Southwest Power Pool

# GEN-2015-089

## Impact Restudy for Generator Modification

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# REVISION HISTORY

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| 04/17/2019 | SPP | Initial report issued. |
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# CONTENTS

Revision History ........................................ i
Summary ........................................ 1
A: Consultant's Material Modification Study Report ........................................ 2

# SUMMARY

The GEN-2015-089 Interconnection Customer has requested a modification to its 200 MW Interconnection Request. This system impact restudy was performed to determine the effects of changing wind turbine generators from 100 GE 2.0 MW wind turbine generators (for a total of 200 MW) to 55 GE 3.5 MW and 2 GE 3.75 wind turbine generators (for a total of 200 MW). In addition, the modification request included changes to the generation interconnection line, collection system and the generator substation transformer. The point of interconnection (POI) for GEN-2015-089 remains at the Western Area Power Administration (WAPA) Utica 230kV Substation.

This study was performed by Aneden Consulting to determine whether the request for modification is considered Material. A short circuit analysis, a low-wind/no-wind condition analysis, and stability analysis was performed for this modification request. The study report follows this executive summary.

The generating facility will be required to maintain a 95% lagging (providing VARs) and 95% leading (absorbing VArs) in accordance with FERC Order 827. Additionally, the project will be required to install approximately 14.2 MVArs of reactor shunts on its substation 230 kV bus or provide an alternate means of reactive power compensation. This is necessary to offset the capacitive effect on the transmission network caused by the project's transmission line and collector system during low-wind/no-wind conditions.

The restudy showed that the results of the dynamic stability analysis showed that there was an existing system performance violation that was not associated with the GEN-2015-089 modification request. The DISIS-2016-002 study is ongoing and there were several upgrades not included in the models. There were no other machine rotor angle damping or transient voltage recovery violations observed in the simulated fault events. Additionally, the project wind farm 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 requested modification is not considered Material.

It should be noted that this study analyzed the requested modification to change generator technology and layout. Powerflow analysis was not performed. This study analyzed many of the most probable contingencies, but it is not an all-inclusive list and cannot account for every operational situation. It is likely that the customer may be required to reduce its generation output to 0 MW, 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.

# A: CONSULTANT'S MATERIAL MODIFICATION STUDY REPORT

See next page for the Consultant's Material Modification Study report.


**Submitted to**
**Southwest Power Pool**

SPP Southwest Power Pool

Report On

## GEN-2015-089
## Modification Request Impact Study

Revision R2

Date of Submittal
April 17, 2019

anedenconsulting.com

# TABLE OF CONTENTS

Executive Summary ..... ES-1
1.0 Introduction ..... 1
1.1 Scope ..... 1
1.2 Study Limitations ..... 2
2.0 Project and Modification Request ..... 3
3.0 Reactive Power Analysis ..... 5
3.1 Methodology and Criteria ..... 5
3.2 Results ..... 5
4.0 Short Circuit Analysis ..... 6
4.1 Methodology ..... 6
4.2 Results ..... 6
5.0 Dynamic Stability Analysis ..... 8
5.1 Methodology and Criteria ..... 8
5.2 Fault Definitions ..... 8
5.3 Results ..... 14
6.0 Conclusions ..... 19

## LIST OF TABLES

Table ES-1: Existing GEN-2015-089 Configuration ..... ES-1
Table ES-2: GEN-2015-089 Modification Request ..... ES-1
Table 1-1: Existing GEN-2015-089 Configuration ..... 1
Table 2-1: GEN-2015-089 Modification Request ..... 4
Table 3-1: Shunt Reactor Size for Low Wind Study ..... 5
Table 4-1: 2018SP Short Circuit Results ..... 6
Table 4-2: 2026SP Short Circuit Results ..... 6
Table 4-3: 2018SP GGS Short Circuit Results ..... 7
Table 4-4: 2026SP GGS Short Circuit Results ..... 7
Table 5-1: Fault Definitions ..... 9
Table 5-2: GEN-2015-089 Dynamic Stability Results ..... 14

## LIST OF FIGURES

Figure 2-1: GEN-2015-089 Single Line Diagram (Existing Configuration) ..... 3
Figure 2-2: GEN-2015-089 Single Line Diagram (New Configuration) ..... 3
Figure 3-1: GEN-2015-089 Single Line Diagram (Shunt Reactor) ..... 5
Figure 5-1: FLT9025B-3PH Base Case vs Modification Case (Pre-Upgrade) ..... 17
Figure 5-2: FLT9025B-3PH Modification Case with and without Upgrades ..... 18

## APPENDICES

APPENDIX A: Short Circuit Results
APPENDIX B: SPP Disturbance Performance Requirements
APPENDIX C: GEN-2015-089 Generator Dynamic Model
APPENDIX D: Dynamic Stability Simulation Plots

# Executive Summary

Aneden Consulting (Aneden) was retained by the Southwest Power Pool (SPP) to perform a Modification Request Impact Study (Study) for GEN-2015-089, an active generation interconnection request with point of interconnection (POI) on the Utica 230kV substation.

The GEN-2015-089 project was proposed to interconnect in the Western Area Power Administration (WAPA) control area with a capacity of 200 MW as shown in Table ES-1 below. This Study has been requested to evaluate the modification of GEN-2015-089 to change turbine configuration to a total of 55 x GE 3.5 MW and 2 x GE 3.75 MW wind turbines for a total capacity of 200 MW. In addition, the modification request included changes to the generation interconnection line, collection system and the generator substation transformer. The modification request changes are shown in Table ES-2 below.

**Table ES-1: Existing GEN-2015-089 Configuration**

| Request | Capacity (MW) | Existing Generator Configuration | Point of Interconnection |
|---|---|---|---|
| GEN-2015-089 | 200 | GE 2.0 MW (563232) | Utica 230kV (652526) |

**Table ES-2: GEN-2015-089 Modification Request**

<table>
<tr><th>Facility</th><th>Existing</th><th colspan="2">Modification Request</th></tr>
<tr><td>Point of Interconnection</td><td>Utica Junction 230 kV Substation (652526)</td><td colspan="2">Utica Junction 230 kV Substation (652526)</td></tr>
<tr><td>Configuration/Capacity</td><td>100 x GE 2.0 MW = 200 MW</td><td colspan="2">55 x GE 3.5 MW (Gen 1) + 2 x GE 3.75 MW (Gen 2) = 200 MW</td></tr>
<tr><td>Generation Interconnection Line</td><td>Length = 25.5 miles<br>R = 0.003251 pu<br>X = 0.017362 pu<br>B = 0.111000 pu</td><td>230 kV Line:<br>Length = 0.1 miles<br>R = 0.000023 pu<br>X = 0.000219 pu<br>B = 0.000778 pu</td><td>115 kV Line:<br>Length = 27.8 miles<br>R = 0.013720 pu<br>X = 0.131700 pu<br>B = 0.026450 pu</td></tr>
<tr><td>Generator Substation Transformer</td><td>230/34.5 kV Transformer:<br>Z = 9%, Winding 132 MVA, Rating 220 MVA</td><td colspan="2">230/115 kV Transformer:<br>Z = 8%, Winding 135 MVA, Rating 225 MVA</td></tr>
<tr><td>Collector Substation Transformer</td><td>N/A</td><td colspan="2">115/34.5 kV Transformer:<br>Z = 11.5%, Winding 135 MVA, Rating 225 MVA</td></tr>
<tr><td>GSU Transformer</td><td>Equivalent Qty: 100<br>Z = 5.75%, Rating 231.5 MVA</td><td>Gen 1 Equivalent Qty: 55<br>Z = 8.5%, Rating 262.8 MVA</td><td>Gen 2 Equivalent Qty: 2<br>Z = 8.5%, Rating 9.6 MVA</td></tr>
<tr><td>Equivalent Collector Line</td><td>R = 0.007570 pu<br>X = 0.023580 pu<br>B = 0.177890 pu</td><td colspan="2">R = 0.005394 pu<br>X = 0.008302 pu<br>B = 0.110381 pu</td></tr>
<tr><td>Reactive Power Devices</td><td>N/A</td><td colspan="2">3 x 25 MVAR & 1 x 15 MVAR (+90 MVAR total) Capacitor Banks at the Generator 115 kV Substation</td></tr>
</table>

GEN-2015-089 was last studied as part of Group 9 in the DISIS-2016-001. Aneden performed reactive power analysis, short circuit analysis and dynamic stability analysis using the modification request data on the initial DISIS-2016-002 Group 9 study models.

All analyses were performed using the PTI PSS/E version 33.7 software and the results are summarized below.

A power factor analysis was not performed as there was no change in the point of interconnection for GEN-2015-089.

The results of the reactive power analysis, also known as the low-wind/no-wind condition analysis, performed using the three main models (non-GGS) showed that the GEN-2015-089 project may require a 14.2 MVAr shunt reactor on the 230kV bus of the project substation. The shunt reactor is needed to reduce the reactive power transfer at the POI to approximately zero during low/no wind conditions while the generation interconnection project remains connected to the grid.

The results from short circuit analysis showed that the maximum change in the fault currents in the immediate systems at or near GEN-2015-089 was approximately 0.5 kA for the 2018SP and 2026SP (main and an additional dispatch scenario to evaluate the Gerald Gentleman Station registered NERC flowgate #6006: GGS). All three-phase fault current levels with the GEN-2015-089 generator online were below 37 kA for the 2018SP models and 2026SP models.

The dynamic stability analysis was performed using the six from DISIS-2016-002 models 2017 Winter Peak, 2018 Summer Peak, 2026 Summer Peak, 2017 Winter Peak GGS, 2018 Summer Peak GGS, and 2026 Summer Peak GGS. Up to 91 contingencies were simulated, which included three-phase faults, three phase faults on prior outage cases, and single-line-to-ground faults with stuck breakers faults.

The results of the dynamic stability analysis showed that there was one existing system performance violation that was not associated with the GEN-2015-089 modification. Since the DISIS-2016-002 study is ongoing, there were several upgrades not included in the models. Additional upgrades were implemented to resolve existing (pre-modification) system performance violations. With those additional upgrades implemented, the results of the dynamic stability analysis showed that there were no machine rotor angle damping or transient voltage recovery violations observed in the simulated fault events associated with this modification request study. Additionally, the project wind farm 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 this Study show that the GEN-2015-089 Modification Request does not constitute a material modification.

# 1.0 Introduction

Aneden Consulting (Aneden) was retained by the Southwest Power Pool (SPP) to perform a Modification Request Impact Study (Study) for GEN-2015-089, an active generation interconnection request with point of interconnection (POI) at the Utica 230 kV substation.

The GEN-2015-089 project was proposed to interconnect in the Western Area Power Administration (WAPA) control area with a combined capacity of 200 MW as shown in Table 1-1 below. Details of the modification request are provided in Section 2.0 below.

**Table 1-1: Existing GEN-2015-089 Configuration**

| Request | Capacity (MW) | Existing Generator Configuration | Point of Interconnection |
|---|---|---|---|
| GEN-2015-089 | 200 | GE 2.0 MW (563232) | Utica 230kV (652526) |

## 1.1 Scope

The Study included reactive power, short circuit and dynamic stability analyses. The methodology, assumptions and results of the analyses are presented in the following five main sections:

1. Project and Modification Request
2. Reactive Power Analysis
3. Short Circuit Analysis
4. Dynamic Stability Analysis
5. Conclusions

The analyses were performed using a set of modified study models developed using the modification request data and the six initial DISIS-2016-002 study models:

1. 2017 Winter Peak (2017WP),
2. 2018 Summer Peak (2018SP),
3. 2026 Summer Peak (2026SP),
4. 2017 GGS Winter Peak Case (2017WP_GGS),
5. 2018 GGS Summer Peak Case (2018SP_GGS), and
6. 2026 GGS Summer Peak Case (2026SP_GGS).

Since the DISIS-2016-002 is undergoing additional restudies, only the following assigned network upgrades were included in the base DISIS-2016-002-2 models used in this modification request study:

1. SPP R Plan (16WP and 17SP advancement)
    a. Thedford 345/115/13.8 kV transformer
    b. Gentleman to Thedford 345 kV circuit #1
    c. Holt County to Thedford 345 kV circuit #1
2. Gentleman to Keystone 345 kV circuit #2

All analyses were performed using the PTI PSS/E version 33.7 software. The results of each analysis are presented in the following sections.

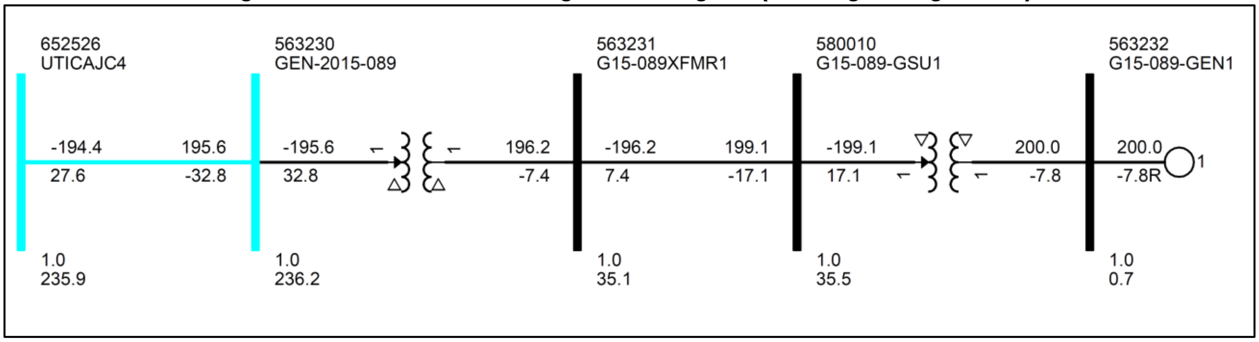
## 1.2 Study Limitations

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.

# 2.0 Project and Modification Request

Figure 2-1 shows the power flow model single line diagram for the existing GEN-2015-089 configuration. GEN-2015-089 was originally studied as part of Group 9 in the DISIS-2016-001 study.

**Figure 2-1: GEN-2015-089 Single Line Diagram (Existing Configuration)**




The GEN-2015-089 Modification Request included a turbine configuration change to a total of 55 x GE 3.5 MW and 2 x GE 3.75 MW wind turbines for a total capacity of 200 MW. In addition, the modification request also included changes to the collection system, the generator substation transformer and the generation interconnection line. The major modification request changes are shown in Figure 2-2 and Table 2-1 below.

**Figure 2-2: GEN-2015-089 Single Line Diagram (New Configuration)**

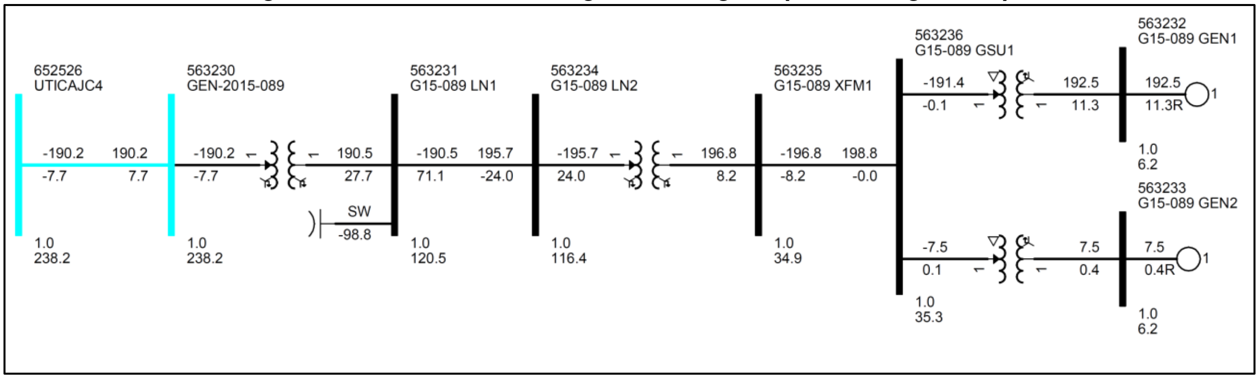


**Table 2-1: GEN-2015-089 Modification Request**

| Facility | Existing | Modification Request | |
|---|---|---|---|
| Point of Interconnection | Utica Junction 230 kV Substation (652526) | Utica Junction 230 kV Substation (652526) | |
| Configuration/Capacity | 100 x GE 2.0 MW = 200 MW | 55 x GE 3.5 MW (Gen 1) + 2 x GE 3.75 MW (Gen 2) = 200 MW | |
| Generation Interconnection Line | 230 kV Line:<br>Length = 25.5 miles<br>R = 0.003251 pu<br>X = 0.017362 pu<br>B = 0.111000 pu | 230 kV Line:<br>Length = 0.1 miles<br>R = 0.000023 pu<br>X = 0.000219 pu<br>B = 0.000778 pu | 115 kV Line:<br>Length = 27.8 miles<br>R = 0.013720 pu<br>X = 0.131700 pu<br>B = 0.026450 pu |
| Generator Substation Transformer | Z = 9%, Winding 132 MVA, Rating 220 MVA | 230/115 kV Transformer:<br>Z = 8%, Winding 135 MVA, Rating 225 MVA | |
| Collector Substation Transformer | N/A | 115/34.5 kV Transformer:<br>Z = 11.5%, Winding 135 MVA, Rating 225 MVA | |
| GSU Transformer | Equivalent Qty: 100<br>Z = 5.7%, Rating 231.5 MVA | Gen 1 Equivalent Qty: 55:<br>Z = 8.5%, Rating 262.8 MVA | Gen 2 Equivalent Qty: 2:<br>Z = 8.5%, Rating 9.6 MVA |
| Equivalent Collector Line | R = 0.007570 pu<br>X = 0.023580 pu<br>B = 0.177890 pu | R = 0.005394 pu<br>X = 0.008302 pu<br>B = 0.110381 pu | |
| Reactive Power Devices | N/A | 3 x 25 MVAR & 1 x 15 MVAR (+90 MVAR total) Capacitor Banks at the Generator 115 kV Substation | |

# 3.0 Reactive Power Analysis

The reactive power analysis, also known as the low-wind/no-wind condition analysis, was performed for GEN-2015-089 to determine the reactive power contribution from the project's interconnection line and collector transformer and cables during low/no wind conditions while the project is still connected to the grid and to size shunt reactors that would reduce the project reactive power contribution to the POI to approximately zero.

## 3.1 Methodology and Criteria

For the GEN-2015-089 project, the generator and shunt reactor were switched out of service while other collector system elements remained in-service. A shunt reactor was tested at the collection substation 230 kV bus to set the MVAr flow into the POI to approximately zero.

## 3.2 Results

The results from the reactive power analysis showed that the GEN-2015-089 projects required approximately 14.2 MVAr shunt reactance at the high side of the project substation, to reduce the POI MVAr to zero. This represents the contributions from the project collection system without the project capacitor bank. Figure 3-1 illustrates the shunt reactor size required to reduce the POI MVAr to approximately zero. Reactive compensation can be provided either by discrete reactive devices or by the generator itself if it possesses that capability.

**Figure 3-1: GEN-2015-089 Single Line Diagram (Shunt Reactor)**

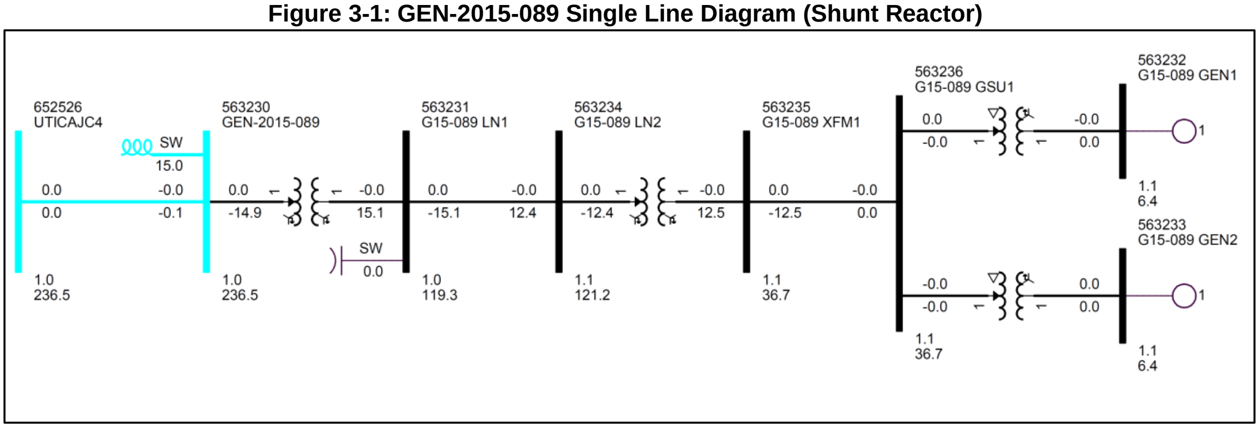



Table 3-1 shows the shunt reactor size determined for the three study models used in the assessment. Note that the capacitors banks on the 115 kV bus were switched offline.

**Table 3-1: Shunt Reactor Size for Low Wind Study**

| Machine | POI Bus Number | POI Bus Name | Reactor Size (MVAr) | | |
|---|---|---|---|---|---|
| | | | 17WP | 18SP | 26SP |
| GEN-2015-089 | 652526 | Utica Junction | 14.2 | 14.2 | 14.2 |

# 4.0 Short Circuit Analysis

A short-circuit study was performed using the 2018SP and 2026SP models, and the 2018SP GGS and 2026SP GGS models for GEN-2015-089. The detail results of the short-circuit analysis are provided in Appendix A.

## 4.1 Methodology

The short-circuit analysis included applying a 3-phase fault on buses up to 5 levels away from the 230 kV POI bus. The PSS/E "Automatic Sequence Fault Calculation (ASCC)" fault analysis module was used to calculate the fault current levels with and without the project online.

## 4.2 Results

The results of the short circuit analysis for the 2018SP and 2026SP models are summarized in Table 4-1 and Table 4-2 respectively. The maximum increase in fault current was about 6.7%, 0.51 kA.  The maximum fault current calculated within 5 buses with GEN-2015-089 was less than 37 kA for the 2018SP and 2026SP models respectively.

**Table 4-1: 2018SP Short Circuit Results**

| Voltage (kV) | Max. Current (kA) | Max kA Change | Max %Change |
|---|---|---|---|
| 69 | 21.2 | 0.01 | 0.4% |
| 115 | 36.4 | 0.20 | 2.3% |
| 161 | 26.8 | 0.02 | 0.1% |
| 230 | 20.2 | 0.50 | 6.7% |
| 345 | 25.4 | 0.03 | 0.2% |
| **Max** | **36.4** | **0.50** | **6.7%** |

**Table 4-2: 2026SP Short Circuit Results**

| Voltage (kV) | Max. Current (kA) | Max kA Change | Max %Change |
|---|---|---|---|
| 69 | 21.2 | 0.01 | 0.4% |
| 115 | 36.7 | 0.20 | 2.3% |
| 161 | 26.9 | 0.02 | 0.1% |
| 230 | 19.7 | 0.51 | 6.7% |
| 345 | 25.5 | 0.03 | 0.2% |
| **Max** | **36.7** | **0.51** | **6.7%** |

The results of the short circuit analysis for the 2018SP GGS and 2026SP GGS models are summarized in Table 4-3 and Table 4-4 respectively. The maximum increase in fault current was about 6.7% (0.5kA). The maximum fault current calculated within 5 buses with GEN-2015-089 was less than 37 kA for the 2018SP GGS and 2026SP GGS models.

**Table 4-3: 2018SP GGS Short Circuit Results**

| Voltage (kV) | Max. Current (kA) | Max kA Change | Max %Change |
|---|---|---|---|
| 69 | 21.2 | 0.03 | 0.7% |
| 115 | 36.4 | 0.20 | 2.3% |
| 161 | 26.8 | 0.02 | 0.1% |
| 230 | 20.2 | 0.50 | 6.7% |
| 345 | 25.4 | 0.03 | 0.2% |
| **Max** | **36.4** | **0.50** | **6.7%** |

**Table 4-4: 2026SP GGS Short Circuit Results**

| Voltage (kV) | Max. Current (kA) | Max kA Change | Max %Change |
|---|---|---|---|
| 69 | 21.2 | 0.01 | 0.4% |
| 115 | 36.7 | 0.20 | 2.3% |
| 161 | 26.9 | 0.02 | 0.1% |
| 230 | 19.8 | 0.50 | 6.7% |
| 345 | 25.5 | 0.03 | 0.2% |
| **Max** | **36.7** | **0.50** | **6.7%** |

# 5.0 Dynamic Stability Analysis

Aneden performed a dynamic stability analysis to identify the impact of the turbine configuration change and other modifications to the GEN-2015-089 project. The analysis was performed according to SPP's Disturbance Performance Requirements shown in Appendix B. The modification details are described in Section 2.0 above and the dynamic modeling data is provided in Appendix C. The simulation plots can be found in Appendix D.

## 5.1 Methodology and Criteria

The dynamic stability analysis was performed using models developed with the requested 55 x GE 3.5 MW and 2 x GE 3.75 MW turbine configuration for the GEN-2015-089 generating facilities. This stability analysis was performed using PTI's PSS/E version 33.7 software.

The stability models were developed using the models from DISIS-2016-002 for Group 9 including network upgrades identified in Section 1.0. The modifications requested to project GEN-2015-089 were used to create modified stability models for this impact study.

The modified dynamics model data for the DISIS-2016-002 Group 9 request, GEN-2015-089 is provided in Appendix C. 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-2015-089 and other equally and prior queued projects in Group 9. In addition, voltages of five (5) buses away from the POI of GEN-2015-089 were monitored and plotted. The machine rotor angle for synchronous machines and speed for asynchronous machines within this study area including 534 (SUNC), 536 (WERE), 540 (GMO), 541 (KCPL), 635 (MEC), 640 (NPPD), 645 (OPPD), 650 (LES), 652 (WAPA) were monitored. In addition, the voltages of all 100 kV and above buses within the study area were monitored.

## 5.2 Fault Definitions

Aneden selected a subset of the fault events simulated specifically for GEN-2015-089 in the DISIS-2016-002 Group 9 study. The new set of faults were simulated using the modified study models. The fault events include three-phase faults, three phase faults on prior outage cases, and single-line-to-ground faults with stuck breakers. The simulated faults are listed and described in Table 5-1 below. These contingencies were applied to the modified 2017 Winter Peak, 2018 Summer Peak, and the 2026 Summer Peak models (including the GGS models).

**Table 5-1: Fault Definitions**

| Fault ID | Fault Descriptions |
|---|---|
| FLT107-3PH | 3 phase fault on the UticaJ4 (652526) 230 kV to Rasmusn4 (652536) 230kV circuit 1 line<br>a. Apply fault at the UticaJ4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT108-3PH | 3 phase fault on the UticaJ4 (652526) 230kV to VFODNES4 (652398) 230kV circuit 1 line<br>a. Apply fault at the UticaJ4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT109-3PH | 3 phase fault on the UticaJ4 (652526) 230 kV to FTRANDL4 (652509) 230 kV circuit 1 line<br>a. Apply fault at the UticaJ4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT110-3PH | 3 phase fault on the Uticajc4 230/115/13.2kV (652526/652626/652627) Transformer.<br>a. Apply fault at the UticaJ4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line Uticajc4 230/115/13.2kV (652526/652626/652627) Transformer |
| FLT111-SB | RASMUSN4 230 kV Stuck Breaker Scenario 1<br>a. Apply fault at the Rasmusn4 230 kV bus.<br>b. Clear fault after 16 cycles and trip the following elements<br>c. RASMUSN4 (652536) to UticaJ4 (652526) 230 kV<br>d. RASMUSN4 (652536) to Siouxcy4 (652565) 230 kV |
| FLT113-SB | FTRANDL4 230 kV Stuck Breaker Scenario 1<br>a. Apply fault at the VFODNES4 230 kV bus.<br>b. Clear fault after 16 cycles and trip the following elements<br>c. FTRANDL4 (652509) to UticaJ4 (652526) 230 kV<br>d. FTRANDL4 (652509) to Meadowgrove4 (640540) 230 kV |
| FLT9001-3PH | 3 phase fault on the VFODNES 230/69 kV (652398/652399) Transformer.<br>a. Apply fault at the VFODNES (652398) 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted VFODNES 230/69 kV (652398/652399) Transformer. |
| FLT9002-3PH | 3 phase fault on the VFODNES 230/115/12.5 kV (652398/652397/652396) Transformer.<br>a. Apply fault at the VFODNES (652398) 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted VFODNES 230/115/12.5 kV (652398/652397/652396) Transformer. |
| FLT9003-3PH | 3 phase fault on the VFODNES (652398) 230 kV to SIOUXFL4 (652523) 230 kV circuit 1 line<br>a. Apply fault at the VFODNES 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9004-3PH | 3 phase fault on the SIOUXFL4 (652523) 230 kV to LETCHER4 (652606) 230 kV circuit 1 line<br>a. Apply fault at the SIOUXFL4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9005-3PH | 3 phase fault on the SIOUXFL4 (652523) 230 kV to PAHOJA4 (652578) 230 kV circuit 1 line<br>a. Apply fault at the SIOUXFL4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9006-3PH | 3 phase fault on the SIOUXFL4 (652523) 230 kV to SPLT RK4 (602004) 230 kV circuit 1 line<br>a. Apply fault at the SIOUXFL4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9007-3PH | 3 phase fault on the SIOUXFL4 (652523) 230 kV to HANLON (652513) 230 kV circuit 1 line<br>a. Apply fault at the SIOUXFL4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9008-3PH | 3 phase fault on the SIOUXFL4 230/115/13.2 kV (652523/652524/652233) Transformer<br>a. Apply fault at the SIOUXFL4 (652523) 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted SIOUXFL4 230/115/13.2 kV (652523/652524/652233) Transformer. |
| FLT9009-3PH | 3 phase fault on the VFODNES7 (652397) 115 kV to HANLON (652591) 115 kV circuit 1 line<br>a. Apply fault at the VFODNES7 115 kV bus<br>b. Clear fault after 7 cycles by tripping the faulted line. |

**Table 5-1 continued**

| Fault ID | Fault Descriptions |
|---|---|
| FLT9010-3PH | 3 phase fault on the FTRANDL4 (652509) 230 kV to MEADOWGROVE (640540) 230 kV circuit 1 line<br>a. Apply fault at the FTRANDL4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9011-3PH | 3 phase fault on the FTRANDL4 (652509) 230 kV to SIOUXCY4 (652565) 230 kV circuit 1 line<br>a. Apply fault at the FTRANDL4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9012-3PH | 3 phase fault on the FTRANDL4 (652509) 230 kV to FTTHOMP4 (652507) 230 kV circuit 1 line<br>a. Apply fault at the FTRANDL4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9013-3PH | 3 phase fault on the FTRANDL4 (652509) 230 kV to LAKPLAT4 (652516) 230 kV circuit 1 line<br>a. Apply fault at the FTRANDL4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9014-3PH | 3 phase fault on the LAKPLAT 230/69 kV (652516/652277) Transformer.<br>a. Apply fault at the LAKPLAT (652516) 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted LAKPLAT 230/69 kV (652516/652277) Transformer. |
| FLT9015-3PH | 3 phase fault on the LAKPLAT4 (652516) 230 kV to FTTHOMP4 (652507) 230 kV circuit 1 line<br>a. Apply fault at the LAKPLAT4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9016-3PH | 3 phase fault on the FTTHOMP4 (652507) 230 kV to BIGBND14 (652540) 230 kV circuit 1 line<br>a. Apply fault at the FTTHOMP4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9017-3PH | 3 phase fault on the FTTHOMP4 (652507) 230 kV to WESSINGTON4 (652607) 230 kV circuit 1 line<br>a. Apply fault at the FTTHOMP4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9018-3PH | 3 phase fault on the FTTHOMP4 (652507) 230 kV to BIGBND24 (652541) 230 kV circuit 1 line<br>a. Apply fault at the FTTHOMP4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9019-3PH | 3 phase fault on the FTTHOMP4 (652507) 230 kV to HURON (652514) 230 kV circuit 1 line<br>a. Apply fault at the FTTHOMP4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9020-3PH | 3 phase fault on the FTTHOMP4 (652507) 230 kV to G16-094-TAP (587764) 230 kV circuit 1 line<br>a. Apply fault at the FTTHOMP4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9021-3PH | 3 phase fault on the FTTHOMP4 (652507) 230 kV to OAHE (652519) 230 kV circuit 1 line<br>a. Apply fault at the FTTHOMP4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9022-3PH | 3 phase fault on the FTTHOMP 345/230/13.8 kV (652506/652507/652273) Transformer.<br>a. Apply fault at the FTTHOMP (652507) 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted FTTHOMP 345/230/13.8 kV (652506/652507/652273) Transformer. |
| FLT9023-3PH | 3 phase fault on the FTTHOMP 230/69 kV (652507/652276) Transformer.<br>a. Apply fault at the FTTHOMP 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted FTTHOMP 230/69 kV (652507/652276) Transformer. |
| FLT9024-3PH | 3 phase fault on the 345 kV FTTHOMP3 (652506) to FTTHOM1-LNX3 (652806) circuit Z to GEN-2016-017 Tap (560074) circuit 1 line<br>a. Apply fault at the FTTHOMP3 345 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |

**Table 5-1 continued**

| Fault ID | Fault Descriptions |
|---|---|
| FLT9025B-3PH | 3 phase fault on the 345 kV FTTHOMP3 (652506) to FTTHOM2-LNX3 (652807) circuit Z to GRPRAR2-LNX3 (652833) circuit 1 to Grand Prairie (652532) circuit Z line<br>a. Apply fault at the FTTHOMP3 345 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9026-3PH | 3 phase fault on the G16-094-TAP (587764) 230 kV to OAHE (652519) 230 kV circuit 1 line<br>a. Apply fault at the G16-094-TAP 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9027-3PH | 3 phase fault on the RASMUSN4 (652536) 230 kV to SIOUXCY4 (652565) 230 kV circuit 1 line<br>a. Apply fault at the RASMUSN4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9028-3PH | 3 phase fault on the RASMUSN 230/69 kV (652536/652287) Transformer.<br>a. Apply fault at the RASMUSN (652536) 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted RASMUSN 230/69 kV (652536/652287) Transformer. |
| FLT9029-3PH | 3 phase fault on the SIOUXCY 345/230/13.8 kV (652564/652565/652305) Transformer.<br>a. Apply fault at the SIOUXCY (652565) 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted SIOUXCY 345/230/13.8 kV (652564/652565/652305) Transformer. |
| FLT9030-3PH | 3 phase fault on the SIOUXCY 230/161/13.8 kV (652565/652566/652308) Transformer.<br>a. Apply fault at the SIOUXCY (652565) 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line SIOUXCY 230/161/13.8 kV (652565/652566/652308) Transformer. |
| FLT9031-3PH | 3 phase fault on the SIOUXCY (652565) 230 kV to TWIN CH4 (640386) 230 kV circuit 1 line<br>a. Apply fault at the SIOUXCY 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9032-3PH | 3 phase fault on the SIOUXCY (652565) 230 kV to DENISON4 (652567) 230 kV circuit 1 line<br>a. Apply fault at the SIOUXCY 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9033-3PH | 3 phase fault on the SIOUXCY (652565) 230 kV to EAGLE (659900) 230 kV circuit 1 line<br>a. Apply fault at the SIOUXCY 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9034-3PH | 3 phase fault on the SIOUXCY3 (652564) 345 kV to SIOUXCY-LNX3 (652864) 345 kV circuit Z line<br>a. Apply fault at the SIOUXCY3 345 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9035-3PH | 3 phase fault on the SIOUXCY3 (652564) 345 kV to RAUN (635200) 345 kV circuit Z line<br>a. Apply fault at the SIOUXCY3 345 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9036-3PH | 3 phase fault on the FTTHOMP4 (652507) 230 kV to LETCHER4 (652606) 230 kV circuit 1 line<br>a. Apply fault at the FTTHOMP4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9037-3PH | 3 phase fault on the UTICAJC7 (652626) 115 kV to FREEMAN-ER7 (655418) 115 kV circuit 1 line<br>a. Apply fault at the UTICAJC7 115 kV bus<br>b. Clear fault after 7 cycles by tripping the faulted line. |
| FLT9038-3PH | 3 phase fault on the UTICAJC7 (652626) 115 kV to MENNOJT7 (660007) 115 kV circuit 1 line<br>a. Apply fault at the UTICAJC7 115 kV bus<br>b. Clear fault after 7 cycles by tripping the faulted line. |
| FLT9039-3PH | 3 phase fault on the UTICAJC7 (652626) 115 kV to NAPA JCT7 (660026) 115 kV circuit 1 line<br>a. Apply fault at the UTICAJC7 115 kV bus<br>b. Clear fault after 7 cycles by tripping the faulted line. |
| FLT9040-3PH | 3 phase fault on the MEADOWGROVE (640540) 230 kV to COLMBUS4 (640133) 230 kV circuit 1 line<br>a. Apply fault at the MEADOWGROVE 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |

**Table 5-1 continued**

| Fault ID | Fault Descriptions |
|---|---|
| FLT9041-3PH | 3 phase fault on the MEADOWGROVE (640540) 230 kV to PR BRZ4 (648506) 230 kV circuit 1 line<br>a. Apply fault at the MEADOWGROVE 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line, trip generators at PR BRZ |
| FLT9001-PO1 | Prior Outage of UTICALJC4 230 kV (652526) to RASMUSN 230 kV (652536) circuit 1 line<br>3 phase fault on the VFODNES 230/69 kV (652398/652399) Transformer.<br>a. Apply fault at the VFODNES 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line VFODNES 230/69 kV (652398/652399) Transformer. |
| FLT9002-PO1 | Prior Outage of UTICALJC4 230 kV (652526) to RASMUSN 230 kV (652536) circuit 1 line<br>3 phase fault on the VFODNES 230/115/12.5 kV (652398/652397/652396) Transformer.<br>a. Apply fault at the VFODNES 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line VFODNES 230/115/12.5 kV (652398/652397/652396) Transformer. |
| FLT9003-PO1 | Prior Outage of UTICALJC4 230 kV (652526) to RASMUSN 230 kV (652536) circuit 1 line<br>3 phase fault on the VFODNES (652398) 230 kV to SIOUXFL4 (652523) 230 kV circuit 1 line<br>a. Apply fault at the VFODNES 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9010-PO1 | 3 phase fault on the FTRANDL4 (652509) 230 kV to MEADOWGROVE (640540) 230 kV circuit 1 line<br>a. Apply fault at the FTRANDL4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9011-PO1 | Prior Outage of UTICALJC4 230 kV (652526) to RASMUSN 230 kV (652536) circuit 1 line<br>3 phase fault on the FTRANDL4 (652509) 230 kV to SIOUXCY4 (652565) 230 kV circuit 1 line<br>a. Apply fault at the FTRANDL4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9012-PO1 | Prior Outage of UTICALJC4 230 kV (652526) to RASMUSN 230 kV (652536) circuit 1 line<br>3 phase fault on the FTRANDL4 (652509) 230 kV to FTTHOMP4 (652507) 230 kV circuit 1 line<br>a. Apply fault at the FTRANDL4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9013-PO1 | Prior Outage of UTICALJC4 230 kV (652526) to RASMUSN 230 kV (652536) circuit 1 line<br>3 phase fault on the FTRANDL4 (652509) 230 kV to LAKPLAT4 (652516) 230 kV circuit 1 line<br>a. Apply fault at the FTRANDL4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9037-PO1 | Prior Outage of UTICALJC4 230 kV (652526) to RASMUSN 230 kV (652536) circuit 1 line<br>3 phase fault on the UTICAJC7 (652626) 115 kV to FREEMAN-ER7 (655418) 115 kV circuit 1 line<br>a. Apply fault at the UTICAJC7 115 kV bus<br>b. Clear fault after 7 cycles by tripping the faulted line. |
| FLT9038-PO1 | Prior Outage of UTICALJC4 230 kV (652526) to RASMUSN 230 kV (652536) circuit 1 line<br>3 phase fault on the UTICAJC7 (652626) 115 kV to MENNOJT7 (660007) 115 kV circuit 1 line<br>a. Apply fault at the UTICAJC7 115 kV bus<br>b. Clear fault after 7 cycles by tripping the faulted line. |
| FLT9039-PO3 | Prior Outage of UTICALJC4 230 kV (652526) to FTRANDL4 (652509) circuit 1 line<br>3 phase fault on the UTICAJC7 (652626) 115 kV to NAPA JCT7 (660026) 115 kV circuit 1 line<br>a. Apply fault at the UTICAJC7 115 kV bus<br>b. Clear fault after 7 cycles by tripping the faulted line. |
| FLT9010-PO4 | Prior Outage of UTICALJC4 230 kV (652526) to VFODNES4 230 kV (652398) circuit 1 line<br>3 phase fault on the FTRANDL4 (652509) 230 kV to MEADOWGROVE (640540) 230 kV circuit 1 line<br>a. Apply fault at the FTRANDL4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9011-PO4 | Prior Outage of UTICALJC4 230 kV (652526) to VFODNES4 230 kV (652398) circuit 1 line<br>3 phase fault on the FTRANDL4 (652509) 230 kV to SIOUXCY4 (652565) 230 kV circuit 1 line<br>a. Apply fault at the FTRANDL4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |

**Table 5-1 continued**

| Fault ID | Fault Descriptions |
|---|---|
| FLT9012-PO4 | Prior Outage of UTICALJC4 230 kV (652526) to VFODNES4 230 kV (652398) circuit 1 line<br>3 phase fault on the FTRANDL4 (652509) 230 kV to FTTHOMP4 (652507) 230 kV circuit 1 line<br>a. Apply fault at the FTRANDL4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9013-PO4 | Prior Outage of UTICALJC4 230 kV (652526) to VFODNES4 230 kV (652398) circuit 1 line<br>3 phase fault on the FTRANDL4 (652509) 230 kV to LAKPLAT4 (652516) 230 kV circuit 1 line<br>a. Apply fault at the FTRANDL4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9027-PO4 | Prior Outage of UTICALJC4 230 kV (652526) to VFODNES4 230 kV (652398) circuit 1 line<br>3 phase fault on the RASMUSN4 (652536) 230 kV to SIOUXCY4 (652565) 230 kV circuit 1 line<br>a. Apply fault at the RASMUSN4 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9028-PO4 | Prior Outage of UTICALJC4 230 kV (652526) to VFODNES4 230 kV (652398) circuit 1 line<br>3 phase fault on the RASMUSN 230/69 kV (652536/652287) Transformer.<br>a. Apply fault at the RASMUSN 230 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line RASMUSN 230/69 kV (652536/652287) Transformer. |
| FLT9037-PO4 | Prior Outage of UTICALJC4 230 kV (652526) to VFODNES4 230 kV (652398) circuit 1 line<br>3 phase fault on the UTICAJC7 (652626) 115 kV to FREEMAN-ER7 (655418) 115 kV circuit 1 line<br>a. Apply fault at the UTICAJC7 115 kV bus<br>b. Clear fault after 6 cycles by tripping the faulted line. |
| FLT9038-PO4 | Prior Outage of UTICALJC4 230 kV (652526) to VFODNES4 230 kV (652398) circuit 1 line<br>3 phase fault on the UTICAJC7 (652626) 115 kV to MENNOJT7 (660007) 115 kV circuit 1 line<br>a. Apply fault at the UTICAJC7 115 kV bus<br>b. Clear fault after 7 cycles by tripping the faulted line. |
| FLT9039-PO4 | Prior Outage of UTICALJC4 230 kV (652526) to VFODNES4 230 kV (652398) circuit 1 line<br>3 phase fault on the UTICAJC7 (652626) 115 kV to NAPA JCT7 (660026) 115 kV circuit 1 line<br>a. Apply fault at the UTICAJC7 115 kV bus<br>b. Clear fault after 7 cycles by tripping the faulted line. |
| FLT1001-SB | Stuck Breaker at UTICAJC7 (652626)<br>a. Apply single phase fault at UTICAJC7 (652626) 115 kV bus.<br>b. Clear fault after 16 cycles and trip the following elements<br>c. UTICAJC7 (652526) 230 kV/ (652626)115 kV/ (652627) 13.2 kV transformer<br>d. UTICAJC7 (652626) 115 kV to FREEMAN-ER7 (655418) 115 kV circuit 1 line |
| FLT1002-SB | VFODNES4 230 kV Stuck Breaker Scenario 1<br>a. Apply fault at the VFODNES4 230 kV bus.<br>b. Clear fault after 16 cycles and trip the following elements<br>c. VFODNES4 (652398) to UticaJ4 (652526) 230 kV<br>d. VFODNES4 230kV (652398) to 69kV (652399) Transformer |
| FLT1003-SB | VFODNES4 230 kV Stuck Breaker Scenario 2<br>a. Apply fault at the VFODNES4 230 kV bus.<br>b. Clear fault after 16 cycles and trip the following elements<br>c. VFODNES4 (652398) to UticaJ4 (652526) 230 kV<br>d. VFODNES4 230kV (652398) to 115kV (652397) to 12.5kV (652396) Transformer |
| FLT1004-SB | VFODNES4 230 kV Stuck Breaker Scenario 3<br>a. Apply fault at the VFODNES4 230 kV bus.<br>b. Clear fault after 16 cycles and trip the following elements<br>c. VFODNES4 (652398) to Siouxcy4 (652523) 230 kV<br>d. VFODNES4 230kV (652398) to 69kV (652399) Transformer |

**Table 5-1 continued**

| Fault ID | Fault Descriptions |
|---|---|
| FLT1005-SB | VFODNES4 230 kV Stuck Breaker Scenario 4<br>a. Apply fault at the VFODNES4 230 kV bus.<br>b. Clear fault after 16 cycles and trip the following elements<br>c. VFODNES4 (652398) to Siouxcy4 (652523) 230 kV<br>d. VFODNES4 230kV (652398) to 115kV (652397) to 12.5kV (652396) Transformer |
| FLT1006-SB | UTICAJC4 230 kV Stuck Breaker Scenario 1<br>a. Apply fault at the UTICAJC4 (652526) 230 kV bus.<br>b. Clear fault after 16 cycles and trip the following elements<br>c. RASMUSN4 (652536) to UticaJ4 (652526) 230 kV<br>d. VFODNES4 (652398) to UticaJ4 (652526) 230 kV |
| FLT1007-SB | UTICAJC4 230 kV Stuck Breaker Scenario 2<br>a. Apply fault at the UTICAJC4 (652526) 230 kV bus.<br>b. Clear fault after 16 cycles and trip the following elements<br>c. RASMUSN4 (652536) to UticaJ4 (652526) 230 kV<br>d. FTRANDL4 (652509) to UticaJ4 (652526) 230 kV |
| FLT1008-SB | UTICAJC4 230 kV Stuck Breaker Scenario 3<br>a. Apply fault at the UTICAJC4 (652526) 230 kV bus.<br>b. Clear fault after 16 cycles and trip the following elements<br>c. UTICAJC4 (652526) 230 kV to (652626) 115kV to (652627) 13.2kV Transformer<br>d. VFODNES4 (652398) to UticaJ4 (652526) 230 kV |
| FLT1009-SB | UTICAJC4 230 kV Stuck Breaker Scenario 4<br>a. Apply fault at the UTICAJC4 (652526) 230 kV bus.<br>b. Clear fault after 16 cycles and trip the following elements<br>c. UTICAJC4 (652526) 230 kV to (652626) 115kV to (652627) 13.2kV Transformer<br>d. FTRANDL4 (652509) to UticaJ4 (652526) 230 kV |

## 5.3 Results

Table 5-2 shows the results of the fault events simulated for each of the models (main and GGS). The associated stability plots are provided in Appendix D. There was one existing base case issue FLT9025B, as shown in the table and described in more detail below.

There were no other damping or voltage recovery violations observed during the simulated faults. Additionally, the project wind farm 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.

**Table 5-2: GEN-2015-089 Dynamic Stability Results**

| Fault ID | Main | | | GGS | | |
|---|---|---|---|---|---|---|
| | 17W | 18S | 26S | 17W | 18S | 26S |
| FLT107-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT108-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT109-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT110-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT111-SB | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT113-SB | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT1001-SB | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT1002-SB | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT1003-SB | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT1004-SB | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT1005-SB | Stable | Stable | Stable | Stable | Stable | Stable |

**Table 5-2 continued**

| Fault ID | Main | | | GGS | | |
|---|---|---|---|---|---|---|
| | 17W | 18S | 26S | 17W | 18S | 26S |
| FLT1006-SB | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT1007-SB | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT1008-SB | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT1009-SB | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9001-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9002-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9003-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9004-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9005-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9006-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9007-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9008-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9009-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9010-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9011-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9012-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9013-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9014-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9015-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9016-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9017-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9018-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9019-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9020-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9021-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9022-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9023-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9024-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9025B-3PH | Stable | Stable | Stable | Oscillation* | Stable | Stable |
| FLT9026-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9027-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9028-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9029-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9030-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9031-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9032-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9033-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9034-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9035-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9036-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9037-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9038-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9039-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9040-3PH | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9041-3PH | Stable | Stable | Stable | Stable | Stable | Stable |

*System unstable before GEN-2015-089 modification

**Table 5-2 continued**

| Fault ID | Main | | | GGS | | |
|---|---|---|---|---|---|---|
| | 17W | 18S | 26S | 17W | 18S | 26S |
| FLT9002-PO1 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9003-PO1 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9010-PO1 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9011-PO1 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9012-PO1 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9013-PO1 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9037-PO1 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9038-PO1 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9039-PO1 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9001-PO2 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9002-PO2 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9003-PO2 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9010-PO2 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9011-PO2 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9012-PO2 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9013-PO2 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9027-PO2 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9028-PO2 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9001-PO3 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9002-PO3 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9003-PO3 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9027-PO3 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9028-PO3 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9037-PO3 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9038-PO3 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9039-PO3 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9010-PO4 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9011-PO4 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9012-PO4 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9013-PO4 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9027-PO4 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9028-PO4 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9037-PO4 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9038-PO4 | Stable | Stable | Stable | Stable | Stable | Stable |
| FLT9039-PO4 | Stable | Stable | Stable | Stable | Stable | Stable |

FLT9025B oscillations was observed in the 17W GGS base case and modification request models. The following previously assigned upgrades that were not included in the base DISIS-2016-002 models used to generate the results shown in Table 5-2 were applied to the 17W GGS model. FLT9025B was then re-simulated with these upgrades in place to see the impact on the system performance:

1. Antelope to Grand Prairie 345kV circuit #1
2. Keystone to Red Willow 345kV circuit #1
3. Post Rock to Red Willow 345kV circuit #1

With the additional upgrades included in the models, FLT9025B was stable both in the base cases on the post-modification cases.

Figure 5-1 shows the system performance in the base case and modification request case without the three upgrades. The system performance for this fault does not appear to be impacted by the modification.

**Figure 5-1: FLT9025B-3PH Base Case vs Modification Case (Pre-Upgrade)**

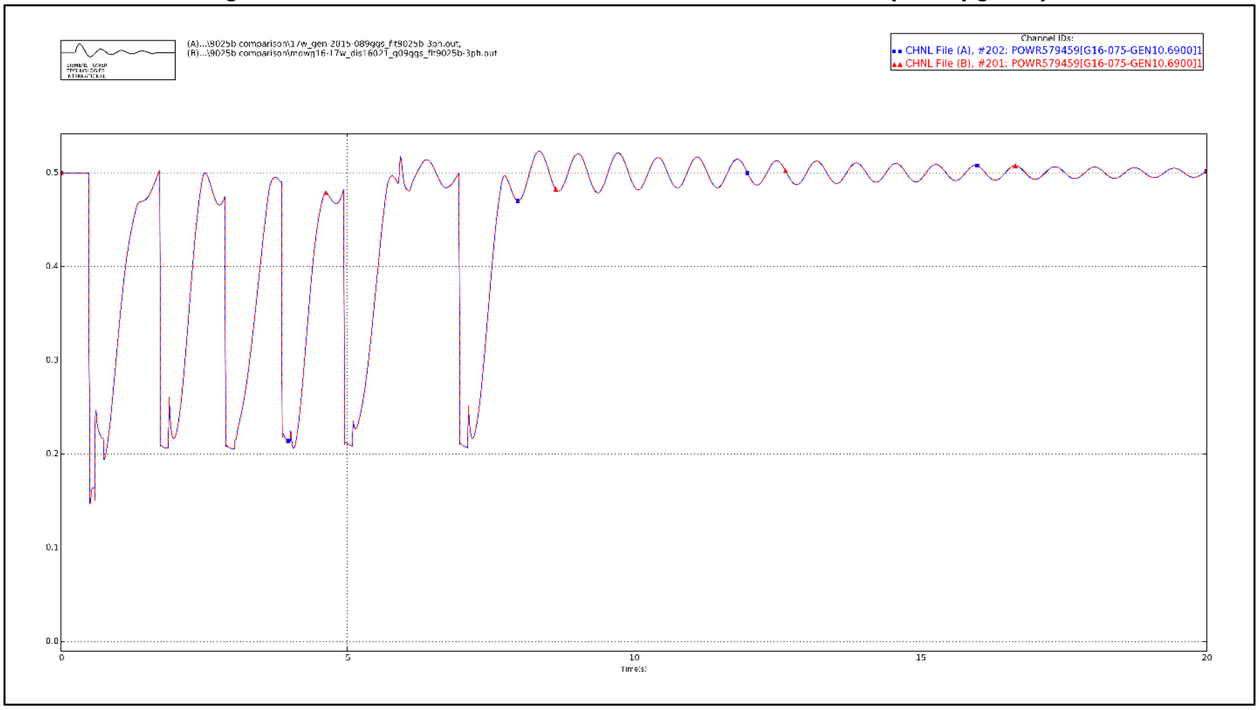
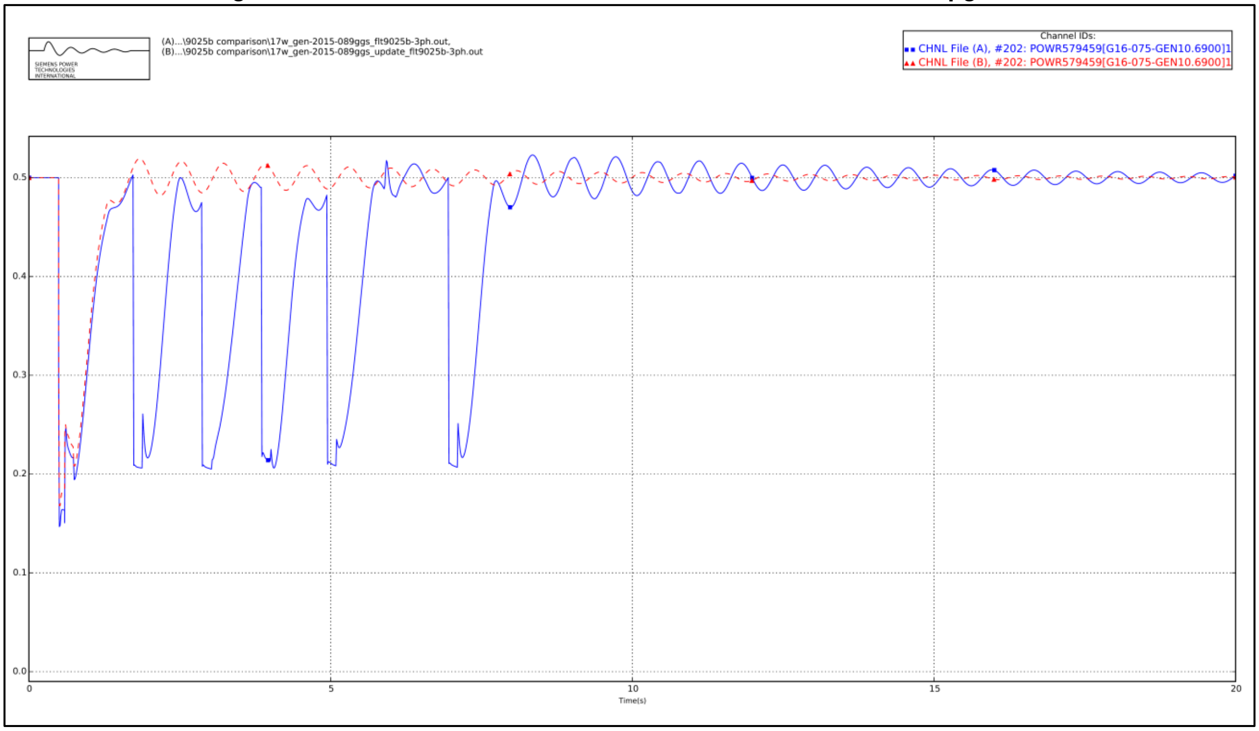



Figure 5-2 shows that the instability was mitigated with DISIS-2016-002 identified network upgrades in place.

**Figure 5-2: FLT9025B-3PH Modification Case with and without Upgrades**



# 6.0 Conclusions

The Interconnection Customer for GEN-2015-089 requested a Modification Request Impact Study to assess the impact of the turbine and facility changes to a configuration with a total of 55 x GE 3.5 MW and 2 x GE 3.75 MW wind turbines for a total capacity of 200 MW. In addition, the modification request included changes to the generation interconnection line, collection system and the generator substation transformer.

A power factor analysis was not performed as there was no change in the point of interconnection for GEN-2015-089.

The results of the reactive power analysis, also known as the low-wind/no-wind condition analysis, performed using all three models showed that the combined GEN-2015-089 project may require a 14.2 MVAr shunt reactor on the 230kV bus of the project substation. The shunt reactor is needed to reduce the reactive power transfer at the POI to approximately zero during low/no wind conditions while the generation interconnection project remains connected to the grid.

The results from short circuit analysis showed that the maximum change in the fault currents in the immediate systems at or near GEN-2015-089 was approximately 0.5 kA for the 2018SP and 2026SP cases (main and GGS). All three-phase current levels with the GEN-2015-089 generator online were below 37 kA for the 2018SP models and 2026SP models.

The results of the dynamic stability analysis showed that there was one existing system performance violation that was not associated with the GEN-2015-089 modification. Since the DISIS-2016-002 study is ongoing, there were several upgrades not included in the models. Additional upgrades were implemented to resolve existing (pre-modification) system performance violations. With those additional upgrades implemented, the results of the dynamic stability analysis showed that there were no other machine rotor angle damping or transient voltage recovery violations observed in the simulated fault events. Additionally, the project wind farm 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 this Study show that the GEN-2015-089 Modification Request does not constitute a material modification.