GEN-2010-005

Impact Restudy for Generator Modification

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By SPP Generator Interconnections Dept.

REVISION HISTORY

DATE OR VERSION NUMBER	AUTHOR	CHANGE DESCRIPTION
01/28/2020	SPP	Initial report issued.

CONTENTS

SUMMARY

The GEN-2010-005 Interconnection Customer has requested a modification to its 299.2 MW Interconnection Request. This system impact restudy was performed to determine the effects of changing the Phase II turbines from 64 Vestas V110 2.0 MW wind turbine generators (for a total of 128 MW) to 36 Vestas V110 2.0 MW, 8 Vestas V110 2.05 MW, and 18 Vestas V120 2.2 MW wind turbine generators (for a total of 128 MW). In addition, the modification request included changes to the collection system, GSU transformer and the generator substation transformer. The point of interconnection (POI) for GEN-2010-005 remains at the Viola 345 kV 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) at the POI in accordance with FERC Order 827. Additionally, the GEN-2010-005 project will be required to install approximately 5.5 MVArs of incremental reactor shunts on its substation 345 kV bus or provide an alternate means of reactive power compensation in addition to the Phase I compensation requirements. A total of 58.2 MVArs of shunt reactance at the GEN-2016-153 project substation was found to reduce the capacitive effect of the combined GEN-2007-025 and GEN-2010-005 Phase I and II projects at the POI. 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.

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-2010-005
Modification Request Impact Study

Revision R1

Date of Submittal
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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 Phase II of GEN-2010-005, an active generation interconnection request with a point of interconnection (POI) at the Viola 345 kV Substation.

The GEN-2010-005 project consists of two phases and is proposed to interconnect in the Westar Energy, Inc (WERE) control area with a capacity of 299.2 MW as shown in Table ES-1 below. GEN-2010-005 is part of a collection of windfarms interconnected into the Viola 345 kV Substation, including GEN-2007-025 and GEN-2016-153 as shown in Table ES-2.

Table ES-1: Existing GEN-2010-005 Configuration

Request	Capacity (MW)	Existing Generator Configuration	Point of Interconnection
GEN-2010-005	299.2	107 x GE 1.6 (Phase I) = 171.2 MW 64 x Vestas V110 2.0MW (Phase II) = 128 MW	Viola Substation (532798)

Table ES-2: GEN-2007-025 & GEN-2016-153 Configuration

Request	Capacity (MW)	Generator Configuration	Point of Interconnection
GEN-2016-153	134.0	67 x Vestas V110 2.0MW	Viola Substation (532798)
GEN-2007-025	299.2	187 x GE 1.6	Viola Substation (532798)

This Study has been requested to evaluate the modification of GEN-2010-005 to change the Phase II turbine configuration to a total of 36 x Vestas V110 2.0MW + 8 x Vestas V110 2.05MW + 18 x Vestas V120 2.2MW wind turbines for total capacity of 128 MW. In addition, the modification request included changes to the collection system, GSU transformer, and the main substation transformer. The modification request changes are shown in Table ES-3 below. No changes were made to the configuration of GEN-2007-025 and GEN-2016-153.

Table ES-3: GEN-2010-005 Phase II Modification Request

Facility	Existing	Modification
Point of Interconnection	Viola Substation (532798)	Viola Substation (532798)
Configuration/Capacity	64 x Vestas V110 2.0MW = 128 MW	36 x Vestas V110 2.0MW + 8 x Vestas V110 2.05MW + 18 x Vestas V120 2.2MW = 128 MW
Generation Interconnection Line	Length = 5 miles R = 0.000250 pu X = 0.003020 pu B = 0.035180 pu	Length = 5 miles R = 0.000250 pu X = 0.003020 pu B = 0.035180 pu
Main Substation Transformer	Z = 10.29%, Winding 84 MVA, Rating 140 MVA	Z = 10.5%, Winding 84 MVA, Rating 140 MVA
GSU Transformer	Gen 1 Equivalent Qty: 64: Z = 8.96%, Rating 134.4 MVA	Gen Equivalent Qty: 62: Z = 8.44%, Rating 142.6 MVA
Equivalent Collector Line	R = 0.012010 pu X = 0.014150 pu B = 0.041200 pu	R = 0.006495 pu X = 0.008852 pu B = 0.020240 pu

Aneden performed reactive power analysis, short circuit analysis, and dynamic stability analysis using the modification request data on the initial DISIS-2016-002-1 Group 8 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-2010-005.

The results of the reactive power analysis, also known as the low-wind/no-wind condition analysis, performed using the three main models showed that Phase II of the GEN-2010-005 project may require an incremental 5.5 MVAr shunt reactor on the 345 kV bus of the project substation or an electrical equivalent. 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.

An approximately 58.3 MVAr shunt reactor at the GEN-2016-153 project substation would reduce the capacitive effect of the combined GEN-2007-025 and GEN-2010-005 Phase I and II projects at the POI. This amount has increased from the prior GEN-2010-005 study[1].

[1] GEN-2010-005 Impact Restudy for Generator Modification (Turbine Change) posted in March of 2017

The results from the short circuit analysis showed that the maximum change in the fault currents in the immediate systems at or near GEN-2010-005 was approximately 0.12 kA for both the 2018SP and 2026SP cases. All three-phase fault current levels with the GEN-2010-005 Phase II generator online were below 42 kA for the 2018SP models and 2026SP models.

The dynamic stability analysis was performed using the three loading scenarios 2017WP, 2018SP and 2026SP simulating up to 54 contingencies that included previously studied single-phase faults, three-phase faults, three phase faults on prior outage cases, and single-line-to-ground faults stuck breakers faults.

The results of the dynamic stability analysis showed that FLT03-PO2, the prior outage on the Viola POI bus to Wichita 345 kV line, followed by a three-phase fault on and loss of the Renfrow to Hunter 345 kV line, would cause GEN-2010-005 to become unstable in the 2017WP case. This unstable response was only observed in the 2017WP case, and not the 2018SP and 2026SP cases. This is because the 2018SP and 2026SP cases included upgrades at and connected to the Viola 345/138 kV Substation, which have been in service since April 19, 2018, but are not modeled in the 2017WP case.

To verify that the Viola upgrades provide mitigation for the FLT03-PO2 observed instability in the 2017WP case, the model was modified to include the following changes in order to represent the Viola 345/138 kV upgrades for this fault event:

1. Viola 345/138/13.8 kV Transformer
2. Viola – Gill 138 kV line
3. Viola – Clearwater 138 kV line
4. Disconnect Milan Tap – Clearwater 138kV line

After including the upgrades, there were no violations found in the 2017WP case.

There were no other 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 other 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-2010-005 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 Phase II of GEN-2010-005, an active generation interconnection request with point of interconnection (POI) at the Viola 345 kV Substation.

The GEN-2010-005 project consists of two phases and is proposed to interconnect in the Westar Energy, Inc (WERE) control area with a combined capacity of 299.2 MW as shown in Table 1-1 below. GEN-2010-005 is part of a collection of windfarms interconnected into the POI, including GEN-2007-025 and GEN-2016-153 as shown in Table 1-2. Details of the modification request for Phase II of GEN-2010-005 is provided in Section 2.0 below. No changes were made to the configuration of GEN-2007-025 and GEN-2016-153.

Table 1-1: Existing GEN-2010-005 Configuration

<table>
<tr><th>Request</th><th>Capacity (MW)</th><th>Existing Generator Configuration</th><th colspan="2">Generation Interconnection Line</th><th>Point of Interconnection</th></tr>
<tr><td rowspan="2">GEN-2010-005</td><td rowspan="2">299.2</td><td>107 x GE 1.6 (Phase I) = 171.2 MW</td><td>From GEN-2016-153 Substation to East Bus
Length = 12.7 miles
R = 0.000630 pu
X = 0.007670 pu
B = 0.089390 pu</td><td>From East Bus to West Bus
Length = 5.4 miles
R = 0.000269 pu
X = 0.003257 pu
B = 0.037927 pu</td><td rowspan="2">Viola Substation (532798)</td></tr>
<tr><td>64 x Vestas V110 2.0MW (Phase II) = 128 MW</td><td colspan="2">From West Bus to Phase II Bus
Length = 5 miles
R = 0.000250 pu
X = 0.003020 pu
B = 0.035180 pu</td></tr>
</table>

Table 1-2: GEN-2007-025 & GEN-2016-153 Configuration

<table>
<tr><th>Request</th><th>Capacity (MW)</th><th>Generator Configuration</th><th colspan="2">Generation Interconnection Line</th><th>Point of Interconnection</th></tr>
<tr><td>GEN-2016-153</td><td>134.0</td><td>67 x Vestas V110 2.0MW</td><td colspan="2">From Viola to GEN-2016-153 Substation
Length = 2.2 miles
R = 0.000360 pu
X = 0.001130 pu
B = 0.000000 pu</td><td>Viola Substation (532798)</td></tr>
<tr><td>GEN-2007-025</td><td>299.2</td><td>187 x GE 1.6</td><td>From GEN-2016-153 Substation to East Bus
Length = 12.7 miles
R = 0.000630 pu
X = 0.007670 pu
B = 0.089390 pu</td><td>From East Bus to West Bus
Length = 5.4 miles
R = 0.000269 pu
X = 0.003257 pu
B = 0.037927 pu</td><td>Viola Substation (532798)</td></tr>
</table>

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 #1 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.

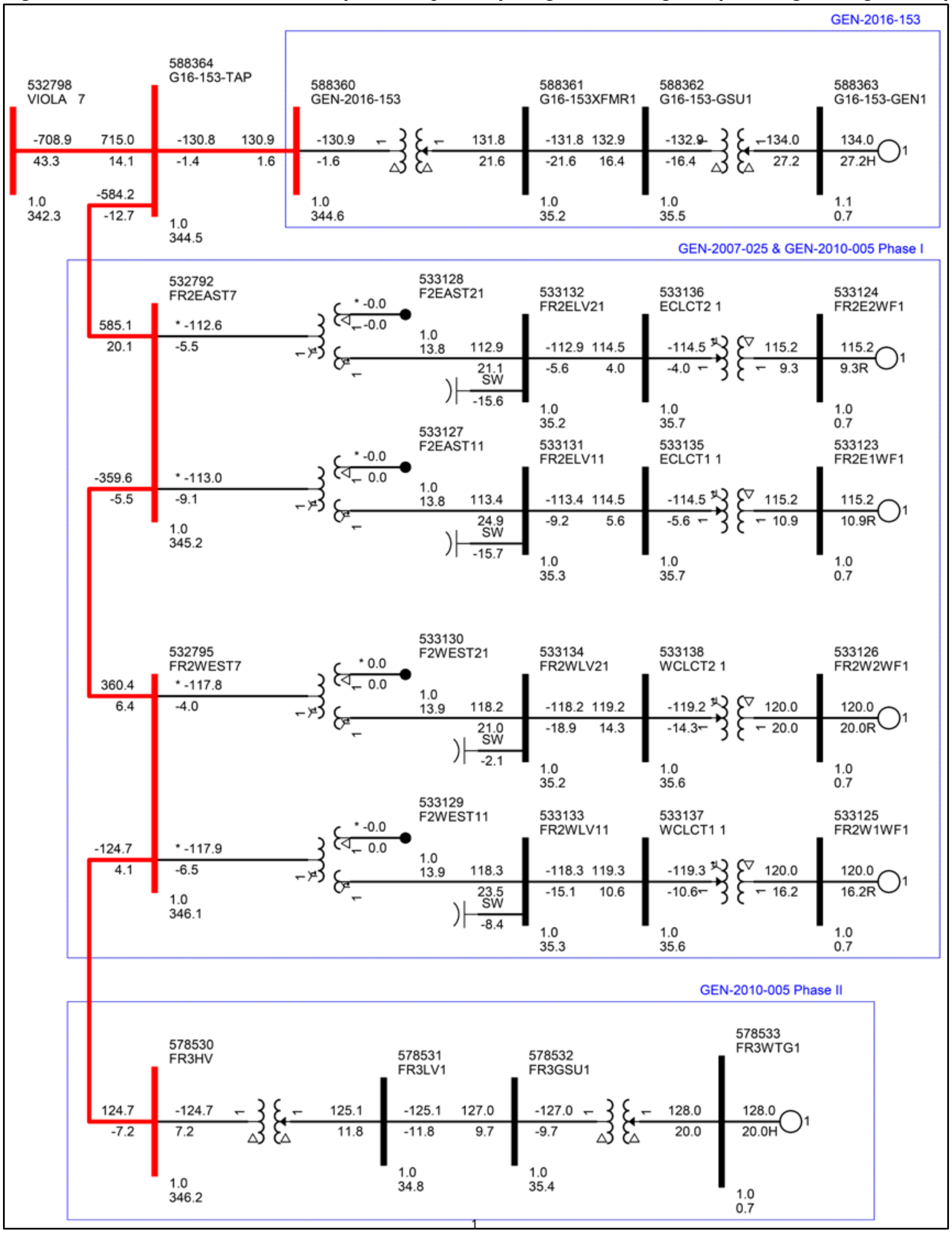
1.2 Study Limitations

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-2010-005 was originally studied as part of Group 8 in the DISIS-2016-002 study. Figure 2-1 shows the power flow model single line diagram for the existing GEN-2010-005 Phase II configuration which shares a POI with GEN-2007-025, GEN-2010-005 Phase I, and GEN-2016-153.

Figure 2-1: GEN-2010-005 Phase II (& Prior Queued) Single Line Diagram (Existing Configuration)

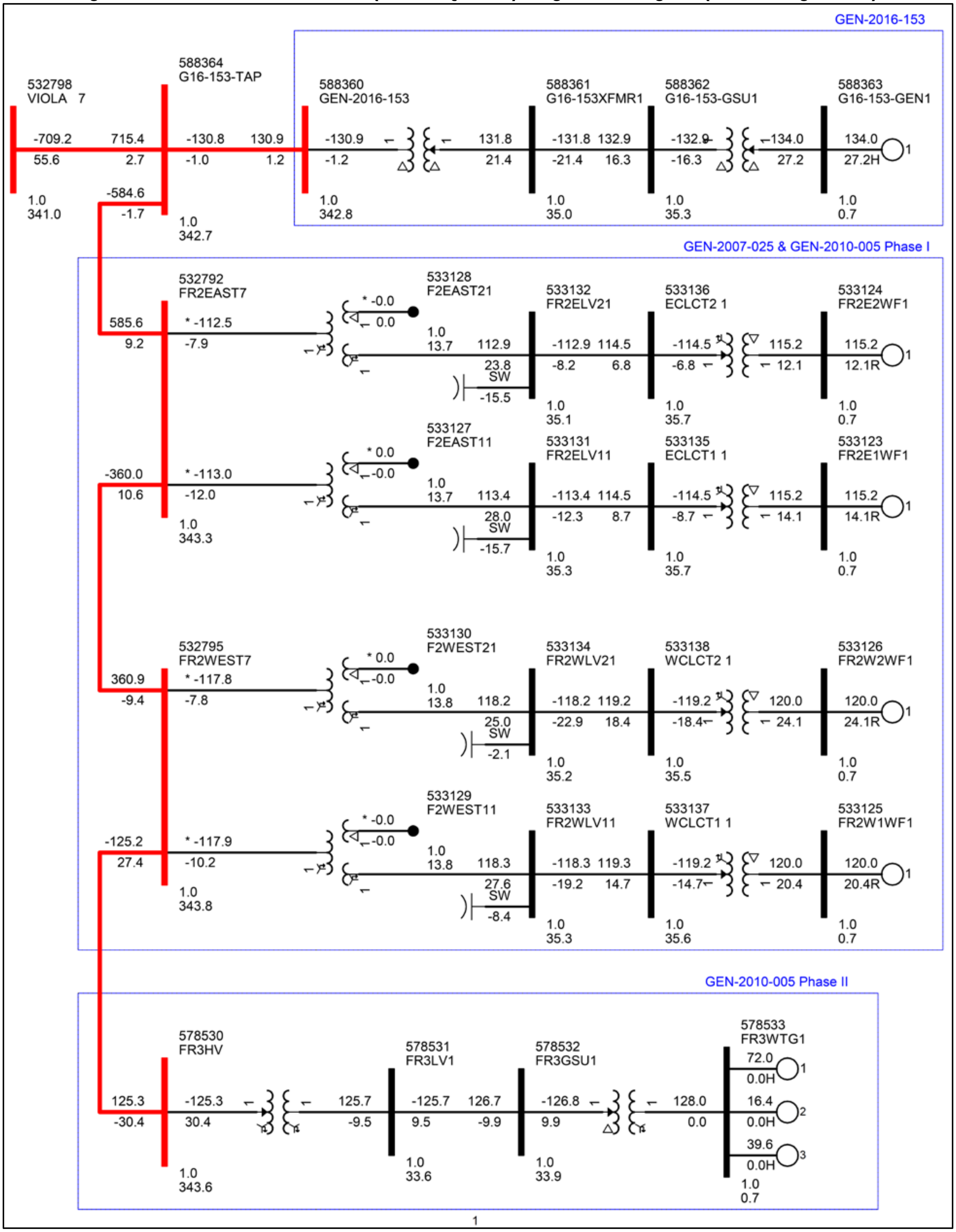


The GEN-2010-005 Phase II Modification Request included a turbine configuration change to a total of 36 x Vestas V110 2.0MW + 8 x Vestas V110 2.05MW + 18 x Vestas V120 2.2MW wind turbines for total capacity of 128 MW. In addition, the modification request also included changes to the collection system, GSU transformer, and the main substation transformer. The major modification request changes are shown in Table 2-1 and Figure 2-2 below. No changes were made to the configuration of GEN-2007-025 and GEN-2016-153.

Table 2-1: GEN-2010-005 Phase II Modification Request

Facility	Existing	Modification
Point of Interconnection	Viola Substation (532798)	Viola Substation (532798)
Configuration/Capacity	64 x Vestas V110 2.0MW = 128 MW	36 x Vestas V110 2.0MW + 8 x Vestas V110 2.05MW + 18 x Vestas V120 2.2MW = 128 MW
Generation Interconnection Line	Length = 5 miles R = 0.000250 pu X = 0.003020 pu B = 0.035180 pu	Length = 5 miles R = 0.000250 pu X = 0.003020 pu B = 0.035180 pu
Main Substation Transformer	Z = 10.29%, Winding 84 MVA, Rating 140 MVA	Z = 10.5%, Winding 84 MVA, Rating 140 MVA
GSU Transformer	Gen 1 Equivalent Qty: 64: Z = 8.96%, Rating 134.4 MVA	Gen Equivalent Qty: 62: Z = 8.44%, Rating 142.6 MVA
Equivalent Collector Line	R = 0.012010 pu X = 0.014150 pu B = 0.041200 pu	R = 0.006495 pu X = 0.008852 pu B = 0.020240 pu

Figure 2-2: GEN-2010-005 Phase II (& Prior Queued) Single Line Diagram (New Configuration)



3.0 Reactive Power Analysis

The reactive power analysis, also known as the low-wind/no-wind condition analysis, was performed for Phase II of GEN-2010-005 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. GEN-2007-025 and Phase I of GEN-2010-005 were also included as they are part of the same generating facility.

3.1 Methodology and Criteria

Initially, the GEN-2016-153 project was disconnected in order to account for the reactive power contributions of the combined GEN-2010-005 and GEN-2007-025 projects interconnected into the same POI. The GEN-2007-025 and GEN-2010-005 project generators and capacitors were switched out of service while the other collector system elements remained in service. A single reactor was placed at the G16-153-TAP 345 kV bus to reduce the reactive power contribution from these combined projects into the POI to approximately zero. The incremental reactive power component was then determined for only Phase II of GEN-2010-005.

3.2 Results

The results from the reactive power analysis showed that Phase II of the GEN-2010-005 project required an approximately 5.5 MVAr incremental shunt reactor at the project substation, to reduce the POI MVAr to zero. Reactive compensation can be provided either by discrete reactive devices or by the generator itself if it possesses that capability.

Figure 3-1 illustrates that an approximately 58.3 MVAr shunt reactor at the GEN-2016-153 project substation would reduce the capacitive effect of the combined GEN-2007-025 and GEN-2010-005 Phase I and II projects at the POI (with GEN-2016-153 disconnected for study purposes). This amount has increased from the prior GEN-2010-005 study[2] as the location of the compensation equipment studied has changed.

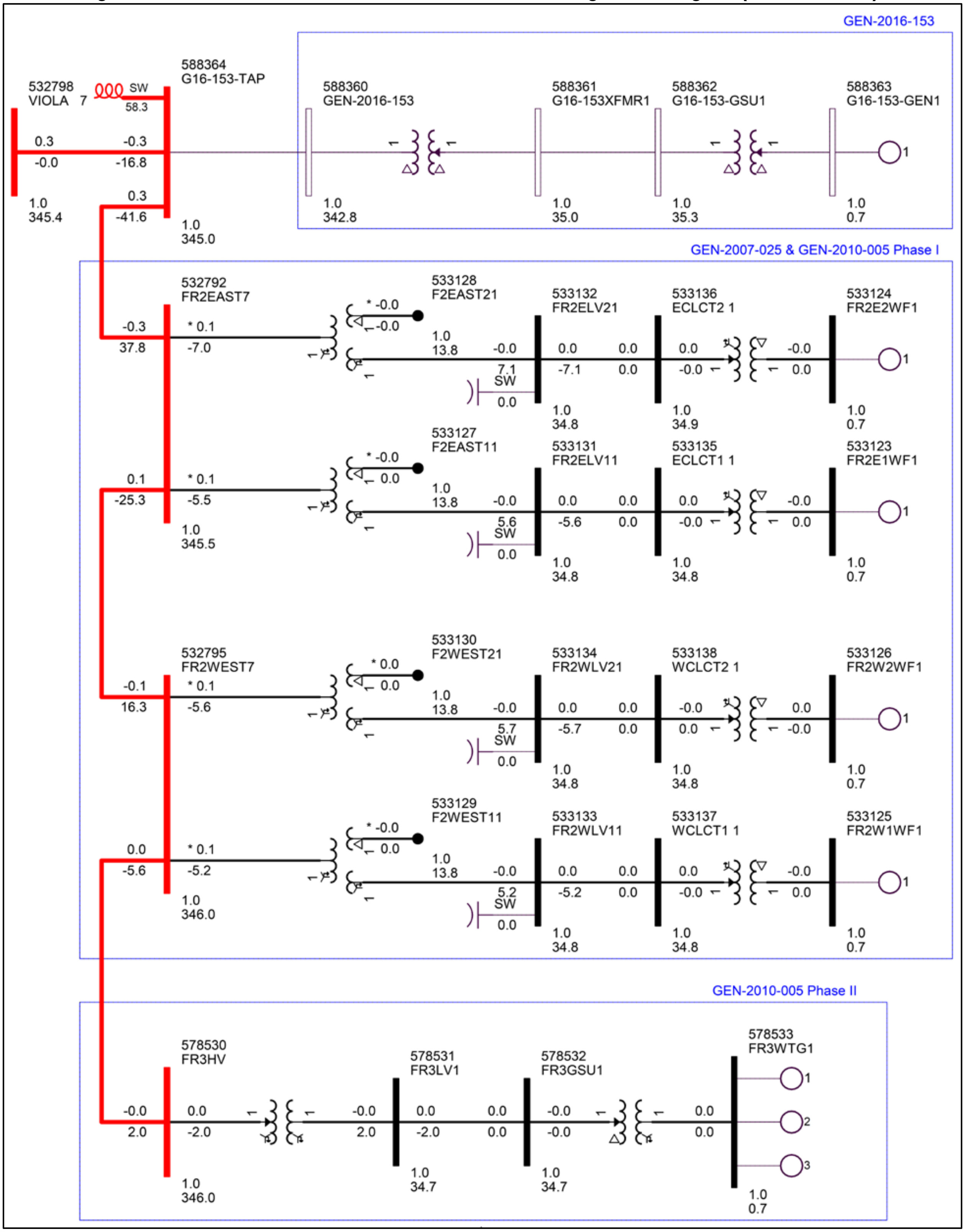
Table 3-1 shows the shunt reactor size determined for the three study models used in the assessment for both GEN-2010-005 Phase II and for the total size determined for GEN-2007-025 and GEN-2010-005 Phase I and II generating facility.

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

Machine	POI Bus Number	POI Bus Name	Reactor Size (MVAr)		
			17WP	18SP	26SP
GEN-2010-005 Phase II	532798	Viola	5.5	5.5	5.5
GEN-2007-025 & GEN-2010-005 Phase I & II	532798	Viola	58.3	58.3	58.3

[2] GEN-2010-005 Impact Restudy for Generator Modification (Turbine Change) posted in March of 2017

Figure 3-1: GEN-2007-025 & GEN-2010-005 Phase I & II Single Line Diagram (Shunt Reactor)



4.0 Short Circuit Analysis

A short-circuit study was performed using the 2018SP and 2026SP models for Phase II of GEN-2010-005. 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 and Table 4-2 respectively. The maximum increase in fault current was about 2.3%, 0.12 kA. The maximum fault current calculated within 5 buses of the GEN-2010-005 POI was less than 42 kA for the 2018SP and 2026SP models respectively. The maximum change of 2.3% was observed at the FR2WEST7 345 kV bus 532795, which had GEN-OFF and GEN-ON fault levels of 5.24 and 5.36 kA respectively.

Table 4-1: 2018SP Short Circuit Results

Voltage (kV)	Max. Current (kA)	Max kA Change	Max %Change
69	33.2	0.00	0.0%
115	23.1	0.00	0.0%
138	40.8	0.03	0.1%
161	0.0	0.00	0.0%
230	22.0	-0.01	-0.1%
345	31.4	0.12	2.3%
Max	**40.8**	**0.12**	**2.3%**

Table 4-2: 2026SP Short Circuit Results

Voltage (kV)	Max. Current (kA)	Max kA Change	Max %Change
69	33.2	0.00	-0.1%
115	25.9	0.00	0.0%
138	41.1	0.03	0.1%
161	0.0	0.00	0.0%
230	22.1	-0.01	-0.1%
345	31.3	0.12	2.3%
Max	**41.1**	**0.12**	**2.3%**

5.0 Dynamic Stability Analysis

Aneden performed a dynamic stability analysis to identify the impact of the turbine configuration change and other modifications to Phase II of the GEN-2010-005 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 38 Vestas V110 2.0 MW turbines, 8 Vestas V110 2.05 MW turbines, and 18 Vestas V120 2.2 MW turbine configuration for Phase II of the GEN-2010-005 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 8. The modifications requested to Phase II of project GEN-2010-005 were used to create modified stability models for this impact study.

The modified dynamics model data for Phase II of the DISIS-2016-002-1 Group 8 request GEN-2010-005 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 Phase II of GEN-2010-005 and other equally and prior queued projects in Group 8. In addition, voltages of five (5) buses away from the POI of GEN-2010-005 were monitored and plotted. The machine rotor angle for synchronous machines and speed for asynchronous machines within this study area including 520 (AEPW), 524 (OKGE), 525 (WFEC), 526 (SPS), 531 (MIDW), 534 (SUNC), 536 (WERE), 540 (GMO), 541 (KCPL) 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-2010-005 and selected additional fault events for GEN-2010-005 as required. The new set of faults were simulated using the modified study models. The fault events included previously identified single-phase faults, 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 the Viola (532798) to Renfrow (515543) 345kV line, near Viola. a. Apply fault at the Viola 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT02- 3PH	3 phase fault on the Viola (532798) to Wichita (532796) 345kV line, near Viola. a. Apply fault at the Viola 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT03- 3PH	3 phase fault on the Renfrow (515543) to Hunter (515476) 345kV line, near Renfrow. a. Apply fault at the Renfrow 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT04- 3PH	3 phase fault on the Renfrow 345kV (515543) to Renfrow 138kV (515544) to Renfrow 13.8kV (515545) transformer, near Renfrow 345kV. a. Apply fault at the Renfrow 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
FLT05- 3PH	3 phase fault on the Hunter (515476) to Woodring (514715) 345kV line, near Hunter. a. Apply fault at the Hunter 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT17- 3PH	3 phase fault on the Rosehill (532794) to Benton (532791) 345kV line, near Rosehill. a. Apply fault at the Rosehill 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT18- 3PH	3 phase fault on the Rosehill (532794) to Wolf Creek (532797) 345kV line, near Rosehill. a. Apply fault at the Rosehill 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT26- 3PH	3 phase fault on the Benton (532791) to Wolf Creek (532796) 345kV line, near Benton. a. Apply fault at the Benton 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT27- 3PH	3 phase fault on the Benton 345kV (532791) to Benton 138kV (532986) to Benton 13.8kV (532821) transformer, near Benton 345kV. a. Apply fault at the Benton 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
FLT28- 3PH	3 phase fault on the Wichita (532796) to Reno (532771) 345kV line, near Wichita. a. Apply fault at the Wichita 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT29- 3PH	3 phase fault on the Wichita (532796) to Benton (532791) 345kV line, near Wichita. a. Apply fault at the Wichita 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.

Table 5-1 continued

Fault ID	Fault Descriptions
FLT31- 3PH	3 phase fault on the Wichita 345kV (532796) to Evans 138kV (533040) to Evans 13.8kV (532830) transformer, near Wichita 345kV. a. Apply fault at the Wichita 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
FLT37- 3PH	3 phase fault on the Reno 345kV (532771) to Reno 138kV (533416) to Reno 14.4kV (532807) transformer, near Reno 345kV. a. Apply fault at the Reno 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
FLT44- 3PH	3 phase fault on the EMPEC (532768) to G14001Tap (562476) 345kV line, near EMPEC. a. Apply fault at the EMPEC 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT63- 1PH	Single phase fault on the Viola (532798) to Renfrow (515543) 345kV line, near Viola. a. Apply fault at the Viola 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT64- 1PH	Single phase fault on the Viola (532798) to Wichita (532796) 345kV line, near Viola. a. Apply fault at the Viola 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT65- 1PH	Single phase fault on the Renfrow (515543) to Hunter (515476) 345kV line, near Renfrow. a. Apply fault at the Renfrow 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT66- 1PH	Single phase fault on the Hunter (515476) to Woodring (514715) 345kV line, near Hunter. a. Apply fault at the Hunter 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT73- 1PH	Single phase fault on the Rosehill (532794) to Benton (532791) 345kV line, near Rosehill. a. Apply fault at the Rosehill 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT74- 1PH	Single phase fault on the Rosehill (532794) to Wolf Creek (532797) 345kV line, near Rosehill. a. Apply fault at the Rosehill 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT77- 1PH	Single phase fault on the Wichita (532796) to Reno (532771) 345kV line, near Wichita. a. Apply fault at the Wichita 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT78- 1PH	Single phase fault on the Wichita (532796) to Benton (532791) 345kV line, near Wichita. a. Apply fault at the Wichita 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.

Table 5-1 continued

Fault ID	Fault Descriptions
FLT83- 1PH	Single phase fault on the EMPEC (532768) to G14001Tap (562476) 345kV line, near EMPEC. a. Apply fault at the EMPEC 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT9001- 3PH (18S and 26S)	3 phase fault on the Viola 345kV (532798) to Viola 138kV (533075) to Viola 13.8kV (532832) transformer, near Viola 345kV. a. Apply fault at the Viola 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
FLT9002- 3PH	3 phase fault on the Renfrow (515543) to Grntwd7 (515646) 345kV line, near Renfrow. a. Apply fault at the Renfrow 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. Trip Generator Grntwdg1 (515660) and Generator Grntwdg2 (515661). c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9005- 3PH	3 phase fault on the Benton (532791) to GEN-2016-162 (588320) 345kV line, near Benton. a. Apply fault at the Benton 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. Trip Generator G16-162-GEN1 (588323) and G16-163-GEN1 (588333). c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9006- 3PH	3 phase fault on the Benton (532791) to Wolfcrk7 (532797) 345kV line, near Benton. a. Apply fault at the Benton 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT9007- 3PH	3 phase fault on the Benton (532791) to Rosehil7 (532794) 345kV line, near Benton. a. Apply fault at the Benton 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT9008- 3PH	3 phase fault on the Wichita (532796) to Buffalo7 (532782) 345kV line CRT 1, near Wichita. a. Apply fault at the Wichita 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT9009- 3PH	3 phase fault on the Wichita (532796) to G14-001-TAP (562476) 345kV line, near Wichita. a. Apply fault at the Wichita 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT9010- 3PH	3 phase fault on the Buffalo7 (532782) to Thistle7 (539801) 345kV line CRT 1, near Buffalo7. a. Apply fault at the Buffalo7 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT9011- 3PH	3 phase fault on the Buffalo7 (532782) to Kingman7 (532783) 345kV line, near Buffalo7. a. Apply fault at the Buffalo7 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. Trip generators. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9012- 3PH	3 phase fault on the Buffalo7 (532782) to GEN-2016-073 (587500) 345kV line, near Buffalo7. a. Apply fault at the Buffalo7 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. Trip Generator G16-073-GEN1 (587503). c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.

Table 5-1 continued

Fault ID	Fault Descriptions
FLT9013- 3PH	3 phase fault on the G14-001-TAP (562476) to EMPEC7 (532768) 345kV line, near G14-001-TAP. a. Apply fault at the G14-001-TAP 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT9014- 3PH	3 phase fault on the G14-001-TAP (562476) to GEN-2014-001 (583850) 345kV line, near G14-001-TAP. a. Apply fault at the G14-001-TAP 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. Trip Generator G14-001-GEN1 (583853) and Generator G14-001-GEN2 (583856). c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9015- 3PH	3 phase fault on the Reno (532771) to G16-111-TAP (587884) 345kV line, near Reno. a. Apply fault at the Reno 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT1001- SB	Stuck Breaker at Renfrow (515543) a. Apply single phase fault at Renfrow 345kV bus. b. Clear fault after 16 cycles and trip the following elements c. Renfrow (515543) - Viola (532798) 345kV line d. Renfrow (515543) - Grntwd7 (515646) 345kV line. Trip generators.
FLT1002- SB	Stuck Breaker at Wichita (532796) a. Apply single phase fault at Wichita 345kV bus. b. Clear fault after 16 cycles and trip the following elements c. Wichita (532796) - G14-001-TAP (562476) 345kV line d. Wichita (532796) - Reno 7 (532771) 345kV line
FLT28- PO1	Prior Outage of the Viola (532798) to Renfrow (515543) 345kV line 3 phase fault on the Wichita (532796) to Reno (532771) 345kV line, near Wichita. a. Apply fault at the Wichita 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT29- PO1	Prior Outage of the Viola (532798) to Renfrow (515543) 345kV line 3 phase fault on the Wichita (532796) to Benton (532791) 345kV line, near Wichita. a. Apply fault at the Wichita 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT31- PO1	Prior Outage of the Viola (532798) to Renfrow (515543) 345kV line 3 phase fault on the Wichita 345kV (532796) to Evans 138kV (533040) to Evans 13.8kV (532830) transformer, near Wichita 345kV. a. Apply fault at the Wichita 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
FLT9008- PO1	Prior Outage of the Viola (532798) to Renfrow (515543) 345kV line 3 phase fault on the Wichita (532796) to Buffalo7 (532782) 345kV line CRT 1, near Wichita. a. Apply fault at the Wichita 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT9009- PO1	Prior Outage of the Viola (532798) to Renfrow (515543) 345kV line 3 phase fault on the Wichita (532796) to G14-001-TAP (562476) 345kV line, near Wichita. a. Apply fault at the Wichita 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT04- PO2	Prior Outage of the Viola (532798) to Wichita (532796) 345kV line 3 phase fault on the Renfrow 345kV (515543) to Renfrow 138kV (515544) to Renfrow 13.8kV (515545) transformer, near Renfrow 345kV. a. Apply fault at the Renfrow 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.

Table 5-1 continued

Fault ID	Fault Descriptions
FLT03- PO2	Prior Outage of the Viola (532798) to Wichita (532796) 345kV line 3 phase fault on the Renfrow (515543) to Hunter (515476) 345kV line, near Renfrow. a. Apply fault at the Renfrow 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT9002- PO2	Prior Outage of the Viola (532798) to Wichita (532796) 345kV line 3 phase fault on the Renfrow (515543) to Grntwd7 (515646) 345kV line, near Renfrow. a. Apply fault at the Renfrow 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. Trip Generator Grntwdg1 (515660) and Generator Grntwdg2 (515661). c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT28- PO3 (18S and 26S)	Prior Outage of the Viola 345kV (532798) to Viola 138kV (533075) to Viola 13.8kV (532832) transformer 3 phase fault on the Wichita (532796) to Reno (532771) 345kV line, near Wichita. a. Apply fault at the Wichita 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT29- PO3 (18S and 26S)	Prior Outage of the Viola 345kV (532798) to Viola 138kV (533075) to Viola 13.8kV (532832) transformer 3 phase fault on the Wichita (532796) to Benton (532791) 345kV line, near Wichita. a. Apply fault at the Wichita 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT31- PO3 (18S and 26S)	Prior Outage of the Viola 345kV (532798) to Viola 138kV (533075) to Viola 13.8kV (532832) transformer 3 phase fault on the Wichita 345kV (532796) to Evans 138kV (533040) to Evans 13.8kV (532830) transformer, near Wichita 345kV. a. Apply fault at the Wichita 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
FLT9008- PO3 (18S and 26S)	Prior Outage of the Viola 345kV (532798) to Viola 138kV (533075) to Viola 13.8kV (532832) transformer 3 phase fault on the Wichita (532796) to Buffalo7 (532782) 345kV line CRT 1, near Wichita. a. Apply fault at the Wichita 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT9009- PO3 (18S and 26S)	Prior Outage of the Viola 345kV (532798) to Viola 138kV (533075) to Viola 13.8kV (532832) transformer 3 phase fault on the Wichita (532796) to G14-001-TAP (562476) 345kV line, near Wichita. a. Apply fault at the Wichita 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.
FLT04- PO3 (18S and 26S)	Prior Outage of the Viola 345kV (532798) to Viola 138kV (533075) to Viola 13.8kV (532832) transformer 3 phase fault on the Renfrow 345kV (515543) to Renfrow 138kV (515544) to Renfrow 13.8kV (515545) transformer, near Renfrow 345kV. a. Apply fault at the Renfrow 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
FLT03- PO3 (18S and 26S)	Prior Outage of the Viola 345kV (532798) to Viola 138kV (533075) to Viola 13.8kV (532832) transformer 3 phase fault on the Renfrow (515543) to Hunter (515476) 345kV line, near Renfrow. a. Apply fault at the Renfrow 345kV bus. b. Clear fault after 5 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 5 cycles, then trip the line in (b) and remove fault.

Table 5-1 continued

Fault ID	Fault Descriptions
FLT9002- PO3 (18S and 26S)	Prior Outage of the Viola 345kV (532798) to Viola 138kV (533075) to Viola 13.8kV (532832) transformer 3 phase fault on the Renfrow (515543) to Grntwd7 (515646) 345kV line, near Renfrow. a. Apply fault at the Renfrow 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. Trip Generator Grntwdg1 (515660) and Generator Grntwdg2 (515661). c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.

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-2010-005 Dynamic Stability Results

Fault ID	17W			18S			26S		
	Volt. Recovery	Volt. Violation	Stable	Volt. Recovery	Volt. Violation	Stable	Volt. Recovery	Volt. 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
FLT17- 3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT18- 3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT26- 3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT27- 3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT28- 3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT29- 3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT31- 3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT37- 3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT44- 3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT63- 1PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT64- 1PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT65- 1PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT66- 1PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT73- 1PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT74- 1PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT77- 1PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT78- 1PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT83- 1PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9001- 3PH				Pass	Pass	Stable	Pass	Pass	Stable
FLT9002- 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	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9008- 3PH	Pass	Pass	Stable	Pass	Pass	Stable	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

Table 5-2 continued

Fault ID	17W			18S			26S		
	Volt. Recovery	Volt. Violation	Stable	Volt. Recovery	Volt. Violation	Stable	Volt. Recovery	Volt. Violation	Stable
FLT9011- 3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9012- 3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9013- 3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9014- 3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9015- 3PH	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
FLT28- PO1	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT29- PO1	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT31- PO1	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9008- PO1	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9009- PO1	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT04- PO2	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT03- PO2	Fail	Fail	Unstable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9002- PO2	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT28- PO3				Pass	Pass	Stable	Pass	Pass	Stable
FLT29- PO3				Pass	Pass	Stable	Pass	Pass	Stable
FLT31- PO3				Pass	Pass	Stable	Pass	Pass	Stable
FLT9008- PO3				Pass	Pass	Stable	Pass	Pass	Stable
FLT9009- PO3				Pass	Pass	Stable	Pass	Pass	Stable
FLT04- PO3				Pass	Pass	Stable	Pass	Pass	Stable
FLT03- PO3				Pass	Pass	Stable	Pass	Pass	Stable
FLT9002- PO3				Pass	Pass	Stable	Pass	Pass	Stable

FLT03-PO2, the prior outage on the Viola POI bus to Wichita 345 kV line, followed by a three-phase fault on and loss of the Renfrow to Hunter 345 kV line, would cause GEN-2010-005 to become unstable in the 2017WP case. This unstable response was only observed in the 2017WP case, and not the 2018SP and 2026SP cases. This is because the 2018SP and 2026SP cases included upgrades at and connected to the Viola 345/138 kV Substation, which have been in service since April 19, 2018 but were not modeled in the 2017WP case.

To verify that the Viola upgrades provided mitigation for the FLT03-PO2 observed instability in the 2017WP case, the model was modified to include the following changes in order to represent the Viola 345/138 kV upgrades for this fault event:

1. Viola 345/138/13.8 kV Transformer
2. Viola – Gill 138 kV line
3. Viola – Clearwater 138 kV line
4. Disconnect Milan Tap – Clearwater 138kV line

After including the upgrades, there were no violations found in the 2017WP case.

Figure 5-1 and Figure 5-2 show the GEN-2010-005 response during the FLT03-PO2 event in the 2017WP case for the existing GEN-2010-005 Phase II configuration and the modified GEN-2010-005 Phase II configuration respectively.

Figure 5-1: FLT03-PO2 GEN-2010-005 Response 2017WP (Existing Configuration)

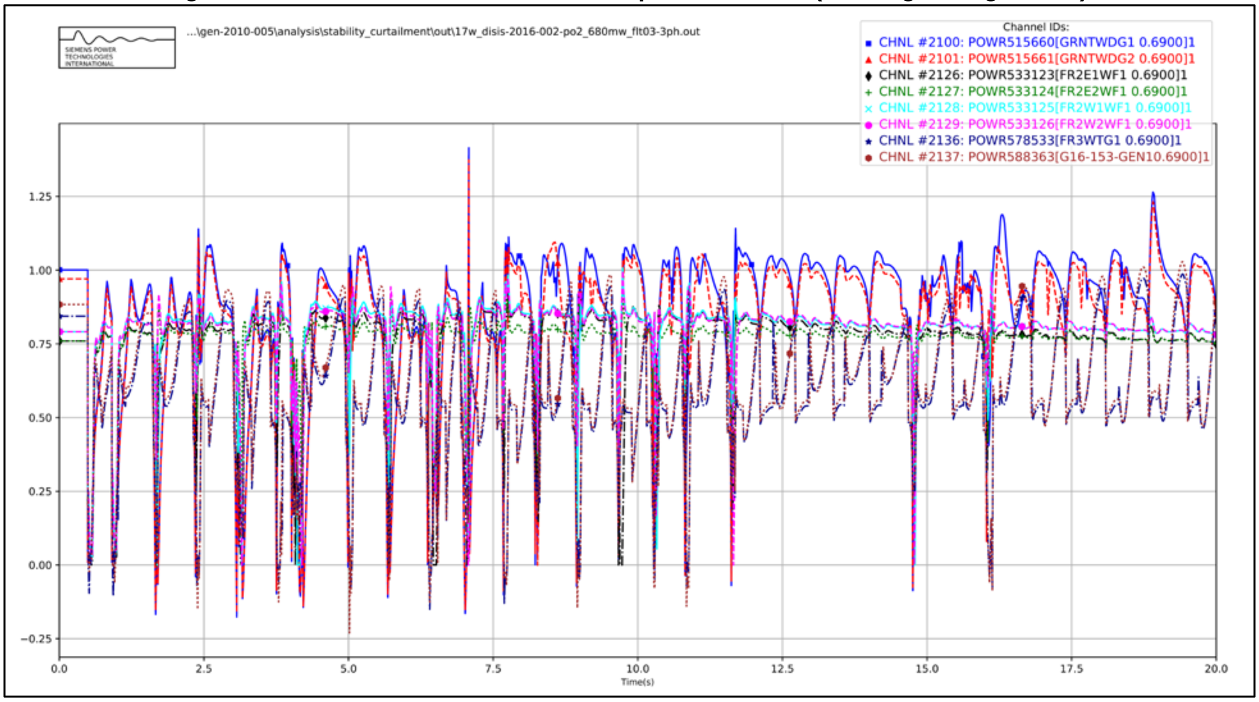


Figure 5-2: FLT03-PO2 GEN-2010-005 Phase II Response 2017WP (Modification Request)

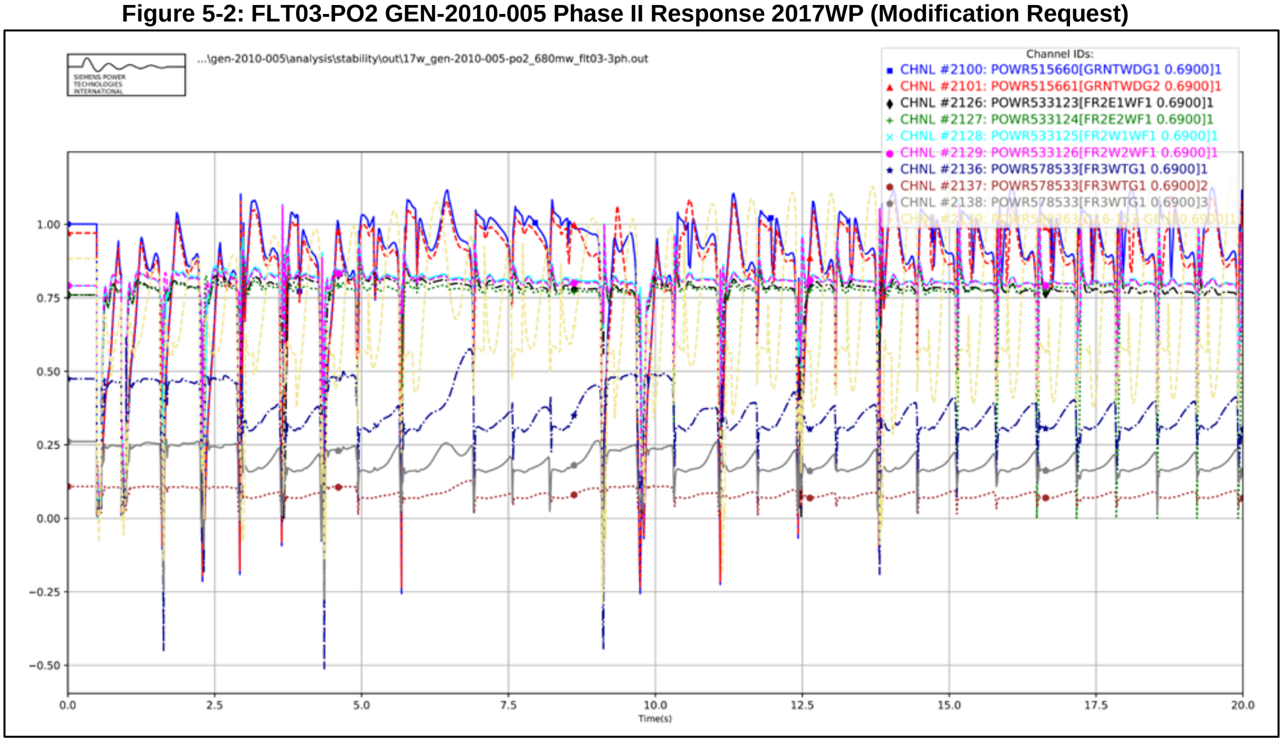
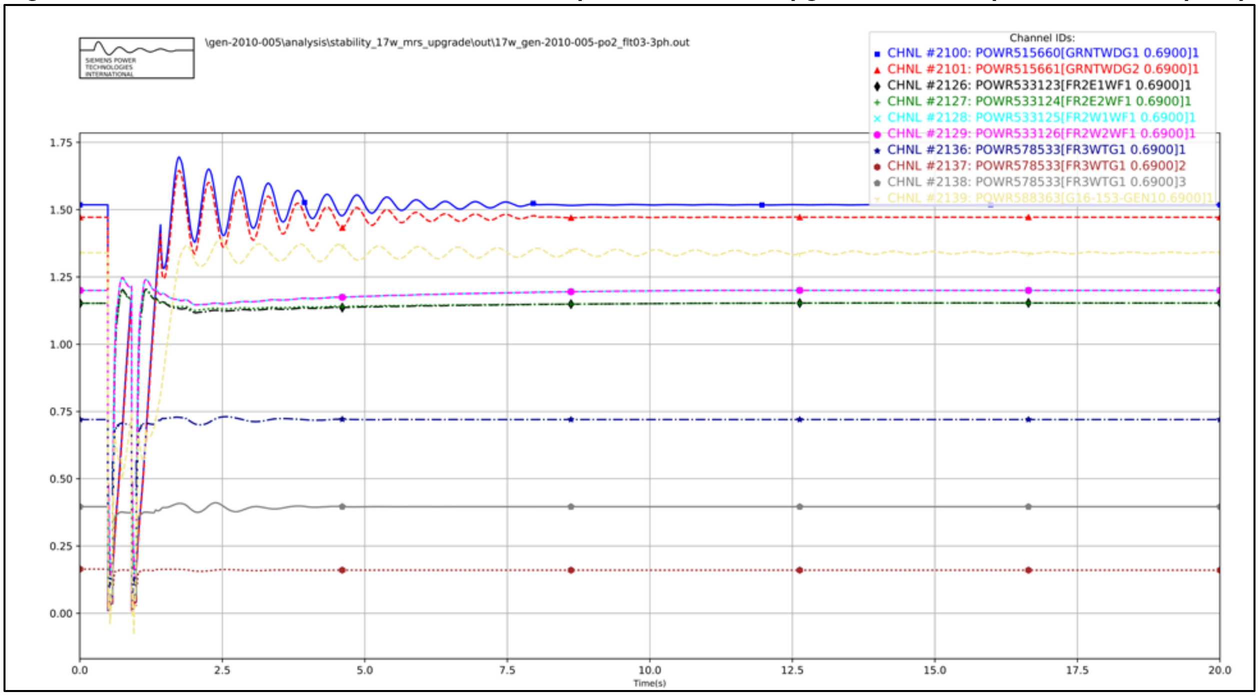


Figure 5-3 shows the stable GEN-2010-005 response in the 2017WP case after including the Viola 345/138 kV upgrades.

Figure 5-3: FLT03-PO2 GEN-2010-005 Phase II Response with Viola Upgrades 2017WP (Modification Request)



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.

6.0 Conclusions

The Interconnection Customer for GEN-2010-005 requested a Modification Request Impact Study to assess the impact of the turbine and facility changes to Phase II of the configuration with a total of 36 x Vestas V110 2.0MW + 8 x Vestas V110 2.05MW + 18 x Vestas V120 2.2MW wind turbines for a total capacity of 128 MW. In addition, the modification request included changes to the collection system, GSU transformer, and the main substation transformer.

A power factor analysis was not performed as there was no change in the point of interconnection for GEN-2010-005.

The results of the reactive power analysis, also known as the low-wind/no-wind condition analysis, performed using all three models showed that Phase II of the GEN-2010-005 project may require an incremental 5.5 MVAr shunt reactor on the 345 kV bus of the project substation or an electrical equivalent. The shunt reactor is needed to reduce the project's reactive power transfer at the POI to approximately zero during low/no wind conditions while the generation interconnection project remains connected to the grid.

An approximately 58.3 MVAr shunt reactor at the GEN-2016-153 project substation would reduce the capacitive effect of the combined GEN-2007-025 and GEN-2010-005 Phase I and II projects at the POI. This amount has increased from the prior GEN-2010-005 study[3].

The results from the short circuit analysis showed that the maximum change in the fault currents in the immediate systems at or near GEN-2010-005 was approximately 0.12 kA for both the 2018SP and 2026SP cases. All three-phase fault current levels with the GEN-2010-005 Phase II generator online were below 42 kA for the 2018SP models and 2026SP models.

The results of the dynamic stability analysis showed that FLT03-PO2, the prior outage on the Viola POI bus to Wichita 345 kV line, followed by a three-phase fault on and loss of the Renfrow to Hunter 345 kV line, would cause GEN-2010-005 to become unstable in the 2017WP case. This unstable response was only observed in the 2017WP case, and not the 2018SP and 2026SP cases. This is because the 2018SP and 2026SP cases included upgrades at and connected to the Viola 345/138 kV Substation, which have been in service since April 19, 2018, but were not modeled in the 2017WP case.

To verify that the Viola upgrades provide mitigation for the FLT03-PO2 observed instability in the 2017WP case, the model was modified to include the following changes in order to represent the Viola 345/138 kV upgrades for this fault event:

1. Viola 345/138/13.8 kV Transformer
2. Viola – Gill 138 kV line
3. Viola – Clearwater 138 kV line
4. Disconnect Milan Tap – Clearwater 138kV line

After including the upgrades, there were no violations found in the 2017WP case.

[3] GEN-2010-005 Impact Restudy for Generator Modification (Turbine Change) posted in March of 2017

There were no other 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 other 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-2010-005 Phase II Modification Request does not constitute a material modification.