

GEN-2011-025
Impact Restudy for
Generator Modification
(Turbine Change)

March 2018
Generator Interconnection



Revision History

Date	Author	Change Description
03/21/2018	SPP	First draft

Executive Summary

The Interconnection Customer for GEN-2011-025 has requested wind turbine generator modifications to its Generator Interconnection Agreement. The requested change is from forty-four (44) GE 1.79MW wind turbine generators (aggregate power of 78.76MW) to four (4) GE 1.715MW wind turbine generators, one (1) GE 2.0MW wind turbine generator, one (1) GE 2.1MW wind turbine generator and thirty (30) GE 2.3MW wind turbine generators (aggregate power of 79.96MW). GEN-2011-025 was initially studied in DISIS-2011-001 Group 6 with Fifty (50) G.E. 1.6 MW wind turbine generators (aggregate power of 80.0 MW).

The point of interconnection (POI) remains unchanged and is at a new Southwestern Public Service Company (SPS) 115kV switching station on the Crosby to Floyd County 115kV transmission line.

The proposed new wind turbine generators, GE 1.715MW, GE 2.0MW, GE 2.1MW and GE 2.3MW, are electrically equivalent to the GE 1.79MW being replaced, and the dynamic characteristics are essentially the same. The topology of the project has changed in order to accommodate the reduction in quantity of wind turbine generators to be used in the project. This study analyzed the change in system impedance between the original project and the modified project and found it to be an 8.5% increase, and, therefore, the modified project will have a steady state and dynamic performance similar to the original study. The results of the previous generator modification study of GEN-2011-025¹, except for the results of the reactor analysis, are still valid for GEN-2011-025.

Power factor requirements for GEN-2011-025 can be found in the previous system impact study and are still valid for this change request. The facility will be required to maintain a 95% lagging (providing VARs) and 95% leading (absorbing VARs) power factor at the POI.

A low-wind/no-wind condition analysis was performed for this modification request. GEN-2011-025 will be required to install approximately 4 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 projects' transmission line and collector system during low-wind/no-wind conditions. 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-2011-025 with the GE 1.715MW, GE 2.0MW, GE 2.1MW and GE 2.3MW wind turbine generators should be able to reliably interconnect to the SPP transmission grid.

¹ See *GEN-2011-025 Impact Restudy for Generator Modification (Turbine Change)* posted 4/8/2015, which may be accessed through the following link:
http://spppoasis.spp.org/documents/swpp/transmission/studies/files/2011_Generation_Studies/GEN-2011-025%20Impact%20Restudy%20GE1.79MW.pdf

The results of this study show that the requested generator turbine modification does not constitute a Material Modification.

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.

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1. Introduction

The Interconnection Customer for GEN-2011-025 has requested a change in wind turbine generators. Table 1-1 shows the interconnection request as studied in the previous generator modification request. Table 1-2 shows the requested wind turbine modification for the project.

Table 1-1: Interconnection Request (Previous Study)

Capacity (MW)	Generator Model	Point of Interconnection
78.76 (original GIA = 80MW)	44 x GE 1.79MW	Tap on Floyd County - Crosby 115kV line

Table 1-2: Interconnection Request (Modification)

Capacity (MW)	Generator Model	Point of Interconnection
79.96	4 x GE 1.715MW, 1 x GE 2.0MW, 1 x GE 2.1MW, and 30 x GE 2.3MW	Tap on Floyd County - Crosby 115kV line

The proposed new wind turbine generators, GE 1.715MW, GE 2.0MW, GE 2.1MW and GE 2.3MW, are electrically equivalent to the GE 1.79MW being replaced, and the dynamic characteristics are essentially the same. The total number of wind turbines is reduced which required a change in topology.

The low-wind/no-wind analysis determines the capacitive effect at the POI caused by the project’s collector system and transmission line capacitance. 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-2011-025 is a new tap on the Floyd County - Crosby 115kV line. The interconnection request as previously studied is shown in Figure 2-1.

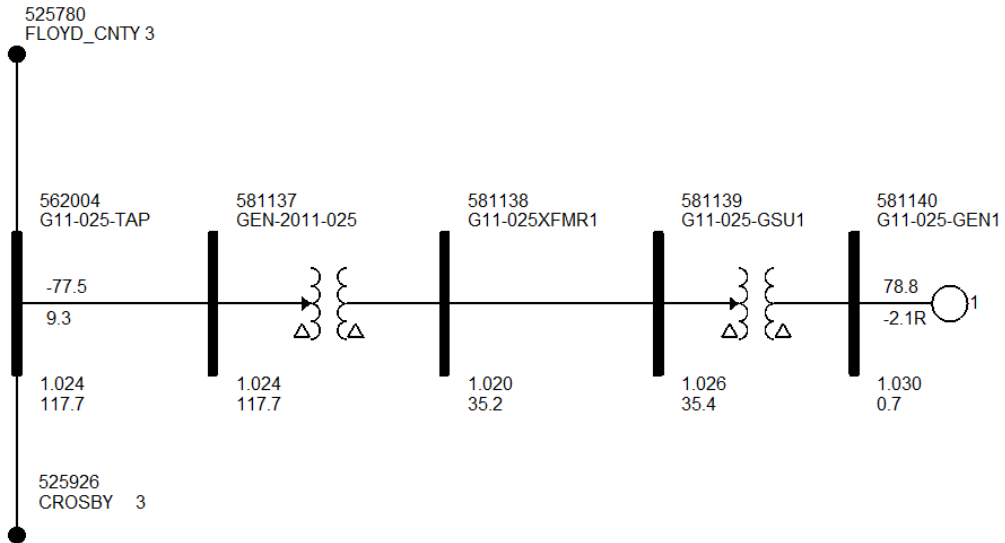


Figure 2-1: Power Flow Model and POI for GEN-2011-025 as previously studied

An updated equivalent power flow model was developed from the data provided by the interconnection customer and is shown in Figure 2-2.

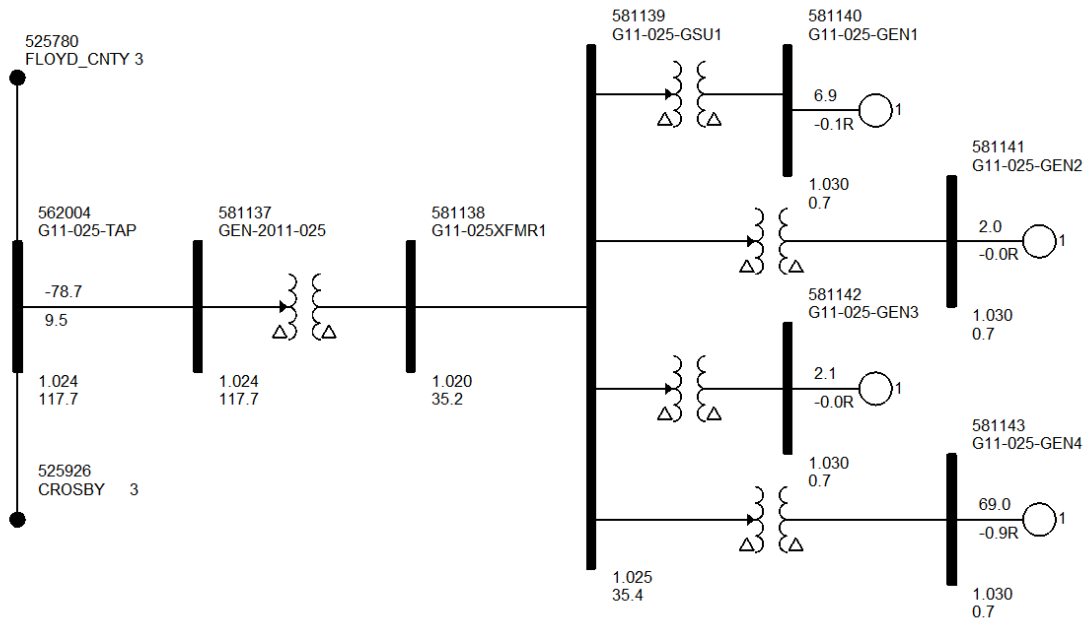


Figure 2-2: Power Flow Model and POI for the Modified GEN-2011-025

3. Modification Evaluation

The electrical characteristics and the dynamic response of the GE 1.715MW, GE 2.0MW, GE 2.1MW, GE 2.3MW, and the GE 1.79MW wind turbine generators are nearly identical. The change in topology due to the reduced number of wind turbines was analyzed to determine how much the system impedance changed from the previous topology to the modified topology. This was done by using the ASCC (Automatic Sequence Fault Calculation) feature of PSSE to determine the Thevenin equivalent impedances for the previous and the modified topologies.

The Customer's facilities collection station (shown as bus number 562004 in Figures 2-1 and 2-2) was disconnected from the Floyd – Crosby 115kV line and then used as the "home" bus for the PSSE ASCC function. The Thevenin impedance was obtained before and after the modification. The generator Z_{source} was subtracted from the Thevenin impedance since it is the same as for all three of the GE wind turbines. The resultant Thevenin impedance is due to:

- The short transmission line from GEN-2011-025 substation to the Interconnection Customer's facilities collection station,
- The substation transformer(s),
- The equivalent collector system,
- The generator step up units.

Note that all other elements not related to GEN-2011-025 were disconnected to remove their effects in determining the equivalent impedances.

The equivalent impedances are as follows:

$$Z_{TH}(\text{previous}) = 160.7 \angle 88.93^\circ \text{ Ohms}$$
$$Z_{TH}(\text{modified}) = 174.4 \angle 88.98^\circ \text{ Ohms}$$

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

$$D = [Z_{TH}(\text{modified}) - Z_{TH}(\text{previous})] / Z_{TH}(\text{previous}) * 100 \%$$
$$D = [174.4 - 160.7] / 160.7 * 100$$
$$D = 8.5 \% \text{ increase}$$

The change in impedance is an 8.5 % increase, and the modification will have minimal impact on the results in the previous restudy.

4. Stability Analysis

A stability analysis for this modification request was not performed. The results from the previous study are still valid

5. Power Factor Analysis

A power factor analysis for this modification request was not performed. Power factor requirements for GEN-2011-025 can be found in the previous system impact study and are still valid for this change request. The facility will be required to maintain a 95% lagging (providing VARs) and 95% leading (absorbing VARs) power factor at the POI.

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 and the generation facility still connected to the grid.

Results

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

Table 6-1: Summary of Shunt Reactor Requirements

Capacity	POI	Approximate Shunt Reactor Required
79.96	Tap on Floyd County - Crosby 115kV line	4 Mvar

Figure 6-1 shows the capacitive effect that GEN-2011-025 has on the POI when the generators are offline and the rest of the facility remains online. The capacitive effect is primarily due to the charging of the collector system and the charging on the transmission lead to the Interconnection Customer's facilities collection station.

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 wind farm project. For GEN-2011-025 the reactor required is approximately 4 Mvar as shown in Figure 6-2.

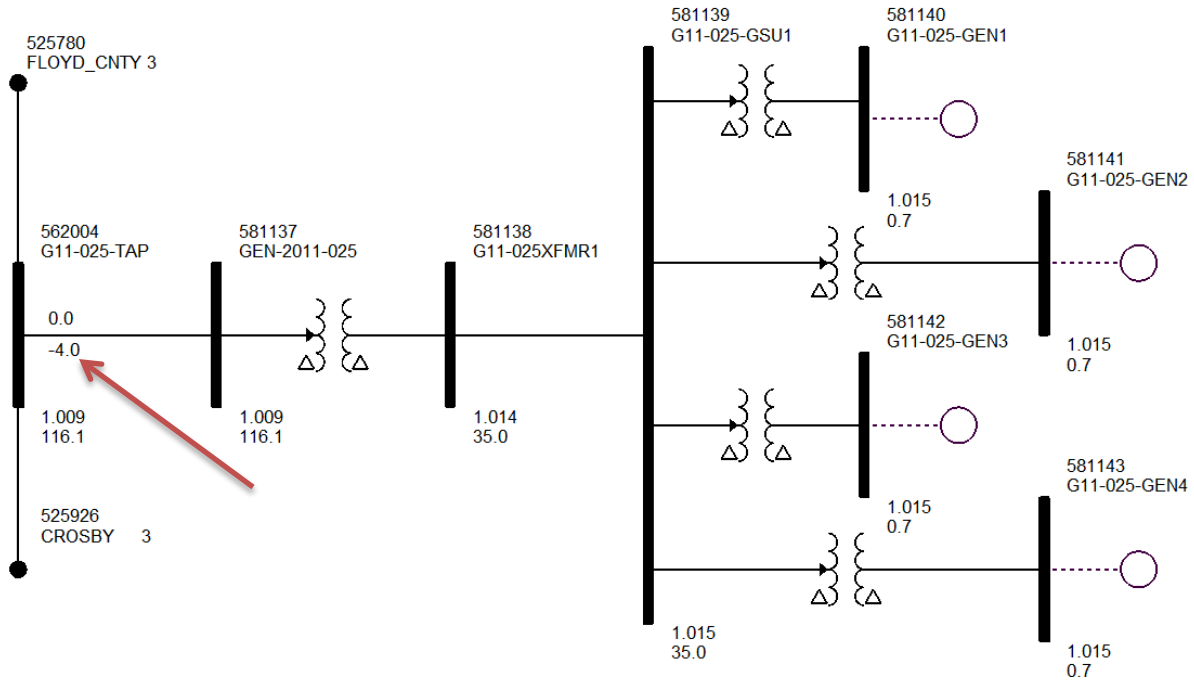


Figure 6-1: GEN-2011-025 with generators off and no shunt reactors

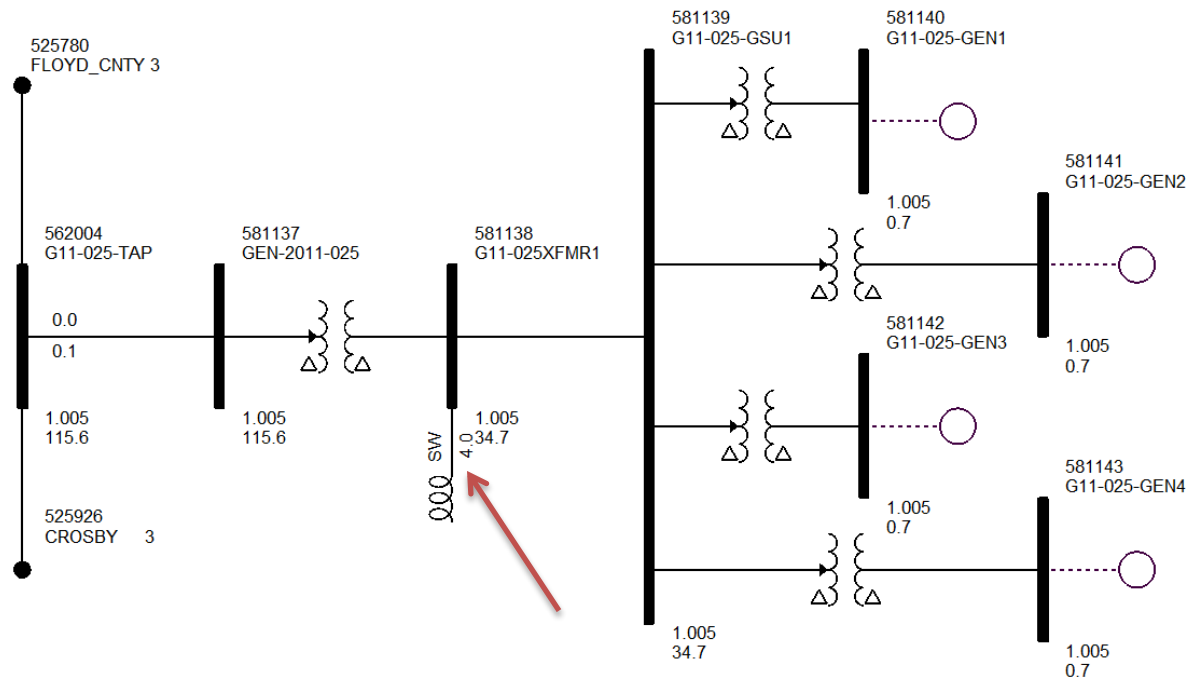


Figure 6-2: GEN-2011-025 with generators off and with shunt reactor

7. Short Circuit Analysis

A short circuit analysis for this modification request was not performed. The results from the previous study are still valid.

8. Conclusion

The Interconnection Customer for GEN-2011-025 has requested a modification to its Generator Interconnection Agreement to change wind turbine generators from GE 1.79MW to a combination of GE 1.715MW, GE 2.0MW, GE 2.1MW and GE 2.3MW as shown in Table 1-2.

With the exception of the reactor requirement the results of the previous study for generator modification are still valid for GEN-2011-025 as modified with GE 1.715MW, GE 2.0MW, GE 2.1MW and GE 2.3MW wind turbine generators.

The facility will be required to maintain a 95% lagging (providing VARs) and 95% leading (absorbing VARs) power factor at the POI.

A low-wind/no-wind condition analysis was performed for this wind turbine modification request. GEN-2011-025 will be required to install approximately 4 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 projects' transmission line and collector system during low-wind/no-wind conditions. The Interconnection Customer may utilize the G.E. "WindFREE" option to meet this requirement.

The results of this study show that the requested generator turbine modification does not constitute a Material Modification.

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.