Provisional Interconnection Study Report

250MW Solar Photovoltaic and Battery Energy Storage Generating Facility

Comanche – Midway 230kV line

Pueblo County, Colorado

7/10/2020

Xcel Energy®

Table of Contents

1.0 Executive Summary

Th Provisional Interconnection Service[1] Request (PI-2020-2) is a request to interconnect a new 250MW Solar Photovoltaic (PV) and Battery Energy Storage (BES) hybrid Generating Facility on the Comanche – Midway 230kV line.

The Generating Facility is an AC-coupled hybrid Generating Facility with two distinct Generating Facility groups - 200MW Solar PV facility and 100MW BES facility. The net output of the Solar PV and BES Generating Facilities will be limited to 250MW using a custom PLC centralized power plant controller which will also adjust voltage, vars and droop.

The 230kV tap position on the Comanche – MidwayPS 230kV line will require building a new switching station referred to as "Mirasol 230kV Switching Station". A Certificate of Public Need and Benefit (CPCN) is required to build the Mirasol 230kV Switching Station.

The proposed Commercial Operation Date (COD) of the Generating Facility is December 1, 2022. Accordingly, based on the typical construction timeframes for similar projects, the back-feed date is assumed to be June 1, 2022, approximately six (6) months before the COD.

The total estimated cost of the Public Service Company of Colorado (PSCo) transmission system improvements required for the 250MW Provisional Interconnection Service on the Comanche – Midway 230kV line is $23.607 Million

The Provisional Interconnection Service allotted to the Generating Facility is 250MW

The Provisional Interconnection Service identified is contingent upon the transmission system improvements identified in Section 7 of this report.

Security: The Customer has made a commitment to enter the next available Definitive Interconnection Study process and elect Energy Resource Interconnection Service (ERIS)[2], the security associated with the potential Upgrades that might be identified at the conclusion of the Large Generation Interconnection Procedure (LGIP) is expected to be approximately $5 Million.

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[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] **Energy Resource Interconnection Service** shall mean an Interconnection Service that allows the Interconnection Customer to connect its Generating Facility to the Transmission Provider's Transmission System to be eligible to deliver the Generating Facility's electric output using the existing firm or non-firm capacity of the Transmission Provider's Transmission System on an as available basis. Energy Resource Interconnection Service in and of itself does not convey transmission service

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

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

2.0 Introduction

PI-2020-2 is the Provisional Interconnection Service Request for a new 250MW Solar PV and BES hybrid Generating Facility.

PI-2020-2 is an AC-Coupled hybrid Generating Facility and consists of two distinct Generating Facility groups - 200MW Solar PV facility and 100MW BES facility. The 200MW Solar PV facility will consist of ninety-seven (97) GE LV5 2.3MVA, ±0.90 PF inverters, each with its own 600V/34.5kV, 2.3MVA, Z=6.3% and X/R=7.5 pad-mounted step-up transformer. The 100MW BES facility will consist of forty-six (46) Parker 890-GTB2200 2.2MVA, 1.0 (unity) PF inverters, each with its own 480V/34.5kV, 2.2MVA, Z=5.75% and X/R=7.5 pad-mounted step-up transformer. The Customer has confirmed that the Parker inverters are capable of ±0.95 PF even though the manufacturer data sheet specifies 1.0 (unity) PF. The BES will comprise of Lithium-ion batteries and will have maximum and minimum state of charge of 100% and 5% respectively.

The 34.5kV collector system will connect to two (2) 34.5/230kV, 102/138/170MVA, Z=8.5% and X/R=40 main step-up transformer which in turn will connect to PSCo's Comanche – MidwayPS 230kV line via a 0.1 mile generation tie-line.

The BES will only charge from the Solar PV generator under the requested Provisional Service.

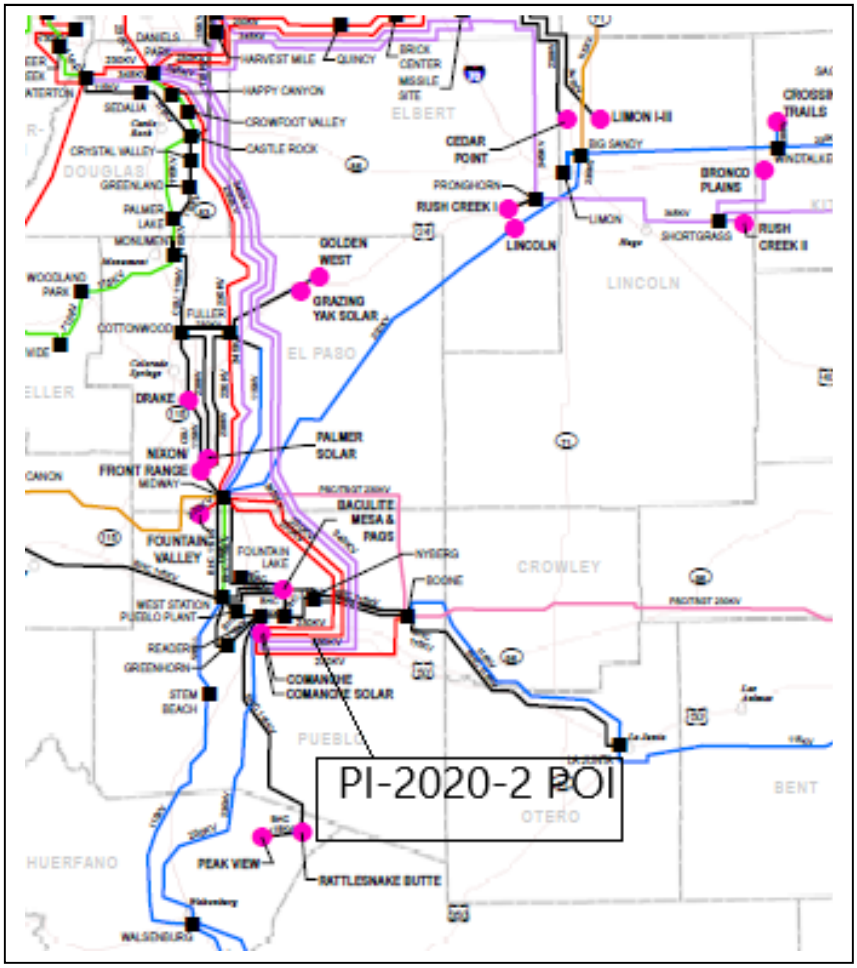
The 230kV tap position on the Comanche – MidwayPS 230kV line will require building a new switching station referred to as "Mirasol 230kV Substation". A Certificate of Public Need and Benefit (CPCN) is required to build the Mirasol 230kV Substation.

The proposed COD of the Generating Facility is December 1, 2022. Accordingly, based on the typical construction timeframes for similar projects, the back-feed date is assumed to be June 1, 2022, approximately six (6) months before the COD.

The hybrid Generating Facility will provide primary frequency response (±5% droop, 0.0005hz) over the entire range of operation, including when the BES is charging from the PV. The Solar PV and BES Generating Facilities will operate in backfeed voltage control mode. The net output of the Solar PV and BES Generating Facilities will be limited to 250MW using a custom PLC centralized power plant controller which will also adjust voltage, vars and droop.

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

Figure 1 – Point of Interconnection of PI-2020-2



The Customer has confirmed that PI-2020-2 represents the same project as previously studied Provisional Interconnection Service requests of GI-2018-25 and GI-2019-4. The modeling data, Generating Facility configuration, POI, COD and inverter of PI-20202-2 are same as GI-2018-25 and GI-2019-4. The Customer has committed to enter the PSCo LGIP in the next available Definitive Interconnection Study Process as an ERIS request.

As stated in the study agreement, this report for PI-2020-2 was developed using the previously completed Provisional Interconnection reports for GI-2018-25 and GI-2019-4.

3.0 Study Scope

The main purpose of this study is to determine the system impact of interconnecting a new 250MW hybrid Generating Facility for Provisional Interconnect at the Mirasol 230kV Switching Station.

The scope of this report includes steady state (thermal and voltage) analysis, transient stability analysis, short circuit analysis, and Appropriation Level cost estimates (+/-20% accuracy) for Interconnection Facilities and Station Network Upgrades. The study also identifies the estimated Security[3] and Contingent Facilities associated with the Provisional Service.

This report is based on completed Provisional Interconnection Service study reports of GI-2018-25 and GI-2019-4, refer to the available reports for study scope, analysis criteria and powerflow modeling assumptions. The PI-2020-2 studies modeled Comanche #1 online.

https://www.rmao.com/public/wtpp/Final_Studies/Provisional%20Study%20report%20for%20GI-2018-25.pdf

https://www.rmao.com/public/wtpp/Final_Studies/Provisional%20Study%20report%20for%20GI-2018-25.pdf

4.0 Provisional Interconnection Service Analysis

4.1 Voltage and Reactive Power Capability Evaluation

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

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

According to the modeling data provided by the Customer, PI-2020-2 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

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

The analysis indicates that the Generating Facility is capable of maintaining +/-0.95 pf at the generator terminal and high side of the main step-up transformer, while staying within 0.95-1.05 pu voltage at the POI. According to the Interconnection Customer, PI-2020-2 hybrid generating facility will operate in back-feed voltage control mode, so PV and BES facility capabilities are not evaluated individually.

Table 1 – Reactive capability evaluation of PI-2020-2

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
250MW/ -145.6Mvar	0.903/0.900	1.003	245.3	-207.2	0.764	lead	1.003	245.3	-207.2	0.764
250MW/ 145.7Mvar	1.138/1.140	1.058	247	107.9	0.916	lag	1.058	247	107.9	0.916
25MW / -9.6Mvar	1.033/1.032	1.037	25	-8.2	0.950	lead	1.037	25	-8.2	0.950
25MW / 6.8Mvar	1.045/1.046	1.039	25	8.2	0.950	lag	1.039	25	8.3	0.949

4.2 Steady State Analysis

The results of the single contingency analysis (P1 and P2-1) are given in Table 2.

Table 2 Power Flow Analysis Results of PI-2020-2 – 250MW Generating Facility at Mirasol 230kV Switching Station

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

Overloaded Facility	Type	Owner	Facility Normal Rating (MVA)	Facility Loading in Benchmark Case		Facility Loading in Study Case		% Change due to Study Pocket GIRs	Single Contingency Definition
				MVA Flow	% Line Loading	MVA Flow	% Line Loading		
Briargate S – Cottonwood S 115kV	Line	CSU	150.0	147.9	98.6%	153.2	102.1%	3.5%	Cottonwood – Kettle Creek 115kV line

The addition of PI-2020-2 increased the loading on the Briargate – Cottonwood 115kV line from 98.6% to 102.1%. However, for less stressed dispatch conditions when the generation at Comanche Substation is lower, the maximum output of 250MW may be possible without overloads, depending on the available firm and non-firm capacity of the transmission system

The Customer is required to design and build the Generating Facility to mitigate for any potential inverter interactions with the neighboring inverter based Generating Facility(ies) and/or the inverters of the hybrid Generating Facility.

4.3 Transient Stability Results

The following results were obtained for the disturbances analysed:

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

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

Table 3 – Transient Stability Analysis Results

Stability Scenarios						
#	Fault Location	Fault Type	Facility Tripped	Clearing Time (cycles)	Post-Fault Voltage Recovery	Angular Stability
1	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& and Comanche – Tundra 345 KV Switching Station	4.0	Maximum transient voltage dips within criteria	Stable with positive damping

4.4 Short Circuit and Breaker Duty Analysis Results

The calculated short circuit levels and Thevenin system equivalent impedances at the Mirasol 230kV Switching Station are shown in Table 4.

Table 4 – Short Circuit Parameters at the Mirasol 230kV Switching Station POI

	Before PI-2020-2 Interconnection	After PI-2020-2 Interconnection

Three Phase Current	11,821A	12,053A
Single Line to Ground Current	9,275A	10,760A
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	8.967+j15.892 ohms

5.0 Cost Estimates

The total cost of the required Upgrades for PI-2020-2 to interconnect for Provisional Service at the new Mirasol 230kV Switching Station tapping the Comanche – Midway 230kV line is **$23.607 Million.**

The cost of Transmission Provider's Interconnection Facilities is $1.262 Million

The cost of Station Network Upgrades is $22.345 Million

The list of improvements required to accommodate the Provisional Interconnection of the new 250MW hybrid Generating Facility at the Mirasol 230kV Switching Station tapping the Comanche – Midway 230kV line are given in Tables 4a and 4b.

Table 4a – PI-2020-2 Transmission Provider's Interconnection Facilities

Element	Description	Cost Est. (Millions)
PSCo's Mirasol 230kV Switching Station	Interconnect Customer to tap at the Mirasol 230kV 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. • Associated line tap into substation	$1.242
	Siting and Land Rights support for siting studies, land and ROW acquisition and construction	$0.020
	Total Cost Estimate for Transmission Providers Interconnection Facilities	**$1.262**

Time Frame	**Site, design, procure and construct**	**36 Months**

Table 4b – PI-2020-2 Station Network Upgrades

Element	Description	Cost Est. (Millions)
PSCo's Mirasol 230kV 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 • Eight 230kV 2000A disconnect switches (assume all switch stands will be installed) • Six 230kV CCVTs • Two SSVTs • Six 230kV Surge Arresters • Eight Deadends / 2 DE Girder • One Electrical Equipment Enclosure • Station controls and wiring • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures	$18.020
PSCo's Mirasol 230kV Switching Station	Install required communications in the EEE at the new switching station	$0.482
PSCo's Comanche 230kV Bus	Update line relaying on line to Mirasol, two CCVTs, three arresters	$0.506
PSCo's Midway 230kV Bus	Update line relaying on line to Mirasol, two CCVTs, three arresters	$0.470
PSCo's Mirasol 230kV Switching Station	Terminate the tranmission line into the new Mirasol switching station	$2.847
	Siting and Land Rights support for substation construction	$0.020
	Total Cost Estimate for Network Upgrades for Interconnection	**$22.345**
Time Frame	**Site, design, procure and construct**	**36 Months**

Upgrades identified in Tables 4a and 4b are illustrated in Figure 2 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.

The PSCo Engineering has developed Appropriation Level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades required for the interconnection of the Provisional Interconnection. The cost estimates are in 2020 dollars with escalation and contingencies applied. Allowances for Funds Used During Construction (AFUDC) is not included. These estimated costs include all applicable labor and overheads associated with the siting, engineering, design, and construction of these new PSCo facilities. This estimate does not include the cost for any Customer owned equipment and associated design and engineering.

- 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 Mirasol 230kV Switching Station.
- The Customer will be required to design, procure, install, own, operate and maintain a Load Frequency/Automated Generation Control (LF/AGC) RTU at their Customer Substation. PSCo / Xcel will need indications, readings and data from the LFAGC RTU.

A Certificate of Public Convenience & Necessity (CPCN) is needed for the construction of the PI-2020-2 230kV Switching Station. The estimated time frame for regulatory activities (CPCN) and to site, design, procure and construct the interconnection facilities is approximately 36 months after authorization to proceed has been obtained. Any delays in obtaining the CPCN may delay the COD of PI-2020-2.

6.0 Summary of Provisional Interconnection Service Analysis

The total estimated cost of the PSCo transmission system improvements required for PI-2020-2 to qualify for Provisional Interconnection Service is: $23.607 Million.

The Provisional Interconnection Service allotted to the Generating Facility is 250MW

The Provisional Interconnection Service results above are contingent upon the transmission system improvements identified in Section 7 of this report.

The net generation output of the hybrid facility at the POI shall not exceed 250MW at any time, which will be monitored by PSCo and limited by the Plant Controller at all times.

Security: The Customer has made a commitment to enter the next available Definitive Interconnection Study process and elect Energy Resource Interconnection Service (ERIS), the security associated with the potential Upgrades that might be identified at the conclusion of the LGIP is expected to be approximately $5 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.

A Certificate of Public Convenience & Necessity (CPCN) is needed for the construction of the PI-2020-2 230kV Switching Station. The estimated time frame for regulatory activities (CPCN) and to site, design, procure and construct the interconnection facilities is approximately 36 months after authorization to proceed has been obtained. Any delays in obtaining the CPCN may delay the COD of PI-2020-2.

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

7.0 Contingent Facilities

The following is the list of the unbuilt Interconnection Facilities and Network Upgrades upon which the PI-2020-2 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-2020-2'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-2020-2 (refer to Table 4a and 4b of this report)

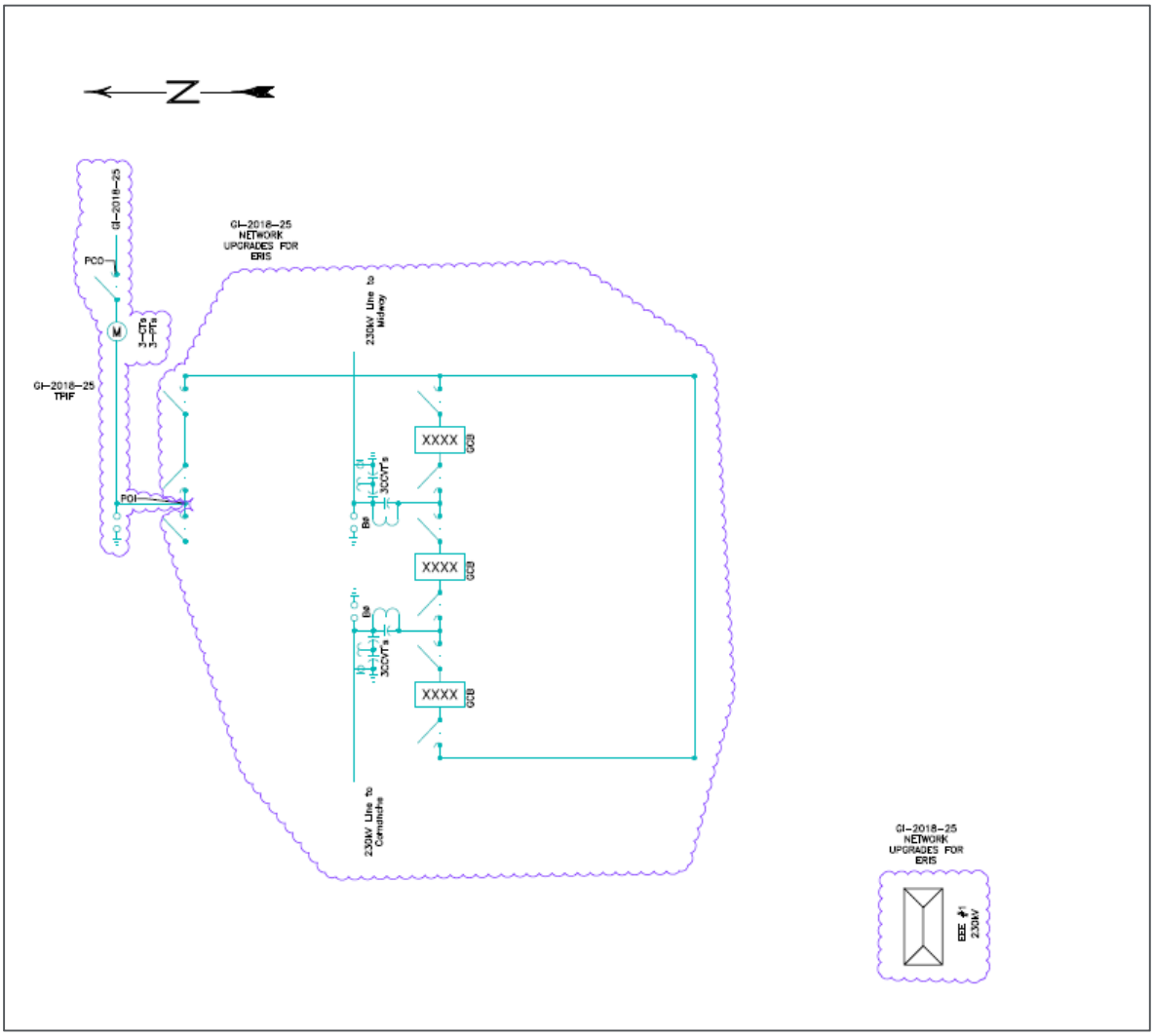
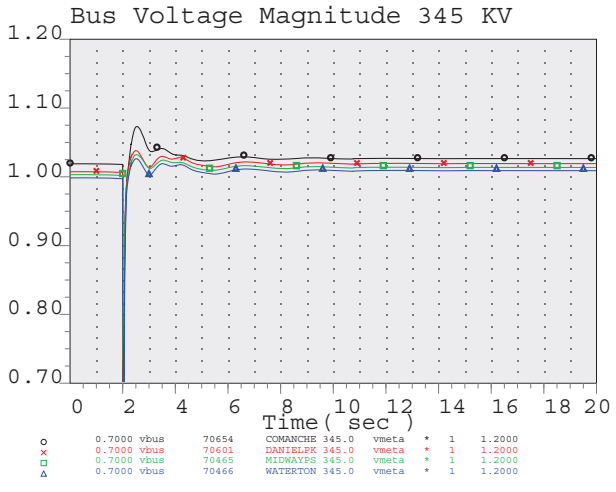
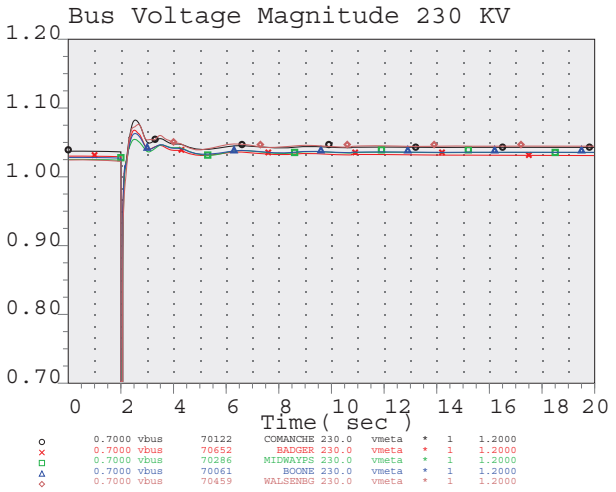
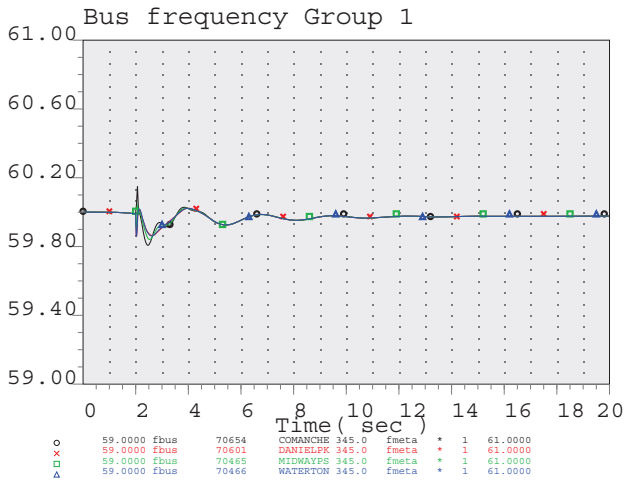


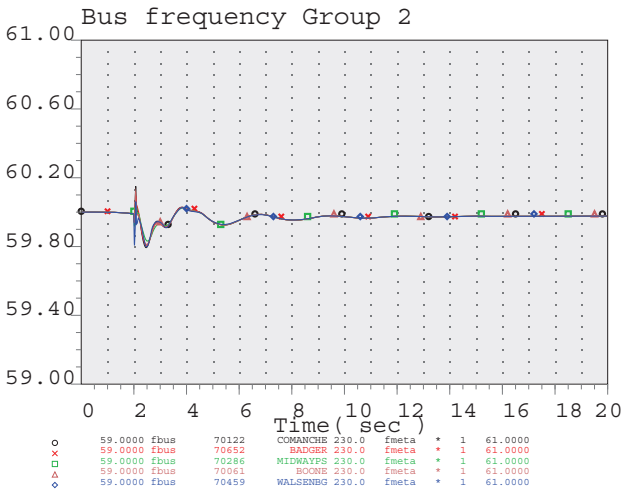
Figure 2 – Preliminary one-line of PI-2020-2 Mirasol 230kV Switching Station POI

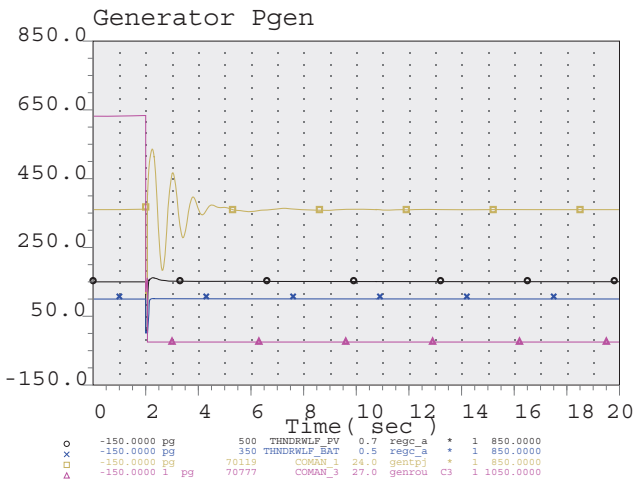
Appendix A - Transient Stability Plots

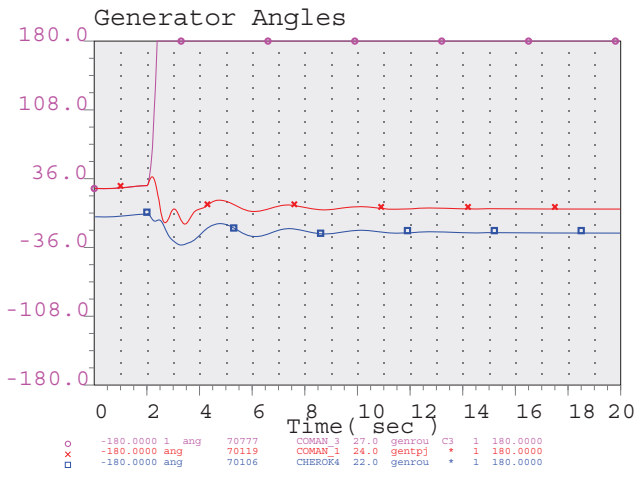






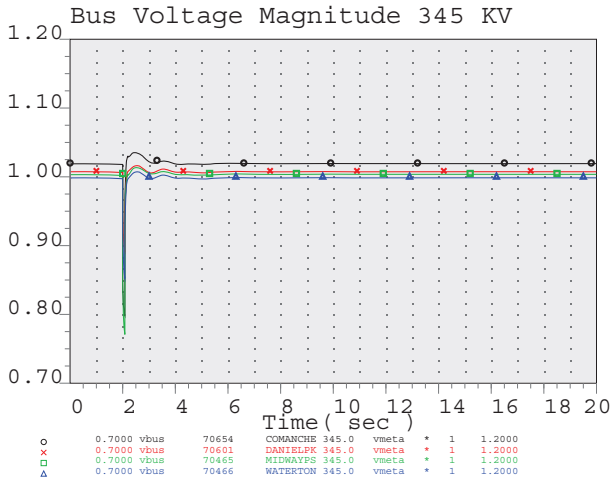


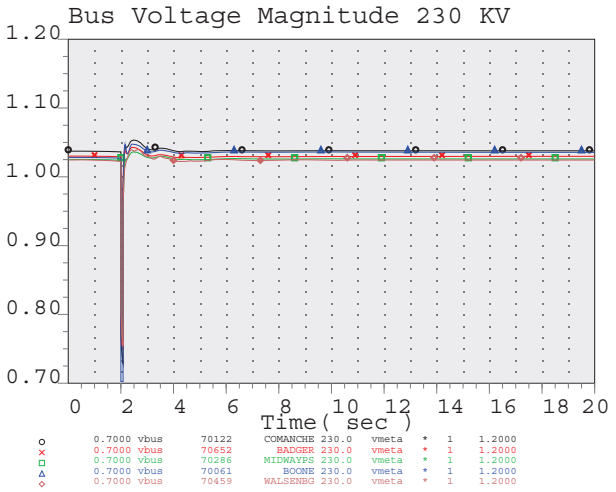


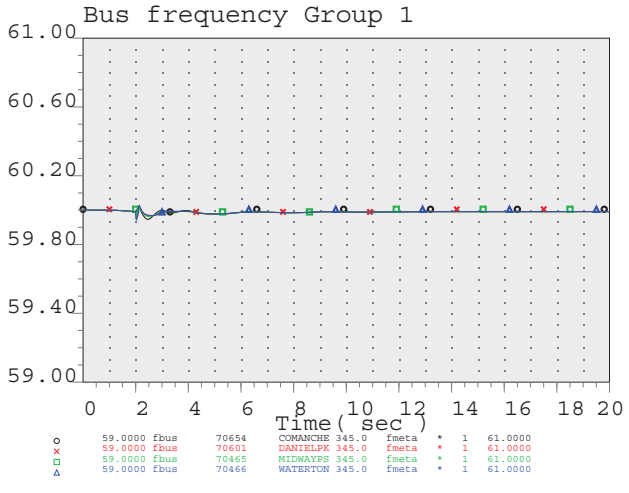


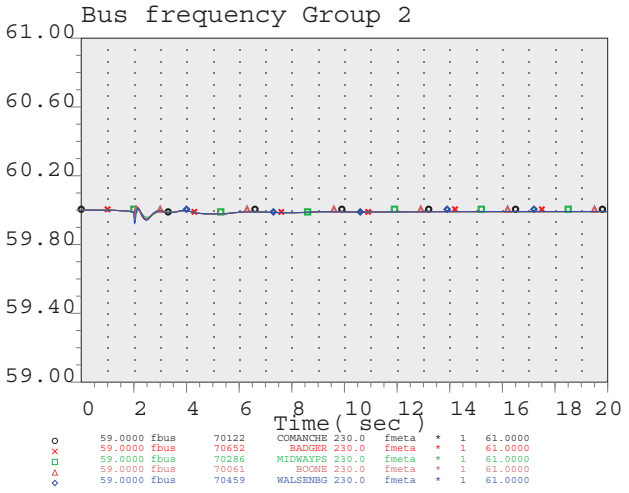
PV - 150 MW & BES - 100 MW

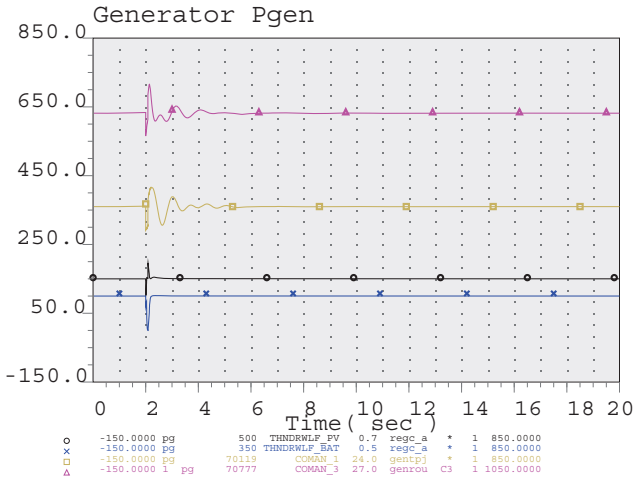
Fault: Comanche 345 KV 4 cycle 3-ph bus fault
Outage: Comanche unit 3

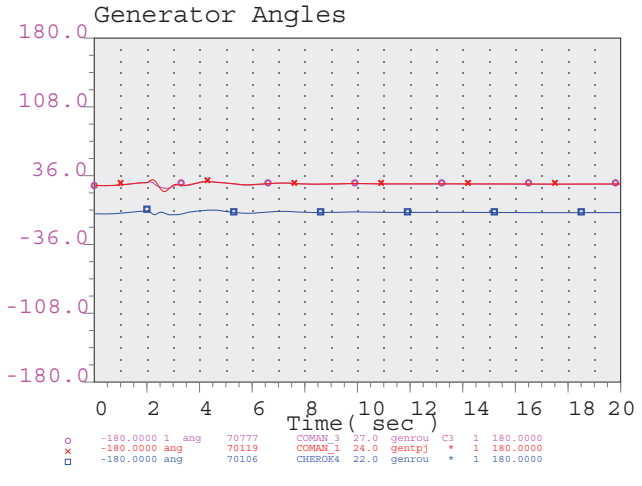






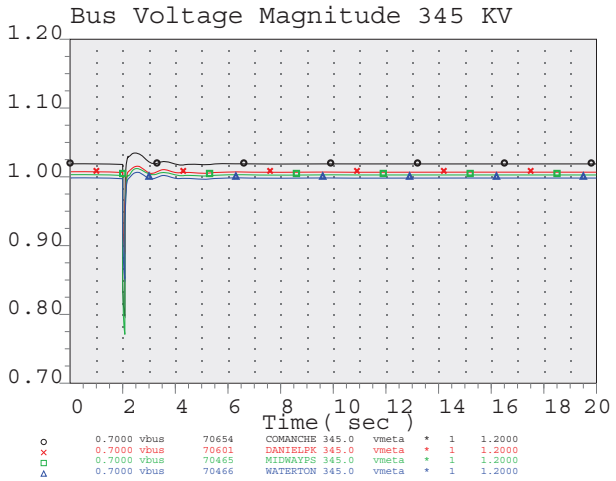


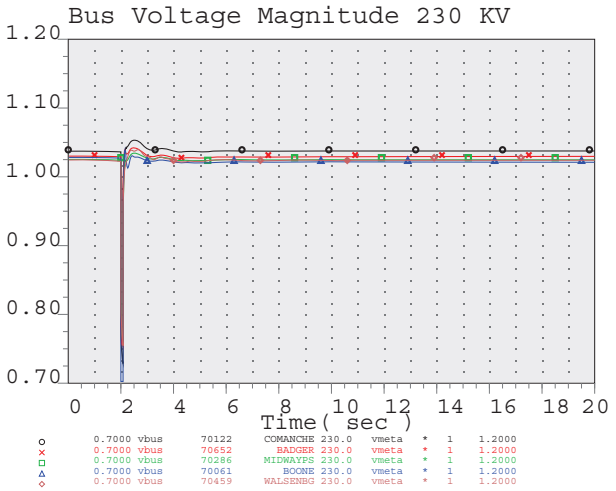


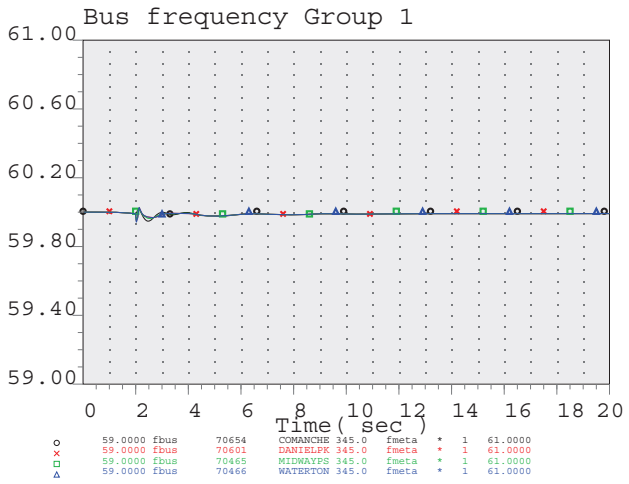


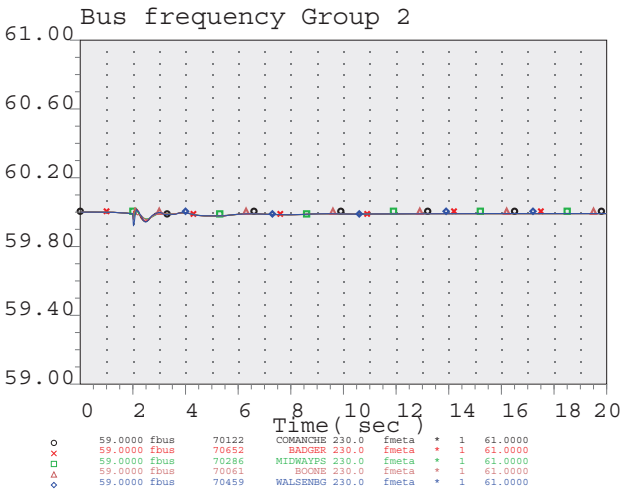
PV - 150 MW & BES - 100 MW

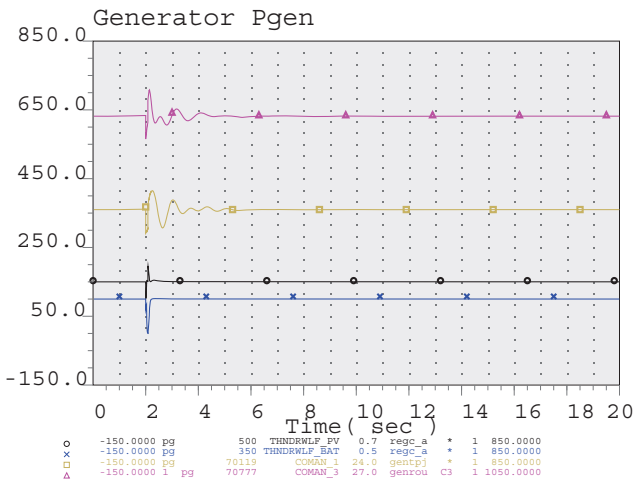
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage:lose Boone 230/115 KV bank

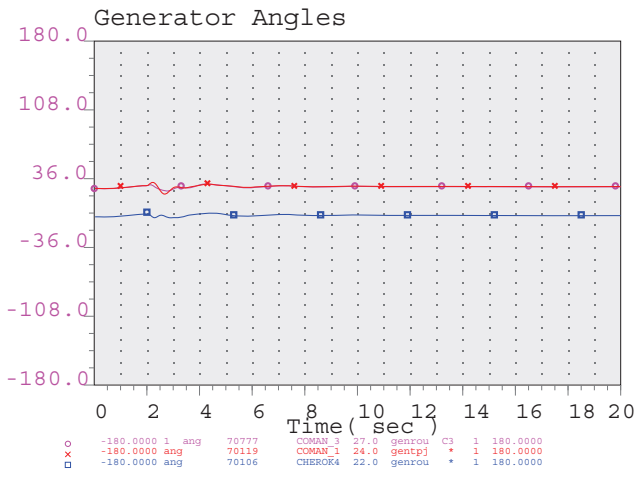






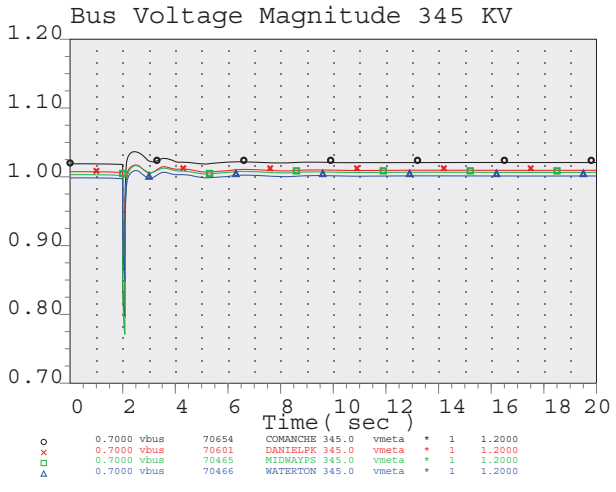


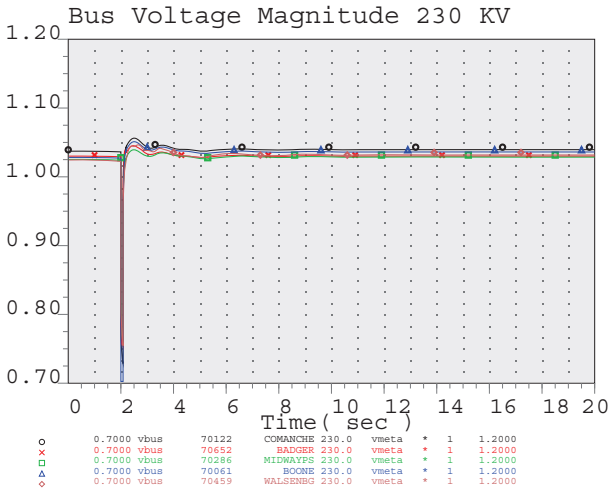


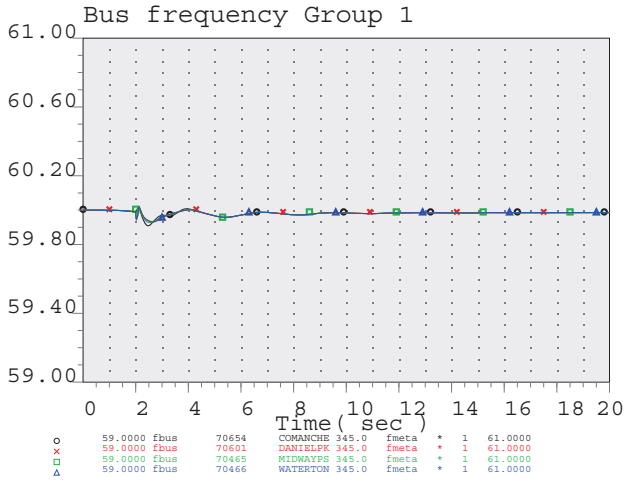


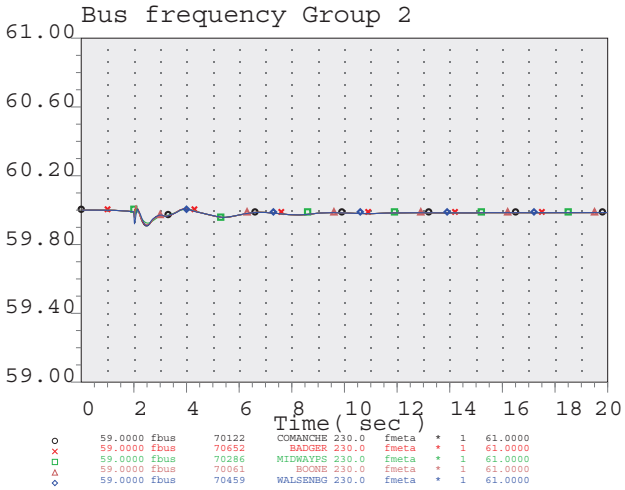
PV - 150 MW & BES - 100 MW

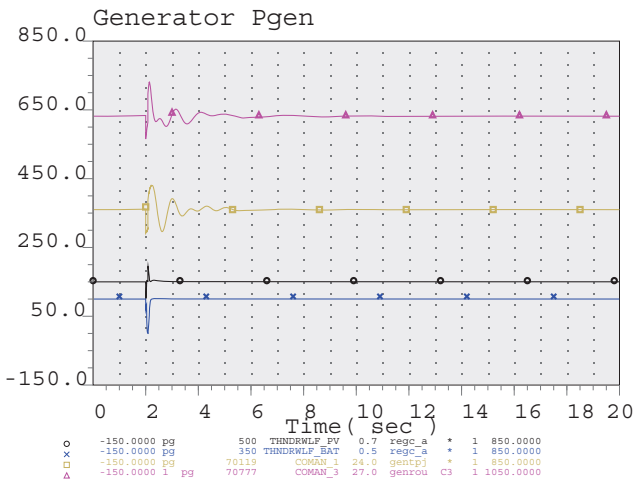
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Boone - Comanche 230 KV line

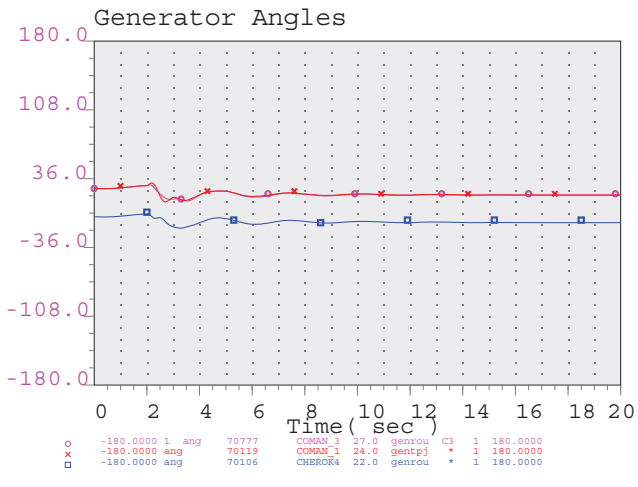






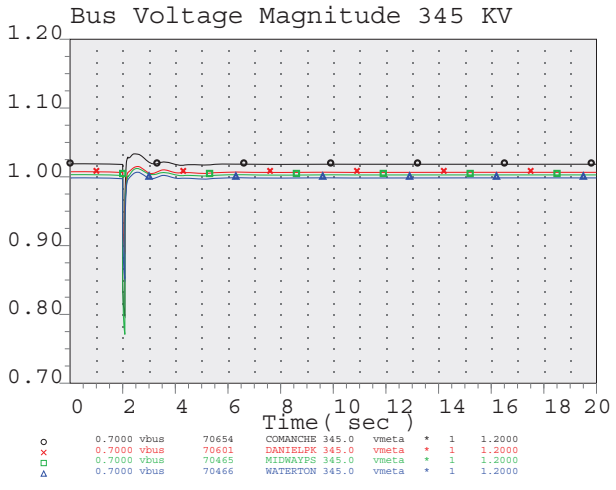


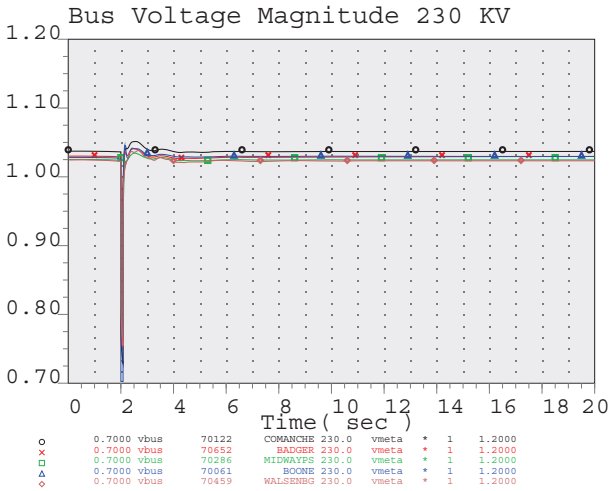


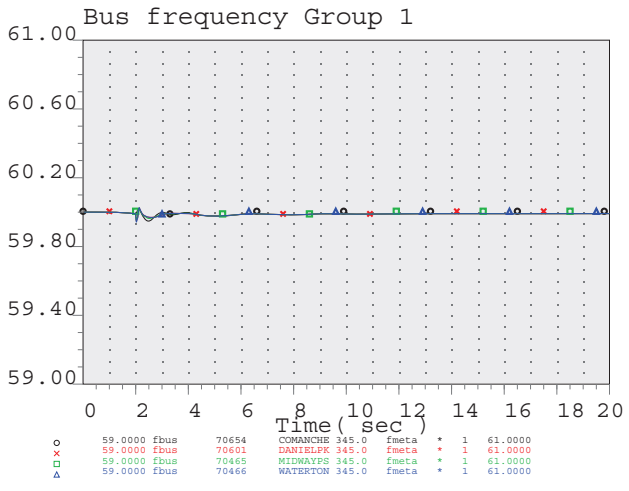


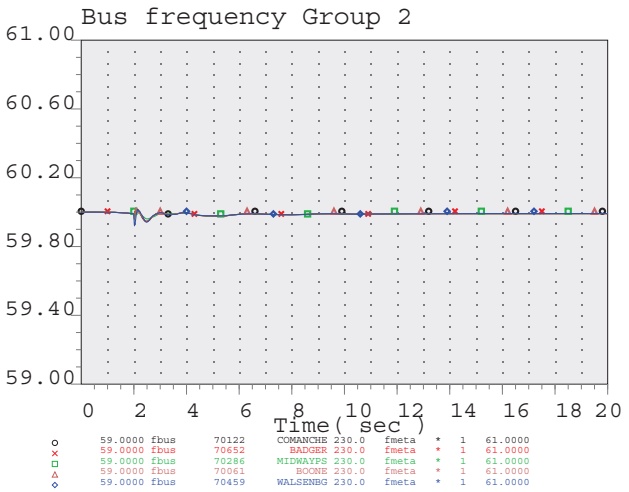
PV - 150 MW & BES - 100 MW

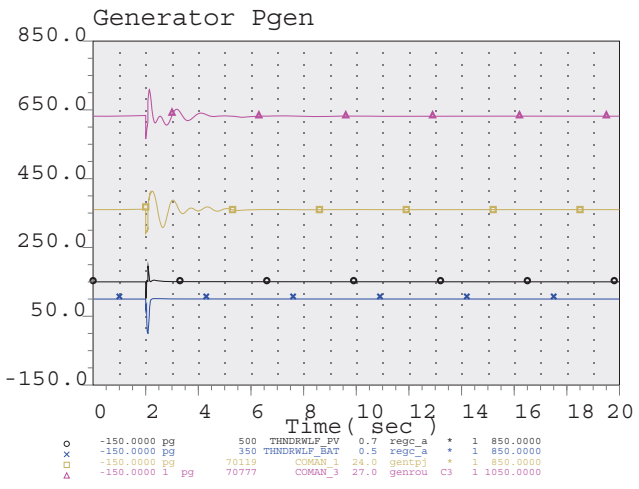
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Boone - Lamar 230 KV line and Lamar gen

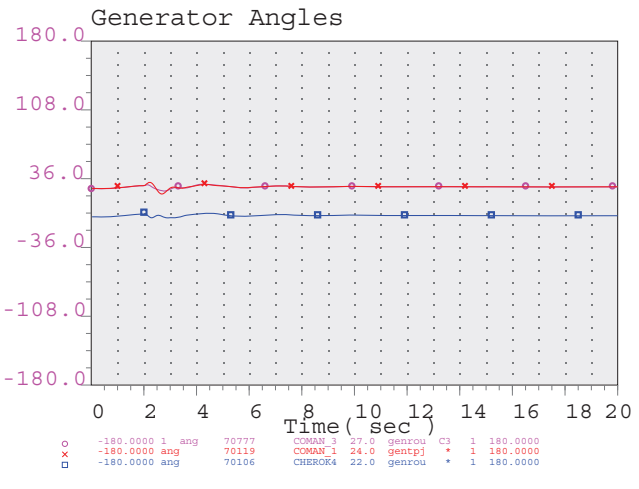






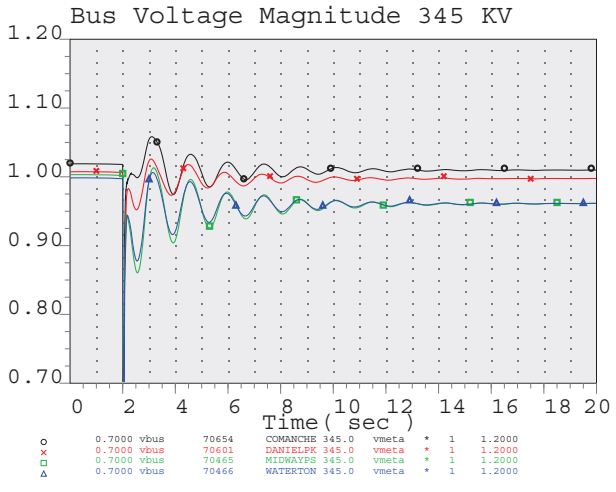


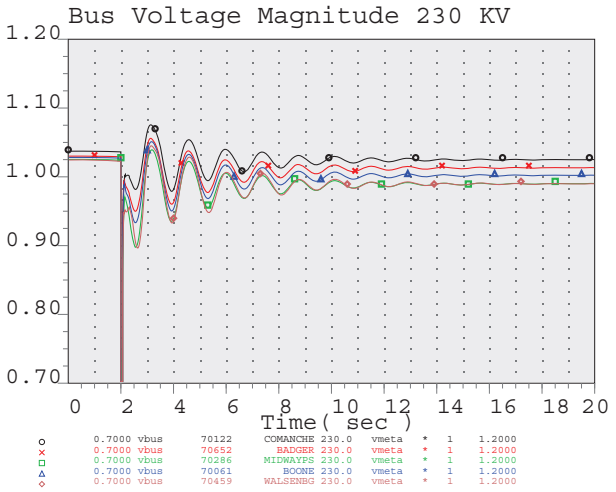


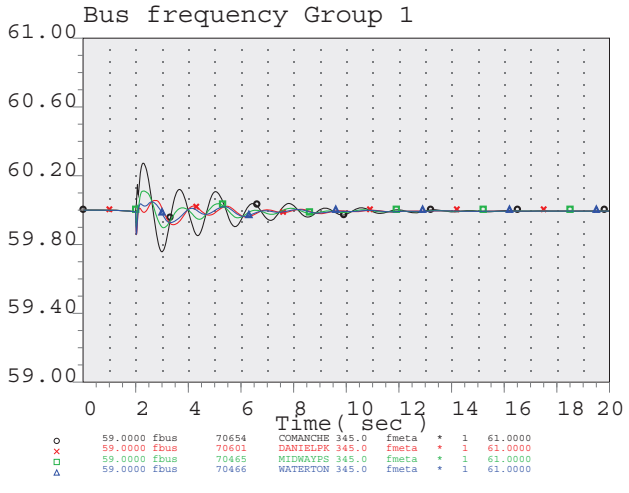


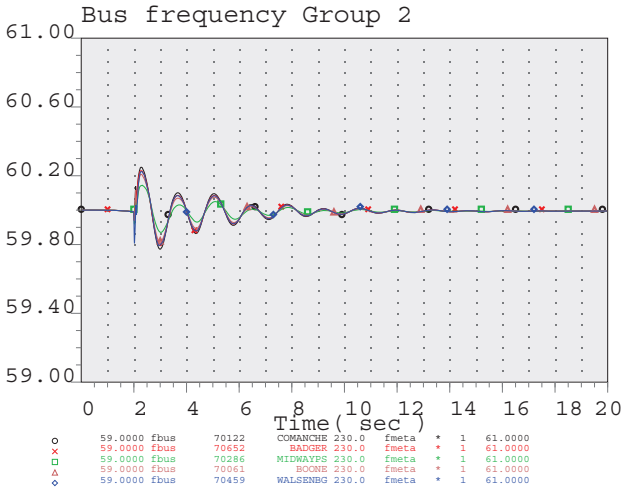
PV - 150 MW & BES - 100 MW

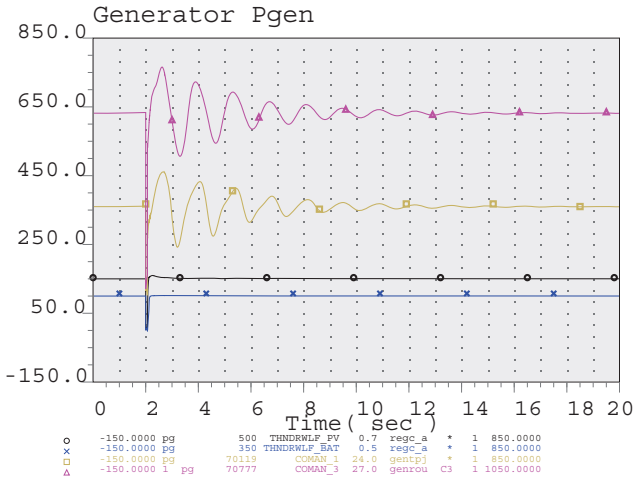
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Boone - Midway 230 KV line

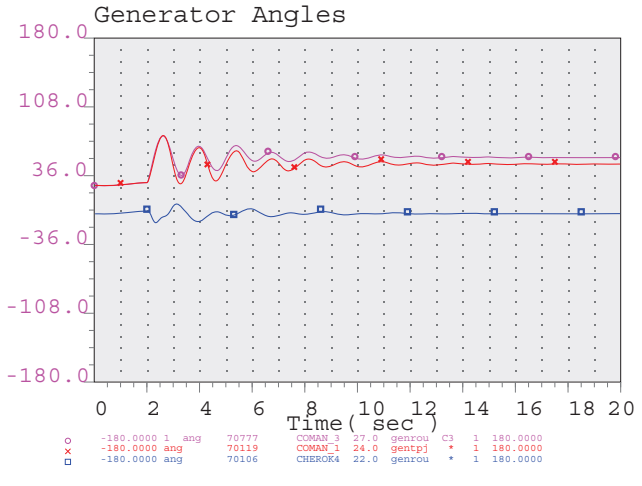






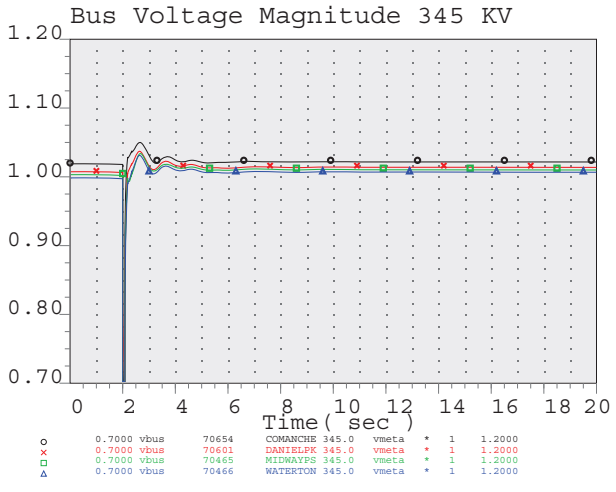


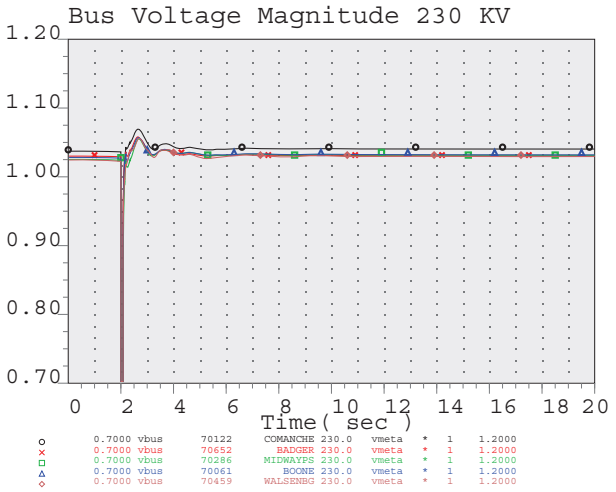


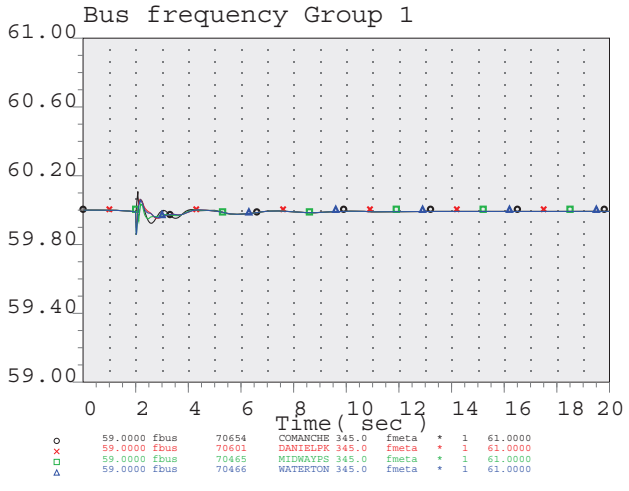


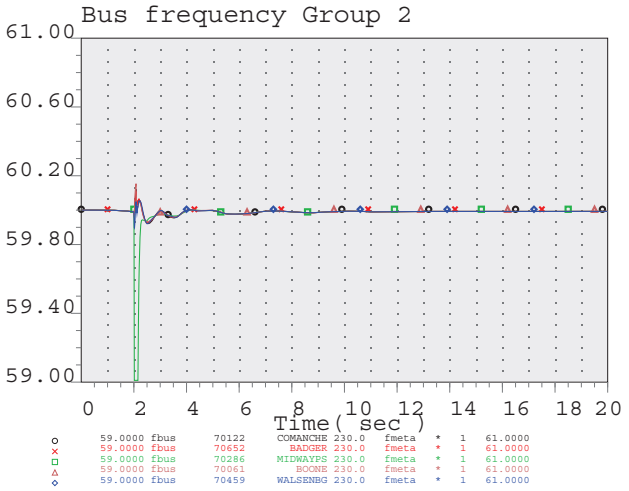
PV - 150 MW & BES - 100 MW

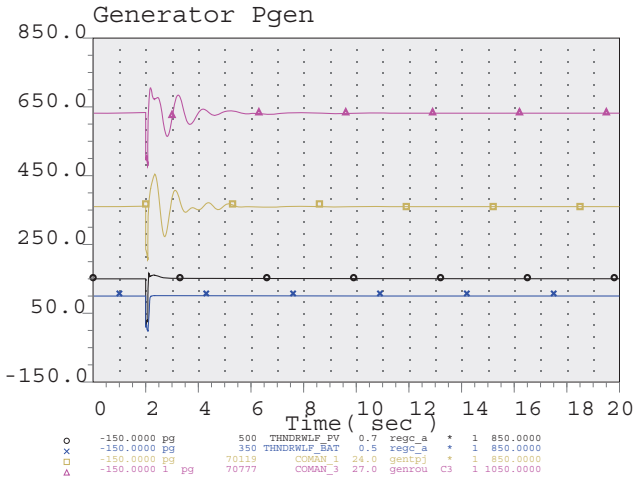
Fault: Comanche 345 KV 4 cycle 3-ph bus fault
outage: lose Comanche - Daniels Park 345 KV double circuit

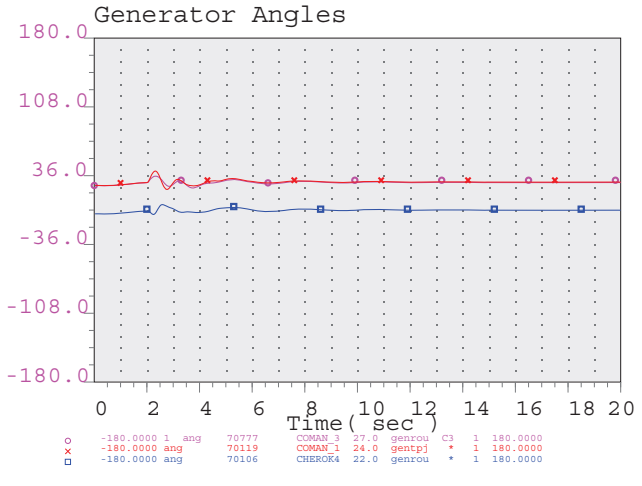






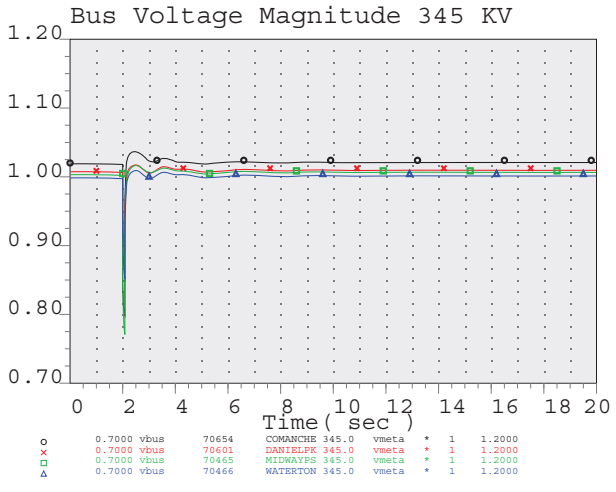


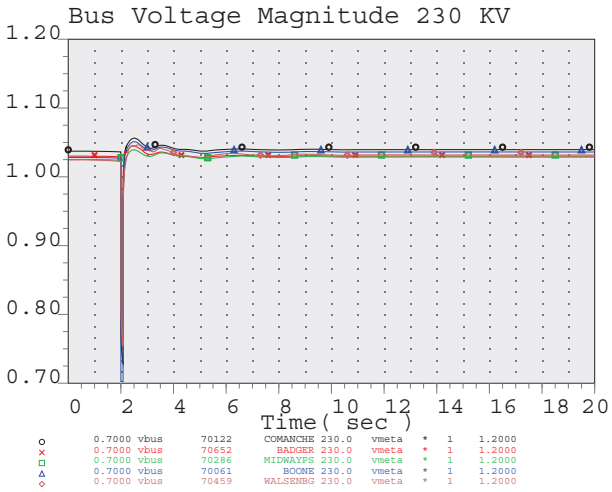


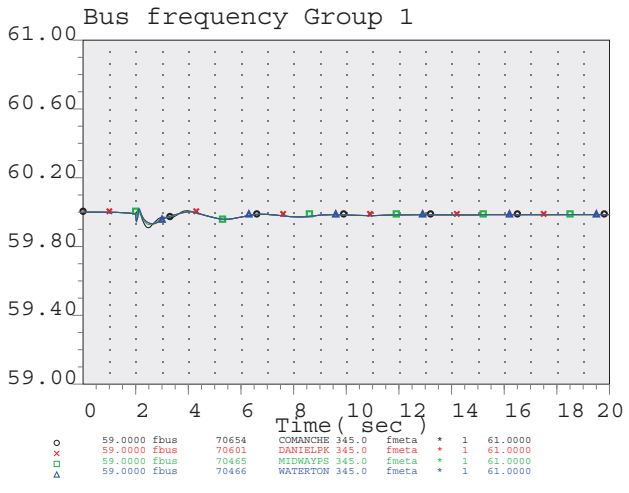


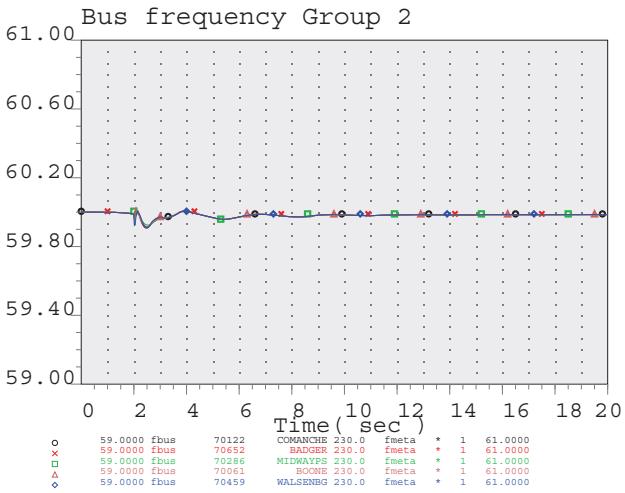
PV - 150 MW & BES - 100 MW

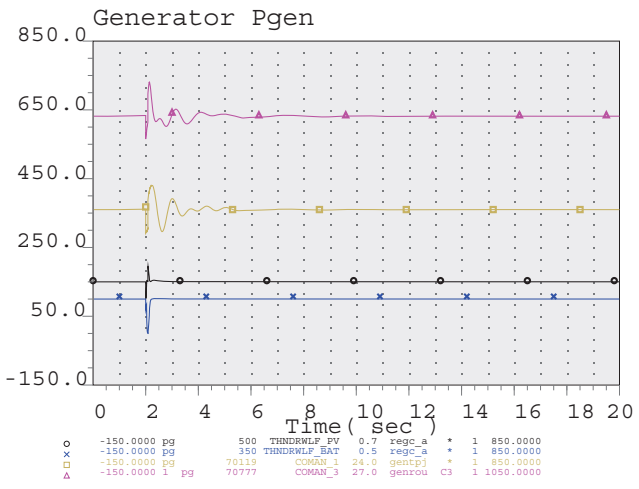
Fault: MIDWAYPS 230 KV 5 cycle 3-ph bus fault
Outage: lose Fountain Valley gen

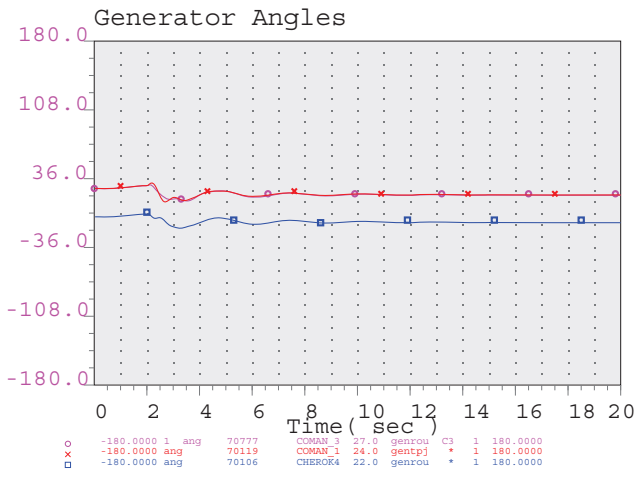






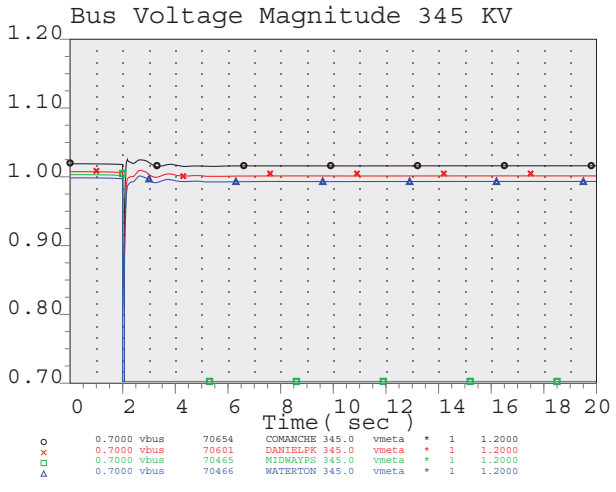


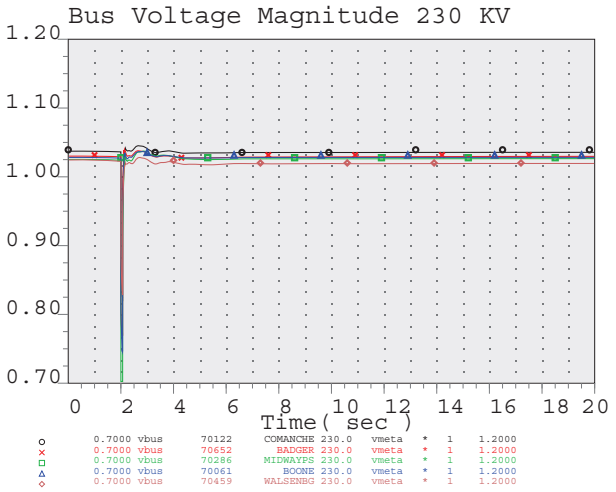


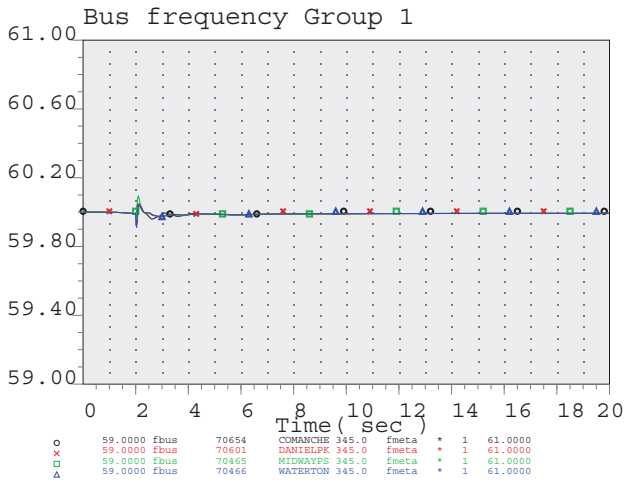


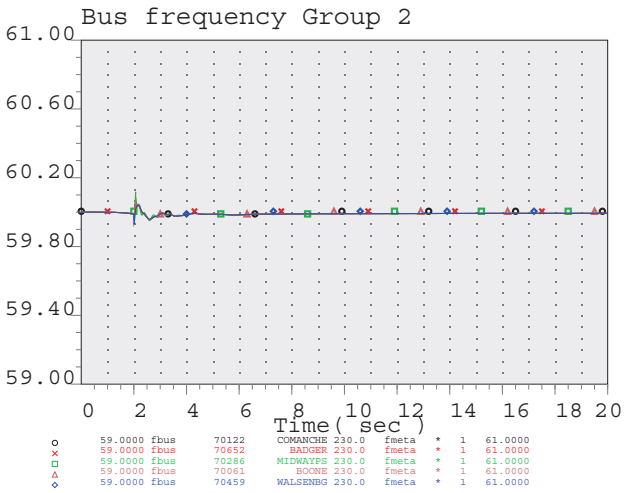
PV - 150 MW & BES - 100 MW

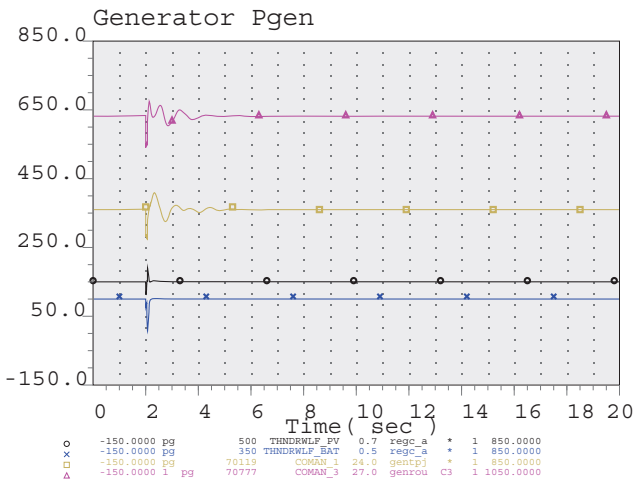
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Lamar - Boone 230 KV line and Lamar gen

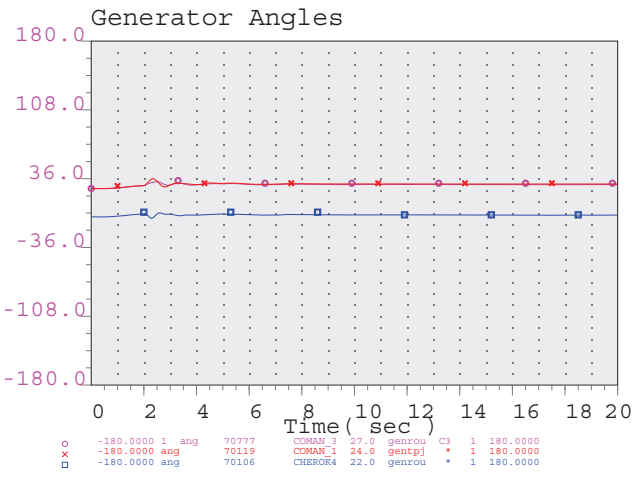






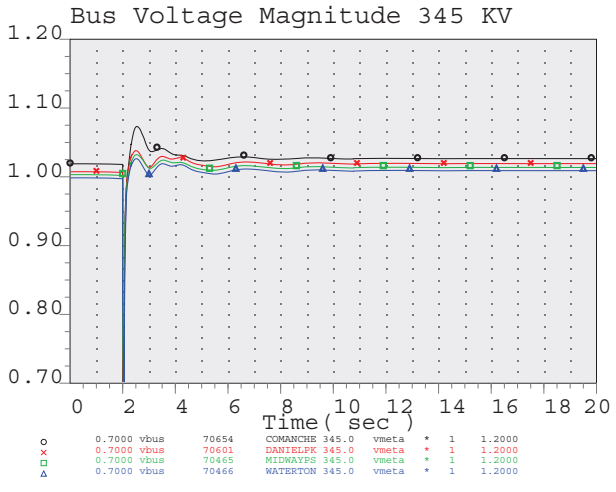


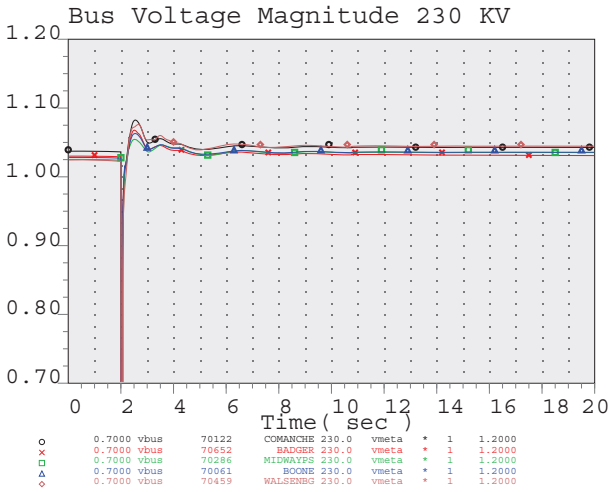


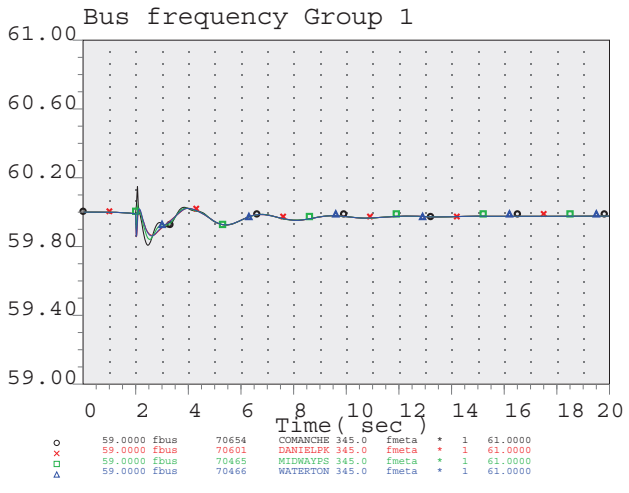


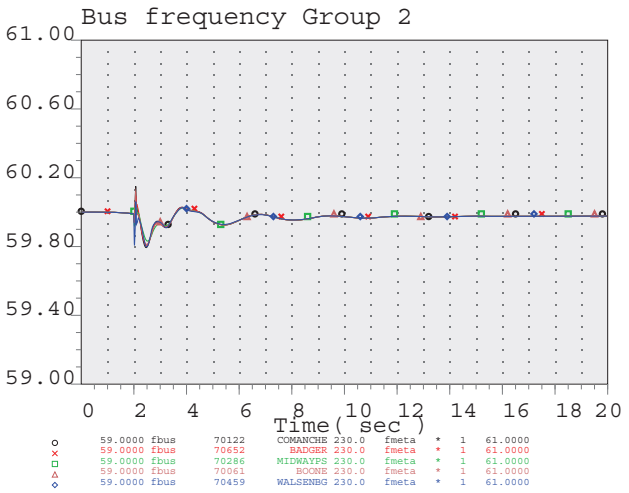
PV - 150 MW & BES - 100 MW

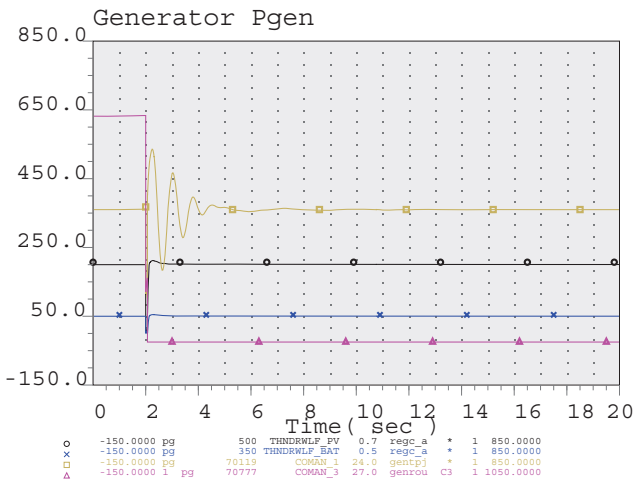
Fault: MIDWAYPS 345 KV 4 cycle 3-ph bus fault
Outage: lose MidwayPS 345/230 KV and MidwayPS - Waterton 345 KV line

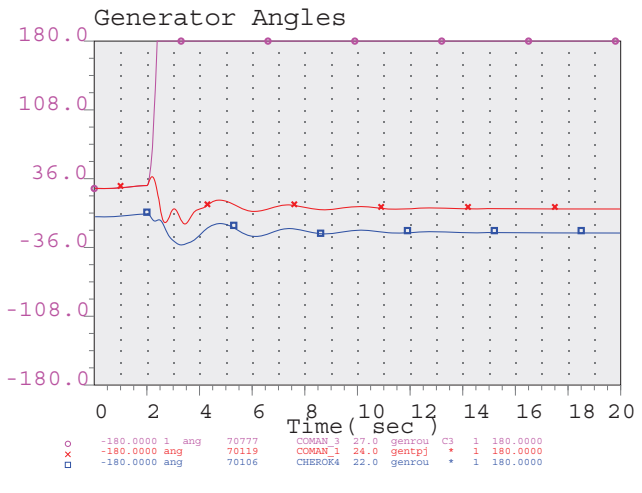






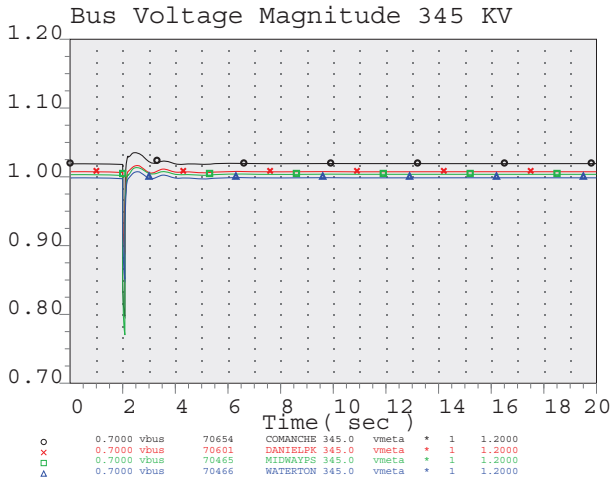


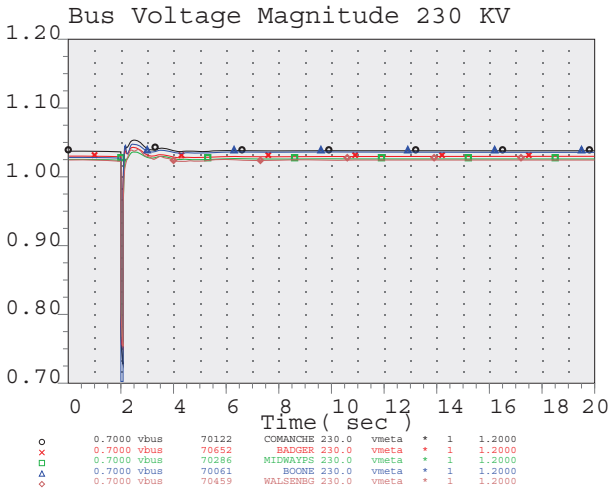


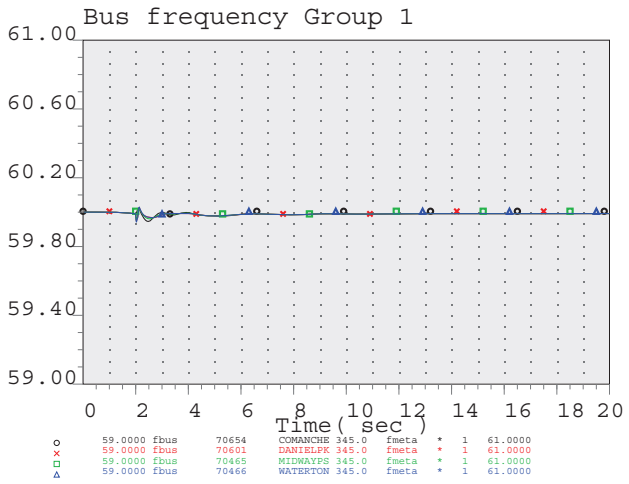


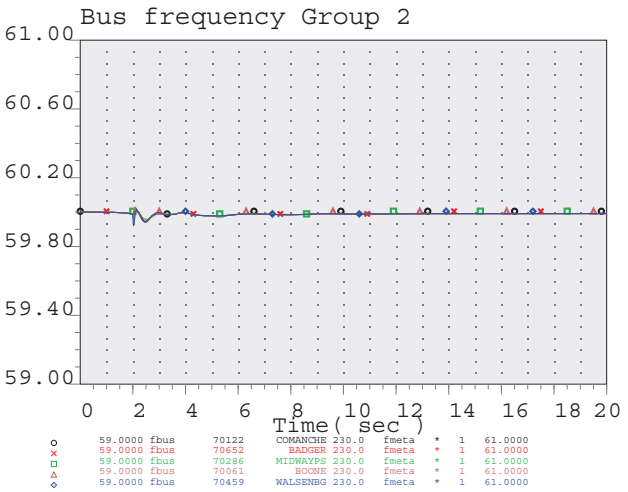
PV - 200 MW & BES - 50 MW

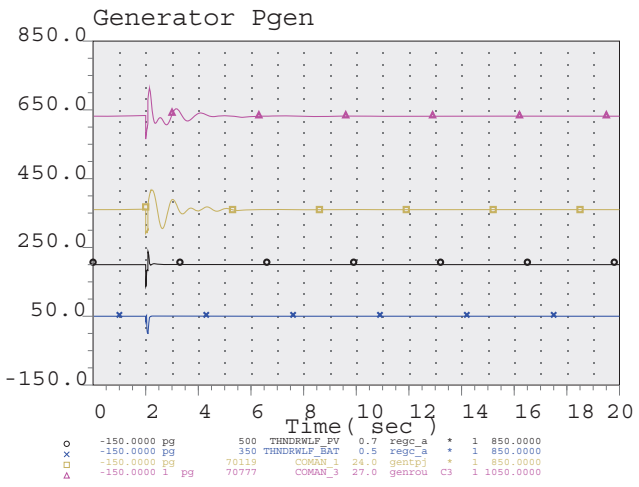
Fault: Comanche 345 KV 4 cycle 3-ph bus fault
Outage: Comanche unit 3

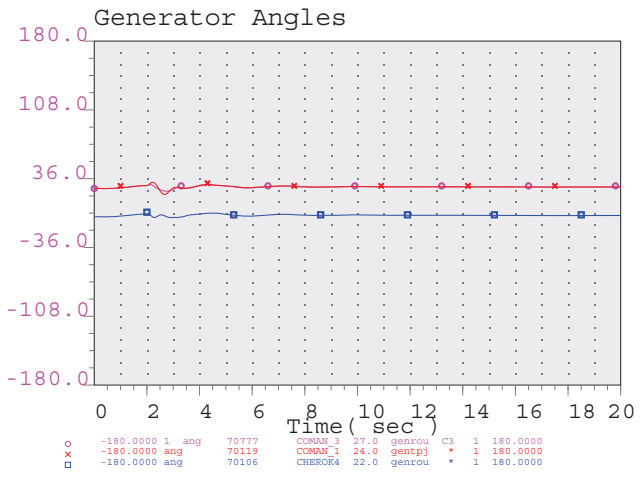






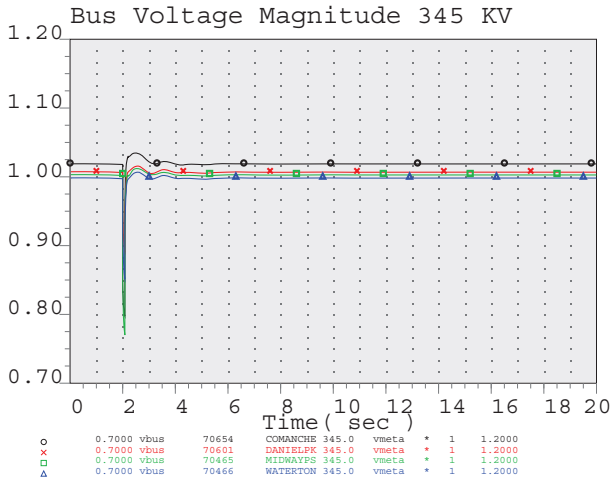


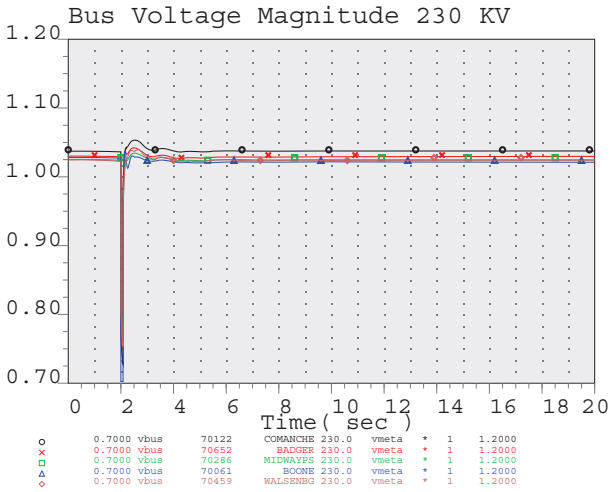


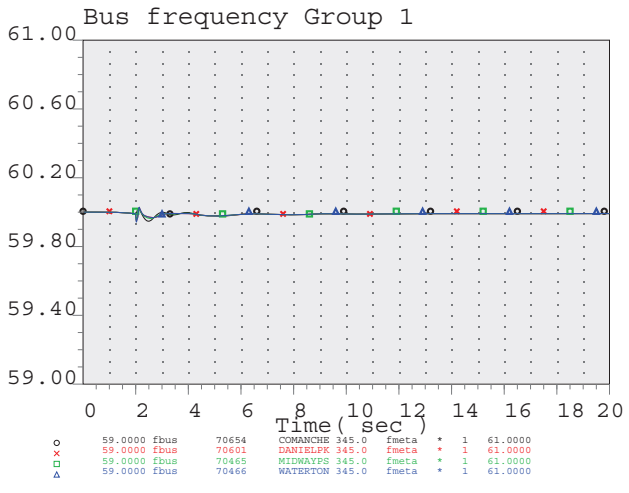


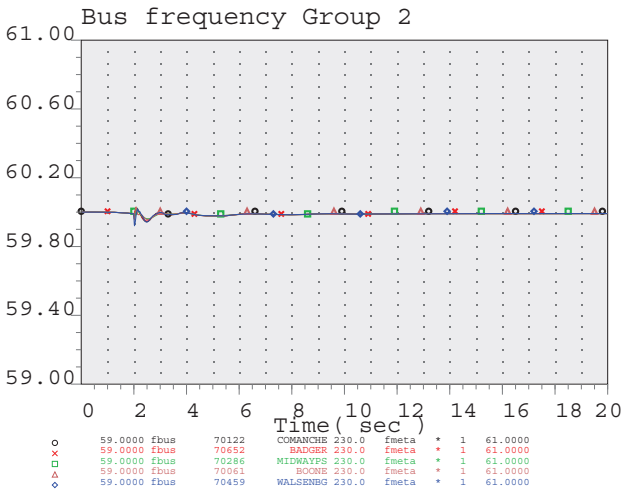
PV - 200 MW & BES - 50 MW

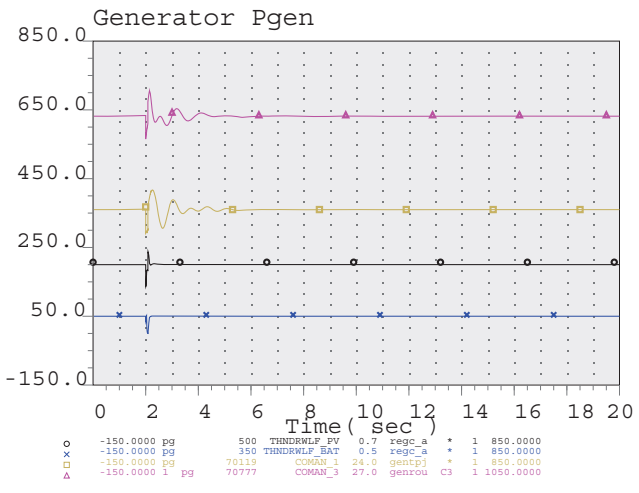
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage:lose Boone 230/115 KV bank

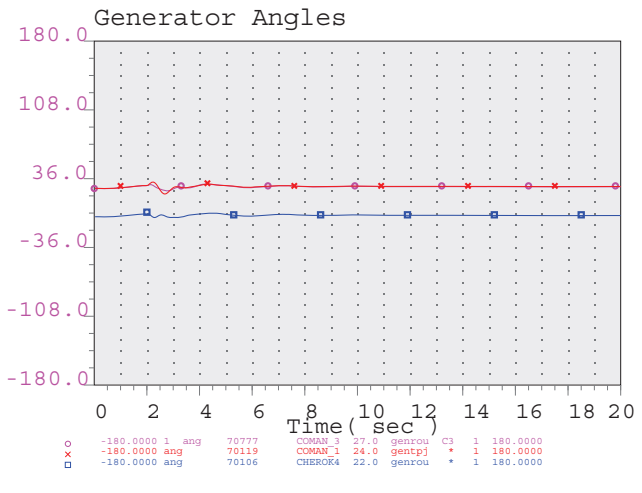






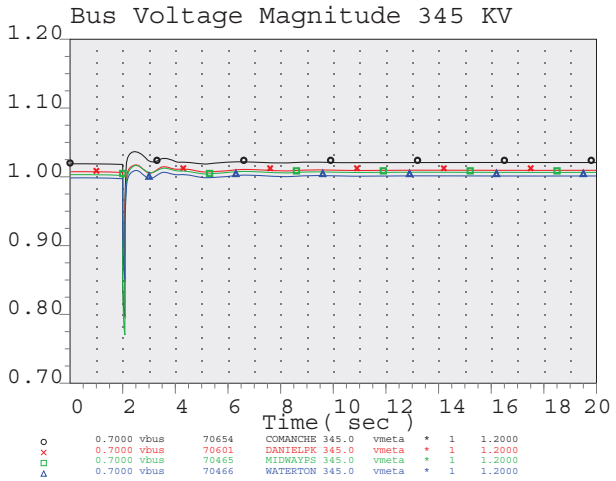


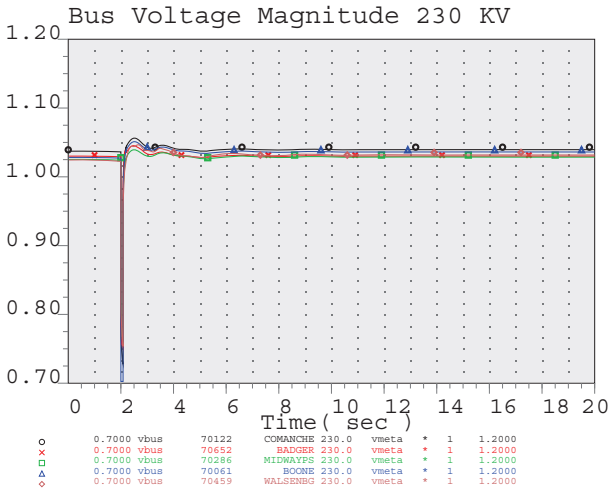


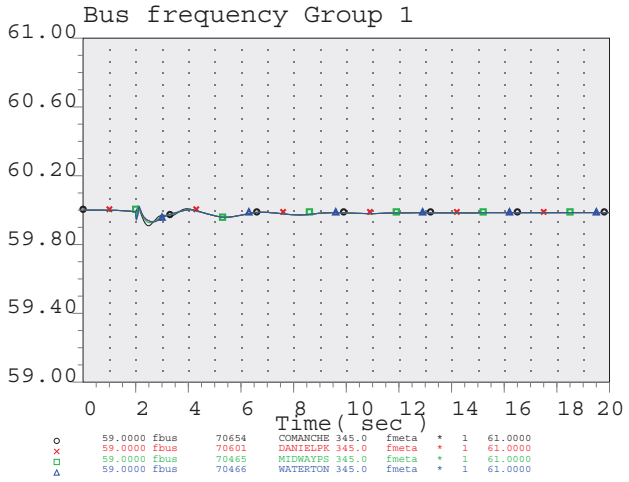


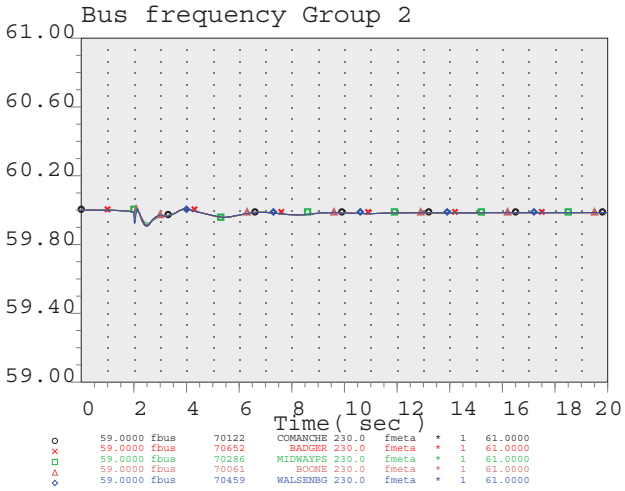
PV - 200 MW & BES - 50 MW

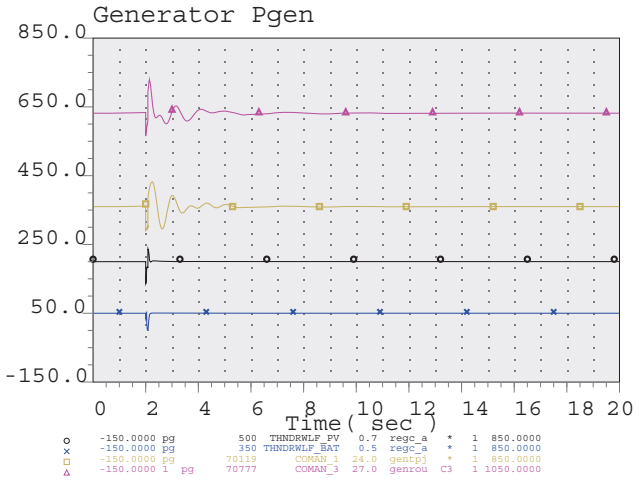
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Boone - Comanche 230 KV line

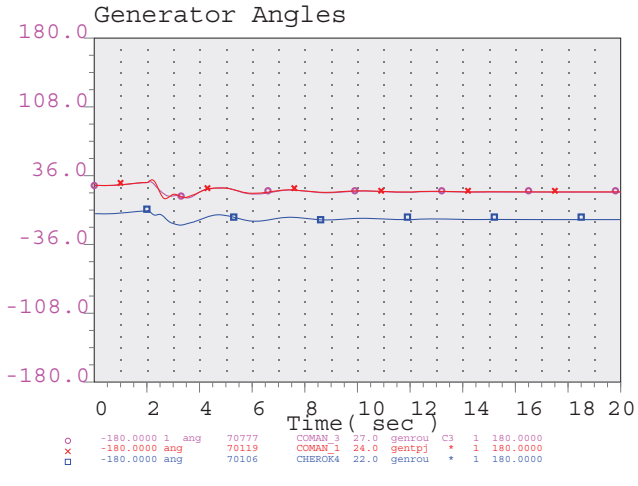






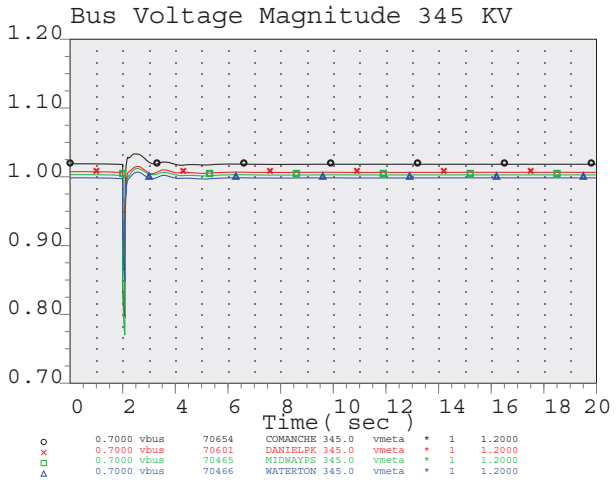


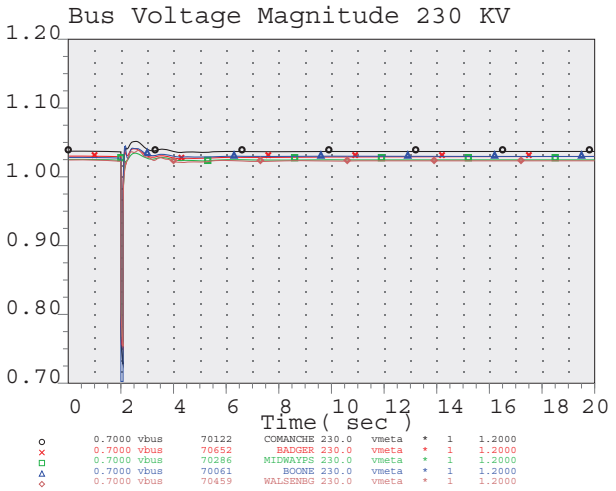


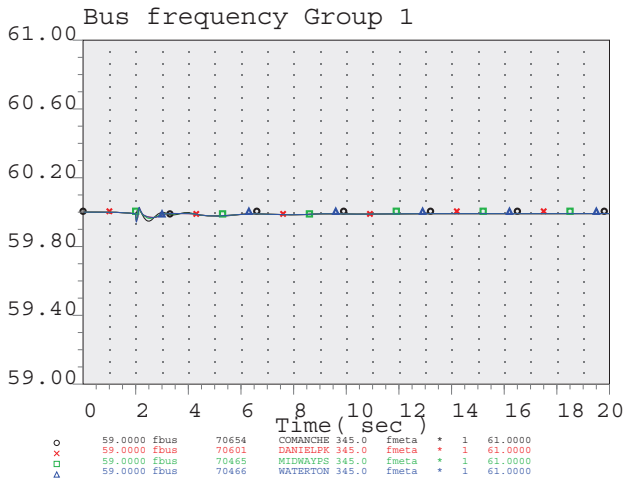


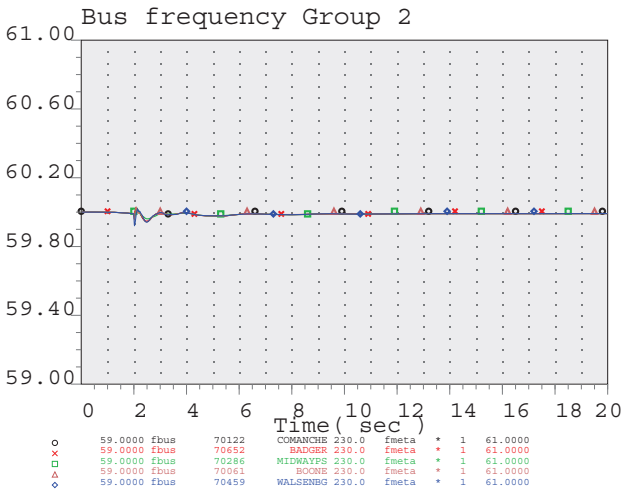
PV - 200 MW & BES - 50 MW

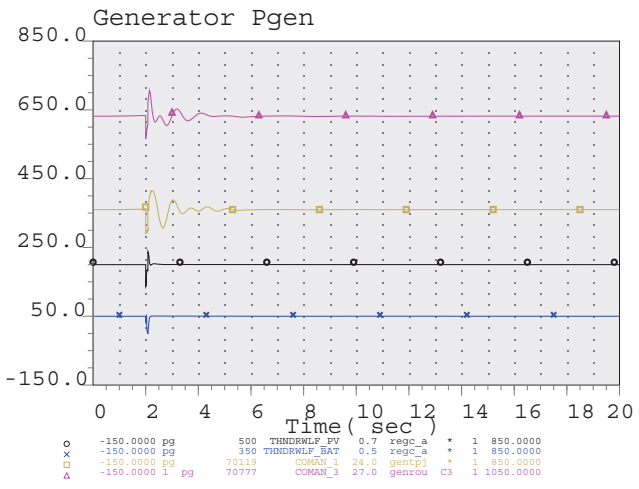
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Boone - Lamar 230 KV line and Lamar gen

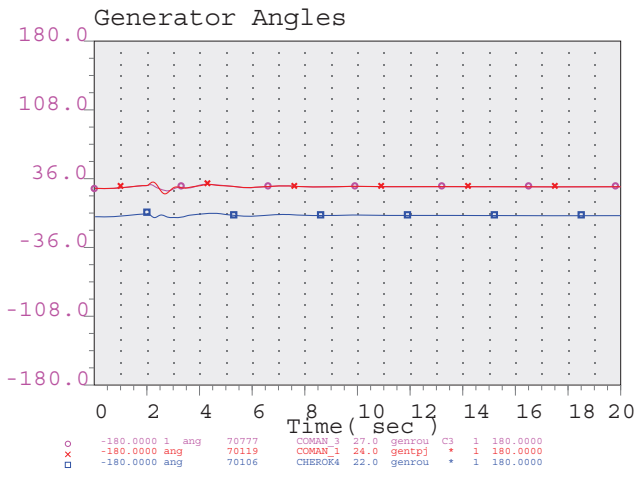






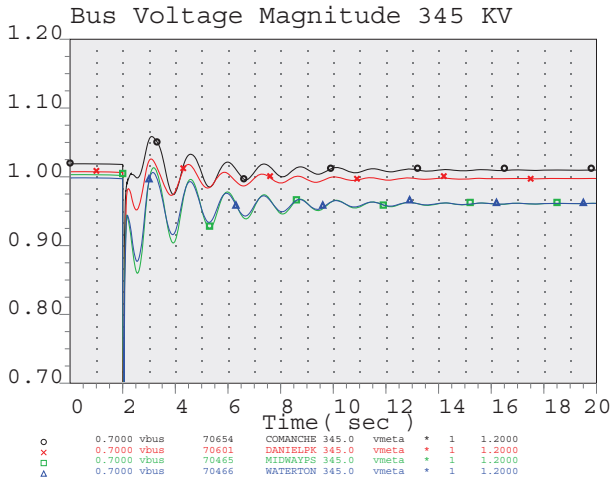


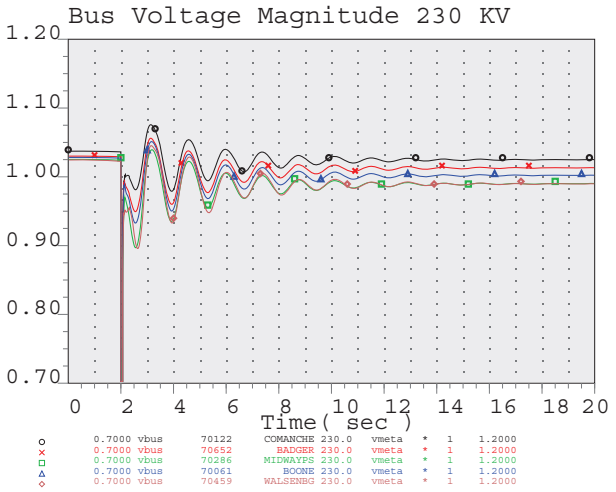


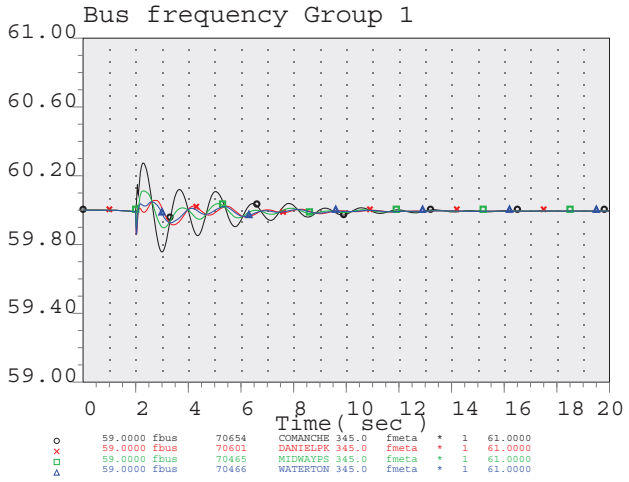


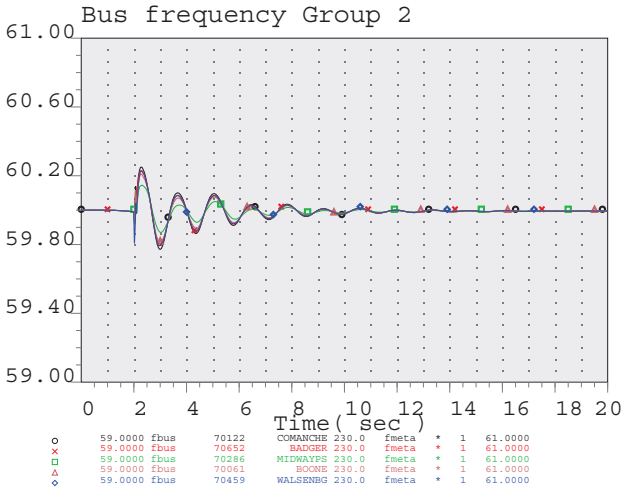
PV - 200 MW & BES - 50 MW

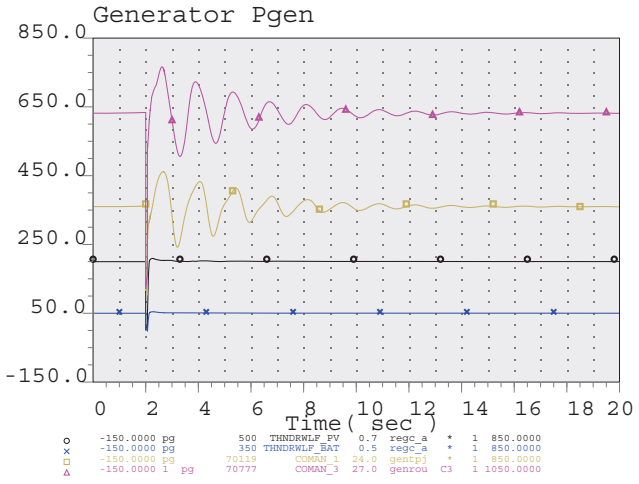
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Boone - Midway 230 KV line

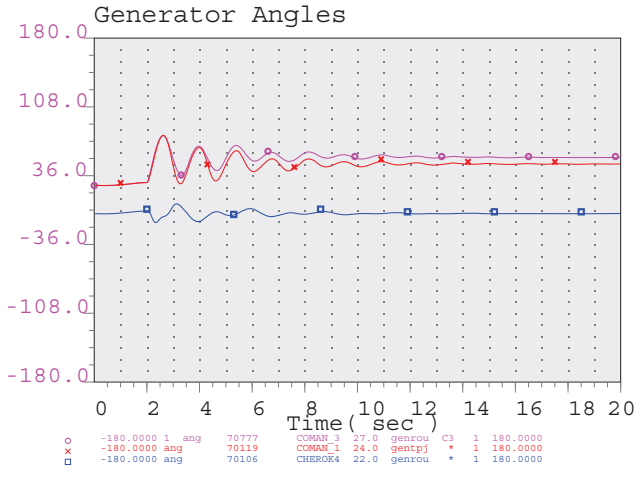






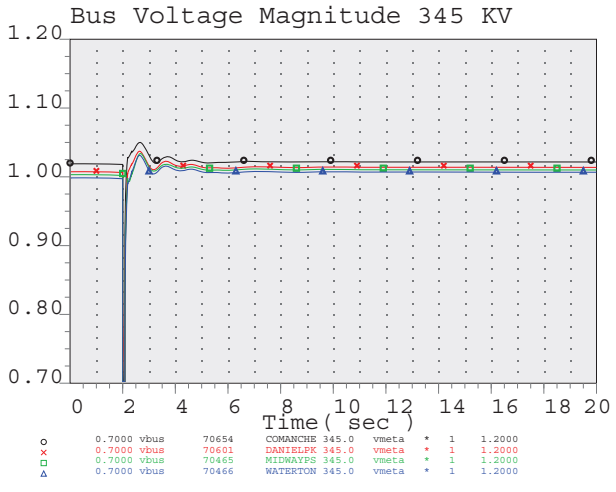


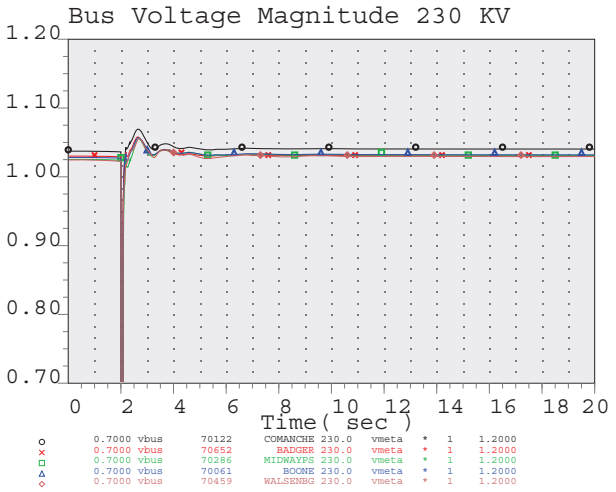


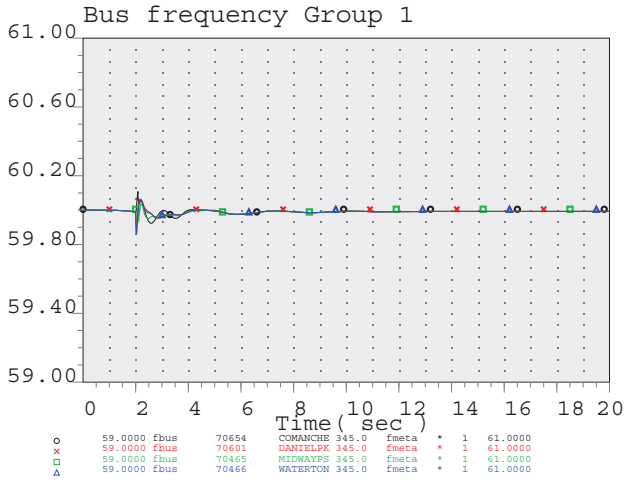


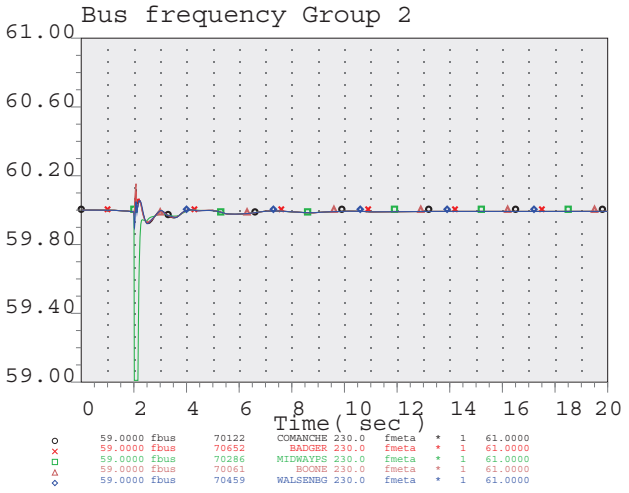
PV - 200 MW & BES - 50 MW

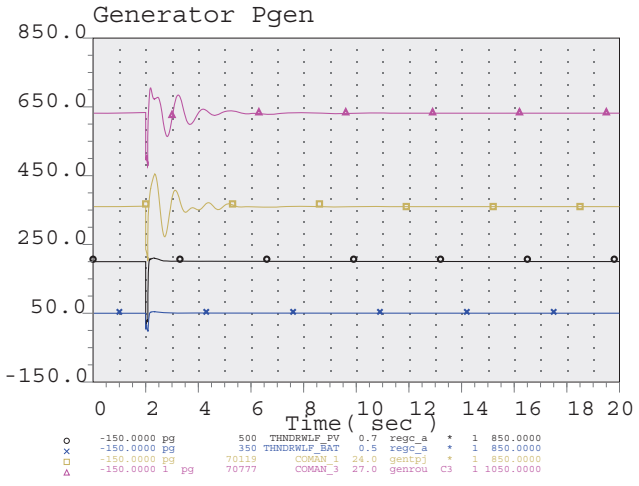
Fault: Comanche 345 KV 4 cycle 3-ph bus fault
outage: lose Comanche - Daniels Park 345 KV double circuit

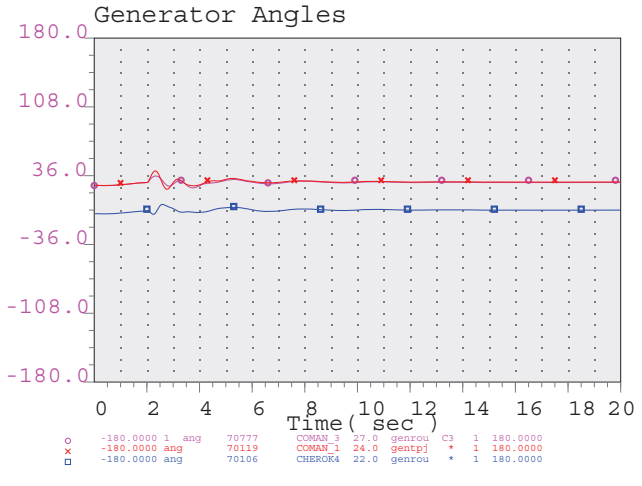






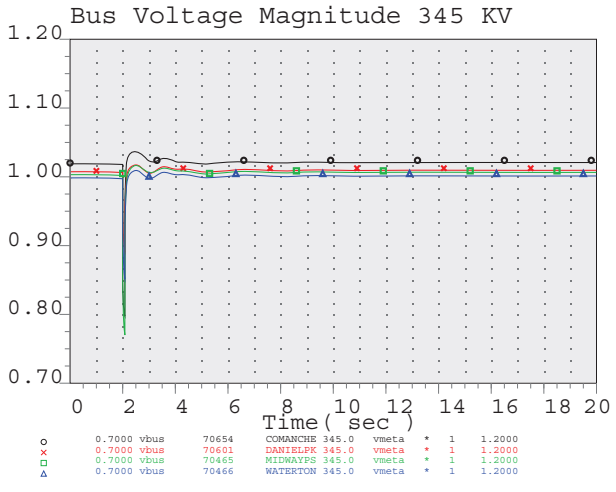


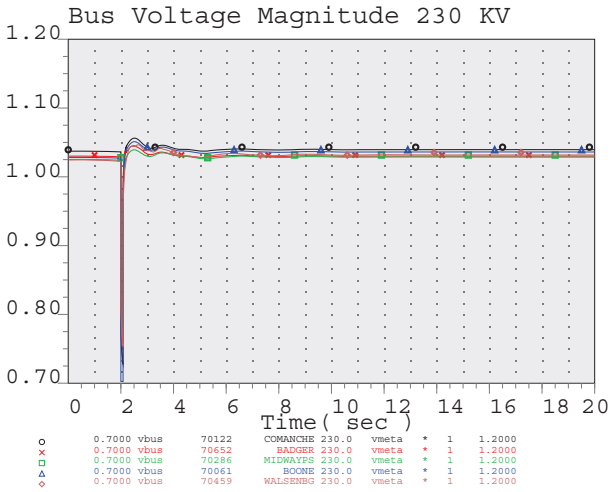


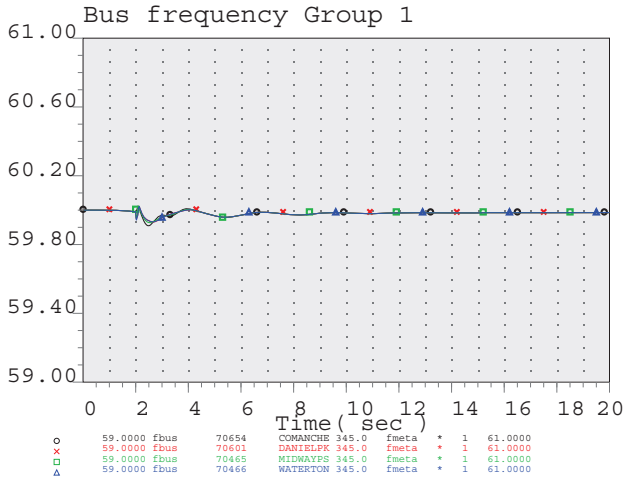


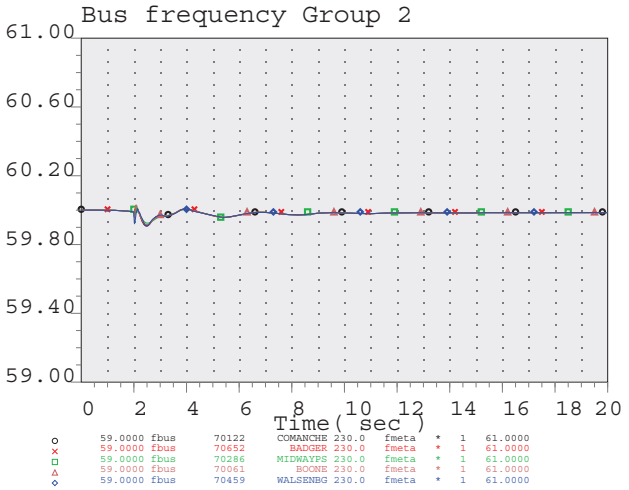
PV - 200 MW & BES - 50 MW

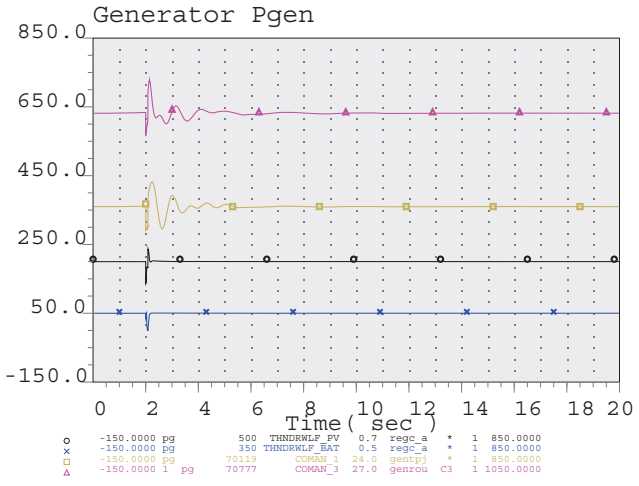
Fault: MIDWAYPS 230 KV 5 cycle 3-ph bus fault
Outage: lose Fountain Valley gen

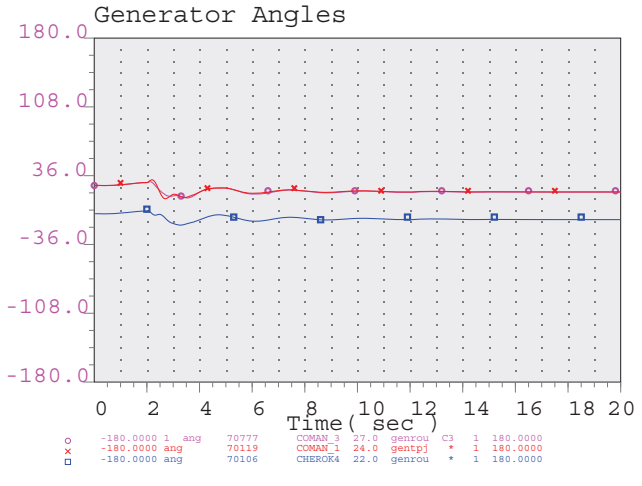






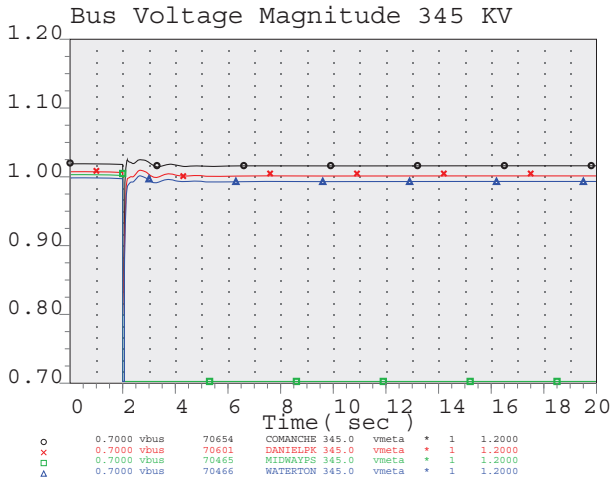


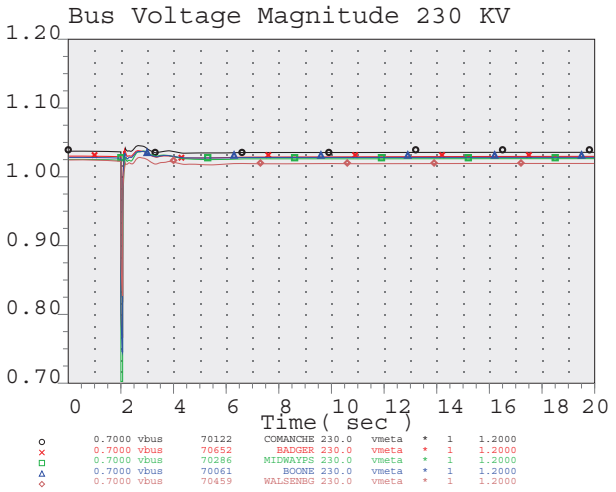


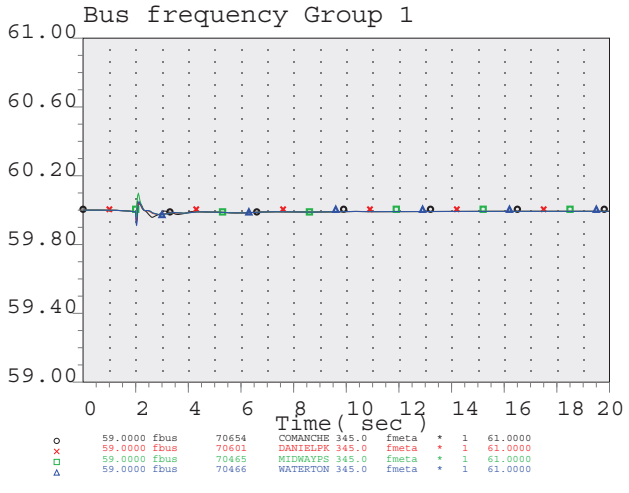


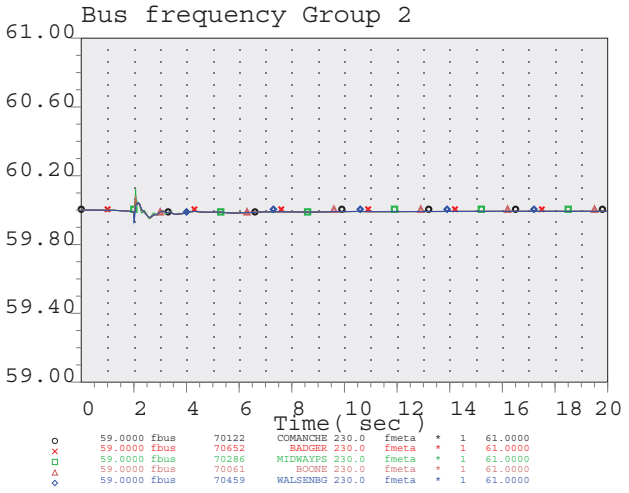
PV - 200 MW & BES - 50 MW

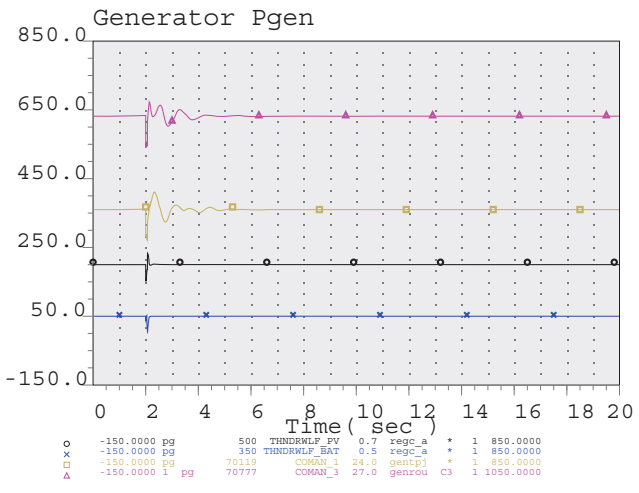
Fault: Boone 230 KV 5 cycle 3-ph bus fault
Outage: lose Lamar - Boone 230 KV line and Lamar gen

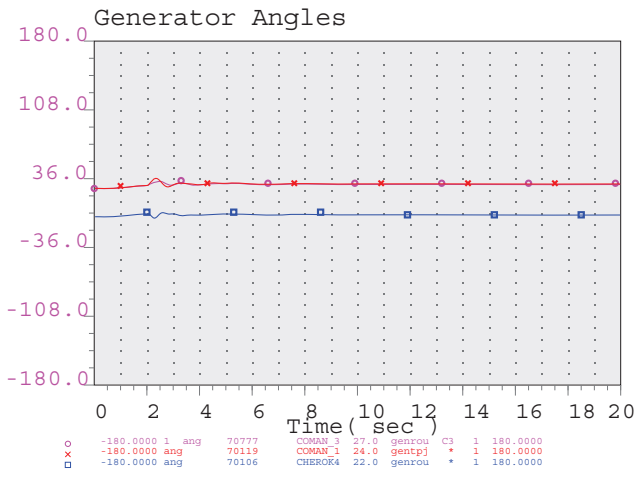












PV - 200 MW & BES - 50 MW

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