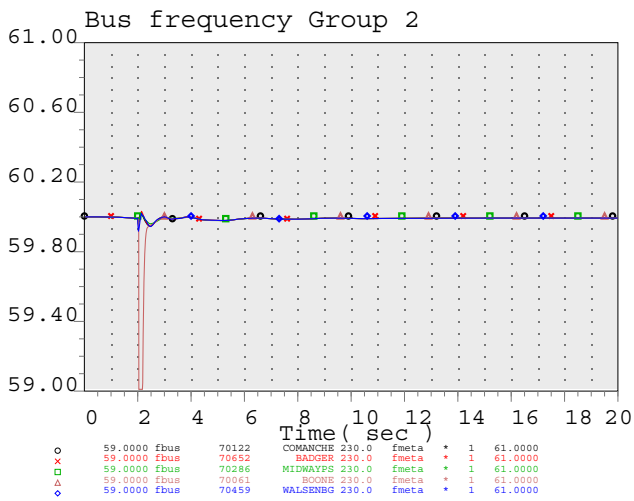
PV - 0 MW & BES - 100 MW

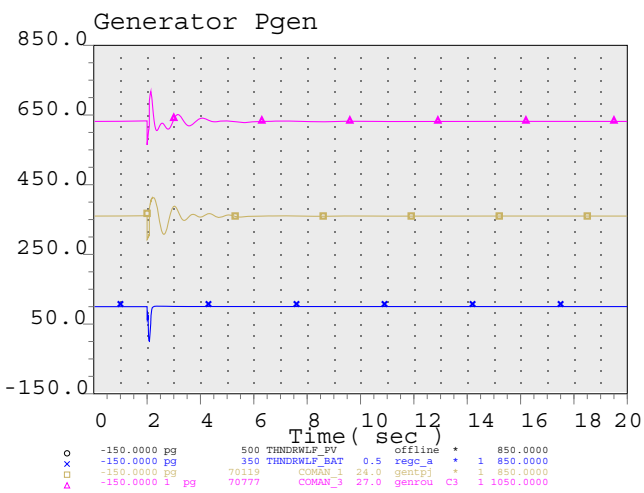
Fault: Comanche 345 KV 4 cycle 3-ph bus fault
Outage: Comanche unit 3

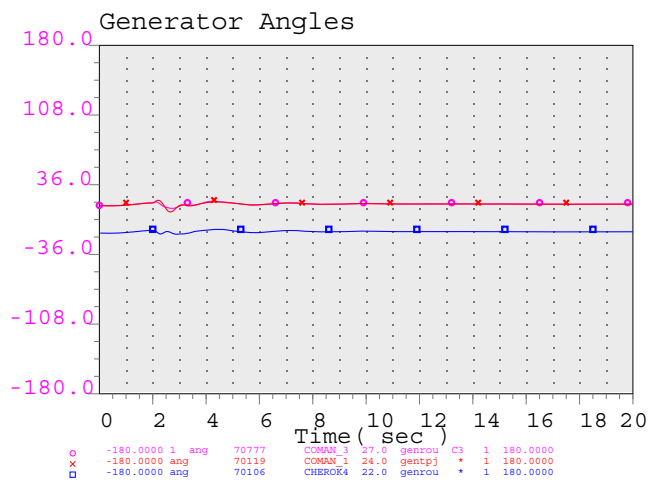






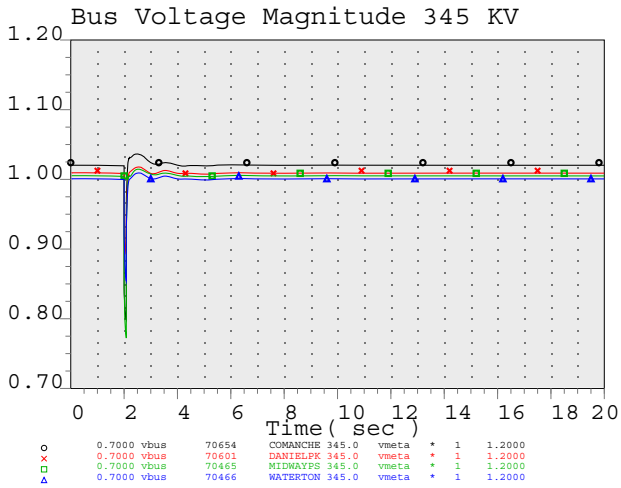


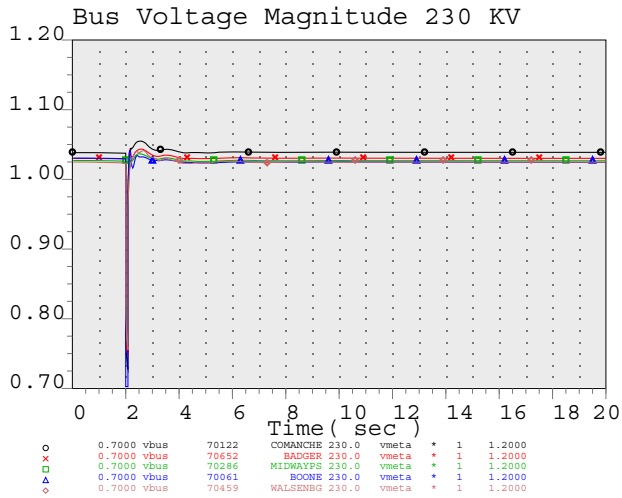


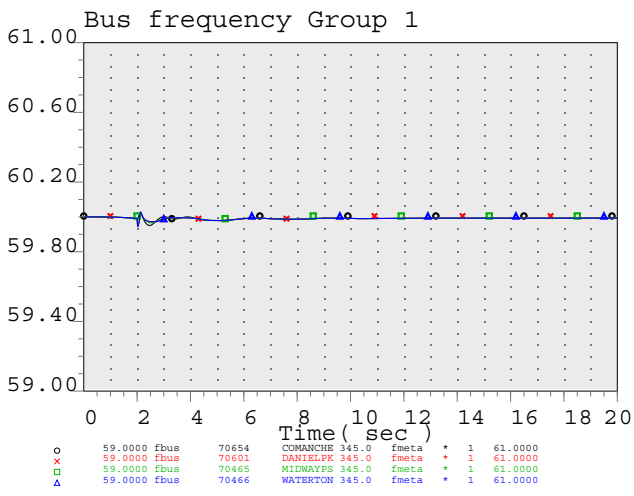


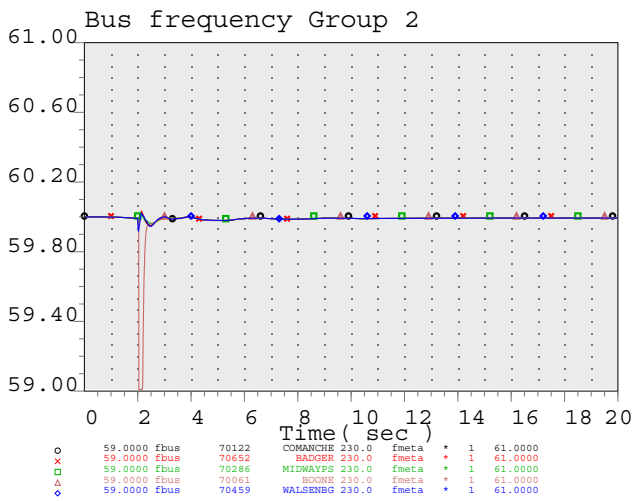
PV - 0 MW & BES - 100 MW

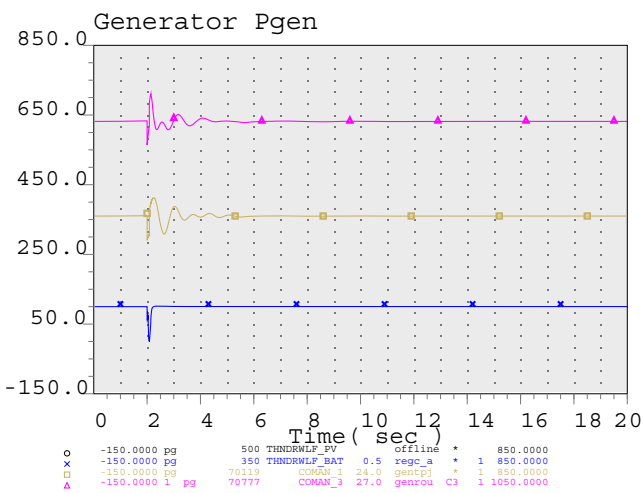
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage:lose Boone 230/115 KV bank

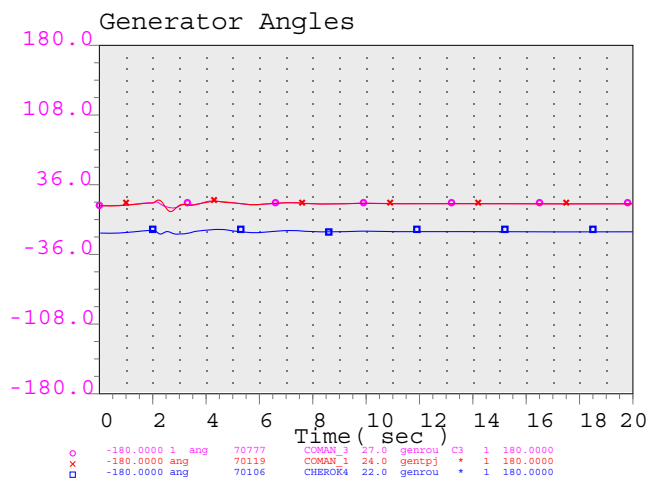






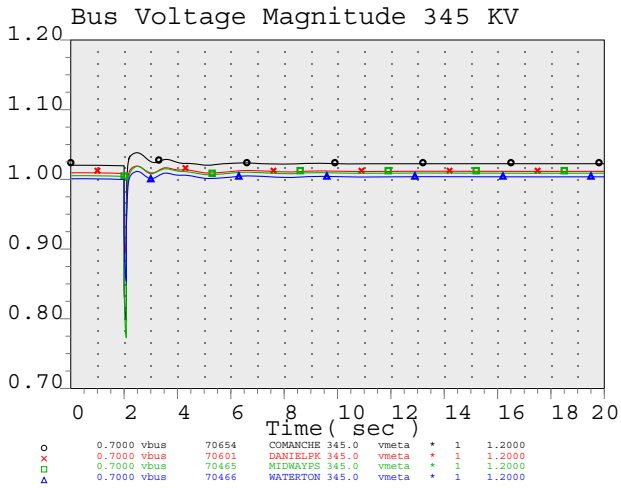


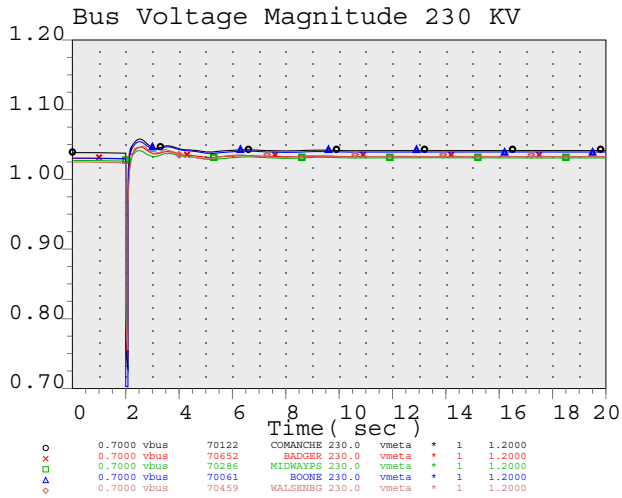


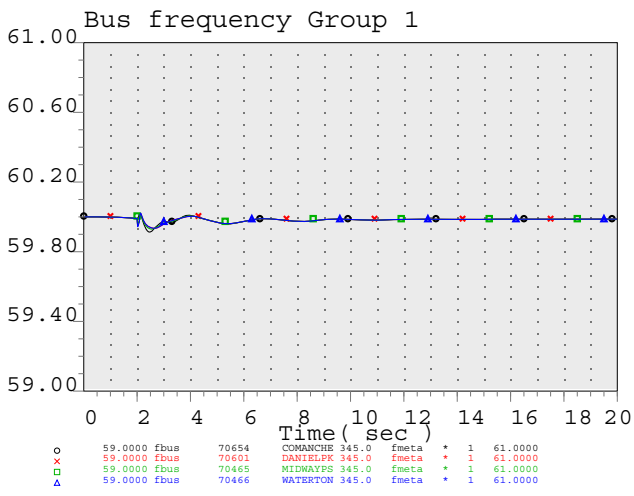


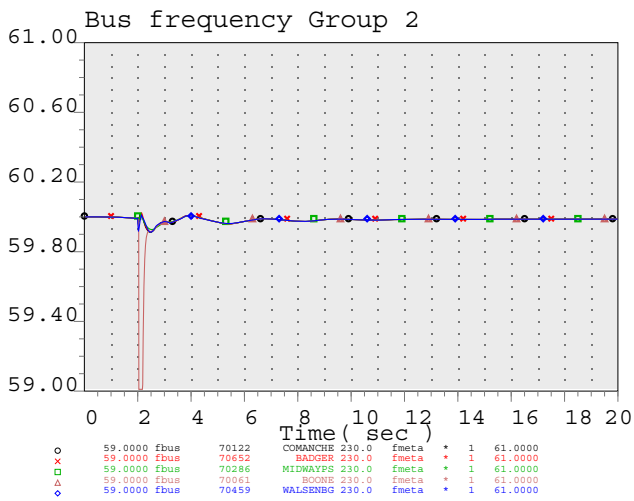
PV - 0 MW & BES - 100 MW

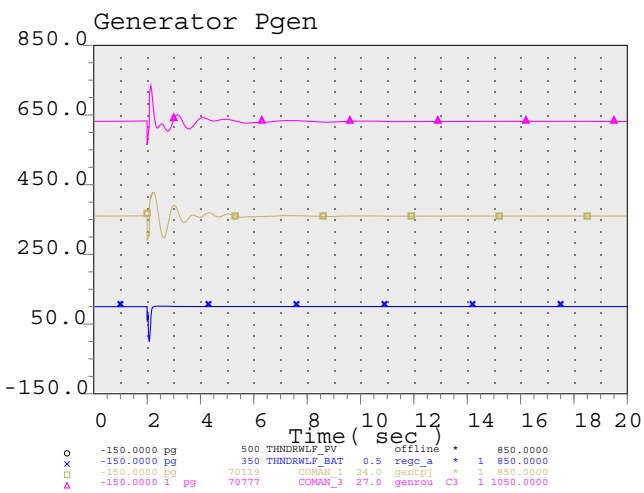
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Boone - Comanche 230 KV line

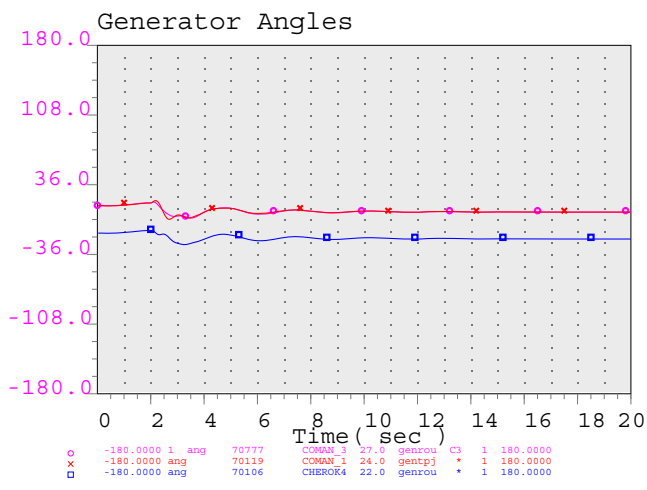






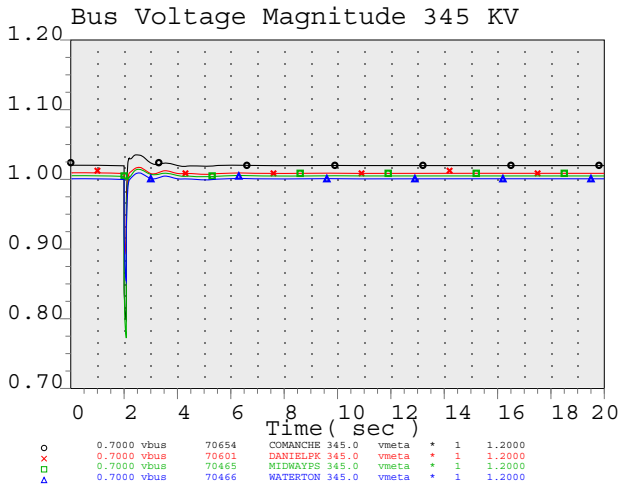


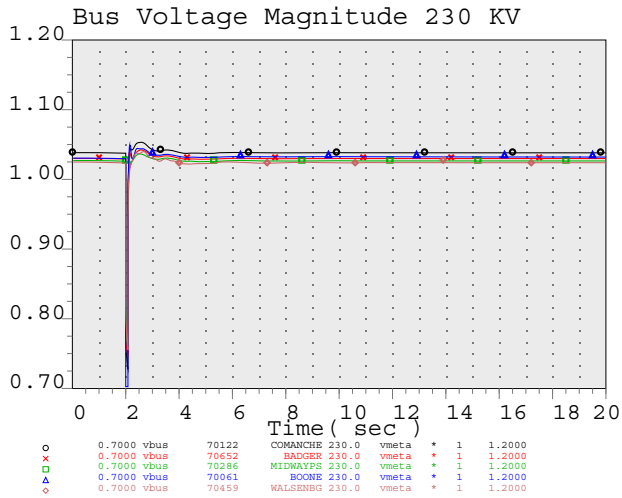


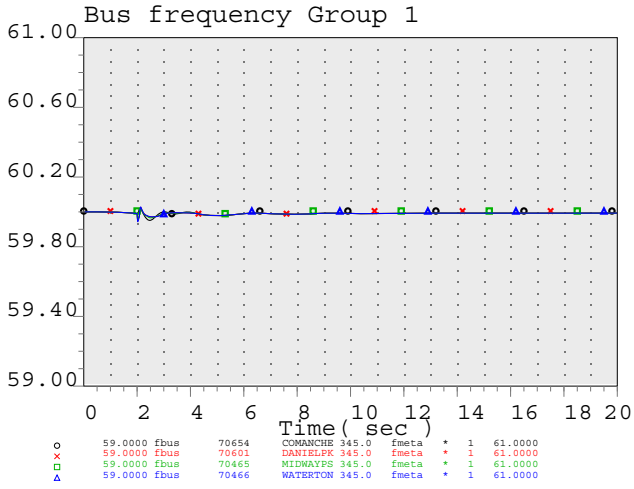


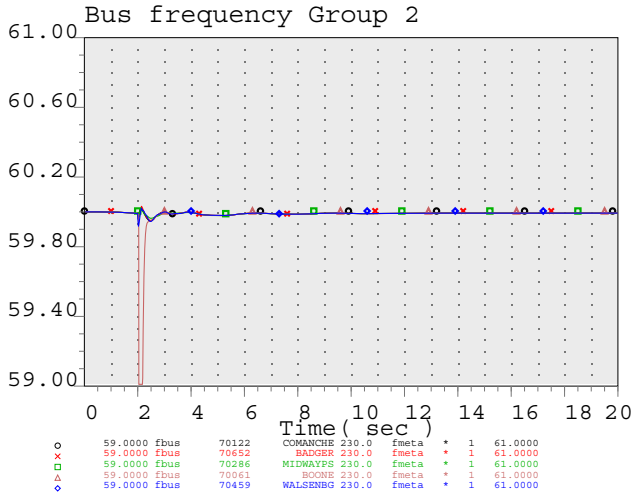
PV - 0 MW & BES - 100 MW

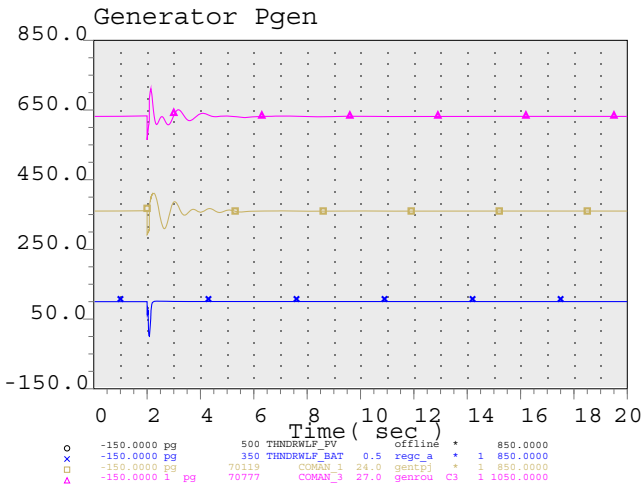
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Boone - Lamar 230 KV line and Lamar gen

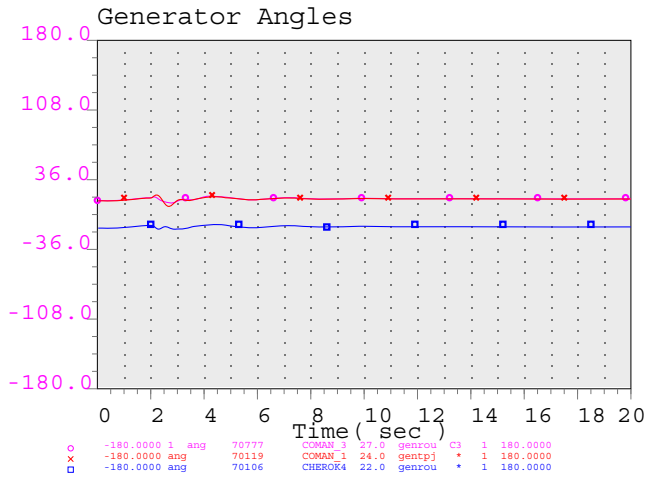






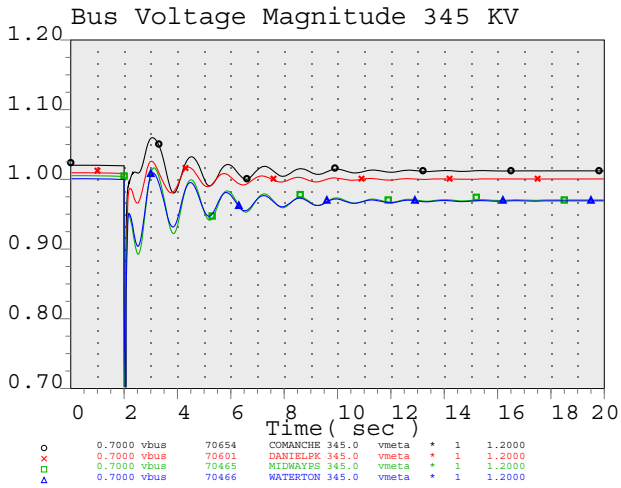


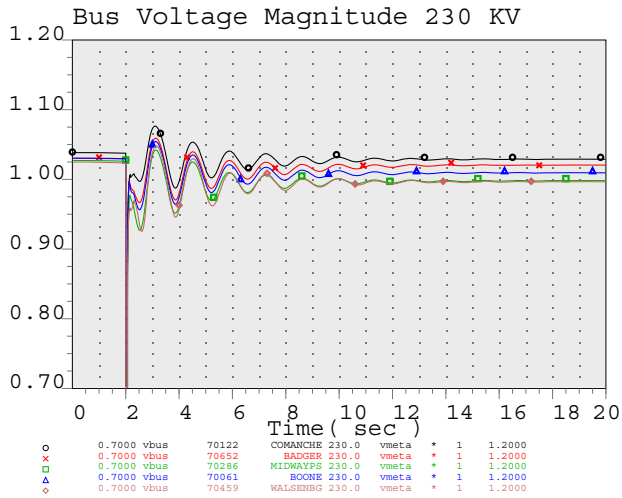


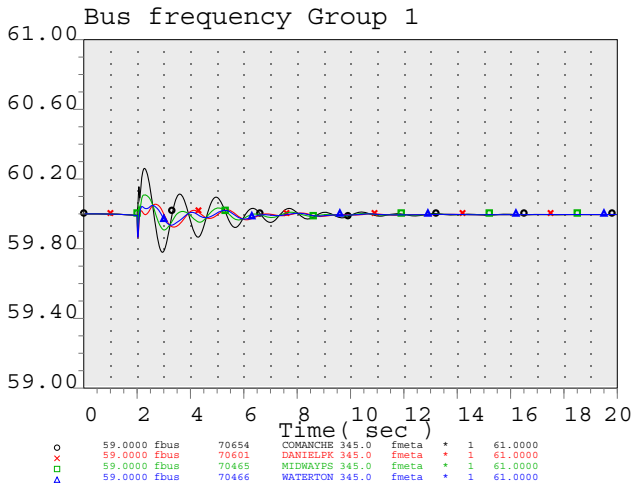


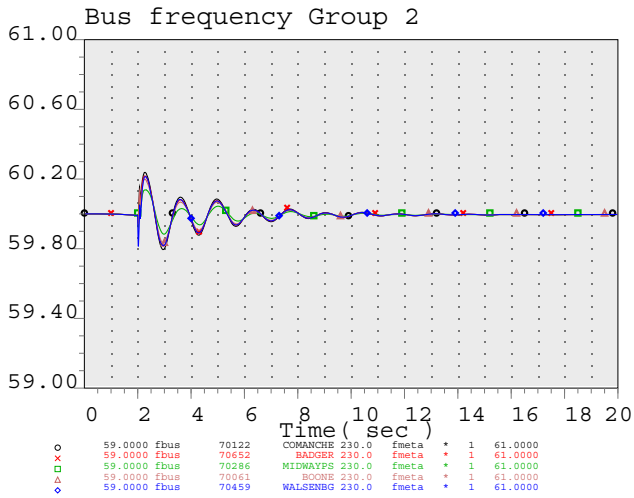
PV - 0 MW & BES - 100 MW

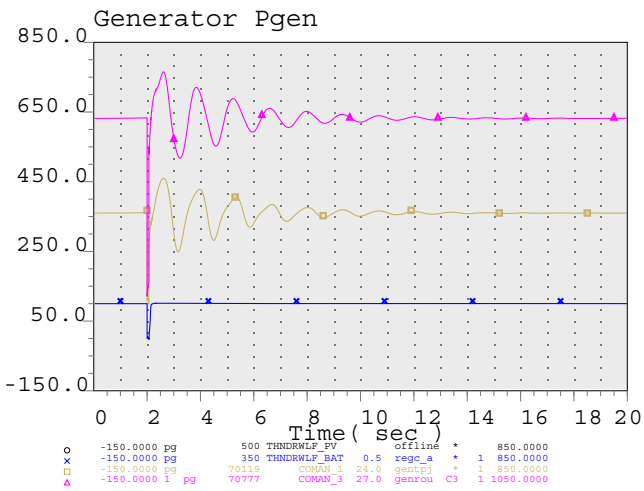
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Boone - Midway 230 KV line

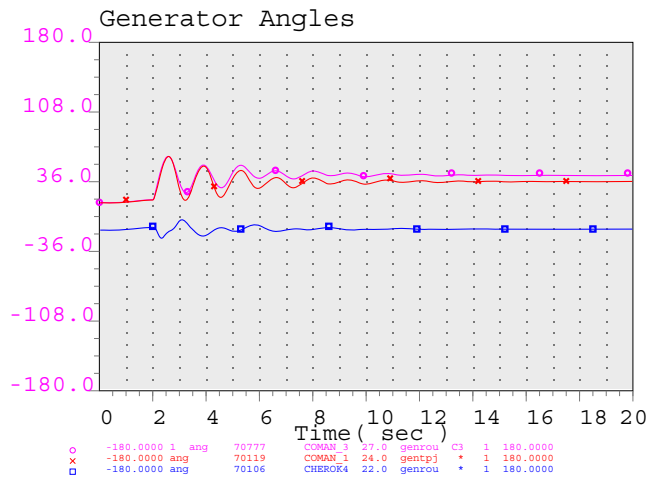






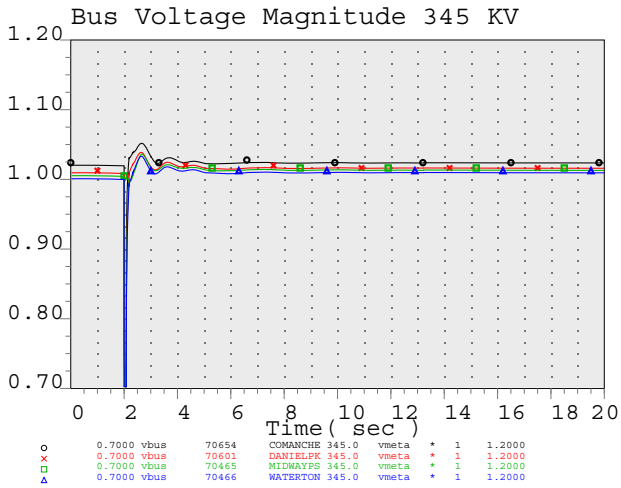


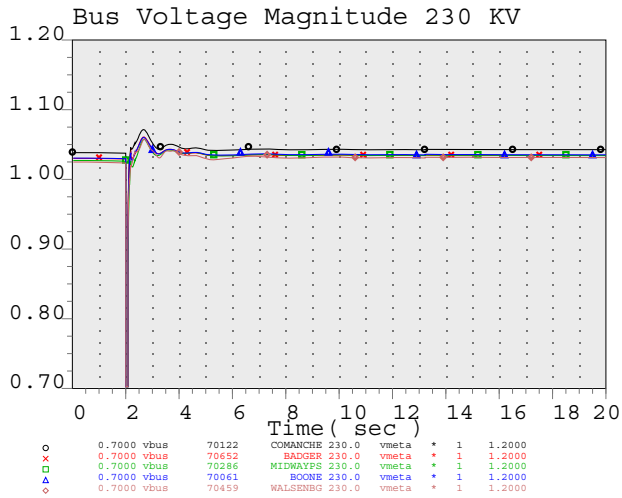


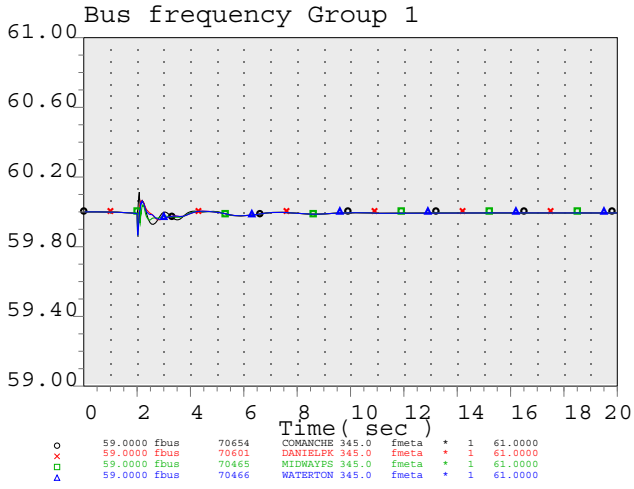


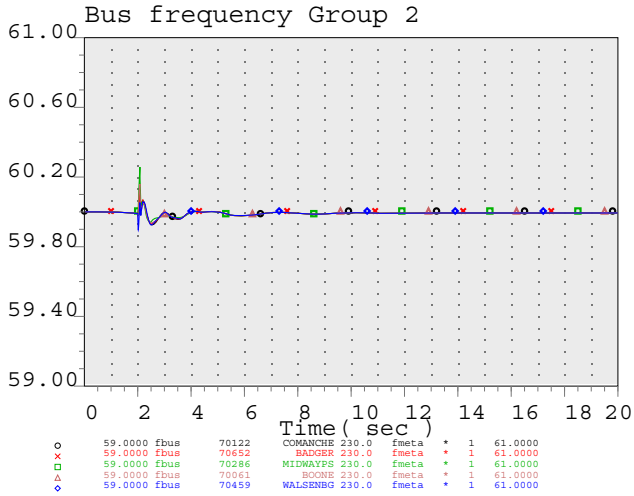
PV - 0 MW & BES - 100 MW

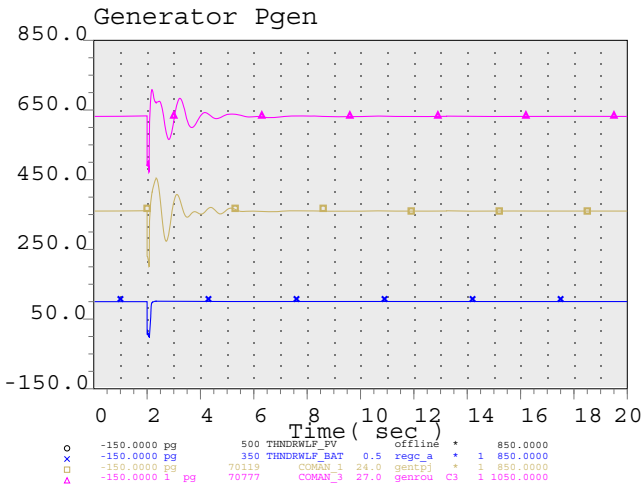
Fault: Comanche 345 KV 4 cycle 3-ph bus fault
outage: lose Comanche - Daniels Park 345 KV double circuit

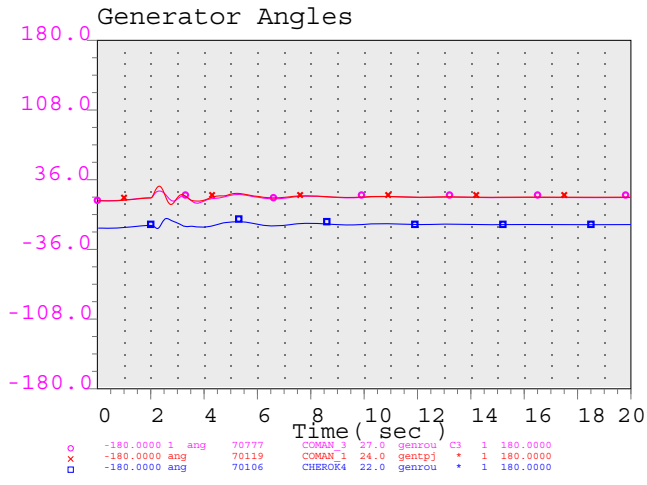






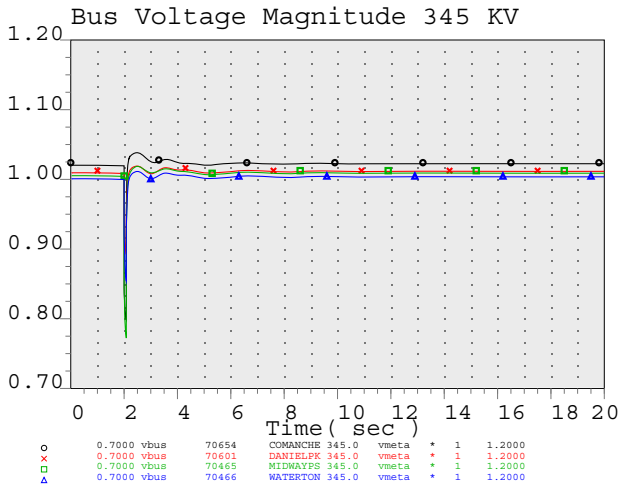


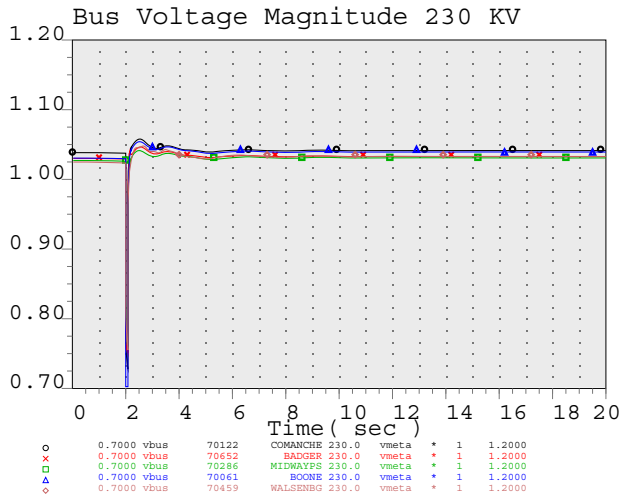


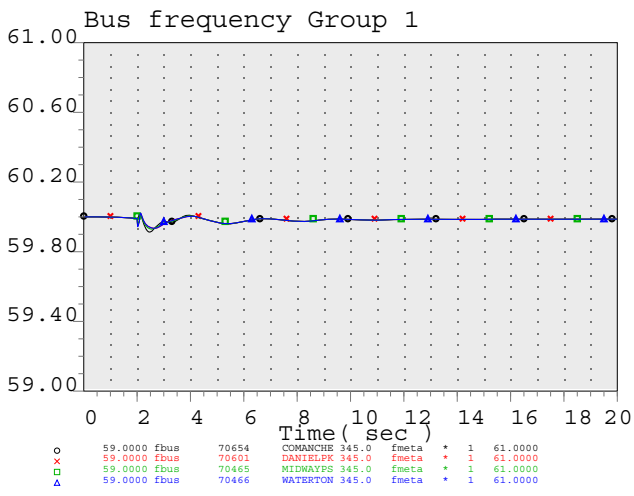


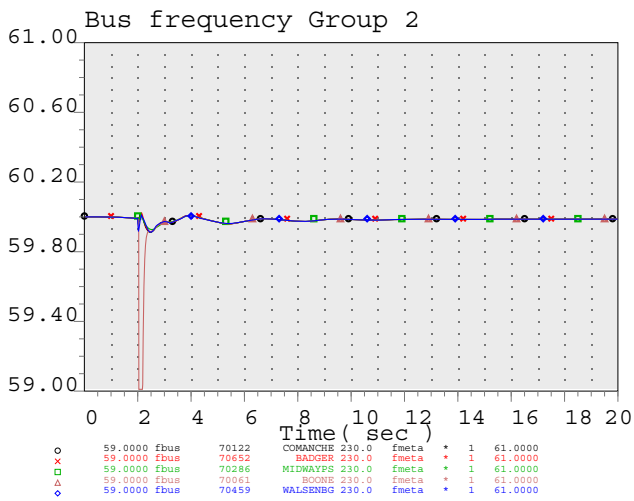
PV - 0 MW & BES - 100 MW

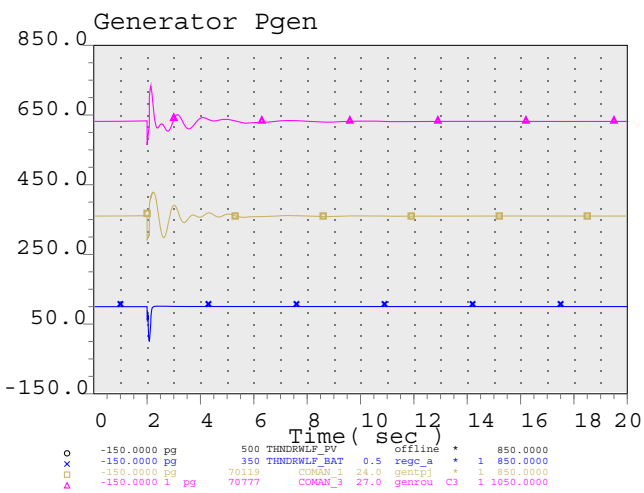
Fault: MIDWAYPS 230 KV 5 cycle 3-ph bus fault
Outage: lose Fountain Valley gen

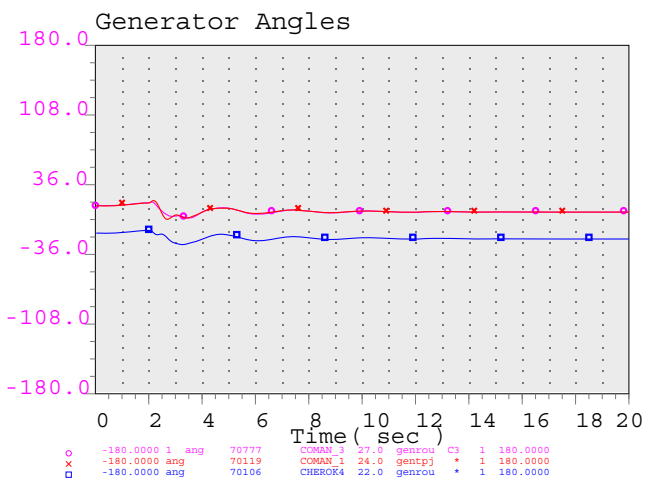




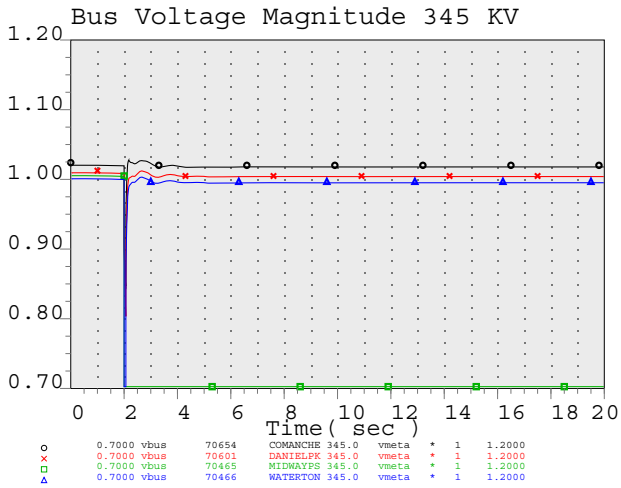


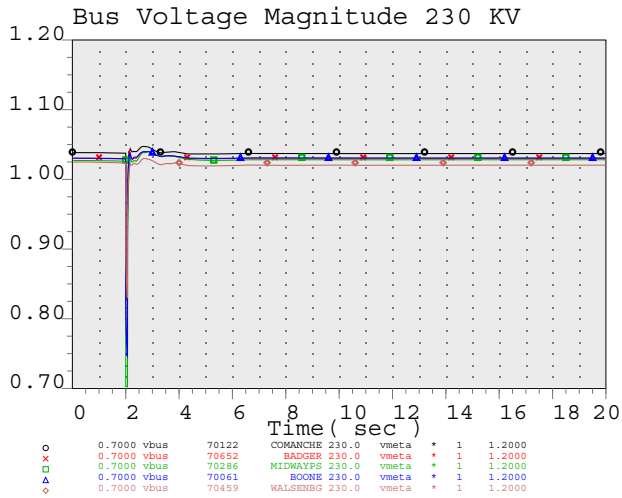


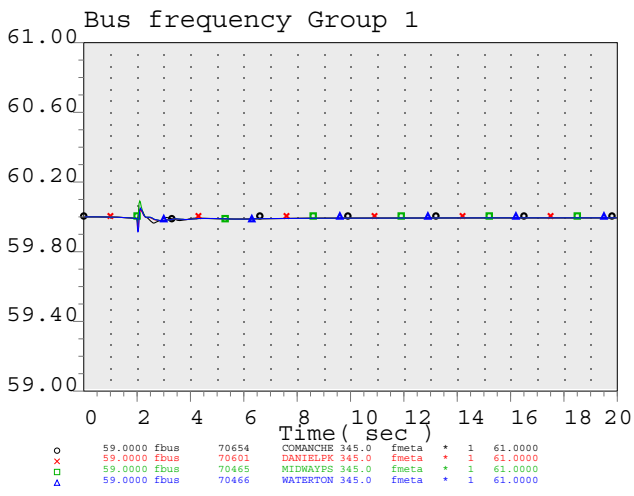


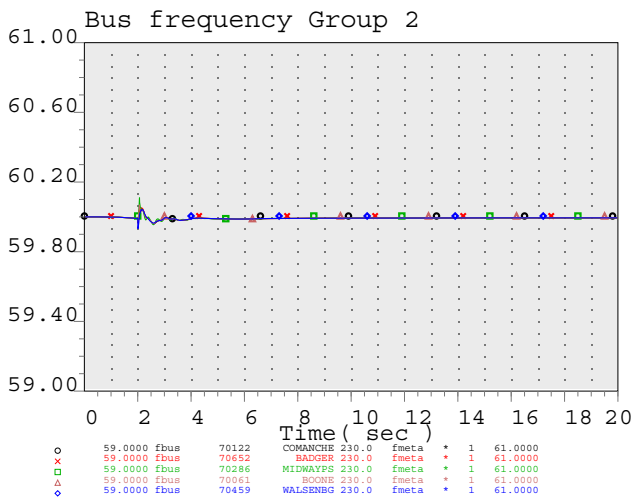


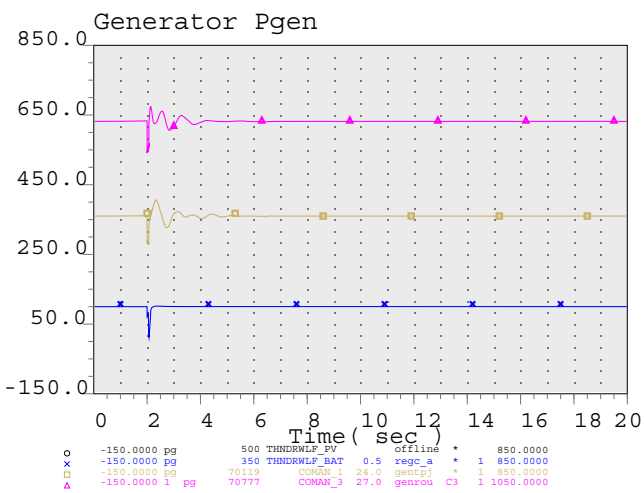
PV - 0 MW & BES - 100 MW

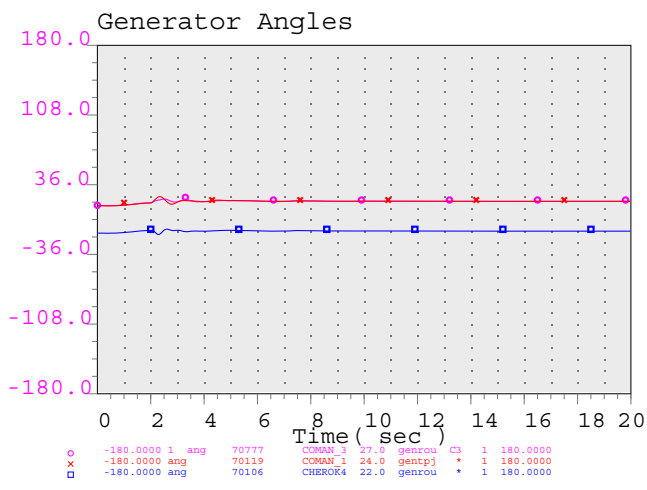






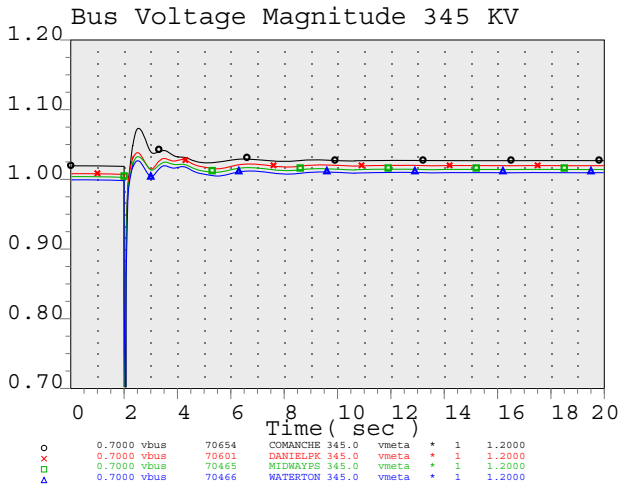


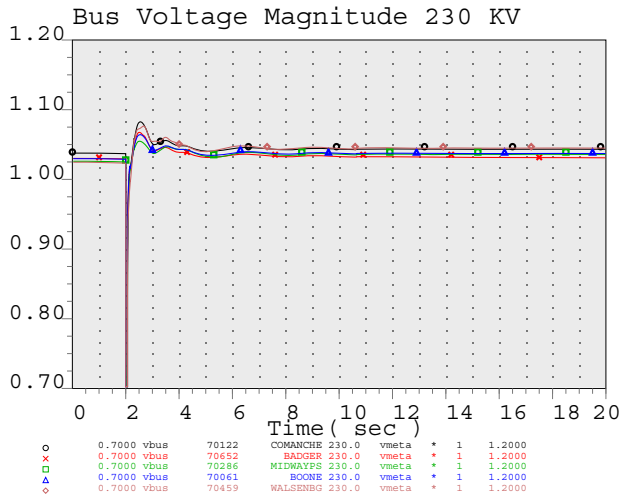


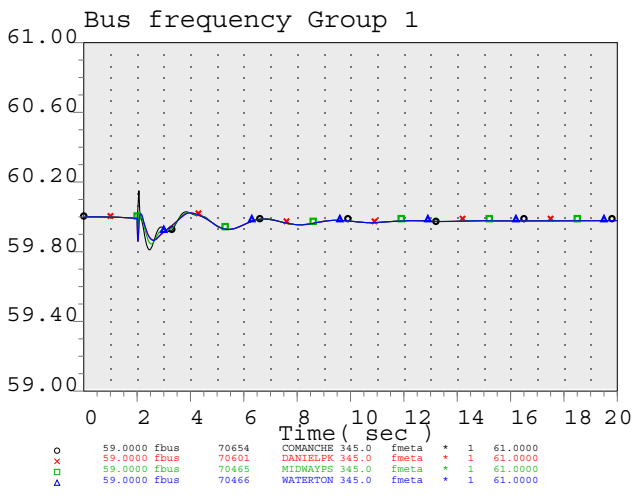


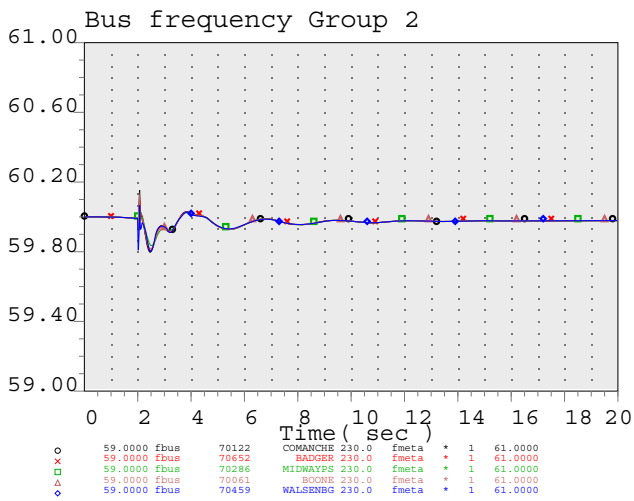
PV - 0 MW & BES - 100 MW

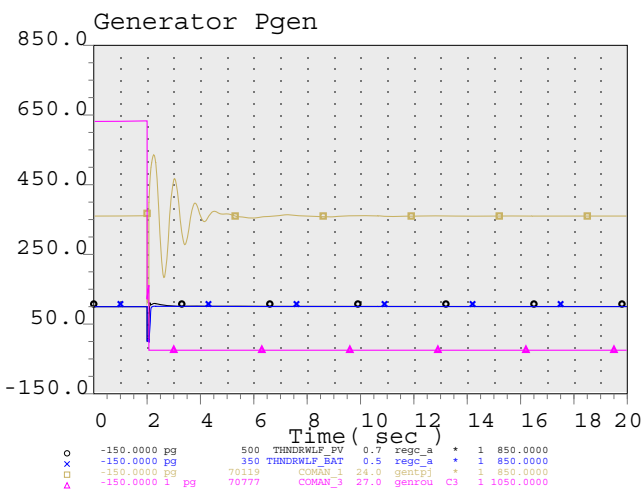
Fault: MIDWAYPS 345 KV 4 cycle 3-ph bus fault
Outage: lose MidwayPS 345/230 KV and MidwayPS - Waterton 345 KV line

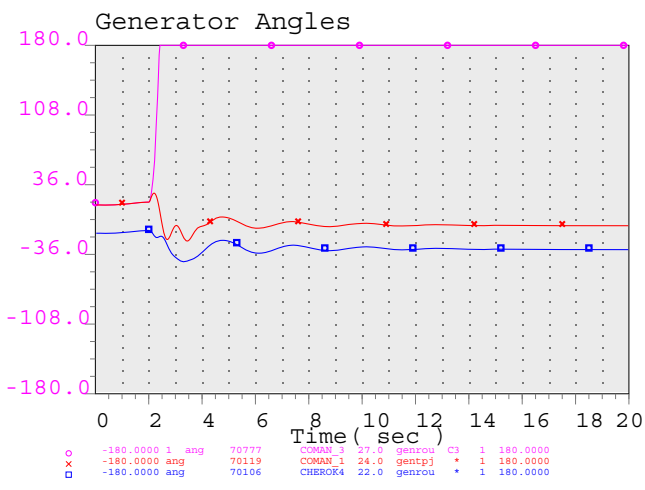






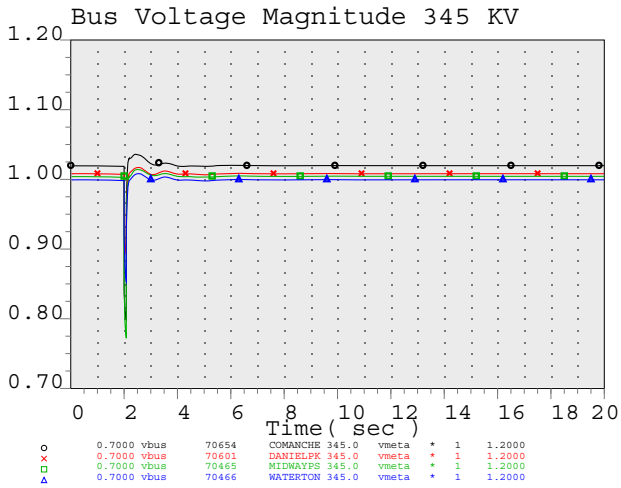


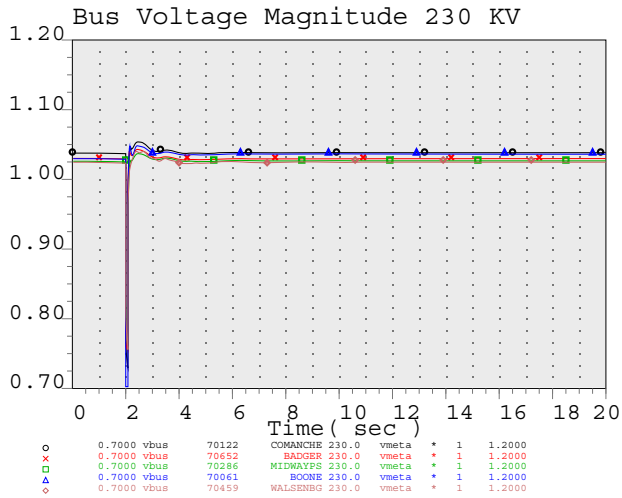


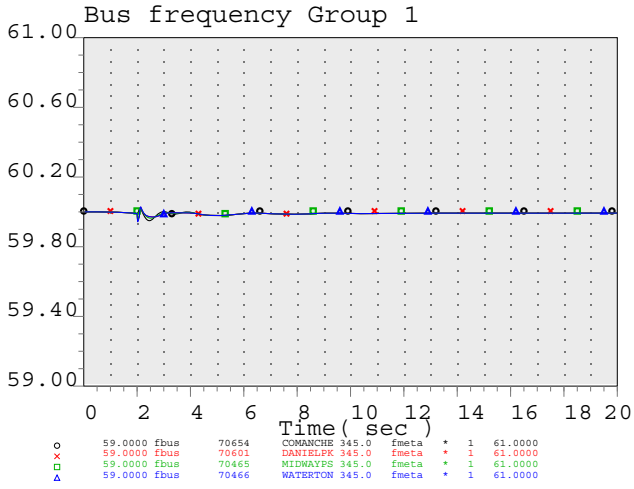


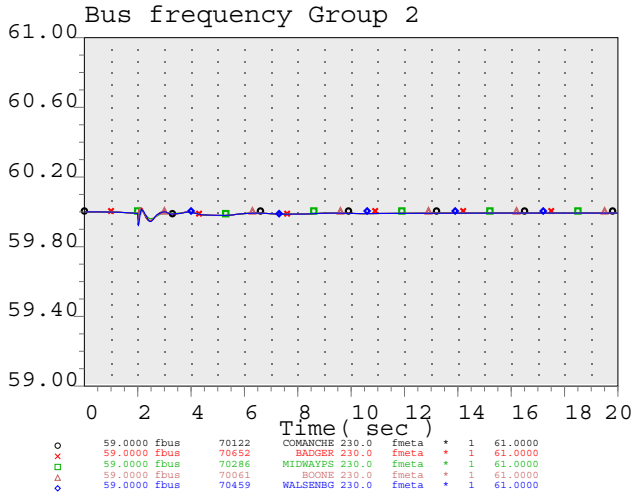
PV - 100 MW & BES - 100 MW

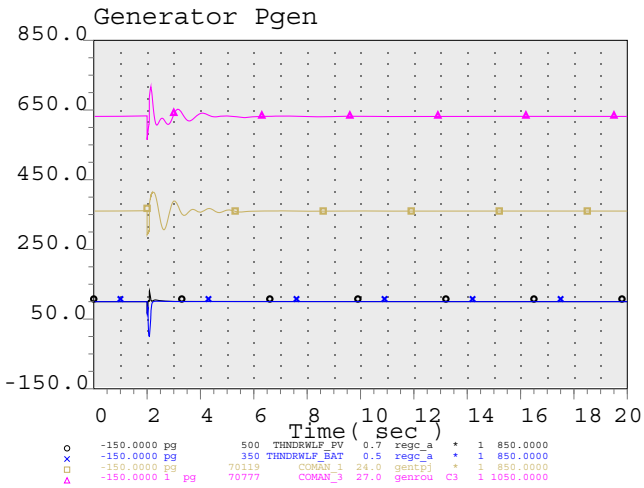
Fault: Comanche 345 KV 4 cycle 3-ph bus fault
Outage: Comanche unit 3

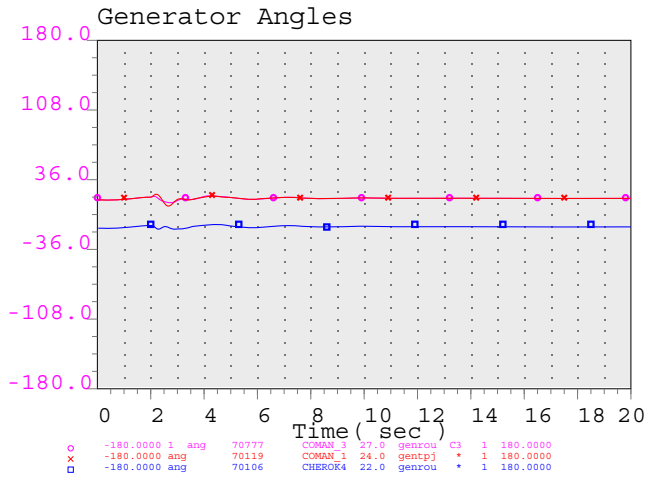






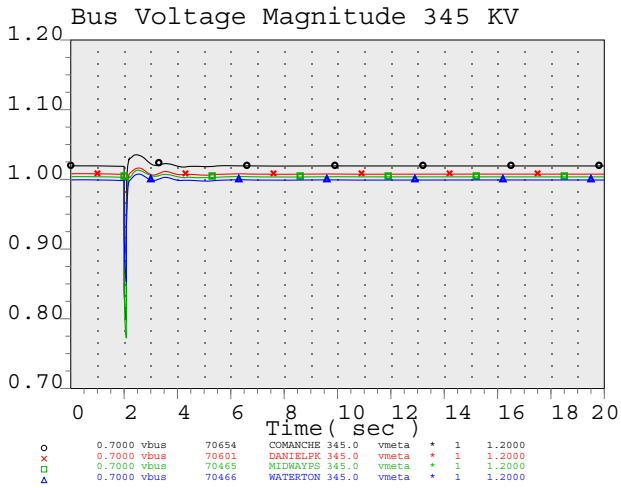


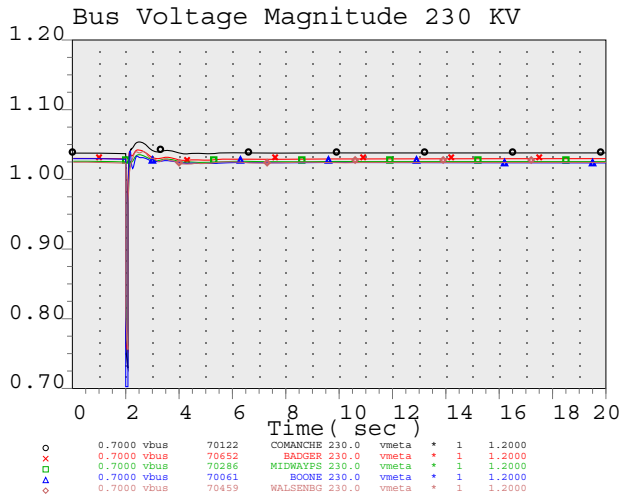


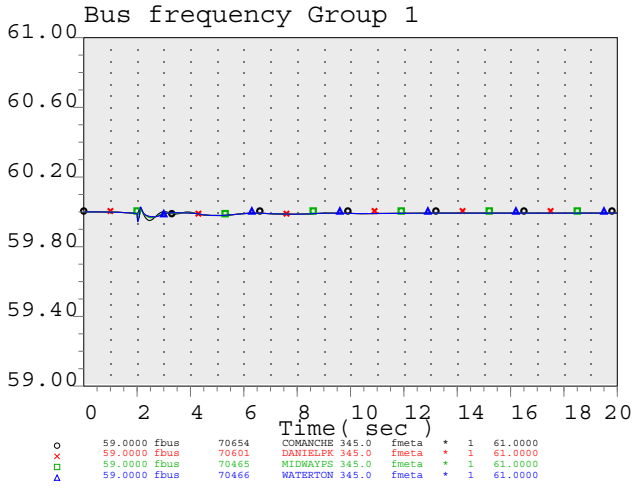


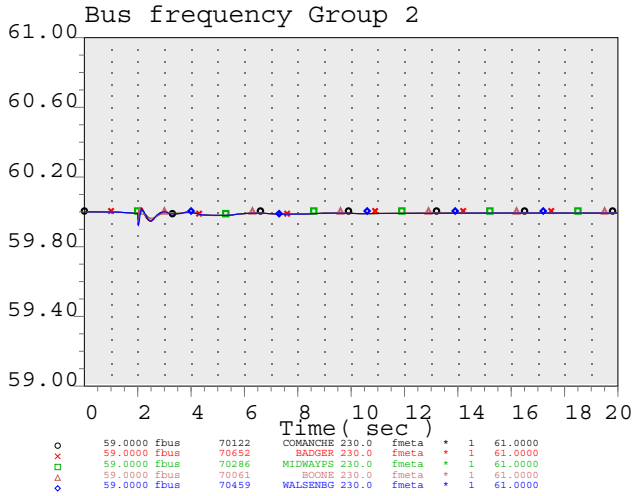
PV - 100 MW & BES - 100 MW

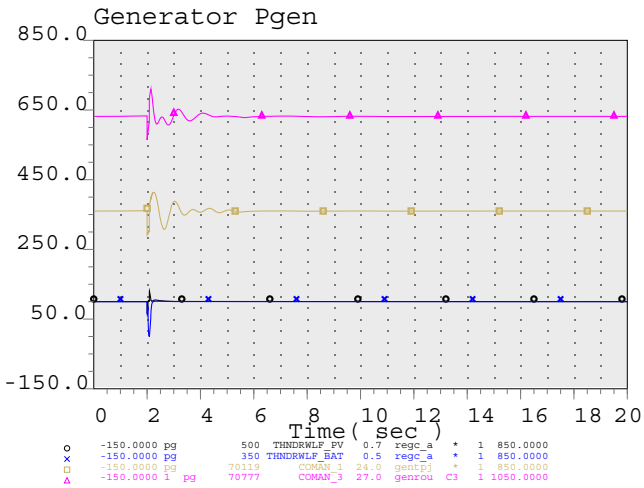
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Boone 230/115 KV bank

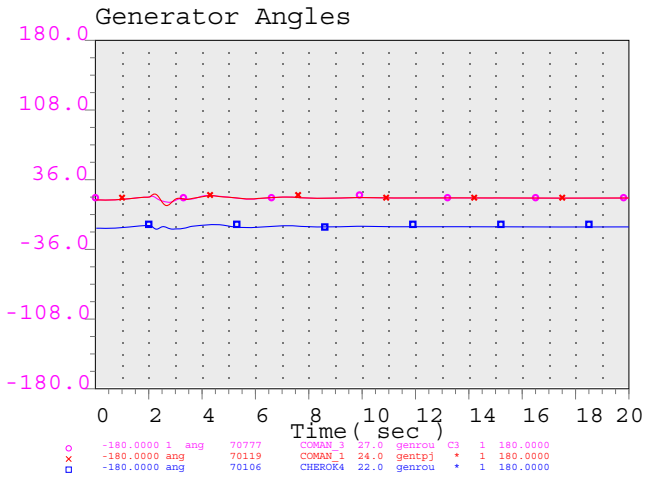






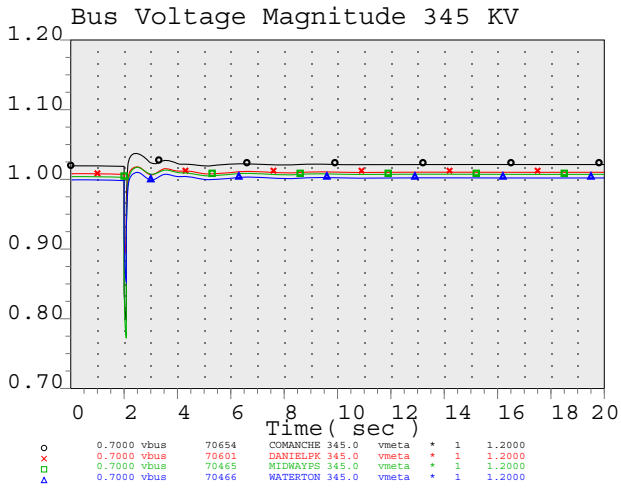


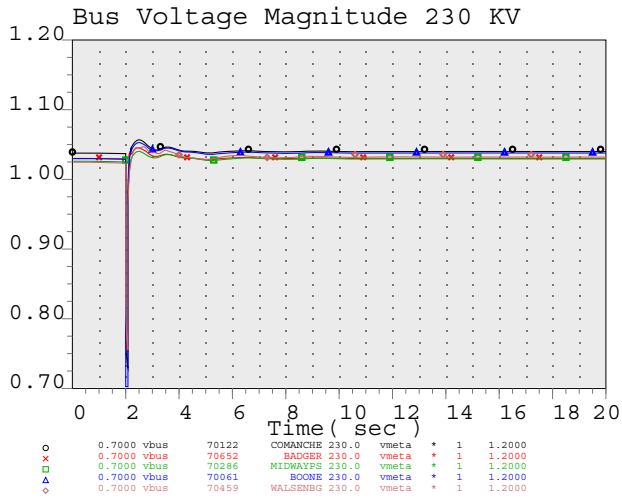


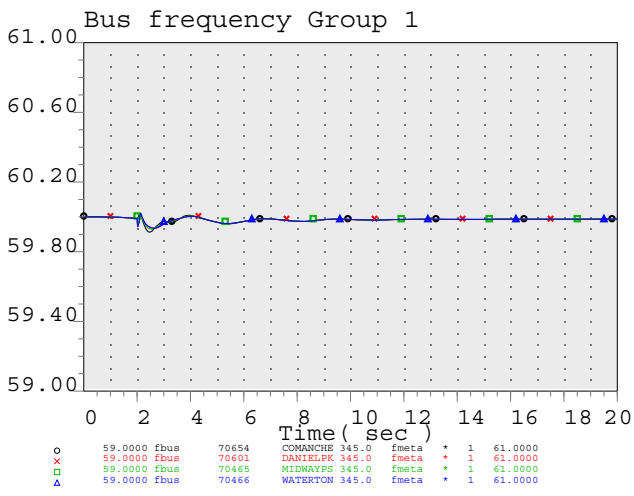


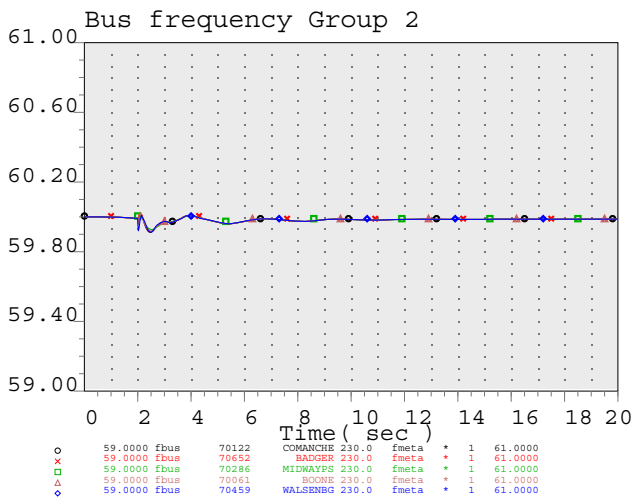
PV - 100 MW & BES - 100 MW

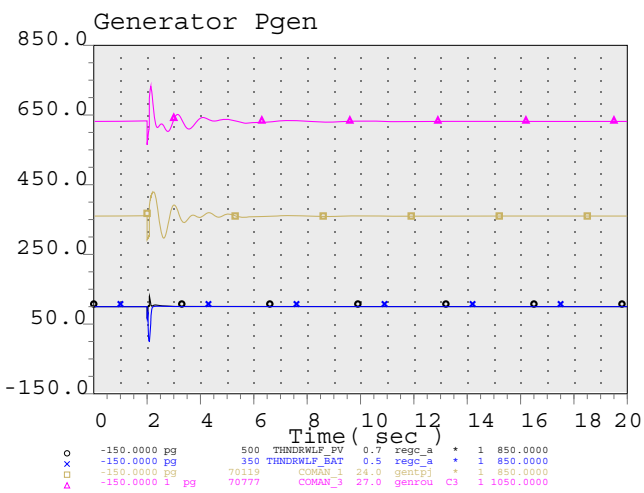
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Boone - Comanche 230 KV line

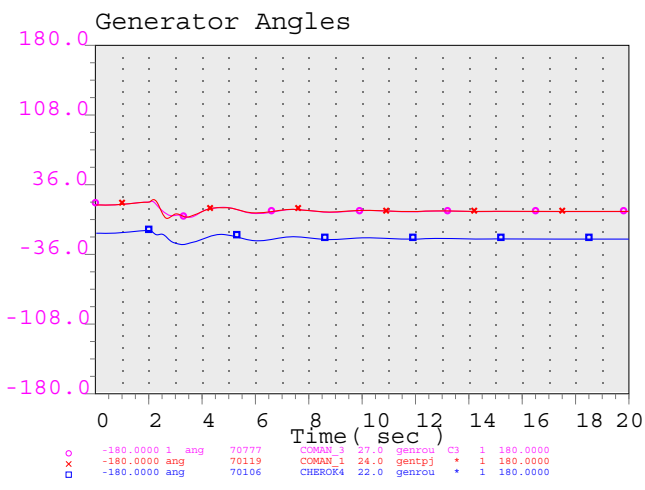






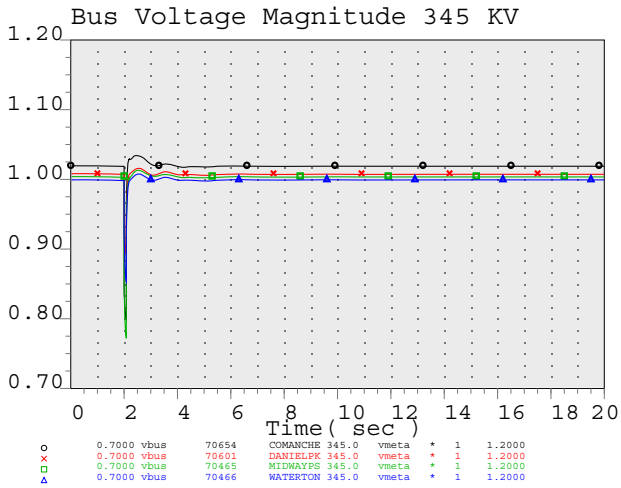


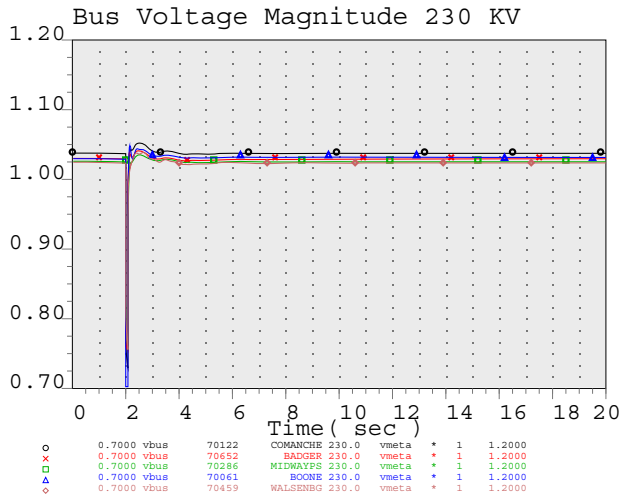


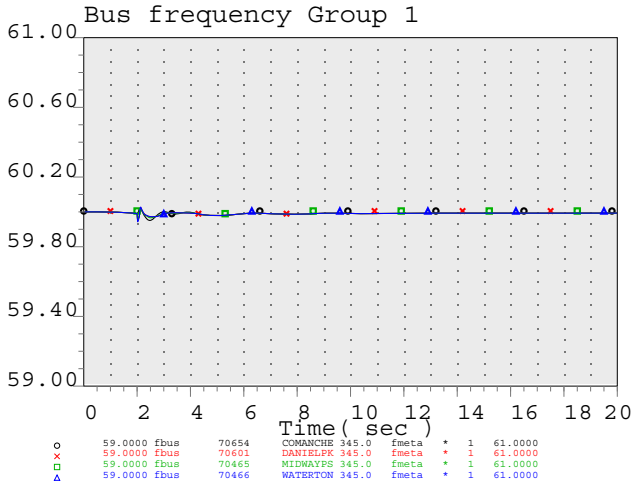


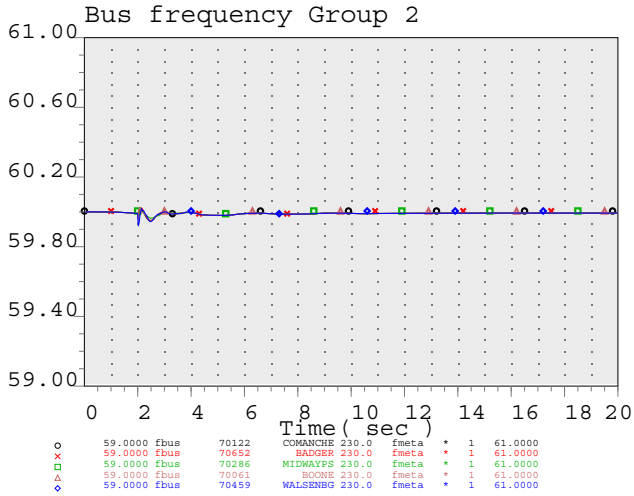
PV - 100 MW & BES - 100 MW

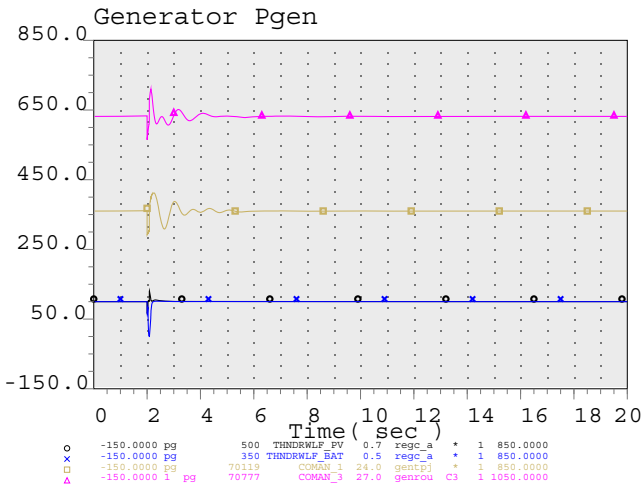
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Boone - Lamar 230 KV line and Lamar gen

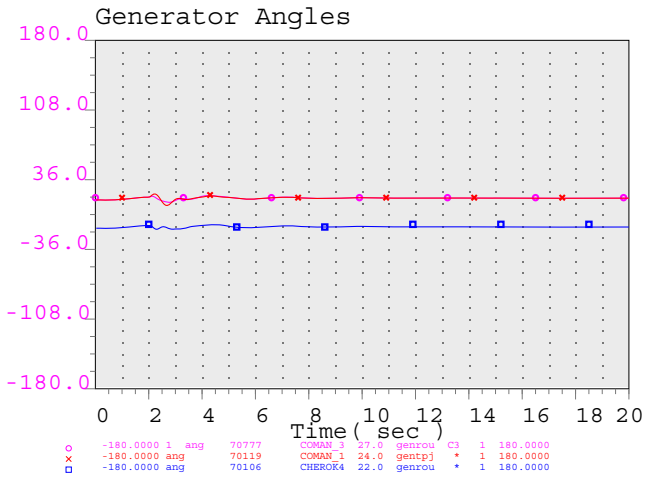






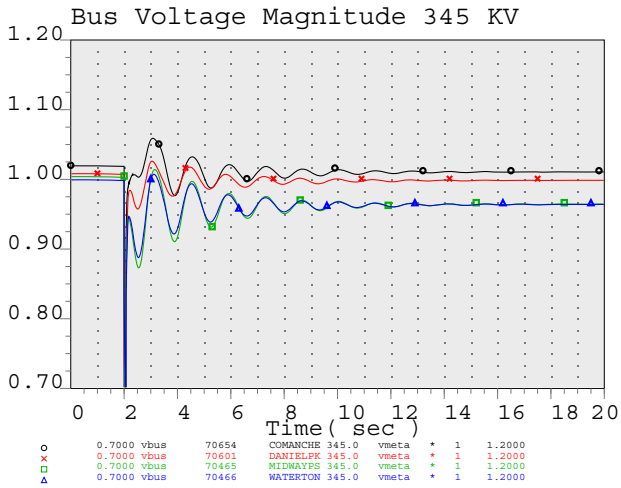


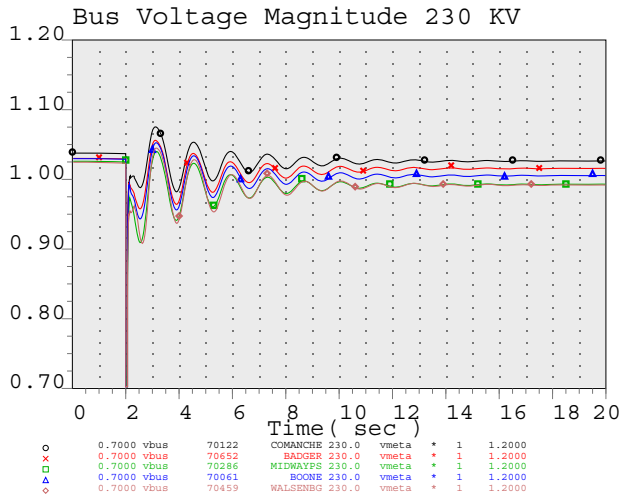


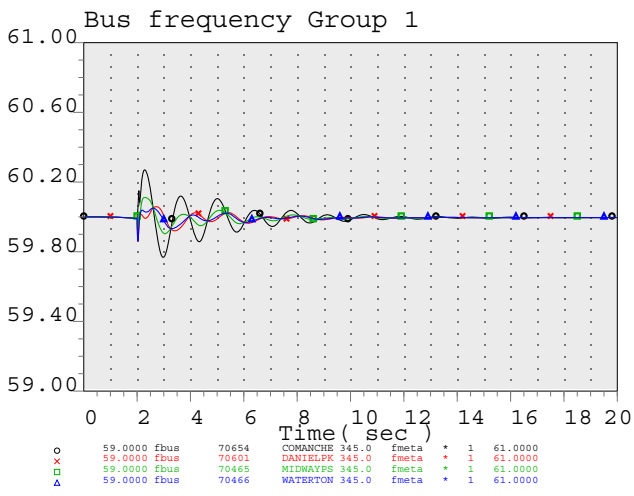


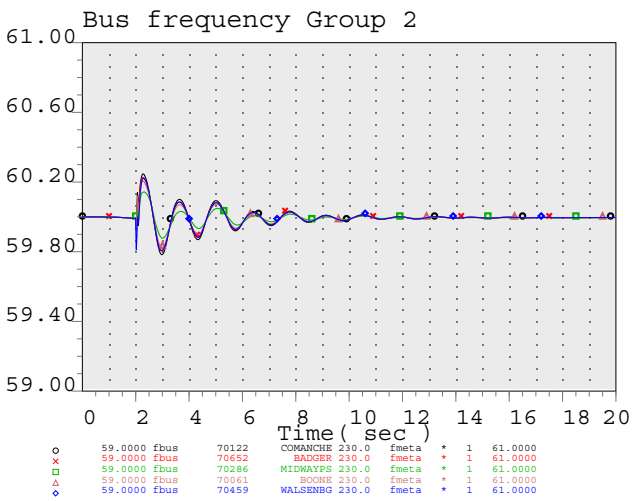
PV - 100 MW & BES - 100 MW

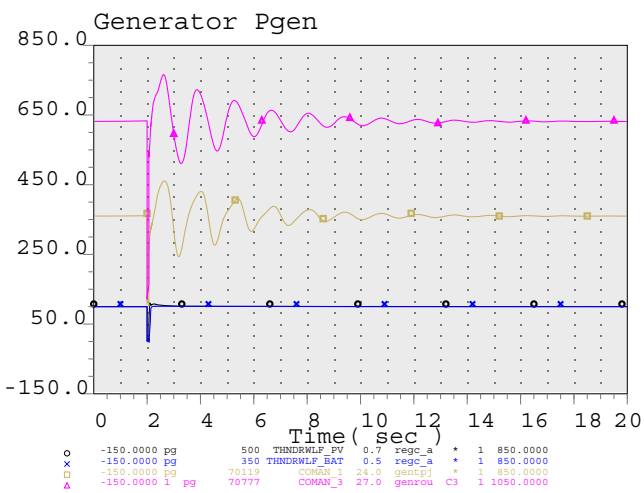
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Boone - Midway 230 KV line

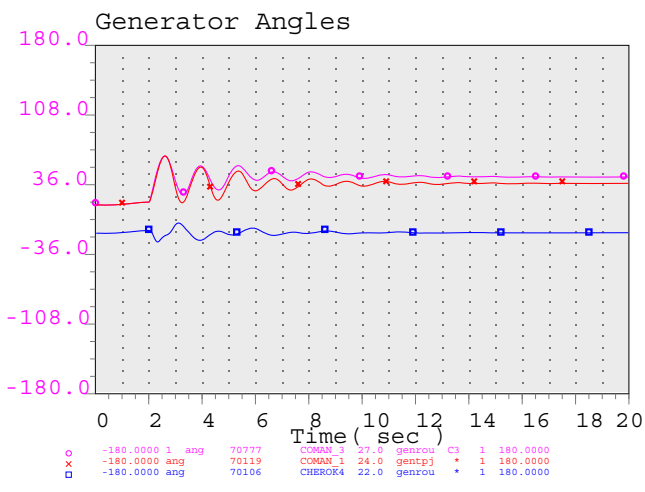






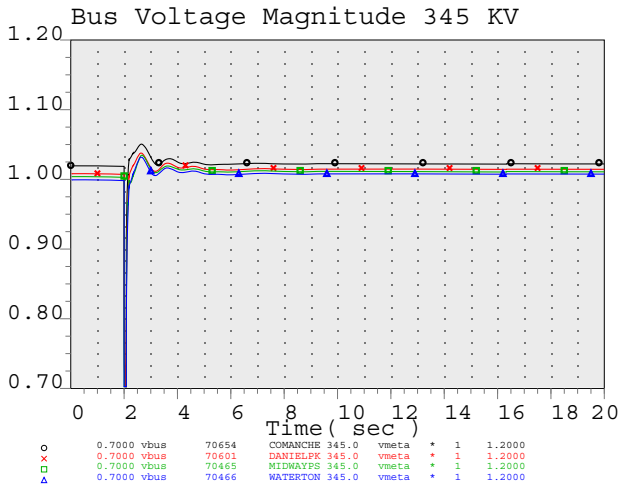


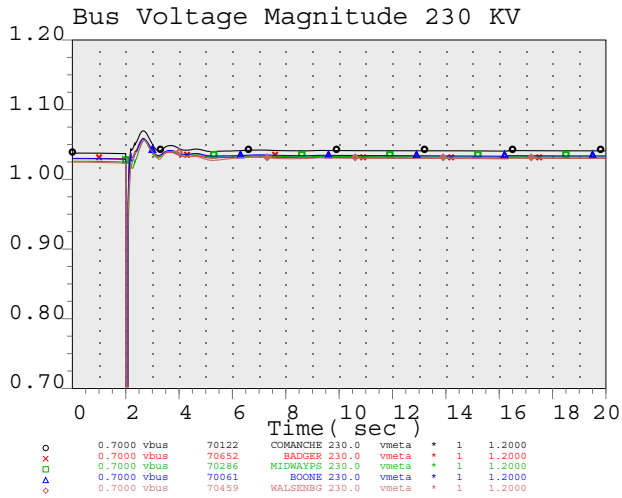


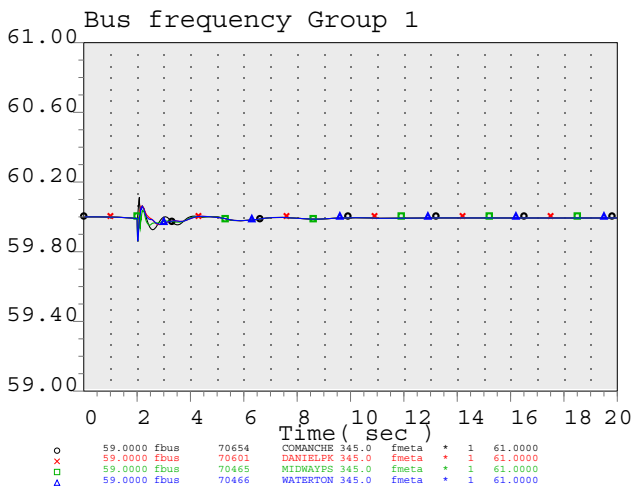


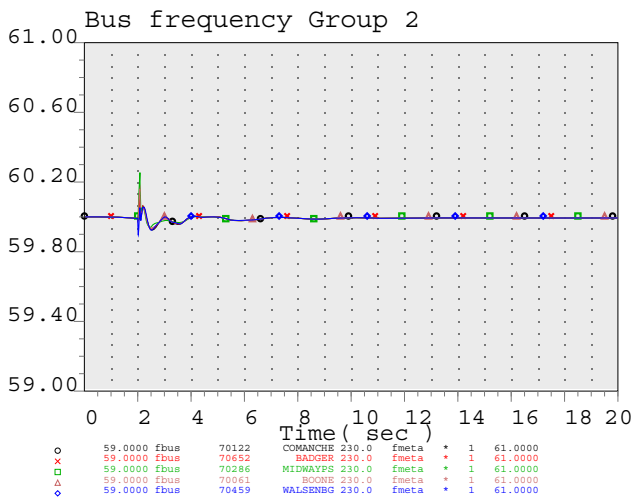
PV - 100 MW & BES - 100 MW

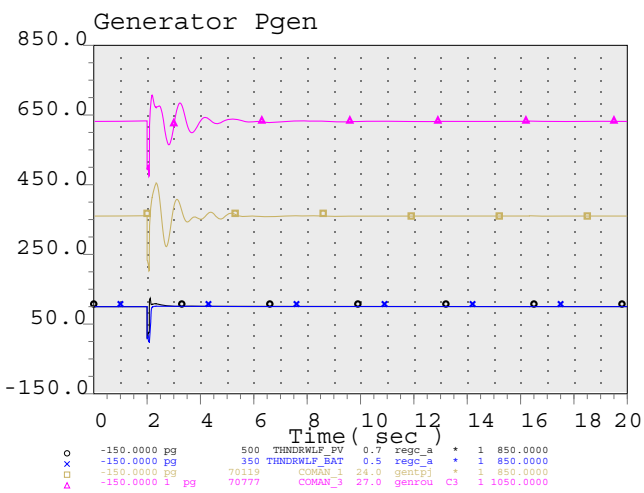
Fault: Comanche 345 KV 4 cycle 3-ph bus fault
Outage: lose Comanche - Daniels Park 345 KV double circuit

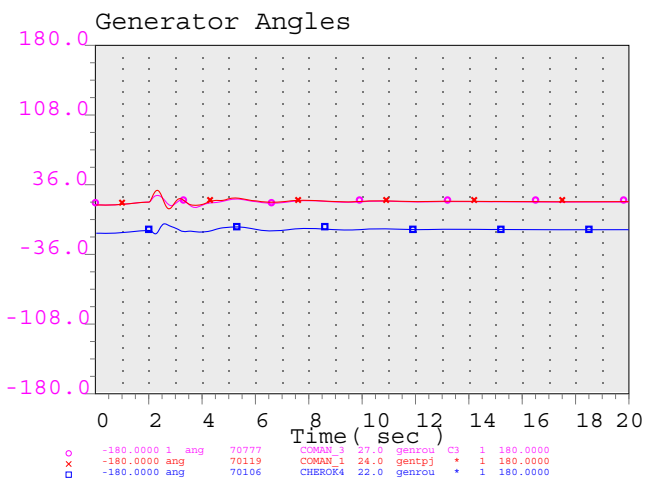






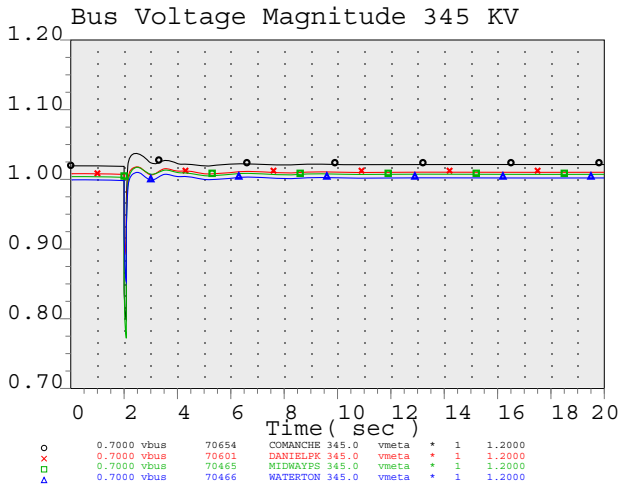


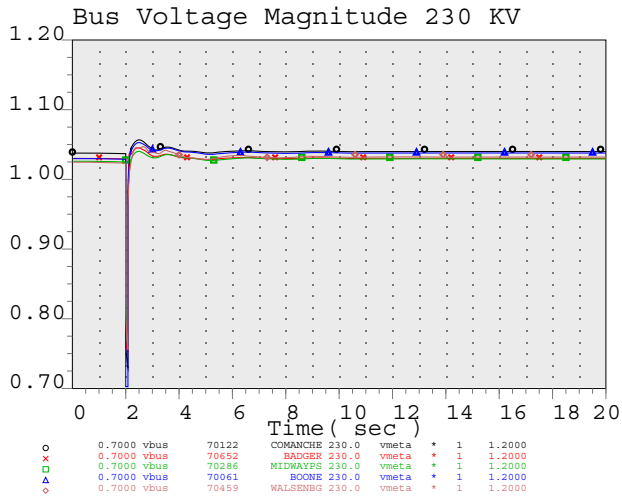


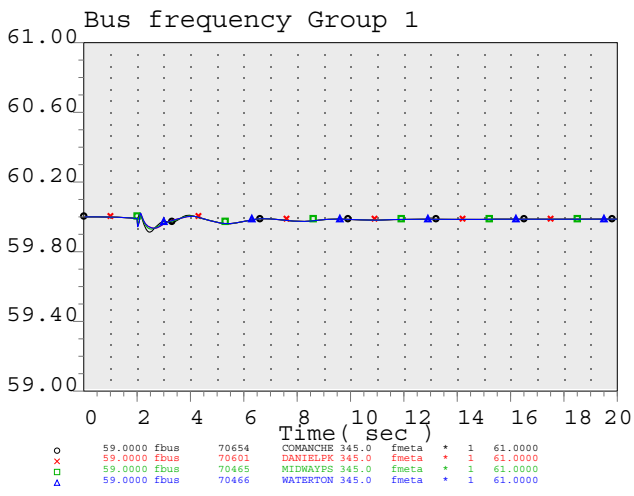


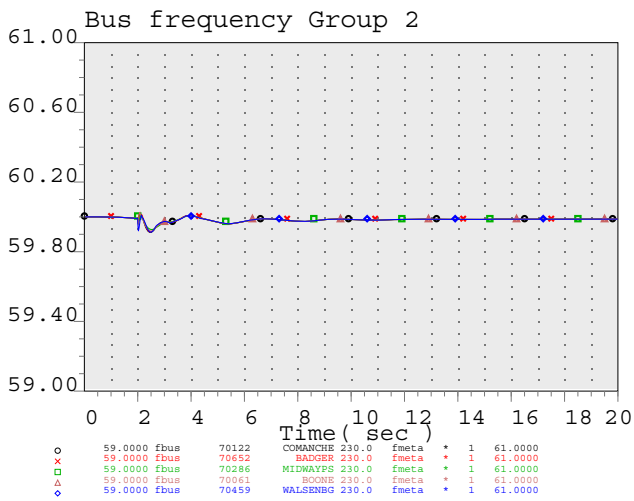
PV - 100 MW & BES - 100 MW

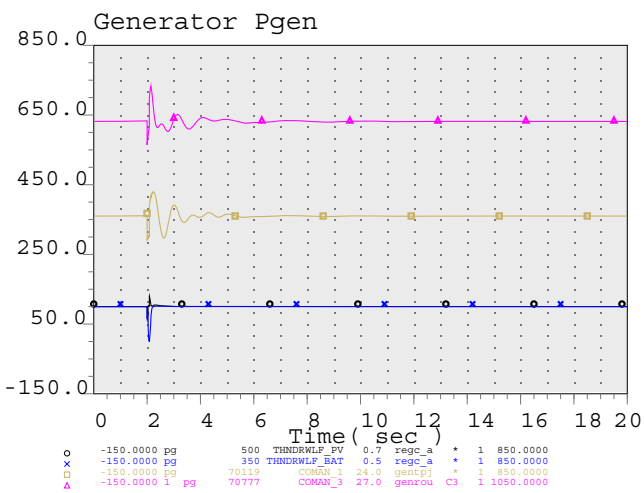
Fault: MIDWAYPS 230 KV 5 cycle 3-ph bus fault
Outage: lose Fountain Valley gen

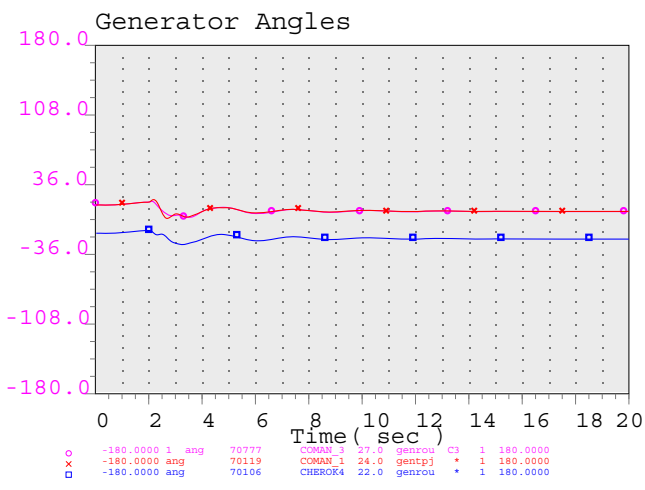






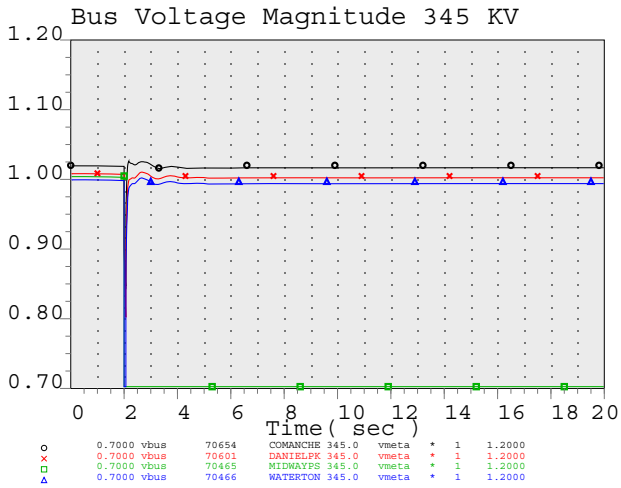


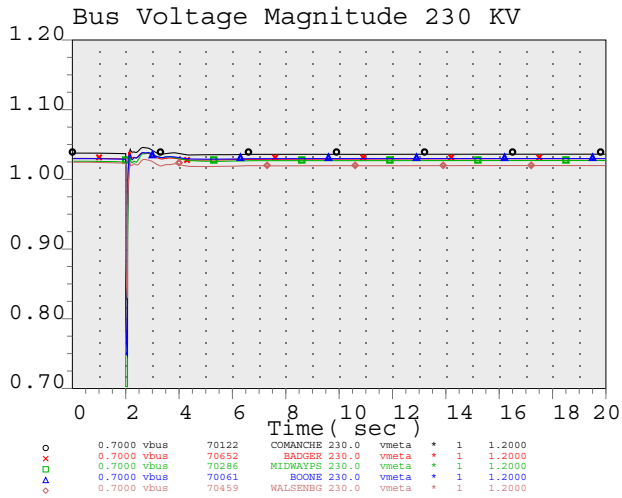


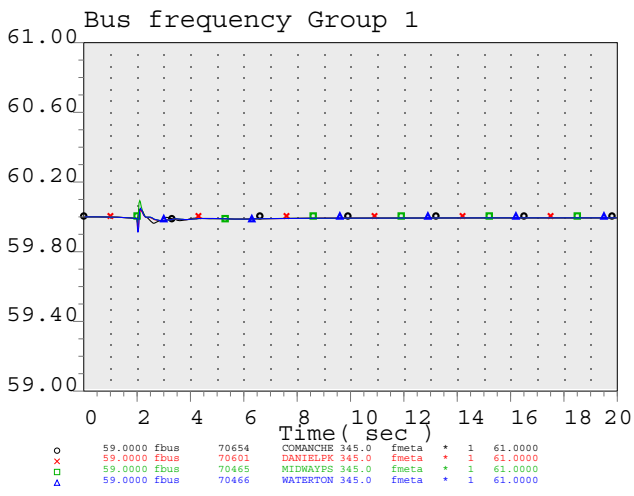


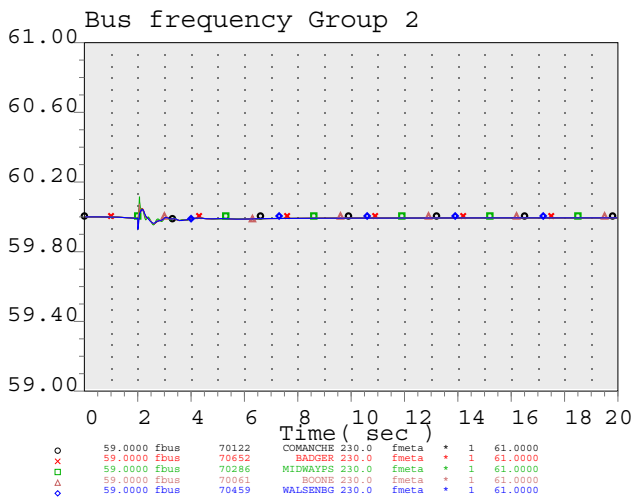
PV - 100 MW & BES - 100 MW

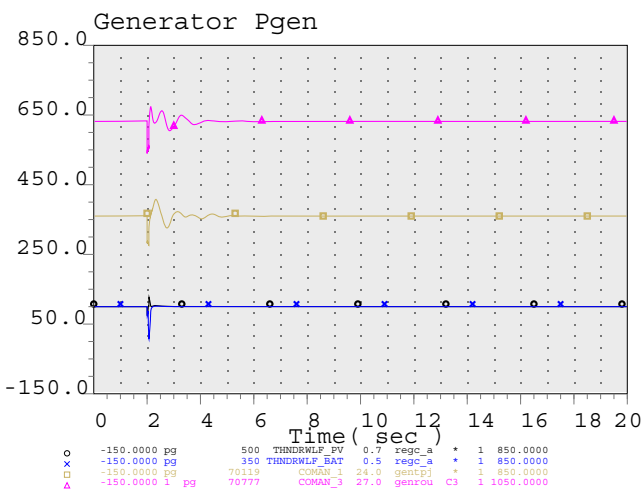
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Lamar - Boone 230 KV line and Lamar gen

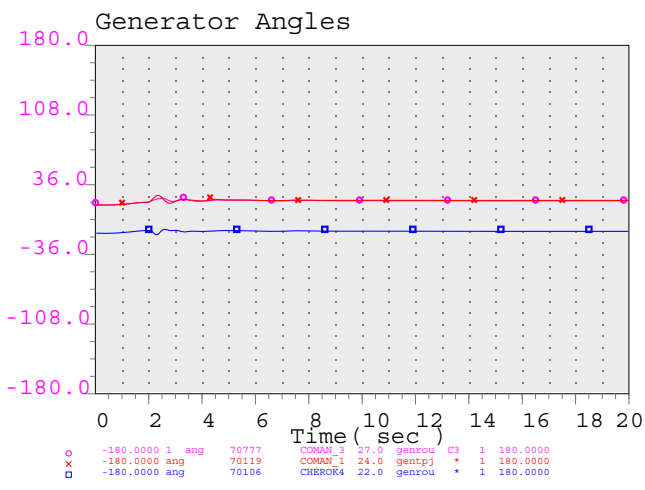






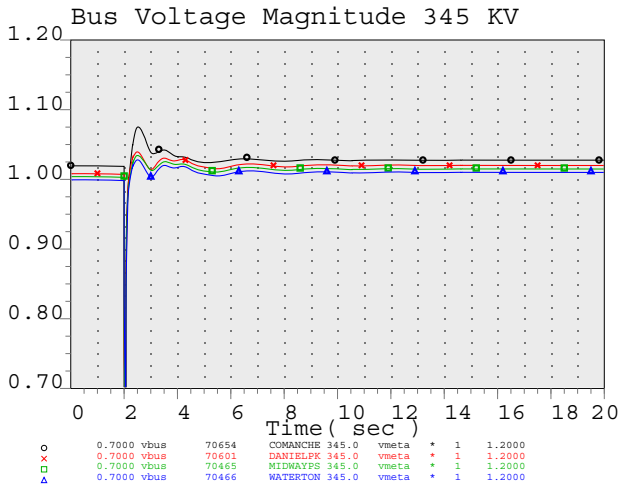


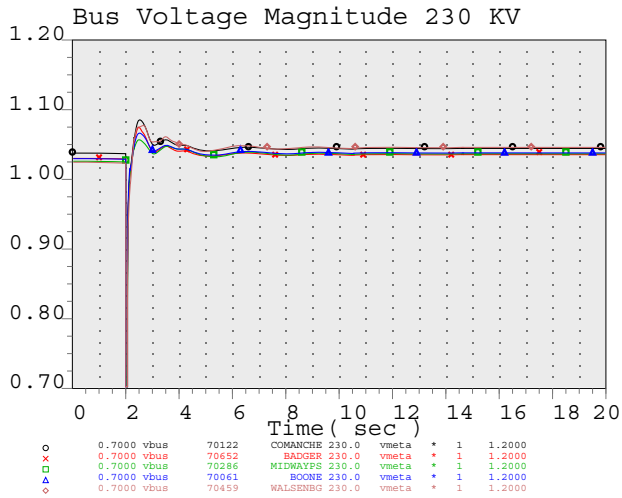


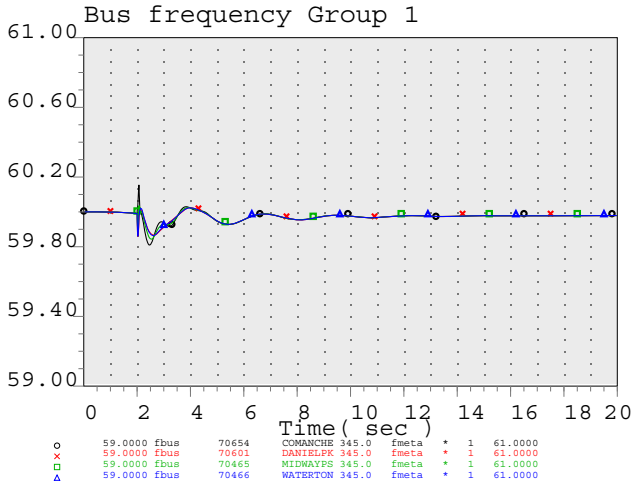


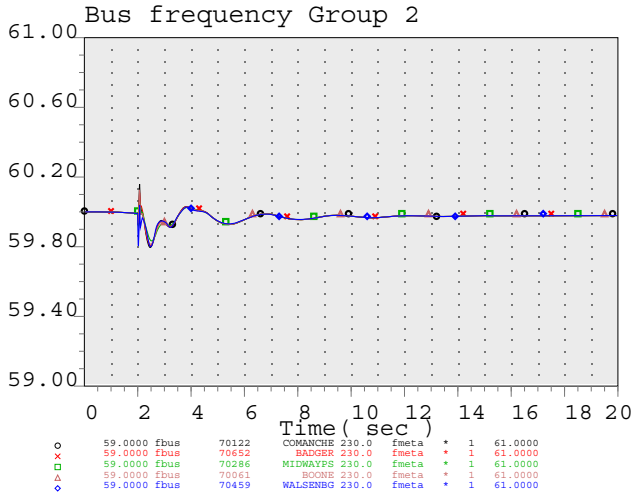
PV - 100 MW & BES - 100 MW

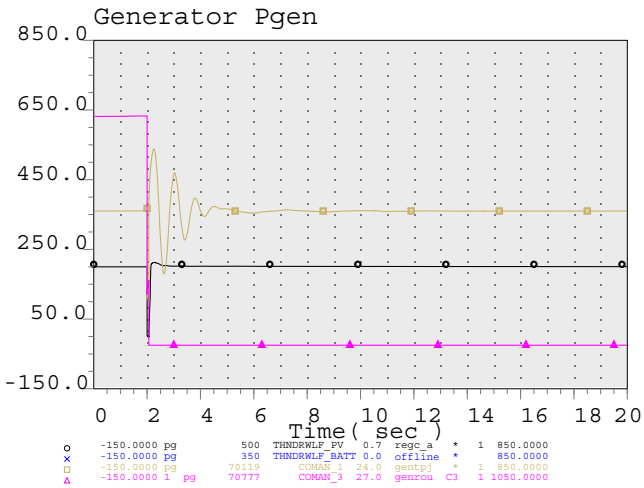
Fault: MIDWAYPS 345 KV 4 cycle 3-ph bus fault
Outage: lose MidwayPS 345/230 KV and MidwayPS - Waterton 345 KV line

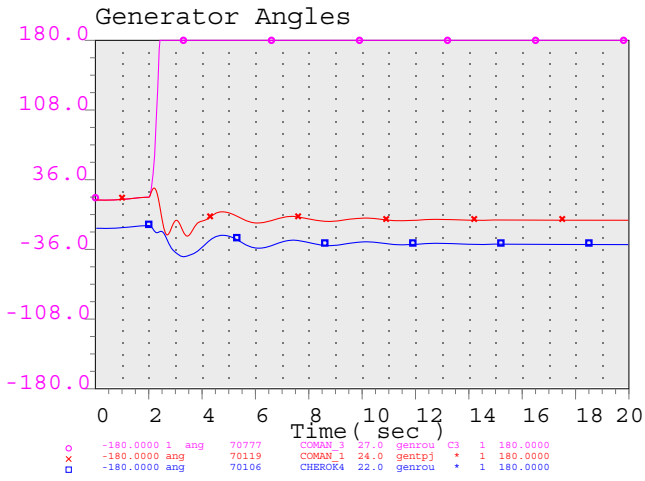






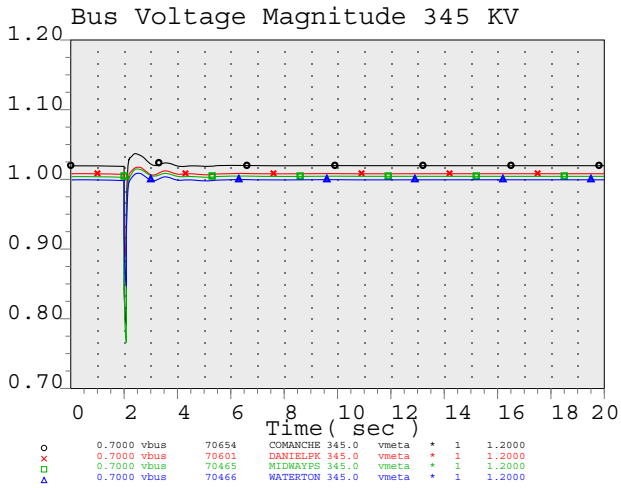


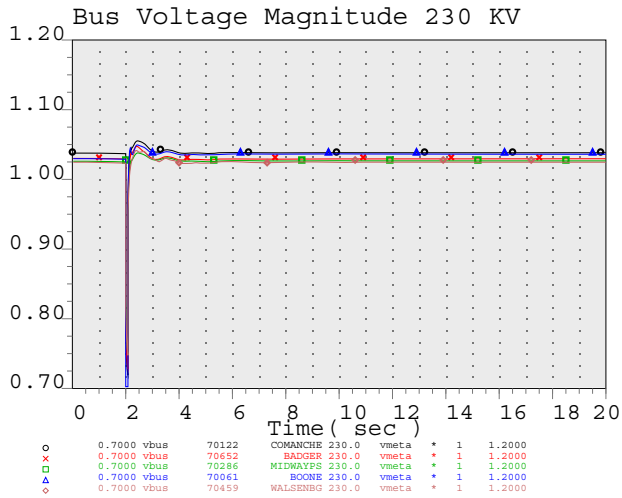


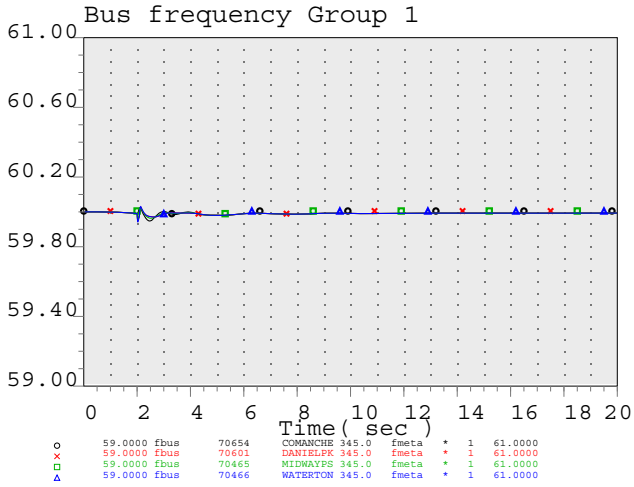


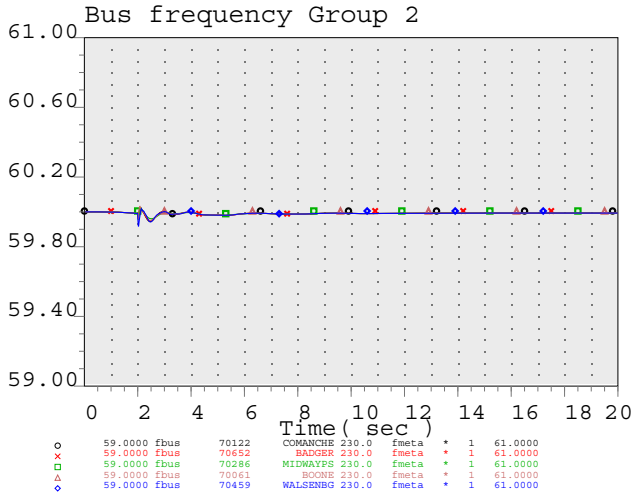
PV - 200 MW & BES - 0 MW

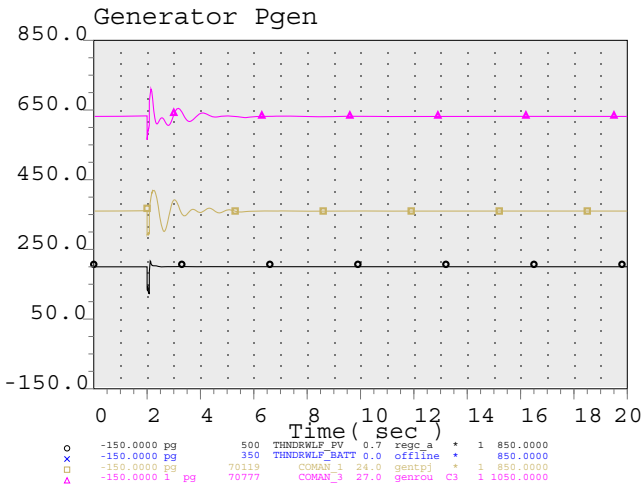
Fault: Comanche 345 KV 4 cycle 3-ph bus fault
Outage: Comanche unit 3

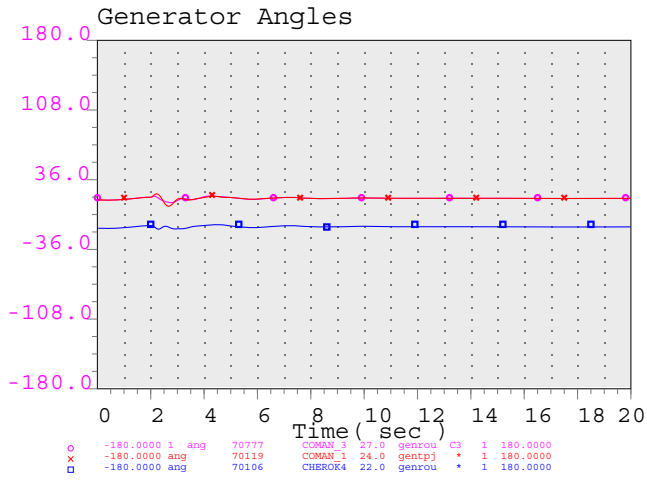






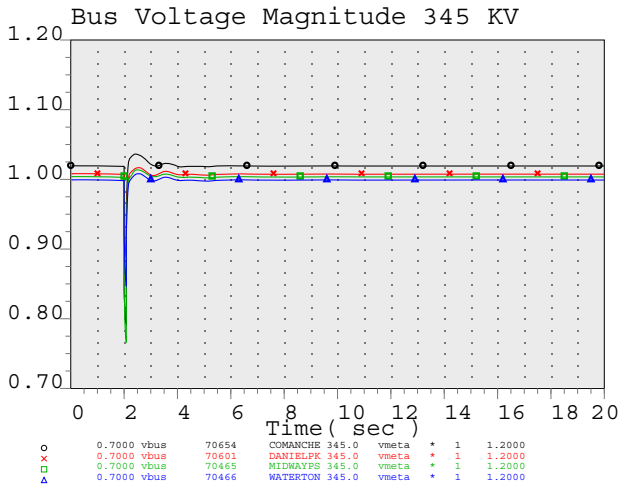


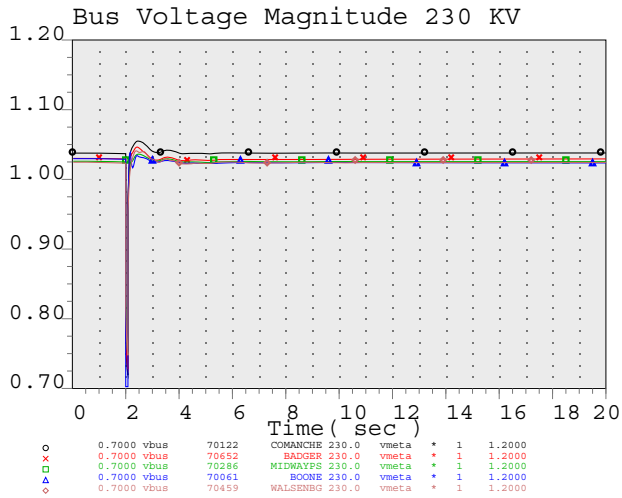


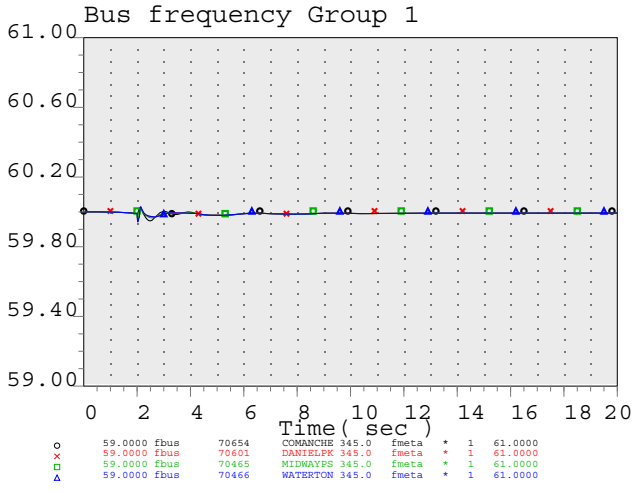


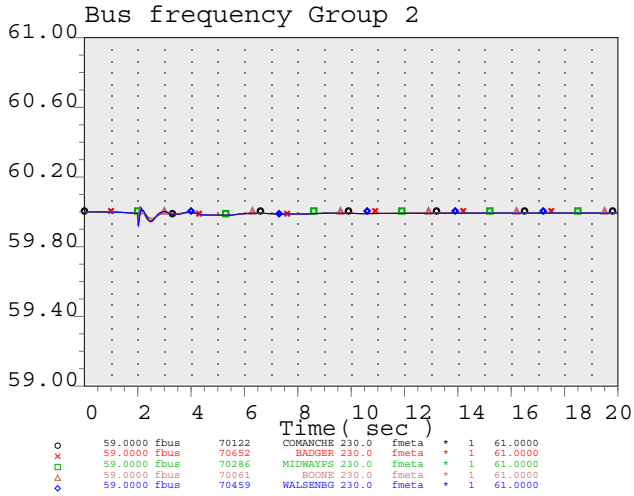
PV - 200 MW & BES - 0 MW

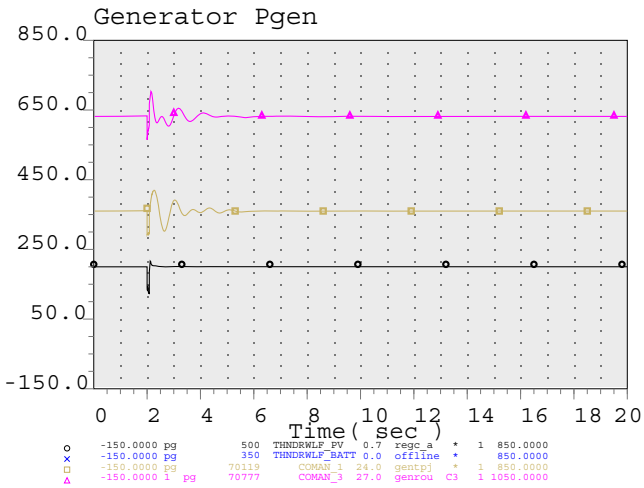
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Boone 230/115 KV bank

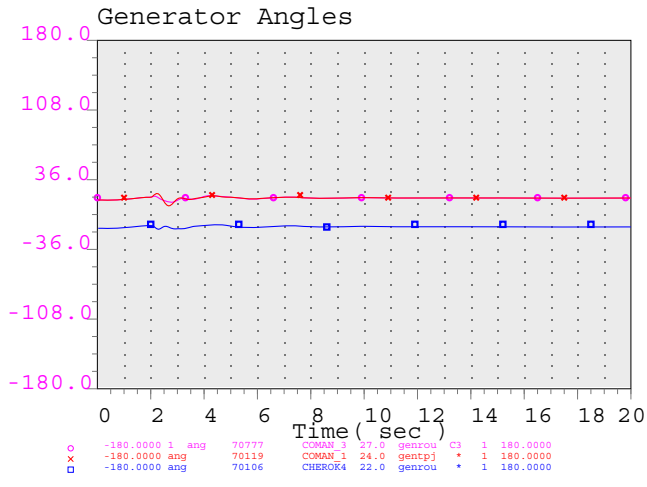






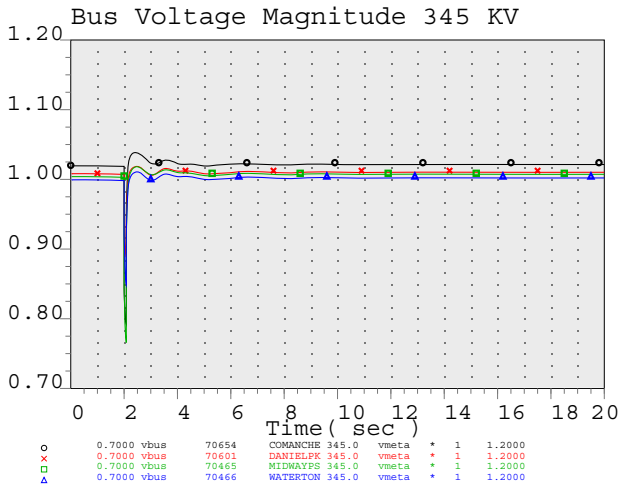


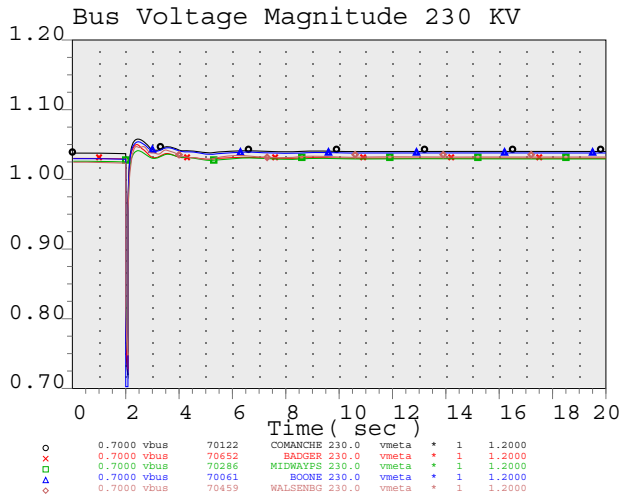


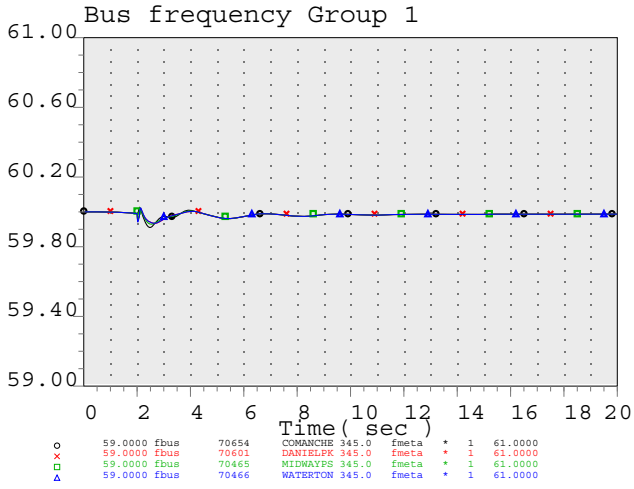


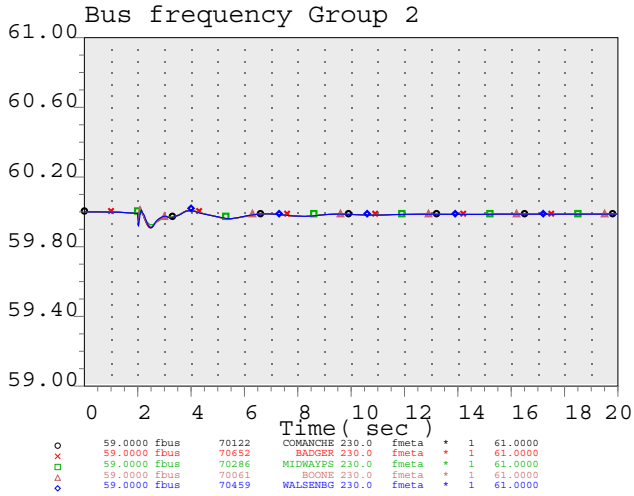
PV - 200 MW & BES - 0 MW

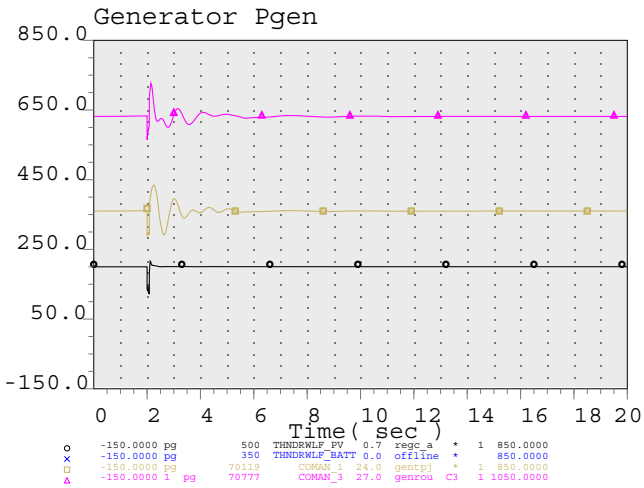
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Boone - Comanche 230kV line

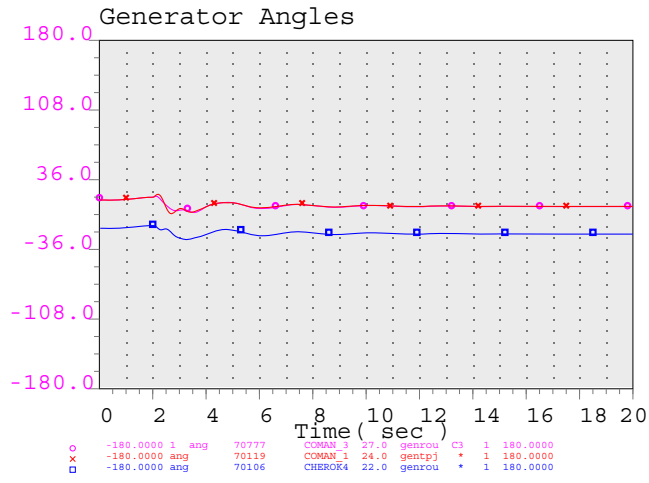






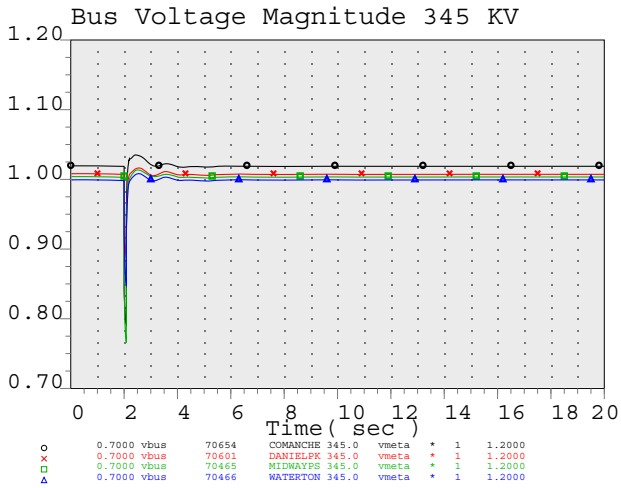


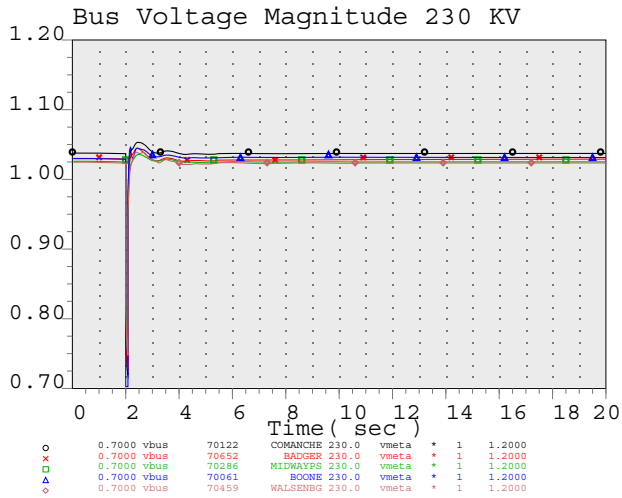


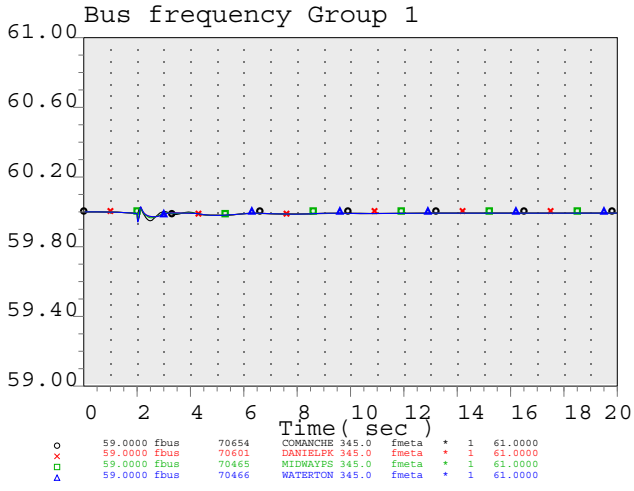


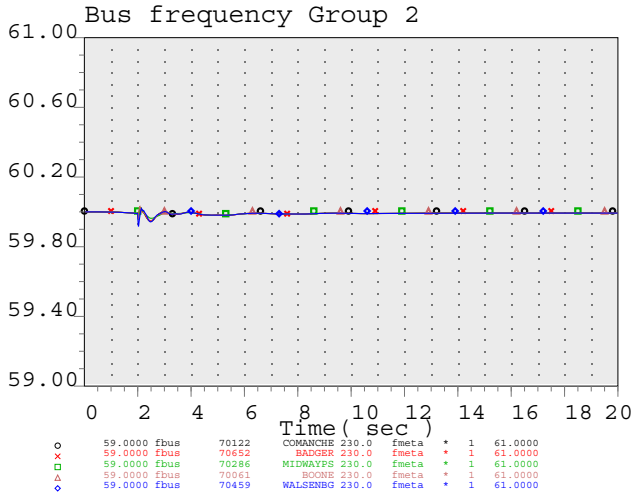
PV - 200 MW & BES - 0 MW

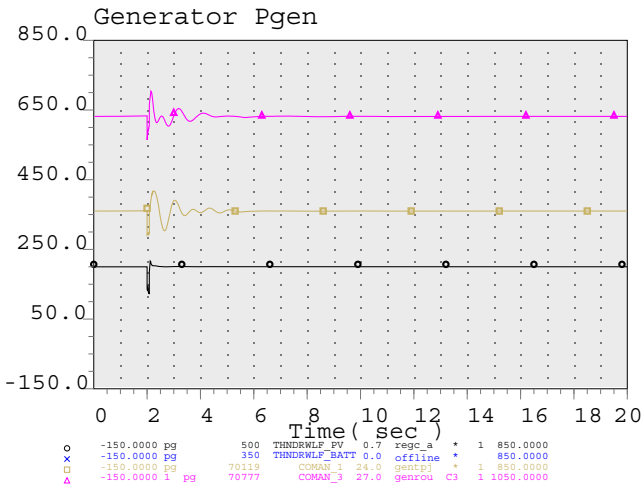
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Boone - Lamar 230 KV line and Lamar gen

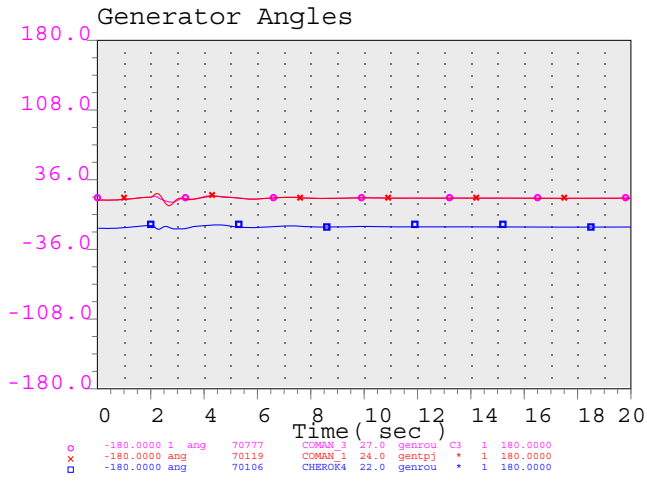






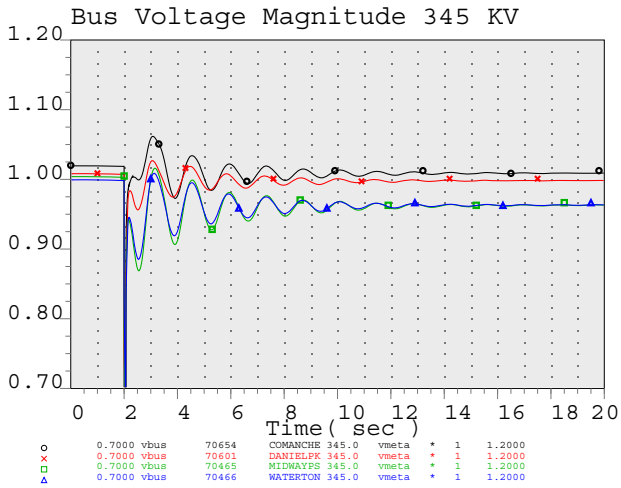


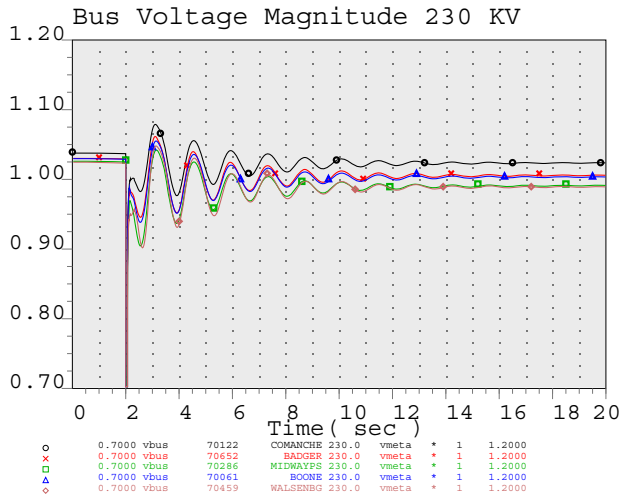


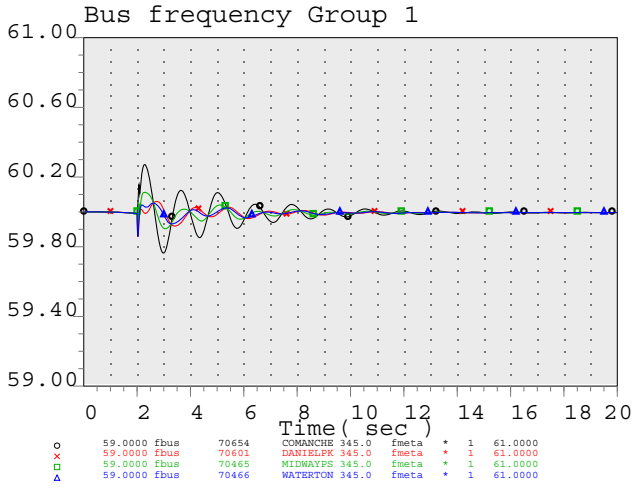


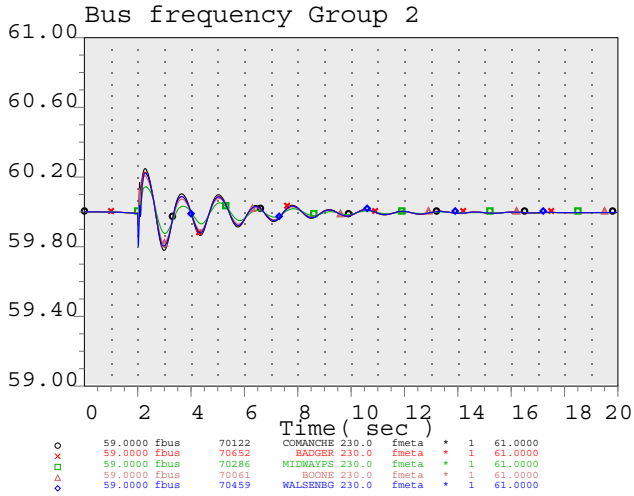
PV - 200 MW & BES - 0 MW

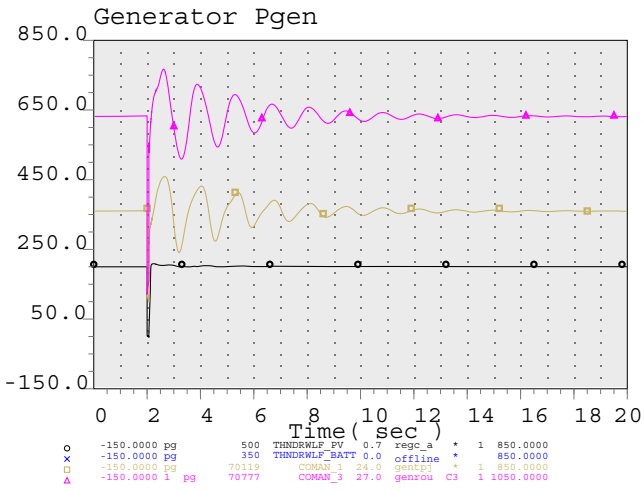
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Boone - Midway 230 KV line

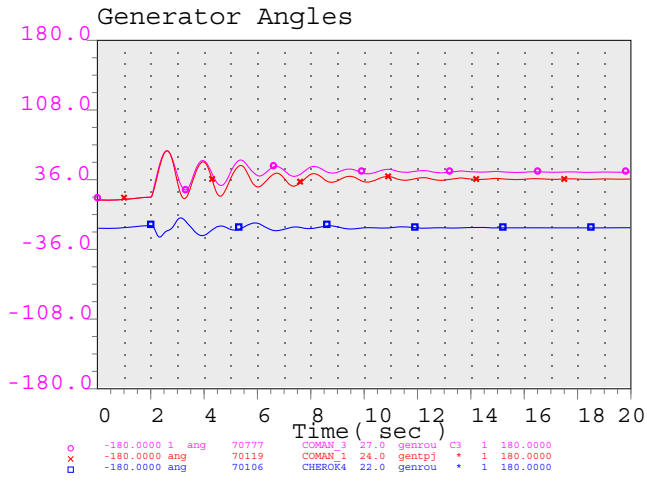






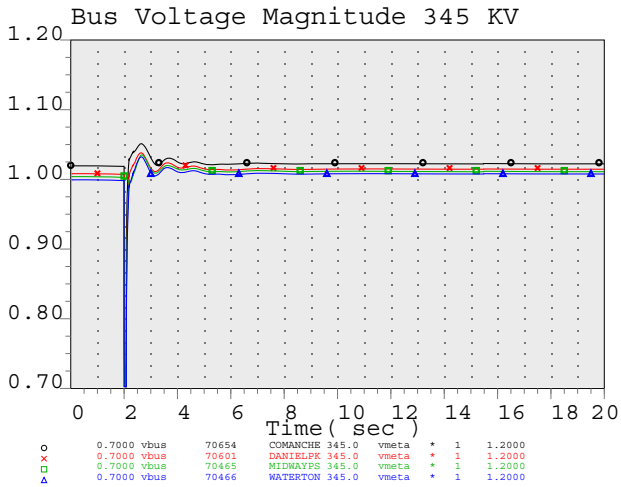


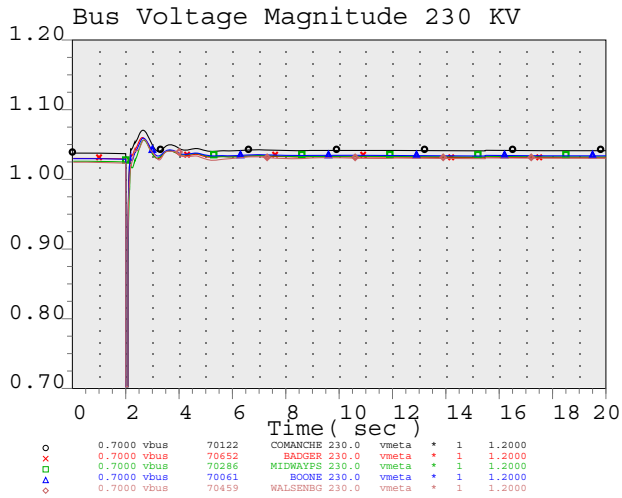


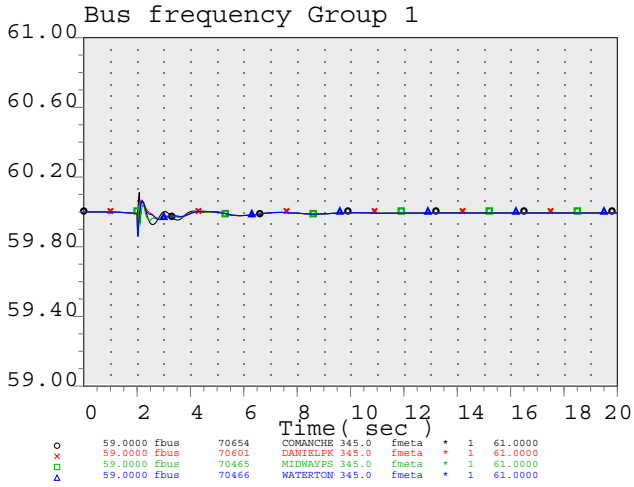


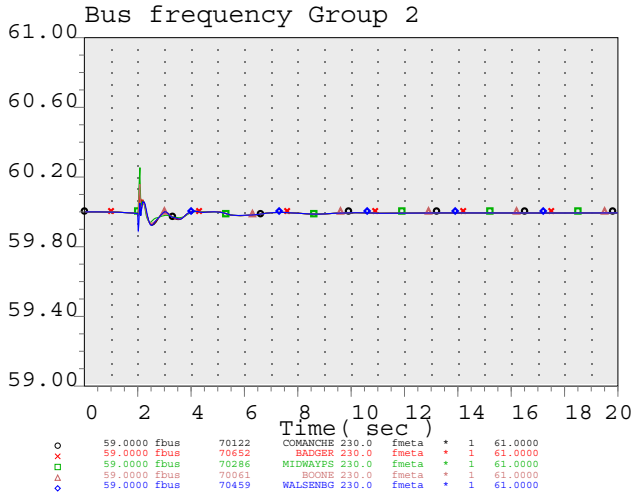
PV - 200 MW & BES - 0 MW

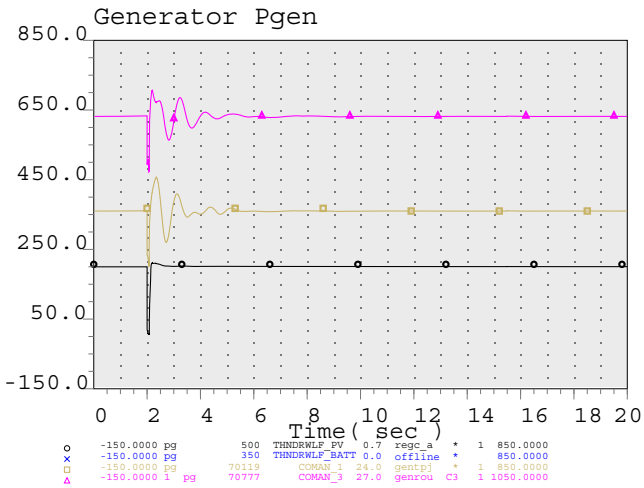
Fault: Comanche 345 KV 4 cycle 3-ph bus fault
Outage: lose Comanche - Daniels Park 345 KV double circuit

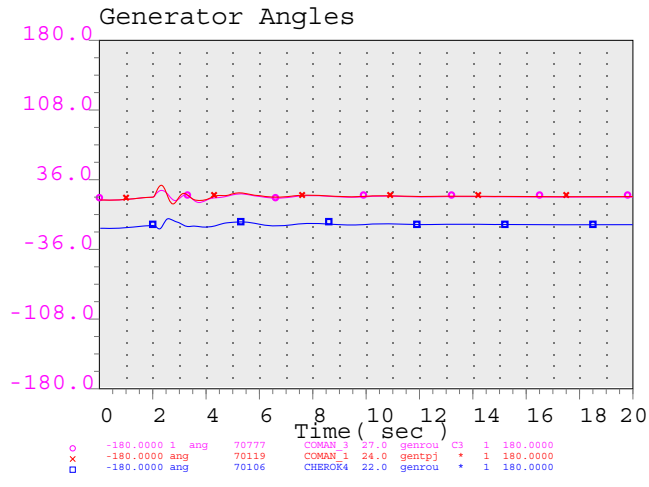






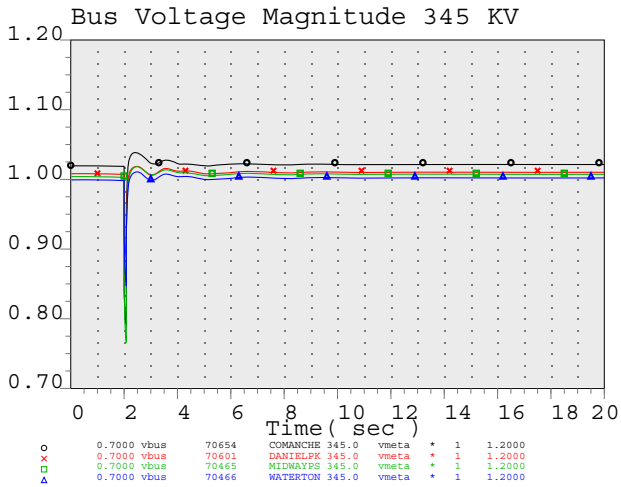


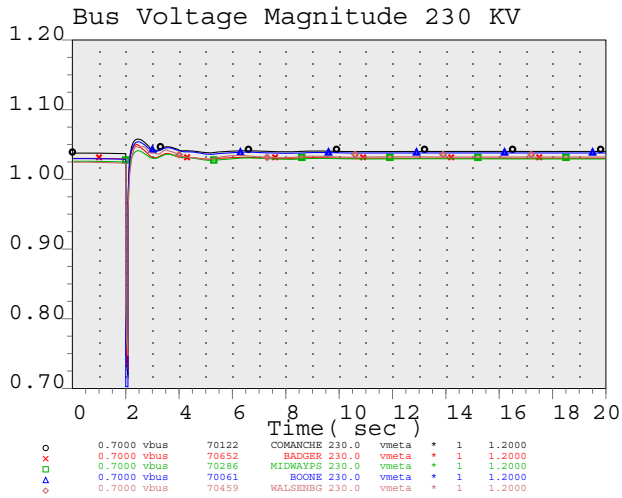


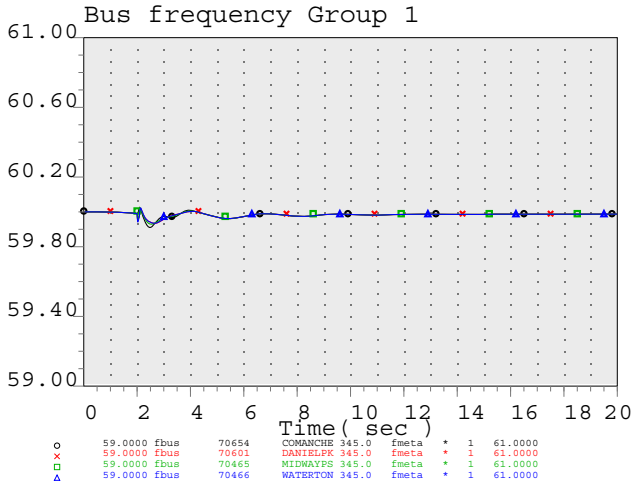


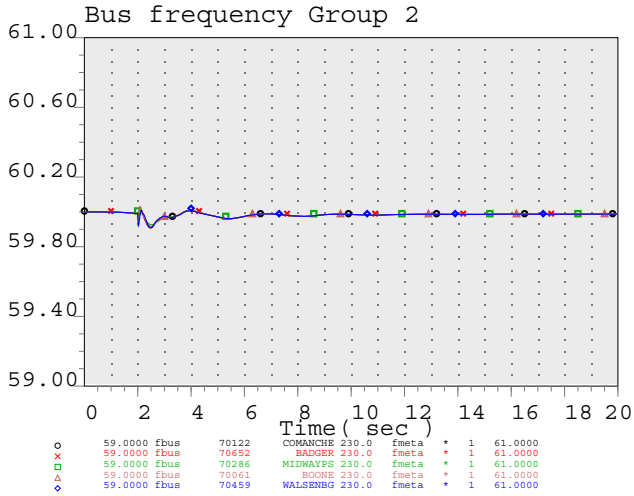
PV - 200 MW & BES - 0 MW

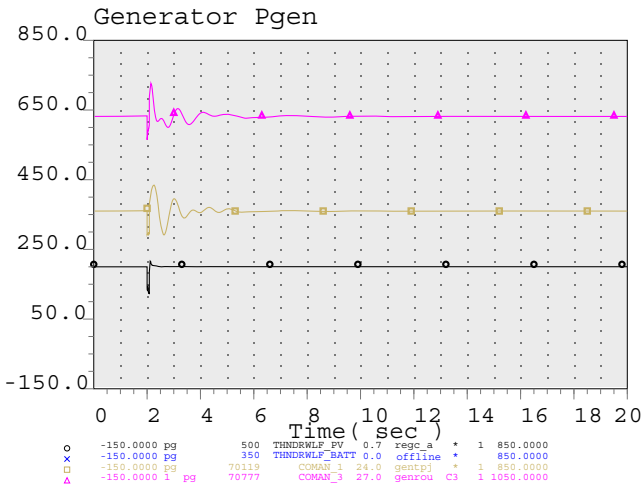
Fault: MIDWAYPS 230 KV 5 cycle 3-ph bus fault
Outage: lose Fountain Valley gen

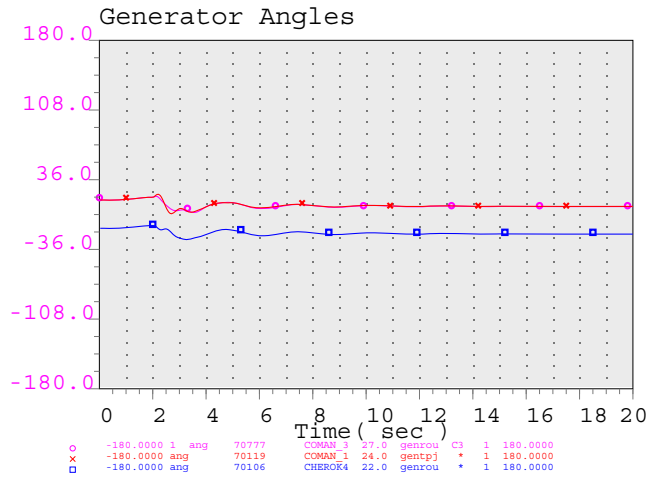






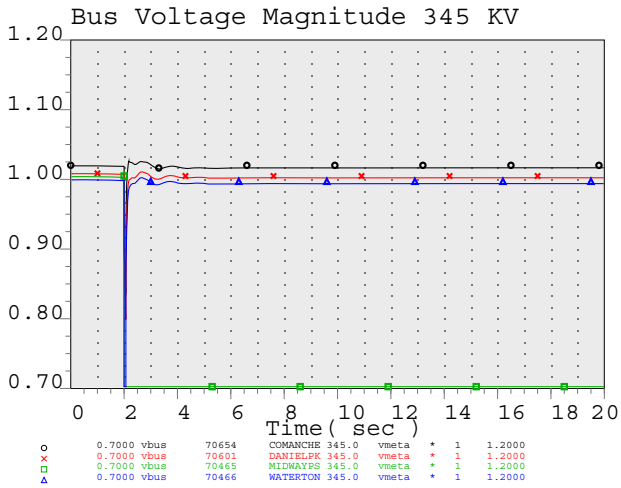


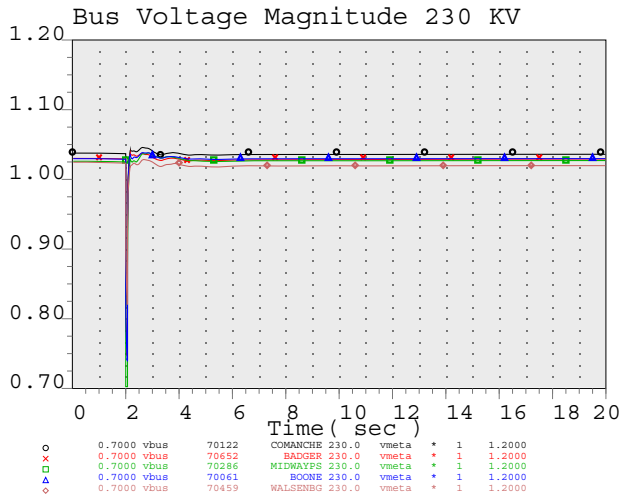


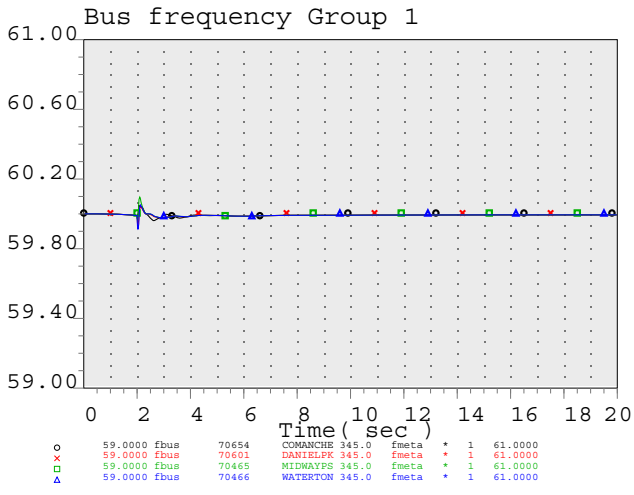


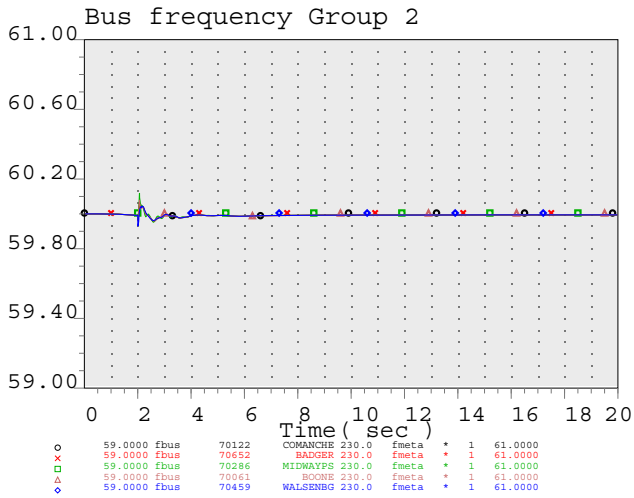
PV - 200 MW & BES - 0 MW

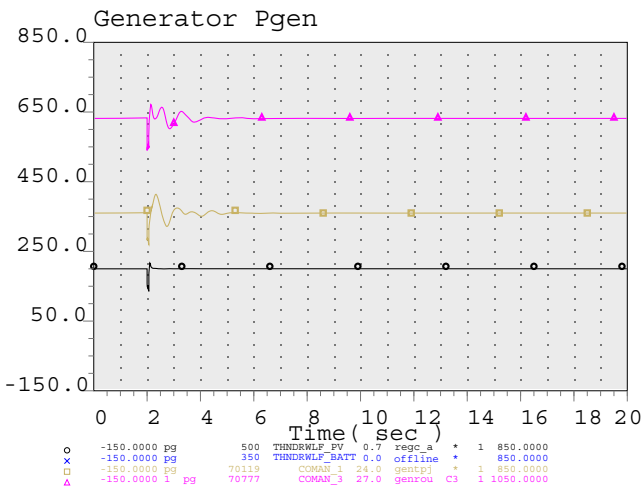
Fault: Boone 230 KV 5 cycle 3-ph bus fault
outage: lose Lamar - Boone 230 KV line and Lamar gen

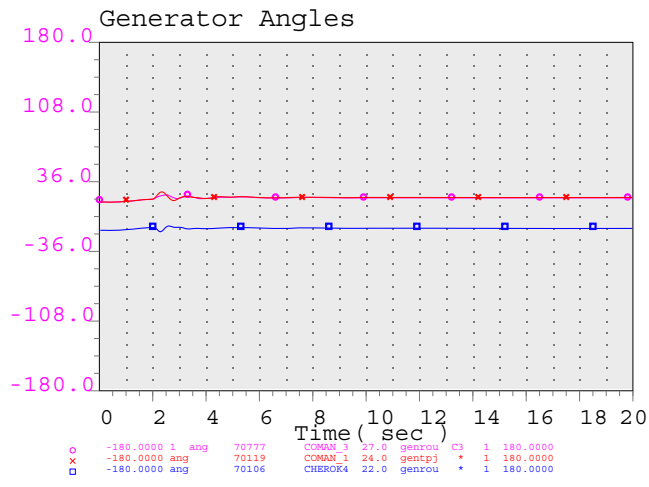






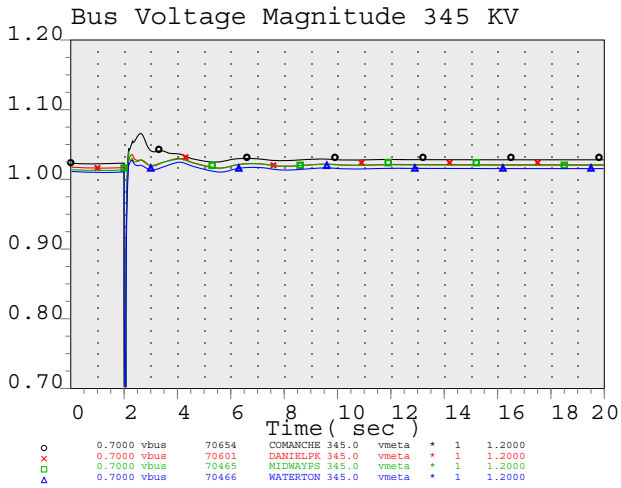


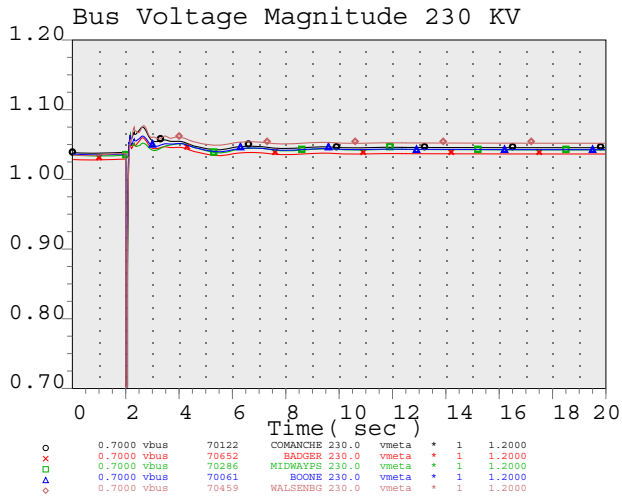


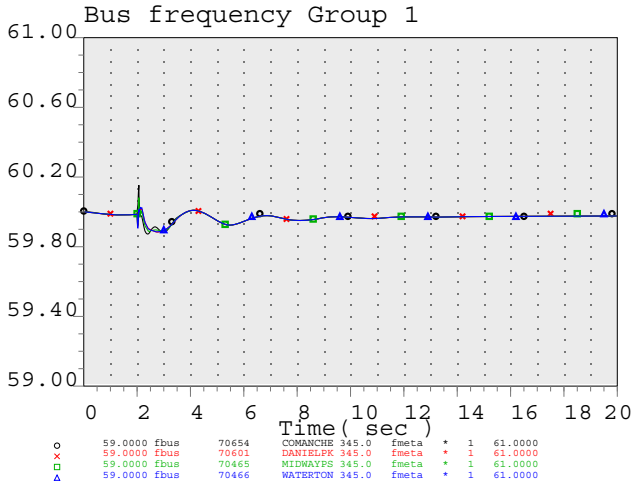


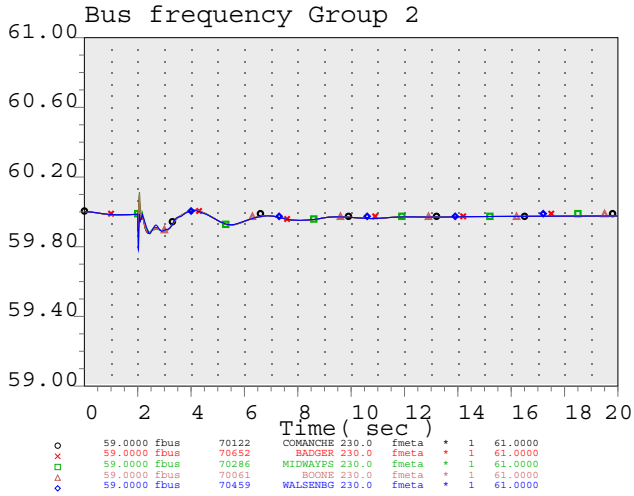
PV - 200 MW & BES - 0 MW

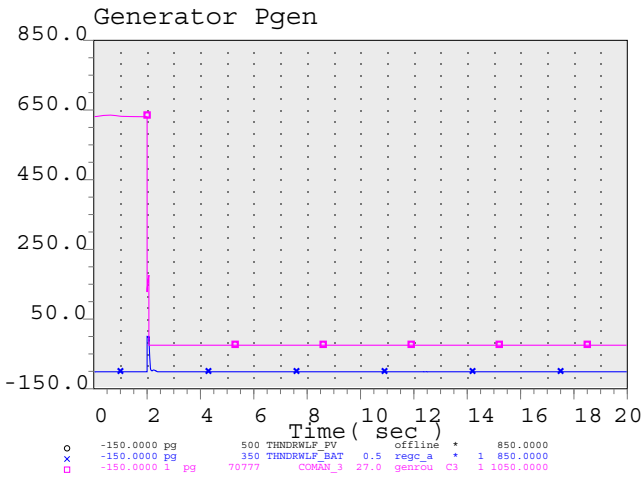
Fault: MIDWAYPS 345 KV 5 cycle 3-ph bus fault
Outage: lose MidwayPS 345/230 KV_and_MidwayPS - Waterton 345 KV line

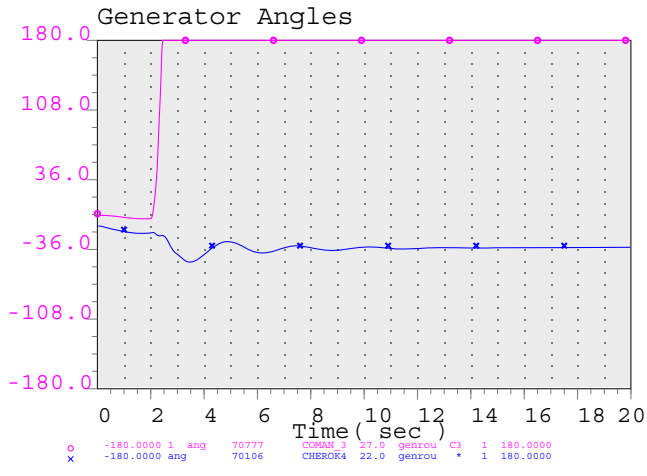






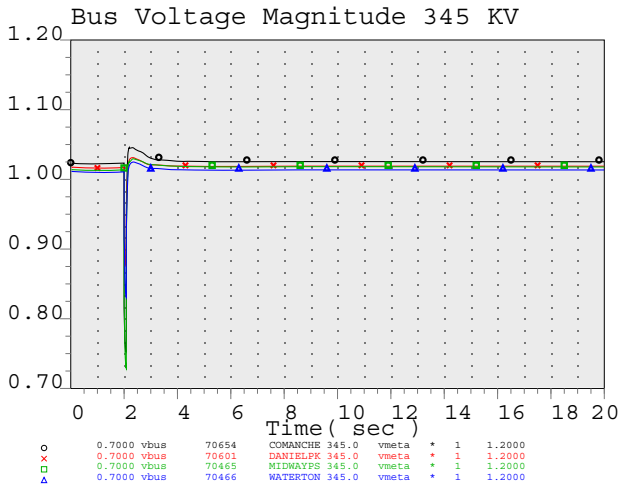


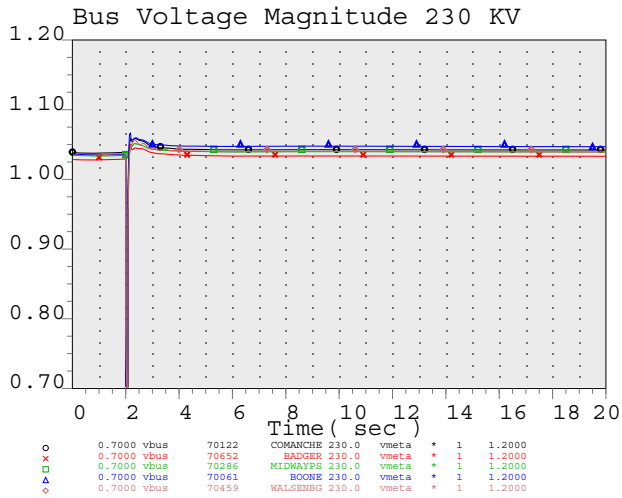


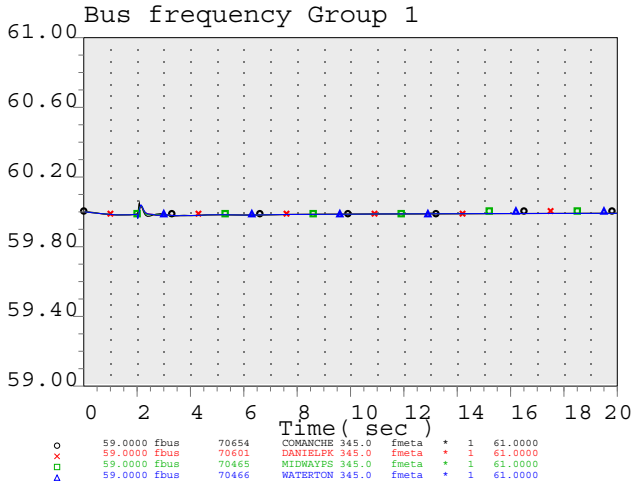


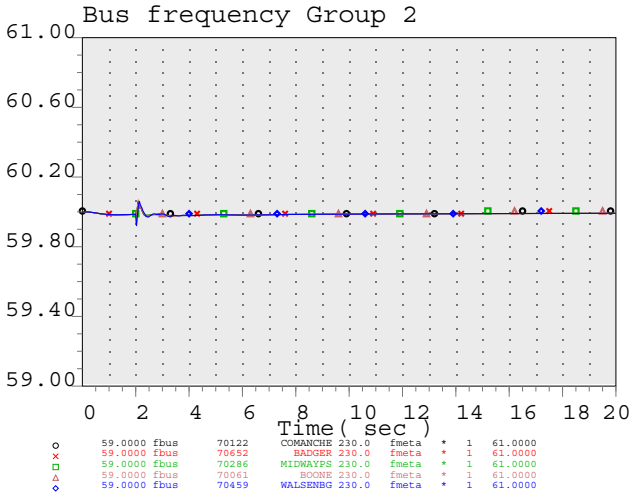
PV - 0 MW & BES - 105 MW charging

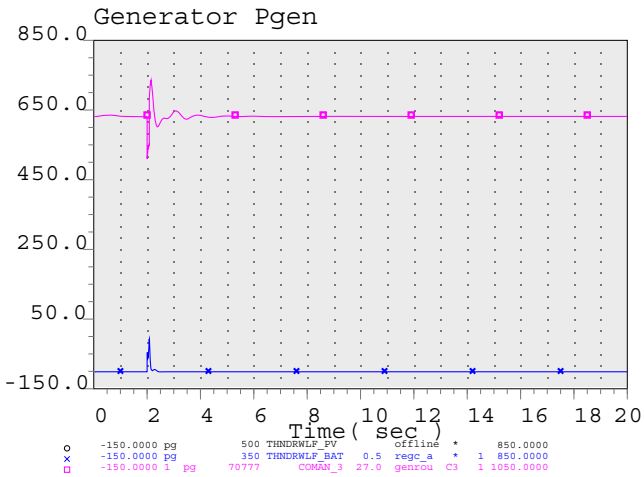
Fault: Comanche 345 KV 4 cycle 3-ph bus fault
Outage: Comanche unit 3

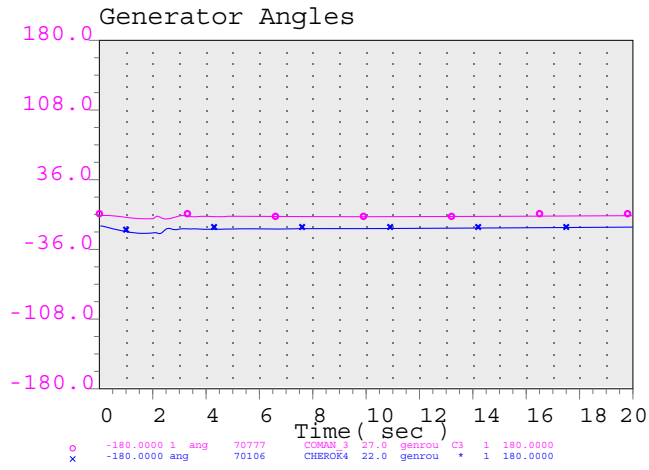






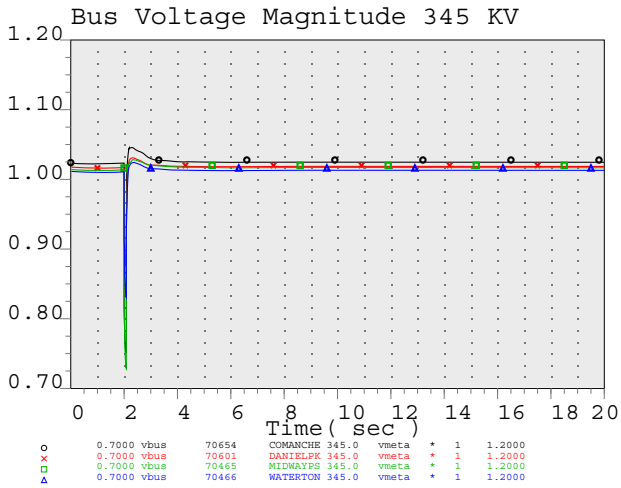


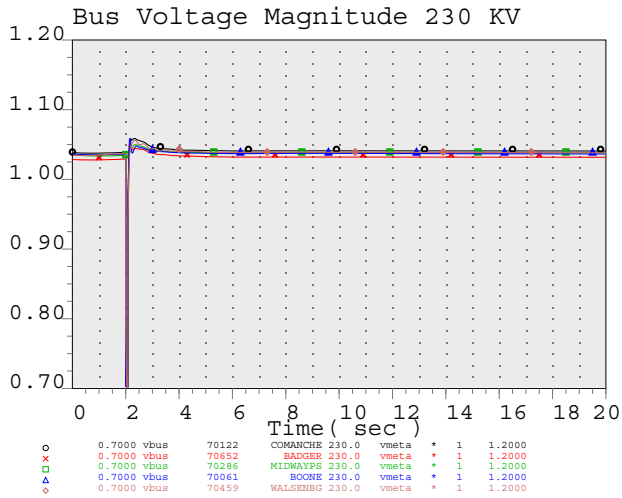


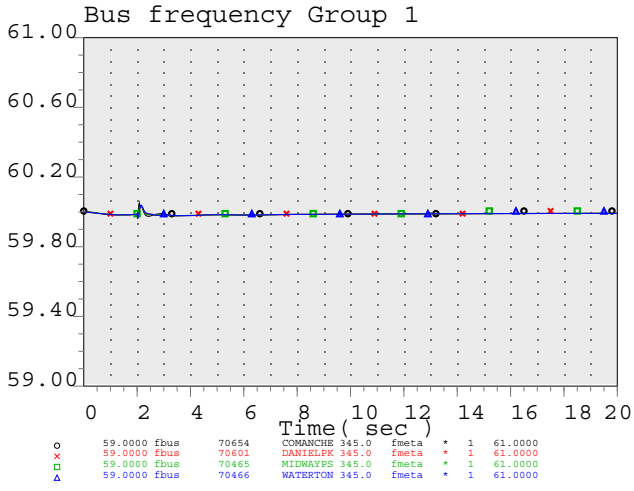


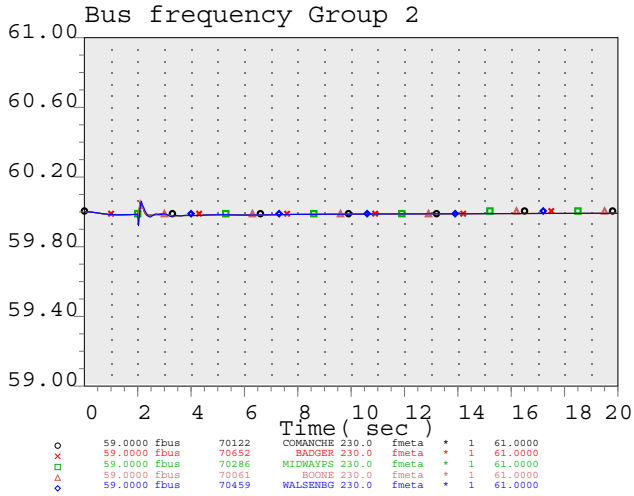
PV - 0 MW & BES - 105 MW charging

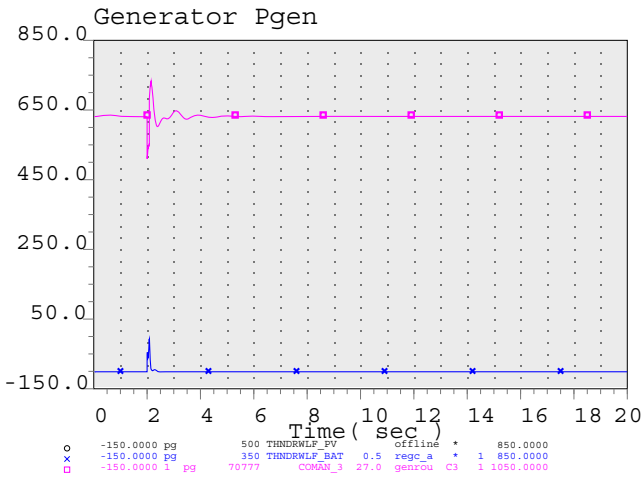
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Boone 230/115 KV bank

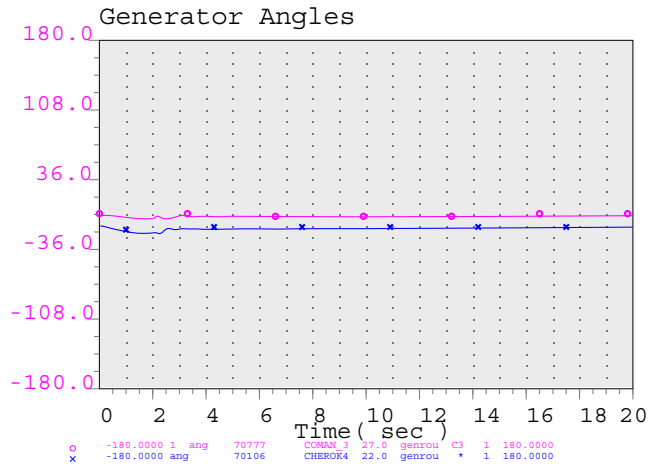






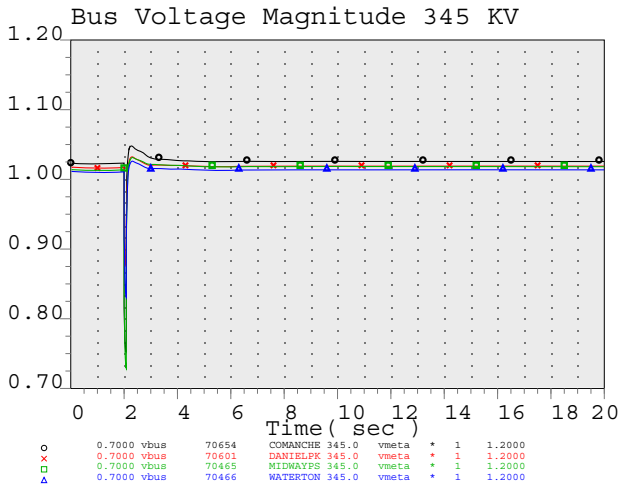


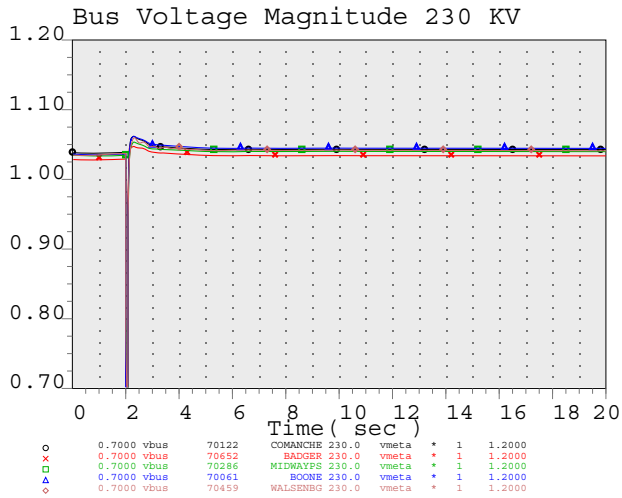


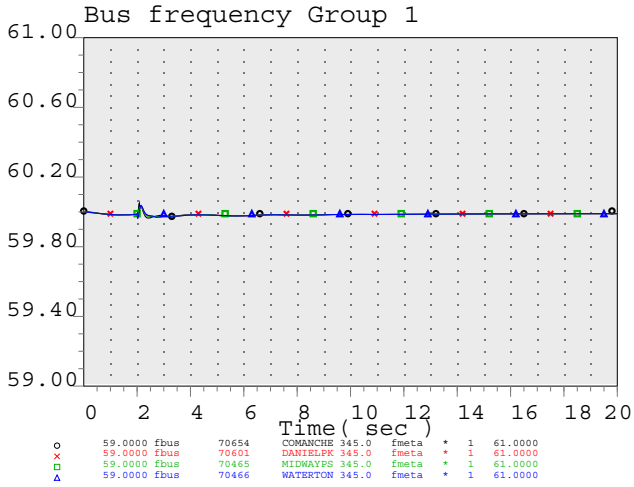


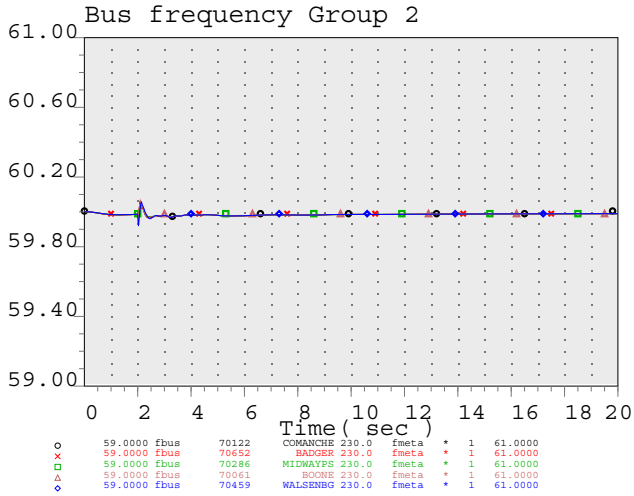
PV - 0 MW & BES - 105 MW charging

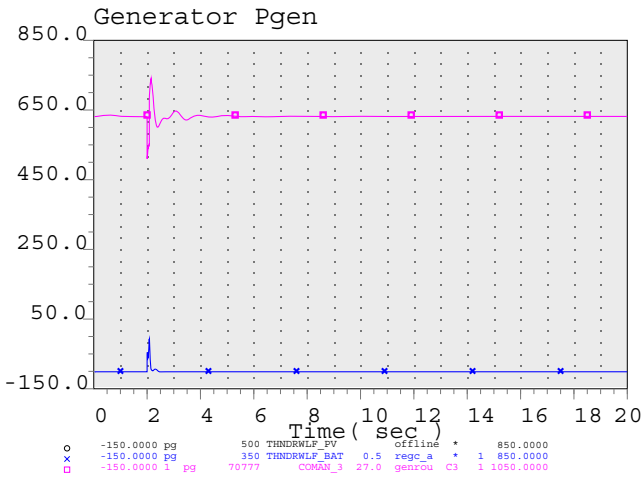
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Boone - Comanche 230 KV line

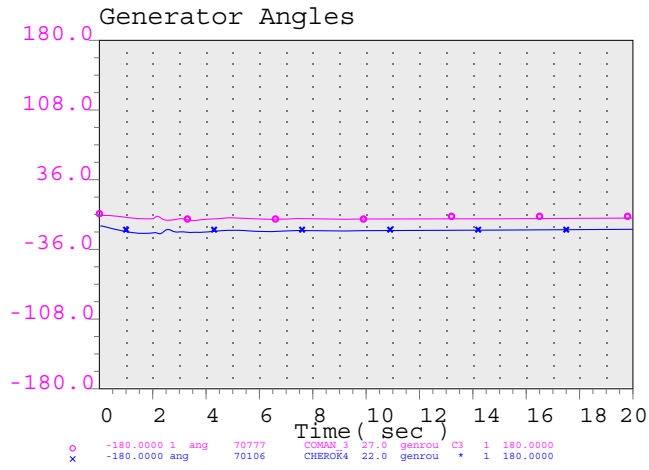






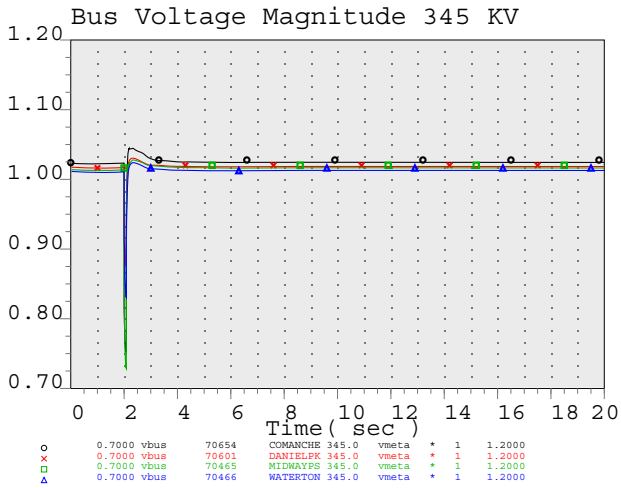


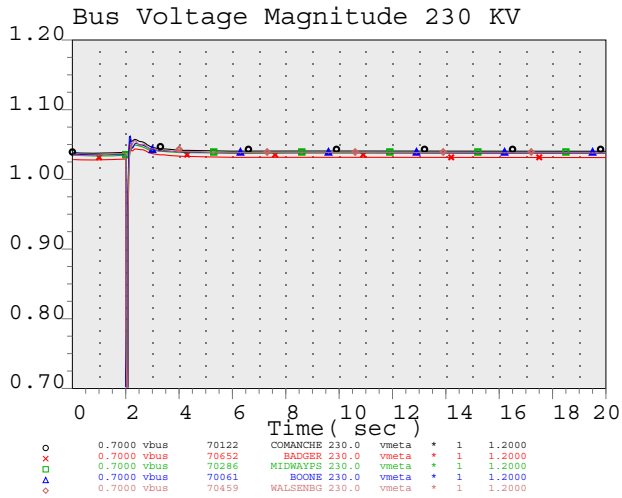


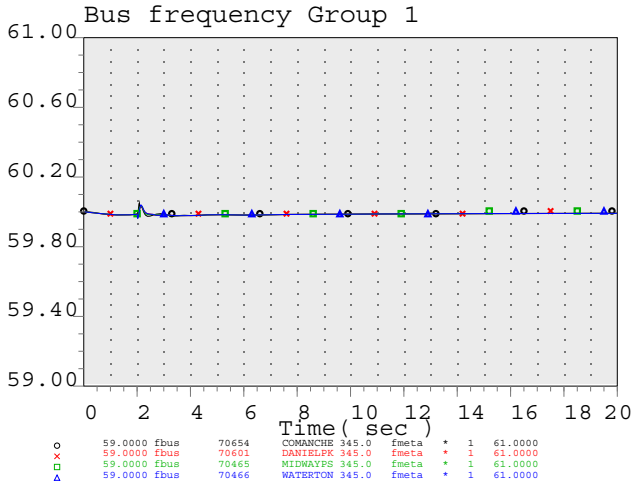


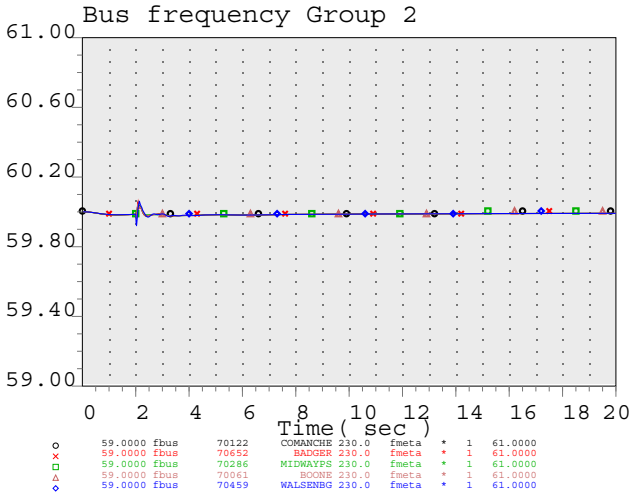
PV - 0 MW & BES - 105 MW charging

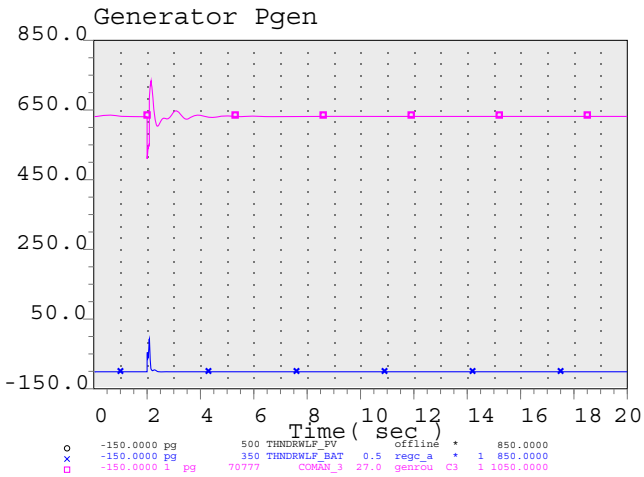
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Boone - Lamar 230 KV line and Lamar gen

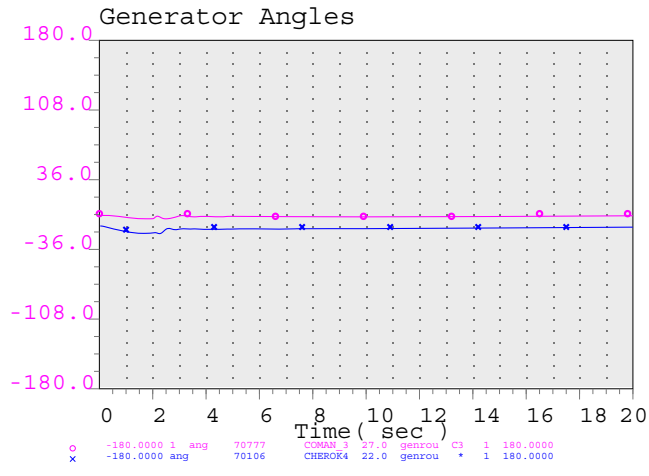






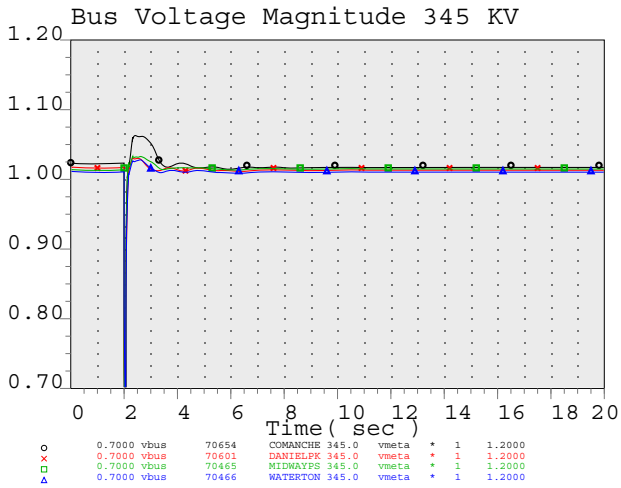


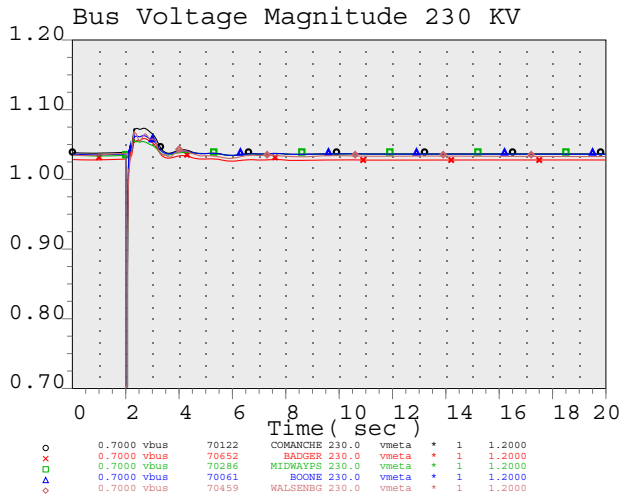


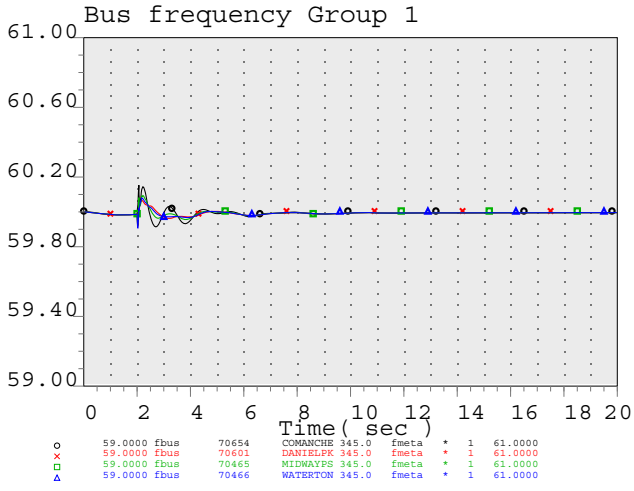


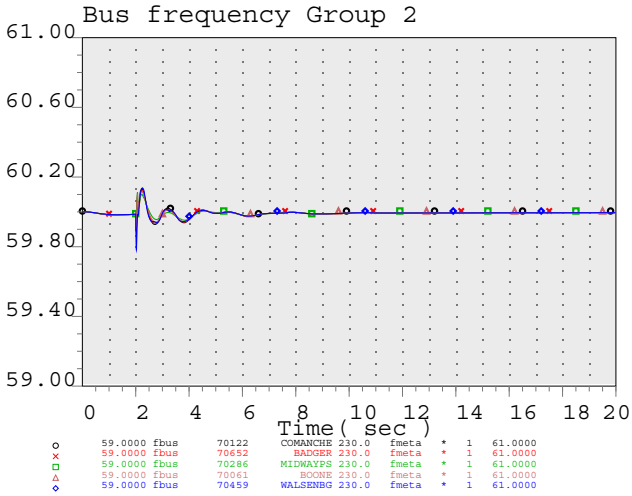
PV - 0 MW & BES - 105 MW charging

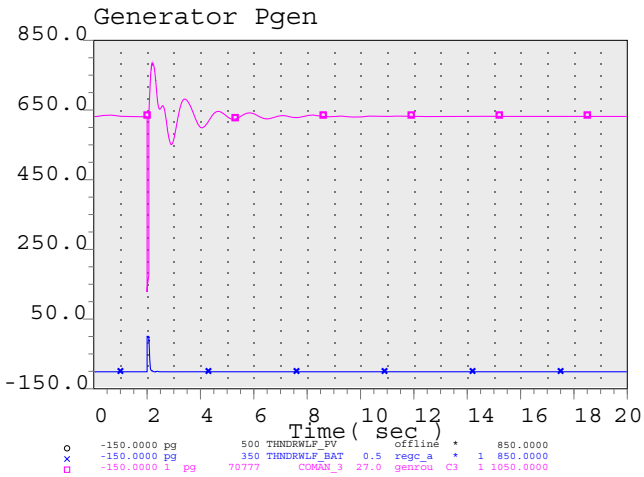
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Boone - Midway 230 KV line

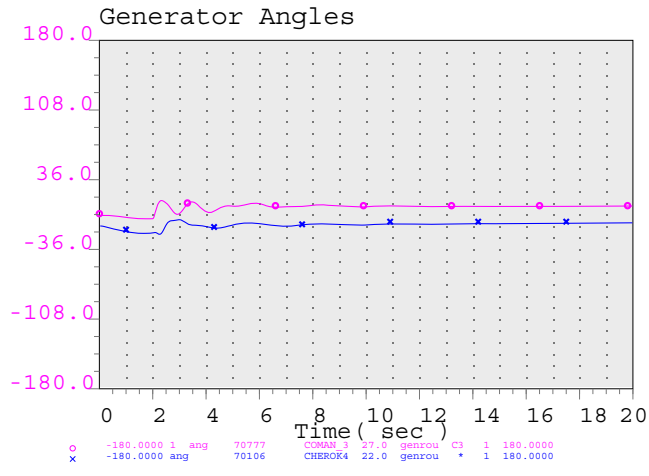




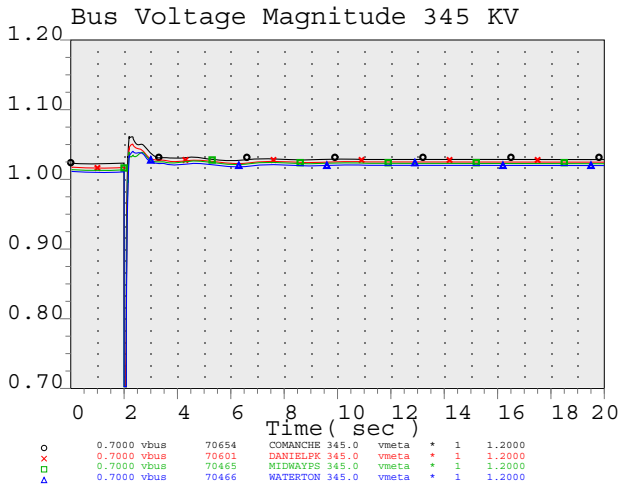


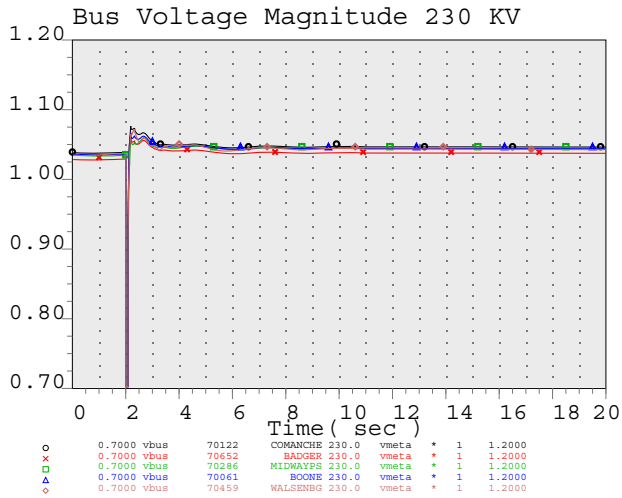


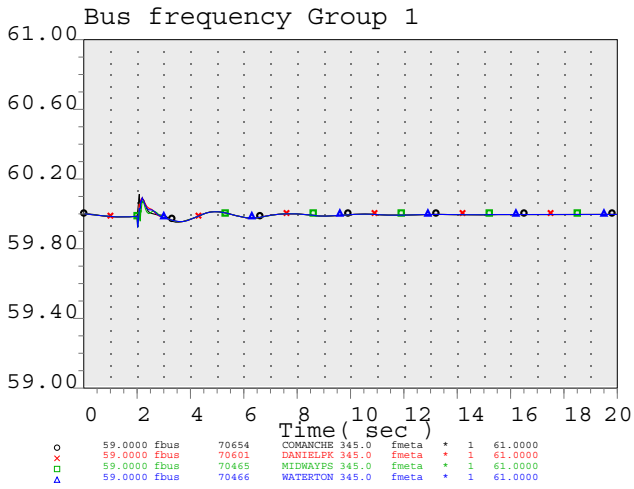


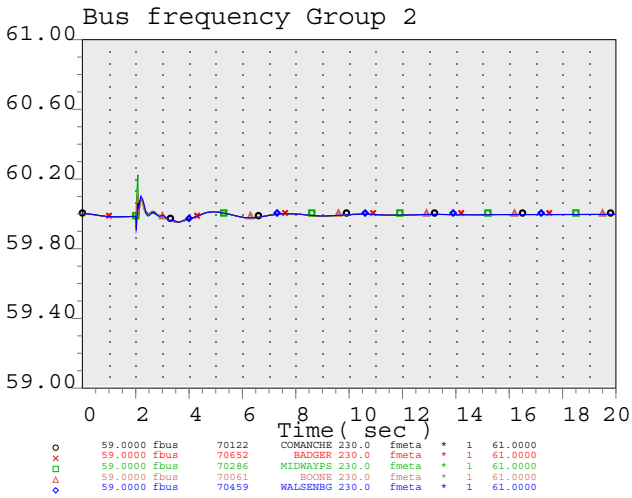


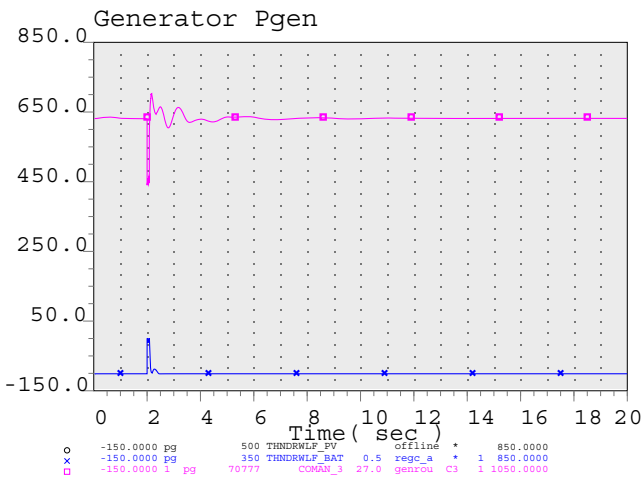
PV - 0 MW & BES - 105 MW charging

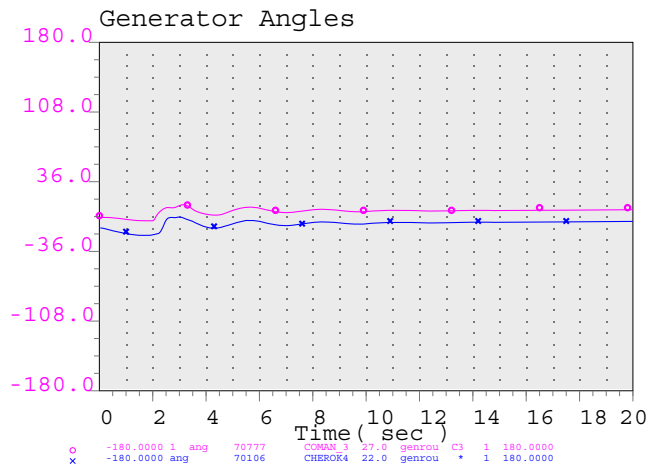




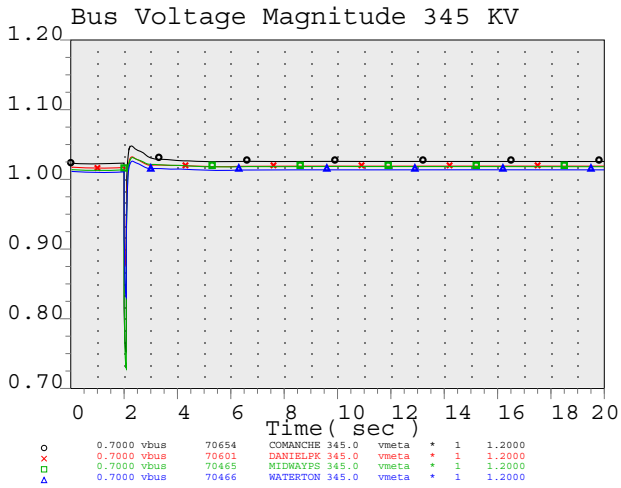


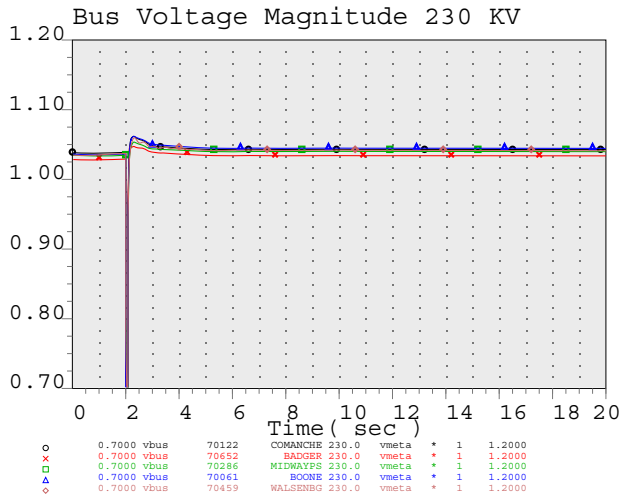


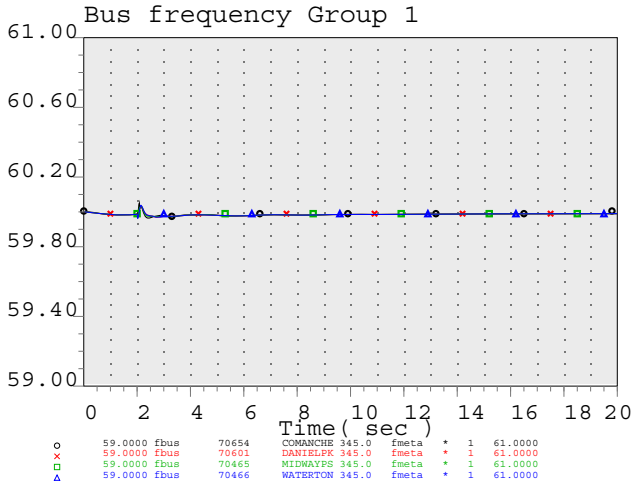


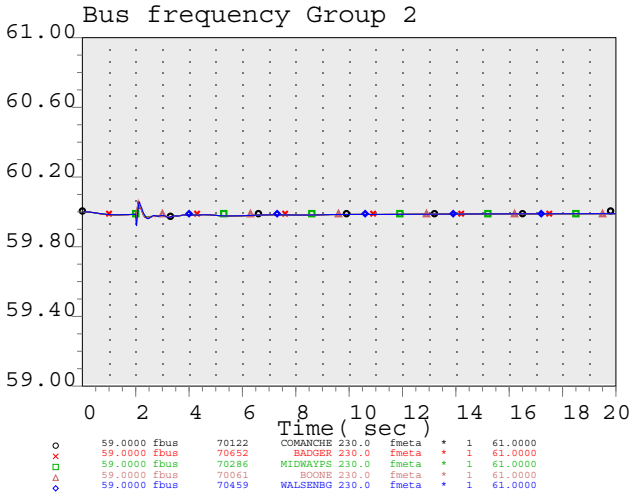


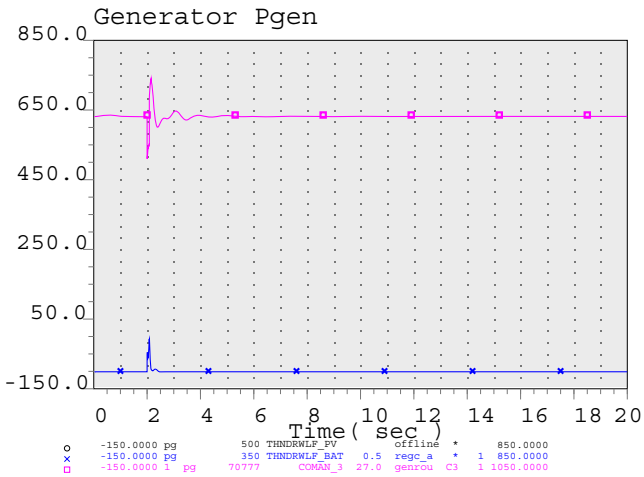
PV - 0 MW & BES - 105 MW charging

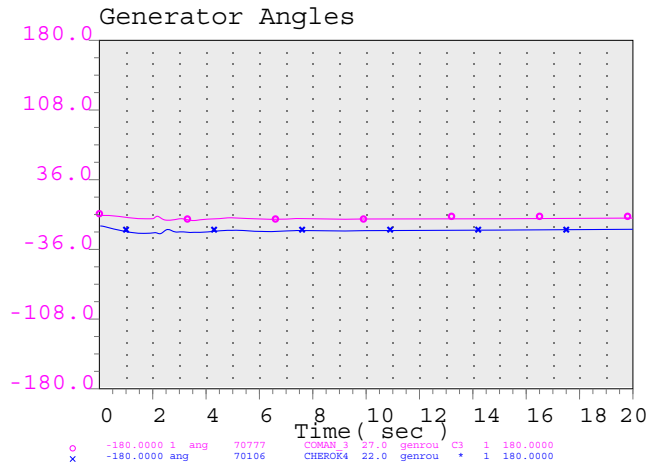






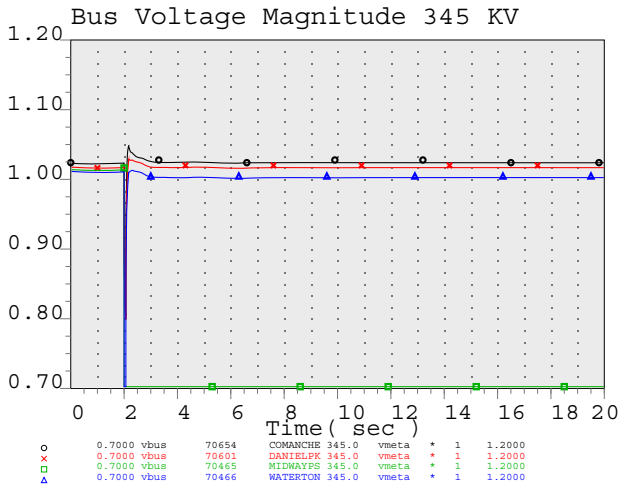


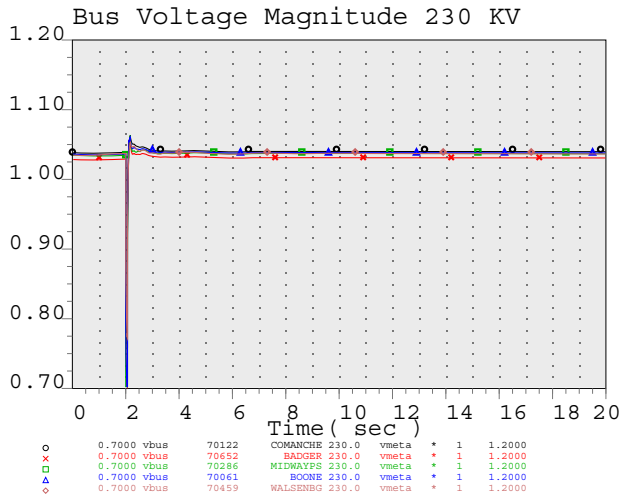


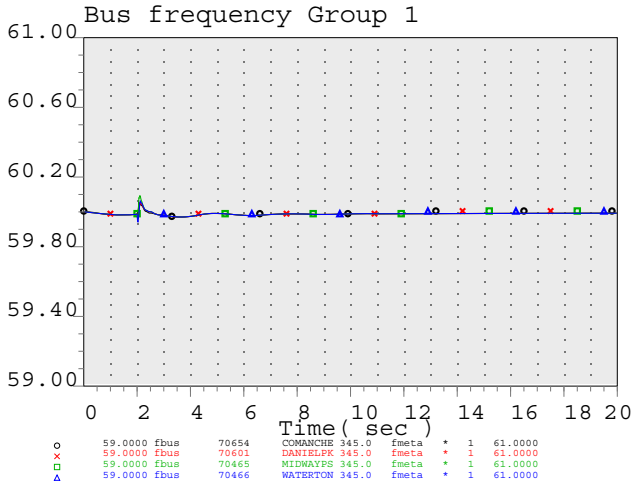


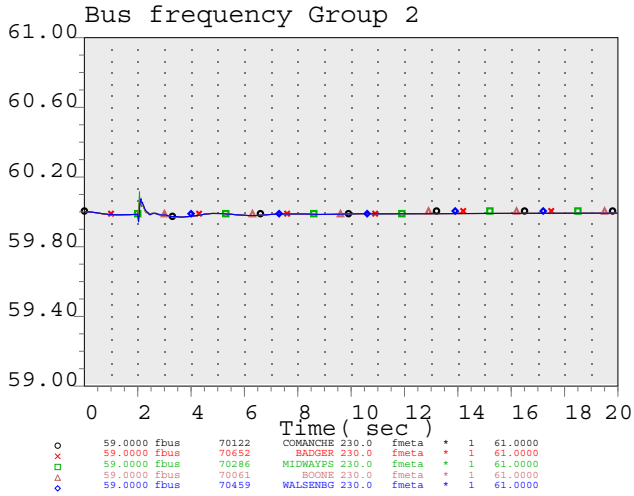
PV - 0 MW & BES - 105 MW charging

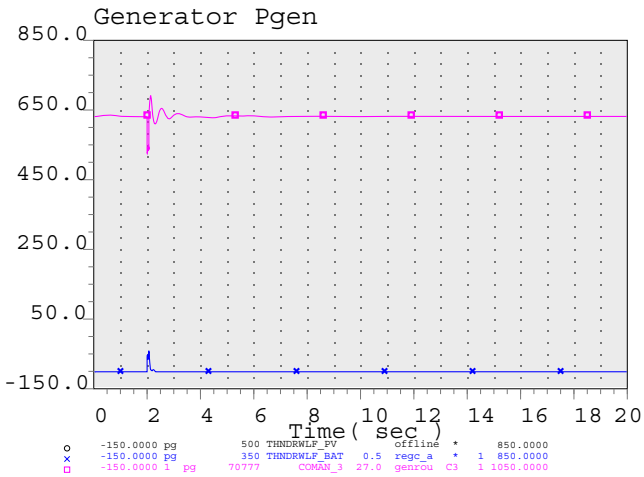
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Lamar - Boone 230 KV line and Lamar gen

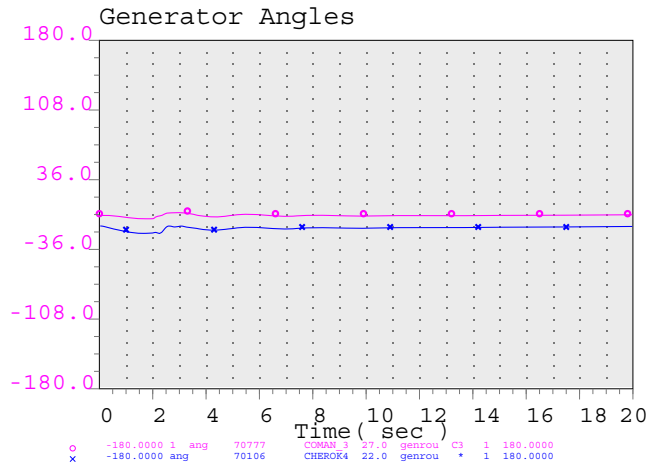












PV - 0 MW & BES - 105 MW charging