GEN-2022-GR1

GENERATOR REPLACEMENT STUDY

By SPP Generator Interconnection

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REVISION HISTORY

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CONTENTS

EXECUTIVE SUMMARY

Pursuant to SPP Open Access Transmission Tariff (SPP tariff) Attachment V section 3.9 and SPP Business Practice 7800, Interconnection Customers can request replacement requests for its Existing Generating Facilities. The Interconnection Customer of an Existing Generating Facility (EGF) at the Pirkey 138kV Point of Interconnection (POI), requested to be studied in the SPP Generator Replacement process.

The generation interconnects in the American Electric Power West (AEPW) area with 775 MW of available replacement capacity. This Study has been requested to evaluate the replacement with 201 Power Electronics FS3190M solar inverters. This generating capacity for the Replacement Generating Facility (RGF), also known as GEN-2022-GR1 (582.9 MW) exceeds its requested Interconnection Service amount, 580 MW. As a result, the customer must install monitoring and control equipment as needed to ensure that the amount of power injected at the POI does not exceed the Interconnection Service amount.

The Generator Replacement Process consists of two parts: a Reliability Assessment Study and a Replacement Impact Study. The Reliability Assessment Study determines any system reliability impacts between the removal of the EGF from service and the commission date of the RGF and system adjustments to mitigate those issues. The Replacement Impact Study determines whether or not the RGF has a material adverse impact on the Transmission System when compared to the EGF (Material Modification).

In the Reliability Assessment Study initial operational screening, it was determined that additional detailed analysis would be needed to fully determine the impacts removing the EGF from service. Study scoping discussions with the Interconnection Customer and Transmission Owner determined that SPP would perform a planning sensitivity analysis for informational purposes alongside the operational analysis. Ultimately, **no issues requiring mitigation** were identified.

The Replacement Impact Study evaluated the impacts due to the change in stability model from a synchronous generator (GENROU) to asynchronous generators (REGCAU1), requiring short-circuit and dynamic stability analyses. The change in facility design to include collector system and generation tie line resulted in a charging current compensation analysis.

The requested replacement does not have a material adverse impact. The requested generator replacement of the EGF with GEN-2022-GR1 was determined **not a Material Modification**.

It is likely that the customer may be required to reduce its generation output in real-time, also known as curtailment, under certain system conditions to allow system operators to maintain the reliability of the transmission network.

Nothing in this study should be construed as a guarantee of transmission service or delivery rights. Transfer of an existing resource designation from the EGF to the RGF can be achieved by submitting a transfer of designation request pursuant to Section 30.2.1 of the SPP tariff. If the customer would like to obtain new deliverability to final customers, a separate request for transmission service must be requested on Southwest Power Pool's OASIS by the customer.

SCOPE OF STUDY

Pursuant to SPP tariff Attachment V section 3.9 and SPP Business Practice 7800, Interconnection Customers can request replacement requests for its Existing Generating Facilities. A Generator Replacement Impact Study is an interconnection study performed to evaluate the impacts of replacing existing generation with new generation. Two analyses covering different time frames are evaluated:

- Reliability Assessment Study – The time between removing from service the Existing Generating Facility (EGF) and commission of the Replacement Generating Facility (RGF)
- Replacement Impact Study – The time after the commission of the RGF

If the Replacement Impact Study identifies any materially adverse impact from operating the RGF when compared to the EGF, such impacts shall be deemed a Material Modification.

For any impacts to the system identified in the Reliability Assessment Study, non-transmission solutions, such as redispatch, remedial action schemes, or reactive setting adjustments, will be identified to mitigate issues in the time between removing the EGF from service and RGF commission.

RELIABILITY ASSESSMENT STUDY

The Reliability Assessment Study evaluates regional transmission impacts from removing the EGF from service.

Based on the initial operational screening, it was determined that additional detailed analysis would be needed to fully determine the impacts of removing the EGF from service. After a study scoping discussion with the Interconnection Customer, it was determined that SPP would perform a planning sensitivity analysis to determine whether system constraints exist under anticipated alternate system conditions alongside the operational analysis.

SPP performed the planning analysis using modified 2022 ITP Base Reliability models to reflect the most current modeling information.

REPLACEMENT IMPACT STUDY

The Replacement Impact Study was performed using the PTI PSS/E version 33.10 software.

STABILITY AND SHORT CIRCUIT ANALYSES

To determine whether stability and short circuit analyses are required, SPP evaluates the difference between the stability model, stability model parameters, and, if needed, the collector system impedance between the existing configuration and the requested modification. Dynamic stability analysis and short circuit analysis would be required if the differences listed above may result in a significant impact on the most recently performed DISIS stability analysis.

CHARGING CURRENT COMPENSATION ANALYSIS

A charging current compensation analysis was performed on the requested replacement configuration as it is a non-synchronous resource. The charging current compensation analysis determines the capacitive effect at the POI caused by the project's collector system and transmission line's capacitance. A shunt reactor size is determined in order to offset the capacitive effect and maintain no reactive power injection into the POI while the project's generators and capacitors are offline.

STUDY LIMITATIONS

The assessments and conclusions provided in this report are based on assumptions and information provided to SPP. While the assumptions and information provided may be appropriate for the purposes of this report, SPP does not guarantee that those conditions assumed will occur. As such, the conclusions and results presented in this report may vary depending on the extent to which actual future conditions differ from the assumptions made or information used herein.

PROJECT AND REPLACEMENT REQUEST

The GEN-2022-GR1 Interconnection Customer has requested a replacement to its EGF, a synchronous coal-fired generator with a POI at Pirkey 138kV, with a retirement date of March 31, 2023. The capacity available for replacement is 775 MW, based on the nameplate of the generating facility. Of the capacity available, the Interconnection Customer has requested 580 MW of Energy Resource Interconnection Service. The requested RGF is a solar request consisting of 201 x Power Electronics FS3190M inverters, totaling 582.9 MW. The installed capacity exceeds the requested interconnection service, and the customer must ensure that the amount of power injected at the POI does not exceed the Interconnection Service amount listed in its GIA. The RGF has a planned commercial operation date of March 30, 2026. The EGF predated the SPP GI queue and does not have an SPP GIA.

The POI of the EGF and RGF is the Pirkey 138kV substation in the American Electric Power West (AEPW) area, and the EGF and RGF are not expected to be operational simultaneously. Figure 1 and Figure 2 show the powerflow model single-line diagram for the EGF and RGF configurations, respectively. Table 1 further details the EGF and RGF configurations and parameters.

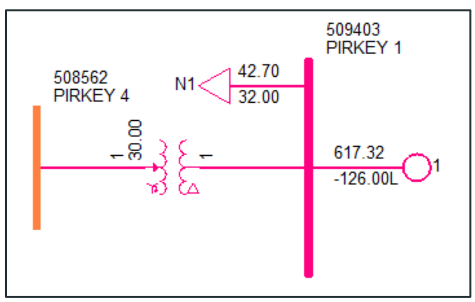

Figure 1: EGF Configuration

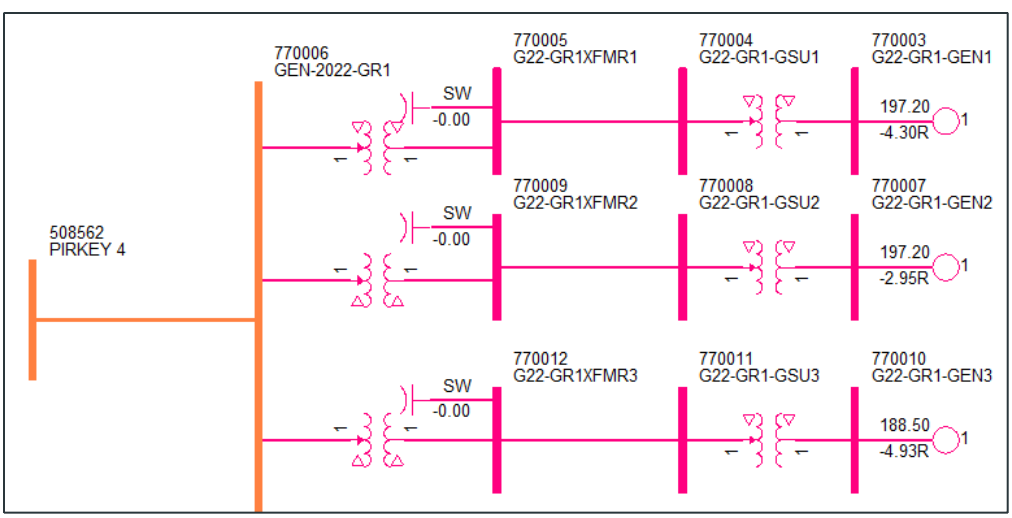

Figure 2: RGF Configuration

Facility	Existing Generating Facility Configuration	Replacement Generating Facility Configuration		
Point of Interconnection	Pirkey 138kV Substation (508562)	Pirkey 138kV Substation (508562)		
Configuration/Capacity	775 MW	201 x Power Electronics FS3190M = 582.9 MW PPC to limit injection to 580 MW		
Generation Interconnection Line	N/A	Length = 0.189 miles		
		R = 0.00001 pu		
		X = 0.00006 pu		
		B = 0.00002 pu		
Main Substation Transformer[1]	N/A	**MPT1**	**MPT2**	**MPT3**
		R = 0.002713 pu	R = 0.002713 pu	R = 0.002713 pu
		X = 0.094961 pu	X = 0.094961 pu	X = 0.094961 pu
		Winding MVA = 138 MVA	Winding MVA = 138 MVA	Winding MVA = 138 MVA
		Rating MVA = 230 MVA	Rating MVA = 230 MVA	Rating MVA = 230 MVA
GSU Transformer[1]		Gen Equivalent Qty: 68	Gen Equivalent Qty: 68	Gen Equivalent Qty: 65
	R = 0.000251 pu	R = 0.006335 pu	R = 0.006335 pu	R = 0.006335 pu
	X = 0.010243 pu	X = 0.072223 pu	X = 0.072223 pu	X = 0.072223 pu
	Winding MVA = 100 MVA	Winding MVA = 224.4 MVA	Winding MVA = 224.4 MVA	Winding MVA = 214.5 MVA
	Rating MVA = 750 MVA	Rating MVA = 224.4 MVA	Rating MVA = 224.4 MVA	Rating MVA = 214.5 MVA
Equivalent Collector Line[2]	N/A	R = 0.001443859 pu	R = 0.001134021 pu	R = 0.001414462 pu
		X = 0.001807229 pu	X = 0.001254025 pu	X = 0.001800776 pu
		B = 0.027800492 pu	B = 0.013168945 pu	B = 0.025558115 pu
Generator Dynamic Model[3] & Power Factor	GENROU[3] Leading and Lagging: ±0.9849	REGCAU1[3] Leading and Lagging: ±0.879		
1) X/R based on Winding MVA, 2) All pu are on 100 MVA Base 3) DYR stability model name				

Table 1: EGF and RGF Configuration Details

Because the Interconnection Customer requested less Interconnection Service for the RGF than was made available by the EGF, the remaining capacity is assumed unused as part of this replacement request. Should the Interconnection Customer choose to proceed with this replacement, the remaining unused capacity would be subject to a separate replacement request such that the total replacement capacity does not exceed this amount and other requirements from SPP tariff Attachment V section 3.9 are met.

RELIABILITY ASSESSMENT STUDY

PLANNING ANALYSIS

MODEL DEVELOPMENT

BASE CASE

Because the EGF was assumed out-of-service in the 2022 TPL model set and, thus, studied as out-of-service via the 2022 TPL Assessment, additional base case model development and subsequent powerflow, stability, and short-circuit analyses were unnecessary.

SENSITIVITY CASE

In discussions between SPP and the Interconnection Customer, it was determined that an informational powerflow sensitivity analysis would be performed to investigate impacts of removing the EGF from service with respect to flows on the Welsh HVDC tie between SPP and ERCOT. The following 2022 TPL models were used as a base for the sensitivity case:

- 2024 Light Load
- 2024 Summer Peak
- 2027 Summer Peak
- 2032 Summer Peak

Each base case model was modified by adding a 600 MW transfer to ERCOT across the Welsh HVDC tie and turning off the generation at Kiowa to simulate an operational switch from the Eastern Interconnection to ERCOT. This represents a high export to ERCOT during peak load conditions.

SPP compared the 2022 TPL to the sensitivity cases to determine the impact of removing the EGF from service to the SPP transmission system. As there currently is not transmission service to provide export across the Welsh HVDC tie, analysis results in these cases are informational only and do not require transmission reinforcements as mitigation.

ANALYSIS RESULTS

BASE CASE

SPP compared the 2022 TPL base case to the sensitivity case by using the PSSE Activity ACCC and V&R Energy's Physical and Operational Margins (POM) suite and PTI's PSSE powerflow software to determine the impacts of removing the EGF from service.

Assumptions for powerflow analysis:

- Monitored Elements
  - SPP facilities 69 kV and above
  - First-tier companies 100 kV and above
- Contingencies
  - P1, P2, P3, P4, P5, P6 and P7 events[1] for all models

SENSITIVITY CASE

Table 2 lists SPP thermal violations found in the sensitivity case. No voltage violations were identified in this case. Each of these constraints are located in the Tulsa, Oklahoma area remote from the EGF in the Shreveport, Louisiana area. The constraints are attributed to the increased dispatch of resources in the constrained area to provide an offset for the Kiowa units and Welsh HVDC export (assumptions in the sensitivity case). A potential mitigation would be dispatching other SPP resources that do not demonstrate similar shift factors on these constraints.

As no issues were observed in the study area, removing the EGF from service was determined to meet SPP Planning Criteria.

Season	Area	Event Category	Monitored Branch	Loading (%)	Contingency
24S	AEPW	P1	52DELTP4 - 36LEWIS4	100.1	509783 'R.S.S.-4' 138 - 509849 'ORU ETP4' 138 1
32S	AEPW	P1	52DELTP4 - 36LEWIS4	101.7	509783 'R.S.S.-4' 138 - 509849 'ORU ETP4' 138 1
27S	AEPW	P1	52DELTP4 - 36LEWIS4	102.1	509783 'R.S.S.-4' 138 - 509849 'ORU ETP4' 138 1
27S	AEPW	P1	52DELTP4 - 36LEWIS4	100.2	509783 'R.S.S.-4' 138 - 509853 'ORU-WTP4' 138 1
24S	AEPW	EE	52DELTP4 - T.S.E.-4	100.3	EESS:345:APEW:ONETA--7::::
24S	AEPW	P2	52DELTP4 - 36LEWIS4	100.1	P23:138:AEPW:RIVERSIDE_CB_1337A_NBTB::::
24S	AEPW	P2	52DELTP4 - 36LEWIS4	101	P23:138:AEPW:RIVERSIDE_CB_1341A_NBTB::::
27S	AEPW	EE	R.S.S.-4 - 52DELWT4	102.7	EESS:345:APEW:RSS-138 ROW::::
27S	AEPW	P2	52DELTP4 - 36LEWIS4	100.2	P23:138:AEPW:RIVERSIDE_CB_1325A_NBTB::::

Table 2: Planning Sensitivity Case Thermal Violations

[1] NERC TPL-001 Standard Table 1

OPERATIONAL ANALYSIS

POWERFLOW

MODEL DEVELOPMENT

BASE AND PEAK LOAD CASES

Energy Management System (EMS) snapshots were selected as base cases to reflect real-time observed conditions in the Shreveport/Texarkana portion of the AEPW system with the highest observed flows. Cases were selected to include the East DC tie exporting to ERCOT and the PSOSWEPCO interface experiencing a real-time overload. Historically, these conditions may result in thermal and voltage issues for the area.

Additionally, an EMS peak load case was used to assess the Shreveport/Texarkana portion of the AEPW system with peak load and the EGF in offline status.

- Real-time EMS cases:
    - Base cases
        - 3/18/2022 1120
        - 6/26/2022 0430
    - Peak load case
        - 9/1/2021 1600

The EGF was offline in each real-time EMS case.

SENSITIVITY CASE

In the sensitivity analysis, scenarios were created from each real-time EMS case adjusted with different outage conditions. The prior outage conditions considered were:

- Welsh Unit 2 (generating unit)
- Valliant - Lydia (345kV transmission line)
- Valliant - NW Texarkana (345kV transmission line)
- Sarepta - Longwood (345kV transmission line)

ANALYSIS

Steady state analysis was performed using Power World Simulator Version 22.

Assumptions for powerflow analysis:

- Monitored Elements
    - AEPW (CSWS) Facilities 69 kV and above

- Contingencies
    - P1 single line or transformer within each SPP member area
        - Sensitivity cases are equivalent to P3 or P6 prior to system adjustments
- Analysis Criteria
    - System Intact
        - Loading within Normal Rating
        - Bus voltages within 0.95-1.05 pu
    - Post-contingency
        - Loading within Emergency Rating
        - Bus voltages within 0.90-1.1 pu

The contingency with the highest exceedance for a ratings violation on each monitored facility is reported.

RESULTS

Table 3 lists operational analysis thermal violations observed in each real-time EMS sensitivity case along with the EGF's generator shift factor (GSF) on the constraint. No voltage violations were observed in close proximity to the Pirkey 138kV POI.

Case	Area	Event Category	Monitored Branch	Loading (%)	Contingency	Pirkey GSF (%)
3/18/2022 @ 1120 (Base)	CSWS	P1	Lydia B341 – Welsh 43	110.3	Nw Texarkana – Welsh 43	21.3
3/18/2022 @ 1120 (Welsh2 Out)	CSWS	P1	Lydia B341 – Welsh 43	122.89	Nw Texarkana – Welsh 43	21.3
3/18/2022 @ 1120 (Val_NWTx Out)	CSWS	P1	Lydia B341 – Welsh 43	109.86	Nw Texarkana – Welsh 43	21.3
3/18/2022 @ 1120 (Sarpt_Long Out)	CSWS	P1	Lydia B341 – Welsh 43	128.32	Nw Texarkana – Welsh 43	21.3
3/18/2022 @ 1120 (Base)	CSWS	P1	Lydia B341 – Valliant18	100.49	Nw Texarkana – Valliant18	18.4
3/18/2022 @ 1120 (Welsh2 Out)	CSWS	P1	Lydia B341 – Valliant18	109.98	Nw Texarkana – Valliant18	18.4
3/18/2022 @ 1120 (Val_NWTx Out)	CSWS	P1	Lydia B341 – Valliant18	112.68	Nw Texarkana – Valliant18	18.4
3/18/2022 @ 1120 (Sarpt_Long Out)	CSWS	P1	Lydia B341 – Valliant18	112.82	Nw Texarkana – Valliant18	18.4
3/18/2022 @ 1120 (Sarpt_Long Out)	CSWS	P1	PITTSB9 1 – Valliant18	100.85	Valliant18 – Lydia B341	15.1
3/18/2022 @ 1120 (Welsh2 Out)	CSWS	P1	NWTEXAR B34N – Welsh 43	104.88	Welsh 43 – Lydia B341	12.5
3/18/2022 @ 1120 (Sarept_Long Out)	CSWS	P1	NWTEXAR B34N – Welsh 43	112.92	Welsh 43 – Lydia B341	12.5
6/26/2022 @ 0430 (Welsh2 Out)	CSWS	P1	Lydia B341 – Welsh 43	110.3	Nw Texarkana – Welsh 43	18

Case	Area	Event Category	Monitored Branch	Loading (%)	Contingency	Pirkey GSF (%)
6/26/2022 @ 0430 (Sarept_Long Out)	CSWS	P1	Lydia B341 – Welsh 43	110.3	Nw Texarkana – Welsh 43	18
6/26/2022 @ 0430 (Val_NWTx Out))	CSWS	P1	Lydia B341 – Valliant18	109.98	Nw Texarkana – Valliant18	15.7
6/26/2022 @ 0430 (Sarept_Long Out)	CSWS	P1	Lydia B341 – Valliant18	109.98	Nw Texarkana – Valliant18	15.7
6/26/2022 @ 0430 (Sarept_Long Out)	CSWS	P1	PITTSB9 1 – Valliant18	100.85	Valliant18 – Lydia B341	12.8

Table 3: Operational Thermal Constraints

SUMMARY

Based on the analysis results in Table 3, the base cases selected encountered rating violations whereas the high load case did not have ratings violations. All thermal violations that were seen in the operational steady-state are post-contingent violations of the emergency rating. These violations are not real-time exceedances where the normal rating is breached. The selected cases reflect system conditions prior to SPP Market or operator action. Due to the EGF being offline in all the selected cases, the violations displayed in Table 3 include the EGF's GSF to show the potential for relief the EGF could provide unit on the AEPW system.

All thermal constraints that were identified were on the 345 kV system for the loss of a neighboring 345 kV line. The highest loading experienced in the analysis resulted from the sensitivity case on 3/18/2022 @ 1120 with Sarepta – Longwood 345 kV outaged. This outage condition yielded a thermal overload of 128% on the Lydia – Welsh 345 kV monitored element. Although the EGF has a 21.3% GSF on this constraint, there are other available generator options that can be dispatched to help provide mitigation to the constraint. For all thermal violations listed, there were other available generators to provide relief on the constraint. No voltage violations were present due to removing the EGF from service.

Based on the operational powerflow results, impacts from removing the EGF from service can be mitigated as long as other resources in the area remain available to mitigate the overloads seen in this analysis.

STABILITY

MODEL DEVELOPMENT

BASE CASE

Base cases were selected to reflect real-time observed conditions in the Shreveport/Texarkana portion of the AEPW system with variations in observed flows on the EastDC tie to ERCOT and the PSOSWEPCO interface as well as online generation in the area. Cases were selected to assess the impacts of removing the EGF from service on the stability of the system for observed operating boundary conditions. A summary of each case evaluated is provided in Table 4.

CASE	EASTDC	PSOSWEPCO INTERFACE	SHREVEPORT/TEXARKANA AEPW GENERATION
5/09/2022 @ 1500	High Import	Low Import	High Output
5/27/2022 @ 0200	Moderate Export	Neutral	Low Output
6/13/2022 @ 1600	Moderate Import	Low Import	High Output
7/10/2022 @ 0200	High Export	High Import	Low Output

Table 4: Real-Time TSAT Cases

Each base case model initially contained the EGF unit as online. The cases were adjusted by switching the EGF unit offline and scaling online AEPW generation to offset the power reduction.

The generation facilities in the Shreveport/Texarkana portion of the AEPW system for this analysis included: Arson Hill, Eastman, Knoxlee, Welsh, and Wilkes. Table 5 contains a summary of online Shreveport/Texarkana generation following the scaling with the EGF offline.

CASE	ADJUSTED BASE CASE DISPATCH	MAXIMUM CAPACITY	MINIMUM CAPACITY
5/09/2022 @ 1500	1,906 MW	2,161 MW	595 MW
5/27/2022 @ 0200	605 MW	1,431 MW	465 MW
6/13/2022 @ 1600	1,972 MW	2,148 MW	550 MW
7/10/2022 @ 0200	894 MW	1,791 MW	550 MW

Table 5: Shreveport/Texarkana AEPW Online Generation

SENSITIVITY CASE

Multiple sensitivity cases were developed by performing transfer analysis on each base case to identify the stability limits for increases in the remaining online generation within the Shreveport/Texarkana portion of the AEPW system. AEPW generation outside of the Shreveport/Texarkana portion of the AEPW system was scaled to offset the dispatched MWs.

ANALYSIS

Transient stability analysis was performed using DSA Tools TSAT Version 21.

Assumptions for transient stability analysis

- Monitored Elements
    - Buses where faults were applied for any event
    - Generating resources within the Shreveport/Texarkana portion of the AEPW system
- Contingencies

  - P1 events for each 345kV connected circuit in the Shreveport/Texarkana portion of the AEPW system as well as lower kV facilities at these substations.
  - P4, P5, P6, P7, and extreme events in the Shreveport/Texarkana portion of the AEPW system provided to SPP by AEPW for TPL analysis
- Analysis Criteria
  - The system shall remain stable
  - Cascading and uncontrolled islanding shall not occur
  - P1-P7 Events:
    - Prohibits non-consequential loss of generation or load
  - Extreme Events:
    - Permits non-cascading automatic protection system loss of generation or load
  - SPP Disturbance Performance Requirements[2]
    - Voltages remain < 1.2 pu
    - Voltages remain above 0.7 pu, 2.5 sec following fault clearing
    - Rotor angle oscillations damped > 0.81633% (95% successive positive peak ratio)

RESULTS

Table 6 lists stability analysis violations observed in the base case and each sensitivity case.

TSAT application monitors individual bus voltage frequency. For many contingency events several buses were observed to experience a local voltage frequency below 59.6 Hz for at least 0.1 seconds (6 cycles). These events include: P-7 Fault=AEPW-2022-46-P7-Welsh, P-7 Fault=AEPW-2022-47-P7-Welsh, and multiple extreme events. These frequency deviations are not explicit stability issues but may require further analysis by the facility owners.

TSAT application monitors generator rotor angle damping for compliance with SPP Disturbance Performance Requirements3. For a few extreme contingency events where units located close to the fault tripped a damping violation was calculated for resources remote from the study location. Upon visual inspection of the rotor angle no issues were found. These false positives may be attributed to a mismatch between generation and load skewing the algorithm result.

The Turk Power plant tripped from out-of-step condition for 5/27/2022 @ 0200 case for events P-1 Turk - Sugar Hill 138 kV and P-1 Turk - McNabb 115 kV. During the scaling to offset the EGF, this case set the output of the Turk Power Plant at maximum. Reducing the output from 687 MW

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[2] SPP Disturbance Performance Requirements: https://www.spp.org/documents/28859/spp%20disturbance%20performance%20requirements%20(twg%20approved).pdf

[3] SPP Disturbance Performance Requirements: https://www.spp.org/documents/28859/spp%20disturbance%20performance%20requirements%20(twg%20approved).pdf

to 647 MW was found to be stable for these events though 650 MW was unstable. The TSAT representation of the Turk Power Plant did not include auxiliary loading in its model.

Out-of-step condition was observed for various resources for multiple extreme events. The remaining system was found to remain stable and no further evaluation was performed in this analysis.

Case	Event Category	Dispatch MW	Contingency	Result
5/09/2022 @ 1500	Extreme	Base case	Fault=AEPW-2022-48-Extreme_2_b-Welsh	**Welsh units 1 & 2 tripped from out-of-step condition**
5/09/2022 @ 1500	Extreme	Base case	Fault=AEPW-2022-53-Extreme_2_b-Diana	**LeBrock unit 3 tripped from out-of-step condition**
5/09/2022 @ 1500	Extreme	Base case	Fault=AEPW-2022-54-Extreme_2_b-Welsh	**Welsh units 1 & 2 tripped from out-of-step condition**
5/09/2022 @ 1500	Extreme	Base Case	Fault=AEPW-2022-62-Extreme_2d-Linwood	**STALL units 1, 2 and 3 tripped from out-of-step condition**
5/09/2022 @ 1500	Extreme	Base Case	Fault=AEPW-2022-64-Extreme_2d-FtHumbug	**STALL units 1, 2 and 3 tripped from out-of-step condition**
5/09/2022 @ 1500	Extreme	Base case	Fault=AEPW-2022-67-Extreme_2f-Diana	**Welsh units 1 & 2 and Wilkes unit 1 tripped from out-of-step condition**
5/09/2022 @ 1500	Extreme	Base case	Fault=AEPW-2022-68-Extreme_2f-Diana	**Welsh units 1 & 2 tripped from out-of-step condition**
5/27/2022 @ 0200	P1	Base case	Turk - Sugar Hill 138 kV	**Turk plant tripped from out-of-step condition** Reducing dispatch to 647 MW resulted in stable event
5/27/2022 @ 0200	P1	Base case	Turk - McNabb 115 kV	**Turk plant tripped from out-of-step condition** Reducing dispatch to 647 MW resulted in stable event
5/27/2022 @ 0200	Extreme	Base case	Fault=AEPW-2022-48-Extreme_2_b-Welsh	**Turk plant tripped from out-of-step condition**
5/27/2022 @ 0200	Extreme	Base case	Fault=AEPW-2022-50-Extreme_2_b-NWTexarkana	**Turk plant tripped from out-of-step condition**
5/27/2022 @ 0200	Extreme	Base case	Fault=AEPW-2022-51-Extreme_2_b-NWTexarkana	**Turk plant tripped from out-of-step condition**
5/27/2022 @ 0200	Extreme	Base case	Fault=AEPW-2022-54-Extreme_2_b-Welsh	**Turk plant tripped from out-of-step condition**
5/27/2022 @ 0200	Extreme	Base case	Fault=AEPW-2022-62-Extreme_2d-Linwood	**STALL units 1, 2 and 3 tripped from out-of-step condition**
5/27/2022 @ 0200	Extreme	Base case	Fault=AEPW-2022-63-Extreme_2d-SugarHill	**Turk plant tripped from out-of-step condition**

Case	Event Category	Dispatch MW	Contingency	Result
5/27/2022 @ 0200	Extreme	Base case	Fault=AEPW-2022-64-Extreme_2d-FtHumbug	**STALL units 1, 2 and 3 tripped from out-of-step condition**
6/13/2022 @ 1600	P6	Base case	Fault=AEPW-2022-40-P6-Welsh	Powerflow solution issue resolved with adjustment to GSU impedance of the MPS Crossroads generating facility. No stability issues observed.
6/13/2022 @ 1600	P6	Base case	Fault=AEPW-2022-41-P6-Welsh	Powerflow solution issue resolved with adjustment to GSU impedance of the MPS Crossroads generating facility. No stability issues observed.
6/13/2022 @ 1600	Extreme	Base case	Fault=AEPW-2022-48-Extreme_2_b-Welsh	**Welsh units 1 & 2 tripped from out-of-step condition**
6/13/2022 @ 1600	Extreme	Base Case	Fault=AEPW-2022-49-Extreme_2_b-Wilkes	**Wilkes unit 1 tripped from out-of-step condition**
6/13/2022 @ 1600	Extreme	Base case	Fault=AEPW-2022-54-Extreme_2_b-Welsh	**Welsh units 1 & 2 tripped from out-of-step condition**
6/13/2022 @ 1600	Extreme	Base Case	Fault=AEPW-2022-62-Extreme_2d-Linwood	**STALL units 1, 2 and 3 tripped from out-of-step condition**
6/13/2022 @ 1600	Extreme	Base Case	Fault=AEPW-2022-64-Extreme_2d-FtHumbug	**STALL units 1, 2 and 3 tripped from out-of-step condition**
7/10/2022 @ 0200	Extreme	Base Case	Fault=AEPW-2022-51-Extreme_2_b-NWTexarkana	**Turk plant tripped from out-of-step condition**
7/10/2022 @ 0200	Extreme	Base Case	Fault=AEPW-2022-62-Extreme_2d-Linwood	**STALL units 1, 2 and 3 tripped from out-of-step condition**
7/10/2022 @ 0200	Extreme	Base Case	Fault=AEPW-2022-64-Extreme_2d-FtHumbug	**STALL units 1, 2 and 3 tripped from out-of-step condition**
5/09/2022 @ 1500	Extreme	1,227	Fault=AEPW-2022-48-Extreme_2_b-Welsh	**Welsh units 1 & 2 tripped from out-of-step condition**
5/09/2022 @ 1500	Extreme	1,227	Fault=AEPW-2022-54-Extreme_2_b-Welsh	**Welsh units 1 & 2 tripped from out-of-step condition**
5/09/2022 @ 1500	Extreme	1,227	Fault=AEPW-2022-62-Extreme_2d-Linwood	**STALL units 1, 2 and 3 tripped from out-of-step condition**
5/09/2022 @ 1500	Extreme	1,227	Fault=AEPW-2022-64-Extreme_2d-FtHumbug	**STALL units 1, 2 and 3 tripped from out-of-step condition**
5/09/2022 @ 1500	Extreme	1,227	Fault=AEPW-2022-68-Extreme_2f-Diana	**Welsh units 1 & 2 and Broken Bow Hydro units 1 & 2 tripped out-of-step condition**
5/27/2022 @ 0200	P1	568	Turk - Sugar Hill 138 kV	**Turk plant tripped from out-of-step condition** Reduction in output of generation facilities in the Shreveport/Texarkana portion of the AEPW system did not resolve this instability
5/27/2022 @ 0200	P1	464	Turk - McNabb 115 kV	**Turk plant tripped from out-of-step condition**

Case	Event Category	Dispatch MW	Contingency	Result
				Reduction in output of generation facilities in the Shreveport/Texarkana portion of the AEPW system did not resolve this instability
5/27/2022 @ 0200	Extreme	568	Fault=AEPW-2022-48-Extreme_2_b-Welsh	**Turk plant tripped from out-of-step condition**
5/27/2022 @ 0200	Extreme	465	Fault=AEPW-2022-50-Extreme_2_b-NWTexarkana	**Turk plant tripped from out-of-step condition**
5/27/2022 @ 0200	Extreme	465	Fault=AEPW-2022-51-Extreme_2_b-NWTexarkana	**Turk plant tripped from out-of-step condition**
5/27/2022 @ 0200	Extreme	465	Fault=AEPW-2022-54-Extreme_2_b-Welsh	**Turk plant tripped from out-of-step condition**
5/27/2022 @ 0200	Extreme	465	Fault=AEPW-2022-62-Extreme_2d-Linwood	**STALL units 1, 2 and 3 tripped from out-of-step condition**
5/27/2022 @ 0200	Extreme	465	Fault=AEPW-2022-63-Extreme_2d-SugarHill	**Turk plant tripped from out-of-step condition**
5/27/2022 @ 0200	Extreme	465	Fault=AEPW-2022-64-Extreme_2d-FtHumbug	**STALL units 1, 2 and 3 tripped from out-of-step condition**
6/13/2022 @ 1600	Extreme	1,972	Fault=AEPW-2022-48-Extreme_2_b-Welsh	**Welsh units 1 & 2 tripped from out-of-step condition**
6/13/2022 @ 1600	Extreme	1,186	Fault=AEPW-2022-49-Extreme_2_b-Wilkes	**Wilkes unit 1 tripped from out-of-step condition**
6/13/2022 @ 1600	Extreme	1,186	Fault=AEPW-2022-54-Extreme_2_b-Welsh	**Welsh units 1 & 2 tripped from out-of-step condition**
6/13/2022 @ 1600	Extreme	1,186	Fault=AEPW-2022-62-Extreme_2d-Linwood	**STALL units 1, 2 and 3 tripped from out-of-step condition**
6/13/2022 @ 1600	Extreme	1,186	Fault=AEPW-2022-64-Extreme_2d-FtHumbug	**STALL units 1, 2 and 3 tripped from out-of-step condition**
7/10/2022 @ 0200	Extreme	590	Fault=AEPW-2022-62-Extreme_2d-Linwood	**STALL units 1, 2 and 3 tripped from out-of-step condition**
7/10/2022 @ 0200	Extreme	550	Fault=AEPW-2022-64-Extreme_2d-FtHumbug	**STALL units 1, 2 and 3 tripped from out-of-step condition**

Table 6: Operational Stability Violations

SUMMARY

The transient stability analysis was performed in TSAT 21.0 using the base case and sensitivity cases. Each case was observed to experience stability insecurity for extreme and various other events. Insecure contingencies were reran with relaxed screening requirements to quantify the potential instability. These results are summarized in Table 6.

The relaxed requirements included:

- Changed the MW Tripped Due to out-of-step condition from 50.0 MW to 1000.00 MW
- Transient Voltage Violation Option adjusted from Insecure to Warning Only
- Damping Violation Option adjusted from Insecure to Warning Only
- Transient Frequency Violation Criterion adjusted from Insecure to Warning Only

The analysis on the sensitivity cases, only considering P1-P7 events, identified the following transient secure dispatch limits in Table 7 for online resources within the Shreveport/Texarkana portion of the AEPW system:

Case	Shreveport/Texarkana AEPW Generation Stability Limit	Adjusted Base Case Dispatch
5/09/2022 @ 1500	2,161 MW (unconstrained)	1,906 MW
5/27/2022 @ 0200	1,163 MW (excludes Turk Out-of-Step events)	605 MW
6/13/2022 @ 1600	2,148 MW (unconstrained)	1,972 MW
7/10/2022 @ 0200	1,776 MW	894 MW

Table 7: Transaction Analysis Stability Limit

Extreme event and other events were observed to result in generating unit(s) tripping offline due to out-of-step condition (loss of synchronism). Further analysis by the Transmission Operator(s) and Generator Operator(s) is recommended for each of these events. Analysis should identify whether preventative corrective actions such as stability interfaces or operational guides are appropriate and if so to proceed with their development and implementation (if not existing).

REPLACEMENT IMPACT STUDY

EXISTING VS. REPLACEMENT COMPARISON

To determine which analyses are required for the Study, the differences between the existing configuration and the requested replacement were evaluated. SPP performed this comparison and the resulting analyses using a set of modified study models developed based on the replacement request data and the DISIS-2017-001 study models.

Because the dynamic model for the EGF and RGF are different (GENROU and REGCAU1, respectively), SPP determined short-circuit and dynamic stability analysis was required. This is because the short-circuit contribution and stability responses of the existing configuration and the requested modification's configuration may differ. The generator dynamic model for the RGF can be found in Appendix A.

Since short-circuit and dynamic stability analyses were already required, neither a stability model parameters comparison nor an equivalent impedance comparison were needed for the determination of the scope of the study.

In accordance with FERC Order No. 827, the generating facility will be required to provide dynamic reactive power within the range of 0.95 leading to 0.95 lagging at the high-side of the generator substation.

CHARGING CURRENT COMPENSATION ANALYSIS

The charging current compensation analysis was performed for GEN-2022-GR1 to determine the capacitive charging effects under reduced generation conditions (unsuitable wind speeds, unsuitable solar irradiance, insufficient state of charge, idle conditions, curtailment, etc.) at the generation site and to size shunt reactors that would reduce the project reactive power contribution to the POI to approximately zero.

METHODOLOGY AND CRITERIA

The GEN-2022-GR1 generators and capacitor banks were switched out of service while other collection system elements remained in-service. A shunt reactor was tested at the project's collection substation 34.5 kV bus to offset the MVAr flow into the POI to approximately zero. The size of the shunt reactor is equivalent to the charging current value at unity voltage and the compensation provided is proportional to the voltage effects on the charging current (i.e., for voltages above unity, reactive compensation is greater than the size of the reactor).

SPP performed the charging current compensation analysis using the replacement request data based on the DISIS 2017-001 stability study 2028 Summer Peak (28SP) model.

RESULTS

The results from the analysis showed that the GEN-2022-GR1 project needed approximately 6.7 MVAr of compensation at its collector substation, to reduce the POI reactive power injection to zero. Figure 3 illustrates the shunt reactor size needed to reduce the POI reactive power injection to approximately zero with the updated configuration.

The information gathered from the charging current compensation analysis is provided as information to the Interconnection Customer and Transmission Owner (TO) and/or Transmission Operator. The applicable reactive power requirements will be further reviewed by the Transmission Owner and/or Transmission Operator.

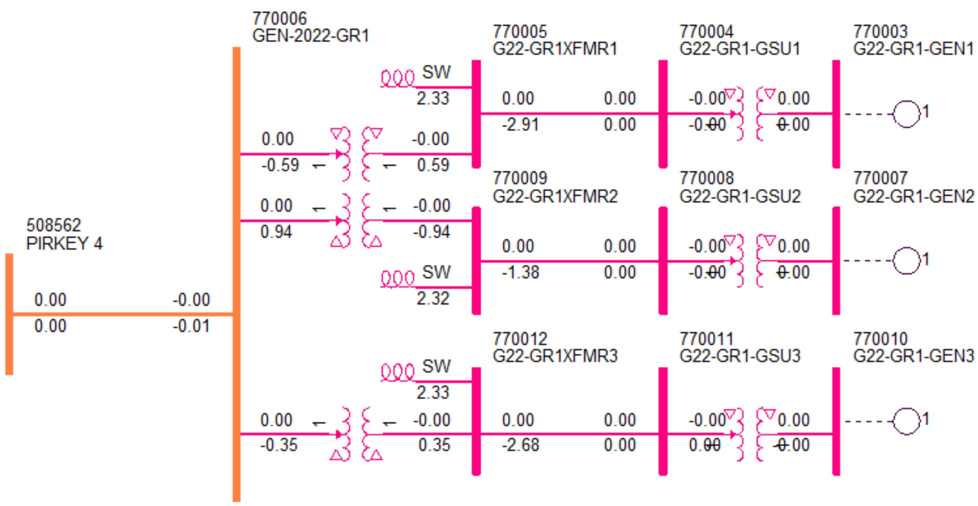

Figure 3: GEN-2022-GR1 Single Line Diagram (Shunt Sizes)

SHORT-CIRCUIT ANALYSIS

A short circuit study was performed using the 21SP and 28SP stability models for GEN-2022-GR1. The detailed results of the short-circuit analysis are provided in Appendix B.

METHODOLOGY

The short-circuit analysis included applying a three-phase fault on buses up to five levels away from the POI bus. The PSS/E "Automatic Sequence Fault Calculation (ASCC)" fault analysis module was used to calculate the fault current levels in the transmission system with and without GEN-2022-GR1 RGF online.

SPP created a short circuit model using the 2021 Summer Peak and 2028 Summer Peak DISIS-2017-001 stability study model by adjusting the GEN-2022-GR1 short-circuit parameters consistent with the replacement data. The adjusted parameters are shown in Table 8 below.

Parameter	Value by Generator Bus#		
	770003	770007	770010
Machine MVA Base	224.40	224.40	214.50
R (pu*)	0.0	0.0	0.0
X'' (pu*)	0.6618	0.6618	0.6618

*pu values based on machine MVA Base

Table 8: GEN-2022-GR1 Short-Circuit Parameters

RESULTS

The results of the short circuit analysis for the 21SP model are summarized in Table 9 and Table 10, and the results for the 28SP model are summarized in Table 9 and Table 11. The GEN-2022-GR1 POI bus fault current magnitudes are provided in Table 9 showing a maximum fault current of 33.7 kA with the GEN-2022-GR1 project online.

The maximum fault current calculated within five buses of the GEN-2022-GR1 POI (including the POI bus) was less than 33.7 kA for the 21SP model. The maximum GEN-2022-GR1 contribution to three-phase fault current was about 10.2% and 3.1 kA.

Case	GEN-OFF Current (kA)	GEN-ON Current (kA)	Max kA Change	Max %Change
21SP	30.6	33.7	3.1	10.1%
28SP	30.4	33.6	3.1	10.2%

Table 9: POI Short-Circuit Results

Voltage (kV)	Max. Current (kA)	Max kA Change	Max %Change
69	22.2	0.2	1.1%
138	33.7	3.1	10.2%
230	14.7	0.01	0.1%
345	20.5	0.2	1.1%
Max	**33.7**	**3.1**	**10.2%**

Table 10: 21SP Short-Circuit Results

Voltage (kV)	Max. Current (kA)	Max kA Change	Max %Change
69	22.1	0.2	1.1%
138	33.6	3.1	10.2%
230	14.7	0.01	0.1%
345	20.4	0.2	1.1%
Max	**33.6**	**3.1**	**10.2%**

Table 11: 28SP Short Circuit Results

DYNAMIC STABILITY ANALYSIS

SPP performed a dynamic stability analysis to identify the impact of the GEN-2022-GR1 project. The analysis was performed according to SPP's Disturbance Performance Requirements[4]. The dynamic modeling data is provided in Appendix A. The simulation plots can be found in Appendix C.

METHODOLOGY AND CRITERIA

The dynamic stability analysis was performed using models developed with the requested GEN-2022-GR1 configuration of 201 Power Electronics FS3190M (REGCAU1). This stability analysis was performed using PTI's PSS/E version 33.10 software.

The replacement requested for the GEN-2022-GR1 project was used to create modified stability models for this impact study based on the DISIS 2017-001 stability study models:

1. 2019 Winter Peak (19W),
2. 2021 Light Load (21L),
3. 2021 Summer Peak (21S), and
4. 2028 Summer Peak (28S).

The following system adjustments were made to address existing base case issues that are not attributed to the replacement request:

- GEN-2016-106, GEN-2014-039, and MISO request J535, which have been withdrawn, were disconnected
- AECI request GI-61 powerflow and dynamics data updated to 2020 MDAG configuration and parameters
- X Source (pu) changed from 0.186000 to 0.235650 for the machine at 521145
- R Source (pu) changed from 0.003510 to 0.000000 and X Source (pu) changed from 0.188000 to 0.167000 for the machine at 513597
- MISO requests J385 and J400 dynamics data updated to DISIS-2018-001 parameters
- Winding 2 Ratio changed from 1.0 to 0.96 on the 539119-539120-1 transformer
- REPCAU1 monitored branch To and From bus numbers for line drop compensation for GEN-2017-022 and GEN-2017-028
- GGOV1 Kimw, power controller (reset) gain was changed from 1.0 to 0.002 for the OEC generators at buses 511939, 511940, 511942, and 511943

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[4] SPP Disturbance Performance Requirements: https://www.spp.org/documents/28859/spp%20disturbance%20performance%20requirements%20(twg%20approved).pdf

The dynamic model data for the GEN-2022-GR1 project is provided in Appendix A. The modified power flow models and associated dynamics database were initialized (no-fault test) to confirm that there were no errors in the initial conditions of the system and the dynamic data.

During the fault simulations, the active power (PELEC), reactive power (QELEC), and terminal voltage (ETERM) were monitored for GEN-2022-GR1 and other equally- and prior-queued projects in the cluster group. In addition, voltages of five buses away from the POI of GEN-2022-GR1 were monitored and plotted. The machine rotor angle for synchronous machines and speed for asynchronous machines within this study area including 520 (AEPW), 524 (OKGE), 525 (WFEC), 526 (SPS), 531 (MIDW), 534 (SUNC), 536 (WERE), 640 (NPPD), 645 (OPPD), 650 (LES), and 652 (WAPA) were monitored.

FAULT DEFINITIONS

SPP developed fault events as required in order to study the replacement. The new set of faults were simulated using the modified study models from both scenarios. The fault events included three-phase faults and single-line-to-ground faults with stuck breakers. The simulated faults are listed and described in Table 12. These contingencies were applied to the modified 2019 Winter Peak, 2021 Light Load, 2021 Summer Peak, and the 2028 Summer Peak models.

Fault ID	Planning Event	Fault Descriptions
FLT9001-3PH	P1	• Apply 3-phase fault on LEBROCK7 345kV to PIRKEY 7 Circuit 1, near LEBROCK7 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9002-3PH	P1	• Apply 3-phase fault on LEBROCK7 345kV to PIRKEY 7 Circuit 2, near LEBROCK7 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9003-3PH	P1	• Apply 3-phase fault on LEBROCK7 345kV to TENRUSK7 Circuit 1, near LEBROCK7 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9004-3PH	P1	• Apply 3-phase fault on TENRUSK7 345kV to TENGEN 7 Circuit 1, near TENRUSK7 • Clear fault for 6 cycles by tripping the Faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9005-3PH	P1	• Apply 3-phase fault on TENRUSK7 345kV to CROCKET7 Circuit 1, near TENRUSK7 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9006-3PH	P1	• Apply 3-phase fault on CROCKET7 345kV to 7GRIMES% Circuit 1, near CROCKET7 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault

Fault ID	Planning Event	Fault Descriptions
FLT9007-3PH	P1	• 3 phase fault on the CROCKET4 to CROCK-B1 Circuit 1 345kV/138kV/13.8kV Three-Winding Transformer near CROCKET7 345kV bus • Apply fault at the CROCKET7 345kV bus • Clear fault after 6 cycles and trip the faulted transformer
FLT9008-3PH	P1	• 3-phase fault on PIRKEY 4 to PIRKY1-1 Circuit 1 345kV/138kV/13.8kV Three-Winding Transformer near PIRKEY 7 • Apply fault at the PIRKEY 7 bus • Clear fault after 6 cycles and trip the faulted transformer
FLT9009-3PH	P1	• Apply 3-phase fault on PIRKEY 7 345kV to DIANA 7 Circuit 1, near PIRKEY 7 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9010-3PH	P1	• 3-phase fault on PIRKEY 4 to PIRKY2-1 Circuit 1 345kV/138kV/13.8kV Three-Winding Transformer for 6 cycles near PIRKEY 7 • Apply fault at the PIRKEY 7 bus • Clear fault after 6 cycles and trip the faulted transformer
FLT9011-3PH	P1	• 3-phase fault on DIANA 4 to DIANA-N1 Circuit 1 345kV/138kV/13.8kV Three-Winding Transformer near DIANA 7 • Apply fault at the DIANA 7 bus • Clear fault after 6 cycles and trip the faulted transformer
FLT9012-3PH	P1	• 3-phase fault on DIANA 4 to DIANA-M1 Circuit 3 345kV/138kV/13.8kV Three-Winding Transformer near DIANA 7 • Apply fault at the DIANA 7 bus • Clear fault after 6 cycles and trip the faulted transformer
FLT9013-3PH	P1	• 3-phase fault on DIANA 4 to DIANA-M1 Circuit 2 345kV/138kV/13.8kV Three-Winding Transformer near DIANA 7 • Apply fault at the DIANA 7 bus • Clear fault after 6 cycles and trip the faulted transformer
FLT9014-3PH	P1	• Apply 3-phase fault on DIANA 7 345kV to SW SHV 7 Circuit 1, near DIANA 7 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9015-3PH	P1	• Apply 3-phase fault on DIANA 7 345kV to WELSH 7 Circuit 1, near DIANA 7 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9016-3PH	P1	• Apply 3-phase fault on DIANA 7 345kV to WELSH 7 Circuit 2, near DIANA 7 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9017-3PH	P1	• 3-phase fault on WHITNEY2 to WHIT1-1 Circuit 1 138kV/69kV/13.8kV Three-Winding Transformer near WHITNEY4 • Apply fault at the WHITNEY4 bus • Clear fault after 6 cycles and trip the faulted transformer
FLT9018-3PH	P1	• 3-phase fault on WHITNEY2 to WHIT1-1 Circuit 2 138kV/69kV/13.8kV Three-Winding Transformer near WHITNEY4 • Apply fault at the WHITNEY4 bus • Clear fault after 6 cycles and trip the faulted transformer

Fault ID	Planning Event	Fault Descriptions
FLT9019-3PH	P1	• Apply 3-phase fault on WHITNEY4 138kV to EASTEX 4 Circuit 1, near WHITNEY4 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9020-3PH	P1	• Apply 3-phase fault on WHITNEY4 138kV to LONGVHT4 Circuit 1, near WHITNEY4 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9021-3PH	P1	• Apply 3-phase fault on PIRKEY 4 138kV to WHITNEY4 Circuit 1, near PIRKEY 4 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9022-3PH	P1	• Apply 3-phase fault on PIRKEY 4 138kV to MARSHL-4 Circuit 1, near PIRKEY 4 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9023-3PH	P1	• Apply 3-phase fault on PIRKEY 4 138kV to EASTON 4 Circuit 1, near PIRKEY 4 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9024-3PH	P1	• Apply 3-phase fault on PIRKEY 4 138kV to SABMINT4 Circuit 1, near PIRKEY 4 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9025-3PH	P1	• 3-phase fault on MARAUTO2 to MRSH4#21 Circuit 1 138kV/69kV/13.8kV Three-Winding Transformer near MARSHL-4 • Apply fault at the MARSHL-4 bus • Clear fault after 6 cycles and trip the faulted transformer
FLT9026-3PH	P1	• 3-phase fault on MARAUTO2 to MRSH4#21 Circuit 2 138kV/69kV/13.8kV Three-Winding Transformer near MARSHL-4 • Apply fault at the MARSHL-4 bus • Clear fault after 6 cycles and trip the faulted transformer
FLT9027-3PH	P1	• Apply 3-phase fault on SABMINT4 138kV to SEMRSHL4 Circuit 1, near SABMINT4 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9028-3PH	P1	• Apply 3-phase fault on SABMINT4 138kV to SABINEM4 Circuit 1, near SABMINT4 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9029-3PH	P1	• Apply 3-phase fault on SEMRSHL4 138kV to SCOTTSV4 Circuit 1, near SEMRSHL4 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9030-3PH	P1	• Apply 3-phase fault on KNOXLEE4 138kV to OAK2HIL4 Circuit 1, near KNOXLEE4 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault

Fault ID	Planning Event	Fault Descriptions
FLT9031-3PH	P1	• 3-phase fault on KNOXLEE2 to KXLEE-1 Circuit 1 138kV/69kV/13.8kV Three-Winding Transformer near KNOXLEE4 • Apply fault at the KNOXLEE4 bus • Clear fault after 6 cycles and trip the faulted transformer
FLT9032-3PH	P1	• Apply 3-phase fault on KNOXLEE4 138kV to CHEROKE4 Circuit 1, near KNOXLEE4 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9033-3PH	P1	• Apply 3-phase fault on KNOXLEE4 138kV to MONROER4 Circuit 1, near KNOXLEE4 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9034-3PH	P1	• Apply 3-phase fault on KNOXLEE4 138kV to SOTXEST4 Circuit 1, near KNOXLEE4 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9035-3PH	P1	• Apply 3-phase fault on KNOXLEE4 138kV to HARRISN4 Circuit 1, near KNOXLEE4 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9036-3PH	P1	• Apply 3-phase fault on KNOXLEE4 138kV to HARRISN4 Circuit 1, near KNOXLEE4 • Clear fault for 6 cycles by tripping the faulted circuit • Wait 20 cycles then re-close the faulted line • Leave fault on for 6 cycles, then re-open the circuit and clear the fault
FLT9001-SLG	P4	• Apply single-phase fault at PIRKEY 4 on the 138kV bus • After 16 cycles, trip the following elements • Trip the EASTON 4 138kV Bus • Trip the SABMINT4 138kV Bus
FLT9002-SLG	P4	• Apply single-phase fault at PIRKEY 4 on the 138kV bus • After 16 cycles, trip the following elements • Trip the PIRKEY 4 to MARSHL-4 138kV Transmission Line Ckt 1 • Trip the PIRKEY 4 to WHITNEY4 138kV Transmission Line Ckt 1
FLT9003-SLG	P4	• Apply single-phase fault at PIRKEY 4 on the 138kV bus • After 16 cycles, trip the following elements • Trip the SABMINT4 138kV Bus • Trip the PIRKEY 4 to PIRKEY 7 to PIRKY1-1 138kV/345kV Transformer Ckt 1
FLT9004-SLG	P4	• Apply single-phase fault at PIRKEY 4 on the 138kV bus • After 16 cycles, trip the following elements • Trip the PIRKEY 4 to MARSHL-4 138kV Transmission Line Ckt 1 • Trip the PIRKEY 4 to PIRKEY 7 to PIRKY1-1 138kV/345kV Transformer Ckt 1
FLT9005-SLG	P4	• Apply single-phase fault at PIRKEY 4 on the 138kV bus • After 16 cycles, trip the following elements • Trip the PIRKEY 4 to WHITNEY4 138kV Transmission Line Ckt 1 • Trip the PIRKEY 4 to PIRKEY 7 to PIRKY1-1 138kV/345kV Transformer Ckt 1
FLT9006-SLG	P4	• Apply single-phase fault at PIRKEY 4 on the 138kV bus • After 16 cycles, trip the following elements • Trip the PIRKEY 4 to PIRKEY 7 to PIRKY1-1 138kV/345kV Transformer Ckt 2 • Trip GEN-2022-GR1 Bus

Fault ID	Planning Event	Fault Descriptions
FLT9007-SLG	P4	• Apply single-phase fault at PIRKEY 4 on the 138kV bus • After 16 cycles, trip the following elements • Trip the EASTON 4 138kV Bus
FLT9008-SLG	P4	• Apply single-phase fault at LEBROCK7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the LEBROCK7 to PIRKEY 7 345kV Transmission Line Ckt 1 • Trip LEBROCG1 345kV Bus
FLT9009-SLG	P4	• Apply single-phase fault at LEBROCK7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the LEBROCK7 to TENRUSK7 7 345kV Transmission Line Ckt 1 • Trip LEBROCG1 345kV Bus
FLT9010-SLG	P4	• Apply single-phase fault at LEBROCK7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the LEBROCK7 to TENRUSK7 345kV Transmission Line Ckt 1 • Trip LEBROCG2 345kV Bus
FLT9011-SLG	P4	• Apply single-phase fault at LEBROCK7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the LEBROCK7 to TENRUSK7 345kV Transmission Line Ckt 2 • Trip LEBROCG2 345kV Bus
FLT9012-SLG	P4	• Apply single-phase fault at LEBROCK7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the LEBROCK7 to TENRUSK7 345kV Transmission Line Ckt 2 • Trip LEBROCS1 345kV Bus
FLT9013-SLG	P4	• Apply single-phase fault at LEBROCK7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the LEBROCK7 to TENRUSK7 345kV Transmission Line Ckt 1 • Trip LEBROCS1 345kV Bus
FLT9014-SLG	P4	• Apply single-phase fault at TENRUSK7 on the 345kV bus • After 16 cycles, trip the following elements • Trip TENRUSK7 345kV Bus
FLT9015-SLG	P4	• Apply single-phase fault at CROCKET7 on the 345kV bus • After 16 cycles, trip the following elements • Trip CROCKET7 345kV Bus
FLT9016-SLG	P4	• Apply single-phase fault at PIRKEY 7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the LEBROCK7 to PIRKEY 7 345kV Transmission Line Ckt 1 • Trip the PIRKEY 7 to PIRKEY 4 to PIRKY2-1 345/138kV Transmission Line Ckt 1
FLT9017-SLG	P4	• Apply single-phase fault at PIRKEY 7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the LEBROCK7 to PIRKEY 7 345kV Transmission Line Ckt 1 • Trip the PIRKEY 7 to PIRKEY 4 to PIRKY2-1 345/138kV Transmission Line Ckt 2
FLT9018-SLG	P4	• Apply single-phase fault at PIRKEY 7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the LEBROCK7 to PIRKEY 7 345kV Transmission Line Ckt 2 • Trip the PIRKEY 7 to PIRKEY 4 to PIRKY2-1 345/138kV Transmission Line Ckt 1
FLT9019-SLG	P4	• Apply single-phase fault at PIRKEY 7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the LEBROCK7 to PIRKEY 7 345kV Transmission Line Ckt 2

Fault ID	Planning Event	Fault Descriptions
		• Trip the PIRKEY 7 to PIRKEY 4 to PIRKY2-1 345/138kV Transmission Line Ckt 2
FLT9020-SLG	P4	• Apply single-phase fault at PIRKEY 7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the PIRKEY 7 to DIANA 7 345kV Transmission Line Ckt 1 • Trip the PIRKEY 7 to PIRKEY 4 to PIRKY2-1 345/138kV Transmission Line Ckt 2
FLT9021-SLG	P4	• Apply single-phase fault at PIRKEY 7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the PIRKEY 7 to DIANA 7 345kV Transmission Line Ckt 1 • Trip the PIRKEY 7 to LEBROCK7 345kV Transmission Line Ckt 1
FLT9022-SLG	P4	• Apply single-phase fault at DIANA 7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the DIANA 7 to PIRKEY 7 345kV Transmission Line Ckt 1 • Trip the DIANA 7 to SW SHV 7 345kV Transmission Line Ckt 1
FLT9023-SLG	P4	• Apply single-phase fault at DIANA 7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the DIANA 7 to SW SHV 7 345kV Transmission Line Ckt 1 • Trip the DIANA 7 to WELSH 7 345kV Transmission Line Ckt 1
FLT9024-SLG	P4	• Apply single-phase fault at DIANA 7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the DIANA 7 to WELSH 7 345kV Transmission Line Ckt 2 • Trip the DIANA 7 to DIANA 4 to DIANA-M1 Circuit 3 345kV/138kV/13.8kV Three-Winding Transformer
FLT9025-SLG	P4	• Apply single-phase fault at DIANA 7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the DIANA 7 to WELSH 7 345kV Transmission Line Ckt 1 • Trip the DIANA 7 to DIANA 4 to DIANA-M1 Circuit 3 345kV/138kV/13.8kV Three-Winding Transformer
FLT9026-SLG	P4	• Apply single-phase fault at DIANA 7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the DIANA 7 to WELSH 7 345kV Transmission Line Ckt 1 • Trip the DIANA 7 to DIANA 4 to DIANA-M1 Circuit 3 345kV/138kV/13.8kV Three-Winding Transformer
FLT9027-SLG	P4	• Apply single-phase fault at DIANA 7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the DIANA 7 to DIANA 4 to DIANA-M1 Circuit 3 345kV/138kV/13.8kV Three-Winding Transformer • Trip the DIANA 7 to DIANA 4 to DIANA-M1 Circuit 3 345kV/138kV/13.8kV Three-Winding Transformer
FLT9028-SLG	P4	• Apply single-phase fault at DIANA 7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the DIANA 7 to DIANA 4 to DIANA-N1 Circuit 1 345kV/138kV/13.8kV Three-Winding Transformer
FLT9029-SLG	P4	• Apply single-phase fault at DIANA 7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the DIANA 7 to DIANA 4 to DIANA-N1 Circuit 1 345kV/138kV/13.8kV Three-Winding Transformer • Trip the DIANA 7 to DIANA 4 to DIANA-N1 Circuit 1 345kV/138kV/13.8kV Three-Winding Transformer

Fault ID	Planning Event	Fault Descriptions
FLT9030-SLG	P4	• Apply single-phase fault at DIANA 7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the DIANA 7 to DIANA 4 to DIANA-N1 Circuit 1 345kV/138kV/13.8kV Three-Winding Transformer • Trip the DIANA 7 to PIRKEY 7 345kV Transmission Line Ckt 1
FLT9031-SLG	P4	• Apply single-phase fault at DIANA 7 on the 345kV bus • After 16 cycles, trip the following elements • Trip the DIANA 7 to DIANA 4 to DIANA-N1 Circuit 1 345kV/138kV/13.8kV Three-Winding Transformer • Trip the DIANA 7 to WELSH 7 345kV Transmission Line Ckt 1 • Trip the DIANA 7 to PIRKEY 7 345kV Transmission Line Ckt 1
FLT9032-SLG	P4	• Apply single-phase fault at DIANA 7 on the 345kV bus • Trip the DIANA 7 to DIANA 4 to DIANA-N1 Circuit 1 345kV/138kV/13.8kV Three-Winding Transformer • After 16 cycles, trip the following elements • Trip the DIANA 7 to WELSH 7 345kV Transmission Line Ckt 1 • Trip the DIANA 7 to PIRKEY 7 345kV Transmission Line Ckt 1

Table 12: Fault Definitions

RESULTS

Table 13 shows the relevant results of the fault events simulated for each of the modified cases. The associated stability plots are also provided in Appendix C.

Fault ID	19W			21L			21S			28S		
	Voltage Recovery	Voltage Violation	Stable	Voltage Recovery	Voltage Violation	Stable	Voltage Recovery	Voltage Violation	Stable	Voltage Recovery	Voltage Violation	Stable
FLT9001-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9002-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9003-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9004-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9005-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable

Fault ID	19W			21L			21S			28S		
	Voltage Recovery	Voltage Violation	Stable	Voltage Recovery	Voltage Violation	Stable	Voltage Recovery	Voltage Violation	Stable	Voltage Recovery	Voltage Violation	Stable
FLT9006-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9007-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9008-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9009-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9010-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9011-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9012-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9013-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9014-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9015-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9016-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9017-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9018-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9019-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable

Fault ID	19W			21L			21S			28S		
	Voltage Recovery	Voltage Violation	Stable	Voltage Recovery	Voltage Violation	Stable	Voltage Recovery	Voltage Violation	Stable	Voltage Recovery	Voltage Violation	Stable
FLT9020-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9021-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9022-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9023-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9024-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9025-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9026-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9027-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9028-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9029-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9030-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9031-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9032-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9033-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable

Fault ID	19W			21L			21S			28S		
	Voltage Recovery	Voltage Violation	Stable	Voltage Recovery	Voltage Violation	Stable	Voltage Recovery	Voltage Violation	Stable	Voltage Recovery	Voltage Violation	Stable
FLT9034-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9035-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9036-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9001-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9002-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9003-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9004-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9005-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9006-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9007-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9008-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9009-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9010-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9011-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable

Fault ID	19W			21L			21S			28S		
	Voltage Recovery	Voltage Violation	Stable	Voltage Recovery	Voltage Violation	Stable	Voltage Recovery	Voltage Violation	Stable	Voltage Recovery	Voltage Violation	Stable
FLT9012-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9013-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9014-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9015-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9016-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9017-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9018-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9019-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9020-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9021-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9023-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9024-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9025-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9026-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable

Fault ID	19W			21L			21S			28S		
	Voltage Recovery	Voltage Violation	Stable	Voltage Recovery	Voltage Violation	Stable	Voltage Recovery	Voltage Violation	Stable	Voltage Recovery	Voltage Violation	Stable
FLT9027-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9028-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9029-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9030-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9031-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9032-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9033-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9034-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9035-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9036-SLG	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable

Table 13: Dynamic Stability Results

There were no damping or voltage recovery violations attributed to the GEN-2022-GR1 replacement request observed during the simulated faults. Additionally, the project was found to stay connected during the contingencies that were studied and, therefore, will meet the Low Voltage Ride Through (LVRT) requirements of FERC Order #661A.

INSTALLED CAPACITY EXCEEDS GIA CAPACITY

Under FERC Order 845, Interconnection Customers are allowed to request Interconnection Service that is lower than the full generating capacity of their planned generating facilities. The

Interconnection Customers must install acceptable control and protection devices that prevent the injection above their requested Interconnection Service amount measured at the POI.

NECESSARY INTERCONNECTION FACILITIES

This study identified necessary Interconnection Facilities to accommodate GEN-2022-GR1:

Upgrade Name	Upgrade Description
Pirkey 138kV GEN-2022-GR1 Interconnection (TOIF) (AEP)	Interconnection upgrades and cost estimates needed to interconnect the following Interconnection Customer facility, GEN-2022-GR1, into the POI at Pirkey 138kV.
Pirkey 138kV GEN-2022-GR1 Interconnection (Non-Shared NU) (AEP)	Interconnection upgrades and cost estimates needed to interconnect the following Interconnection Customer facility, GEN-2022-GR1, into the POI at Pirkey 138kV.

Table 14: Necessary Interconnection Facilities

Should the Interconnection Customer choose to move forward with this request, an Interconnection Facilities Study will be necessary to determine the full scope, cost, and time required to interconnect these upgrades. SPP will work with the Transmission Owner(s) indicated for the Interconnection Facilities Study.

RESULTS

RELIABILITY ASSESSMENT STUDY

In accordance with Attachment V and Business Practice 7800, the Reliability Assessment Study for Generator Replacements evaluates regional transmission impacts from removing the EGF from service and any non-transmission mitigations necessary for those impacts.

Based on the findings of the operations and planning analysis, **no mitigations will be necessary** due to the removal of the EGF from service.

REPLACEMENT IMPACT STUDY

In accordance with SPP tariff Attachment V, any material adverse impact from operating the RGF when compared to the EGF would be identified as a Material Modification. In the case that the Interconnection Customer chooses to move forward with the RGF, it must submit the RGF as a new Interconnection Request.

Because no material adverse impacts to the SPP Transmission System were identified, SPP determined the requested replacement is **not a Material Modification**. SPP determined that the requested replacement did not cause a materially adverse impact to the dynamic stability and short-circuit characteristics of the SPP system.

This determination implies that no new upgrades beyond those required for interconnection of the RGF are required, thus not resulting in a material adverse impact on the cost or timing of any other Interconnection Request with a later Queue priority date.

NEXT STEPS

As the requested replacement is determined to not be a Material Modification, pursuant to SPP tariff Attachment V section 3.9.3, the Interconnection Customer shall inform SPP within 30 Calendar Days after having received these study results of its election to proceed.

If the Interconnection Customer chooses to proceed with the studied replacement, SPP will initiate an Interconnection Facilities Study and subsequently tender a draft GIA. The Interconnection Customer shall withdraw any associated Attachment AB retirement requests of the EGF, if applicable, and complete the Attachment AE requirements for de-registration of the EGF and registration of the RGF, including transfer or termination of applicable existing transmission service. If the Interconnection Customer would like to obtain new deliverability to final customers, a separate request for transmission service must be requested on Southwest Power Pool's OASIS.

Failure by the Interconnection Customer to provide an election to proceed within 30 Calendar Days will result in withdrawal of the Interconnection Request pursuant to section 3.7 of SPP tariff Attachment V.