GEN-2015-024 and GEN-2015-025 Impact Restudy for Generator Modification (Turbine Change)

June 2016
Generator Interconnection

SPP Southwest Power Pool

Revision History

Date	Author	Change Description
06/22/2016	SPP	GEN-2015-024 and GEN-2015-025 Impact Restudy for Generator Modification (Turbine Change) issued.

Executive Summary

The Interconnection Customer(s) for both GEN-2015-024 and GEN-2015-025 has requested wind turbine generator modifications to its Generator Interconnection Requests. GEN-2015-024 is to be changed from one hundred ten (110) GE 2.0MW wind turbine generators (aggregate power of 220.0MW) to one hundred twenty-one (121) GE 1.8MW wind turbine generators (aggregate power of 217.8MW). GEN-2015-025 is to be changed from one hundred ten (110) GE 2.0MW wind turbine generators (aggregate power of 220.0MW) to a combination of one hundred fifteen (115) GE 1.8MW wind turbine generators and five (5) GE 1.79MW wind turbine generators (aggregate power of 215.95MW).

The Interconnection Customer provided a PSSE raw data file that incorporated the modifications for both GEN-2015-024 and GEN-2015-025. The point of interconnection (POI) remains unchanged and is a tap on the Wichita to Thistle 345kV line circuits one and two.

The proposed new wind turbine generators, GE 1.8MW and GE 1.79MW, are electrically equivalent to the GE 2.0MW being replaced, and the dynamic characteristics are essentially the same. Since the maximum power of the replacement wind turbines are less than the GE 2.0MW wind turbines, the topology of each project must change in order to accommodate the additional wind turbine generators necessary to maintain the original (or near original) nameplate power output of each project. This study analyzed the change in system impedance between the original projects and the modified projects and found it to be 1.0%, and, therefore, the modified projects will have a dynamic performance similar to the original study. The requested changes are not a material modification. The results of the DISIS-2015-001-1 Group 8 Impact Study, except for the results of the reactor analysis, are still valid for both GEN-2015-024 and GEN-2015-025.

A low-wind/no-wind condition analysis was performed for this modification request. GEN-2015-024 will be required to install approximately 46 Mvars of shunt reactors on its substation 34.5kV bus(es). GEN-2015-025 will be required to install approximately 40 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 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-2015-024 with GE 1.8MW wind turbine generators and GEN-2015-025 with the GE 1.8MW and GE 1.79MW wind turbine generators should be able to reliably interconnect to the SPP transmission grid.

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

1. Introduction

The Interconnection Customer(s) for both GEN-2015-024 and GEN-2015-025 has requested a change in wind turbine generators. Table 1-1 shows the interconnection requests as originally studied in DISIS-2015-001-1 Group 8. Table 1-2 shows the requested wind turbine modification for each project.

Table 1-1: Interconnection Request (Original Study)

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2015-024	220.0	110 x GE 2.0MW	Tap Wichita to Thistle 345kV ckts 1 and 2
GEN-2015-025	220.0	110 x GE 2.0MW	Tap Wichita to Thistle 345kV ckts 1 and 2

Table 1-2: Interconnection Request (Modification)

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2015-024	217.8	121 x GE 1.8MW	Tap Wichita to Thistle 345kV ckts 1 and 2
GEN-2015-025	215.95	115 x GE 1.8MW and 5 x GE 1.79MW	Tap Wichita to Thistle 345kV ckts 1 and 2

The proposed new wind turbine generators, GE 1.8MW and GE 1.79MW, are electrically equivalent to the GE 2.0MW being replaced, and the dynamic characteristics are essentially the same. Since the maximum power of the replacement wind turbines are less than the GE 2.0MW wind turbines, the topology of each project must change in order to accommodate the additional wind turbine generators necessary to maintain the original (or near original) power output of each project. The change in topology was analyzed, and it was determined that this is not a material modification.

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-2015-024 and GEN-2015-025 interconnection requests is a tap on the Wichita to Thistle 345 line, circuits 1 and 2. The interconnection requests as originally studied are shown in Figure 2-1.

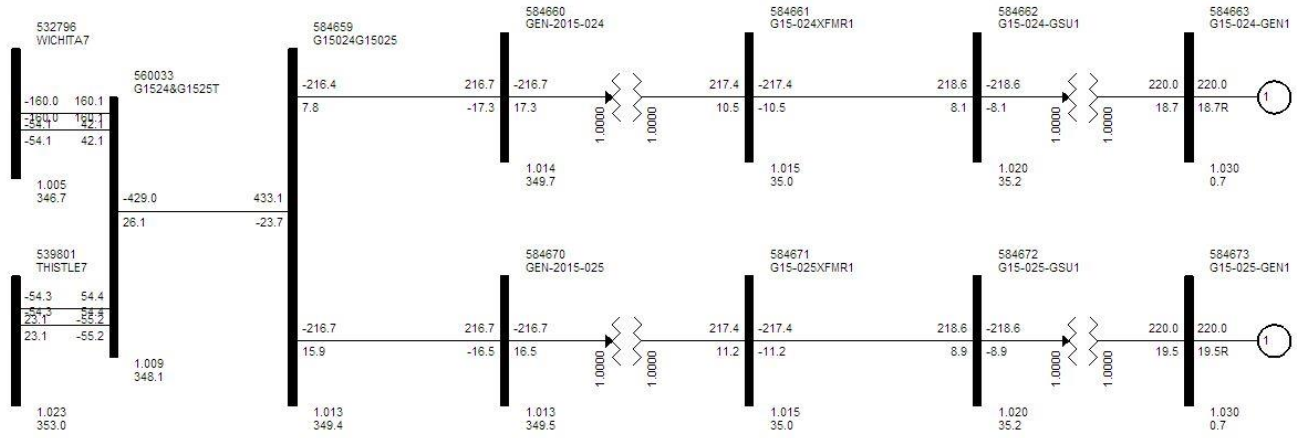

Figure 2-1: Power Flow Model and POI for GEN-2015-024 and GEN-2015-025 as originally studied

The Interconnection Customer provided a PSSE raw data file that contained the modified requests. The resulting power flow model included all the wind turbine generators (a total of 241 wind turbines), generator step up units, and interconnecting branches that comprised both interconnection requests. An equivalent power flow model was developed from the PSSE raw data and is shown in Figure 2-2.

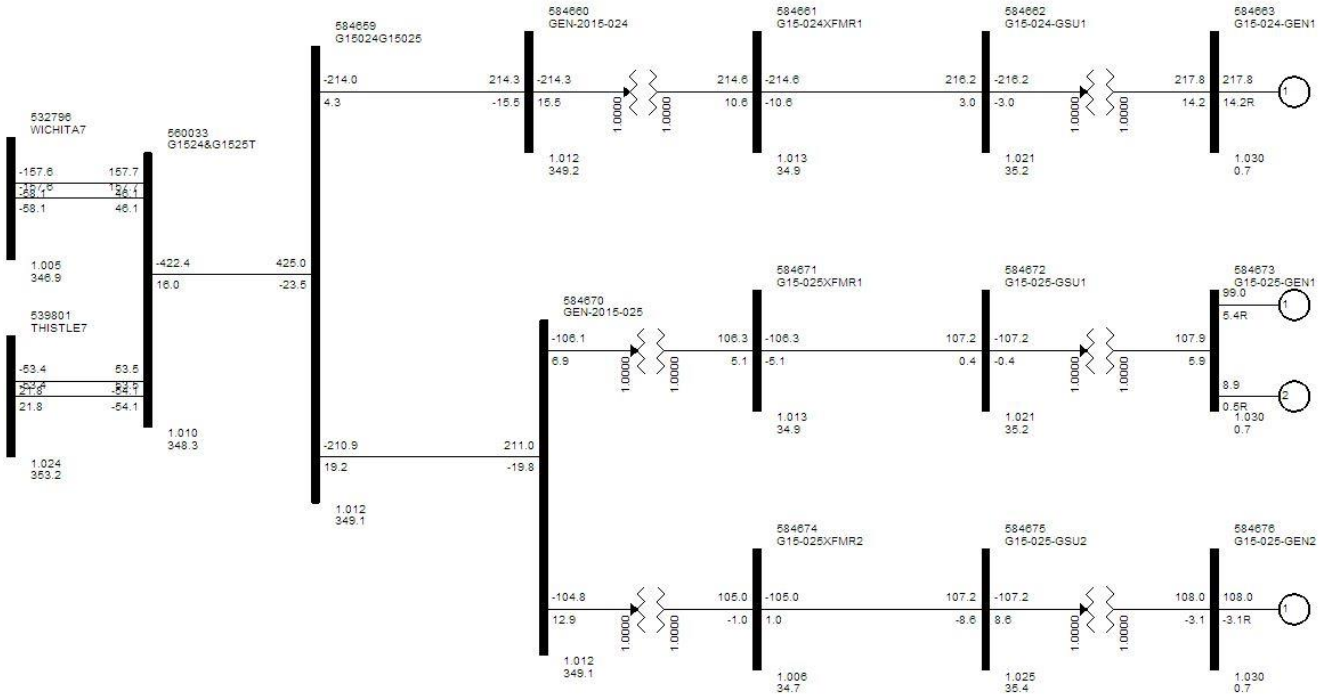

Figure 2-2: Power Flow Model and POI for the Modified GEN-2015-024 and GEN-2015-025 requests

3. Modification Evaluation

The Interconnection Customer supplied a PSSE raw data file that provided the model for both GEN-2015-024 and GEN-2015-025. All the GE wind turbines, associated generator step units and interconnections were explicitly modeled in GEN-2015-024 (121 wind turbines) and GEN-2015-024 (120 wind turbines). An equivalent model for each request was made as shown in Figure 2-2.

The electrical characteristics and the dynamic response of the GE 1.79MW, the GE 1.8MW, and the GE 2.0MW wind turbine generators are nearly identical. The circuit topology for each project changed due to the additional wind turbines required in order to retain the original (or near original) nameplate power of 220MW of each request. 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 methodology used includes both projects. The Wichita and Thistle 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 shared 45 mile transmission line from the POI to GEN-2015-025,
- The 15 mile transmission line from GEN-2015-025 to GEN-2015-024,
- The substation transformers of both projects,
- The equivalent collector systems of both projects,
- The generator step up units of both projects

The equivalent impedances are as follows:

Zth(original) = 0.005967 + j 0.06723 PU
Zth(modified) = 0.006390 + 0.06787 PU

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

D = [Zth(original) – Zth(modified)] / Zth(original) * 100 %
D = [0.06749-0.06817] / 0.06749] * 100
D = 1.00 % increase

Since the change in impedance is a 1.0 % increase, the modification will have minimal impact on the stability results in DISIS-2015-001-1 Group 8 study. It is not necessary to perform another stability analysis for this modification request.

4. Stability Analysis

Since the change in impedance is a 1.0 % increase, the modification will have minimal impact on the stability results in DISIS-2015-001-1 Group 8 study. It is not necessary to perform another stability analysis for this modification request. The results of the stability analysis for GEN-2015-024 and GEN-2015-025 referenced in Appendix K for Group 8 in the original posting of DISIS-2015-001-1 are still valid.

5. Power Factor Analysis

Results

Refer to Appendix K for Group 8 in the original posting of DISIS-2015-001-1.

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 5-1.

Table 6-1: Summary of Shunt Reactor Requirements

Request	Capacity	POI	Approximate Shunt Reactor Required
GEN-2015-024	217.8MW	Tap Wichita to Thistle 345kV ckts 1 and 2	46Mvar
GEN-2015-025	215.95MW	Tap Wichita to Thistle 345kV ckts 1 and 2	40Mvar

Figure 5-1 shows the capacitive effect that GEN-2015-024 and GEN-2015-025 have on the POI when the generators are offline and the rest of the facilities remain online. The capacitive effect (shown in the rectangle boxes in Figure 5-1) is due to the charging of the collector systems of each project, the charging on the transmission leads in the projects, and the charging on the shared 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 wind farm projects. For GEN-2015-024 the reactor required is 45.8Mvar (10.2Mvar + 13.8Mvar + ½ of 43.6Mvar). For GEN-2015-025 the reactor required is 39.5Mvar (5.9Mvar + 11.3 Mvar + 0.8Mvar + ½ of 43.6Mvar). Figure 5-2 shows the result of placing a 46Mvar reactor at the low side bus of the 34.5/345kV transformer in GEN-2015-024 and a 17Mvar and a 23Mvar (40Mvar total) on the low side busses of the 34.5/345kV transformers in GEN-2015-025.

Note that the reactor requirements have increased significantly from the previous study of GEN-2015-024 and GEN-2015-025. Figure 5-3 shows the one line of both projects in the previous study. The updated collector systems increased the reactor requirement approximately 21 Mvars and the updated transmission line to the POI added approximately 6Mvars.

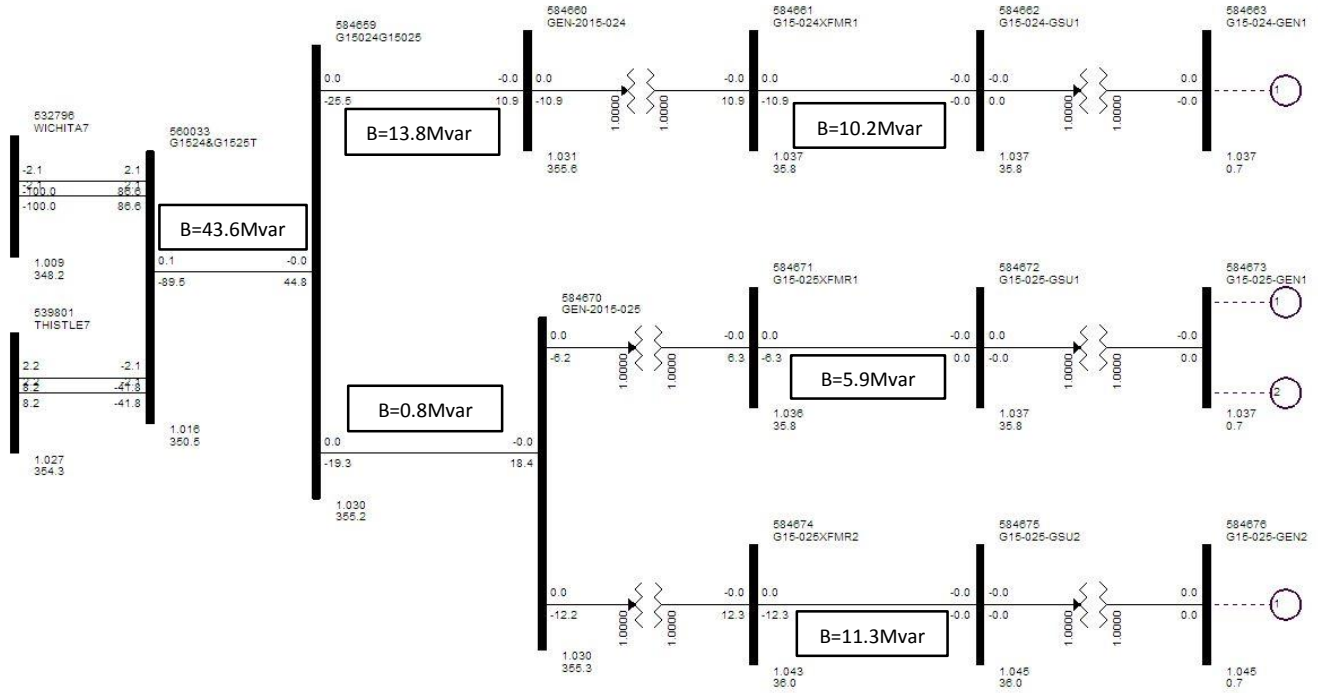

Figure 6-1: GEN-2015-024 and GEN-2015-025 with generators off and no shunt reactors

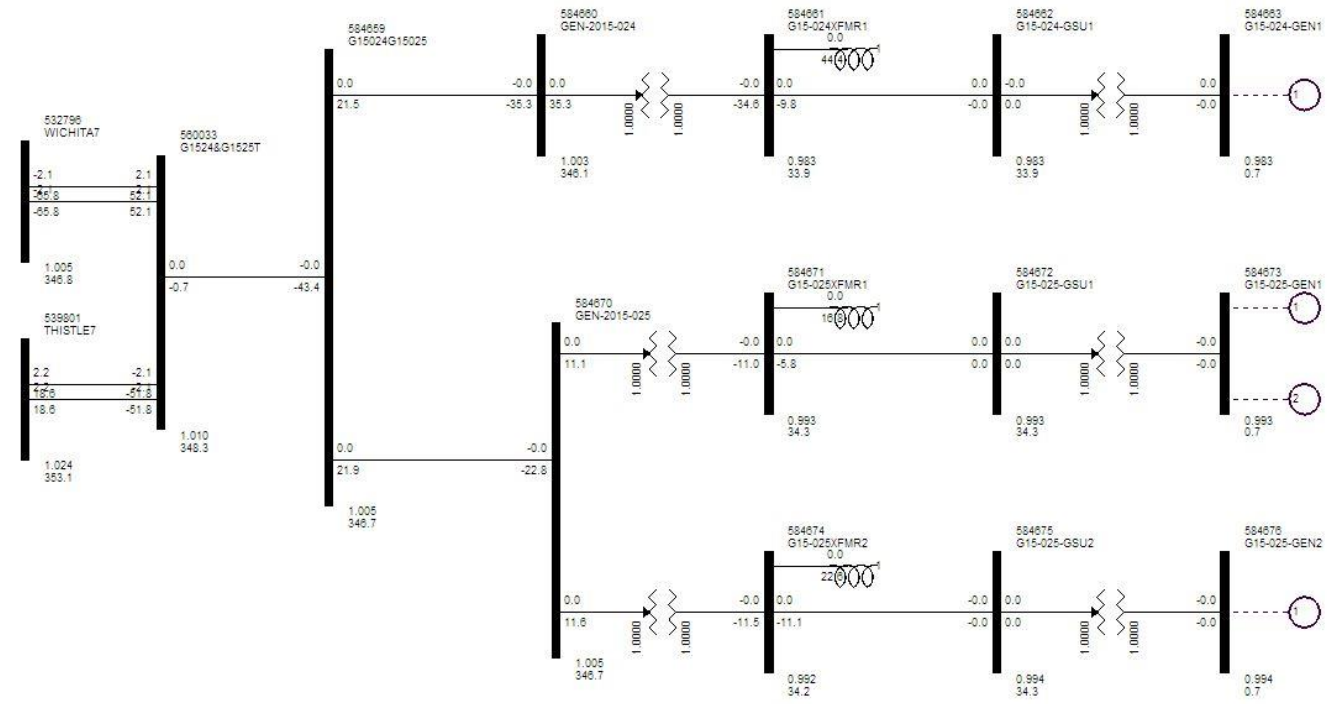

Figure 6-2: GEN-2015-024 and GEN-2015-025 with generators off and with shunt reactors

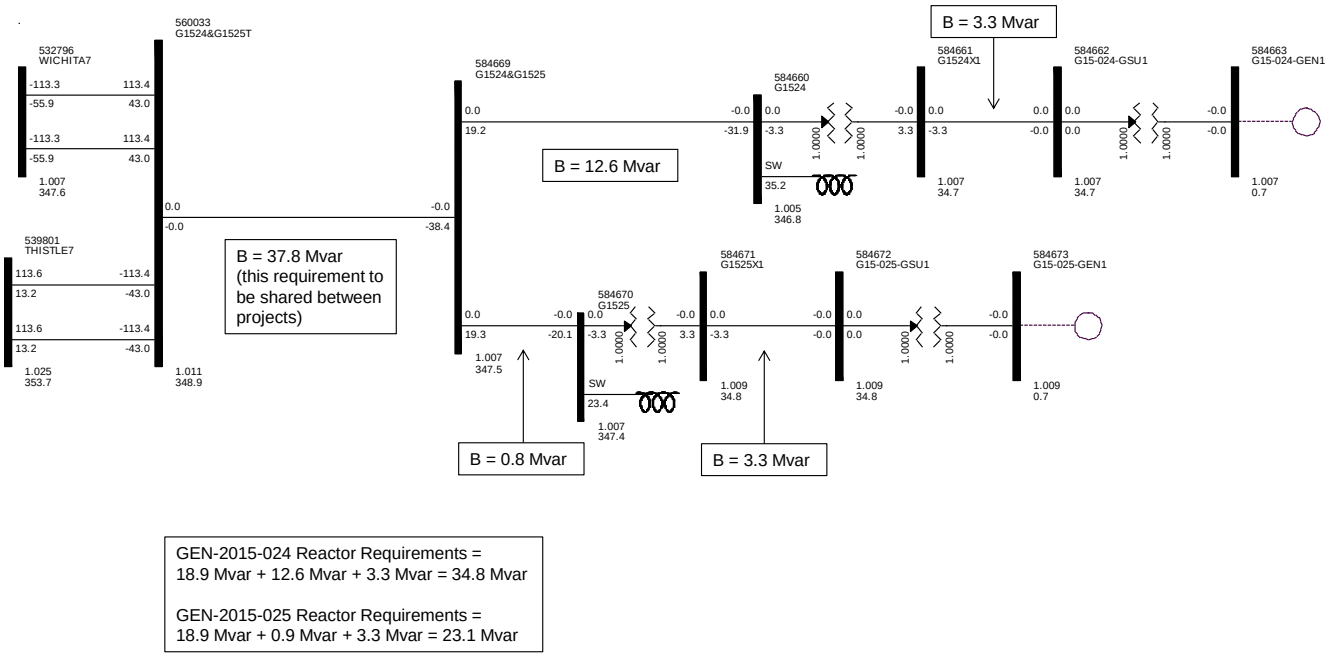

Figure 6-3: Original Study of GEN-2015-024 and GEN-2015-025 with generators off and with shunt reactors[1]

7. Short Circuit Analysis

Results

Refer to Appendix K for Group 8 in the original posting of DISIS-2015-001-1.

[1] Drawing is from "DISIS-2015-001-1 (Group 08) Definitive Impact Study" final report produced by Mitsubishi Electric Power Products, Inc. (MEPPI) and dated October 2015. The report is found in "Appendix K: Group 8 Dynamic Stability Analysis Report" in the SPP DISIS-2015-001-1 study posted in December 2015.

8. Conclusion

The Interconnection Customer for GEN-2015-024 and GEN-2014-025 has requested a modification to its Interconnection Requests to change wind turbine generators from GE 2.0MW to GE 1.8MW and GE 1.79MW wind turbine generators as shown in Table 7-1.

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2015-024	217.8	121 x GE 1.8MW	Tap Wichita to Thistle 345kV ckts 1 and 2
GEN-2015-025	215.95	115 x GE 1.8MW and 5 x GE 1.79MW	Tap Wichita to Thistle 345kV ckts 1 and 2

Table 8-1: Interconnection Request

The analysis has shown that the requested wind turbine modifications to GEN-2015-024 and GEN-2015-025 are not material modifications. With exception of the reactor requirements the results of DISIS-2015-001-1 Group 8 study are still valid for GEN-2015-024 and GEN-025 as modified with GE 1.8MW and GE 1.79MW wind turbine generators.

A low-wind/no-wind condition analysis was performed for this wind turbine modification request. GEN-2015-024 will be required to install approximately 46 Mvars of shunt reactors on its substation 34.5kV bus(es). GEN-2015-025 will be required to install approximately 40 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 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.

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.