GEN-2016-061

Impact Restudy for Generator Modification

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By SPP Generator Interconnections Dept.

REVISION HISTORY

DATE OR VERSION NUMBER	AUTHOR	CHANGE DESCRIPTION
06/17/2020	SPP	Initial Report Issued.

EXECUTIVE SUMMARY

The GEN-2016-061 Interconnection Customer has requested a modification to its Interconnection Request. SPP has performed this system impact restudy to determine the effects of changing wind turbine generators from the previously studied one hundred nine (109) GE 2.3 MW wind turbine generators to eighty-eight (88) GE 2.82 MW turbine generators. The total capacity of GEN-2016-061 reduces from 250.7 MW to 248.16 MW. The point of interconnection (POI) for GEN-2016-061 remains at a new substation along the Sooner – Woodring 345 kV line.

SPP determined that power flow and short-circuit should not be performed. However, SPP determined that an impedance comparison should be performed to evaluate whether fault analysis is appropriate. SPP also performed charging current compensation analysis to determine the required charging current compensation for the requested modification configuration.

The impedance comparison resulted in an insignificant impedance difference between the existing design and the requested modification, which helped determine that fault analysis should not be performed.

A charging current compensation analysis was performed for this modification request. The project will be required to install a total of approximately 10.03 MVAr of reactor shunts on its collection 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 or no-wind conditions. The customer may elect to provide reactive compensation by other equipment and it is the customer's responsibility to design and verify the compensation.

The requested modification has been determined to not be a Material Modification. The requested modification does not have a material impact on the cost or timing of any Interconnection Request with a later Queue priority date.

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.

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REQUESTED MODIFICATION

The GEN-2016-061 Interconnection Customer has requested a modification to its Interconnection Request. The study assumptions for the existing project are shown in Table 1-1.

The restudy will evaluate the requested modification to change from the previously studied one hundred nine (109) GE 2.3 MW wind turbine generators to eighty-eight (88) GE 2.82 MW turbine generators. The total capacity of GEN-2016-061 reduces from 250.7 MW to 248.16 MW. Table 1- 2 contains a detailed comparison of the existing configuration and requested modification. One-line drawings for the existing configuration and requested modification are shown in Figure 1-1 and Figure 1-2, respectfully.

TABLE 1-1: EXISTING INTERCONNECTION REQUEST

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2016-061	250.7	GE 2.3MW (wind)	Sooner (514803) - Woodring (514715) 345kV Line

TABLE 1-2: GEN-2016-061 MODIFICATION REQUEST

Facility	Existing	Modification
Point of Interconnection	Sooner (514803) - Woodring (514715) 345kV Line	Sooner (514803) - Woodring (514715) 345kV Line
Configuration/Capacity	109 x GE 2.3MW = 250.7 MW	88 x GE 2.82 MW = 248.16 MW
Generation Interconnection Line	Length = 0.5 miles R = 0.000028 pu X = 0.000237 pu B = 0.003100 pu	Length = 0.056 miles (300 feet) R = 0.0000 pu X = 0.0001 pu B = 0.0000 pu
Main Substation Transformer	X = 10%, R = 0.23%, Winding 170 MVA, Rating 280 MVA	(2 units) X = 9.49%; R = 0.163%; Winding 84 MVA; Rating 140 MVA
Equivalent Collector System	R = 0.004178 X = 0.005815 B = 0.11283	R = 0.006031 X = 0.00246 B = 0.100323
Equivalent GSU Transformer	Gen 1 Equivalent Qty: 109: X = 5.69% ,R = 0.8%, Rating 279 MVA	Gen 1 Equivalent Qty: 88: X = 5.75%, R = 0.5%, Rating 286 MVA

FIGURE 1-1: GEN-2016-061 EXISTING ONE-LINE DIAGRAM

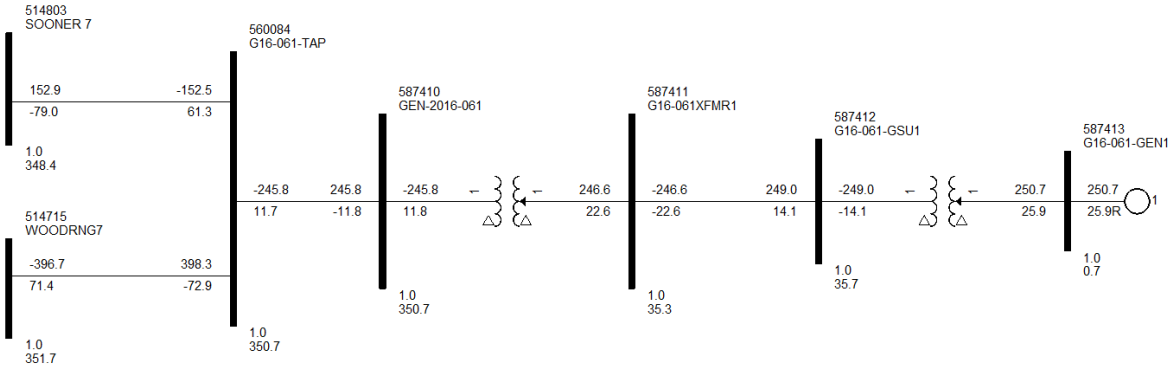
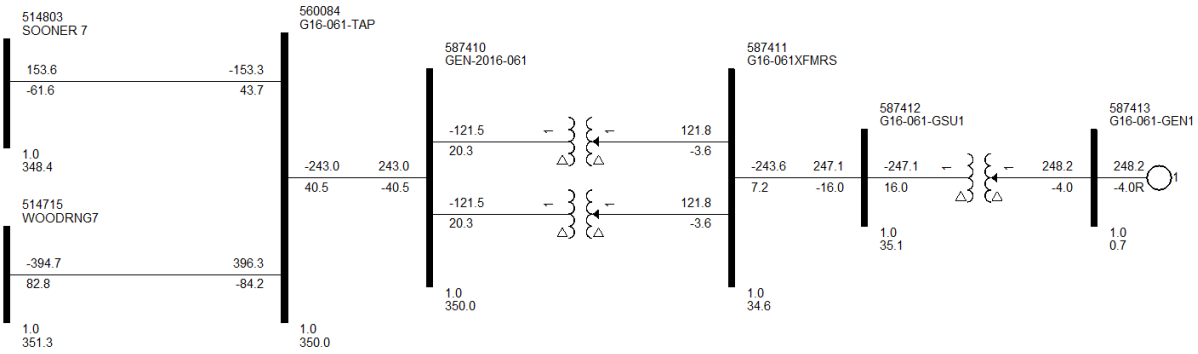


FIGURE 1-2: GEN-2016-061 MODIFICATION ONE-LINE DIAGRAM



SCOPE OF STUDY

An Impact Restudy 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 below analysis sections include reasoning as to why the analysis was either included or excluded from the scope of study.

POWER FLOW, SHORT-CIRCUIT ANALYSIS

To determine whether power flow and short-circuit analysis is required, SPP evaluates the difference in the real power output at the POI between the existing configuration and the requested modification.

SPP determined that power flow and short-circuit analysis is not required due to insignificant change (< 1%) in the real power output at the POI between the existing configuration and requested modification.

STABILITY ANALYSIS

To determine whether stability analysis is required, SPP evaluates the difference between the turbine collection and collector system impedance between the existing configuration and the requested modification. Fault analysis would be required if either of the differences listed above were determined to have a significant impact on the most recently performed DISIS stability analysis.

For the turbine collection, as the turbine changes were from GE turbines to GE turbines, SPP determined that fault analysis should not be required due to the equivalent stability responses of the existing GE turbine and the requested modification's GE turbine.

For the collector system impedance, SPP determined that a comparison of the collector system impedance between the existing design and the requested modification design is required. If the change between the two impedance values is significant, SPP would require fault analysis be performed to determine the impact of the requested modification.

CHARGING CURRENT COMPENSATION ANALYSIS

SPP requires that a charging current compensation analysis be performed on the requested modification configuration as it is a non-synchronous resource. The charging current compensation 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 plant's generators and capacitors are off-line.

STABILITY ANALYSIS

SPP determined that a comparison of the collector system impedance between the existing design and the requested modification design is required. If the change between the two impedance values is significant, SPP would require that fault analysis be performed to determine the stability impact of the requested modification.

IMPEDANCE COMPARISON ANALYSIS

The equivalent impedance between the POI and the equivalent generator was calculated from all the model components (generator lead, substation and step-up transformers, and equivalent collector system cables) for GEN-2016-061 on the existing design and requested modification. The relative change in the impedances before and after the modification request were then compared.

RESULTS

Table 3-1 shows the decrease in the total impedance from the existing design to the requested modification.

Table 3-1: GEN-2016-061 Combined Impedance Comparison

Interconnection Request	Existing Impedance Z (p.u.)	MRIS Impedance Z (p.u.)	Impedance Change Z
GEN-2016-061	8.56%	7.97%	6.88%

SPP determined that the change in impedance is not significant enough to require fault analysis be performed to determine the impact of the requested modification.

CHARGING CURRENT COMPENSATION ANALYSIS

Interconnection requests for generation projects that interconnect on the SPP system are analyzed for 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.

MODEL PREPARATION

The project generators and capacitors (if any) utilizing the same interconnection facilities were turned off in the base case. The resulting reactive power injection into the transmission network comes from the capacitance of the project's transmission lines and collector cables. This reactive power injection is measured at the POI. Shunt reactors are added at the study project substation low voltage bus to bring the MVAr flow into the POI down to approximately zero.

FIGURE 2-1: GEN-2016-061 WITH GENERATION OFF AND NO SHUNT REACTOR

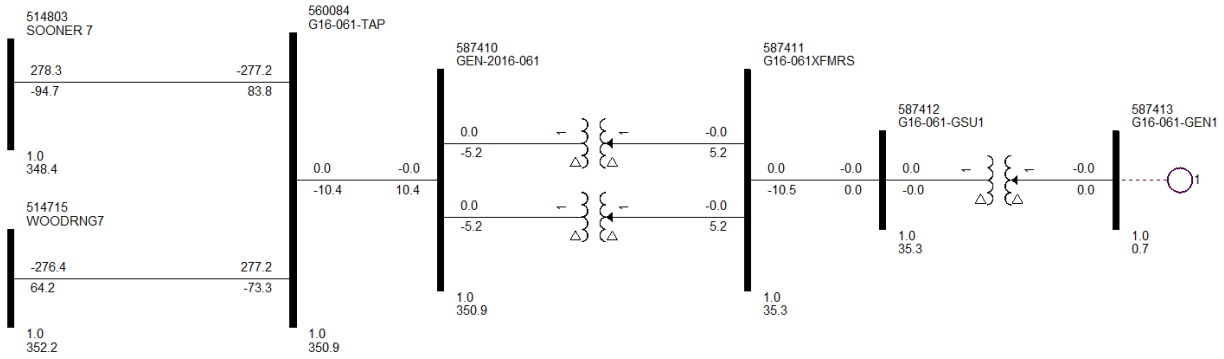
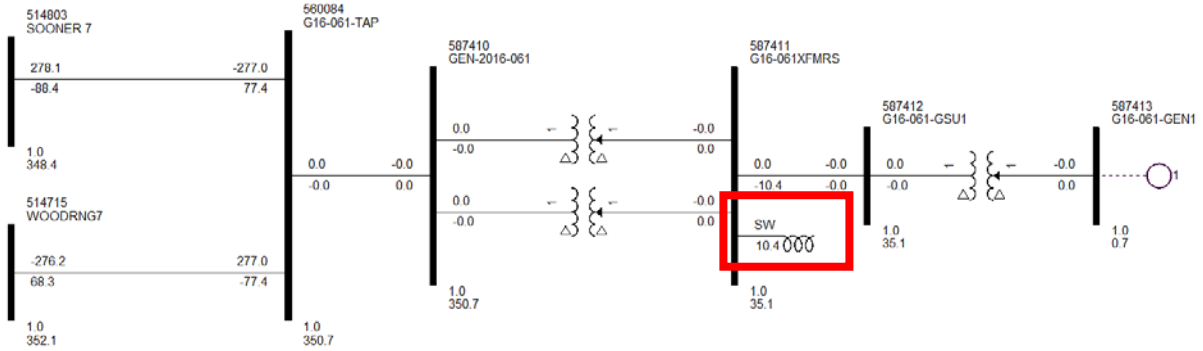


FIGURE 2-2: GEN-2016-061 WITH GENERATION OFF AND SHUNT REACTOR



RESULTS

The size of the shunt reactor 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). The final shunt reactor requirement for each of the studied interconnection requests is shown in Table 4-1. This is a reduction from the previously identified value of 11.7 MVAr in the DISIS-2016-001-1 Group 8 report. If the customer elects to provide reactive compensation by other equipment, the amount of compensation required may be higher due to its voltage effect. It is the customer's responsibility to design and verify the compensation. One line drawings used in the analysis are shown in Appendix A: Low Wind Analysis.

TABLE 3-1: SUMMARY OF SHUNT REACTOR REQUIREMENTS

Request	Capacity	POI	Approximate Shunt Reactor Required at Customer's 34.5 kV Collector Substation
GEN-2016-061	248.16	Sooner (514803) - Woodring (514715) 345kV Line	10.03 MVAr

MATERIAL MODIFICATION DETERMINATION

Since stability, power flow, and short-circuit analyses were deemed not to be required, SPP determined that DISIS results of the requested modification would be equivalent to the results of the existing configuration.

The requested modification is not a Material Modification. The equivalent results imply that any network upgrades already required by GEN-2016-061 would not change due to the requested modification, thus not resulting in a material impact on the cost or timing of any Interconnection Request with a later Queue priority date.

CONCLUSION

The SPP GEN-2016-061 Impact Restudy evaluated the impact of interconnecting the project shown below in Table 6-1.

TABLE 4-1: INTERCONNECTION REQUEST WITH MODIFICATION

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2016-061	248.16 MW	88 GE 2.82 MW	Sooner (514803) - Woodring (514715) 345kV Line

SPP determined that power flow and short-circuit should not be performed. However, SPP determined that an impedance comparison should be performed to evaluate whether fault analysis is appropriate. SPP also performed charging current compensation analysis to determine the required charging current compensation for the requested modification configuration.

The impedance comparison resulted in an impedance difference of 6.88% between the existing design and the requested modification, which helped determine that fault analysis should not be performed.

A charging current compensation analysis was performed for this modification request. The project will be required to install a total of approximately 10.03 MVAr of reactor shunts on its collection substation 34.5kV bus; this is a reduction from the previously identified value of 11.7 MVAr in the DISIS-2016-001-1 Group 8 report. 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 customer may elect to provide reactive compensation by other equipment. It is the customer's responsibility to design and verify the compensation.

The requested modification has been determined to not be a Material Modification. As the DISIS results of the requested modification would be equivalent to the results of the existing configuration, there would be no impact on the cost or timing of any Interconnection Request with a later Queue priority date.

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.