GEN-2007-021
Impact Restudy for Generator Modification (Turbine Change)

March 2014
Generator Interconnection

Southwest Power Pool

Executive Summary

The GEN-2007-021 interconnection request was first studied as part of the ICS-2008-001 Impact Cluster Study, Cluster Group 1, which was posted in July 2009. The Interconnection Customer then requested a change in wind generator technology to the GE 1.6MW wind turbine. The restudy was posted in December 2010. The Customer has a signed a Generator Interconnection Agreement (GIA) with.

The GIA calls for the Customer to install one hundred twenty-five (125) General Electric 1.6MW wind turbines for a total of 200.0MW nameplate capacity. The Customer is also required to maintain a 95% lagging (supplying reactive power) and a 95% leading (absorbing reactive power) at the Point of Interconnection. The Point of Interconnection (POI) is the new Oklahoma Gas and Electric Company (OKGE) Tatonga 345kV substation.

In February 2014, the Customer requested a change to its generator configuration to use the General Electric 1.7MW wind turbines while not exceeding the original GIA nameplate capacity. The Customer has supplied all generator, turbine layout, cabling impedances, and transformer impedances. SPP has determined that the Customer may install one hundred seventeen (117) General Electric 1.7MW wind turbines for a total of 198.9MW of nameplate capacity. The GE 1.7MW wind generators have identical electrical characteristics to the previously studied GE 1.6MW wind generators. Neither a new transient stability study nor a low voltage ride through analysis is required for this modification request. The change is not considered a Material Modification.

A power factor analysis and a no-wind/low-wind condition analysis were performed for this modification request. The power factor requirement remains 95% lagging (supplying reactive power) and 95% leading (absorbing reactive power) at the POI. Additionally, the project will be required to install approximately 15Mvar of reactive shunts on its substation 34.5kV bus. This is necessary to offset the capacitive effects of the project's transmission line and collector system during low-wind or no-wind conditions.

With the assumptions outlined in this report and with all the required network upgrades from the GEN-2007-021GIA in place, GEN-2007-021 with the GE 1.7MW 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.

I. Introduction

The GEN-2007-021 Interconnection Customer has requested a modification to its Generator Interconnection Agreement from the GE 1.6MW wind turbine generator to the GE 1.7MW wind turbine generator. Since the GE 1.6MW and the GE 1.7MW wind turbine generators have identical electrical characteristics neither a transient stability study nor a low voltage ride-through analysis was required for this study. The requested change is not considered a Material Modification. However, a power factor analysis and a no-wind/low-wind condition analysis were done. The in-service date assumed for the generation addition is December 31, 2014.

The power factor analysis determines the power factor at the POI for the wind interconnection project for pre-contingency and post-contingency conditions. Additionally, a shunt reactor size was determined in order to compensate for line and cable capacitance and to maintain 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 System Impact Study constitutes a request for transmission service or grants the Interconnection Customer any rights to transmission service.

II. Facilities

A one-line drawing for the GEN-2007-021 generation interconnection request is shown in Figure II-1.

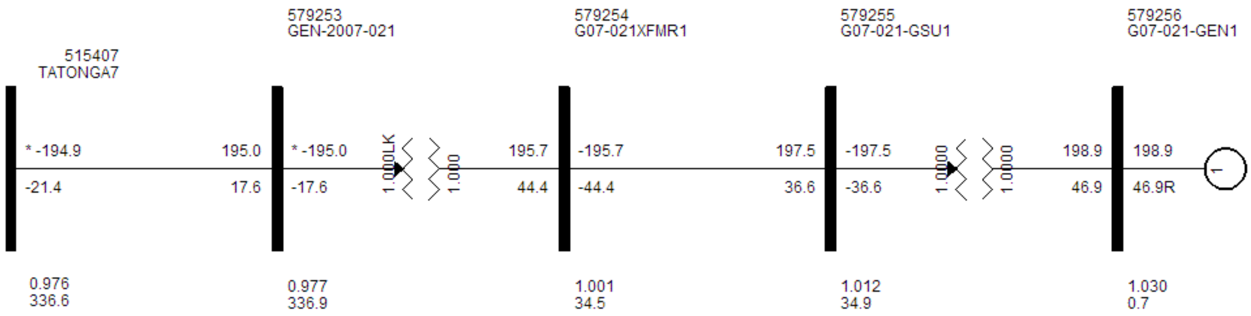

Figure II-1: GEN-2007-021 One-line Diagram

III. Stability Analysis

Since the GE 1.6MW wind turbine and the GE 1.7MW generators have identical electrical characteristics, the transient stability analysis and the low voltage ride through analysis were not performed. As such the change is not considered a Material Modification.

IV. Power Factor Analysis

A set of power flow contingencies was used to determine the power factor requirements for the wind farm to maintain scheduled voltage at the POI. The voltage schedule was set equal to the voltage at the POI before the project is added, with a minimum of 1.0 per unit. A fictitious reactive power source replaced the study project to maintain scheduled voltage during all studied contingencies. The MW and Mvar injections from the study project at the POI were recorded and the resulting power factors were calculated for all contingencies for the 2014 winter peak, the 2015 summer peak and the 2024 summer peak cases. The most leading and most lagging power factors determine the minimum power factor range capability that the study project must install before commercial operation.

Per FERC and SPP Tariff requirements, if the power factor needed to maintain scheduled voltage is less than 0.95 lagging, then the requirement is limited to 0.95 lagging. The lower limit for leading power factor requirement is also 0.95. If a project never operated leading under any contingency, then the leading requirement is set to 1.0. The same applies on the lagging side.

The final power factor requirements are shown in Table IV-1 below. These are only the minimum power factor ranges based on steady-state analysis. The contingencies used in determining the power factor requirements and the results for each of the three cases (2014WP, 2015SP and 2024SP) are shown in Appendix A.

Table IV-1: Power Factor Requirements [a]

Request	Size (MW)	Generator Model	Point of Interconnection	Final PF Requirement	
				Lagging [b]	Leading [c]
GEN-2007-021	198.9	GE 1.7MW	Tatonga 345kV	0.950[d]	1.000[e]

Notes:

a. The table shows the minimum required power factor capability at the point of interconnection that must be designed and installed with the plant. The power factor capability at the POI includes the net effect of the generators, transformers, line impedances, and any reactive compensation devices installed on the plant side of the meter. Installing more capability than the minimum requirement is acceptable.

b. Lagging is when the generating plant is supplying reactive power to the transmission grid, like a shunt capacitor. In this situation, the alternating current sinusoid “lags” behind the alternating voltage sinusoid, meaning that the current peaks shortly after the voltage.

c. Leading is when the generating plant is taking reactive power from the transmission grid, like a shunt reactor. In this situation, the alternating current sinusoid “leads” the alternating voltage sinusoid, meaning that the current peaks shortly before the voltage.

d. Electrical need is lower, but PF requirement limited to 0.95 by FERC order.

e. Project never operated leading under any contingency, the leading requirement is set to 1.0

In a separate test, the project generators and capacitors (if any) were turned off in the base case (Figure IV-1). The resulting reactive power injection at the POI comes from the capacitance of the project’s transmission lines and collector cables. Shunt reactors were added at the plant substation 34.5 kV buses to bring the POI Mvar flow down to approximately zero (Figure IV-2). Final shunt reactor requirement for this project is approximately 15Mvars. The one-line diagram in Figure IV-2 shows actual Mvar output at the specific voltages in the base case. The results shown are for the 2014WP case. The other two cases (2015SP and 2024SP) were almost identical since the plant design is the same in all cases.

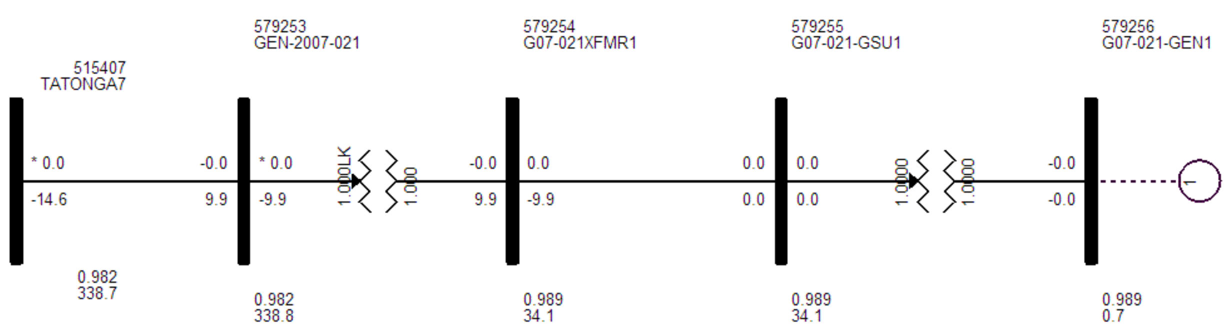

Figure IV-1: GEN-2007-021with generators and capacitors turned off and no shunt reactors

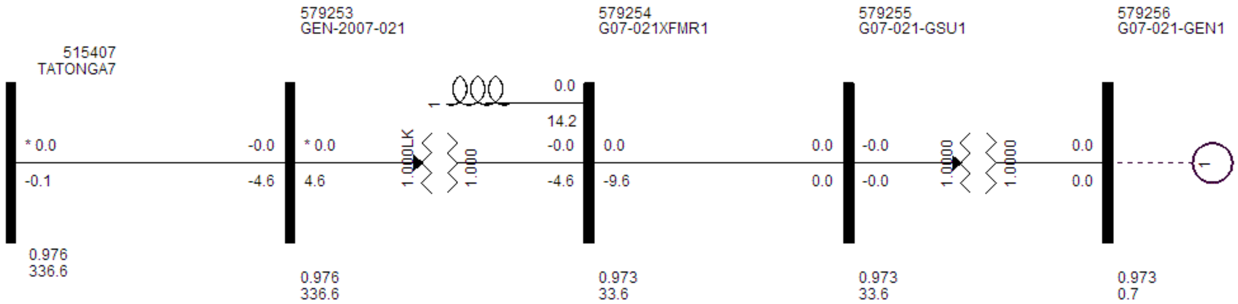

Figure IV-2: GEN-2007-021with generators and capacitors turned off and shunt reactors added

V. Conclusion

The GEN-2007-021 Interconnection Customer has requested a change from the GE 1.6MW wind turbine generators to the GE 1.7MW wind turbine generators. Since the two generators are electrically identical, the request is not a Material Modification. Therefore, it is not necessary to perform a complete system impact study for the change requested. Neither a stability analysis nor a low voltage ride-through analysis was performed; however, a power factor analysis and a no-wind/low-wind condition analysis were done.

The power factor analysis of the study cases showed that the GEN-2007-021 project is required to maintain a power factor requirement of the pro-forma standard 0.95 leading (absorbing) to 0.95 lagging (supplying) at the Point of Interconnection. Additionally, the project will be required to install approximately 15Mvar of reactive shunts on its substation 34.5kV bus. This is necessary to offset the capacitive effects at the POI caused by the project's transmission line and collector system during low-wind or no-wind conditions.

Any changes to the assumptions made in this study, may require a restudy at the expense of the Customer.

Nothing in this System Impact Study constitutes a request for transmission service or confers upon the Interconnection Customer any right to receive transmission service.

APPENDIX A

POWER FACTOR ANALYSIS

2014 Winter Voltage = 1.0 pu POI – Tatonga 345kV (515407)	GEN-2007-021			
Contingency Name	Power at POI	VARS at POI	Power Factor	
FLT_00_NoFault	198.9	53.955	0.965	LAG
FLT_01_TATONGA7_G11051TAP_345kV	198.9	7.113	0.999	LAG
FLT_03_TATONGA7_MATHWSN7_345kV	198.9	68.413	0.946	LAG
FLT_05_MATHWSN7_WOODRNG7_345kV	198.9	59.474	0.958	LAG
FLT_07_MATHWSN7_NORTWST7_345kV	198.9	54.326	0.965	LAG
FLT_09_MATHWSN7_CIMARON7_345kV	198.9	53.840	0.965	LAG
FLT_11_WWRDEHV7_BORDER7_345kV	198.9	60.482	0.957	LAG
FLT_13_WWRDEHV7_G11051TAP_345kV	198.9	9.182	0.999	LAG
FLT_15_WWRDEHV7_G12016TAP_345kV	198.9	54.122	0.965	LAG
FLT_17_WWRDEHV7_G13034TAP_345kV	198.9	53.960	0.965	LAG
FLT_19_SWEETWATER7_TUCOINT7_345kV	198.9	59.417	0.958	LAG
FLT_21_WOODRNG7_SOONER7_345kV	198.9	55.345	0.963	LAG
FLT_23_WOODRNG7_HUNTERS7_345kV	198.9	56.195	0.962	LAG
FLT_25_NORTWST7_SPRNGCK7_345kV	198.9	57.238	0.961	LAG
FLT_27_NORTWST7_CIMARON7_345kV	198.9	54.680	0.964	LAG
FLT_29_NORTWST7_ARCADIA7_345kV	198.9	58.042	0.960	LAG
FLT_31_CIMARON7_MINCO7_345kV	198.9	58.106	0.960	LAG
FLT_33_CIMARON7_DRAPER7_345kV	198.9	57.487	0.961	LAG
FLT_35_THISTLE7_WICHITA7_345kV	198.9	64.186	0.952	LAG
FLT_37_THISTLE7_CLARKCOUNTY7_345kV	198.9	55.326	0.963	LAG
FLT_39_BEAVERCO_HITCHLAND7_345kV	198.9	55.083	0.964	LAG
FLT_41_BEAVERCO_BUCKNER7_345kV	198.9	59.721	0.958	LAG
FLT_43_BEAVERCO_G13034TAP_345kV	198.9	57.240	0.961	LAG
FLT_45_CIMARON7_CIMARON4_345_138kV	198.9	52.390	0.967	LAG
FLT_46_NORTWST7_NORTWST4_345_138kV	198.9	52.906	0.966	LAG
FLT_47_THISTLE7_THISTLE4_345_138kV	198.9	55.761	0.963	LAG
FLT_48_WWRDEHV7_WWRDEHV4_345_138kV	198.9	52.202	0.967	LAG
FLT_49_G12016TAP_MOORLND4_345_138kV	198.9	54.684	0.964	LAG
FLT_50_WOODRNG7_WWRDEHV4_345_138kV	198.9	53.283	0.966	LAG

2015 Summer Voltage = 1.0 pu POI – Tatonga 345kV (515407)	GEN-2007-021			
Contingency Name	Power at POI	VARS at POI	Power Factor	
FLT_00_NoFault	198.9	35.345	0.985	LAG
FLT_01_TATONGA7_G11051TAP_345kV	198.9	2.111	1.000	LAG
FLT_03_TATONGA7_MATHWSN7_345kV	198.9	51.369	0.968	LAG
FLT_05_MATHWSN7_WOODRNG7_345kV	198.9	38.753	0.982	LAG
FLT_07_MATHWSN7_NORTWST7_345kV	198.9	36.646	0.983	LAG
FLT_09_MATHWSN7_CIMARON7_345kV	198.9	35.181	0.985	LAG
FLT_11_WWRDEHV7_BORDER7_345kV	198.9	41.250	0.979	LAG
FLT_13_WWRDEHV7_G11051TAP_345kV	198.9	4.274	1.000	LAG
FLT_15_WWRDEHV7_G12016TAP_345kV	198.9	35.611	0.984	LAG
FLT_17_WWRDEHV7_G13034TAP_345kV	198.9	35.515	0.984	LAG
FLT_19_SWEETWATER7_TUCOINT7_345kV	198.9	40.075	0.980	LAG
FLT_21_WOODRNG7_SOONER7_345kV	198.9	36.325	0.984	LAG
FLT_23_WOODRNG7_HUNTERS7_345kV	198.9	36.864	0.983	LAG
FLT_25_NORTWST7_SPRNGCK7_345kV	198.9	41.465	0.979	LAG
FLT_27_NORTWST7_CIMARON7_345kV	198.9	36.062	0.984	LAG
FLT_29_NORTWST7_ARCADIA7_345kV	198.9	37.415	0.983	LAG
FLT_31_CIMARON7_MINCO7_345kV	198.9	38.730	0.982	LAG
FLT_33_CIMARON7_DRAPER7_345kV	198.9	37.393	0.983	LAG
FLT_35_THISTLE7_WICHITA7_345kV	198.9	44.084	0.976	LAG
FLT_37_THISTLE7_CLARKCOUNTY7_345kV	198.9	36.373	0.984	LAG
FLT_39_BEAVERCO_HITCHLAND7_345kV	198.9	36.597	0.983	LAG
FLT_41_BEAVERCO_BUCKNER7_345kV	198.9	40.057	0.980	LAG
FLT_43_BEAVERCO_G13034TAP_345kV	198.9	38.982	0.981	LAG
FLT_45_CIMARON7_CIMARON4_345_138kV	198.9	34.363	0.985	LAG
FLT_46_NORTWST7_NORTWST4_345_138kV	198.9	34.614	0.985	LAG
FLT_47_THISTLE7_THISTLE4_345_138kV	198.9	36.965	0.983	LAG
FLT_48_WWRDEHV7_WWRDEHV4_345_138kV	198.9	33.517	0.986	LAG
FLT_49_G12016TAP_MOORLND4_345_138kV	198.9	35.854	0.984	LAG
FLT_50_WOODRNG7_WWRDEHV4_345_138kV	198.9	34.059	0.986	LAG

2024 Summer Voltage = 1.0 pu POI – Tatonga 345kV (515407)	GEN-2007-021			
Contingency Name	Power at POI	VARS at POI	Power Factor	
FLT_00_NoFault	198.9	43.805	0.977	LAG
FLT_01_TATONGA7_G11051TAP_345kV	198.9	43.384	0.977	LAG
FLT_03_TATONGA7_MATHWSN7_345kV	198.9	58.094	0.960	LAG
FLT_05_MATHWSN7_WOODRNG7_345kV	198.9	45.892	0.974	LAG
FLT_07_MATHWSN7_NORTWST7_345kV	198.9	45.658	0.975	LAG
FLT_09_MATHWSN7_CIMARON7_345kV	198.9	43.931	0.976	LAG
FLT_11_WWRDEHV7_BORDER7_345kV	198.9	47.949	0.972	LAG
FLT_13_WWRDEHV7_G11051TAP_345kV	198.9	41.328	0.979	LAG
FLT_15_WWRDEHV7_G12016TAP_345kV	198.9	42.942	0.977	LAG
FLT_17_WWRDEHV7_G13034TAP_345kV	198.9	43.630	0.977	LAG
FLT_19_SWEETWATER7_TUCOINT7_345kV	198.9	45.264	0.975	LAG
FLT_21_WOODRNG7_SOONER7_345kV	198.9	46.157	0.974	LAG
FLT_23_WOODRNG7_HUNTERS7_345kV	198.9	44.803	0.976	LAG
FLT_25_NORTWST7_SPRNGCK7_345kV	198.9	49.378	0.971	LAG
FLT_27_NORTWST7_CIMARON7_345kV	198.9	44.911	0.975	LAG
FLT_29_NORTWST7_ARCADIA7_345kV	198.9	49.103	0.971	LAG
FLT_31_CIMARON7_MINCO7_345kV	198.9	49.602	0.970	LAG
FLT_33_CIMARON7_DRAPER7_345kV	198.9	47.128	0.973	LAG
FLT_35_THISTLE7_WICHITA7_345kV	198.9	53.837	0.965	LAG
FLT_37_THISTLE7_CLARKCOUNTY7_345kV	198.9	45.638	0.975	LAG
FLT_39_BEAVERCO_HITCHLAND7_345kV	198.9	45.316	0.975	LAG
FLT_41_BEAVERCO_BUCKNER7_345kV	198.9	51.251	0.968	LAG
FLT_43_BEAVERCO_G13034TAP_345kV	198.9	48.614	0.971	LAG
FLT_45_CIMARON7_CIMARON4_345_138kV	198.9	43.109	0.977	LAG
FLT_46_NORTWST7_NORTWST4_345_138kV	198.9	42.809	0.978	LAG
FLT_47_THISTLE7_THISTLE4_345_138kV	198.9	45.345	0.975	LAG
FLT_48_WWRDEHV7_WWRDEHV4_345_138kV	198.9	43.405	0.977	LAG
FLT_49_G12016TAP_MOORLND4_345_138kV	198.9	44.553	0.976	LAG
FLT_50_WOODRNG7_WWRDEHV4_345_138kV	198.9	42.235	0.978	LAG