Southwest Power Pool

Impact Re-Study for Generation Interconnection Request GEN-2005-012

SPP Generation Interconnection

(GEN-2005-012)

January 2011

Executive Summary

<OMITTED TEXT> (Customer) has requested an Impact Re-Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnection of 248.4 MW of wind generation within the balancing authority of Sunflower Electric Power Corporation (SUNC) in Ford County, Kansas.
The wind farm facility has been studied with a point of interconnection at Spearville 345kV substation. The Interconnection Customer has requested to switch wind turbines manufacturers from Vestas to Siemens.

The purpose of this restudy is to evaluate the Customer's request to use Siemens SWT223 2.3 MW wind turbines for the proposed generation. For the stability analysis the wind generation facility was studied with one-hundred-nine (108) Siemens SWT223 2.3 MW wind turbine generators. This stability study addresses the dynamic stability effects of interconnecting the plant to the rest of the SUNC transmission system. Two seasonal base cases were used in the study to analyze the stability impacts of the proposed generation facility. The cases studied were modified 2011 summer peak and 2011 winter peak cases that were adjusted to reflect system conditions at the requested in-service date. Each case was modified to include prior queued projects that are listed in the body of the report. Thirty (30) contingencies were identified for use in this study. The Siemens wind turbines were modeled using information provided by the Customer.

The study has indicated that the Interconnection Customer will able to interconnect 248.4 MW using the Siemens SWT223 2.3 MW wind turbines.

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

1.0 Introduction

<OMITTED TEXT> (Customer) has requested an Impact Re-Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnection of 248.4 MW of wind generation within the balancing authority of Sunflower Electric Power Corporation (SUNC) in Ford County, Kansas.

This Impact study addresses the dynamic stability effects of interconnecting the plant to the rest of the SUNC transmission system. The wind generation facility was studied with one-hundred-nine (108) Siemens SWT223 2.3 MW wind turbine generators. Two seasonal base cases were used in the study to analyze the stability impacts of the proposed generation facility. The cases studied were modified versions of the 2011 summer peak and 2011 winter peak to reflect the system conditions at the requested in-service date. Each case was modified to include prior queued projects that are listed in the body of the report. Thirty (30) contingencies were identified for this study.

2.0 Purpose

The purpose of this Impact Re-Study is to evaluate the impact of the proposed interconnection on the reliability of the Transmission System. The study considers the Base Case as well as all Generating Facilities (and with respect to (b) below, any identified Network Upgrades associated with such higher queued interconnection) that, on the date the study is commenced:

a) are directly interconnected to the Transmission System;
b) are interconnected to Affected Systems and may have an impact on the Interconnection Request;
c) have a pending higher queued Interconnection Request to interconnect to the Transmission System listed in Table 1; or
d) have no Queue Position but have executed an LGIA or requested that an unexecuted LGIA be filed with FERC.

Any changes to these assumptions, for example, one or more of the previously queued projects not included in this study signing an interconnection agreement, may require a re-study of this request 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.

3.0 Facilities

3.1 Interconnection Facility

The Point of Interconnection will be at the Spearville 345kV Substation.

4.0 Stability Analysis

4.1 Contingencies Simulated

Thirty (30) contingencies were considered for the transient stability simulations. These contingencies included three phase faults and single phase line faults at locations defined by SPP. Single-phase line faults were simulated by applying a fault impedance to the positive sequence network at the fault location to represent the effect of the negative and zero sequence networks on the positive sequence network. The fault impedance was computed to give a positive sequence voltage at the specified fault location of approximately 60% of pre-fault voltage. This method is in agreement with SPP current practice.

In study we included the following prior queued requests:

Table 1: Prior Queued Requests

Request	MW
GEN-2001-039A	105
GEN-2002-025A	150
GEN-2004-014	154.5
Montezuma	110

The faults that were defined and simulated are listed in

Table 2.

Table 2: Contingencies Evaluated

Cont. No.	Cont. Name	Description
1	FLT1_3PH	3 phase fault on the Spearville (531469) to Holcomb (531449) 345kV line, near Spearville. a. Apply fault at the Spearville 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
2	FLT2_1PH	*Single phase fault and sequence like previous*
3	FLT3_3PH	3 phase fault on the Ft Dodge (539671) to Dcbeef (539645) 115kV line, near Ft Dodge. a. Apply fault at the Ft Dodge 115kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
4	FL4_1PH	*Single phase fault and sequence like previous*
5	FLT5_3PH	3 phase fault on the Holcomb 345/115 kV autotransformer near 345kV bus. a. Apply fault at the Holcomb 345kV bus (531449). b. Clear fault after 5 cycles by tripping the faulted transformer.
6	FLT6_1PH	*Single phase fault and sequence like previous*

Cont. No.	Cont. Name	Description
7	FL7_3PH	3 phase fault on the Spearville 345/230 kV autotransformer near 345kV bus (531469). a. Apply fault at the Spearville 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
8	FLT8_1PH	*Single phase fault and sequence like previous*
9	FLT9_3PH	3 phase fault on the Ft Dodge (539671) to GEN-2001-039A (579025) 115kV line, near Ft Dodge. a. Apply fault at the Ft Dodge 115kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
10	FLT10_1PH	*Single phase fault and sequence like previous*
11	FLT11_3PH	3 phase fault on the Spearville 230kV/115kV autotransformer near the 230 kV bus (539695). a. Apply fault at the Northwest 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
12	FLT12_1PH	*Single phase fault and sequence like previous*
13	FLT13_3PH	3 phase fault on the Spearville (539695) to Mullergren (539679) 230kV line, near Spearville. a. Apply fault at the Spearville 230kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
14	FLT14_1PH	*Single phase fault and sequence like previous*
15	FLT15_3PH	3 phase fault on the Mullergren (539679) to South Hays (530582) 230kV line, near Mullergren. a. Apply fault at the Mullergren 230kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
16	FLT16_1PH	*Single phase fault and sequence like previous*
17	FLT17_3PH	3 phase fault on the Mullergren (539679) to Circle (532871) 230kV line, near Mullergren (539679). a. Apply fault at the Mullergren 230kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
18	FLT18_1PH	*Single phase fault and sequence like previous*
19	FLT19_3PH	3 phase fault on the Ft Dodge (539671) to North Ft Dodge (539771) 115kV line, near Ft Dodge. a. Apply fault at the Ft Dodge 115kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
20	FLT20_1PH	*Single phase fault and sequence like previous*

Cont. No.	Cont. Name	Description
21	FLT21_3PH	3 phase fault on the Spearville (531469) to Post Rock (530583) 345kV line, near Spearville. a. Apply fault at the Spearville 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
22	FLT22_1PH	*Single phase fault and sequence like previous*
23	FLT23_3PH	3 phase fault on the Post Rock 345kV/230kV autotransformer near the 345 kV bus (530583). a. Apply fault at the Post Rock 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
24	FLT24_1PH	*Single phase fault and sequence like previous*
25	FTL25_3PH	3 phase fault on the Cimarron River Tap (539652) to Cimarron Plate (539654) 115kV line, near Cimarron River Tap. a. Apply fault at the Cimarron River Tap 115kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
26	FLT26_1PH	*Single phase fault and sequence like previous*
27	FLT27_3PH	3 phase fault on the Cimarron River Tap (539652) to E-Liberr (539672) 115kV line, near Cimarron River Tap. a. Apply fault at the Cimarron River Tap 115kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
28	FLT28_1PH	*Single phase fault and sequence like previous*
29	FLT29_3PH	3 phase fault on the Spearville (539694) to North Ft Dodge (539771) 115kV line, near Spearville. a. Apply fault at the Spearville 115kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
30	FLT31_1PH	*Single phase fault and sequence like previous*

4.2 Further Model Preparation

The base cases contain prior queued projects as shown in Table 1. All prior queued projects are dispatched at 100% nameplate.

The wind generation from the study customer and the previously queued customers were dispatched into the SPP footprint.

Initial simulations were carried out on both base cases and cases with the added generation for a no-disturbance run of 20 seconds to verify the numerical stability of the model. All cases were confirmed to be stable.

4.3 Results

Results of the stability analysis are summarized in Table 3. The results indicate that the transmission system is stable for all contingencies tested, summer and winter cases. For the summer and winter cases the Montezuma wind farm tripped off-line for some contingencies due to inability to ride through low voltages. Montezuma is a grandfathered wind farm and is allowed to trip off under these conditions. Also, the Montezuma project was seen to cause some oscillations in the system for certain other faults. These oscillations occurs with and without the study project and are seen to be a numerical issue in the manufacturer's dynamic model for the wind turbines. However, replacing the Montezuma generator with a generic generator model indicates the summer and winter cases are stable without oscillations.

Stability plots for the simulations are in Appendix A.

Table 3: Results of Simulated Contingencies

Cont. No.	Cont. Name	Description	2011 Summer	2011 Winter
1	FLT1_3PH	3 phase fault on the Spearville (531469) to Holcomb (531449) 345kV line, near Spearville	Stable[1]	Stable[1]
2	FLT2_1PH	*Single phase fault and sequence like previous*	Stable[2]	Stable[2]
3	FLT3_3PH	3 phase fault on the Ft Dodge (539671) to Dcbeef (539645) 115kV line, near Ft Dodge. a. Apply fault at the Ft Dodge 115kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	Stable[1]	Stable[1]
4	FL4_1PH	*Single phase fault and sequence like previous*	Stable[1]	Stable[1]
5	FLT5_3PH	3 phase fault on the Holcomb 345/115 kV autotransformer near 345kV bus. a. Apply fault at the Holcomb 345kV bus (531449). b. Clear fault after 5 cycles by tripping the faulted transformer.	Stable[2]	Stable[1]
6	FLT6_1PH	*Single phase fault and sequence like previous*	Stable[2]	Stable[2]
7	FL7_3PH	3 phase fault on the Spearville 345/230 kV autotransformer near 345kV bus (531469). a. Apply fault at the Spearville 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.	Stable[1]	Stable[1]
8	FLT8_1PH	*Single phase fault and sequence like previous*	Stable[2]	Stable[2]
9	FLT9_3PH	3 phase fault on the Ft Dodge (539671) to GEN-2001-039A (579025) 115kV line, near Ft Dodge. a. Apply fault at the Ft Dodge 115kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	Stable[1]	Stable[1]
10	FLT10_1PH	*Single phase fault and sequence like previous*	Stable[1]	Stable[1]
11	FLT11_3PH	3 phase fault on the Spearville 230kV/115kV autotransformer near the 230 kV bus (539695). a. Apply fault at the Northwest 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.	Stable[1]	Stable[1]
12	FLT12_1PH	*Single phase fault and sequence like previous*	Stable[2]	Stable[1]
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14	FLT14_1PH	*Single phase fault and sequence like previous*	Stable[2]	Stable[2]

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16	FLT16_1PH	*Single phase fault and sequence like previous*	Stable	Stable[2]
17	FLT17_3PH	3 phase fault on the Mullergren (539679) to Circle (532871) 230kV line, near Mullergren (539679). a. Apply fault at the Mullergren 230kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	Stable[2]	Stable
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19	FLT19_3PH	3 phase fault on the Ft Dodge (539671) to North Ft Dodge (539771) 115kV line, near Ft Dodge. a. Apply fault at the Ft Dodge 115kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	Stable[1]	Stable[1]
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21	FLT21_3PH	3 phase fault on the Spearville (531469) to Post Rock (530583) 345kV line, near Spearville. a. Apply fault at the Spearville 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	Stable[1]	Stable[1]
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23	FLT23_3PH	3 phase fault on the Post Rock 345kV/230kV autotransformer near the 345 kV bus (530583). a. Apply fault at the Post Rock 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.	Stable[2]	Stable[1]
24	FLT24_1PH	*Single phase fault and sequence like previous*	Stable[2]	Stable[2]
25	FLT25_3PH	3 phase fault on the Cimarron River Tap (539652) to Cimarron Plate (539654) 115kV line, near Cimarron River Tap. a. Apply fault at the Cimarron River Tap 115kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	Stable[2]	Stable[2]
26	FLT26_1PH	*Single phase fault and sequence like previous*	Stable	Stable[2]

Cont. No.	Cont. Name	Description	2011 Summer	2011 Winter
27	FLT27_3PH	3 phase fault on the Cimarron River Tap (539652) to E-Liberr (539672) 115kV line, near Cimarron River Tap. a. Apply fault at the Cimarron River Tap 115kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	Stable[2]	Stable[2]
28	FLT28_1PH	*Single phase fault and sequence like previous*	Stable	Stable[2]
29	FLT29_3PH	3 phase fault on the Spearville (539694) to North Ft Dodge (539771) 115kV line, near Spearville. a. Apply fault at the Spearville 115kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	Stable[1]	Stable[1]
30	FLT30_1PH	*Single phase fault and sequence like previous*	Stable[2]	Stable[1]

1. Montezuma trips off on low voltage or high voltage.
2. Montezuma is seen to cause oscillations in the system due to numerical problems with the Vestas VS47 model.

4.4 FERC LVRT Compliance

FERC Order #661A places specific requirements on wind farms through its Low Voltage Ride Through (LVRT) provisions. For Interconnection Agreements signed after December 31, 2006, wind farms shall stay on line for faults at the POI that draw the voltage down at the POI to 0.0 pu.

The project wind farm (GEN-2005-012) at the requested power level of 248.4 MW remains online for all the fault contingencies described in section 4.1, GEN-2005-012 is found to be in compliance with FERC Order #661A.

5.0 Conclusion

<OMITTED TEXT> (Customer) has requested an Impact Re-Study for interconnection service of 248.4 MW of wind generation within the balancing authority of Sunflower Electric Power Corporation (SUNC) in Ford County, Kansas.

The results of this study show that the wind generation facility and the transmission system remain stable for all contingencies studied. . Additionally for the summer and winter cases the project Montezuma tripped off-line for low voltage conditions. Also, Montezuma is seen to cause potential oscillations in the system for the numerical problems caused by the manufacturer's dynamic model. However, replacing the Montezuma generator with a different generator model the summer and winter cases are stable without oscillations.

GEN-2005-012 is found to be in compliance with FERC Order #661A.

The estimates do not include any costs associated with the deliverability of the energy to final customers. These costs are determined by separate studies if the Customer requests transmission service through Southwest Power Pool's OASIS. It should be noted that the models used for simulation do not contain all SPP transmission service.

APPENDIX A.

STABILITY PLOTS

All plots available on request.