GEN-2015-007

Impact Restudy for Generator Modification (Turbine Change)

Published January 2019

By Generator Interconnection

REVISION HISTORY

DATE OR VERSION NUMBER	AUTHOR	CHANGE DESCRIPTION	COMMENTS
1/30/2019	Generator Interconnection		Initial Posting

EXECUTIVE SUMMARY

The GEN-2015-007 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 80 GE 2.0 MW wind turbine generators (for a total capacity of 160 MW) to 64 GE 2.3 MW, 6 GE 1.715 MW, and 1 GE 2.5 MW wind turbine generators (for a total capacity of 159.99 MW). The Point of Interconnection (POI) for this request remains unchanged at the Nebraska Public Power District (NPPD) Hoskins 345kV substation.

This study was performed by Aneden Consulting to determine whether the request for modification is considered Material. The study report follows this executive summary.

The restudy showed that no other stability problems were found during the summer and the winter peak conditions as a result of changing to the GE 2.3 MW, GE 1.715 MW, and GE 2.5 MW wind turbine generators. 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.

With the assumptions outlined in this report and with all the required network upgrades in place, GEN-2015-007 with 64 GE 2.3 MW, 6 GE 1.715 MW, and 1 GE 2.5 MW wind turbine generators should be able to interconnect reliably to the SPP transmission grid. This restudy confirms that the requested modification in wind turbine generators is not considered Material.

A low-wind/no-wind condition analysis was performed for this modification request. To prevent reactive power injection into the transmission system during low/no wind operation, the Interconnection Customer will be required to install approximately 21.7 MVAr of shunt reactors to be located on the 345 kV bus or install and utilize an equivalent means of compensating for the injection of reactive power into the transmission system at the Point of Interconnection.

It should be noted that this study analyzed the requested modification to change generator technology 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.

Aneden Consulting report follows.

Submitted to

Southwest Power Pool

Report On

GEN-2015-007
Modification Request Impact Study

Revision R1

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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 GEN-2015-007, an active generation interconnection request with point of interconnection (POI) on the Hoskins 345 kV substation.

The GEN-2015-007 project was proposed to interconnect in the Nebraska Public Power District (NPPD) control area with a capacity of 160 MW as shown in Table ES-1 below. This Study has been requested to evaluate the modification of GEN-2015-007 to change turbine configuration to a total of 6 x GE 1.715 MW, 1 x GE 2.5 MW, and 64 x GE 2.3 MW turbines for a total capacity of 159.99 MW. 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-2015-007 Configuration

Request	Capacity (MW)	Existing Generator Configuration	Point of Interconnection
GEN-2015-007	160	80 x GE 2.0 MW	Hoskins 345 kV Substation (640226)

Table ES-2: GEN-2015-007 Modification Request

Facility	Existing	Modification Request
Point of Interconnection	Hoskins 345 kV Substation (640226)	Hoskins 345 kV Substation (640226)
Configuration/Capacity	80 x GE 2.0 MW = 160 MW	6 x GE 1.715 MW 1 x GE 2.5 MW 64 x GE 2.3 MW Total = 159.99 MW
Generation Interconnection Line(s)	Length = 16.0 miles R = 0.000780 pu X = 0.007980 pu B = 0.134400 pu	Length = 14.7 miles R = 0.000570 X = 0.006490 B = 0.128100
Main Substation Transformer	T1: Z = 8.5%, Rating 190 MVA	T1: Z1-2 = 8.0%, Rating 180 MVA
Equivalent Collector Line 1	R = 0.041970 pu X = 0.038570 pu B = 0.032650 pu	R = 0.004826 X = 0.007879 B = 0.088406
Capacitor	N/A	C1: 14 MVAR, 1 Step

GEN-2015-007 was originally studied as part of Group 9 in the DISIS-2015-001. Aneden performed reactive power analysis, short circuit analysis and dynamic stability analysis using the modification request data using on the DISIS-2016-001 ReStudy #1 Group 9 study models listed below:

1. 2016 Winter Peak (2016WP)
2. 2017 Summer Peak (2017SP)
3. 2025 Summer Peak (2025SP)
4. 2016 GGS Winter Peak Case (2016WP_GGS)
5. 2017 GGS Summer Peak Case (2017SP_GGS)
6. 2025 GGS Summer Peak Case (2025SP_GGS)

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-2015-007.

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 GEN-2015-007 project may require a 21.7 MVAr shunt reactor on the 345 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-2015-007 was approximately .72 kA for the 2017SP and 2025SP cases, and .73 kA for the 2017SP and 2025SP GGS cases. All three-phase current levels with the GEN-2015-007 generator online were below 42 kA for the 2017SP models and 43.5 kA for the 2025SP models.

The dynamic stability analysis was performed using the six models 2016 Winter Peak, 2017 Summer Peak, 2025 Summer Peak, 2016 Winter Peak GGS, 2017 Summer Peak GGS, and 2025 Summer Peak GGS. Up to 31 contingencies were simulated, which included three-phase faults, three phase faults on prior outage cases, and single-line-to-ground faults and stuck breakers faults.

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

The results of this Study show that the GEN-2015-007 Modification Request does not constitute a material modification.

1.0 Introduction

Aneden Consulting (Aneden) was retained by the Southwest Power Pool (SPP) to perform a Modification Request Impact Study (Study) for GEN-2015-007, an active generation interconnection request with point of interconnection (POI) at the Hoskins 345 kV substation.

The GEN-2015-007 project was proposed to interconnect in the Nebraska Public Power District (NPPD) control area with a combined capacity of 160 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-2015-007 Configuration

Request	Capacity (MW)	Existing Generator Configuration	Point of Interconnection
GEN-2015-007	160	80 x GE 2.0 MW	Hoskins 345 kV Substation (640226)

1.1 Scope

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

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

The analyses were performed using a set of modified study models developed using the modification request data and the six DISIS-2016-001 ReStudy #1 study models:

1. 2016 Winter Peak (2016WP),
2. 2017 Summer Peak (2017SP),
3. 2025 Summer Peak (2025SP),
4. 2016 GGS Winter Peak Case (2016WP_GGS),
5. 2017 GGS Summer Peak Case (2017SP_GGS), and
6. 2025 GGS Summer Peak Case (2025SP_GGS).

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

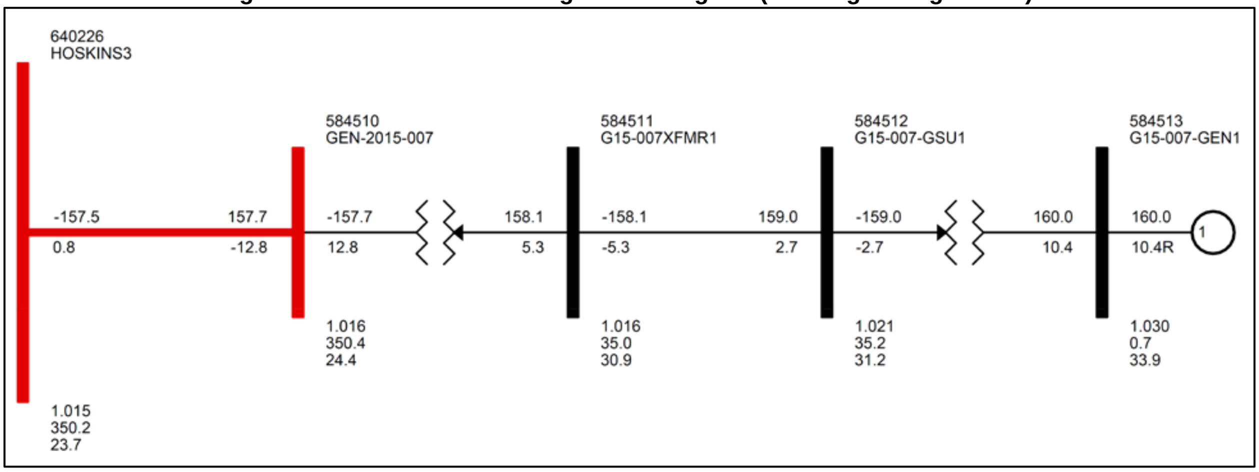
1.2 Study Limitations

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-2015-007 configuration. GEN-2015-007 was originally studied as part of Group 9 in the DISIS-2015-001 study.

Figure 2-1: GEN-2015-007 Single Line Diagram (Existing Configuration)



The GEN-2015-007 Modification Request included a turbine configuration change to a total of 6 x GE 1.715 MW, 1 x GE 2.5 MW, and 64 x GE 2.3 MW, a combined capacity of 159.99 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-2015-007 Single Line Diagram (New Configuration)

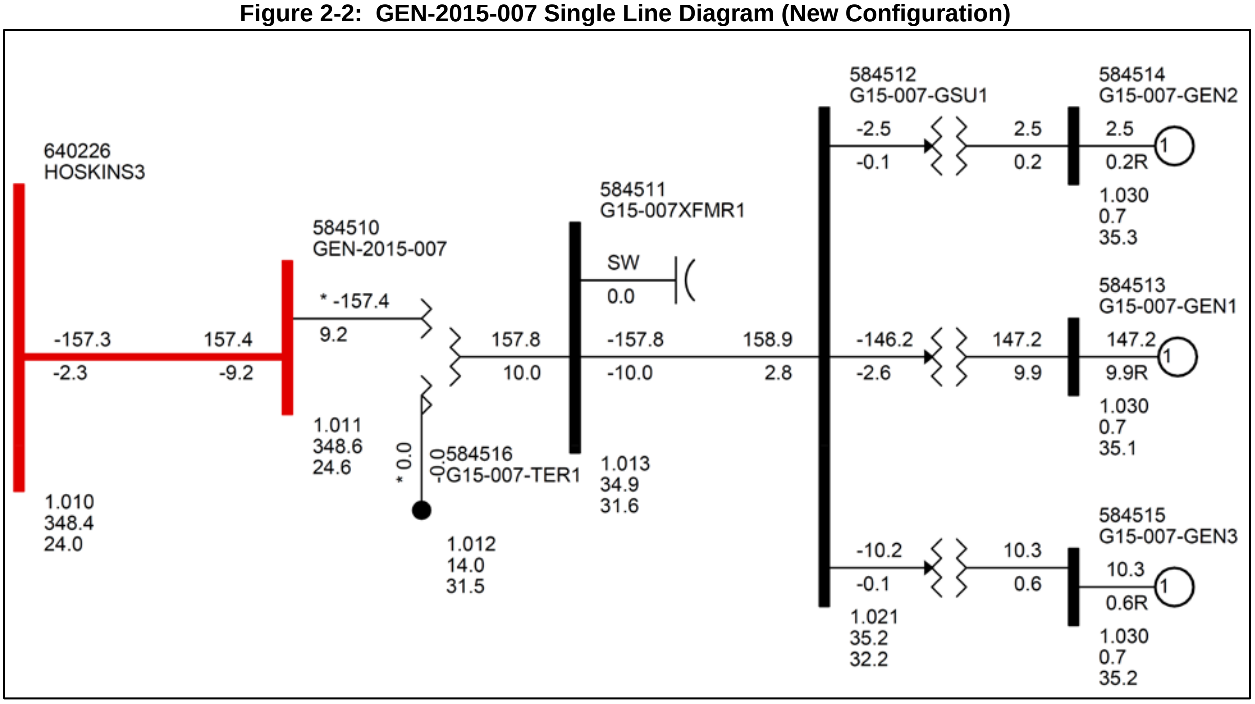


Table 2-1: GEN-2015-007 Modification Request

Facility	Existing	Modification Request
Point of Interconnection	Hoskins 345 kV Substation (640226)	Hoskins 345 kV Substation (640226)
Configuration/Capacity	80 x GE 2.0 MW = 160 MW	6 x GE 1.715 MW 1 x GE 2.5 MW 64 x GE 2.3 MW Total = 159.99 MW
Generation Interconnection Line(s)	Length = 16.0 miles R = 0.000780 pu X = 0.007980 pu B = 0.134400 pu	Length = 14.7 miles R = 0.000570 X = 0.006490 B = 0.128100
Main Substation Transformer	T1: Z = 8.5%, Rating 190 MVA	T1: Z1-2 = 8.0%, Rating 180 MVA
Equivalent Collector Line 1	R = 0.041970 pu X = 0.038570 pu B = 0.032650 pu	R = 0.004826 X = 0.007879 B = 0.088406
Capacitor	N/A	C1: 14 MVAR, 1 Step

3.0 Reactive Power Analysis

The reactive power analysis, also known as the low-wind/no-wind condition analysis, was performed for GEN-2015-007 to determine the reactive power contribution from the project's interconnection line and collector transformer and cables during low/no wind conditions while the project is still connected to the grid and to size shunt reactors that would reduce the project reactive power contribution to the POI to approximately zero.

3.1 Methodology and Criteria

For the GEN-2015-007 project, the generator and shunt reactor were switched out of service while other collector system elements remained in-service. A shunt reactor was tested at the collection substation 345 kV bus to set the MVAr flow into the POI to approximately zero.

3.2 Results

The results from the reactive power analysis showed that the GEN-2015-007 projects required approximately 21.7 MVAr shunt reactance at the high side of the project substation, to reduce the POI MVAr to zero. This represents the contributions from the project collection system without the project capacitor bank. Figure 3-1 illustrates the shunt reactor size required to reduce the POI 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-2015-007 Single Line Diagram (Shunt Reactor)

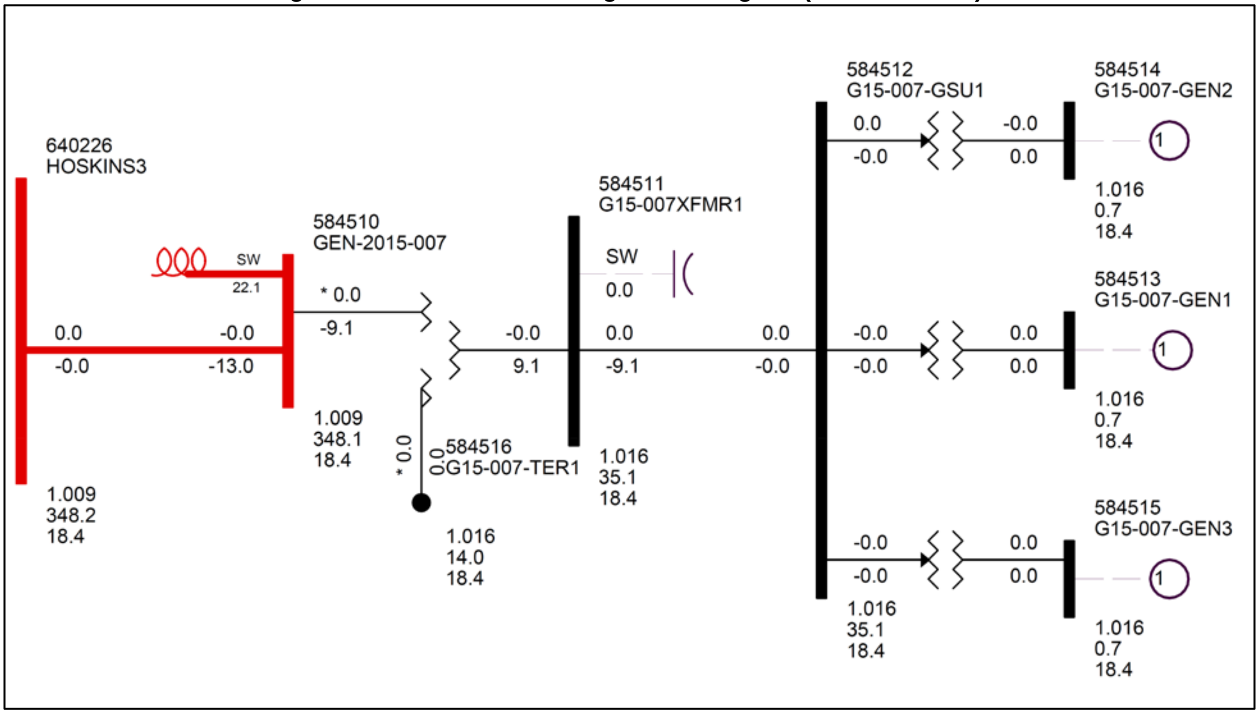


Table 3-1 shows the shunt reactor size determined for the three study models used in the assessment.

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

Machine	POI Bus Number	POI Bus Name	Reactor Size (MVAr)		
			16WP	17SP	25SP
GEN-2015-007	640226	HOSKINS	21.7	21.7	21.7

4.0 Short Circuit Analysis

A short-circuit study was performed using the power flow models for the 2017SP and 2025SP models, and the 2017SP GGS and 2025SP GGS models for GEN-2015-007. 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 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 2017SP and 2025SP models are summarized in Table 4-1 and Table 4-2 respectively. The maximum increase in fault current was about 0.723 kA. The maximum fault current calculated within 5 buses with GEN-2015-007 was less than 42 kA for the 2017SP model and 44 kA for the 2025SP model.

Table 4-1: 2017SP Short Circuit Results

Bus Distance	Max. Change (kA)	Max %Change
0	0.723	6.44%
1	0.573	5.66%
2	0.233	1.83%
3	0.198	1.53%
4	0.131	0.77%
5	0.099	0.62%

Table 4-2: 2025SP Short Circuit Results

Bus Distance	Max. Change (kA)	Max %Change
0	0.722	6.39%
1	0.572	5.62%
2	0.235	1.79%
3	0.202	1.52%
4	0.128	0.75%
5	0.097	0.60%

The results of the short circuit analysis for the 2017SP and 2025SP GGS models are summarized in Table 4-3 and Table 4-4 respectively. The maximum increase in fault current was about 0.726 kA. The maximum fault current calculated within 5 buses with GEN-2015-007 was less than 42 kA for the 2017SP GGS model and 44 kA for the 2025SP GGS model.

Table 4-3: 2017SP GGS Short Circuit Results

Bus Distance	Max. Change (kA)	Max %Change
0	0.726	6.50%
1	0.577	5.72%
2	0.238	1.88%
3	0.203	1.58%
4	0.135	0.80%
5	0.103	0.65%

Table 4-4: 2025SP GGS Short Circuit Results

Bus Distance	Max. Change (kA)	Max %Change
0	0.726	6.45%
1	0.575	5.68%
2	0.241	1.85%
3	0.206	1.57%
4	0.133	0.78%
5	0.101	0.64%

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-2015-007 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 6 x GE 1.715 MW, 1 x GE 2.5 MW, and 64 x GE 2.3 MW turbine configuration for the GEN-2015-007 generating facilities. 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 for Group 9 including network upgrades identified in that restudy. The modifications requested to project GEN-2015-007 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-2015-001 Group 9 request, GEN-2015-007 is provided in Appendix C.

During the fault simulations, the active power (PELEC), reactive power (QELEC) and terminal voltage (ETERM) were monitored for GEN-2015-007 and other equally and prior queued projects in Group 9. In addition, voltages of five (5) buses away from the POI of GEN-2015-007 were monitored and plotted. The machine rotor angle for synchronous machines and speed for asynchronous machines within this study area including 534 (SUNC), 536 (WERE), 540 (GMO), 541 (KCPL), 635 (MEC), 640 (NPPD), 645 (OPPD), 650 (LES), 652 (WAPA) were monitored. In addition, the voltages of all 100 kV and above buses within the study area were monitored.

5.2 Fault Definitions

Aneden selected a subset of the fault events simulated specifically for GEN-2015-007 in the DISIS-2016-001-1 Group 9 study. The new set of faults were simulated using the modified study models. The fault events include three phase faults and prior outage events. 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 (including the GGS models).

Table 5-1: Fault Definitions

Fault ID	Fault Descriptions
FLT01-3PH	3 phase fault on the Hoskins (640226) to Antelope (640520) 345kV line circuit 1, near Hoskins.
	a. Apply fault at the Hoskins 345kV bus.
	b. Clear fault after 5 cycles by tripping the faulted line.
FLT02-3PH	3 phase fault on the Hoskins (640226) to Shell Creek (640342) 345kV line circuit 1, near Hoskins.
	a. Apply fault at the Hoskins 345kV bus.
	b. Clear fault after 5 cycles by tripping the faulted line.
FLT03-3PH	3 phase fault on the Hoskins (640226) to Raun (635200) 345kV line circuit 1, near Hoskins.
	a. Apply fault at the Hoskins 345kV bus.
	b. Clear fault after 5 cycles by tripping the faulted line.
FLT04-3PH	3 phase fault on the Hoskins 345/230/13.8kV (640226/640227/643082) transformer, near Hoskins.
	a. Apply fault at the Hoskins 345kV bus.
	b. Clear fault after 5 cycles by tripping the faulted transformer.
FLT05-3PH	3 phase fault on the Hoskins 345/115/13.8kV (640226/640228/640231) transformer, near Hoskins.
	a. Apply fault at the Hoskins 345kV bus.
	b. Clear fault after 5 cycles by tripping the faulted transformer.
FLT06-3PH	3 phase fault on the Raun (635200) to Sioux City (652564) 345kV line circuit 1, near Raun.
	a. Apply fault at the Raun 345kV bus.
	b. Clear fault after 6 cycles by tripping the faulted line.
FLT07-3PH	3 phase fault on the Raun (635200) to Lehigh (636010) 345kV line circuit 1, near Raun.
	a. Apply fault at the Raun 345kV bus.
	b. Clear fault after 6 cycles by tripping the faulted line.
FLT08-3PH	3 phase fault on the Raun (635200) to S3451 (645451) 345kV line circuit 1, near Raun.
	a. Apply fault at the Raun 345kV bus.
	b. Clear fault after 6 cycles by tripping the faulted line.
FLT09-3PH	3 phase fault on the Raun (635200) to Highland (635400) 345kV line circuit 1, near Raun.
	a. Apply fault at the Raun 345kV bus.
	b. Clear fault after 6 cycles by tripping the faulted line.
FLT10-3PH	3 phase fault on the Raun 345/161kV (635200/635201) transformer, near Raun.
	a. Apply fault at the Raun 345kV bus.
	b. Clear fault after 6 cycles by tripping the faulted line.
FLT12-3PH	3 phase fault on the Shell Creek (640342) to Columbus (640125) 345kV line circuit 1, near Shell Creek.
	a. Apply fault at the Shell Creek 345kV bus.
	b. Clear fault after 5 cycles by tripping the faulted line.
FLT13-3PH	3 phase fault on the Shell Creek 345/230/13.8kV (640342/640343/643136) transformer, near Shell Creek.
	a. Apply fault at the Shell Creek 345kV bus.
	b. Clear fault after 5 cycles by tripping the faulted line.
FLT14-3PH	3 phase fault on the Antelope 345/115/13.8kV (640520/640521/640524) transformer, near Antelope.
	a. Apply fault at the Antelope 345kV bus.
	b. Clear fault after 5 cycles by tripping the faulted line.
FLT15-3PH	3 phase fault on the Hoskins 230/115/13.8kV (640227/640228/643083) transformer, near Hoskins.
	a. Apply fault at the Hoskins 345kV bus.
	b. Clear fault after 6 cycles by tripping the faulted line.
FLT16-3PH	3 phase fault on the Hoskins (640227) to G10-051-Tap (560347) 230kV line circuit 1, near Hoskins.
	a. Apply fault at the Hoskins 230kV bus.
	b. Clear fault after 6 cycles by tripping the faulted line.
FLT17-3PH	3 phase fault on the Hoskins (640228) to Norfolk (640298) 115kV line circuit 1, near Hoskins.
	a. Apply fault at the Hoskins 115kV bus.
	b. Clear fault after 6.5 cycles by tripping the faulted line.
FLT18-3PH	3 phase fault on the Hoskins (640228) to Belden (640080) 115kV line circuit 1, near Hoskins.
	a. Apply fault at the Hoskins 115kV bus.
	b. Clear fault after 6.5 cycles by tripping the faulted line.

Table 5-1 continued

Fault ID	Fault Descriptions
FLT19-3PH	3 phase fault on the Hoskins (640228) to Norfolk North (640296) 115kV line circuit 1, near Hoskins.
	a. Apply fault at the Hoskins 115kV bus.
	b. Clear fault after 6.5 cycles by tripping the faulted line.
FLT20-3PH	3 phase fault on the Hoskins (640228) to Stanton West (640363) 115kV line circuit 1, near Hoskins.
	a. Apply fault at the Hoskins 115kV bus.
	b. Clear fault after 6.5 cycles by tripping the faulted line.
FLT21-SB	**Hoskins 345 kV Stuck Breaker Scenario 1**
	a. Apply fault at the Hoskins 345kV bus.
	b. Clear fault after 16 cycles and trip the following elements
	c. Hoskins (640226) – Shell Creek (640342) 345kV
	d. Hoskins (640226) – Raun (635200) 345kV
FLT22-SB	**Hoskins 345 kV Stuck Breaker Scenario 2**
	a. Apply fault at the Hoskins 345kV bus.
	b. Clear fault after 16 cycles and trip the following elements
	c. Hoskins (640226) – Shell Creek (640342) 345kV
	d. Hoskins (640226) – Antelope (640520) 345kV
FLT23-SB	**Hoskins 345 kV Stuck Breaker Scenario 3**
	a. Apply fault at the Hoskins 345kV bus.
	b. Clear fault after 16 cycles and trip the following elements
	c. Hoskins 345/230/13.8kV (640226/640227/643082) transformer
	d. Hoskins 345/115/13.8kV (640226/640228/640231) transformer
FLT01-PO1	**Prior Outage of Hoskins 345 kV (640226) to Raun 345 kV (635200) CKT 1;** 3 phase fault on Hoskins 345kV (640226) to Antelope 345kV (640520), near Hoskins.
	a. Apply fault at the Hoskins 345kV bus.
	b. Clear fault after 5 cycles by tripping the faulted line.
FLT02-PO1	**Prior Outage of Hoskins 345 kV (640226) to Raun 345 kV (635200) CKT 1;** 3 phase fault on Hoskins 345kV (640226) to Shell Creek 345kV (640342), near Hoskins.
	a. Apply fault at the Hoskins 345kV bus.
	b. Clear fault after 5 cycles by tripping the faulted line.
FLT05-PO1	**Prior Outage of Hoskins 345 kV (640226) to Raun 345 kV (635200) CKT 1;** 3 phase fault on Hoskins 345/115/13.8kV (640226/640228/640298) transformer, near Hoskins.
	a. Apply fault at the Hoskins 345kV bus.
	b. Clear fault after 5 cycles by tripping the faulted line.
FLT03-PO2	**Prior Outage of Hoskins 345 kV (640226) to Antelope 345 kV (640520) CKT 1;** 3 phase fault on Hoskins 345kV (640226) to Raun 345kV (635200), near Hoskins.
	a. Apply fault at the Hoskins 345kV bus.
	b. Clear fault after 5 cycles by tripping the faulted line.
FLT02-PO2	**Prior Outage of Hoskins 345 kV (640226) to Antelope 345 kV (640520) CKT 1;** 3 phase fault on Hoskins 345kV (640226) to Shell Creek 345kV (640342), near Hoskins.
	a. Apply fault at the Hoskins 345kV bus.
	b. Clear fault after 5 cycles by tripping the faulted line.
FLT05-PO2	**Prior Outage of Hoskins 345 kV (640226) to Antelope 345 kV (640520) CKT 1;** 3 phase fault on Hoskins 345/115/13.8kV (640226/640228/640298) transformer, near Hoskins.
	a. Apply fault at the Hoskins 345kV bus.
	b. Clear fault after 5 cycles by tripping the faulted line.
FLT01-PO3	**Prior Outage of Hoskins 345/230/13.8 kV (640226/640227/643082) Transformer;** 3 phase fault on Hoskins 345kV (640226) to Antelope 345kV (640520), near Hoskins.
	a. Apply fault at the Hoskins 345kV bus.
	b. Clear fault after 5 cycles by tripping the faulted line.
FLT02-PO3	**Prior Outage of Hoskins 345/230/13.8 kV (640226/640227/643082) Transformer;** 3 phase fault on Hoskins 345kV (640226) to Shell Creek 345kV (640342), near Hoskins.
	a. Apply fault at the Hoskins 345kV bus.
	b. Clear fault after 5 cycles by tripping the faulted line.

Table 5-1 continued

Fault ID	Fault Descriptions
FLT03-PO3	**Prior Outage of Hoskins 345/230/13.8 kV (640226/640227/643082) Transformer;** 3 phase fault on Hoskins 345kV (640226) to Raun 345kV (635200), near Hoskins.
	a. Apply fault at the Hoskins 345kV bus.
	b. Clear fault after 5 cycles by tripping the faulted line.

5.3 Results

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

Table 5-2: GEN-2015-007 Dynamic Stability Results

Fault ID	G09			G09_GGS		
	16WP	17SP	25SP	16WP	17SP	25SP
FLT01-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT02-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT03-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT04-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT05-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT06-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT07-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT08-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT09-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT10-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT12-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT13-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT14-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT15-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT16-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT17-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT18-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT19-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT20-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT21-SB	Stable	Stable	Stable	Stable	Stable	Stable
FLT22-SB	Stable	Stable	Stable	Stable	Stable	Stable
FLT23-SB	Stable	Stable	Stable	Stable	Stable	Stable
FLT01-PO1	Stable	Stable	Stable	Stable	Stable	Stable
FLT02-PO1	Stable	Stable	Stable	Stable	Stable	Stable
FLT05-PO1	Stable	Stable	Stable	Stable	Stable	Stable
FLT03-PO2	Stable	Stable	Stable	Stable	Stable	Stable
FLT02-PO2	Stable	Stable	Stable	Stable	Stable	Stable
FLT05-PO2	Stable	Stable	Stable	Stable	Stable	Stable
FLT01-PO3	Stable	Stable	Stable	Stable	Stable	Stable
FLT02-PO3	Stable	Stable	Stable	Stable	Stable	Stable
FLT03-PO3	Stable	Stable	Stable	Stable	Stable	Stable

6.0 Conclusions

The Interconnection Customer for GEN-2015-007 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	Hoskins 345 kV Substation (640226)	Hoskins 345 kV Substation (640226)
Configuration/Capacity	80 x GE 2.0 MW = 160 MW	6 x GE 1.715 MW 1 x GE 2.5 MW 64 x GE 2.3 MW Total = 159.99 MW
Generation Interconnection Line(s)	Length = 16.0 miles R = 0.000780 pu X = 0.007980 pu B = 0.134400 pu	Length = 14.7 miles R = 0.000570 X = 0.006490 B = 0.128100
Main Substation Transformer	T1: Z = 8.5%, Rating 190 MVA	T1: Z1-2 = 8.0%, Rating 180 MVA
Equivalent Collector Line 1	R = 0.041970 pu X = 0.038570 pu B = 0.032650 pu	R = 0.004826 X = 0.007879 B = 0.088406
Capacitor	N/A	C1: 14 MVAR, 1 Step

A power factor analysis was not performed as there was no change in the point of interconnection for GEN-2015-007.

The results of the reactive power analysis, also known as the low-wind/no-wind condition analysis, performed using all three models showed that the combined GEN-2015-007 project may require a 21.7 MVAr shunt reactor on the 345 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-2015-007 was approximately 0.72 kA for the 2017SP and 2025SP cases, and 0.73 kA for the 2017SP and 2025SP GGS cases. All three-phase current levels with the GEN-2015-007 generator online were below 42 kA for the 2017SP models and 44 kA for the 2025SP models.

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

The results of this Study show that the GEN-2015-007 Modification Request does not constitute a material modification.