GEN-2014-001IS

Impact Restudy for Generator Modification

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REVISION HISTORY

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08/02/2019	SPP	Initial report issued.

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SUMMARY

The GEN-2014-001IS Interconnection Customer has requested a modification to its 103.5 MW Interconnection Request. This system impact restudy was performed to determine the effects of changing wind turbine generators from the previously studied 61 GE 116 1.67 MW wind turbines generators (for a total capacity of 103.7 MW) to 5 GE 116 2.3 MW and 33 GE 127 2.78 MW wind turbine generators (for a total capacity of 103.24 MW). In addition, the modification request included changes to the generation interconnection line, collection system and the generator substation transformer. The point of interconnection (POI) for GEN-2014-001IS remains at the Sulphur 115 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) in accordance with FERC Order 827. Additionally, the project will be required to install approximately 6.29 MVArs of reactor shunts on its substation 115 kV bus or provide an alternate means of reactive power compensation. This is necessary to offset the capacitive effect on the transmission network caused by the project's transmission line and collector system during low-wind/no-wind conditions.

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.

The results of the dynamic stability analysis showed that the prior outage on the GEN-2014-001IS POI bus to Newell 115 kV line, followed by a three-phase fault on and loss of the Maurine 230/115 kV transformer, would cause GEN-2014-001IS to become unstable. As a result, GEN-2014-001IS will have to be curtailed to 90 MW following the prior outage on the GEN-2014-001IS POI bus to Newell 115 kV line.

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-2014-001IS
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-2014-001IS, an active generation interconnection request with a point of interconnection (POI) at the Tap of Maurine 115 kV to Newell 115 kV Substation, also known as the Sulphur 115 kV.

The GEN-2014-001IS project is proposed to interconnect in the Western Area Power Administration (WAPA) control area with a capacity of 103.7 MW as shown in Table ES-1 below. This Study has been requested to evaluate the modification of GEN-2014-001IS to change turbine configuration to a total of 5 x GE 116 2.3 MW + 33 x GE 127 2.78 MW wind turbines for total capacity of 103.24 MW. In addition, the modification request included changes to the collection system, generation interconnection line and the generator substation transformer. The modification request changes are shown in Table ES-2 below.

Table ES-1: GEN-2014-001IS Configuration

Request	Capacity (MW)	Existing Generator Configuration	Point of Interconnection
GEN-2014-001IS	103.7	61 x GE 1.7 MW	Tap of Maurine 115 kV to Newell 115 kV

Table ES-2: GEN-2014-001IS Modification Request

Facility	Existing	Modification Request
Point of Interconnection	Tap of Maurine 115 kV to Newell 115 kV	Tap of Maurine 115 kV to Newell 115 kV
Configuration/Capacity	61 x GE 1.7 MW = 103.7 MW	5 x GE 116 2.3 MW (Gen 1) + 33 x GE 127 2.78 MW (Gen 2) = 103.24 MW
Generation Interconnection Line	[redacted]	[redacted]
Main Substation Transformer	[redacted]	[redacted]
GSU Transformer	[redacted]	[redacted] [redacted]
Equivalent Collector Line	[redacted]	[redacted]

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 15 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-2014-001IS.

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 the GEN-2014-001IS project may require a 6.29 MVAr shunt reactor on the 115kV bus of the project substation. The shunt reactor is needed to reduce the reactive power transfer at the POI to approximately zero during low/no wind conditions while the generation interconnection project remains connected to the grid.

The results from the short circuit analysis showed that the maximum change in the fault currents in the immediate systems at or near GEN-2014-001IS was approximately 1.29 kA for the 2018SP case and 1.32 kA for the 2026SP case respectively. All three-phase fault current levels with the GEN-2014-001IS generator online were below 21 kA for the 2018SP models and 2026SP models.

The dynamic stability analysis was performed using the three DISIS-2016-002-1 models 2017 Winter Peak, 2018 Summer Peak, 2026 Summer Peak. Up to 26 events were simulated, which included three-phase faults, three-phase faults on prior outage cases, and single-line-to-ground faults with stuck breakers faults.

The results of the dynamic stability analysis showed that FLT9009-PO2, the prior outage on the GEN-2014-001IS POI bus to Newell 115 kV line, followed by a three-phase fault on and loss of the Maurine 230/115 kV transformer, would cause GEN-2014-001IS to become unstable. This unstable response was not observed in the original GEN-2014-001IS model and sensitivity analysis showed that the change in the turbine gain (KQi=MVAR/Volt) as well as the combined main transformer and equivalent line impedances were the cause of the instability. GEN-2014-001IS may have to be curtailed to 90MW after the prior outage of the GEN-2014-001IS POI bus to Newell 115 kV line to remain stable following the fault on the Maurine 230/115 kV transformer. This unstable response from GEN-2014-001IS was not observed in the existing representation of GEN-2014-001IS in the DISIS-2016-002-1 Group 15 models.

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-2014-001IS 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-2014-001IS, an active generation interconnection request with point of interconnection (POI) at the Tap of Maurine 115 kV to Newell 115 kV Substation, also known as the Sulphur 115 kV.

The GEN-2014-001IS project is proposed to interconnect in the Western Area Power Administration (WAPA) control area with a combined capacity of 103.7 MW as shown in Table 1-1 below. Details of the modification request is provided in Section 2.0 below.

Table 1-1: Existing GEN-2014-001IS Configuration

Request	Capacity (MW)	Existing Generator Configuration	Point of Interconnection
GEN-2014-001IS	103.7	61 x GE 1.7 MW	Tap of Maurine 115 kV to Newell 115 kV

1.1 Scope

The Study included an equivalent impedance comparison and a reactive power analysis. The methodology, assumptions, and results of the analyses are presented in the following four 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 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.

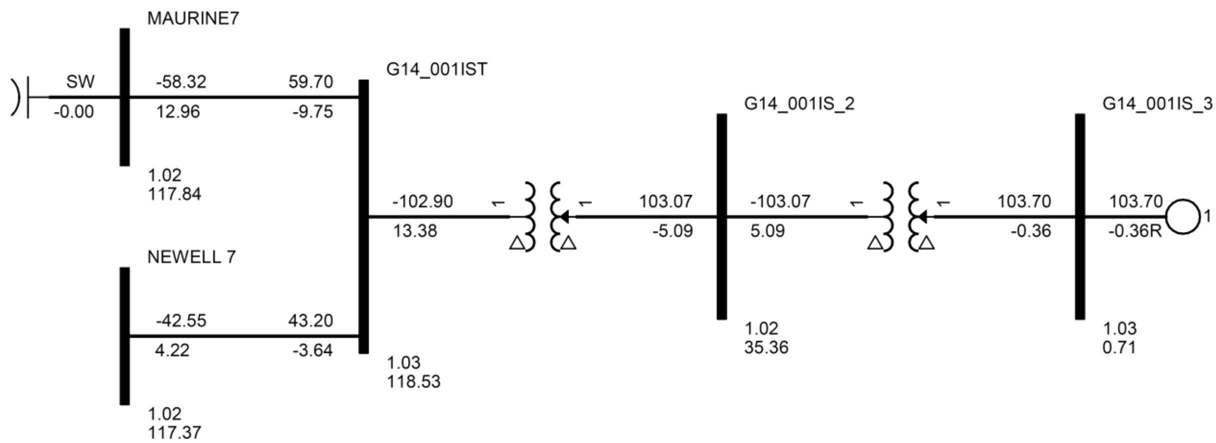
1.2 Study Limitations

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-2014-001IS was originally studied as part of Group 15 in the DISIS-2016-002 study. Figure 2-1 shows the power flow model single line diagram for the existing GEN-2014-001IS configuration.

Figure 2-1: GEN-2014-001IS Single Line Diagram (Existing Configuration)



The GEN-2014-001IS Modification Request included a turbine configuration change to a total of 5 x GE 116 2.3 MW + 33 x GE 127 2.78 MW wind turbines for a total capacity of 103.24 MW. In addition, the modification request also included changes to the collection system and the generator substation transformer. The major modification request changes are shown in Figure 2-2 and Table **2-1** below.

Figure 2-2: GEN-2014-001IS Single Line Diagram (New Configuration)

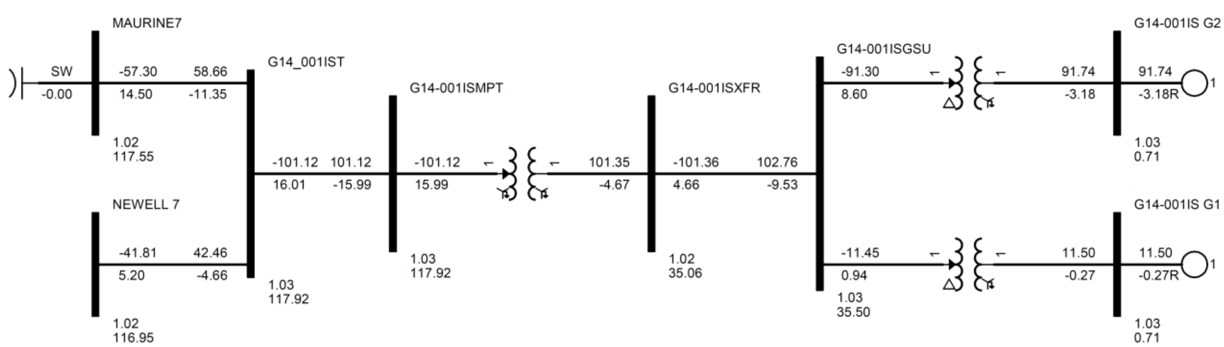


Table 2-1: GEN-2014-001IS Modification Request

Facility	Existing	Modification Request
Point of Interconnection	Tap of Maurine 115 kV to Newell 115 kV	Tap of Maurine 115 kV to Newell 115 kV
Configuration/Capacity	61 x GE 1.7 MW = 103.7 MW	5 x GE 116 2.3 MW (Gen 1) + 33 x GE 127 2.78 MW (Gen 2) = 103.24 MW
Generation Interconnection Line	[redacted]	[redacted] [redacted] [redacted] [redacted]
Main Substation Transformer	[redacted]	[redacted]
GSU Transformer	[redacted] [redacted]	[redacted] | [redacted] [redacted]
Equivalent Collector Line	[redacted]	[redacted] [redacted] [redacted]

3.0 Reactive Power Analysis

The reactive power analysis, also known as the low-wind/no-wind condition analysis, was performed for GEN-2014-001IS 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-2014-001IS project, the generators were switched out of service while other collector system elements remained in-service. A shunt reactor was tested at the collection substation 115 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-2014-001IS project required an approximately 6.29 MVAr shunt reactor at the project substation, to reduce the POI MVAr to zero. Figure 3-1 illustrates the shunt reactor size required to reduce the POI MVAr to approximately zero. Reactive compensation can be provided either by discrete reactive devices or by the generator itself if it possesses that capability.

Figure 3-1: GEN-2014-001IS Single Line Diagram (Shunt Reactor)

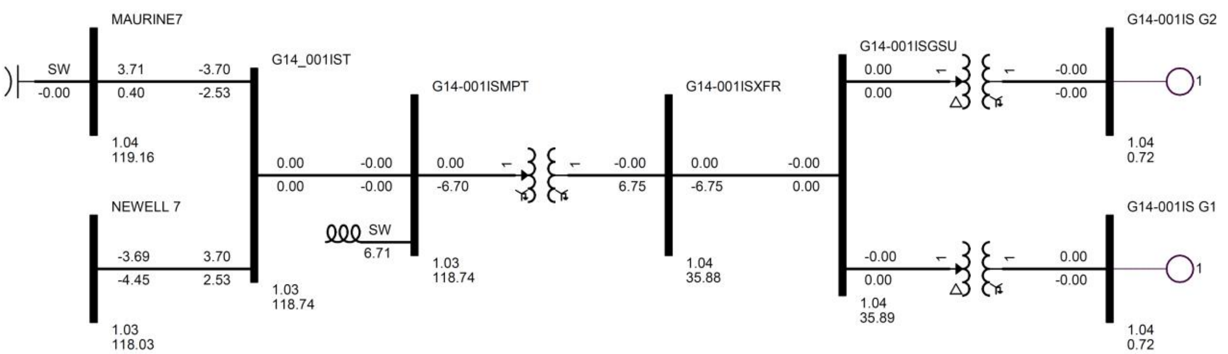


Table 3-1 shows the shunt reactor size determined for the three study models used in the assessment.

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

Machine	POI Bus Name	Reactor Size (MVAr)		
		17WP	18SP	26SP
GEN-2014-001IS	G14_001IS (Tap of Maurine to Newell)	6.29	6.29	6.29

4.0 Short Circuit Analysis

A short-circuit study was performed using the 2018SP and 2026SP models for GEN-2014-001IS. 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 115 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 54.1%, 1.32 kA. The maximum fault current calculated within 5 buses with GEN-2014-001IS was less than 21 kA for the 2018SP and 2026SP models respectively. The maximum change of 54.1% was observed at the GEN-2014-001IS 115 kV POI bus, which had GEN-OFF and GEN-ON fault levels of 2.43 and 3.75 kA respectively.

Table 4-1: 2018SP Short Circuit Results

Voltage (kV)	Max. Current (kA)	Max kA Change	Max %Change
69	3.6	0.13	6.4%
115	12.0	1.29	52.7%
230	19.9	0.26	9.7%
Max	**19.9**	**1.29**	**52.7%**

Table 4-2: 2026SP Short Circuit Results

Voltage (kV)	Max. Current (kA)	Max kA Change	Max %Change
69	3.6	0.14	7.6%
115	12.1	1.32	54.1%
230	20.2	0.26	9.7%
Max	**20.2**	**1.32**	**54.1%**

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-2014-001IS 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 5 GE-116 2.3 MW turbines and 33 GE-127 2.78 MW turbines configuration for the GEN-2014-001IS 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 15. The modifications requested to project GEN-2014-001IS were used to create modified stability models for this impact study.

The modified dynamics model data for the DISIS-2016-002-1 Group 15 request, GEN-2014-001IS is provided in Appendix C. The modified power flow models and associated dynamics database were initialized (no-fault test) to confirm that there were no errors in the initial conditions of the system and the dynamic data.

During the fault simulations, the active power (PELEC), reactive power (QELEC), and terminal voltage (ETERM) were monitored for GEN-2014-001IS and other equally and prior queued projects in Group 15. In addition, voltages of five (5) buses away from the POI of GEN-2014-001IS were monitored and plotted. The machine rotor angle for synchronous machines and speed for asynchronous machines within this study area including 600 (XEL), 608 (MP), 613 (SMMPA), 615 (GRE), 620 (OTP), 640 (NPPD), 645 (OPPD), 650 (LES), 652 (WAPA), 661 (MDU) were monitored. In addition, the voltages of all 100 kV and above buses within the study area were monitored.

5.2 Fault Definitions

Aneden simulated the faults previously simulated by WAPA for GEN-2014-001IS and selected additional fault events for GEN-2014-001IS as required. The new set of faults were simulated using the modified study models. The fault events included three-phase faults, three-phase faults on prior outage cases, and single-line-to-ground faults with stuck breakers. The simulated faults are listed and described in Table 5-1 below. These contingencies were applied to the modified 2017 Winter Peak, 2018 Summer Peak, and the 2026 Summer Peak models.

Table 5-1: Fault Definitions

Fault/WAPA ID	Fault Descriptions
FLT9001-3PH bk3	3 phase fault on the G14_001IST to MAURINE7 115 kV line circuit 1, near G14_001IST. a. Apply fault at the G14_001IST 115 kV bus. b. Clear fault by tripping the faulted line
FLT9002-3PH	3 phase fault on the G14_001IST to NEWELL7 115 kV line circuit 1, near G14_001IST. a. Apply fault at the G14_001IST 115 kV bus. b. Clear fault by tripping the faulted line.
FLT9003-3PH bm3	3 phase fault on the G14_001IST to NEWELL7 115 kV line circuit 1, near G14_001IST. a. Apply fault at the G14_001IST 115 kV bus. b. Clear fault by tripping the NEWELL7 bus.
FLT9004-3PH	3 phase fault on the NEWELL7 115 kV to NEWELL7 69 kV transformer circuit 1, near NEWELL7 115 kV. a. Apply fault at the NEWELL7 115 kV bus. b. Clear fault by tripping the faulted line.
FLT9005-3PH	3 phase fault on the ELKCRK7 to RAPIDCY7 115 kV line circuit 1, near NEWELL7. a. Apply fault at the ELKCRK7 115 kV bus. b. Clear fault by tripping the faulted line.
FLT9006-3PH	3 phase fault on the MAURINE7 115 kV to MAURINE8 69 kV transformer circuit 1, near MAURINE7 115 kV. a. Apply fault at the MAURINE7 115 kV bus. b. Clear fault by tripping the faulted line.
FLT9007-3PH	3 phase fault on the MAURINE7 to FAITH 115 kV line circuit 1, near MAURINE7 115 kV. a. Apply fault at the MAURINE7 115 kV bus. b. Clear fault by tripping the faulted line.
FLT9008-3PH	3 phase fault on the FAITH to EAGLEBT7 115 kV line circuit 1, near FAITH 115 kV. a. Apply fault at the FAITH 115 kV bus. b. Clear fault by tripping the faulted line.
FLT9009-3PH bc3	3 phase fault on the MAURINE7 115 kV to MAURINE4 230 kV to MAURINE9 13.8 kV XFMR circuit 1, near MAURINE7 115 kV. a. Apply fault at the MAURINE7 115 kV bus. b. Clear fault by tripping the faulted transformer.
FLT9010-3PH ba3	3 phase fault on the MAURINE4 to NUNDRWD-LNX3 230 kV line circuit 1, near MAURINE4 230 kV. a. Apply fault at the MAURINE4 230 kV bus. b. Clear fault by tripping the NUNDRWD-LNX3 BUS.
FLT9011-3PH	3 phase fault on the NUNDRWD-LNX3 to NUNDRWD4 230 kV line circuit Z, near NUNDRWD-LNX3 230 kV. a. Apply fault at the NUNDRWD-LNX3 230 kV bus. b. Clear fault by tripping the NUNDRWD-LNX3 BUS.
FLT9012-3PH bb3	3 phase fault on the MAURINE4 to BISON4 230 kV line circuit 1, near MAURINE4 230 kV. a. Apply fault at the MAURINE4 230 kV bus. b. Clear fault by tripping the BISON4 bus.

Table 5-1 continued

Fault/WAPA ID	Fault Descriptions
FLT9013-3PH	3 phase fault on the BISON4 230 kV to BISON8 69 kV transformer circuit 1, near BISON4 230 kV. a. Apply fault at the BISON4 230 kV bus. b. Clear fault by tripping the faulted transformer.
FLT9014-3PH	3 phase fault on the BISON4 230 kV to BISON7 115 kV transformer circuit 1, near BISON4 230 kV. a. Apply fault at the BISON4 230 kV bus. b. Clear fault by tripping the faulted line.
FLT9015-3PH	3 phase fault on the BISON4 to HETINGR4 230 kV line circuit 1, near BISON4. a. Apply fault at the BISON4 230 kV bus. b. Clear fault by tripping the BISON4 bus
FLT1001-SB bus	**Stuck Breaker at MAURINE7** a. Apply single phase fault at MAURINE7 115 kV bus. b. Clear fault and trip the following elements c. MAURINE7 – G14_001IST 115 kV circuit 1 line d. MAURINE7 115 kV bus
FLT1002-SB	**Stuck Breaker at NEWELL7** a. Apply single phase fault at NEWELL7 115 kV bus. b. Clear fault and trip the following elements c. NEWELL7 115 kV – G14_001IST 115 kV circuit 1 line d. NEWELL7 115 kV bus
FLT1003-SB bv1	**Stuck Breaker at Elk Creek** a. Apply single phase fault at Elk Creek 115 kV bus. b. Clear fault and trip the following elements c. Elk Creek 115 kV bus.
FLT1004-SB ba1+bb1	**Stuck Breaker at MAURINE4** a. Apply single phase fault at MAURINE4 230 kV bus. b. Clear fault and trip the following elements c. MAURINE4 230 kV bus
FLT9004-PO1	Prior Outage of G14_001IST to MAURINE7 115 kV line 3 phase fault on the NEWELL7 115 kV to NEWELL7 69 kV transformer circuit 1, near NEWELL7 115 kV. a. Apply fault at the NEWELL7 115 kV bus. b. Clear fault by tripping the faulted line.
FLT9016-PO1	Prior Outage of G14_001IST to MAURINE7 115 kV line 3 phase fault on the RAPIDCY7 to RUSHMRE7 115kV line circuit 1, near RAPIDCY7 115 kV. a. Apply fault at the RAPIDCY7 115 kV bus. b. Clear fault by tripping the faulted line.
FLT9017-PO1	Prior Outage of G14_001IST to MAURINE7 115 kV line 3 phase fault on the RAPIDCY7 to ELSWRTH7 115kV line circuit 1, near RAPIDCY7 115 kV. a. Apply fault at the RAPIDCY7 115 kV bus. b. Clear fault by tripping the faulted line.
FLT9018-PO1	Prior Outage of G14_001IST to MAURINE7 115 kV line 3 phase fault on the RAPIDCY7 to DRY CREEK 7 115kV line circuit 1, near RAPIDCY7 115 kV. a. Apply fault at the RAPIDCY7 115 kV bus. b. Clear fault by tripping the faulted line.

Table 5-1 continued

Fault ID	Fault Descriptions
FLT9019-PO1	Prior Outage of G14_001IST to MAURINE7 115 kV line 3 phase fault on the RAPIDCY7 115kV to RAPIDCY8 69kV XFMR circuit 1, near RAPIDCY7 115 kV. a. Apply fault at the RAPIDCY7 115 kV bus. b. Clear fault by tripping the faulted transformer.
FLT9006-PO2	Prior Outage of G14_001IST to NEWELL7 115 kV line 3 phase fault on the MAURINE7 115 kV to MAURINE8 69 kV transformer circuit 1, near MAURINE7 115 kV. a. Apply fault at the MAURINE7 115 kV bus. b. Clear fault by tripping the faulted line.
FLT9007-PO2	Prior Outage of G14_001IST to NEWELL7 115 kV line 3 phase fault on the MAURINE7 to FAITH 115 kV line circuit 1, near MAURINE7 115 kV. a. Apply fault at the MAURINE7 115 kV bus. b. Clear fault by tripping the faulted line.
FLT9009-PO2	Prior Outage of G14_001IST to NEWELL7 115 kV line 3 phase fault on the MAURINE7 115 kV to MAURINE4 230 kV to MAURINE9 13.8 kV XFMR circuit 1, near MAURINE7 115 kV. a. Apply fault at the MAURINE7 115 kV bus. b. Clear fault by tripping the faulted transformer.

5.3 Results

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

FLT9009-PO2, the prior outage on the GEN-2014-001IS POI bus to Newell 115 kV line, followed by a three-phase fault on and loss of the Maurine 230/115 kV transformer, would cause GEN-2014-001IS to become unstable. GEN-2014-001IS needs to be curtailed to 90MW after the prior outage of the GEN-2014-001IS POI bus to Newell 115 kV line to remain stable following the fault on the Maurine 230/115 kV transformer. This unstable response from GEN-2014-001IS was not observed in the existing representation of GEN-2014-001IS in the DISIS-2016-002-1 Group 15 models.

Table 5-2: GEN-2014-001IS Dynamic Stability Results

Fault ID	17W			18S			26S		
	Volt. Recovery	Volt. Violation	Stable	Volt. Recovery	Volt. Violation	Stable	Volt. Recovery	Volt. Violation	Stable
FLT9001-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9002-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9003-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9004-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9005-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9006-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9007-3PH	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
FLT9011-3PH	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
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
FLT1003-SB	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT1004-SB	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9004-PO1	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9016-PO1	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9017-PO1	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9018-PO1	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9019-PO1	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9006-PO2	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9007-PO2	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9009-PO2*	Fail	Fail	Unstable	Fail	Fail	Unstable	Fail	Fail	Unstable

*GEN-2014-001IS needs to be curtailed to 90 MW in 17W, 18S, and 26S to be stable

Figure 5-1 and Figure 5-2 show the GEN-2014-001IS response with the FLT9009-PO2 event with the existing configuration and the modified configuration respectively.

Figure 5-1: FLT9009-PO2 GEN-2014-001IS Response (Existing Configuration)

[redacted]

Figure 5-2: FLT9009-PO2 GEN-2014-001IS Response (Modification Request)

[redacted]

Some sensitivity analysis was performed to determine the cause of the instability in the modified cases. The following sensitivities were modeled as part of that evaluation:

1. KQi = MVAR/Volt gain, CON(J+17) of the GEWTE2 generator model
2. Generator to POI Impedance: collector substation transformer and the equivalent collector line

The models showed that the original KQi was 0.1 while the KQi of the modification request turbines were 0.41 for both the 2.3 MW and 2.78 MW turbines. The original configuration of the GEN-2014-001IS did not have an equivalent collector line and a different main transformer impedance.

Table 5-3: FLT9009-PO2 Sensitivity Analysis

Case	Kqi	Main Transformer + Equivalent Collector Line	FLT9009-PO2 Response
Base Case	0.1	Original	Stable
Modification Request	0.41	Modified	Unstable
Sensitivity 1 - New Turbines	0.41	Original	Unstable
Sensitivity 2 - New Turbines	0.1	Modified	Unstable
Sensitivity 3 - New Turbines	0.1	Original	Stable

The sensitivity results show that both the change in the gain and the impedance between the generator terminal to main transformer caused instability observed in the MRIS during FLT9009-PO2 not previously observed.

Figure 5-3 shows that GEN-2014-001IS response was stable with FLT9009-PO2 when output was curtailed to 90 MW.

Figure 5-3: FLT9009-PO2 GEN-2014-001IS Response After Curtailment (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-2014-001IS requested a Modification Request Impact Study to assess the impact of the turbine and facility changes to a configuration with a total of 5 x GE 116 2.3 MW + 33 x GE 127 2.78 MW wind turbines for a total capacity of 103.24 MW. In addition, the modification request included changes to the collection system and the generator substation transformer.

A power factor analysis was not performed as there was no change in the point of interconnection for GEN-2014-001IS.

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-2014-001IS project may require a 6.29 MVAr shunt reactor on the 115kV bus of the project substation. The shunt reactor is needed to reduce the reactive power transfer at the POI to approximately zero during low/no wind conditions while the generation interconnection project remains connected to the grid.

The results from the short circuit analysis showed that the maximum change in the fault currents in the immediate systems at or near GEN-2014-001IS was approximately 1.29 kA for the 2018SP and 1.32 kA for the 2026SP cases respectively. All three-phase fault current levels with the GEN-2014-001IS generator online were below 21 kA for the 2018SP models and 2026SP models.

The results of the dynamic stability analysis showed that FLT9009-PO2, the prior outage on the GEN-2014-001IS POI bus to Newell 115 kV line, followed by a three-phase fault on and loss of the Maurine 230/115 kV transformer, would cause GEN-2014-001IS to become unstable. As a result, GEN-2014-001IS will have to be curtailed to 90 MW following the prior outage on the GEN-2014-001IS POI bus to Newell 115 kV line.

Other than that, there were no machine rotor angle damping or transient voltage recovery violations observed in the simulated fault events associated with this modification request study. Additionally, the project wind farm was found to stay connected during the 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-2014-001IS Modification Request does not constitute a material modification.