GEN-2014-064

Impact Restudy for Generator Modification

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By SPP Generator Interconnections Dept.

REVISION HISTORY

DATE OR VERSION NUMBER	AUTHOR	CHANGE DESCRIPTION
05/03/2019	SPP	Initial report issued.

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SUMMARY

The GEN-2014-064 Interconnection Customer has requested a modification to its 248.4 MW Interconnection Request. This system impact restudy was performed to determine the effects of changing wind turbine generators from the previously studied 108 GE 2.3 MW wind turbine generators (for a total of 248.4 MW) to 23 GE 1.715 MW, 57 GE 1.79 MW, and 46 GE 2.3 MW wind turbine generators (for a total of 247.275 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-2014-064 remains at the Oklahoma Gas and Electric (OKGE) Otter 138 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 17.2 MVArs of reactor shunts on its substation 138 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.

The restudy showed that no stability problems were found during the summer and the winter peak conditions. Additionally, the project wind farm was found to stay connected during the contingencies that were studied and, therefore, will meet the Low Voltage Ride Through (LVRT) requirements of FERC Order #661A. The requested modification is not considered Material.

It should be noted that this study analyzed the requested modification to change generator technology and layout. Powerflow analysis was not performed. This study analyzed many of the most probable contingencies, but it is not an all-inclusive list and cannot account for every operational situation. It is likely that the customer may be required to reduce its generation output to 0 MW, also known as curtailment, under certain system conditions to allow system operators to maintain the reliability of the transmission network.

Nothing in this study should be construed as a guarantee of transmission service or delivery rights. If the customer wishes to obtain deliverability to final customers, a separate request for transmission service must be requested on Southwest Power Pool's OASIS by the customer.

A: CONSULTANT'S MATERIAL MODIFICATION STUDY REPORT

See next page for the Consultant's Material Modification Study report.

Aneden Consulting

Submitted to
Southwest Power Pool

SPP Southwest Power Pool

Report On

GEN-2014-064
Modification Request Impact Study

Revision R1

Date of Submittal
May 2, 2019

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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-2014-064, an active generation interconnection request with the same point of interconnection (POI) at the Otter 138 kV Substation.

The GEN-2014-064 project is proposed to interconnect in the Oklahoma Gas and Electric (OG&E) control area with a capacity of 247.275 MW. GEN-2014-064 current configuration includes one hundred and eight (108) GE 2.3 MW wind turbine generators (248.4 MW). This Study has been requested to evaluate the modification request of GEN-2014-064 to change turbine configurations with a combined capacity of 247.275 MW - 23 x GE 1.715 MW + 57 x GE 1.79 MW + 46 x GE 2.3 MW wind turbines.

In addition, the modification request included changes to the generator substation and GSU transformers, the generation interconnection line, and the collection system. The modification request changes are shown in Table ES-1 below.

Table ES-1: GEN-2014-064 Modification Request

Facility	Existing	Modification Request		
Point of Interconnection	Otter 138 kV Substation (514708)	Otter 138 kV Substation (514708)		
Configuration/Capacity	108 x GE 2.3 MW = 248.4 MW	23 x GE 1.715 MW (Gen 1) + 57 x GE 1.79 MW (Gen 2) + 46 x GE 2.3 MW (Gen 3) = 247.275 MW		
Generation Interconnection Line	Length = 0.1 miles R = 0.000100 pu X = 0.000420 pu B = 0.000100 pu	Length = 0.1 miles R = 0.000080 pu X = 0.000120 pu B = 0.003020 pu		
Generator Substation Transformer	138/34.5 kV Transformer: Z = 10%, Winding 170 MVA, Rating 280 MVA	138/34.5 kV Transformer: Z = 9%, Winding 168 MVA, Rating 280 MVA		
GSU Transformer	Equivalent Qty: 108 Z = 5.7%, Rating 276.5 MVA	Gen 1 Equivalent Qty: 23: Z = 5.7%, Rating 46 MVA	Gen 2 Equivalent Qty: 57: Z = 5.7%, Rating 114 MVA	Gen 3 Equivalent Qty: 46: Z = 5.7%, Rating 119.6 MVA
Equivalent Collector Line	R = 0.003600 pu X = 0.005010 pu B = 0.100040 pu	R = 0.005952 pu X = 0.010026 pu B = 0.167747 pu		
Reactive Power Devices	N/A	1 x 21 MVAR 34.5 kV Capacitor Bank		

The modification request retained the same GE wind turbine technology and as such, the combined impedances from the POI up to and including the step-up transformers for GEN-2014-064 were calculated before and after the modification request. The modification request resulted in a change in the combined impedances of approximately 0.68%. As a result, the scope of this modification request study was limited to the reactive power analysis (low wind) analysis.

Aneden performed a reactive power analysis using the modification request data based on the DISIS-2016-002 ReStudy #1 Group 8 study models:

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

A power factor analysis was not performed since there was no modification to the current point of interconnection.

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-2014-064 project may require a 17.2 MVAr shunt reactor at the 138 kV collector 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 of this Study show that this GEN-2014-064 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-2014-064, an active generation interconnection request with point of interconnection (POI) at the Otter 138 kV Substation.

The GEN-2014-064 project is proposed to interconnect in the Oklahoma Gas and Electric (OG&E) control area with a combined capacity of 248.4 MW. GEN-2014-064 current configuration includes one hundred and eight (108) GE 2.3 MW wind turbine generators as shown in Table 1-1 below. Details of the modification request is provided in Section 2.0 below.

Table 1-1: Existing GEN-2014-064 Configuration

Request	Capacity (MW)	Existing Generator Configuration	Point of Interconnection
GEN-2014-064	248.4	108 x GE 2.3 MW	Otter 138 kV Substation (514708)

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. Equivalent Impedance Comparison
3. Reactive Power Analysis
4. 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.

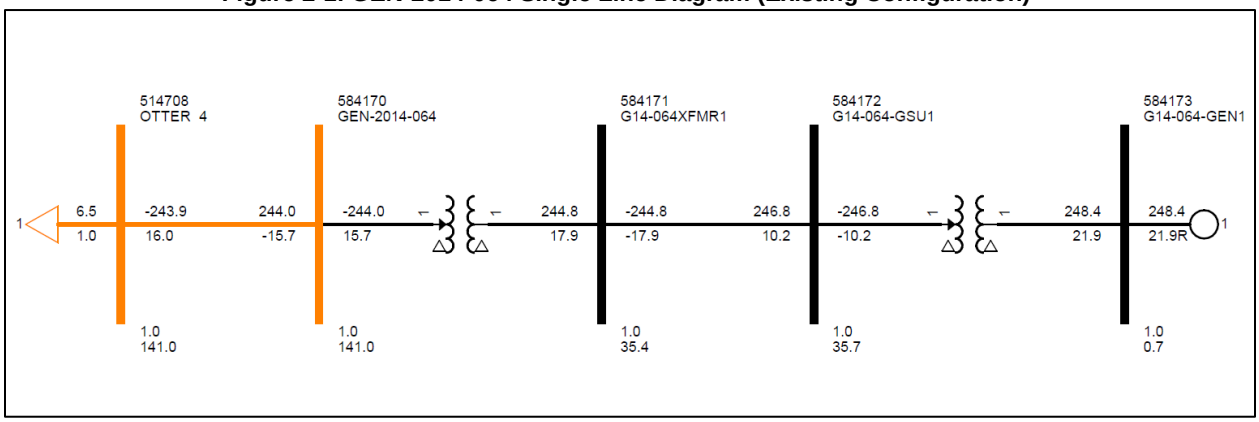
1.2 Study Limitations

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

Figure 2-1 shows the power flow model single line diagram for the existing GEN-2014-064 configuration.

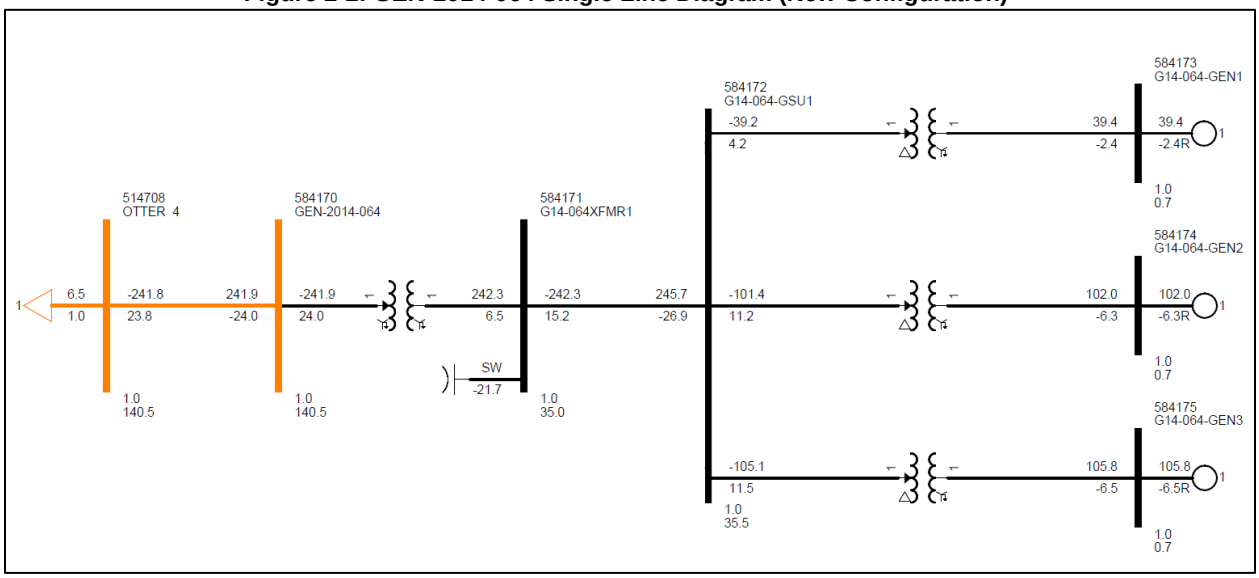
Figure 2-1: GEN-2014-064 Single Line Diagram (Existing Configuration)



The GEN-2014-064 Modification Request included a change to turbine configurations with a combined capacity of 247.275 MW - 23 x GE 1.715 MW + 57 x GE 1.79 MW + 46 x GE 2.3 MW wind turbines.

In addition, the modification request also included changes to the generator substation and GSU transformers, the generation interconnection line, and the collection system. The major modification request changes are shown in Figure 2-2 and Table 2-1 below.

Figure 2-2: GEN-2014-064 Single Line Diagram (New Configuration)



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Generation Interconnection Line	Length = 0.1 miles R = 0.000100 pu X = 0.000420 pu B = 0.000100 pu	Length = 0.1 miles R = 0.000080 pu X = 0.000120 pu B = 0.003020 pu		
Generator Substation Transformer	138/34.5 kV Transformer: Z = 10%, Winding 170 MVA, Rating 280 MVA	138/34.5 kV Transformer: Z = 9%, Winding 168 MVA, Rating 280 MVA		
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Reactive Power Devices	N/A	1 x 21 MVAR 34.5 kV Capacitor Bank		

3.0 Equivalent Impedance Comparison

The equivalent impedance comparison was performed using the modified study models created using the DISIS-2016-002 ReStudy #1 2017WP, 2018SP, and 2026SP models. The methodology and results of the equivalent impedance comparison are described below. The analysis was completed using PSS/E version 33.7 software.

3.1 Methodology and Criteria

The impedances from all the components of the transmission lines, substation and step-up transformers, and equivalent collector line impedances were added in series for GEN-2014-064 before and after the modification request. The percentage increase in the impedances before and after the modification request were then compared. If the percentage increase was greater than 10%, additional dynamic stability analysis would be performed to assess the impact of the modification request.

3.2 Results

Table 3-1 shows the impedance differences before and after the modification request. Table 3-2 shows the increases in impedances from the original impedances to the modification request impedances. The results showed the that impedances increases were below 10%.

Table 3-1: GEN-2014-064 Impedance Comparisons

System Component	Modification Request Impedances (p.u.)			Original Model Impedances (p.u.)		
	R	***X***	***B***	***R***	***X***	***B***
Gen Tie Line from Otter to GEN-2014-064	0.00008	0.00012	0.00302	0.00010	0.00042	0.00010
GEN-2014-064 collector system equivalent	0.00595	0.01003	0.16775	0.00360	0.00501	0.10004
	R	***X***	***MVA Base***	***R***	***X***	***MVA Base***
GEN-2014-064 Main Transformer @ 100 MVA	0.00071	0.05357	100	0.00140	0.05881	100
GEN-2014-064 Equivalent Unit GSU @ 100 MVA Base	0.00272	0.02038	100	0.0027	0.0206	100
	R	***X***	***Z***	***R***	***X***	***Z***
Total Impedance from POI to Generator	0.009464	0.084102	**0.084633**	0.007849	0.084852	**0.085214**

Table 3-2: GEN-2014-064 Combined Impedance Comparison

Interconnection Request	Impedance Z (p.u.)
GEN-2014-064 Impedance Increase	0.68%

4.0 Reactive Power Analysis

The reactive power analysis, also known as the low-wind/no-wind condition analysis, was performed for GEN-2014-064 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.

4.1 Methodology and Criteria

For the GEN-2014-064 project, the generators and the 34.5 kV capacitor were 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.

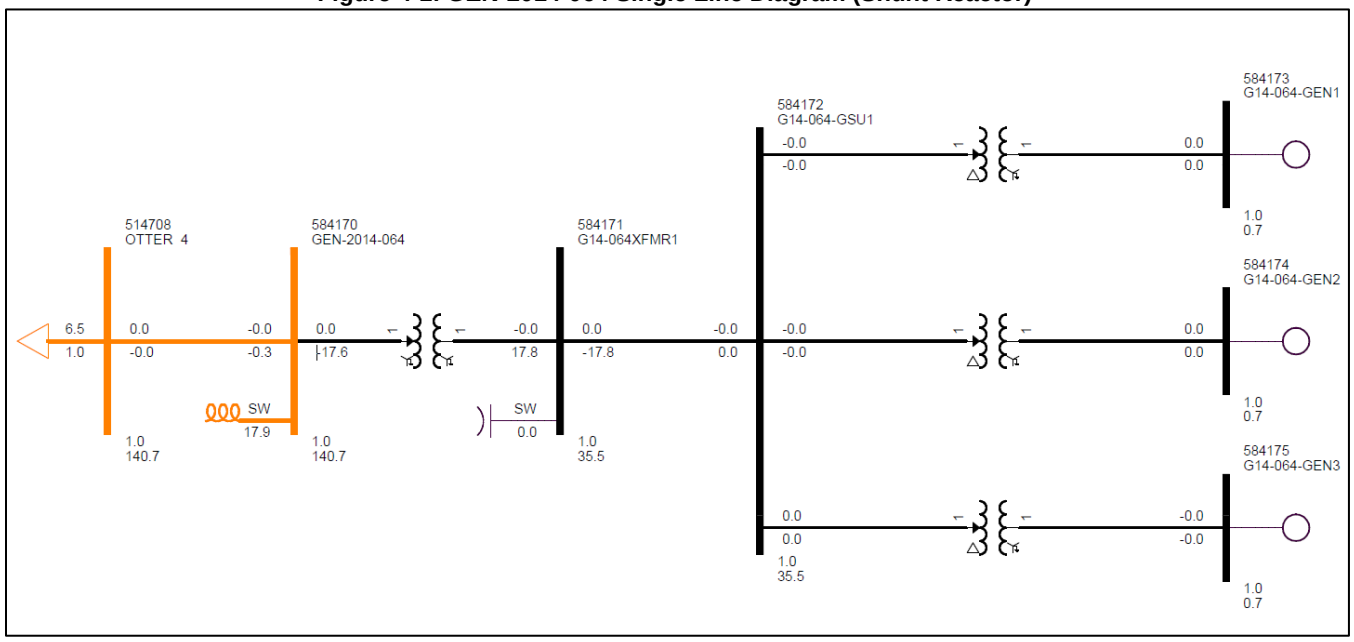
4.2 Results

The results from the reactive power analysis showed that the GEN-2014-064 project required an approximately 17.2 MVAr shunt reactor at the project substation, to reduce the POI MVAr to zero. Figure 4-1 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. Table 4-1 shows the shunt reactor size determined for the three study models used in the assessment. Note that the GEN-2014-064 capacitor bank was not contributing reactive power to the collection system.

Table 4-1: Shunt Reactor Size for Low Wind Study

Machine	POI Bus Number	POI Bus Name	Reactor Size (MVAr)		
			17WP	18SP	26SP
GEN-2014-064	514708	Otter	17.2	17.2	17.2

Figure 4-1: GEN-2014-064 Single Line Diagram (Shunt Reactor)



5.0 Conclusions

The Interconnection Customer for GEN-2014-064 requested a Modification Request Impact Study to assess the impact of the turbine and facility changes.

The modification request resulted in a change in the combined impedances from the point of interconnection to the generator step up transformers of approximately 0.68%. As such a dynamic stability analysis was not deemed necessary and the scope of this modification request study was limited to the reactive power analysis (low wind) analysis.

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-2014-064 project required an approximately 17.2 MVAr shunt reactor on the 138 kV bus of the generator 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.

In conclusion, the results of this Study showed that the Modification Request does not constitute a material modification.