

GEN-2015-005
Impact Restudy for
Generator Modification
(Turbine Change)

December 2016
Generator Interconnection



Revision History

Date	Author	Change Description
12/14/2016	SPP	GEN-2015-005 Impact Restudy for Generator Modification (Turbine Change) issued.

Executive Summary

The Interconnection Customer for GEN-2015-005 has requested a wind turbine generator modification to its Generator Interconnection Request. GEN-2015-005 was previously studied in DISIS-2015-001 Group 13¹ with ninety-two (92) GE 2.0MW wind turbine generators and nine (9) GE 1.79MW wind turbines (aggregate power of 200.1MW). In this modification study the interconnection customer has requested to study GEN-2015-005 with eighty (80) GE 2.1MW wind turbine generators, eight (8) GE 2.0MW wind turbine generators, and nine (9) GE 1.79MW wind turbine generators (aggregate power of 200.1MW).

The Interconnection Customer provided a PSSE raw data file that incorporated the modifications for GEN-2015-005. The point of interconnection (POI) remains unchanged and is a tap on the Nebraska City to Sibley 345kV line.

The proposed new wind turbine generator, the GE 2.1MW, is electrically equivalent to the GE 2.0MW being replaced, and the dynamic characteristics are essentially the same. The project topology changed due to fewer wind turbines needed to maintain the original (or near original) nameplate power output of the project. This study analyzed the change in system impedance between the original project and the modified project and found it to be 3.11%. This change is considered insignificant, and, therefore, the modified project will have a dynamic performance similar to the original study. The requested change is not a material modification. The results of the DISIS-2015-001 Group 13 Impact Study, except for the results of the reactor analysis, are still valid for GEN-2015-005 with the wind turbine modification requested by the interconnection customer.

A low-wind/no-wind condition analysis was performed for this modification request. GEN-2015-005 will be required to install approximately 24.3 Mvars of shunt reactors on its substation 34.5kV bus. 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. In the DISIS-2015-001 Group 13 Impact Study the reactor was determined to be 8.5Mvars. The increase in reactor requirement is mainly due to the change in the collector system charging. The Interconnection Customer may utilize the G.E. "WindFREE" option to meet this requirement.

With the assumptions outlined in this report and with all required network upgrades in place, GEN-2015-005 with eighty (80) GE 2.1MW wind turbine generators, eight (8) GE 2.0MW wind turbine generators, and nine (9) GE 1.79MW wind turbine generators (aggregate power of 200.1MW) should be able to reliably interconnect to the SPP transmission grid.

¹ See "DISIS-2015-001 Definitive Impact Study (Group 13)" final report produced by Power-tek Global Inc., dated July 2015. The report is found in "Appendix T: Group 13 Dynamic Stability Analysis Report" in the SPP DISIS-2015-001 study posted in August 2015.

Nothing in this study should be construed as a guarantee of transmission service. If the Customer wishes to obtain deliverability to a specific customer, a separate request for transmission service shall be requested on Southwest Power Pool's OASIS.

Table of Contents

Revision History	i
Executive Summary.....	ii
Table of Contents.....	iv
1. Introduction	1
2. Facilities	2
Generating Facility	2
3. Modification Evaluation	3
4. Stability Analysis.....	3
5. Power Factor Analysis	4
Results	4
6. Reduced Generation Analysis.....	4
Results	4
7. Short Circuit Analysis	6
Results	6
8. Conclusion	6

1. Introduction

The Interconnection Customer for GEN-2015-005 has requested a change in wind turbine generators. Table 1-1 shows the interconnection requests as originally studied in DISIS-2015-001 Group 13. Table 1-2 shows the requested wind turbine modification.

Table 1-1: Interconnection Request (Original Study)

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2015-05	200.1	92 x GE 2.0MW and 9 x GE 1.79MW	Tap on Nebraska City to Sibley 345kV line

Table 1-2: Interconnection Request (Modification)

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2015-005	200.1	80 x GE 2.1MW, 8 x GE 2.0MW, and 9 x GE 1.79MW	Tap on Nebraska City to Sibley 345kV line

The proposed new wind turbine generator, GE 2.1MW, is electrically equivalent to the GE 2.0MW being replaced, and the dynamic characteristics are essentially the same. The topology of the project must change in order to accommodate the reduced number of wind turbine generators necessary to maintain the original (or near original) power output of the project. The change in topology was analyzed.

The low-wind/no-wind analysis determines the capacitive effect at the POI caused by the project’s collector system and transmission line. A shunt reactor size was determined to offset the capacitive effect and to maintain approximately zero Mvar flow at the POI when the plant generators and capacitors are off-line such as might be seen in low-wind or no-wind conditions.

Nothing in this study constitutes a request for transmission service or grants the Interconnection Customer any rights to transmission service.

2. Facilities

Generating Facility

The point of interconnection (POI) for the GEN-2015-005 interconnection requests is a tap on the Nebraska City to Sibley 345 line. The interconnection requests as originally studied are shown in Figure 2-1.

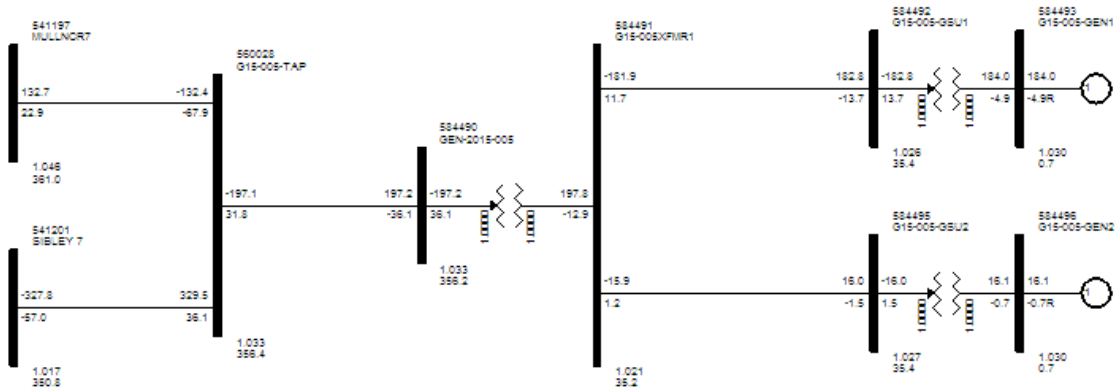


Figure 2-1: Power Flow Model and POI for GEN-2015-005 as originally studied in DISIS-2015-001

The Interconnection Customer provided a PSEE raw data file that contained the modified request. An equivalent power flow model was developed from the PSEE raw data and is shown in Figure 2-2.

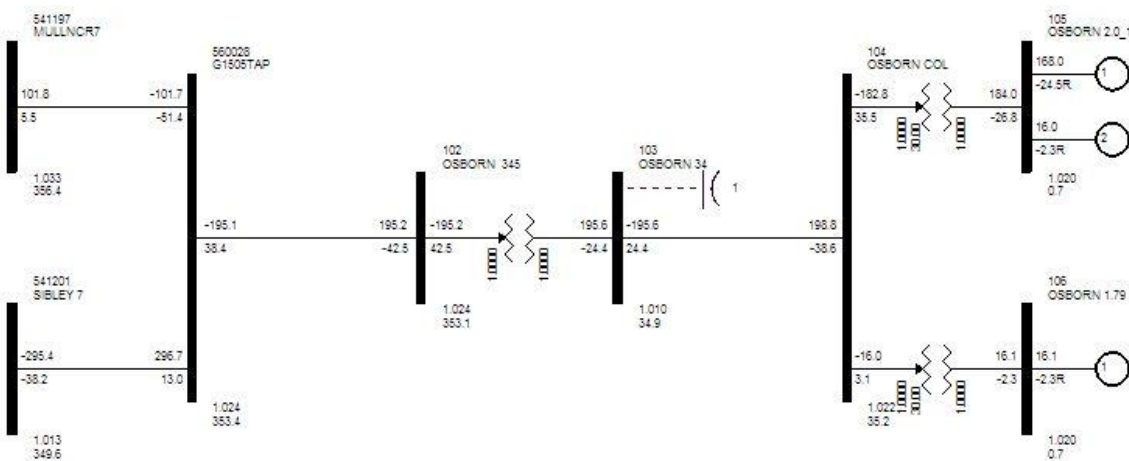


Figure 2-2: Power Flow Model and POI for the Modified GEN-2015-005 request

3. Modification Evaluation

The electrical characteristics and the dynamic response of the GE 2.0MW and the GE 2.1MW wind turbine generators are nearly identical. The circuit topology for the project changed due to the reduction in wind turbines required to retain the original (or near original) nameplate power of 200.1MW. The change in topology was analyzed to determine how much the system impedance changed from the original topology to the modified topology. This was done by using the ASCC feature of PSSE to determine the Thevenin equivalent impedances for the original and the modified topologies.

The Sibley and Mullen Creek (to Nebraska City) 345kV lines were disconnected from the POI. The POI was used as the “home” bus for the PSSE ASCC function. A Thevenin impedance was obtained. The generator Zsource was subtracted from the Thevenin impedance. The resultant Thevenin impedance is due to:

- The 6 mile transmission line from the POI to GEN-2015-005,
- The substation transformer,
- The equivalent collector system,
- The generator step up units.

The equivalent impedances are as follows:

$$Z_{th}(\text{original}) = 0.008042 + j 0.092429 \text{ PU}$$

$$Z_{th}(\text{modified}) = 0.0012995 + 0.089556 \text{ PU}$$

The percent change D is as follows (only the magnitudes of the impedances were used in the following calculation):

$$D = [Z_{th}(\text{original}) - Z_{th}(\text{modified})] / Z_{th}(\text{original}) * 100 \%$$

$$D = [0.092429 - 0.089646] / 0.092429 * 100$$

$$D = 3.11\% \text{ decrease}$$

The change in impedance is a 3.11% decrease, and the modification will have minimal impact on the stability results shown in the DISIS-2015-001-1 Group 13 study. The requested change is not a material modification.

4. Stability Analysis

Since the change in impedance is a 3.11% decrease, the modification will have minimal impact on the stability results in DISIS-2015-001 Group 13 study. It is not necessary to perform another

stability analysis for this modification request. The results of the stability analysis for GEN-2015-005 referenced in Appendix T for Group 13 in the original posting of DISIS-2015-001 are still valid.

5. Power Factor Analysis

Results

Refer to Appendix T for Group 13 in the original posting of DISIS-2015-001 for the power factor analysis.

6. Reduced Generation Analysis

Interconnection requests for wind generation projects that interconnect on the SPP system are analyzed for the capacitive charging effects during reduced generation conditions (unsuitable wind speeds, curtailment, etc.) at the generation site.

Results

Shunt reactor requirements for the interconnection requests are shown below in Table 6-1.

Table 6-1: Summary of Shunt Reactor Requirements

Request	Capacity	POI	Approximate Shunt Reactor Required
GEN-2015-005	200.1MW	Tap Nebraska City to Sibley 345kV	24.3Mvar

Figure 6-1 shows the capacitive effect that GEN-2015-005 has on the POI when the generators are offline and the rest of the facilities remain online. The capacitive effect is due to the charging of the collector system and the charging on the transmission lead to the POI.

To offset the reactive injection at the POI during reduced generation conditions reactors (or other reactive means such as the “WindFree” option available on GE wind turbine generators) will be needed at the generation facility. For GEN-2015-05 the reactor required is approximately 24.3Mvar (19.3Mvar from the collector system + 5.0Mvar from the generator lead to the POI). Figure 6-2 shows the result of placing a 24.3Mvar reactor at the low side bus of the 34.5/345kV transformer in GEN-2015-005.

Note that the reactor requirement has increased significantly from the previous study of GEN-2015-005. The updated collector system increased the reactor requirement approximately 16 Mvars.

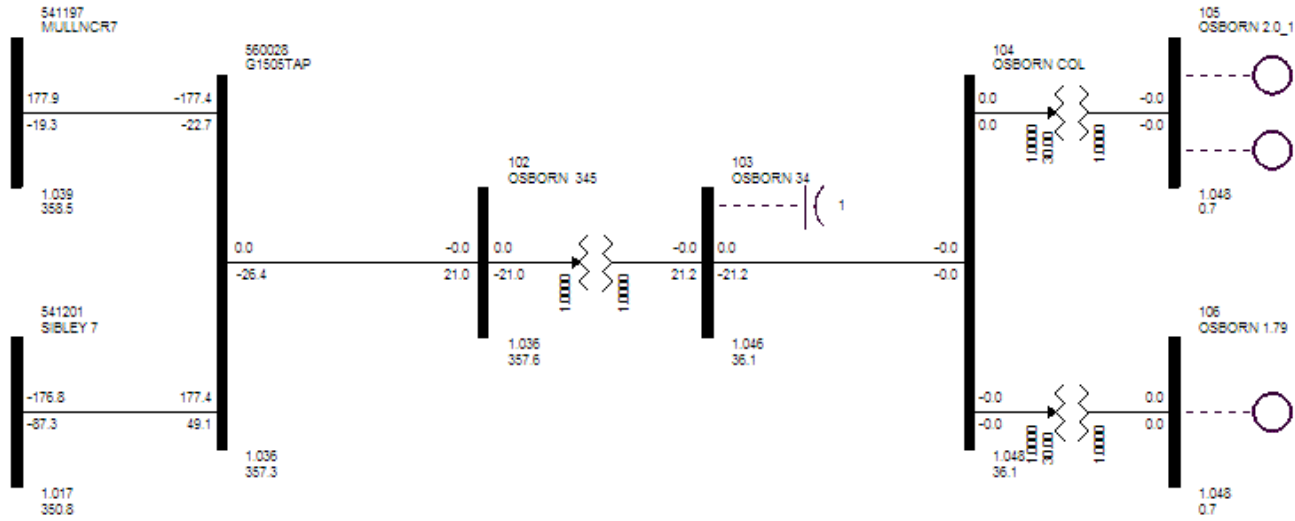


Figure 6-1: GEN-2015-005 with generators off and no shunt reactors

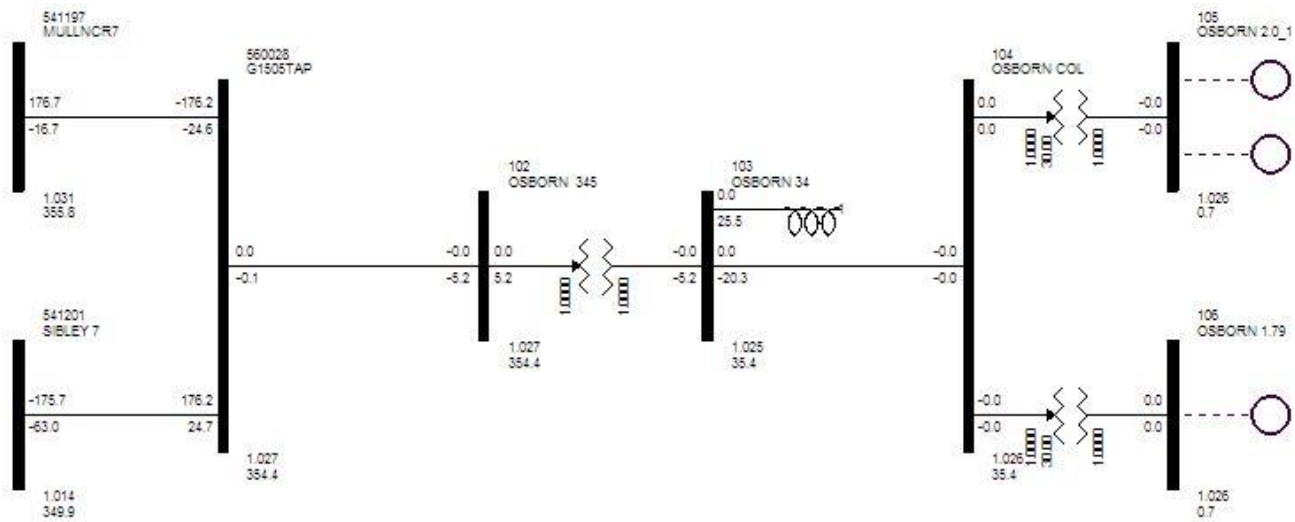


Figure 6-2: GEN-2015-005 with generators off and with shunt reactor

7. Short Circuit Analysis

Results

Refer to Appendix T for Group 13 in the original posting of DISIS-2015-001.

8. Conclusion

The Interconnection Customer for GEN-2015-005 has requested a modification to its Interconnection Request to use the wind turbine generators as shown in Table 8-1.

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2015-005	200.1	80 x GE 2.1MW, 8 x GE 2.0MW, and 9 x GE 1.79MW	Tap on Nebraska City to Sibley 345kV line

Table 8-1: Interconnection Request

The analysis has shown that the requested wind turbine modification to GEN-2015-005 does not constitute a material modification. With exception of the reactor requirements the results of the DISIS-2015-001 Group 13 study are still valid for the requested wind turbine modification.

A low-wind/no-wind condition analysis was performed for this wind turbine modification request. GEN-2015-005 will be required to install approximately 24.3 Mvars of shunt reactors on its substation 34.5kV bus(es). This is necessary to offset the capacitive effect on the transmission network caused by the project’s transmission line to the POI and the collector system during low-wind/no-wind conditions. The Interconnection Customer may utilize the G.E. “WindFREE” option to meet this requirement.

Any changes to the assumptions made in this study, for example, one or more of the previously queued requests withdraw, may require a re-study at the expense of the Customer.

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.