GEN-2015-046

Impact Restudy for Generator Modification

Published June 2020
By SPP Generator Interconnections Dept.

REVISION HISTORY

DATE OR VERSION NUMBER	AUTHOR	CHANGE DESCRIPTION
06/17/2020	SPP	Initial report issued.

CONTENTS

SUMMARY

The GEN-2015-046 Interconnection Customer has requested a modification to its 300 MW Interconnection Request. This system impact restudy was performed to determine the effects of changing turbines from 150 Vestas V110 2.0 MW wind turbine generators (for a total of 300 MW) to 15 Vestas V110 2.0 MW and 56 Nordex-Acciona 4.8 MW wind turbine generators (for a total of 298.8 MW). In addition, the modification request included changes to the generation interconnection line, collection system, main substation transformer, and the generator substation transformer. The point of interconnection (POI) for GEN-2015-046 remains at the Tande 345kV Substation.

A system impact restudy was performed by Aneden Consulting to help determine whether the requested modification is a Material Modification. A Material Modification shall mean those modifications that have a material impact on the cost or timing of any Interconnection Request with a later Queue priority date. Dynamic stability analysis and low-wind/no-wind condition analysis was performed for this modification request. The full study report follows this executive summary.

The results of the dynamic stability analysis showed that with the GEN-2015-046 modification all fault events from a full system intact system state resulted in a stable response following each studied event. However, a fault event involving a prior outage with a combination of the Tande POI bus to Judson 345 kV line and either the Neset to Tioga 230 kV line or the Neset 230/115/13.8 kV 3-winding transformer resulted in tripping of GEN-2015-046 on high voltage protection relays. Tripping was mitigated with a system adjustment of both GEN-2016-151 and GEN-2015-046 curtailed by 170 MW in the 2017WP and 2018SP cases, and 180 MW in the 2026SP case after the prior outage of the Tande POI bus to Judson 345 kV line in order for GEN-2015-046 to remain online following the more severe loss of the Neset to Tioga 230 kV line.

Given the results of the impact analysis, the requested modification is not considered a Material Modification; the requested modification does not have a material impact on the cost or timing of any Interconnection Request with a later Queue priority date.

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 35.1 MVArs of reactor shunts on the 34.5 kV bus of the generator project substation 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.

In real-time operation, 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.

In addition, 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

Report On

GEN-2015-046 Modification Request Impact Study

Revision R1

Date of Submittal
May 31, 2020

anedenconsulting.com

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Executive Summary

Aneden Consulting (Aneden) was retained by the Southwest Power Pool (SPP) to perform a Modification Request Impact Study (Study) for GEN-2015-046, an active generation interconnection request with a point of interconnection (POI) at the Tande 345 kV substation.

The GEN-2015-046 project is proposed to interconnect in the Basin Electric Power Cooperative (BEPC) control area with a capacity of 300 MW as shown in Table ES-1 below. This Study has been requested to evaluate the modification of GEN-2015-046 to change turbine configuration to a total of 15 x Vestas V110 2.0MW + 56 x Nordex-Acciona 4.8MW wind turbines for total capacity of 298.8 MW. In addition, the modification request included changes to the generation interconnection line, collection system, main substation transformer, and the generator substation transformer. The modification request changes are shown in Table ES-2 below.

Table ES-1: GEN-2015-046 Configuration

Request	Capacity (MW)	Existing Generator Configuration	Point of Interconnection
GEN-2015-046	300	150 x Vestas V110 2.0MW = 300 MW	Tande 345 kV (659336)

Table ES-2: GEN-2015-046 Modification Request

<table>
<tr><th>Facility</th><th colspan="2">Existing</th><th colspan="3">Modification</th></tr>
<tr><td>Point of Interconnection</td><td colspan="2">Tande 345 kV (659336)</td><td colspan="3">Tande 345 kV (659336)</td></tr>
<tr><td>Configuration/Capacity</td><td colspan="2">150 x Vestas V110 2.0MW = 300 MW</td><td colspan="3">15 x Vestas V110 2.0MW + 56 x Nordex-Acciona 4.8MW = 298.8 MW</td></tr>
<tr><td>Generation Interconnection Line</td><td colspan="2">Length = 19.6 miles
R = 0.001950 pu
X = 0.012570 pu
B = 0.133010 pu</td><td colspan="3">Length = 19.9 miles
R = 0.001067 pu
X = 0.009452 pu
B = 0.178538 pu</td></tr>
<tr><td>Main Substation Transformer</td><td>X = 9%, R = 0.204%, Winding 120 MVA, Rating 200 MVA</td><td>X = 9%, R = 0.204%, Winding 120 MVA, Rating 200 MVA</td><td>X12 = 10.05%, R12 = 0.239%, X23 = 2.14%, R23 = 0.051%, X13 = 9.19%, R13 = 0.219% Winding 109 MVA, Rating 170 MVA</td><td colspan="2">X12 = 9.22%, R12 = 0.22%, X23 = 1.96%, R23 = 0.047%, X13 = 8.43%, R13 = 0.201% Winding 100 MVA, Rating 167 MVA</td></tr>
<tr><td>GSU Transformer</td><td colspan="2">Gen 1 Equivalent Qty: 150:
X = 7.76%, R = 0.8%, Rating 315 MVA</td><td>Gen 2 Equivalent Qty: 30:
X = 8.96%, R = .896%, Rating 160.5 MVA</td><td>Gen 1 Equivalent Qty: 26:
X = 8.96%, R = .896%, Rating 139.1 MVA</td><td>Gen 3 Equivalent Qty: 15:
X = 9.76%, R = .895%, Rating 30.9 MVA</td></tr>
<tr><td>Equivalent Collector Line</td><td colspan="2">R = 0.003260 pu
X = 0.005200 pu
B = 0.264650 pu</td><td>R = 0.006277pu
X = 0.011301 pu
B = 0.081408 pu</td><td colspan="2">R = 0.006419pu
X = 0.009987 pu
B = 0.084151 pu</td></tr>
</table>

Aneden performed reactive power analysis, short circuit analysis, and dynamic stability analysis using the modification request data on the initial DISIS-2016-002-2 Group 16 study models. J593 was included in the models as a higher queued project, but has been withdrawn from the

Midcontinent Independent System Operator (MISO) queue. 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-2015-046.

The results of the reactive power analysis, also known as the low-wind/no-wind condition analysis, performed using the 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak models showed that the GEN-2015-046 project may require a 35.1 MVAr shunt reactor, a reduction from the previously identified value of 40.0 MVAr in the DISIS-2015-002-4[1] Group 16 report, on the 34.5 kV 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 the short circuit analysis with the updated topology showed that the maximum GEN-2015-046 contribution to three-phase fault currents in the immediate systems at or near GEN-2015-046 was approximately 0.49 kA for the 2018SP and 2026SP cases. All three-phase fault current levels within 5 buses of the POI with the GEN-2015-046 generator online were below 23 kA for the 2018SP models and 2026SP models.

The dynamic stability analysis was performed using the three DISIS-2016-002-2 models 2017 Winter Peak, 2018 Summer Peak, 2026 Summer Peak. Up to 33 events 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 with the GEN-2015-046 modification all fault events from a full system intact system state resulted in a stable response following each studied event. However, a fault event involving a prior outage with a combination of the Tande POI bus to Judson 345 kV line and either the Neset to Tioga 230 kV line or the Neset 230/115/13.8 kV 3-winding transformer resulted in tripping of GEN-2015-046 on high voltage protection relays. Tripping was mitigated with a system adjustment of both GEN-2016-151 and GEN-2015-046 curtailed by 170 MW in the 2017WP and 2018SP cases, and 180 MW in the 2026SP case after the prior outage of the Tande POI bus to Judson 345 kV line in order for GEN-2015-046 to remain online following the more severe loss of the Neset to Tioga 230 kV line.

There were no additional damping or voltage recovery violations 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.

[1] DISIS-2015-002-4 Group 2, 6, 8, & 16 Restudy, November 2017

1.0 Introduction

Aneden Consulting (Aneden) was retained by the Southwest Power Pool (SPP) to perform a Modification Request Impact Study (Study) for GEN-2015-046, an active generation interconnection request with a point of interconnection (POI) at the Tande 345 kV substation.

The GEN-2015-046 project is proposed to interconnect in the Basin Electric Power Cooperative (BEPC) control area with a combined capacity of 300 MW as shown in Table 1-1 below. Details of the modification request is provided in Section 2.0 below.

Table 1-1: Existing GEN-2015-046 Configuration

Request	Capacity (MW)	Existing Generator Configuration	Point of Interconnection
GEN-2015-046	300	150 x Vestas V110 2.0MW = 300 MW	Tande 345 kV (659336)

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

Aneden performed the analyses using a set of modified study models developed using the modification request data and the three DISIS-2016-002 ReStudy #2 study models:

1. 2017 Winter Peak (2017WP),
2. 2018 Summer Peak (2018SP), and
3. 2026 Summer Peak (2026SP).

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

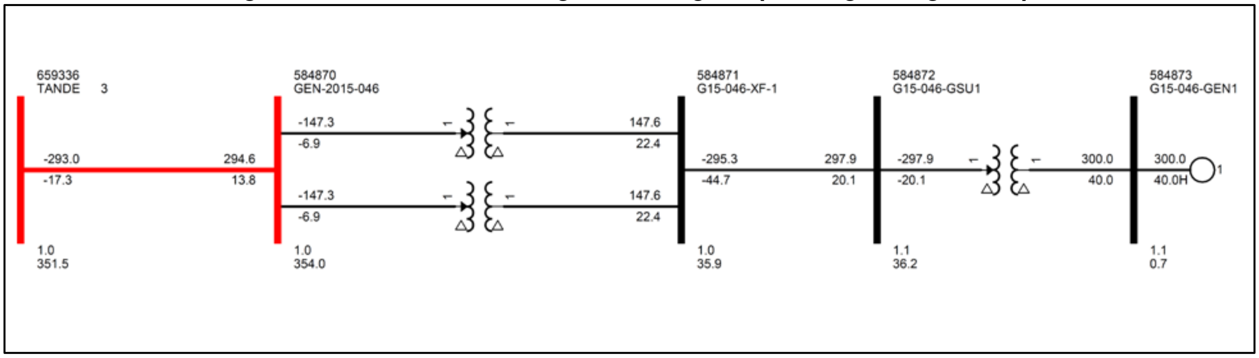
1.2 Study Limitations

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

GEN-2015-046 was originally studied as part of Group 16 in the DISIS-2015-002 study. Figure 2-1 shows the power flow model single line diagram for the existing GEN-2015-046 configuration.

Figure 2-1: GEN-2015-046 Single Line Diagram (Existing Configuration)



The GEN-2015-046 Modification Request included a turbine configuration change to a total of 15 x Vestas V110 2.0MW + 56 x Nordex-Acciona 4.8MW wind turbines for total capacity of 298.8 MW. In addition, the modification request also included changes to the generation interconnection line, collection system, main substation transformer, and the generator substation transformer. The major modification request changes are shown in Figure 2-2 and Table 2-1 below.

Figure 2-2: GEN-2015-046 Single Line Diagram (New Configuration)

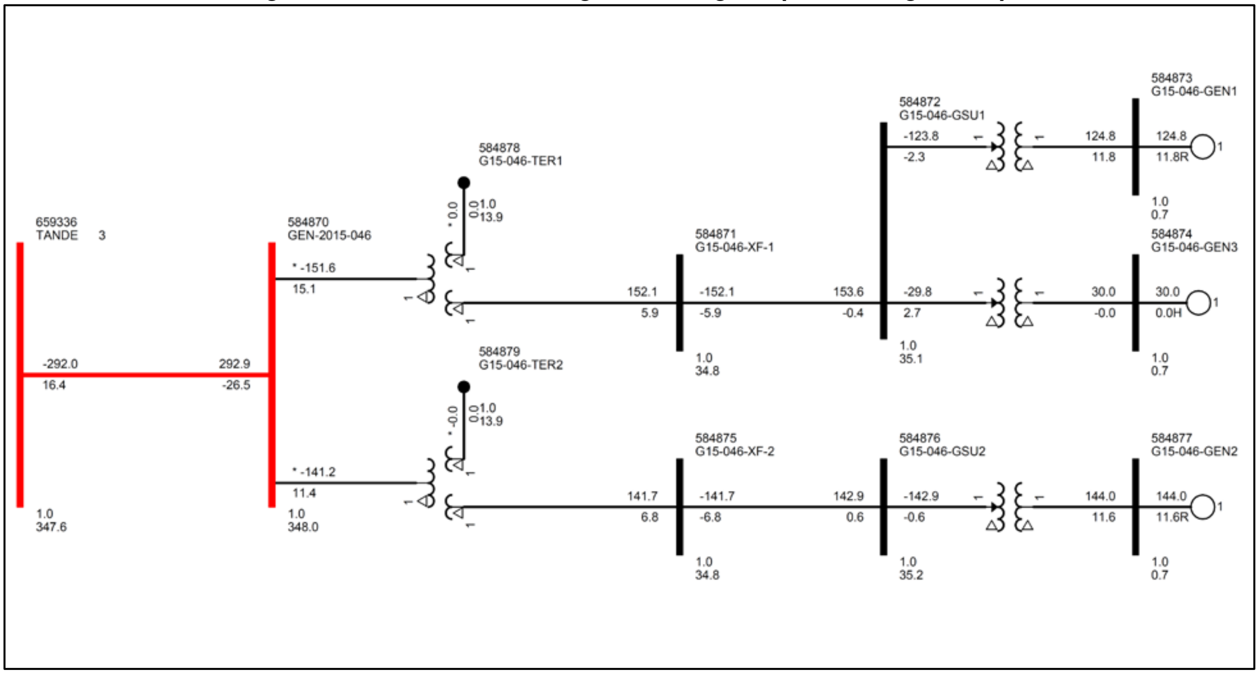


Table 2-1: GEN-2015-046 Modification Request

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B = 0.084151 pu</td></tr>
</table>

3.0 Reactive Power Analysis

The reactive power analysis, also known as the low-wind/no-wind condition analysis, was performed for GEN-2015-046 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. This project was previously studied in DISIS-2015-002-4[2] Group 16 and it was determined that an approximately 40.0 MVAr shunt reactor located at the high voltage side of project substation would provide the required compensation.

3.1 Methodology and Criteria

For the GEN-2015-046 project, the generators were switched out of service while other collector system elements remained in-service. A shunt reactor was tested at the collection substation 34.5 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 following the modification, the GEN-2015-046 project required an approximately 35.1 MVAr shunt reactor at the project substation, to reduce the POI MVAr to zero. 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-2015-046 Single Line Diagram (Shunt Reactor)

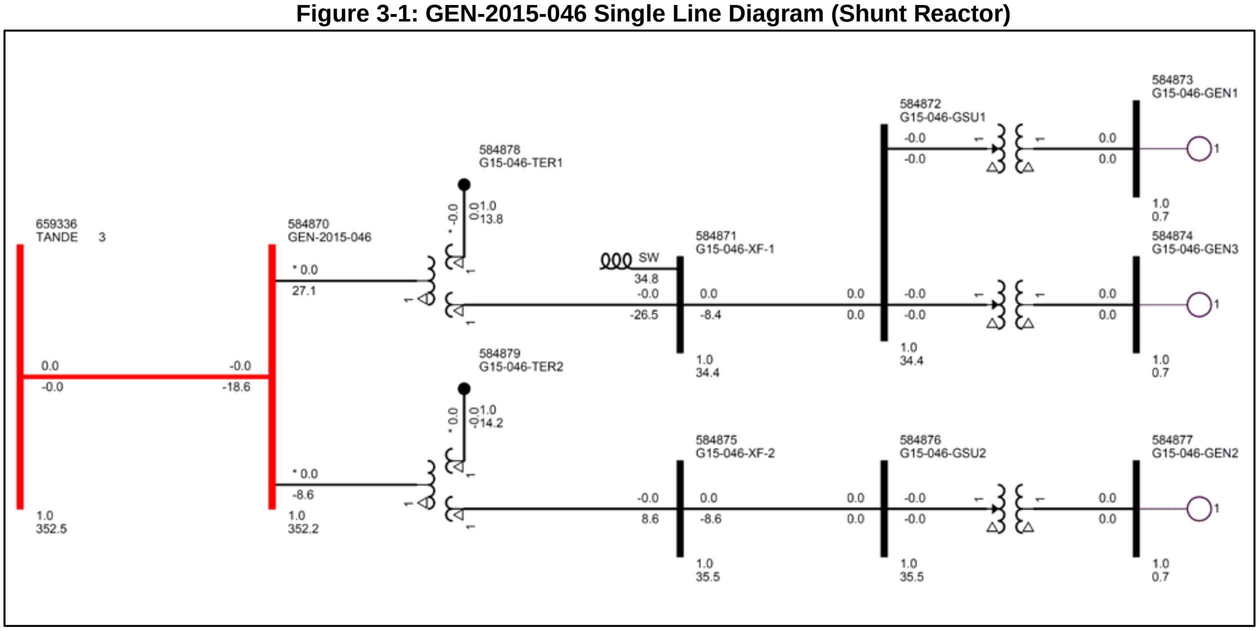


Table 3-1 shows the shunt reactor size determined for the three study models used in the assessment.

[2] DISIS-2015-002-4 Group 2, 6, 8, & 16 Restudy, November 2017

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

Machine	POI Bus Number	POI Bus Name	Reactor Size (MVAr)		
			2017WP	2018SP	2026SP
GEN-2015-046	659336	Tande 345 kV	35.1	35.1	35.1

4.0 Short Circuit Analysis

A short-circuit study was performed using the 2018SP and 2026SP models for GEN-2015-046 with the updated topology. The detailed 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 345 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 through Table 4-3 respectively. The GEN-2015-046 POI bus fault current magnitudes are provided in Table 4-1 showing a maximum fault current of 4.72 kA.

The maximum fault current calculated within 5 buses with GEN-2015-046 was less than 23 kA for the 2018SP and 2026SP models respectively. The maximum GEN-2015-046 contribution to three-phase fault current was about 11.6% and 0.49 kA.

Table 4-1: POI Short Circuit Results

Case	GEN-OFF Current (kA)	GEN-ON Current (kA)	Max kA Change	Max %Change
2018SP	4.20	4.67	0.48	11.4%
2026SP	4.23	4.72	0.49	11.6%

Table 4-2: 2018SP Short Circuit Results

Voltage (kV)	Max. Current (kA)	Max kA Change	Max %Change
69	9.5	-0.05	-0.5%
115	15.4	0.12	0.8%
138	12.6	-0.01	-0.1%
230	22.4	0.18	2.2%
345	15.9	0.48	11.4%
Max	**22.4**	**0.48**	**11.4%**

Table 4-3: 2026SP Short Circuit Results

Voltage (kV)	Max. Current (kA)	Max kA Change	Max %Change
69	9.5	-0.03	-0.3%
115	15.5	0.16	1.1%
230	22.8	0.20	2.4%
345	16.3	0.49	11.6%
Max	**22.8**	**0.49**	**11.6%**

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-2015-046 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 15 Vestas V110 2.0MW and 56 Nordex-Acciona 4.8MW turbine configuration for the GEN-2015-046 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-2016-002-2 for Group 16. J593 was included in the models as a higher queued project, but has been withdrawn from the Midcontinent Independent System Operator (MISO) queue. The modifications requested to project GEN-2015-046 were used to create modified stability models for this impact study. In addition, the following adjustments were made to the 18SP case:

1. Capacitor banks were switched on at J593 (40 MVAr), Tioga 115 kV Substation (20 MVAr), and increased at Logan 115 kV Substation (additional 15 MVAr)
2. Adjusted the J593 main power transformer ratio to 1.05 to avoid high voltage tripping
3. Adjusted the LINDAHL wind farm generator substation transformer tap ratio to 1.05.

The modified dynamics model data for the DISIS-2016-002 Group 16 request, GEN-2015-046 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-2015-046 and other equally and prior queued projects in Group 16. In addition, voltages of five (5) buses away from the POI of GEN-2015-046 were monitored and plotted. The machine rotor angle for synchronous machines and speed for asynchronous machines within this study area including 356 (AMMO), 600 (XEL), 615 (GRE), 620 (OTP), 635 (MEC), 640 (NPPD), 645(OPPD), 652 (WAPA), 661 (MDU) were monitored. In addition, the voltages of all 100 kV and above buses within the study area were monitored.

5.2 Fault Definitions

Aneden simulated the faults previously simulated for GEN-2015-046 and selected additional fault events for GEN-2015-046 as required. The new set of faults were simulated using the modified study models. The fault events included 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.

Table 5-1: Fault Definitions

Fault ID	Fault Descriptions
FLT01-3PH	3 phase fault on Tande 345kV (659336) to Tande-LNX 3 345kV (659427) CKT Z and Tande-LNX 3 345kV (659427) to Judson 345kV (659333) ckt1, near Tande. a. Apply fault at the Tande 345kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault.
FLT02-3PH	3 phase fault on the Tande 345kV (659336) to Tande 230kV (659337) to Tande 13.8kV (659338) XFMR CKT 1, near Tande 345kV. a. Apply fault at the Tande 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.
FLT03-3PH	3 phase fault on the Judson 345kV (659333) to Patentgate 345kV (659390) CKT 1, near Judson. a. Apply fault at the Judson 345kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault.
FLT04-3PH	3 phase fault on the Patentgate 345kV (659390) to Patentgate 115kV (659391) to Patentgate 13.8kV (659392) XFMR CKT 1, near Patentgate 345kV. a. Apply fault at the Patentgate 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.
FLT05-3PH	3 phase fault on the Judson 345kV (659333) to Judson 230kV (659334) to Judson 13.8kV (659335) XFMR CKT 1, near Judson 345kV. a. Apply fault at the Judson 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.
FLT07-3PH	3 phase fault on the Charlie Creek 345kV (659183) to Round Up 345kV (659384) CKT 1, near Charlie Creek. a. Apply fault at the Charlie Creek 345kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault.
FLT08-3PH	3 phase fault on the Charlie Creek 345kV (659183) to Antelope 345kV (659101) CKT 1, near Charlie Creek. a. Apply fault at the Charlie Creek 345kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault.
FLT09-3PH	3 phase fault on the Charlie Creek 345kV (659183) to Belfield 345kV (652424) CKT 1, near Charlie Creek. a. Apply fault at the Charlie Creek 345kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault.
FLT10-3PH	3 phase fault on the Charlie Creek 345kV (659183) to Charlie Creek 230kV (659302) to Charlie Creek 13.8kV (659319) XFMR CKT 2, near Charlie Creek a. Apply fault at the Charlie Creek 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.
FLT11-3PH	3 phase fault on the Neset 230kV (659138) to Neset 115kV (659139) to Neset 13.8kV (659146) XFMR CKT 1, near Neset 230kV. a. Apply fault at the Neset 230kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.
FLT12-3PH	3 phase fault on the Tande 230kV (659337) to Neset 230kV (659138) CKT 1, near Tande. a. Apply fault at the Tande 230kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault.
FLT13-3PH	3 phase fault on the Tioga 230kV (661084) to Wheelock 230kV (659362) CKT 1, near Tioga. a. Apply fault at the Tioga 230kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault.

Table 5-1 continued

Fault ID	Fault Descriptions
FLT14-3PH	3 phase fault on the Tioga 230kV (661084) to Tioga 115kV (661085) to Tioga 13.8kV (661900) XFMR CKT 1, near Tioga 230kV. a. Apply fault at the Tioga 230kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.
FLT15-3PH	3 phase fault on the Neset 115kV (659139) to Tioga 115kV (661085) CKT 1, near Neset. a. Apply fault at the Neset 115kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault.
FLT16-3PH	3 phase fault on the Blaisdell 230kV (659143) to Logan 230kV (659108) CKT 1, near Blaisdell. a. Apply fault at the Blaisdell 230kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault.
FLT44-SB	**Tande (659337) 230kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Tande (659337) 230kV bus on the Tande – Neset 230kV line. b. Wait 16 cycles, and then drop Tande (659337) 230kV to Neset (659138) 230kV line. c. Trip Tande (659336) 345kV to Tande (659337) 230kV to Tande (659338) 13.8kV XFMR and remove the fault.
FLT1001-SB	**Judson (659333) 345 kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Judson (659333) 345 kV bus. b. Wait 16 cycles and remove fault. c. Drop Judson 345kV (659333) to Judson 230kV (659334) to Judson 13.8kV (659335) XFMR CKT 1. d. Drop TANDE-LNX 3 (659427) to JUDSON 3 (659333) 345 kV line circuit 1
FLT1002-SB	**Neset (659138) 230 kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Neset (659138) 230 kV bus. b. Wait 16 cycles and remove fault. c. Drop Neset 230kV (659138) to Neset 115kV (659139) to Neset 13.8kV (659146) XFMR CKT 1 d. Drop NESET 4 (659138) to TIOGA4 4 (661084) 230 kV line circuit 1 e. Drop Neset 230kV (659138) to Tande 230kV (659337) to CKT 1
FLT9002-3PH	3 phase fault on the PATENTGATE 3 (659390) to CHARLIE CREEK (659183) 345 kV line circuit 1, near PATENTGATE 3. a. Apply fault at the PATENTGATE 3 345 kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault.
FLT9003-3PH	3 phase fault on the PATENTGATE 3 (659390) to KUMMERRIDGE 3 (659387) 345 kV line circuit 1, near PATENTGATE 3. a. Apply fault at the PATENTGATE 3 345 kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault.
FLT9004-3PH	3 phase fault on the TANDE 3 (659336) to GEN-2016-151 (588280) 345 kV line circuit 1, near TANDE 3. a. Apply fault at the TANDE 3 345 kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault. e. Drop Gen (588283)
FLT9005-3PH	3 phase fault on the TIOGA4 4 (661084) to BLAISDELL 4 (659143) 230 kV line circuit 1, near TIOGA4 4. a. Apply fault at the TIOGA4 4 230 kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault.
FLT9006-3PH	3 phase fault on the TIOGA4 4 (661084) to J593 (85931) 230 kV line circuit 1, near TIOGA4 4. a. Apply fault at the TIOGA4 4 230 kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault. e. Drop Gen (85934)

Table 5-1 continued

Fault ID	Fault Descriptions
FLT9007-3PH (17WP & 18SP Only)	3 phase fault on the TIOGA4 4 (661084) to BDV 4 (672603) 230 kV line circuit 1, near TIOGA4 4. a. Apply fault at the TIOGA4 4 230 kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault.
FLT9008-3PH (26SP Only)	3 phase fault on the TIOGA4 4 (661084) to LARSON 4 (659372) 230 kV line circuit 1, near TIOGA4 4. a. Apply fault at the TIOGA4 4 230 kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault.
FLT9009-3PH	3 phase fault on the JUDSON 4 (659334) to WILISTN4 (652400) 230 kV line circuit 1, near JUDSON 4. a. Apply fault at the JUDSON 4 230 kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault.
FLT9010-3PH	3 phase fault on the WILISTN4 (652400) to WHEELOCK 4 (659362) 230 kV line circuit 1, near WILISTN4. a. Apply fault at the WILISTN4 230 kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault.
FLT9011-3PH	3 phase fault on the NESET 4 (659138) to TIOGA4 4 (661084) 230 kV line circuit Z, near NESET 4. a. Apply fault at the NESET 4 230 kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault.
FLT9002-PO1 (previously FLT41-PO)	**Prior Outage of Tande Transformer 345/230/13.8 kV (659336) (659337) (659338)** 3 phase fault on the PATENTGATE 3 (659390) to CHARLIE CREEK (659183) 345 kV line circuit 1, near PATENTGATE 3. a. Apply fault at the PATENTGATE 3 345 kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault.
FLT05-PO1 (previously FLT42-PO)	**Prior Outage of Tande Transformer 345/230/13.8 kV (659336) (659337) (659338)** 3 phase fault on the Judson 345kV (659333) to Judson 230kV (659334) to Judson 13.8kV (659335) XFMR CKT 1, near Judson 345kV. a. Apply fault at the Judson 345kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.
FLT03-PO1	**Prior Outage of Tande Transformer 345/230/13.8 kV (659336) (659337) (659338)** 3 phase fault on the Judson 345kV (659333) to Patentgate 345kV (659390) CKT 1, near Judson. a. Apply fault at the Judson 345kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault.
FLT9011-PO2 (previously FLT43-PO)	**Prior Outage of Tande 345kV (659336) to Tande-LNX 3 345kV (659427) CKT Z and Tande-LNX 3 345kV (659427) to Judson 345kV (659333) ckt1** 3 phase fault on the NESET 4 (659138) to TIOGA4 4 (661084) 230 kV line circuit Z, near NESET 4. a. Apply fault at the NESET 4 230 kV bus. b. Clear fault after 6 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 6 cycles, then trip the line in (b) and remove fault.
FLT11-PO2	**Prior Outage of Tande 345kV (659336) to Tande-LNX 3 345kV (659427) CKT Z and Tande-LNX 3 345kV (659427) to Judson 345kV (659333) ckt1** 3 phase fault on the Neset 230kV (659138) to Neset 115kV (659139) to Neset 13.8kV (659146) XFMR CKT 1, near Neset 230kV. a. Apply fault at the Neset 230kV bus. b. Clear fault after 6 cycles by tripping the faulted transformer.

5.3 Results

Table 5-2 shows the results of the fault events simulated for each of the models. The associated stability plots are provided in Appendix D.

Table 5-2: GEN-2015-046 Dynamic Stability Results

Fault ID	2017WP			2018SP			2026SP		
	Voltage Recovery	Voltage Violation	Stable	Voltage Recovery	Voltage Violation	Stable	Voltage Recovery	Voltage Violation	Stable
FLT01-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT02-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT03-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT04-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT05-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT07-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT08-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT09-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT10-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT11-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT12-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT13-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT14-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT15-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT16-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT44-SB	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT1001-SB	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT1002-SB	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9002-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9003-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9004-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9005-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9006-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9007-3PH (17WP & 18SP Only)	Pass	Pass	Stable	Pass	Pass	Stable			
FLT9008-3PH (26SP Only)							Pass	Pass	Stable
FLT9009-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9010-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9011-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9002-PO1	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT05-PO1	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT03-PO1	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9011-PO2	Pass	Pass	Gen Trip*	Pass	Pass	Gen Trip*	Pass	Pass	Gen Trip*
FLT11-PO2	Pass	Pass	Gen Trip*	Pass	Pass	Gen Trip*	Pass	Pass	Gen Trip*

***After PO2, Prior Outage of Tande 345kV to Judson 345kV ckt 1, generator tripping of GEN-2015-046 is mitigated with a system adjustment of GEN-2016-151 & GEN-2015-046 curtailed by a total of 170 MW in 17WP, 170 MW in 18SP, and 180 MW in 26SP**

The results of the dynamic stability analysis showed that with the GEN-2015-046 modification all fault events from a full system intact system state resulted in a stable response following each studied event.

A fault event involving a prior outage with a combination of the Tande POI bus to Judson 345 kV line and either the Neset to Tioga 230 kV line or the Neset 230/115/13.8 kV 3-winding transformer resulted in tripping of GEN-2015-046 on high voltage protection relays.

After each prior outage capacitor banks were used as needed for reactive support in the nearby system as shown in Table 5-3. These capacitor banks were set to provide maximum VARS and switched shunts were enabled in the solution settings to allow the system to adjust as necessary to avoid high voltages.

Table 5-3: Capacitors used for PO2 Support

Bus Number	Bus Name
603280	[MAGIC CITY 7115.00]
655849	[VEEDER -MK7115.00]
655896	[KEENECRNRMK7115.00]
655900	[MOE -MW7115.00]
655904	[BELDEN -MW7115.00]
655907	[ENEWTWN -MW7115.00]
655944	[PLAZA -MW7115.00]
659144	[BLAISDELL 7115.00]
659308	[KENASTON 7115.00]
661052	[KENMARE7 115.00]
661085	[TIOGA4 7 115.00]
661086	[TIOGA7 7 115.00]
85932	[J593 COL1 34.500]
659155	[LOGAN 7 115.00]

In addition, the following settings were adjusted for the modified GEN-2015-046:

1. Both generator substation transformer taps were changed to 1.05
2. Both main power transformer taps were changed to 1.025
3. The Vestas turbine reactive power was set to 6MVAR to achieve a 0.98 power factor
4. The Nordex turbine voltage schedule was changed to 1.0 p.u.

The recently completed DISIS-2016-002-2 (Group 16)[3] study report identified that system stability was achieved with the GEN-2016-151 (200 MW project) curtailed in all three cases as a system adjustment following the prior outage of the Tande POI bus to Judson 345 kV line. The mitigation identified in that report was applied to this Study to determine if GEN-2015-046 will remain online and stable following the subsequent loss of the Neset to Tioga 230 kV line or Neset 230/115/13.8 kV 3-winding transformer.

Figure 5-1 shows the GEN-2015-046 initial tripping response to FLT11-PO2 and Figure 5-2 shows the stable generator response after GEN-2016-151 was curtailed to 100MW.

[3] Definitive Impact Study DISIS-2016-002-2 (Group 16)-Revised, March 2020

Figure 5-1: FLT11-PO2 GEN-2015-046 Initial Response

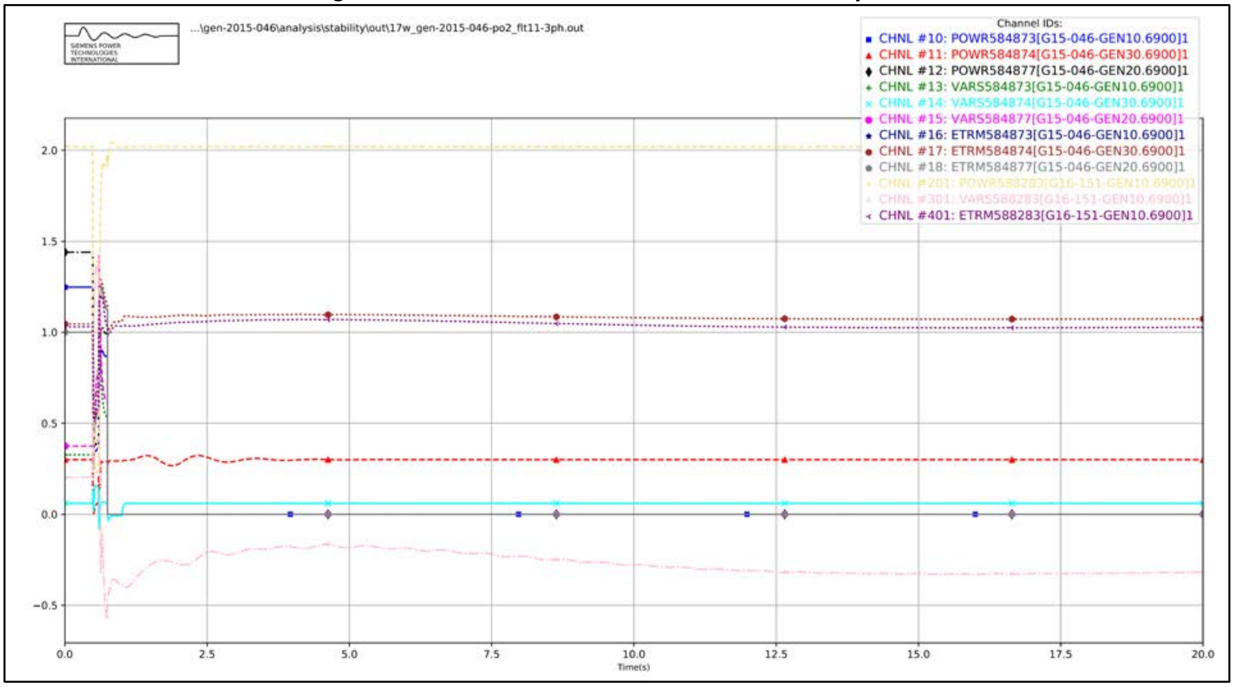
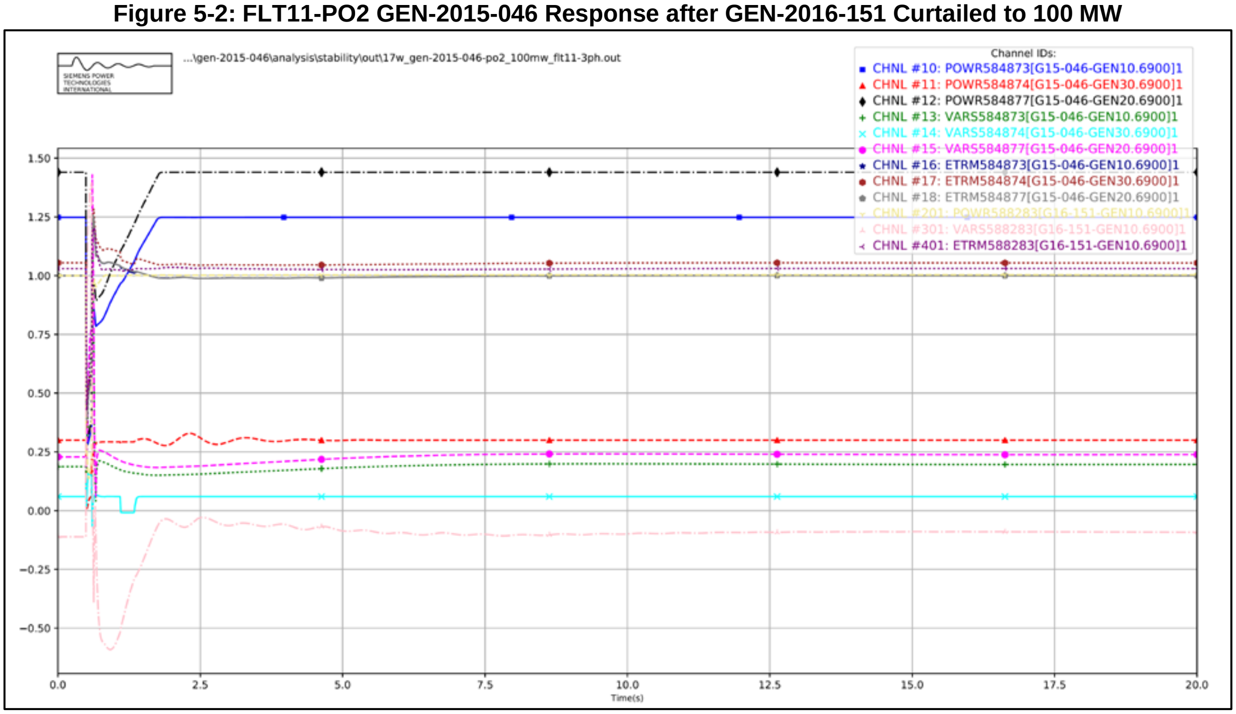


Figure 5-2: FLT11-PO2 GEN-2015-046 Response after GEN-2016-151 Curtailed to 100 MW



In addition, for FLT9011-PO2, further curtailment was required to maintain system stability and prevent tripping of GEN-2015-046. Since both GEN-2015-046 and GEN-2016-151 are interconnected to the Tande 345 kV substation, the curtailment was proportionally split between both projects resulting the following curtailment levels after the prior outage on Tande POI bus to Judson 345 kV line as shown in Table 5-4.

Table 5-4: FLT9011-PO2 GEN-2016-151 and GEN-2015-046 Curtailment Requirement

	Curtailed Amount (MW)			Capacity (MW)
Project	2017WP	2018SP	2026SP	
GEN-2015-046	101.9	101.9	107.9	298.8
GEN-2016-151	68.9	68.9	72.9	202.0
Total	**170.8**	**170.8**	**180.8**	**500.8**

Figure 5-3 shows the GEN-2015-046 initial tripping response to FLT9011-PO2 without curtailment, Figure 5-4 shows that GEN-2015-046 is still unstable when GEN-2016-151 and GEN-2015-046 were curtailed by a total curtailment amount of approximately 160 MW, and Figure 5-5 shows the stable system response after GEN-2016-151 and GEN-2015-046 were curtailed by approximately 170 MW in the 2017WP case. The system swing generator was allowed to absorb all generation curtailments.

Figure 5-3: FLT9011-PO2; GEN-2015-046 Initial Response of Tripping with No Curtailment (17WP)

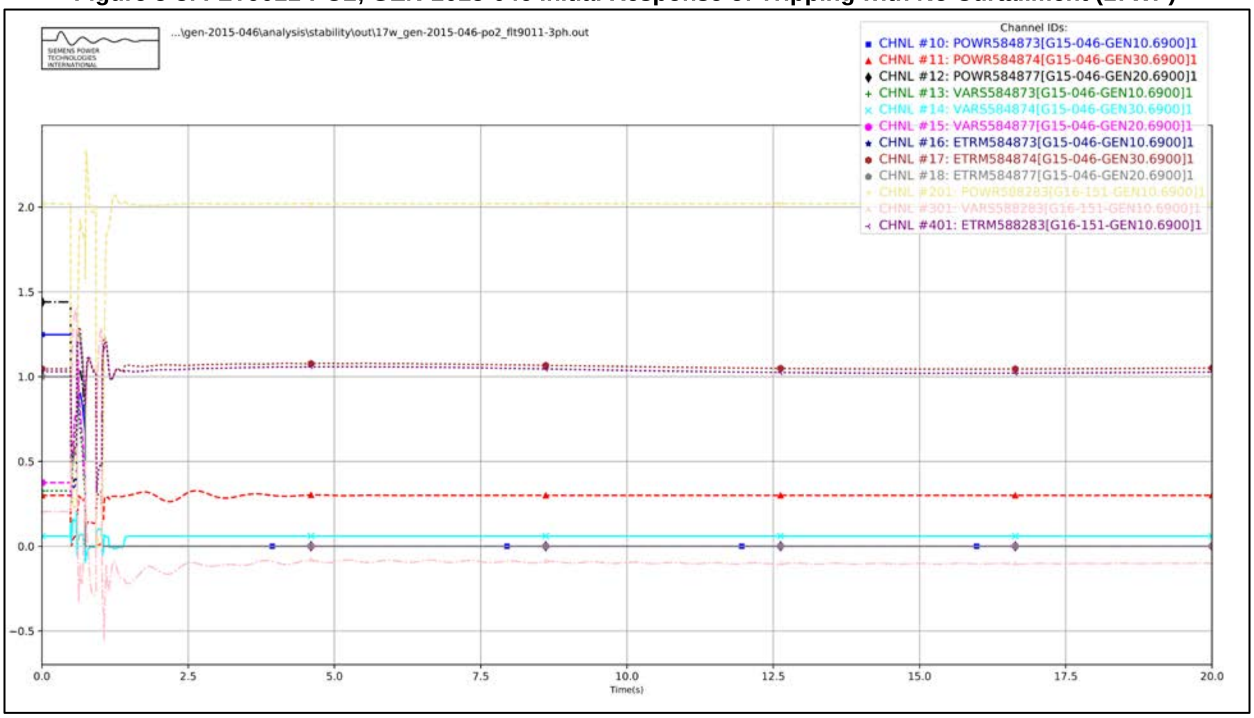


Figure 5-4: FLT9011-PO2; Unstable after GEN-2015-046 & GEN-2016-151 Curtailed by 160 MW (17WP)

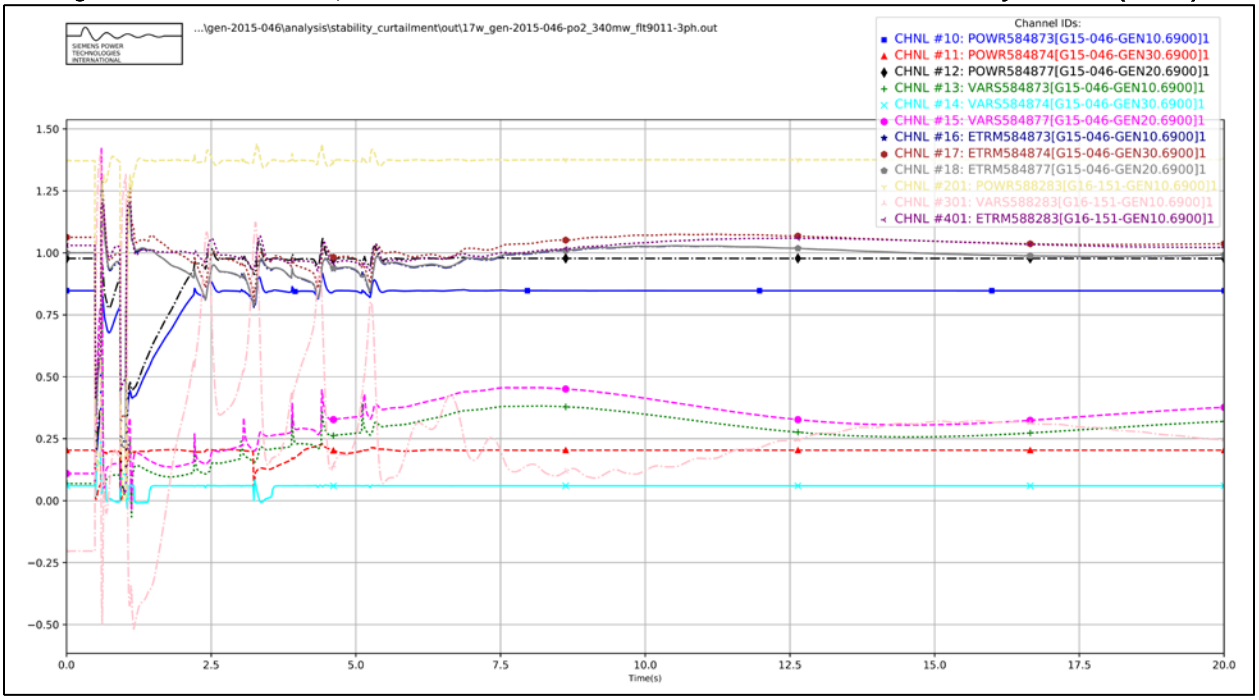
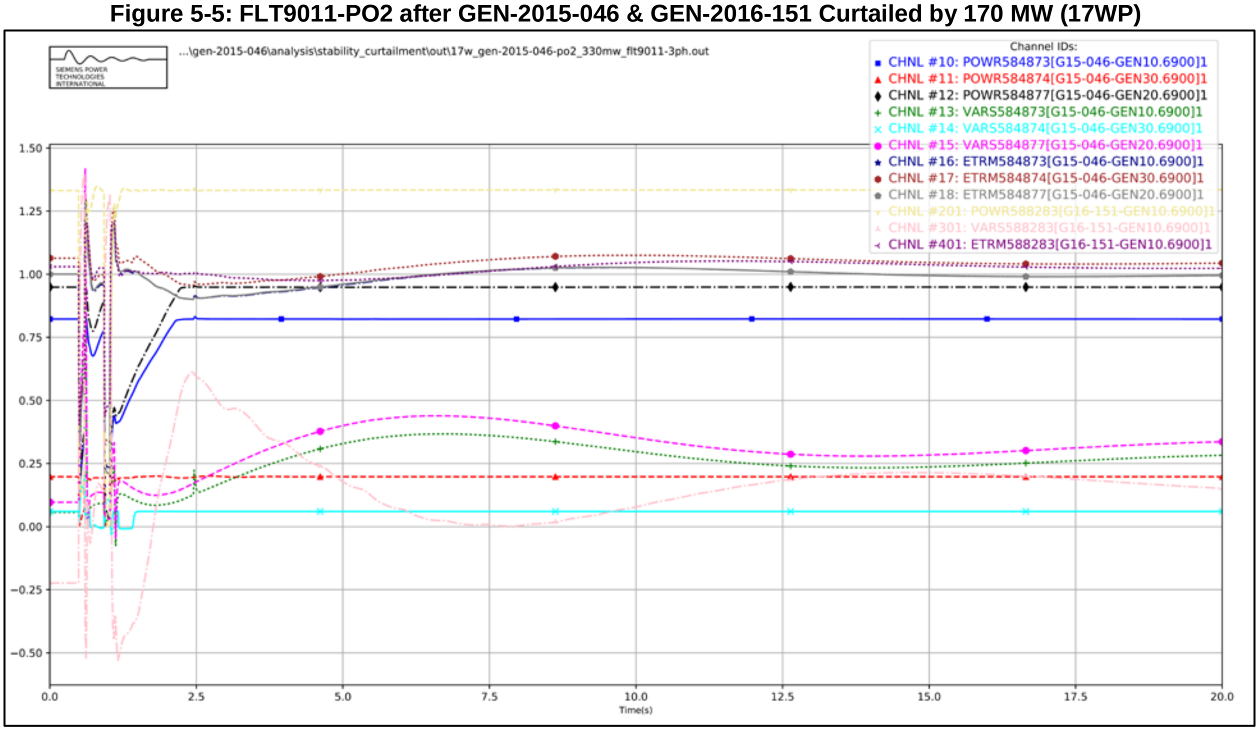


Figure 5-5: FLT9011-PO2 after GEN-2015-046 & GEN-2016-151 Curtailed by 170 MW (17WP)



There were no additional damping or voltage recovery violations 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 Conclusions

The Interconnection Customer for GEN-2015-046 requested a Modification Request Impact Study to assess the impact of the turbine and facility changes to a configuration with a total of 15 x Vestas V110 2.0MW turbines + 56 Nordex-Acciona 4.8MW wind turbines for total capacity of 298.8 MW. In addition, the modification request included changes to the generation interconnection line, collection system, main substation transformer, and the generator substation transformer.

A power factor analysis was not performed as there was no change in the point of interconnection for GEN-2015-046.

The results of the reactive power analysis, also known as the low-wind/no-wind condition analysis, performed using the 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak models showed that the GEN-2015-046 project may require a 35.1 MVAr shunt reactor, a reduction from the previously identified value of 40.0 MVAr in the DISIS-2015-002-4[4] Group 16 report, on the 34.5 kV 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 the short circuit analysis with the updated topology showed that the maximum GEN-2015-046 contribution to three-phase fault currents in the immediate systems at or near GEN-2015-046 was approximately 0.49 kA for the 2018SP and 2026SP cases. All three-phase fault current levels within 5 buses of the POI with the GEN-2015-046 generator online were below 23 kA for the 2018SP models and 2026SP models.

The results of the dynamic stability analysis showed that with the GEN-2015-046 modification all fault events from a full system intact system state resulted in a stable response following each studied event. However, a fault event involving a prior outage with a combination of the Tande POI bus to Judson 345 kV line and either the Neset to Tioga 230 kV line or the Neset 230/115/13.8 kV 3-winding transformer resulted in tripping of GEN-2015-046 on high voltage protection relays. Tripping was mitigated with a system adjustment of both GEN-2016-151 and GEN-2015-046 curtailed by 170 MW in the 2017WP and 2018SP cases, and 180 MW in the 2026SP case after the prior outage of the Tande POI bus to Judson 345 kV line in order for GEN-2015-046 to remain online following the more severe loss of the Neset to Tioga 230 kV line.

There were no additional damping or voltage recovery violations 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.

[4] DISIS-2015-002-4 Group 2, 6, 8, & 16 Restudy, November 2017