Report on

GEN-2014-001 Modification Request Impact Study

Revision R1 **August 3, 2023**

Submitted to
Southwest Power Pool

anedenconsulting.com

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Revision History

DATE OR VERSION NUMBER	AUTHOR	CHANGE DESCRIPTION
8/3/2023	Aneden Consulting	Initial Report Issued

Executive Summary

Aneden Consulting (Aneden) was retained by the Southwest Power Pool (SPP) to perform a Modification Request Impact Study (Study) for GEN-2014-001, an active Generation Interconnection Request (GIR) with a Point of Interconnection (POI) on the Emporia Energy Center to Wichita 345 kV line.

The GEN-2014-001 wind project interconnects in the Evergy Kansas Central (WERE) control area with a capacity of 200.6 MW. GEN-2014-001 had a modification study performed in 2022[1]. As a result, Aneden updated the GEN-2014-001 project configuration in the base models based on SPP's confirmation of the latest project configuration.

This Study has been requested to evaluate the modification of GEN-2014-001 to replace one of the main power transformers but keep the existing turbine configuration of 76 x GE 2.82 MW for a total capacity of 214.32 MW. This generating capability for GEN-2014-001 (214.32 MW) exceeds its Generator Interconnection Agreement (GIA) Interconnection Service amount, 200.6 MW, as listed in Appendix A of the GIA. As a result, the customer must ensure that the amount of power injected at the POI does not exceed the Interconnection Service amount listed in its GIA. The project includes the use of a Power Plant Controller (PPC) to limit the total power injected into the POI.

In addition, the modification request included changes to the generation interconnection line rating. The existing and modified configurations for GEN-2014-001 are shown in Table ES-1.

Table ES-1: GEN-2014-001 Modification Request

Facility	Existing Configuration (based on previous modification)		Current Modification Configuration	
Point of Interconnection	Tap on Empec 345 kV (532768) to Wichita 345 kV (532796) (G14-001-TAP 562476)		Tap on Empec 345 kV (532768) to Wichita 345 kV (532796) (G14-001-TAP 562476)	
Configuration/Capacity	76 x GE 2.82 MW = 214.32 MW PPC to limit POI to 200.6 MW		76 x GE 2.82 MW = 214.32 MW PPC to limit POI to 200.6 MW [203.8 MW Dispatch]	
Generation Interconnection Line	G14-001-TAP to GEN-2014-001: Length = 10.7 miles R = 0.000542 pu X = 0.005124 pu B = 0.094926 pu Rating MVA = 759 MVA	GEN-2014-001 to GEN-2014-001: Length = 12.06 miles R = 0.000618 pu X = 0.005712 pu B = 0.109372 pu Rating MVA = 759 MVA	G14-001-TAP to GEN-2014-001: Length = 10.7 miles R = 0.000542 pu X = 0.005124 pu B = 0.094926 pu Rating MVA = 597 MVA	GEN-2014-001 to GEN-2014-001: Length = 12.06 miles R = 0.000618 pu X = 0.005712 pu B = 0.109372 pu Rating MVA = 597 MVA
Main Substation Transformer[1]	Transformer T1: X = 9.601%, R = 0.195%, Winding MVA = 126 MVA, Rating MVA = 210 MVA	Transformer T2: X = 9.998%, R = 0.2%, Winding MVA = 106 MVA, Rating MVA = 177 MVA	Transformer T1: X = 9.601%, R = 0.195%, Winding MVA = 126 MVA, Rating MVA = 210 MVA	Transformer T2: X = 7.997%, R = 0.203%, Winding MVA = 100 MVA, Rating MVA = 167 MVA
Equivalent GSU Transformer[1]	Gen 1 Equivalent Qty: 39 X = 7.125%, R = 0.712%, Winding MVA = 122.85 MVA, Rating MVA[2] = 122.8 MVA	Gen 2 Equivalent Qty: 37 X = 7.125%, R = 0.712%, Winding MVA = 116.55 MVA, Rating MVA[2] = 116.6 MVA	Gen 1 Equivalent Qty: 39 X = 7.125%, R = 0.712%, Winding MVA = 122.85 MVA, Rating MVA[2] = 122.8 MVA	Gen 2 Equivalent Qty: 37 X = 7.125%, R = 0.712%, Winding MVA = 116.55 MVA, Rating MVA[2] = 116.6 MVA
Equivalent Collector Line[3]	R = 0.006504 pu X = 0.009359 pu B = 0.040359 pu	R = 0.005505 pu X = 0.008145 pu B = 0.034074 pu	R = 0.006504 pu X = 0.009359 pu B = 0.040359 pu	R = 0.005505 pu X = 0.008145 pu B = 0.034074 pu
Generator Dynamic Model[4] & Power Factor	39 x GE 2.82 MW (REGCA1)[4] Leading: 0.90 Lagging: 0.90	37 x GE 2.82 MW (REGCA1)[4] Leading: 0.90 Lagging: 0.90	39 x GE 2.82 MW (REGCA1)[4] Leading: 0.90 Lagging: 0.90	37 x GE 2.82 MW (REGCA1)[4] Leading: 0.90 Lagging: 0.90

1) X and R based on Winding MVA, 2) Rating rounded in PSS/E, 3) All pu are on 100 MVA Base 4) DYR stability model name

[1] GEN-2014-001 Modification Request Impact Study, December 19, 2022

SPP determined that steady-state analysis was not required because the modifications to the project were not significant enough to change the previously studied steady-state conclusions. In addition, an impedance comparison was performed to assess the impact of the modification request. SPP determined that the change in the equivalent impedance (3.38%) was not significant enough to impact the previously studied stability and short circuit results. Therefore, dynamic stability analysis and short circuit analysis were not required.

The scope of this modification request study included an impedance comparison and a reactive power analysis. Aneden performed the analyses using the modification request data and the DISIS-2017-002-1 2025 Summer Peak (25SP) study model.

All analyses were performed using the Siemens PTI PSS/E[2] version 34 software and the results are summarized below.

The results of the reactive power analysis using the 25SP model showed that the GEN-2014-001 project needed a 28.08 MVAr shunt reactor on the 34.5 kV bus of the project substation with the modifications in place, a decrease from the 28.3 MVAr found in the previous modification study[3]. 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 or no-wind conditions. The information gathered from the reactive power analysis is provided as information to the Interconnection Customer and Transmission Owner (TO) and/or Transmission Operator (TOP). The applicable reactive power requirements will be further reviewed by the TO and/or TOP.

Based on the results of the study, SPP determined that the requested modification is not a Material Modification. The requested modification does not have a material adverse impact on the cost or timing of any other Interconnection Request with a later Queue priority date. As the generating capacity of the Interconnection Request is a higher amount than its Interconnection Service, the customer must install monitoring and control equipment as needed to ensure that the amount of power injected at the POI does not exceed the Interconnection Service amount listed in its GIA.

In accordance with FERC Order No. 827, the generating facility will be required to provide dynamic reactive power within the range of 0.95 leading to 0.95 lagging at the high-side of the generator substation.

It is likely that the customer may be required to reduce its generation output to 0 MW in real-time, 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.

[2] Power System Simulator for Engineering
[3] GEN-2014-001 Modification Request Impact Study, December 19, 2022

1.0 Scope of Study

Aneden Consulting (Aneden) was retained by the Southwest Power Pool (SPP) to perform a Modification Request Impact Study (Study) for GEN-2014-001. A Modification Request Impact Study is a generation interconnection study performed to evaluate the impacts of modifying the DISIS study assumptions. The determination of the required scope of the study is dependent upon the specific modification requested and how it may impact the results of the DISIS study. Impacting the DISIS results could potentially affect the cost or timing of any Interconnection Request with a later Queue priority date, deeming the requested modification a Material Modification. The criteria sections below include reasoning as to why an analysis was either included or excluded from the scope of study.

All analyses were performed using the Siemens PTI PSS/E version 34 software. The results of each analysis are presented in the following sections.

1.1 Steady-State Analysis

Steady-state analysis is performed if SPP deems it necessary based on the nature of the requested change. SPP determined that steady-state analysis was not required because the modifications to the project were not significant enough to change the previously studied steady-state conclusions.

1.2 Stability Analysis, Short Circuit Analysis

To determine whether stability and short circuit analyses are required, SPP evaluates the difference between the turbine parameters and, if needed, the equivalent collector system impedance between the existing configuration and the requested modification. Dynamic stability analysis and short circuit analysis would be required if the differences listed above were determined to have a significant impact on the most recently performed DISIS stability analysis.

1.3 Reactive Power Analysis

SPP requires that a reactive power analysis be performed on the requested modification configuration as it is a non-synchronous resource. The reactive power analysis determines the capacitive effect at the POI caused by the project's collector system and transmission line's capacitance. A shunt reactor size is determined in order to offset the capacitive effect and maintain zero (0) MVAr flow at the POI while the project's generators and capacitors are offline.

1.4 Study Limitations

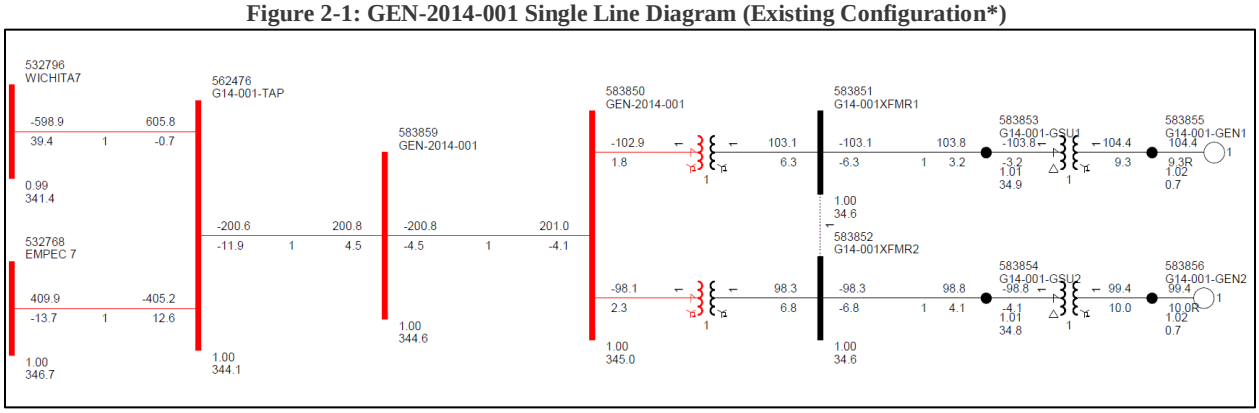
The assessments and conclusions provided in this report are based on assumptions and information provided to Aneden by others. While the assumptions and information provided may be appropriate for the purposes of this report, Aneden does not guarantee that those conditions assumed will occur. In addition, 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

The GEN-2014-001 Interconnection Customer has requested a modification to its Generation Interconnection Request (GIR) with a Point of Interconnection (POI) on the Emporia Energy Center to Wichita 345 kV line. At the time of report posting, GEN-2014-001 is an active Interconnection Request with a queue status of "IA FULLY EXECUTED/ON SCHEDULE." GEN-2014-001 is a wind farm with a maximum summer and winter queue capacity of 200.6 MW with Energy Resource Interconnection Service (ERIS).

The GEN-2014-001 project is currently in the DISIS-2014-001 cluster and interconnects in the Evergy Kansas Central (WERE) control area with a capacity of 200.6 MW. Figure 2-1 shows the power flow model single line diagram for the existing GEN-2014-001 configuration studied in the previous modification study completed in 2022[4]. Aneden updated the GEN-2014-001 project configuration in the base models based on SPP's confirmation of the latest project configuration.

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



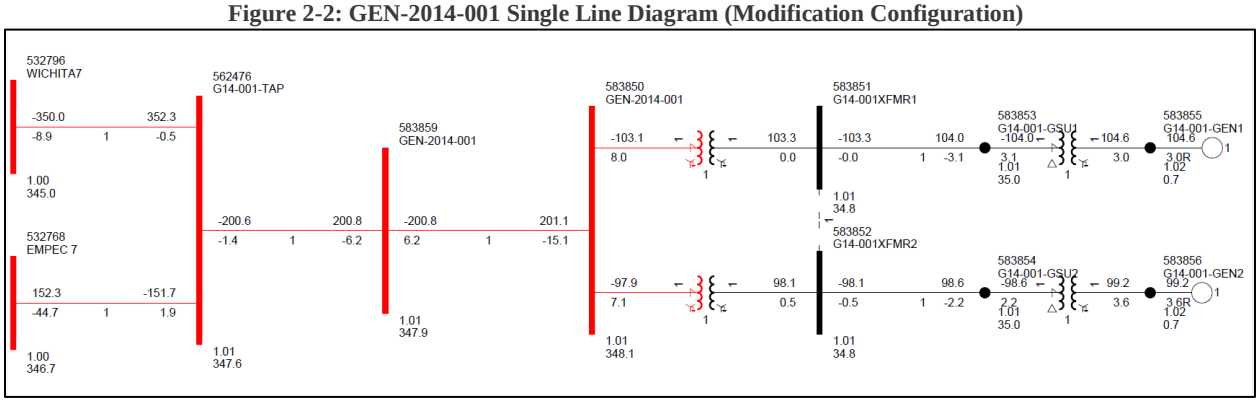
*based on the GEN-2014-001 configuration from the previous modification study[4]

This Study has been requested by the Interconnection Customer to evaluate the modification of GEN-2014-001 to replace one of the main power transformers but keep the existing turbine configuration of 76 x GE 2.82 MW for a total capacity of 214.32 MW. This generating capability for GEN-2014-001 (214.32 MW) exceeds its Generator Interconnection Agreement (GIA) Interconnection Service amount, 200.6 MW, as listed in Appendix A of the GIA. As a result, the customer must ensure that the amount of power injected at the POI does not exceed the Interconnection Service amount listed in its GIA. The project includes the use of a Power Plant Controller (PPC) to limit the total power injected into the POI.

In addition, the modification request included changes to the generation interconnection line rating. Figure 2-2 shows the power flow model single line diagram for the GEN-2014-001 modification. The existing and modified configurations for GEN-2014-001 are shown in Table 2-1.

[4] GEN-2014-001 Modification Request Impact Study, December 19, 2022

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



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1) X and R based on Winding MVA, 2) Rating rounded in PSS/E, 3) All pu are on 100 MVA Base 4) DYR stability model name

3.0 Existing vs Modification Comparison

To determine which analyses are required for the Study, the differences between the existing configuration and the requested modification were evaluated. Aneden performed this comparison and the resulting analyses using a set of modified study models developed based on the modification request data and the DISIS-2017-002-1 study models. The analysis was completed using PSS/E version 34 software.

The methodology and results of the comparisons are described below. Aneden updated the GEN-2014-001 project configuration in the base models based on SPP's confirmation of the latest project configuration studied in 2022.

3.1 Equivalent Impedance Comparison Calculation

The impedances of the transmission lines, main power transformers, equivalent collector line impedances, and generator step-up transformers were added in series for GEN-2014-001 before and after the modification request. The percentage increase in the impedances before and after the modification request were then compared. If the percentage change was greater than 10%, additional dynamic stability analysis and short circuit analysis would be performed to further assess the impact of the requested modification. Table 3-1 shows the impedance differences before and after the modification request. Table 3-2 shows the change in the equivalent impedance from the previously studied modification to the current modification request.

Table 3-1: GEN-2014-001 Impedance Comparison

System Component	Existing Model Impedances (based on previous modification) (p.u.)			Current Modification Request Impedances (p.u.)		
	R	***X***		***R***	***X***	
Gen Tie Line from POI to GEN-2014-001	0.00116	0.01084		0.00116	0.01084	
GEN-2014-001 Collector System Equivalent	0.00603	0.00878		0.00603	0.00878	
	R	***X***	***MVA Base***	***R***	***X***	***MVA Base***
GEN-2014-001 Equivalent Main Transformer @ 100 MVA	0.00160	0.04217	100	0.00088	0.03912	100
GEN-2014-001 Unit GSU @ 100 MVA Base	0.00298	0.02976	100	0.00298	0.02976	100
	R	***X***	***Z***	***R***	***X***	***Z***
Total Impedance from POI to Collector System	0.011769	0.091546	0.092299	0.011045	0.088494	0.089180

Table 3-2: GEN-2014-001 Equivalent Impedance Comparison Results

Interconnection Request	Existing Impedance Z (p.u.)	Current Modification Impedance Z (p.u.)	Impedance Z Absolute Difference %
GEN-2014-001 Impedance Increase	0.09230	0.08918	3.38%

SPP determined that the change in impedance (3.38%) was not significant enough to impact the previously studied stability and short circuit results. Therefore, dynamic stability analysis and short circuit analysis were not required.

3.2 Stability Model Parameters Comparison

As the turbine configuration did not change as a part of this modification study scope, a stability model parameters comparison was not needed for the determination of the scope of the study.

4.0 Reactive Power Analysis

The reactive power analysis was performed for GEN-2014-001 to determine the capacitive charging effects during reduced generation conditions (unsuitable wind speeds, unsuitable solar irradiance, insufficient state of charge, idle conditions, curtailment, etc.) at the generation site and to size shunt reactors that would reduce the project reactive power contribution to the POI to approximately zero.

4.1 Methodology and Criteria

The GEN-2014-001 generators were switched out of service while other system elements remained in-service. Shunt reactors were tested at the project's collection substation 34.5 kV buses to set the MVAr flow into the POI to approximately zero. The size of the shunt reactors is equivalent to the charging current value at unity voltage and the compensation provided is proportional to the voltage effects on the charging current (i.e., for voltages above unity, reactive compensation is greater than the size of the reactor).

Aneden performed the reactive power analysis using the modification request data based on the 25SP DISIS-2017-002-1 stability study model.

4.2 Results

The results from the analysis showed that the GEN-2014-001 project needed approximately 28.08 MVAr of compensation at its project substation to reduce the POI MVAr to zero. This is a decrease from the 28.3 MVAr found in the previous modification study[5]. Figure 4-1 illustrates the shunt reactor size needed to reduce the POI MVAr to approximately zero with the updated topology. The final shunt reactor requirements for GEN-2014-001 are shown in Table 4-1.

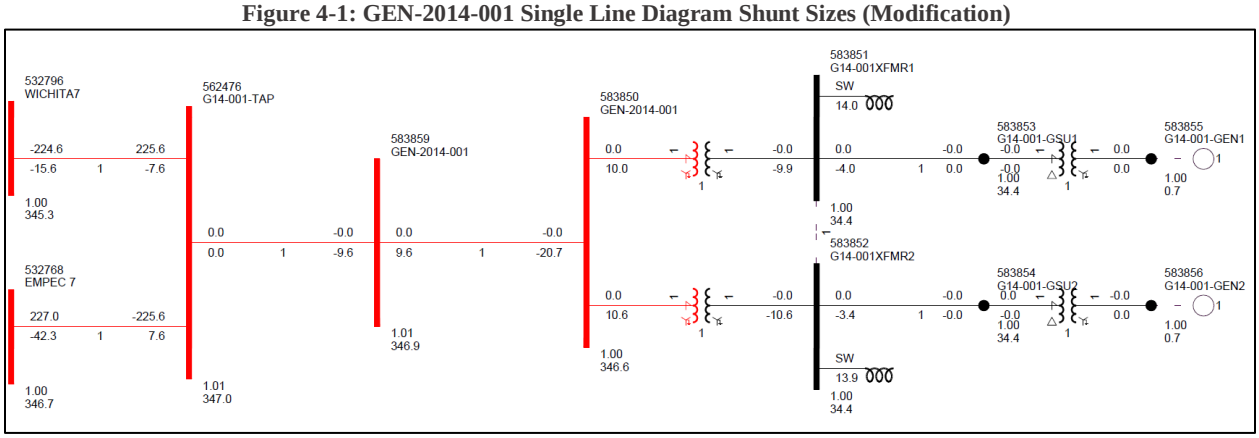
The information gathered from the reactive power analysis is provided as information to the Interconnection Customer and Transmission Owner (TO) and/or Transmission Operator (TOP). The applicable reactive power requirements will be further reviewed by the TO and/or TOP.

Table 4-1: Shunt Reactor Size for Reactive Power Study (Modification)

Machine	POI Bus Number	POI Bus Name	Reactor Size (MVAr)
			25SP
GEN-2014-001	562476	G14-001-TAP	28.08

[5] GEN-2014-001 Modification Request Impact Study, December 19, 2022

Figure 4-1: GEN-2014-001 Single Line Diagram Shunt Sizes (Modification)



5.0 Modified Capacity Exceeds GIA Capacity

Under FERC Order 845, Interconnection Customers are allowed to request Interconnection Service that is lower than the full generating capacity of their planned generating facilities. The Interconnection Customers must install acceptable control and protection devices that prevent the injection above their requested Interconnection Service amount measured at the POI.

As such, Interconnection Customers are allowed to increase the generating capacity of a generating facility without increasing its Interconnection Service amount stated in its GIA. This is allowable as long as they install the proper control and protection devices, and the requested modification is not determined to be a Material Modification.

The generating capacity of GEN-2014-001 (214.32 MW) exceeds its GIA Interconnection Service amount, 200.6 MW, as listed in Appendix A of the GIA.

The customer must install monitoring and control equipment as needed to ensure that the amount of power injected at the POI does not exceed the Interconnection Service amount listed in its GIA.

6.0 Material Modification Determination

In accordance with Attachment V of SPP's Open Access Transmission Tariff, for modifications other than those specifically permitted by Attachment V, SPP shall evaluate the proposed modifications prior to making them and inform the Interconnection Customer in writing of whether the modifications would constitute a Material Modification. Material Modification shall mean (1) modification to an Interconnection Request in the queue that has a material adverse impact on the cost or timing of any other Interconnection Request with a later Queue priority date; or (2) planned modification to an Existing Generating Facility that is undergoing evaluation for a Generating Facility Modification or Generating Facility Replacement, and has a material adverse impact on the Transmission System with respect to: i) steady-state thermal or voltage limits, ii) dynamic system stability and response, or iii) short-circuit capability limit; compared to the impacts of the Existing Generating Facility prior to the modification or replacement.

6.1 Results

SPP determined the requested modification is not a Material Modification based on the results of this Modification Request Impact Study performed by Aneden. Aneden evaluated the impact of the requested modification on the prior study results. Aneden determined that the requested modifications were not significant enough to change the previously studied steady-state, dynamic stability, and short circuit conclusions.

This determination implies that any network upgrades already required by GEN-2014-001 would not be negatively impacted and that no new upgrades are required due to the requested modification, thus not resulting in a material adverse impact on the cost or timing of any other Interconnection Request with a later Queue priority date.