



Report on

GEN-2023-SR13 Surplus Service Impact Study

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Southwest Power Pool



anedenconsulting.com

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Revision History

| DATE OR VERSION NUMBER | AUTHOR | CHANGE DESCRIPTION |
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Executive Summary

Aneden Consulting (Aneden) was retained by the Southwest Power Pool (SPP) to perform a Surplus Interconnection Service Impact Study (Study) for GEN-2023-SR13 to utilize the Surplus Interconnection Service being made available by the combined GEN-2012-033 & GEN-2015-062 project at its existing Point of Interconnection (POI), the Breckinridge 138 kV Substation in the Oklahoma Gas & Electric Company (OG&E) control area.

GEN-2023-SR13, the proposed Surplus Generating Facility (SGF), will connect to the existing GEN-2012-033 & GEN-2015-062 main collection substation and share its main power transformer.

GEN-2012-033 & GEN-2015-062, the Existing Generating Facility (EGF), has an effective Generator Interconnection Agreement (GIA) with a combined POI capacity of 102.56 MW and is making 70 MW of Surplus Interconnection Service available at its POI. Per the SPP Open Access Transmission Tariff (SPP Tariff), the amount of Surplus Interconnection Service available to the SGF is limited by the amount of Interconnection Service granted to the EGF at the same POI. In addition, the Surplus Interconnection Service is only available up to the amount that can be accommodated without requiring Network Upgrades except those specified in the SPP Tariff¹.

The proposed SGF configuration consists of 19 x PE HEM FP4200M Battery Energy Storage System (BESS) inverters operating at 3.6842 MW for a total assumed dispatch of 70 MW. The inverters are rated at 4.2 MW, thus the generating capability of the SGF (79.8 MW) exceeds its requested Surplus Interconnection Service of 70 MW. The injection amount of the SGF must be limited to 70 MW at the POI. The combined generation from both the SGF and the EGF may not exceed 102.56 MW at the POI. GEN-2023-SR13 includes the use of a Power Plant Controller (PPC) to limit the power injection as required. The SGF and EGF information is shown in Table ES-1 below.

The detailed SGF configuration is captured in Table ES-2 below.

Table ES-1: EGF & SGF Configuration

| Request | Interconnection Queue Capacity (MW) | Generator Fuel Type | Point of Interconnection |
|-----------------------------------|-------------------------------------|---------------------|---|
| GEN-2023-SR13 (SGF) | 70 | Battery/Storage | Breckinridge 138 kV Substation (514815) |
| GEN-2012-033 & GEN-2015-062 (EGF) | 102.56 | Wind | Breckinridge 138 kV Substation (514815) |

¹ Allowed Network Upgrades detailed in SPP Open Access Transmission Tariff Attachment V Section 3.3

Table ES-2: SGF Interconnection Configuration

| Facility | SGF Configuration |
|---|---|
| Point of Interconnection | Breckinridge 138 kV Substation (514815) |
| Configuration/Capacity | 19 x PE HEM FP4200M operating at 3.6842 MW (BESS) = 70 MW [dispatch] Units are rated at 4.2 MW, PPC to limit GEN-2023-SR13 to 70 MW at the POI and total POI injection w/ GEN-2012-033 & GEN-2015-062 to 102.56 MW |
| Generation Interconnection Line (Shared with the EGF and unchanged) | Length = 7 miles R = 0.003080 pu X = 0.026190 pu B = 0.008050 pu Rating MVA = 204 MVA |
| Main Substation Transformer ¹ (Shared with the EGF and unchanged) | X12 = 8.808% R12 = 0.237%, X23 = 14.69% R23 = 0.543%, X13 = 3.754% R13 = 0.441%, Winding MVA = 84 MVA, Winding 1 & 2 Rating MVA = 140 MVA Winding 3 Rating MVA = 46.7 MVA |
| Equivalent GSU Transformer ¹ | Gen 1 Equivalent Qty: 19 X = 8.958%, R = 0.87%, Winding MVA = 79.933 MVA, Rating MVA ² = 79.9 MVA |
| Generator Dynamic Model ³ & Power Factor | 19 x PE HEM FP4200M 4.2 MVA (REGCAU1) ³ Leading: 0.878 Lagging: 0.878 |

1) X and R based on Winding MVA, 2) Rating rounded in PSS/E, 3) DYR stability model name

SPP determined that steady-state analysis was not required because the addition of the SGF does not increase the maximum active power output of 102.56 MW. In addition, the EGF was previously studied at maximum Interconnection Service under all necessary reliability conditions.

The scope of this study included reactive power analysis, short circuit analysis, and dynamic stability analysis.

Aneden performed the analyses using the study data provided for the SGF and the DISIS-2017-002-1 study models:

- 2025 Summer Peak (25SP),
- 2025 Winter Peak (25WP)

All analyses were performed using the Siemens PTI PSS/E² version 34 software and the results are summarized below.

The results of the reactive power analysis using the 25SP model showed that the SGF project did not need a shunt reactor at the project substation to reduce the POI MVAR to zero when the EGF project had a shunt compensating for its charging effects. No additional compensation was necessary to offset the capacitive effect on the transmission network caused by the project during reduced generation conditions. The information gathered from the reactive power analysis is provided as information to the Interconnection Customer and Transmission Owner (TO) and/or Transmission Operator (TOP). The applicable reactive power requirements will be further reviewed by the TO and/or TOP.

² Power System Simulator for Engineering

The short circuit analysis was performed using the 25SP stability model modified for short circuit analysis. The results from the short circuit analysis compared the 25SP model with the EGF online and SGF not connected to the SGF study model (EGF and SGF online). The maximum contribution to three-phase fault currents in the immediate transmission systems due to the addition of the SGF was not greater than 0.15 kA. The maximum three-phase fault current level within 5 buses of the POI with the EGF and SGF generators online was below 22 kA for the 25SP model.

The dynamic stability analysis was performed using Siemens PTI PSS/E version 34.8.0 software for the two modified study models: 25SP and 25WP, each with two dispatch scenarios. 29 events were simulated, which included three-phase faults and single-line-to-ground stuck breaker faults.

- Scenario 1: SGF at maximum assumed dispatch, 70 MW, and EGF disconnected.
- Scenario 2: SGF at maximum assumed dispatch, 70 MW, and EGF dispatched with the remaining 32.56 MW for a total combination of 102.56 MW.

The results of the dynamic stability analysis showed several existing base case issues that were found in both the original DISIS-2017-002-1 model and in the model with GEN-2023-SR13 included. These issues were not attributed to the GEN-2023-SR13 surplus request and are detailed in Appendix C.

There were no damping or voltage recovery violations attributed to the GEN-2023-SR13 surplus 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.

The results of the study showed that the Surplus Interconnection Service Request by GEN-2023-SR13 did not negatively impact the reliability of the Transmission System. There were no additional Interconnection Facilities or Network Upgrades identified by the analyses.

SPP has determined that GEN-2023-SR13 may utilize the requested 70 MW of Surplus Interconnection Service being made available by the EGF. The combined generation from both the SGF and the EGF may not exceed 102.56 MW at the POI.

The customer must install monitoring and control equipment as needed to ensure that the SGF does not exceed the granted surplus amount and to ensure that combination of the SGF and EGF power injected at the POI does not exceed the Interconnection Service amount listed in the EGF's GIA. The monitoring and control scheme may be reviewed by the TO and documented in Appendix C of the SGF GIA.

In accordance with FERC Order No. 827, both the SGF and EGF 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.

It is likely that the customer may be required to reduce its generation output to 0 MW 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. If the customer wishes to obtain deliverability to final customers, a separate request for transmission service must be requested on Southwest Power Pool's OASIS by the customer.

1.0 Scope of Study

Aneden Consulting (Aneden) was retained by the Southwest Power Pool (SPP) to perform a Surplus Service Impact Study (Study) for GEN-2023-SR13, the Surplus Generating Facility (SGF). A Surplus Service Impact Study is performed to identify the impact of the Surplus Interconnection Service on the transmission system reliability and any additional Interconnection Facilities necessary pursuant to the SPP Generator Interconnection Procedures (“GIP”) contained in Attachment V Section 3.3 of the SPP Open Access Transmission Tariff (SPP Tariff). The amount of Surplus Interconnection Service available to the SGF is limited by the amount of Interconnection Service granted to the existing interconnection customer for the Existing Generating Facility (EGF) at the same POI. The Surplus Interconnection Service is only available up to the amount that can be accommodated without requiring additional Network Upgrades except those specified in the SPP Tariff³. The required scope of the study is dependent upon the EGF and SGF specifications. The criteria sections below include the basis of the analyses included in the scope of study.

All analyses were performed using the Siemens PTI PSS/E version 34 software. The results of each analysis are presented in the following sections.

1.1 Reactive Power Analysis

SPP requires that a reactive power analysis be performed on the requested configuration if it is a non-synchronous resource. The reactive power analysis determines the added capacitive effect at the POI caused by the project’s collection system and transmission line’s capacitance. A shunt reactor size was determined for the SGF to offset the capacitive effect and maintain zero (0) MVar injection at the POI while the plant’s generators and capacitors were offline, and the EGF project had a shunt compensating for its charging effects.

1.2 Short Circuit Analysis

SPP requires that a short circuit analysis be performed to determine the maximum available fault current requiring interruption by protective equipment with both the SGF and EGF online, along with the amount of increase in maximum fault current due to the addition of the SGF. The analysis was performed on two scenarios, with the EGF in service and SGF offline, and the modified model with both EGF and SGF in service.

1.3 Stability Analysis

SPP requires that a dynamic stability analysis be performed to determine whether the SGF, EGF, and the transmission system will remain stable and within applicable criteria. Dynamic stability analysis was performed on two dispatch scenarios, the first where the SGF was online at 100% of the assumed dispatch with the EGF offline and disconnected, and the second where the SGF was online at 100% of the assumed dispatch and the EGF was picking up the remaining EGF GIA capacity. The stability analyses will identify any additional Interconnection Facilities and Network Upgrades necessary.

1.4 Steady-State Analysis

The steady-state (thermal/voltage) analyses may be performed as necessary to ensure that all required reliability conditions are studied. If the EGF was not studied under off-peak conditions, off-peak steady state analyses shall be performed to the required level necessary to demonstrate reliable operation of the Surplus Interconnection Service. If the original system impact study is not available for the

³ Allowed Network Upgrades detailed in SPP Open Access Transmission Tariff Attachment V Section 3.3

Interconnection Service, both off-peak and peak analysis may need to be performed for the EGF associated with the request.

An SGF that includes a fuel type (synchronous/non-synchronous) different from the EGF may require a steady-state analysis to study impacts resultant from changes in dispatch to all equal and lower queued requests. The steady-state analyses will identify any additional Interconnection Facilities and Network Upgrades necessary.

1.5 Necessary Interconnection Facilities & Network Upgrades

The SPP Tariff⁴ states that the reactive power, short circuit/fault duty, stability, and steady-state analyses (where applicable) for the Surplus Interconnection Service will identify any additional Interconnection Facilities necessary. In addition, the analyses will determine if any Network Upgrades are required for mitigation. The Surplus Interconnection Service is only available up to the amount that can be accommodated without requiring additional Network Upgrades unless (a) those additional Network Upgrades are either (1) located at the Point of Interconnection substation and at the same voltage level as the Generating Facility with an effective GIA, or (2) are System Protection Facilities; and (b) there are no material adverse impacts on the cost or timing of any Interconnection Requests pending at the time the Surplus Interconnection Service request is submitted.

1.6 Study Limitations

The assessments and conclusions provided in this report are based on assumptions and information provided to Aneden by others. While the assumptions and information provided may be appropriate for the purposes of this report, Aneden does not guarantee that those conditions assumed will occur. In addition, Aneden did not independently verify the accuracy or completeness of the information provided. 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.

⁴ SPP Open Access Transmission Tariff Section 3.3.4.1

2.0 Surplus Interconnection Service Request

The GEN-2023-SR13 Interconnection Customer has requested a Surplus Interconnection Service Impact Study (Study) for GEN-2023-SR13 to utilize the Surplus Interconnection Service being made available by the combined GEN-2012-033 & GEN-2015-062 project at its existing Point of Interconnection (POI), the Breckinridge 138 kV Substation in the Oklahoma Gas & Electric Company (OG&E) control area.

GEN-2023-SR13, the proposed SGF, will connect to the existing GEN-2012-033 & GEN-2015-062 main collection substation and share its main power transformer.

GEN-2012-033 & GEN-2015-062, the EGF, has an effective Generation Interconnection Agreement (GIA) with a combined POI capacity of 102.56 MW and is making 70 MW of Surplus Interconnection Service available at its POI. Per the SPP Tariff the amount of Surplus Interconnection Service available to the SGF is limited by the amount of Interconnection Service granted to the EGF at the same POI. In addition, the Surplus Interconnection Service is only available up to the amount that can be accommodated without requiring additional Network Upgrades except those specified in the SPP Tariff.

At the time of the posting of this report, GEN-2012-033 & GEN-2015-062 (EGF) are active existing generators at the same POI (Breckinridge 138 kV) with queue statuses of “IA FULLY EXECUTED/COMMERCIAL OPERATION” and “IA FULLY EXECUTED/ON SCHEDULE” respectively. The GEN-2012-033 & GEN-2015-062 project is a wind farm with a maximum summer and winter combined queue capacity of 102.56 MW and has Energy Resource Interconnection Service (ERIS). The EGF was originally studied in the DISIS-2012-002 and DISIS-2015-002 cluster studies. Figure 2-1 shows the power flow model single line diagram for the EGF configuration.

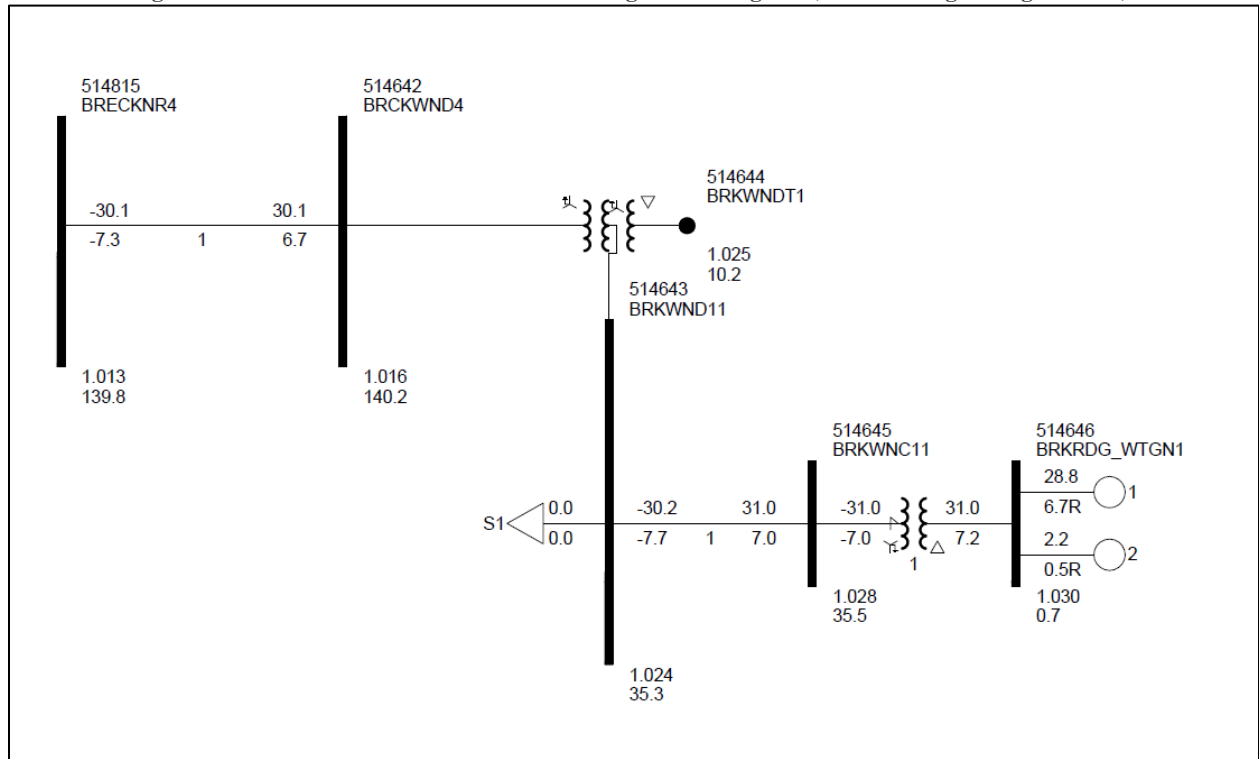
The proposed SGF configuration consists of 19 x PE HEM FP4200M Battery Energy Storage System (BESS) inverters operating at 3.6842 MW for a total assumed dispatch of 70 MW. The inverters are rated at 4.2 MW, thus the generating capability of the SGF (79.8 MW) exceeds its requested Surplus Interconnection Service of 70 MW. The injection amount of the SGF must be limited to 70 MW at the POI. The combined generation from both the SGF and the EGF may not exceed 102.56 MW at the POI. GEN-2023-SR13 includes the use of a Power Plant Controller (PPC) to limit the power injection as required. The SGF and EGF information is shown in Table 2-1 below.

Table 2-1: EGF & SGF Configuration

| Request | Interconnection Queue Capacity (MW) | Generator Fuel Type | Point of Interconnection |
|-----------------------------------|-------------------------------------|---------------------|---|
| GEN-2023-SR13 (SGF) | 70 | Battery/Storage | Breckinridge 138 kV Substation (514815) |
| GEN-2012-033 & GEN-2015-062 (EGF) | 102.56 | Wind | Breckinridge 138 kV Substation (514815) |

The proposed detailed SGF configuration is captured in Figure 2-2 and Table 2-2 below.

Figure 2-1: GEN-2012-033 & GEN-2015-062 Single Line Diagram (EGF Existing Configuration*)



*based on the DISIS-2017-002-1 25SP stability model

Figure 2-2: GEN-2012-033 & GEN-2015-062 and GEN-2023-SR13 Single Line Diagram (EGF & SGF Configuration)

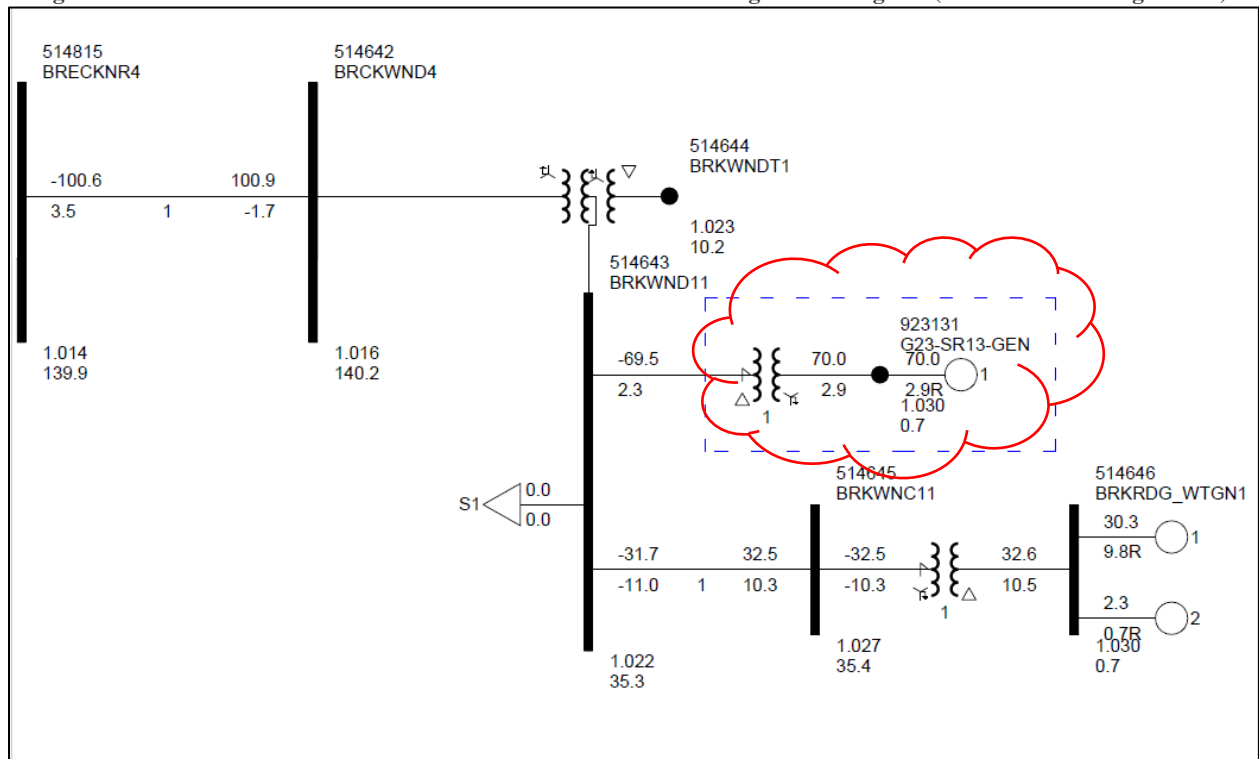


Table 2-2: SGF Interconnection Configuration

| Facility | SGF Configuration |
|---|---|
| Point of Interconnection | Breckinridge 138 kV Substation (514815) |
| Configuration/Capacity | 19 x PE HEM FP4200M operating at 3.6842 MW (BESS) = 70 MW [dispatch] Units are rated at 4.2 MW, PPC to limit GEN-2023-SR13 to 70 MW at the POI and total POI injection w/ GEN-2012-033 & GEN-2015-062 to 102.56 MW |
| Generation Interconnection Line (Shared with the EGF and unchanged) | Length = 7 miles R = 0.003080 pu X = 0.026190 pu B = 0.008050 pu Rating MVA = 204 MVA |
| Main Substation Transformer ¹ (Shared with the EGF and unchanged) | X12 = 8.808% R12 = 0.237%, X23 = 14.69% R23 = 0.543%, X13 = 3.754% R13 = 0.441%, Winding MVA = 84 MVA, Winding 1 & 2 Rating MVA = 140 MVA Winding 3 Rating MVA = 46.7 MVA |
| Equivalent GSU Transformer ¹ | Gen 1 Equivalent Qty: 19 X = 8.958%, R = 0.87%, Winding MVA = 79.933 MVA, Rating MVA ² = 79.9 MVA |
| Generator Dynamic Model ³ & Power Factor | 19 x PE HEM FP4200M 4.2 MVA (REGCAU1) ³ Leading: 0.878 Lagging: 0.878 |

1) X and R based on Winding MVA, 2) Rating rounded in PSS/E, 3) Dyr stability model name

3.0 Reactive Power Analysis

The reactive power analysis was performed for GEN-2023-SR13 to determine the capacitive charging effects due to the SGF during 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.

3.1 Methodology and Criteria

In order to determine the required shunt reactor size the SGF would need to compensate for the current charging attributed to its collection system, the reactive power analysis for the EGF was determined first. Once the shunt size for the EGF was determined, the SGF incremental shunt reactor size was then calculated.

For each of the shunt reactor sizes calculated, all project generators were switched offline while other collector system elements remained in-service. For the SGF reactor size calculation, the EGF generators were also switched offline. A shunt reactor was tested at the project's collection substation 34.5 kV bus to set 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).

Aneden performed the reactive power analysis using the SGF data based on the 25SP DISIS-2017-002-1 stability study model.

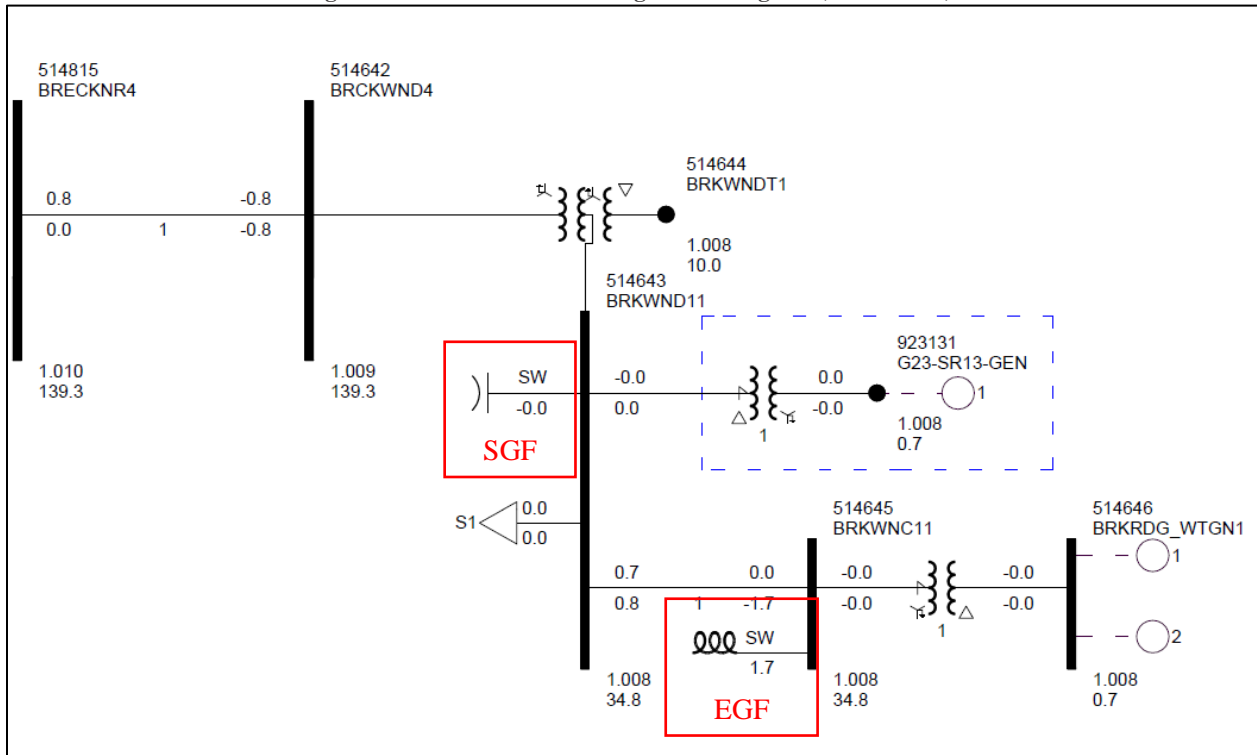
3.2 Results

Per the methodology described above, the shunt size was determined for the EGF prior to calculating the shunt reactor size for the SGF. The shunt size was found to be a 1.7 MVAR reactor for the EGF to reduce the POI MVAR to approximately zero. Note that the EGF shunt value is for the SGF reactive size determination only and not for sizing the predetermined EGF reactive requirements.

The results from the analysis showed that the SGF did not need a shunt reactor at the project substation to reduce the POI MVAR to zero with the pre-determined shunt for the EGF in-service. Figure 3-1 illustrates that no additional compensation was necessary to offset the capacitive effect on the transmission network caused by the project during reduced generation conditions.

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

Figure 3-1: GEN-2023-SR13 Single Line Diagram (Shunt Sizes)



4.0 Short Circuit Analysis

A short circuit study was performed using the 25SP model to determine the maximum available fault current requiring interruption by protective equipment with both the SGF and EGF online for each bus in the relevant subsystem, and the amount of increase in maximum fault current due to the addition of the SGF. The detailed results of the short circuit analysis are provided in Appendix B.

4.1 Methodology

The short circuit analysis included applying a 3-phase fault on buses up to 5 levels away from the 138 kV 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 the SGF online. The first scenario was studied with both the SGF and EGF in service. In the second scenario the SGF was disconnected while the EGF was online in order to determine the impact of the SGF.

Aneden created a short circuit model using the 25SP DISIS-2017-002-1 stability study model by adjusting the SGF short circuit parameters consistent with the submitted data. The adjusted parameters used in the short circuit analysis are shown in Table 4-1 below. No other changes were made to the model.

Table 4-1: Short Circuit Model Parameters*

| Parameter | Value by Generator Bus# |
|------------------|-------------------------|
| | 923131 |
| Machine MVA Base | 79.8 |
| R (pu) | 0.0 |
| X'' (pu) | 0.893 |

*pu values based on Machine MVA Base

4.2 Results

The results of the short circuit analysis compared the 25SP model with the EGF online and SGF not connected to the stability Scenario 2 dispatch model with both the EGF and SGF in service as described in Section 5.1. The GEN-2023-SR13 POI bus (Breckinridge 138 kV - 514815) fault current magnitudes for the comparison cases are provided in Table 4-2 showing a fault current of 15.05 kA with the EGF and SGF online. The addition of the SGF configuration increased the POI bus fault current by 0.15 kA. Table 4-3 shows the maximum fault current magnitudes and fault current increases with the SGF project online.

The maximum fault current calculated within 5 buses of the POI was less than 22 kA for the 25SP model. The maximum contribution to three-phase fault currents due to the addition of the SGF was about 1.0% and 0.15 kA.

Table 4-2: POI Short Circuit Comparison Results

| Case | EGF Only Current (kA) | SGF & EGF Current (kA) | kA Change | %Change |
|------|-----------------------|------------------------|-----------|---------|
| 25SP | 14.89 | 15.05 | 0.15 | 1.0% |

Table 4-3: 25SP Short Circuit Comparison Results

| Voltage (kV) | Max. Current (EGF & SGF) (kA) | Max kA Change | Max %Change |
|--------------|-------------------------------|---------------|-------------|
| 69 | 14.1 | 0.04 | 0.3% |
| 138 | 21.3 | 0.15 | 1.0% |
| 345 | 20.8 | 0.01 | 0.1% |
| Max | 21.3 | 0.15 | 1.0% |

5.0 Dynamic Stability Analysis

Aneden performed a dynamic stability analysis to identify the impact of the SGF project. The analysis was performed according to SPP's Disturbance Performance Requirements⁵. The project details are described in Section 2.0 above and the dynamic modeling data is provided in Appendix A. The existing base case issues and simulation plots can be found in Appendix C.

5.1 Methodology and Criteria

The dynamic stability analysis was performed using models developed with the requested 19 x PE HEM FP4200M operating at 3.6842 MW (REGCAU1) SGF generating facility configuration included in the models. This stability analysis was performed using Siemens PTI's PSS/E version 34.8.0 software.

Two stability model scenarios were developed using the models from DISIS-2017-002-1. The first scenario (Scenario 1) was comprised of the SGF online at 100% of the assumed dispatch (SGF = 70 MW) while the EGF generator was offline and disconnected. The second scenario (Scenario 2) was comprised of the SGF at 100% of the assumed dispatch (SGF = 70 MW) while the EGF generator was picking up the remaining EGF GIA capacity (EGF = 32.56 MW). The study scenarios are shown in Table 5-1.

Table 5-1: Study Scenarios (Generator Dispatch MW)

| Scenario | GEN-2012-033 & GEN-2015-062 EGF (MW) | GEN-2023-SR13 SGF (MW) | EGF + SGF (MW) |
|----------|--------------------------------------|------------------------|----------------|
| 1 | 0 (Offline) | 70 | 70 |
| 2 | 32.56 | 70 | 102.56 |

The GEN-2023-SR13 project details were used to create modified stability models for this impact study based on the DISIS-2017-002-1 stability study models:

- 2025 Summer Peak (25SP),
- 2025 Winter Peak (25WP)

The dynamic model data for the GEN-2023-SR13 project is provided in Appendix A. The power flow models and associated dynamic database were initialized (no-fault test) to confirm that there were no errors in the initial conditions of the system and the dynamic data.

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

- The frequency protective relays at buses 599117, 515551, 599119, 599120, 515882, 515883, 515664, & 515665 were disabled after observing the generators tripping during initial three phase fault simulations. This frequency tripping issue is a known PSS/E limitation when calculating bus frequency as it relates to non-conventional type devices.
- The voltage protective relays at buses 515969, 515968, 515967, 515986, 515985, 515984, 587953, 587953, 539852, 539853, 539845, 539846, 539847, 539848, 515664, & 515665 were

⁵ [SPP Disturbance Performance Requirements:](https://www.spp.org/documents/28859/spp%20disturbance%20performance%20requirements%20(twg%20approved).pdf)

[https://www.spp.org/documents/28859/spp%20disturbance%20performance%20requirements%20\(twg%20approved\).pdf](https://www.spp.org/documents/28859/spp%20disturbance%20performance%20requirements%20(twg%20approved).pdf)

disabled to avoid generator tripping due to an instantaneous over voltage spike after fault clearing.

- The fault simulation file acceleration factor was reduced as needed to resolve stability simulation crashes.

During the fault simulations, the active power (PELEC), reactive power (QELEC), and terminal voltage (ETERM) were monitored for the EGF and SGF and other current and prior queued projects in their cluster group⁶. In addition, voltages of five (5) buses away from the POI of the SGF were monitored and plotted. The machine rotor angle for synchronous machines and speed for asynchronous machines within the study areas including 330 (AECI), 515 (SWPA), 520 (AEPW), 523 (GRDA), 524 (OKGE), 525 (WFEC), 527 (OMPA), and 534 (SUNC) were monitored. The voltages of all 100 kV and above buses within the study area were monitored as well.

5.2 Fault Definitions

Aneden developed and simulated fault events as required to study the SGF. The new set of faults was simulated using the modified study models. The fault events included three-phase faults and single-line-to-ground stuck breaker faults. Single-line-to-ground faults are approximated by applying a fault impedance to bring the faulted bus positive sequence voltage to 0.6 pu. The simulated faults are listed and described in Table 5-2 below. These contingencies were applied to the modified 25SP and 25WP models.

Table 5-2: Fault Definitions

| Fault ID | Planning Event | Fault Descriptions |
|-------------|----------------|--|
| FLT9001-3PH | P1 | 3 phase fault on the BRECKNR4 (514815) to BUNCHCK4 (514701) 138 kV line CKT 1, near BRECKNR4. a. Apply fault at the BRECKNR4 138 kV bus. b. Clear fault after 7 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 7 cycles, then trip the line in (b) and remove fault. |
| FLT9002-3PH | P1 | 3 phase fault on the BRECKNR4 (514815) to ENIDINT4 (515383) 138 kV line CKT 1, near BRECKNR4. a. Apply fault at the BRECKNR4 138 kV bus. b. Clear fault after 7 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 7 cycles, then trip the line in (b) and remove fault. |
| FLT9003-3PH | P1 | 3 phase fault on the BRECKNR4 (514815) to PLNSMEN4 (515641) 138 kV line CKT 1, near BRECKNR4. a. Apply fault at the BRECKNR4 138 kV bus. b. Clear fault after 7 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 7 cycles, then trip the line in (b) and remove fault. |
| FLT9004-3PH | P1 | 3 phase fault on the BRECKNR4 (514815) to SO4TH 4 (514731) 138 kV line CKT 1, near BRECKNR4. a. Apply fault at the BRECKNR4 138 kV bus. b. Clear fault after 7 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 7 cycles, then trip the line in (b) and remove fault. |
| FLT9005-3PH | P1 | 3 phase fault on the BUNCHCK4 (514701) to BLLNGTP4 (515635) 138 kV line CKT 1, near BUNCHCK4. a. Apply fault at the BUNCHCK4 138 kV bus. b. Clear fault after 7 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 7 cycles, then trip the line in (b) and remove fault. |

⁶ Based on the DISIS-2017-002 Cluster Groups

Table 5-2 Continued

| Fault ID | Planning Event | Fault Descriptions |
|-------------|----------------|--|
| FLT9006-3PH | P1 | 3 phase fault on the BLLNGTP4 (515635) to BILLING4 (520836) 138 kV line CKT 1, near BLLNGTP4. a. Apply fault at the BLLNGTP4 138 kV bus. b. Clear fault after 7 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 7 cycles, then trip the line in (b) and remove fault. |
| FLT9007-3PH | P1 | 3 phase fault on the BLLNGTP4 (515635) to FNTANTP4 (515403) 138 kV line CKT 1, near BLLNGTP4. a. Apply fault at the BLLNGTP4 138 kV bus. b. Clear fault after 7 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 7 cycles, then trip the line in (b) and remove fault. |
| FLT9008-3PH | P1 | 3 phase fault on the ENIDINT4 (515383) to NE ENID4 (514769) 138 kV line CKT 1, near ENIDINT4. a. Apply fault at the ENIDINT4 138 kV bus. b. Clear fault after 7 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 7 cycles, then trip the line in (b) and remove fault. |
| FLT9009-3PH | P1 | 3 phase fault on the ENIDINT4 (515383) to ENIDIND4 (515737) 138 kV line CKT 1, near ENIDINT4. a. Apply fault at the ENIDINT4 138 kV bus. b. Clear fault after 7 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 7 cycles, then trip the line in (b) and remove fault. |
| FLT9010-3PH | P1 | 3 phase fault on the PLNSMEN4 (515641) to FAIRMON4 (514712) 138 kV line CKT 1, near PLNSMEN4. a. Apply fault at the PLNSMEN4 138 kV bus. b. Clear fault after 7 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 7 cycles, then trip the line in (b) and remove fault. |
| FLT9011-3PH | P1 | 3 phase fault on the SO4TH 4 (514731) to FRMNTAP4 (514709) 138 kV line CKT 1, near SO4TH 4. a. Apply fault at the SO4TH 4 138 kV bus. b. Clear fault after 7 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 7 cycles, then trip the line in (b) and remove fault. |
| FLT9012-3PH | P1 | 3 phase fault on the SO4TH 4 (514731) to WAUKOTP4 (514711) 138 kV line CKT 1, near SO4TH 4. a. Apply fault at the SO4TH 4 138 kV bus. b. Clear fault after 7 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 7 cycles, then trip the line in (b) and remove fault. |
| FLT9013-3PH | P1 | 3 phase fault on the SO4TH 4 (514731) to IMO 4 (514790) 138 kV line CKT 1, near SO4TH 4. a. Apply fault at the SO4TH 4 138 kV bus. b. Clear fault after 7 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 7 cycles, then trip the line in (b) and remove fault. |
| FLT9014-3PH | P1 | 3 phase fault on the NEENID3 138 kV (514769) /69 kV (514732) /13.8 kV (515741) XFMR CKT 1, near NE ENID4 138 kV. a. Apply fault at the NE ENID4 138kV bus. b. Clear fault after 7 cycles and trip the faulted transformer. |
| FLT9015-3PH | P1 | 3 phase fault on the NE ENID4 (514769) to GLENWD 4 (514734) 138 kV line CKT 1, near NE ENID4. a. Apply fault at the NE ENID4 138 kV bus. b. Clear fault after 7 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 7 cycles, then trip the line in (b) and remove fault. |

Table 5-2 Continued

| Fault ID | Planning Event | Fault Descriptions |
|-------------|----------------|--|
| FLT9016-3PH | P1 | 3 phase fault on the FAIRMON4 (514712) to FRMNTAP4 (514709) 138 kV line CKT 1, near FAIRMON4. a. Apply fault at the FAIRMON4 138 kV bus. b. Clear fault after 7 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 7 cycles, then trip the line in (b) and remove fault. |
| FLT9017-3PH | P1 | 3 phase fault on the FRMNTAP4 (514709) to WOODRNG4 (514714) 138 kV line CKT 1, near FAIRMON4. a. Apply fault at the FAIRMON4 138 kV bus. b. Clear fault after 7 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 7 cycles, then trip the line in (b) and remove fault. |
| FLT9018-3PH | P1 | 3 phase fault on the WAUKOT4 (514711) to WOODRNG4 (514714) 138 kV line CKT 1, near WAUKOT4. a. Apply fault at the WAUKOT4 138 kV bus. b. Clear fault after 7 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 7 cycles, then trip the line in (b) and remove fault. |
| FLT9019-3PH | P1 | 3 phase fault on the WAUKOT4 (514711) to WAUKOMI4 (514710) 138 kV line CKT 1, near WAUKOT4. a. Apply fault at the WAUKOT4 138 kV bus. b. Clear fault after 7 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 7 cycles, then trip the line in (b) and remove fault. |
| FLT9020-3PH | P1 | 3 phase fault on the IMO 4 (514790) to GLENWD 4 (514734) 138 kV line CKT 1, near IMO 4. a. Apply fault at the IMO 4 138 kV bus. b. Clear fault after 7 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 7 cycles, then trip the line in (b) and remove fault. |
| FLT9021-3PH | P1 | 3 phase fault on the IMO1 138 kV (514790) /69 kV (514721) /13.2 kV (515788) XFMR CKT 1, near IMO 4 138 kV. a. Apply fault at the IMO 4 138kV bus. b. Clear fault after 7 cycles and trip the faulted transformer. |
| FLT9022-3PH | P1 | 3 phase fault on the IMO 4 (514790) to MENOTAP4 (514789) 138 kV line CKT 1, near IMO 4. a. Apply fault at the IMO 4 138 kV bus. b. Clear fault after 7 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 7 cycles, then trip the line in (b) and remove fault. |
| FLT9023-3PH | P1 | 3 phase fault on the SO4TH1 138 kV (514731) /69 kV (514730) /13.2 kV (515758) XFMR CKT 1, near SO4TH 4 138 kV. a. Apply fault at the SO4TH 4 138kV bus. b. Clear fault after 7 cycles and trip the faulted transformer. |
| FLT1001-SB | P4 | Stuck Breaker at BRECKNR4 (514815) 138 kV bus a. Apply single phase fault at BRECKNR4 bus. b. Clear fault after 16 cycles and trip the following elements c. Trip the BRECKNR4 (514815) to PLNSMEN4 (515641) 138 kV line CKT 1. d. Trip the BRECKNR4 (514815) to BRCKWND4 (514642) 138 kV line CKT 1. Trip generators G23-SR13-GEN (923131), BRKRDG_WTGN1 (514646). |
| FLT1002-SB | P4 | Stuck Breaker at BRECKNR4 (514815) 138 kV bus a. Apply single phase fault at BRECKNR4 bus. b. Clear fault after 16 cycles and trip the following elements c. Trip the BRECKNR4 (514815) to BUNCHCK4 (514701) 138 kV line CKT 1. d. Trip the BRECKNR4 (514815) to BRCKWND4 (514642) 138 kV line CKT 1. Trip generators G23-SR13-GEN (923131), BRKRDG_WTGN1 (514646). |
| FLT1003-SB | P4 | Stuck Breaker at BRECKNR4 (514815) 138 kV bus a. Apply single phase fault at BRECKNR4 bus. b. Clear fault after 16 cycles and trip the following elements c. Trip the BRECKNR4 (514815) to PLNSMEN4 (515641) 138 kV line CKT 1. d. Trip the BRECKNR4 (514815) to SO4TH 4 (514731) 138 kV line CKT 1. |
| FLT1004-SB | P4 | Stuck Breaker at BRECKNR4 (514815) 138 kV bus a. Apply single phase fault at BRECKNR4 bus. b. Clear fault after 16 cycles and trip the following elements c. Trip the BRECKNR4 (514815) to BUNCHCK4 (514701) 138 kV line CKT 1. d. Trip the BRECKNR4 (514815) to ENIDINT4 (515383) 138 kV line CKT 1. |

Table 5-2 Continued

| Fault ID | Planning Event | Fault Descriptions |
|------------|----------------|---|
| FLT1005-SB | P4 | Stuck Breaker at BRECKNR4 (514815) 138 kV bus a. Apply single phase fault at BRECKNR4 bus. b. Clear fault after 16 cycles and trip the following elements c. Trip the BRECKNR4 (514815) to SO4TH 4 (514731) 138 kV line CKT 1. d. Trip the BRECKNR4 (514815) to ENIDINT4 (515383) 138 kV line CKT 1. |
| FLT1006-SB | P4 | Stuck Breaker at SO4TH 4 (514731) 138 kV bus a. Apply single phase fault at SO4TH 4 bus. b. Clear fault after 16 cycles and trip the following elements c. Trip the whole bus SO4TH 4 (514731). |

5.3 Scenario 1 Results

Table 5-3 shows the relevant results of the fault events simulated for each of the modified models in Scenario 1. Existing DISIS base case issues are documented separately in Appendix C. The associated stability plots are also provided in Appendix C.

Table 5-3: Scenario 1 Dynamic Stability Results (EGF = 0 MW, SGF = 70 MW)

| Fault ID | 25SP | | | 25WP | | |
|-------------|-------------------|------------------|--------|-------------------|------------------|--------|
| | Voltage Violation | Voltage Recovery | Stable | Voltage Violation | Voltage Recovery | Stable |
| FLT9001-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9002-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9003-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9004-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9005-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9006-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9007-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9008-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9009-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9010-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9011-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9012-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9013-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9014-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9015-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9016-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9017-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9018-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9019-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9020-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9021-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9022-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9023-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT1001-SB | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT1002-SB | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT1003-SB | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT1004-SB | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT1005-SB | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT1006-SB | Pass | Pass | Stable | Pass | Pass | Stable |

The results of the Scenario 1 dynamic stability showed several existing base case issues that were found in both the original DISIS-2017-002-1 model and the model with GEN-2023-SR13 included. These issues were not attributed to the GEN-2023-SR13 surplus request and detailed in Appendix C.

There were no damping or voltage recovery violations attributed to the GEN-2023-SR13 surplus 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.

5.4 Scenario 2 Results

Table 5-4 shows the relevant results of the fault events simulated for each of the modified models in Scenario 2. Existing DISIS base case issues are documented separately in Appendix C. The associated stability plots are also provided in Appendix C.

Table 5-4: Scenario 2 Dynamic Stability Results (EGF = 32.56 MW, SGF = 70 MW)

| Fault ID | 25SP | | | 25WP | | |
|-------------|-------------------|------------------|--------|-------------------|------------------|--------|
| | Voltage Violation | Voltage Recovery | Stable | Voltage Violation | Voltage Recovery | Stable |
| FLT9001-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9002-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9003-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9004-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9005-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9006-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9007-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9008-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9009-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9010-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9011-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9012-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9013-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9014-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9015-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9016-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9017-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9018-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9019-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9020-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9021-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9022-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT9023-3PH | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT1001-SB | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT1002-SB | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT1003-SB | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT1004-SB | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT1005-SB | Pass | Pass | Stable | Pass | Pass | Stable |
| FLT1006-SB | Pass | Pass | Stable | Pass | Pass | Stable |

The results of the Scenario 2 dynamic stability showed several existing base case issues that were found in both the original DISIS-2017-002-1 model and the model with GEN-2023-SR13 included. These issues were not attributed to the GEN-2023-SR13 surplus request and detailed in Appendix C.

There were no damping or voltage recovery violations attributed to the GEN-2023-SR13 surplus 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.

6.0 Necessary Interconnection Facilities and Network Upgrades

This study identified the impact of the Surplus Interconnection Service on the transmission system reliability and any additional Interconnection Facilities or Network Upgrades necessary. The Surplus Interconnection Service is only available up to the amount that can be accommodated without requiring additional Network Upgrades unless (a) those additional Network Upgrades are either (1) located at the Point of Interconnection substation and at the same voltage level as the Generating Facility with an effective GIA, or (2) are System Protection Facilities; and (b) there are no material adverse impacts on the cost or timing of any Interconnection Requests pending at the time the Surplus Interconnection Service request is submitted.

6.1 Interconnection Facilities

This study did not identify any additional Interconnection Facilities required by the addition of the SGF.

6.2 Network Upgrades

This study did not identify any Network Upgrades required by the addition of the SGF. SPP will reach out to the TO and/or TOP to determine if there are any additional Network Upgrades that are either (1) located at the Point of Interconnection substation and at the same voltage level as the Generating Facility with an effective GIA, or (2) are System Protection Facilities.

7.0 Surplus Interconnection Service Determination and Requirements

In accordance with Attachment V of the SPP Tariff, SPP shall evaluate the request for Surplus Interconnection Service and inform the Interconnection Customer in writing of whether the Surplus Interconnection Service can be utilized without negatively impacting the reliability of the Transmission System and without any additional Network Upgrades necessary except those specified in the SPP Tariff.

7.1 Surplus Service Determination

SPP determined the request for Surplus Interconnection Service does not negatively impact the reliability of the Transmission System and no required Network Upgrades or Interconnection Facilities were identified by this Surplus Interconnection Service Impact Study performed by Aneden. Aneden evaluated the impact of the requested Surplus Interconnection Service on the prior study results and determined that the requested Surplus Interconnection Service resulted in similar dynamic stability and short circuit analyses and that the prior study steady-state results are not negatively impacted.

SPP has determined that GEN-2023-SR13 may utilize the requested 70 MW of Surplus Interconnection Service being made available by GEN-2012-033 & GEN-2015-062.

7.2 Surplus Service Requirements

The amount of Surplus Interconnection Service available to be used is limited by the amount of Interconnection Service granted to the existing interconnection customer at the same POI. The combined generation from both the SGF and the EGF may not exceed 102.56 MW at the POI, which is the total Interconnection Service amount currently granted to the EGF.

The customer must install monitoring and control equipment as needed to ensure that the SGF does not exceed the granted surplus amount and to ensure that combination of the SGF and EGF power injected at the POI does not exceed the Interconnection Service amount listed in the EGF's GIA. The monitoring and control scheme may be reviewed by the TO and documented in Appendix C of the SGF GIA.

SPP will reach out to the TO and/or TOP to determine if there are any additional Network Upgrades that are either (1) located at the Point of Interconnection substation and at the same voltage level as the Generating Facility with an effective GIA, or (2) are System Protection Facilities.