GEN-2010-051 & GEN-2011-027

Impact Restudy for Generator Modification (Turbine Change)

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By SPP Generator Interconnections Dept.

REVISION HISTORY

DATE OR VERSION NUMBER	AUTHOR	CHANGE DESCRIPTION
10/25/2018	SPP	Initial report issued.

CONTENTS

SUMMARY

The GEN-2010-051 and GEN-2011-027 Interconnection Customer has requested a modification to its Interconnection Request. This system impact restudy was performed to determine the effects of changing wind turbine generators from the previously studied one hundred seventeen (117) GE 1.7 MW wind turbine generators at GEN-2010-051 and sixty-five (65) GE 1.85 MW wind turbine generators at GEN-2011-027 to one hundred one (101) Acciona 3.15 MW wind turbine generators combined. The total nameplate changes from 319.15 MW to 318.15MW. The point of interconnection (POI) is a tap on the Nebraska Public Power District (NPPD) Twin Church to Hoskins 230 kV line.

Specifically, the study was performed to determine whether the request for modification is considered Material. Study models that included Interconnection Requests through DISIS-2016-001 were used that analyzed the timeframes of 2016 winter, 2017 summer, and 2025 summer models.

The restudy showed that the stability analysis has determined with all previously assigned Network Upgrades in service, generators in the monitored areas remained stable and within the pre-contingency, voltage recovery and post fault voltage recovery criterion of 0.7pu to 1.2pu for the entire modeled disturbances with the exception of a prior outage on the Hoskins to GEN-2010-051 and GEN-2011-027 POI 230 kV line followed by a three phase fault on the Twin Church to Sioux City 230 kV line line. In this scenario, GEN-2010-051 and GEN-2011-027 may become unstable; to prevent an unstable response, GEN-2010-051 and GEN-2011-027 may be curtailed to an output of 230 MW. 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.

A power factor analysis was previously performed and remains valid. The facility will be required to maintain a 95% lagging (providing VARs) and 95% leading (absorbing VARs) power factor at the POI. A low-wind/no-wind condition analysis was performed identifying a need for 16.2 MVAr of reactive 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. Reactive compensation can be provided either by discrete reactive devices or by the generator itself if it possesses that capability.

With the assumptions outlined in this report and with all the required network upgrades from the DISIS 2016-001-1 in place, GEN-2010-051 and GEN-2011-027 with the one hundred one (101) Acciona 3.15 MW wind turbine generators should be able to interconnect reliably to the SPP transmission grid.

It should be noted that this study analyzed the requested modification to change generator technology, manufacturer, and layout. 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-2010-051 and GEN-2011-027 Modification Request Impact Study

Revision R1

Date of Submittal
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anedenconsulting.com

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

Executive Summary

Aneden Consulting (Aneden) was retained by the Southwest Power Pool (SPP) to perform a Modification Request Impact Study (Study) for GEN-2010-051 and GEN-2011-027, an active generation interconnection request with point of interconnection (POI) on the Twin Church to Hoskins 230 kV line.

The GEN-2010-051 and GEN-2011-027 projects were proposed to interconnect in the Nebraska Public Power District (NPPD) control area with a combined capacity of 319.15 MW as shown in Table ES-1 below. This Study has been requested to evaluate the modification of GEN-2010-051 and GEN-2011-027 to change turbine configuration change to a total of 101 x Acciona 3.15 MW for a total capacity of 318.15 MW. Both projects were modeled as a single equivalent generator. In addition, the modification request included changes to the generation interconnection line, collection system and the main substation transformer. The modification request changes are shown in Table ES-2 below.

Table ES-1: Existing GEN-2010-051 and GEN-2011-027 Configuration

Request	Capacity (MW)	Existing Generator Configuration	Point of Interconnection
GEN-2010-051	198.9	125 x GE 1.6 MW117 x GE 1.7 MW	Tap on Twin Church – Hoskins 230kV Line (560347)
GEN-2011-027	120.25	65 x GE 1.85 MW	Tap on Twin Church – Hoskins 230kV Line (560347)

Table ES-2: GEN-2010-051 and GEN-2011-027 Modification Request

Facility	Existing	Modification Request
Point of Interconnection	Tap on Twin Church – Hoskins 230kV Line (560347)	Tap on Twin Church – Hoskins 230kV Line (560347)
Configuration/Capacity	117 x GE 1.7 MW = 198.9 MW 65 x GE 1.85 MW = 120.25 MW	101 x Acciona 3.15 MW turbines (318.15 MW)
Generation Interconnection Line(s)	Length = 3.6 miles R = 0.001420 pu X = 0.005800 pu B = 0.009240 pu	Length = 5 miles R = 0.000935pu X = 0.008499 pu B = 0.012266 pu
Main Substation Transformer	T1: Z = 9.0%, Rating 113 MVA T2: Z = 9.0%, Rating 120 MVA T3: Z = 9.0%, Rating 156 MVA	T1: Z = 9.7%, Rating 225 MVA T2: Z = 9.7%, Rating 130 MVA
Equivalent Collector Line 1	R = 0.006480 pu X = 0.014590 pu B = 0.049070 pu	R = 0.003125 pu X = 0.004132 pu B = 0.148210 pu
Equivalent Collector Line 2	R = 0.012510 pu X = 0.028140 pu B = 0.074520 pu	N/A
Equivalent Collector Line 3	R = 0.009250 pu X = 0.020800 pu B = 0.102680 pu	N/A

GEN-2010-051 and GEN-2011-027 were originally studied as part of Group 9 in the DISIS-2010-002 and DISIS-2011-001 in January 2011 and December 2011 respectively. Aneden performed reactive power analysis, short circuit analysis and dynamic stability analysis using the modification request data based on the DISIS-2016-001 ReStudy #1 Group 9 study models:

1. 2016 Winter Peak (2016WP),
2. 2017 Summer Peak (2017SP) and
3. 2025 Summer Peak (2025SP).

All analyses were performed using the PTI PSS/E version 32 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-2010-051 and GEN-2011-027.

The results of the reactive power analysis, also known as the low-wind/no-wind condition analysis, performed using all three models showed that the combined GEN-2010-051 and GEN-2011-027 project may require a 16.2 MVAr shunt reactor on the 230 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 short circuit analysis showed that the maximum change in the fault currents in the immediate systems at or near GEN-2010-051 and GEN-2011-027 was 1.644 kA. All three-phase current levels with the GEN-2010-051 and GEN-2011-027 generator online was below 35 kA and 36 kA in the 2017SP and 2025SP models respectively.

The dynamic stability analysis was performed using the three loading scenarios 2016 Winter Peak, 2017 Summer Peak and 2025 Summer Peak simulating up to 33 contingencies that included three-phase faults, three phase faults on prior outage cases, and single-line-to-ground faults stuck breakers faults.

After the prior outage of the Hoskins to the Point of Interconnection substation 230 kV line, a three-phase fault on the Twin Church to Sioux City 230 kV line caused an undervoltage trip of GEN-2010-051_2011-027. The output of the project may have to be curtailed to about 230 MW after the prior outage to prevent the undervoltage trip of the project.

There were no other machine rotor angle damping or transient voltage recovery violations observed in the simulated fault events. Additionally, the project wind farm was found to stay connected during the contingencies that were studied and, therefore, will meet the Low Voltage Ride Through (LVRT) requirements of FERC Order #661A.

The results of this Study show that the GEN-2010-051 and GEN-2011-027 Modification Request does not constitute a material modification.

1.0 Introduction

Aneden Consulting (Aneden) was retained by the Southwest Power Pool (SPP) to perform a Modification Request Impact Study (Study) for GEN-2010-051 and GEN-2011-027, an active generation interconnection request with point of interconnection (POI) on the Twin Church to Hoskins 230 kV line.

The GEN-2010-051 and GEN-2011-027 projects were proposed to interconnect in the Nebraska Public Power District (NPPD) control area with a combined capacity of 319.15 MW as shown in Table 1-1 below. Details of the modification request as provided in Section 2.0 below.

Table 1-1: Existing GEN-2010-051 and GEN-2011-027 Configuration

Request	Capacity (MW)	Existing Generator Configuration	Point of Interconnection
GEN-2010-051	198.9	125 x GE 1.6 MW117 x GE 1.7 MW	Tap on Twin Church – Hoskins 230kV Line (560347)
GEN-2011-027	120.25	65 x GE 1.85 MW	Tap on Twin Church – Hoskins 230kV Line (560347)

1.1 Scope

The Study included short circuit, power factor, reactive power and dynamic stabilities. 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 a reactive power analysis, short circuit analysis and dynamic stability analysis using a set of modified study models developed using the modification request data and the three DISIS-2016-001 ReStudy #1 study models:

1. 2016 Winter Peak (2016WP),
2. 2017 Summer Peak (2017SP), and
3. 2025 Summer Peak (2025SP).

All analyses were performed using the PTI PSS/E version 32 software. The results of each analysis are presented in the following sections.

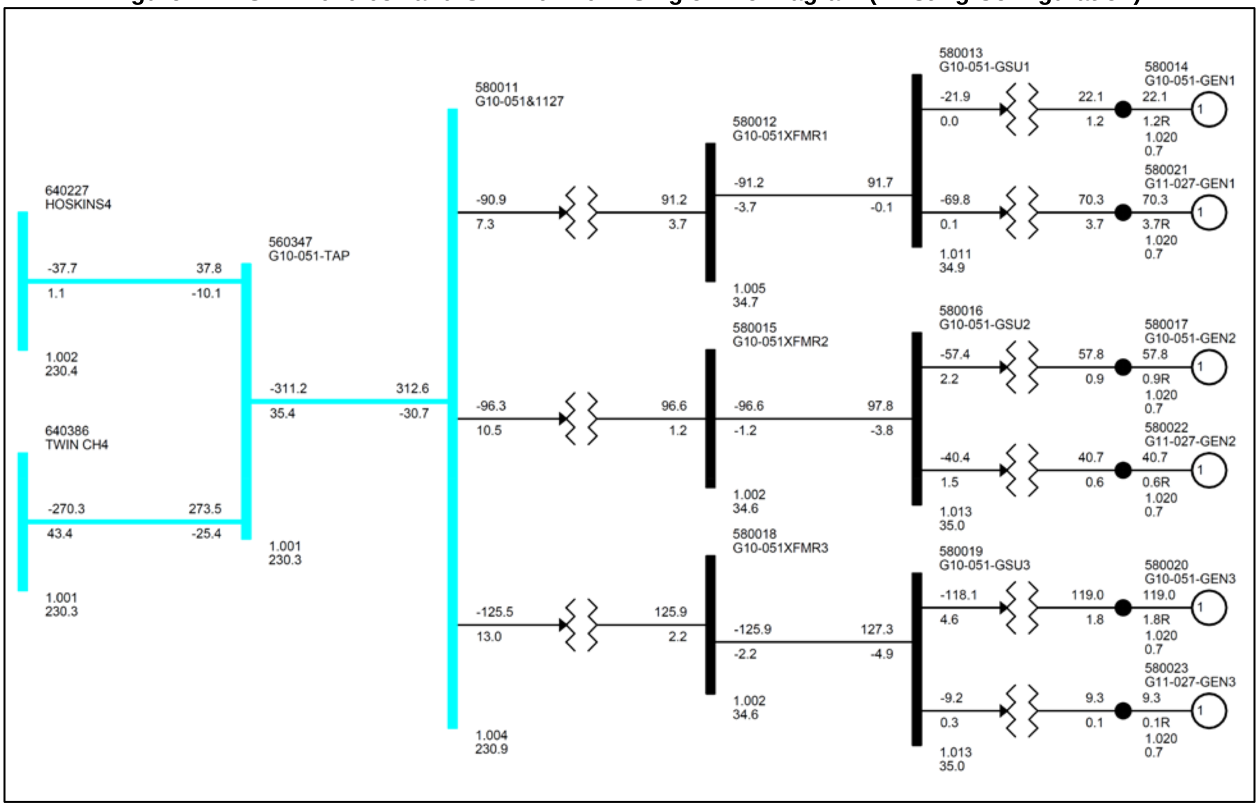
1.2 Study Limitations

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

2.0 Project and Modification Request

Figure 2-1 shows the power flow model single line diagram for the existing GEN-2010-051 and GEN-2011-027 configuration. GEN-2010-051 and GEN-2011-027 were originally studied as part of Group 9 in the DISIS-2010-002 and DISIS-2011-001 in January 2011 and December 2011 respectively.

Figure 2-1: GEN-2010-051 and GEN-2011-027 Single Line Diagram (Existing Configuration)



The GEN-2010-051 and GEN-2011-027 Modification Request included a turbine change to 101 x Acciona 3.15 MW turbines for a total capacity of 318.15 MW. In addition, the modification request also included changes to the collection system, the main substation transformer and the generation interconnection line. The major modification request changes are shown in Figure 2-2 and Table 2-1 below.

Figure 2-2: GEN-2010-051 and GEN-2011-027 Single Line Diagram (New Configuration)

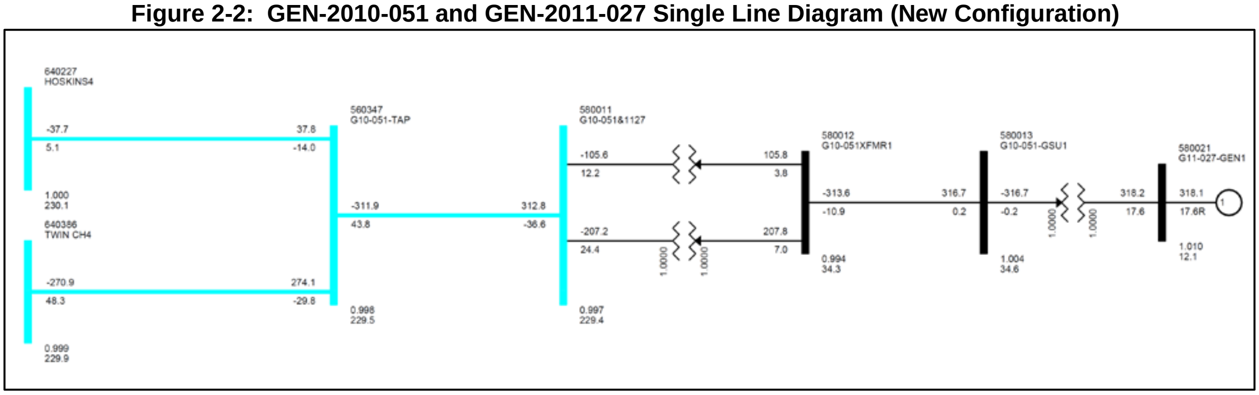


Table 2-1: GEN-2010-051 and GEN-2011-027 Modification Request

Facility	Existing	Modification Request
Point of Interconnection	Tap on Twin Church – Hoskins 230kV Line (560347)	Tap on Twin Church – Hoskins 230kV Line (560347)
Configuration/Capacity	117 x GE 1.7 MW = 198.9 MW 65 x GE 1.85 MW = 120.25 MW	101 x Acciona 3.15 MW turbines (318.15 MW)
Generation Interconnection Line(s)	Length = 3.6 miles R = 0.001420 pu X = 0.005800 pu B = 0.009240 pu	Length = 5 miles R = 0.000935pu X = 0.008499 pu B = 0.012266 pu
Main Substation Transformer	T1: Z = 9.0%, Rating 113 MVA T2: Z = 9.0%, Rating 120 MVA T3: Z = 9.0%, Rating 156 MVA	T1: Z = 9.7%, Rating 225 MVA T2: Z = 9.7%, Rating 130 MVA
Equivalent Collector Line 1	R = 0.006480 pu X = 0.014590 pu B = 0.049070 pu	R = 0.003125 pu X = 0.004132 pu B = 0.148210 pu
Equivalent Collector Line 2	R = 0.012510 pu X = 0.028140 pu B = 0.074520 pu	N/A
Equivalent Collector Line 3	R = 0.009250 pu X = 0.020800 pu B = 0.102680 pu	N/A

3.0 Reactive Power Analysis

The reactive power analysis, also known as the low-wind/no-wind condition analysis, was performed for GEN-2010-051 and GEN-2011-027 to determine the reactive power contribution from the project's interconnection line and collector transformer and cables during low/no wind conditions while the project is still connected to the grid and to size shunt reactors that would reduce the project reactive power contribution to the POI to approximately zero.

3.1 Methodology and Criteria

For the GEN-2010-051 and GEN-2011-027 project, the generator was switched out of service while other collector system elements remained in-service. A shunt reactor was tested at the study project substation high side bus to bring the MVAr flow into the POI down to approximately zero.

3.2 Results

The results from the reactive power analysis showed that the GEN-2010-051 and GEN-2011-027 project required approximately 16.2 MVAr shunt reactance at the high side of the project substation, to reduce the POI MVAr to zero. This represents the contributions from the project collector systems. Figure 3-1 illustrates the shunt reactor size required to reduce the POI voltage 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-2010-051 and GEN-2011-027 Single Line Diagram (Shunt Reactor)

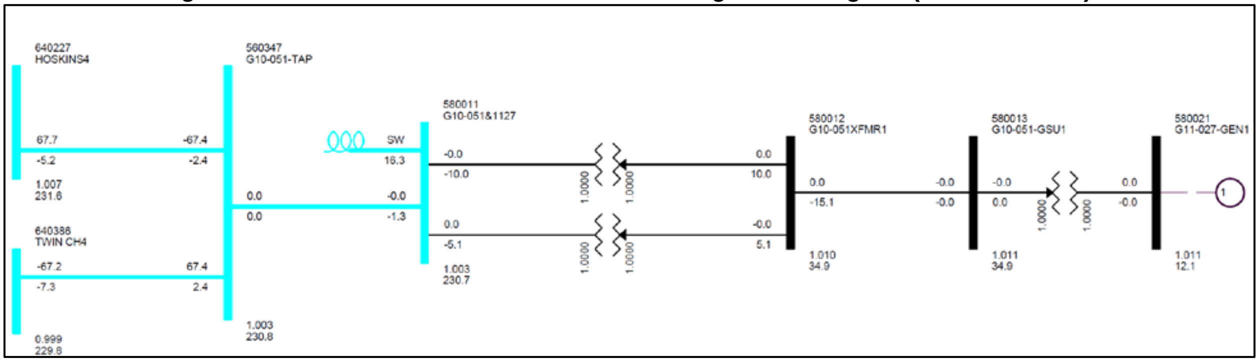


Table 3-1 shows the shunt reactor size determined for the three study models used in the assessment.

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

Machine	POI Bus Number	POI Bus Name	Reactor Size (MVAr)		
			16WP	17SP	25SP
GEN-2010-051_2011-027	560347	G10-051-TAP	16.2	16.2	16.2

4.0 Short Circuit Analysis

A short-circuit study was performed on the power flow models for the 2017SP and 2025SP models for GEN-2010-051 and GEN-2011-027 using the modified Cluster Scenario models. The detail results of the short-circuit analysis are provided in Appendix A.

4.1 Methodology

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

4.2 Results

The results of the short circuit analysis are summarized in Table 4-1 and Table 4-2 for the 2017SP and 2025SP models, respectively. The maximum increase in fault current was about 1.644 kA. The maximum fault current calculated within 5 buses with GEN-2010-051 and GEN-2011-027 was less than 35 kA and 36 kA for the 2017SP and 2025SP models respectively.

Table 4-1: 2017SP Short Circuit Results

Bus Distance	Max. Change (kA)	Max %Change
0	1.644	26.4%
1	0.741	9.1%
2	0.442	4.3%
3	0.236	2.9%
4	0.170	0.8%
5	0.152	0.6%

Table 4-2: 2025SP Short Circuit Results

Bus Distance	Max. Change (kA)	Max %Change
0	1.644	26.2%
1	0.739	9.0%
2	0.438	4.3%
3	0.232	2.8%
4	0.164	0.8%
5	0.146	0.6%

5.0 Dynamic Stability Analysis

Aneden performed a dynamic stability analysis to identify the impact of the turbine change and other modifications to the GEN-2010-051 and GEN-2011-027 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 101 x Acciona 3.15 MW turbines turbine configuration for GEN-2010-051 and GEN-2011-027 generating facility. This stability analysis was performed using PTI's PSS/E version 32 software.

The stability models were developed using the models from the DISIS-2016-001 ReStudy #1 (DISIS-2016-001-1) for Group 9 including network upgrades identified in that restudy. The modifications requested to projects GEN-2010-051 and GEN-2011-027 were used to create modified stability models for this impact study.

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. The modified dynamics model data for the DISIS-2016-001-1 (Group 9) request, GEN-2010-051 and GEN-2011-027 is provided in Appendix C.

During the fault simulations, the active power (PELEC), reactive power (QELEC) and terminal voltage (ETERM) were monitored for GEN-2010-051 and GEN-2011-027 and other equally and prior queued projects in Group 9. In addition, voltages of five (5) buses away from the POI of GEN-2010-051 and GEN-2011-027 were monitored and plotted. The machine rotor angle for synchronous machines and speed for asynchronous machines within this study area including 534 (SUNC), 536 (WERE), 540 (GMO), 541 (KCPL), 640 (NPPD), 645 (OPPD), 650 (LES) and 652 (WAPA) were monitored. In addition, the voltages of all 100 kV and above buses within the study area were monitored.

5.2 Fault Definitions

Aneden selected the fault events simulated specifically for GEN-2010-051 and GEN-2011-027 in the DISIS-2016-001-1 Group 9 study and included additional faults based on the location of the point of interconnection. The new set of faults were simulated using the modified study models. The fault events include three phase faults with reclosing, stuck breaker, and prior outage events. Single-line-to-ground (SLG) fault impedance values were determined by applying a fault on the base case large enough to produce a 0.6 pu voltage value on the faulted bus. This SLG value was then used for the SLG faults.

The simulated faults are listed and described in Table 5-1 below. These contingencies were applied to the modified 2016 Winter Peak, 2017 Summer Peak, and the 2025 Summer Peak models.

Table 5-1: Fault Definitions

Fault ID	Fault Descriptions
FLT02-3PH	3 phase fault on the Hoskins4 230kV (640227) to 345kV (640226) to 13.8KV (643082) transformer near the 230kV bus. a. Apply fault at Hoskins4 230kV bus. b. Clear fault after 6 cycles by tripping faulted transformer.
FLT03-3PH	3 phase fault on the HOSKINS4 230kV (640227) to 115kV (640228) to 13.8KV (643083) transformer near the 230kV bus. a. Apply fault at Hoskins 230kV bus. b. Clear fault after 6 cycles by tripping faulted transformer.
FLT05-3PH	3 phase fault on the GEN-2010-051 Tap (560347) to Twin Church (640386) 230kV near GEN-2010-051 Tap. a. Apply fault at GEN-2010-051 Tap 230kV bus. b. Clear fault after 6 cycles by tripping faulted line.
FLT06-3PH	3 phase fault on the Twin Church (640386) to Sioux City (652565) 230kV near Twin Church. a. Apply fault at Twin Church 230kV bus. b. Clear fault after 6 cycles by tripping faulted line.
FLT07-3PH	3 phase fault on one of the Twin Church 230kV (640386) to 115kV (640387) to 13.8KV (643155) transformers near the 230kV bus. a. Apply fault at Twin Church 230kV bus. b. Clear fault after 6 cycles by tripping faulted transformer.
FLT15-3PH	3 phase fault on the Hoskins (640228) to Norfolk (640298) 115kV line, near Hoskins. a. Apply fault at the Hoskins 115kV bus. b. Clear fault after 6.5 cycles by tripping the faulted line.
FLT16-3PH	3 phase fault on the Norfolk (640298) to Norfolk N (640296) 115kV line, near Norfolk. a. Apply fault at the Norfolk 115kV bus. b. Clear fault after 6.5 cycles by tripping the faulted line.
FLT20-3PH	3 phase fault on the Hoskins (640228) to Norfolk N (640296) 115kV line, near Hoskins. a. Apply fault at the Hoskins 115kV bus. b. Clear fault after 6.5 cycles by tripping the faulted line.
FLT52-3PH	3 phase fault on the HOSKINS3(640226) to Raun (635200) 345kV line, near HOSKINS3(640226). a. Apply fault at the HOSKINS3 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT54-3PH	3 phase fault on the Hoskins (640226) to Shell Creek (640342) 345kV line, near Hoskins. a. Apply fault at the Hoskins 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT55-3PH	3 phase fault on the Hoskins 115kV (640228) to 345kV (640226) to 13.8kV (640231) transformer at the 115kV bus. a. Apply fault at the Hoskins 115kV bus. b. Clear fault after 6.5 cycles by tripping the transformer
FLT56-3PH	3 phase fault on the Belden (640080) to Hoskins (640228) 115kV line, near Belden a. Apply fault at the Belden 115kV bus. b. Clear fault after 6.5 cycles by tripping the faulted line.
FLT9001-3PH	3 phase fault on the G10-051-TAP (560347) to HOSKINS4 (640227) 230kV line, near G10-051-TAP. a. Apply fault at the G10-051-TAP 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
FLT9002-3PH	3 phase fault on the SIOUXCY4 (652565) to EAGLE 4 (659900) 230kV line, near SIOUXCY4. a. Apply fault at the SIOUXCY4 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.

Table 5-1 continued

Fault ID	Fault Descriptions
FLT9004-3PH	3 phase fault on the SIOUXCY4 (652565) to RASMUSN4 (652536) 230kV line, near SIOUXCY4. a. Apply fault at the SIOUXCY4 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
FLT9005-3PH	3 phase fault on the SIOUXCY4 230kV (652565) to 345 kV (652564) to 13.8kV (652304) autotransformer near the 230kV bus a. Apply fault at the SIOUXCY4 230kV bus. b. Clear fault after 6 cycles by tripping the autotransformer
FLT9006-3PH	3 phase fault on the SIOUXCY4 (652565) to DENISON4 (652567) 230kV line, near SIOUXCY4. a. Apply fault at the SIOUXCY4 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
FLT9007-3PH	3 phase fault on the SIOUXCY4 (652565) to FTRANDL4(652509) 230kV line, near SIOUXCY4. a. Apply fault at the SIOUXCY4 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
FLT9008-3PH	3 phase fault on the MEADOWGROVE4(640540) to COLMBUS4(640133) 230kV line, near MEADOWGROVE4. a. Apply fault at the MEADOWGROVE4 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
FLT9009-3PH	3 phase fault on the HOSKINS3(640226) to ANTELOPE 3(640520) 345kV line, near HOSKINS3. a. Apply fault at the HOSKINS3 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT9010-3PH	3 phase fault on the SHELCRK4 230kV (640343) to 345kV (640342) to 13.8kV (643136) autotransformer at the 230kV a. Apply fault at the SHELCRK4 230kV bus. b. Clear fault after 6 cycles by tripping the autotransformer
FLT9011-3PH	3 phase fault on the SHELCRK3(640342) to COLMB.E3(640125) 345kV line, near SHELCRK3. a. Apply fault at the SHELCRK3 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT9012-3PH	3 phase fault on the ANTELOPE 7 115kV (640521) to 345kV (640520) to 13.8kV (640524) autotransformer at the 115kV a. Apply fault at the ANTELOPE 7 115kV bus. b. Clear fault after 6.5 cycles by tripping the autotransformer
FLT9013-3PH	3 phase fault on the HOSKINS7(640228) to STNTN.N7(640363) 115kV line, near HOSKINS7. a. Apply fault at the HOSKINS7 115kV bus. b. Clear fault after 6.5 cycles by tripping the faulted line.
FLT9014-3PH	3 phase fault on the BELDEN 7(640080) to HARTGTN7 (640212) 115kV line, near BELDEN 7. a. Apply fault at the BELDEN 7 115kV bus. b. Clear fault after 6.5 cycles by tripping the faulted line.
FLT02-PO1	Prior Outage of G10-051-TAP (560347) to TWIN CH4 (640386) CKT 1 3 phase fault on the Hoskins4 230kV (640227) to 345kV (640226) to 13.8KV (643082) transformer near the 230kV bus. a. Apply fault at Hoskins4 230kV bus. b. Clear fault after 6 cycles by tripping faulted transformer.
FLT03-PO1	Prior Outage of G10-051-TAP (560347) to TWIN CH4 (640386) CKT 1 3 phase fault on the HOSKINS4 230kV (640227) to 115kV (640228) to 13.8KV (643083) transformer near the 230kV bus. a. Apply fault at Hoskins 230kV bus. b. Clear fault after 6 cycles by tripping faulted transformer.

Table 5-1 continued

Fault ID	Fault Descriptions
FLT06-PO2	Prior Outage of G10-051-TAP (560347) to HOSKINS4 (640227) CKT 1 3 phase fault on the Twin Church (640386) to Sioux City (652565) 230kV near Twin Church. a. Apply fault at Twin Church 230kV bus. b. Clear fault after 6 cycles by tripping faulted line.
FLT07-PO2	Prior Outage of G10-051-TAP (560347) to HOSKINS4 (640227) CKT 1 3 phase fault on one of the Twin Church 230kV (640386) to 115kV (640387) to 13.8KV (643155) transformers near the 230kV bus. a. Apply fault at Twin Church 230kV bus. b. Clear fault after 6 cycles by tripping faulted transformer.
FLT07-PO3	Prior Outage of Twin Church 230kV (640386) to 115kV (640387) to 13.8KV (643156) transformer. 3 phase fault on Twin Church 230kV (640386) to 115kV (640387) to 13.8KV (643155) transformers near the 230kV bus. a. Apply fault at Twin Church 230kV bus. b. Clear fault after 6 cycles by tripping faulted transformer.
FLT9100-SB	Single phase fault on the Hoskins (640227) to GEN-2011- 027 (560347) 230kV near Hoskins a. Apply fault at Hoskins 230kV bus. b. Clear fault after 16 cycles by tripping faulted line. c. Clear the Hoskins4 230kV (640227) to 345kV (640226) to 13.8KV (643082) transformer
FLT9200-SB	Single phase fault on the Twin Church (640386) to GEN-2011- 027 (560347) 230kV near Twin Church a. Apply fault at Twin Church 230kV bus. b. Clear fault after 16 cycles by tripping faulted line. c. Clear the Twin Church 230kV (640386) to 115kV (640387) to 13.8kV (643156) transformer

5.3 Results

There were no damping or voltage recovery violations observed during the simulations and the system returned to stable conditions except for three fault condition described below:

1. FLT06-PO2, prior outage on the GEN-2010-051 and GEN-2011-027 POI to Hoskins 230kV line followed by the three phase fault on the Twin Church to Sioux City 230 kV line caused a undervoltage trip of GEN-2010-051 and GEN-2011-027 . To prevent this issue, GEN-2010-051 and GEN-2011-027 may have to be curtailed to 230 MW after the loss of either the GEN-2010-051 and GEN-2011-027 POI to Hoskins 230kV line or the Twin Church to Sioux City 230 kV line.

Table 5-2 shows the curtailment requires for FLT06-PO2 described above. GEN-2010-051 and GEN-2011-027 output may have to be limited to the amounts listed in Table 5-2.

Table 5-2: GEN-2010-051 and GEN-2011-027 Output Limits for FLT06-PO2 (MW)

Fault	2016WP	2017SP	2025SP
FLT06-PO2	235	230	230

Table 5-3 shows the results of the fault events simulated for each of the models. The associated stability plots are provided in Appendix D. Additionally, the project wind farm was found to stay connected during the contingencies that were studied and, therefore, will meet the Low Voltage Ride Through (LVRT) requirements of FERC Order #661A.

Table 5-3: GEN-2010-051 and GEN-2011-027 Dynamic Stability Results

Fault ID	16WP	17SP	25SP
FLT02-3PH	Stable	Stable	Stable
FLT03-3PH	Stable	Stable	Stable
FLT05-3PH	Stable	Stable	Stable
FLT06-3PH	Stable	Stable	Stable
FLT07-3PH	Stable	Stable	Stable
FLT15-3PH	Stable	Stable	Stable
FLT16-3PH	Stable	Stable	Stable
FLT20-3PH	Stable	Stable	Stable
FLT52-3PH	Stable	Stable	Stable
FLT54-3PH	Stable	Stable	Stable
FLT55-3PH	Stable	Stable	Stable
FLT56-3PH	Stable	Stable	Stable
FLT9001-3PH	Stable	Stable	Stable
FLT9002-3PH	Stable	Stable	Stable
FLT9003-3PH	Stable	Stable	Stable
FLT9004-3PH	Stable	Stable	Stable
FLT9005-3PH	Stable	Stable	Stable
FLT9006-3PH	Stable	Stable	Stable
FLT9007-3PH	Stable	Stable	Stable
FLT9008-3PH	Stable	Stable	Stable
FLT9009-3PH	Stable	Stable	Stable
FLT9010-3PH	Stable	Stable	Stable
FLT9011-3PH	Stable	Stable	Stable
FLT9012-3PH	Stable	Stable	Stable
FLT9013-3PH	Stable	Stable	Stable
FLT9014-3PH	Stable	Stable	Stable
FLT02-PO1	Stable	Stable	Stable
FLT03-PO1	Stable	Stable	Stable
FLT06-PO2	GEN-2010-051 and GEN-2011-027 Tripped on Undervoltage. Project Output Curtailed to 235 MW to prevent trip	GEN-2010-051 and GEN-2011-027 Tripped on Undervoltage. Project Output Curtailed to 230 MW to prevent trip	GEN-2010-051 and GEN-2011-027 Tripped on Undervoltage. Project Output Curtailed to 230 MW to prevent trip
FLT07-PO2	Stable	Stable	Stable
FLT07-PO3	Stable	Stable	Stable
FLT9100-SB	Stable	Stable	Stable
FLT9200-SB	Stable	Stable	Stable

6.0 Conclusions

The Interconnection Customer for GEN-2010-051 and GEN-2011-027 requested a Modification Request Impact Study to assess the impact of the turbine and facility changes presented in Table 6-1 below.

Table 6-1: Modification Request

Facility	Existing	Modification Request
Point of Interconnection	Tap on Twin Church – Hoskins 230kV Line (560347)	Tap on Twin Church – Hoskins 230kV Line (560347)
Configuration/Capacity	117 x GE 1.7 MW = 198.9 MW 65 x GE 1.85 MW = 120.25 MW	101 x Acciona 3.15 MW turbines (318.15 MW)
Generation Interconnection Line(s)	Length = 3.6 miles R = 0.001420 pu X = 0.005800 pu B = 0.009240 pu	Length = 5 miles R = 0.000935pu X = 0.008499 pu B = 0.012266 pu
Main Substation Transformer	T1: Z = 9.0%, Rating 113 MVA T2: Z = 9.0%, Rating 120 MVA T3: Z = 9.0%, Rating 156 MVA	T1: Z = 9.7%, Rating 225 MVA T2: Z = 9.7%, Rating 130 MVA
Equivalent Collector Line 1	R = 0.006480 pu X = 0.014590 pu B = 0.049070 pu	R = 0.003125 pu X = 0.004132 pu B = 0.148210 pu
Equivalent Collector Line 2	R = 0.012510 pu X = 0.028140 pu B = 0.074520 pu	N/A
Equivalent Collector Line 3	R = 0.009250 pu X = 0.020800 pu B = 0.102680 pu	N/A

A power factor analysis was not performed as there was no change in the point of interconnection for GEN-2010-051 and GEN-2011-027.

The results of the reactive power analysis, also known as the low-wind/no-wind condition analysis, performed using all three models showed that the combined GEN-2010-051 and GEN-2011-027 project may require a 16.2 MVAr shunt reactor on the 230 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 short circuit analysis showed that the maximum change in the fault currents in the immediate systems at or near GEN-2010-051 and GEN-2011-027 was 1.644 kA. The largest fault current calculated was below 35 kA and 36 kA in the 2017SP and 2025SP models respectively.

The results of the dynamic stability analysis showed that after the prior outage of the Hoskins to the Point of Interconnection substation 230 kV line, a three phase fault on the Twin Church to Sioux City 230 kV line caused a undervoltage trip of GEN-2010-051 and GEN-2011-027. The output of the project may have to be curtailed to about 230 MW after the prior outage to prevent the undervoltage trip of the project.

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.

In conclusion, the results of this Study showed that the Modification Request shown in Table 6-1 do not constitute a material modification.