Southwest Power Pool

Impact Restudy For Generation Interconnection Request GEN-2001-039A

SPP Generation Interconnection Studies

GEN-2001-039A

September 2011

Executive Summary

<OMITTED TEXT> (Customer) has requested an impact restudy under the Southwest Power Pool Open Access Transmission Tariff (OATT) for the interconnection of 105.0 MW of wind generation within the balancing authority of Mid-Kansas Electric Company (MKEC) in Kiowa County, Kansas. The proposed point of interconnection is a new MKEC 115kV substation located on the Fort Dodge to Greensburg 115kV transmission line. The wind farm facility had been previously studied using the Clipper C93G1 2.5MW wind turbines. In this impact restudy the Interconnection Customer has requested a change in wind turbine generators to the GE xle 1.6MW machines.

This impact restudy addresses the dynamic stability effects of interconnecting the plant to the rest of the MKEC transmission system as a result of changing the wind turbine generator vendor. In order to remain in the original interconnection queue position with 105.0MW, the wind farm is limited to sixty-five (65) GE xle 1.6MW wind turbine generators for at total power of 104.0MW.

Two sets of seasonal base cases were used in the study to analyze the stability impacts of the proposed generation facility. The first set consisted of a modified 2011 summer peak case and a modified 2011 winter peak case that were adjusted to reflect system conditions on December 31, 2012. This set of cases is referred to as the Near Term cases. The Near Term Cases were modified to include prior queued projects as shown in the table 3 of this report.

The second set of cases consisted of a modified 2011 summer peak case and a modified 2011 winter peak case that were adjusted to reflect system conditions beyond December 31, 2014. This set of cases is referred to as the Far Term cases. SPP contracted Excel Engineering to perform the impact restudy on the Far Term cases, and the report is attached in Appendix B. Each Far Term case was modified to include prior queued projects as shown in the attached report.

The stability analysis results show that, for both the Near Term cases and the Far Term cases, the wind generation facility and the transmission system remain stable for all contingencies studied when using the GE xle 1.6MW wind turbine generators. Also, GEN-2001-039A is found to be in compliance with FERC Order #661A.

A power factor analysis was performed for both the Near Term and the Far Term cases. The facility will be required to maintain a 95% lagging (providing vars) and 95% leading (absorbing vars) power factor at the point of interconnection.

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 restudy under the Southwest Power Pool Open Access Transmission Tariff (OATT) for the interconnection of 105.0 MW of wind generation within the balancing authority of Mid-Kansas Electric Company (MKEC) in Kiowa County, Kansas. The proposed point of interconnection (POI) is a new MKEC 115kV substation located on the Fort Dodge to Greensburg 115kV transmission line. The wind farm facility had been previously studied using the Clipper C93G1 2.5MW wind turbines. In this impact restudy the Interconnection Customer has requested a change in wind turbine generators to the GE xle 1.6MW machines.

This impact restudy addresses the dynamic stability effects of interconnecting the plant to the rest of the MKEC transmission system as a result of changing the wind turbine generator vendor. In order to remain in the original interconnection queue position with 105.0MW, the wind farm is limited to sixty-five (65) GE xle 1.6MW wind turbine generators for at total power of 104.0MW.

This report covers both a Near Term study and a Far Term study. The Near Term study reflects the impact of the project for transmission system conditions on December 31, 2012. The results of the Near Term study are reported in the main body of this report. The Far Term study reflects the impact of the project for the transmission system conditions beyond December 31, 2014. The Far Term study was performed by Excel Engineering, and the results are documented as a separate report in Appendix B.

2.0 Purpose

The purpose of this Impact Restudy is to evaluate the impact of changing the wind turbine vendor from the Clipper C93G1 2.5MW wind turbine generators to the GE xle 1.6MW wind turbine generators on the reliability of the Transmission System.

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 Generating Facility

The project was modeled as an equivalent wind turbine generator of 104.0MW output. The wind turbine is connected to an equivalent 0.69/34.5KV generator step-up unit (GSU). The high side of the GSU is connected to one end of a branch that reflects the equivalent impedance of the wind farm collector subsystem. The other end of the branch is connected to the 34.5/345kV substation transformer. A 115kV transmission line connects the Customer’s substation transformer to the POI. This equivalent model representation is illustrated in Figure 1.

3.2 Interconnection Facility

The POI will be a tap on the Transmission Owners Fort Dodge – Green burg 115kV transmission line as shown in Figure 1.

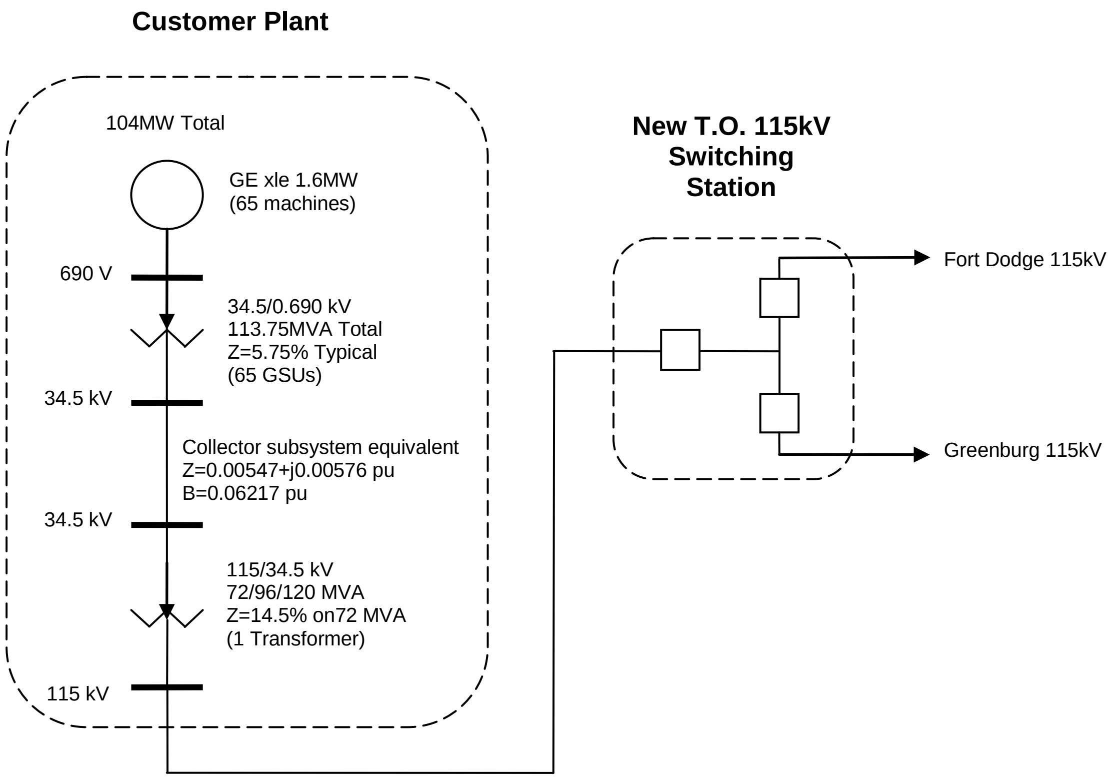

Figure 1. Proposed Interconnection Facility

4.0 Stability Analysis

4.1 Contingencies Simulated

Fifty-seven (57) 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.

The faults that were defined and simulated are listed in Table 1 below.

Table 1: Contingencies Evaluated

Cont. No.	Cont. Name	Description
1.	FLT01-3PH	3 phase fault on the Woodward (515375) to Tatonga (515407) 345kV line, near Woodward. a. Apply fault at the Woodward 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.	FLT02-1PH	*Single phase fault and sequence like previous*
3.	FLT03-3PH	3 phase fault on the Finney (523853) to Hitchland (523097) 345kV line, near Finney. a. Apply fault at the Finney 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.
4.	FLT04-1PH	*Single phase fault and sequence like previous*
5.	FLT05-3PH	3 phase fault on one of the Finney (523853) to Holcomb (531449) 345kV lines, near Finney. a. Apply fault at the Finney 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.
6.	FLT06-1PH	*Single phase fault and sequence like previous*
7.	FLT07-3PH	3 phase fault on the Finney (523853) to Lamar (599950) 345kV line, near Finney. a. Apply fault at Finney 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.
8.	FLT08-1PH	*Single phase fault and sequence like previous*
9.	FLT09-3PH	3 phase fault on the Knoll (530558) to Post Rock (530584) 230kV line, near Knoll. a. Apply fault at the Knoll 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.
10.	FLT10-1PH	*Single phase fault and sequence like previous*
11.	FLT11-3PH	3 phase fault on the Knoll (530558) to Smoky Hills (530592) 230kV line, near Knoll. a. Apply fault at the Knoll 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.
12.	FLT12-1PH	*Single phase fault and sequence like previous*
13.	FLT13-3PH	3 phase fault on the GEN-2007-040 (531000) to Holcomb (531449) 345kV line, near GEN-2007-040. a. Apply fault at the GEN-2007-040 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.

Cont. No.	Cont. Name	Description
14.	FLT14-1PH	*Single phase fault and sequence like previous*
15.	FLT15-3PH	3 phase fault on the GEN-2007-040 (531000) to Spearville (531469) 345kV line, near GEN-2007-040. a. Apply fault at the GEN-2007-040 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.
16.	FLT16-1PH	*Single phase fault and sequence like previous*
17.	FLT17-3PH	3 phase fault on the Pioneer (531391) to Hickock (531378) 115kV line, near Pioneer. a. Apply fault at the Pioneer 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.
18.	FLT18-1PH	*Single phase fault and sequence like previous*
19.	FLT19-3PH	3 phase fault on the Pioneer (531391) to PK Goab (531400) 115kV line, near Pioneer. a. Apply fault at the Pioneer 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*
21.	FLT21-3PH	3 phase fault on the Holcomb 345kV (531449) to 115kV (531448) transformer, near the 345 kV bus. a. Apply fault at the Holcomb 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
22.	FLT22-3PH	3 phase fault on the Holcomb (531449) to Setab (531465) 345kV line, near Holcomb. a. Apply fault at the Holcomb 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.
23.	FLT23-1PH	*Single phase fault and sequence like previous*
24.	FLT24-3PH	3 phase fault on the Spearville 345kV (531469) to 230kV (539695) transformer, near the 345 kV bus. a. Apply fault at the Spearville 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
25.	FLT25-3PH	3 phase fault on the Hugoton (531481) to Walkmyr (531405)115kV line, near Hugoton. a. Apply fault at the Hugoton 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*

Cont. No.	Cont. Name	Description
27.	FLT27-3PH	3 phase fault on the Hugoton (531481) to Grant Tap (531483)115kV line, near Hugoton. a. Apply fault at the Hugoton 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 Kismet (539646) to CMRIVTP (539652) 115kV line, near Kismet. a. Apply fault at the Kismet 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.	FLT30-1PH	*Single phase fault and sequence like previous*
31.	FLT31-3PH	3 phase fault on the Kismet (539646) to Cudahy (539659) 115kV line, near Kismet. a. Apply fault at the Kismet 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.
32.	FLT32-1PH	*Single phase fault and sequence like previous*
33.	FLT33-3PH	3 phase fault on the CMRIVTP (539652) to E-Liberty (539672) 115kV line, near CMRIVTP. a. Apply fault at the CMRIVTP 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.
34.	FLT34-1PH	*Single phase fault and sequence like previous*
35.	FLT35-3PH	3 phase fault on the Cudahy (539659) to GEN-2008-079 Tap (573029) 115kV line, near Cudahy. a. Apply fault at the Cudahy 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.
36.	FLT36-1PH	*Single phase fault and sequence like previous*
37.	FLT37-3PH	3 phase fault on the Medicine Lodge (539673) to Sun City (539697) 115kV line, near Medicine Lodge. a. Apply fault at the Medicine Lodge 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.
38.	FLT38-1PH	*Single phase fault and sequence like previous*
39.	FLT39-3PH	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.
40.	FLT40-1PH	*Single phase fault and sequence like previous*

Cont. No.	Cont. Name	Description
41.	FLT41-3PH	3 phase fault on the Mullergren (539679) to Circle (532871) 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.
42.	FLT42-1PH	*Single phase fault and sequence like previous*
43.	FLT43-3PH	3 phase fault on the Pratt (539687) to Ninnescah (539648) 115kV line, near Pratt. a. Apply fault at the Pratt 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.
44.	FLT44-1PH	*Single phase fault and sequence like previous*
45.	FLT45-3PH	3 phase fault on the Pratt (539687) to Sawyer (539649) 115kV line, near Pratt. a. Apply fault at the Pratt 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.
46.	FLT46-1PH	*Single phase fault and sequence like previous*
47.	FLT47-3PH	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.
48.	FLT48-1PH	*Single phase fault and sequence like previous*
49.	FLT49-3PH	3 phase fault on the Spearville 230kV (539695) to 115kV (539694) transformer, near the 230 kV bus. a. Apply fault at the Spearville 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
50.	FLT50-3PH	3 phase fault on the GEN-2001-039A (579025) to Fort Dodge (539671) 115kV line, near GEN-2001-039A. a. Apply fault at the GEN-2001-039A 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.
51.	FLT51-1PH	*Single phase fault and sequence like previous*
52.	FLT52-3PH	3 phase fault on the Axtell (640065) to Pauline (640312) 345kV line, near Axtell. a. Apply fault at the Axtell 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.
53.	FLT53-1PH	*Single phase fault and sequence like previous*

Cont. No.	Cont. Name	Description
54.	FLT54-3PH	3 phase fault on the Axtell (640065) to Sweetwater (640374) 345kV line, near Axtell. a. Apply fault at the Axtell 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.
55.	FLT55-1PH	*Single phase fault and sequence like previous*
56.	FLT56-3PH	3 phase fault on the GEN-2001-039A (579025) to Greenburg (539664) 115kV line, near GEN-2001-039A. a. Apply fault at the GEN-2001-039A 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.
57.	FLT57-1PH	*Single phase fault and sequence like previous*

4.2 Further Model Preparation

The base cases contain prior queued projects as shown in Table 2.

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.

Table 2: Prior Queued Projects Included

Project	MW
Montezuma	110
GEN-2002-025A	150
GEN-2003-019	250
GEN-2005-012	160
GEN-2006-021	101
GEN-2007-040	133
GEN-2008-018	369
GEN-2008-079	100.5

4.3 Results

Results of the stability analysis are summarized in Table 3. These results are valid for GEN-2001-039A interconnecting with a generation amount up to 104.0MW with Balanced Portfolio Projects Spearville-Post Rock 345kV in-service. The results indicate that for all contingencies studied the transmission system remains stable when using GE xle 1.6MW wind turbine generators.

Sample plots are shown in Appendix A. All plots are available upon request.

Table 3: Results of Simulated Contingencies

Cont. No.	Cont. Name	Description	2011 Summer	2011 Winter
1.	FLT01-3PH	3 phase fault on the Woodward (515375) to Tatonga (515407) 345kV line, near Woodward.	Stable	Stable
2.	FLT02-1PH	*Single phase fault and sequence like previous*	Stable	Stable
3.	FLT03-3PH	3 phase fault on the Finney (523853) to Hitchland (523097) 345kV line, near Finney.	Stable	Stable
4.	FLT04-1PH	*Single phase fault and sequence like previous*	Stable	Stable
5.	FLT05-3PH	3 phase fault on one of the Finney (523853) to Holcomb (531449) 345kV lines, near Finney.	Stable	Stable
6.	FLT06-1PH	*Single phase fault and sequence like previous*	Stable	Stable
7.	FLT07-3PH	3 phase fault on the Finney (523853) to Lamar (599950) 345kV line, near Finney.	Stable	Stable
8.	FLT08-1PH	*Single phase fault and sequence like previous*	Stable	Stable
9.	FLT09-3PH	3 phase fault on the Knoll (530558) to Post Rock (530584) 230kV line, near Knoll.	Stable	Stable
10.	FLT10-1PH	*Single phase fault and sequence like previous*	Stable	Stable
11.	FLT11-3PH	3 phase fault on the Knoll (530558) to Smoky Hills (530592) 230kV line, near Knoll.	Stable	Stable
12.	FLT12-1PH	*Single phase fault and sequence like previous*	Stable	Stable
13.	FLT13-3PH	3 phase fault on the GEN-2007-040 (531000) to Holcomb (531449) 345kV line, near GEN-2007-040.	Stable	Stable
14.	FLT14-1PH	*Single phase fault and sequence like previous*	Stable	Stable
15.	FLT15-3PH	3 phase fault on the GEN-2007-040 (531000) to Spearville (531469) 345kV line, near GEN-2007-040.	Stable	Stable
16.	FLT16-1PH	*Single phase fault and sequence like previous*	Stable	Stable
17.	FLT17-3PH	3 phase fault on the Pioneer (531391) to Hickock (531378) 115kV line, near Pioneer.	Stable	Stable
18.	FLT18-1PH	*Single phase fault and sequence like previous*	Stable	Stable
19.	FLT19-3PH	3 phase fault on the Pioneer (531391) to PK Goab (531400) 115kV line, near Pioneer.	Stable	Stable
20.	FLT20-1PH	*Single phase fault and sequence like previous*	Stable	Stable
21.	FLT21-3PH	3 phase fault on the Holcomb 345kV (531449) to 115kV (531448) transformer, near the 345 kV bus.	Stable	Stable
22.	FLT22-3PH	3 phase fault on the Holcomb (531449) to Setab (531465) 345kV line, near Holcomb.	Stable	Stable
23.	FLT23-1PH	*Single phase fault and sequence like previous*	Stable	Stable
24.	FLT24-3PH	3 phase fault on the Spearville 345kV (531469) to 230kV (539695) transformer, near the 345 kV bus.	Stable	Stable

Cont. No.	Cont. Name	Description	2011 Summer	2011 Winter
25.	FLT25-3PH	3 phase fault on the Hugoton (531481) to Walkmyr (531405)115kV line, near Hugoton.	Stable	Stable
26.	FLT26-1PH	*Single phase fault and sequence like previous*	Stable	Stable
27.	FLT27-3PH	3 phase fault on the Hugoton (531481) to Grant Tap (531483)115kV line, near Hugoton.	Stable	Stable
28.	FLT28-1PH	*Single phase fault and sequence like previous*	Stable	Stable
29.	FLT29-3PH	3 phase fault on the Kismet (539646) to CMRIVTP (539652) 115kV line, near Kismet.	Stable	Stable
30.	FLT30-1PH	*Single phase fault and sequence like previous*	Stable	Stable
31.	FLT31-3PH	3 phase fault on the Kismet (539646) to Cudahy (539659) 115kV line, near Kismet.	Stable	Stable
32.	FLT32-1PH	*Single phase fault and sequence like previous*	Stable	Stable
33.	FLT33-3PH	3 phase fault on the CMRIVTP (539652) to E-Liberty (539672) 115kV line, near CMRIVTP.	Stable	Stable
34.	FLT34-1PH	*Single phase fault and sequence like previous*	Stable	Stable
35.	FLT35-3PH	3 phase fault on the Cudahy (539659) to GEN-2008-079 Tap (573029) 115kV line, near Cudahy.	Stable	Stable
36.	FLT36-1PH	*Single phase fault and sequence like previous*	Stable	Stable
37.	FLT37-3PH	3 phase fault on the Medicine Lodge (539673) to Sun City (539697) 115kV line, near Medicine Lodge.	Stable	Stable
38.	FLT38-1PH	*Single phase fault and sequence like previous*	Stable	Stable
39.	FLT39-3PH	3 phase fault on the Mullergren (539679) to South Hays (530582) 230kV line, near Mullergren.	Stable	Stable
40.	FLT40-1PH	*Single phase fault and sequence like previous*	Stable	Stable
41.	FLT41-3PH	3 phase fault on the Mullergren (539679) to Circle (532871) 230kV line, near Mullergren.	Stable	Stable
42.	FLT42-1PH	*Single phase fault and sequence like previous*	Stable	Stable
43.	FLT43-3PH	3 phase fault on the Pratt (539687) to Ninnescah (539648) 115kV line, near Pratt.	Stable	Stable
44.	FLT44-1PH	*Single phase fault and sequence like previous*	Stable	Stable
45.	FLT45-3PH	3 phase fault on the Pratt (539687) to Sawyer (539649) 115kV line, near Pratt.	Stable	Stable
46.	FLT46-1PH	*Single phase fault and sequence like previous*	Stable	Stable
47.	FLT47-3PH	3 phase fault on the Spearville (539695) to Mullergren (539679) 230kV line, near Spearville.	Stable	Stable
48.	FLT48-1PH	*Single phase fault and sequence like previous*	Stable	Stable
49.	FLT49-3PH	3 phase fault on the Spearville 230kV (539695) to 115kV (539694) transformer, near the 230 kV bus.	Stable	Stable

Cont. No.	Cont. Name	Description	2011 Summer	2011 Winter
50.	FLT50-3PH	3 phase fault on the GEN-2001-039A (579025) to Fort Dodge (539671) 115kV line, near GEN-2001-039A.	Stable	Stable
51.	FLT51-1PH	*Single phase fault and sequence like previous*	Stable	Stable
52.	FLT52-3PH	3 phase fault on the Axtell (640065) to Pauline (640312) 345kV line, near Axtell.	Stable	Stable
53.	FLT53-1PH	*Single phase fault and sequence like previous*	Stable	Stable
54.	FLT54-3PH	3 phase fault on the Axtell (640065) to Sweetwater (640374) 345kV line, near Axtell.	Stable	Stable
55.	FLT55-1PH	*Single phase fault and sequence like previous*	Stable	Stable
56.	FLT56-3PH	3 phase fault on the GEN-2001-039A (579025) to Greenburg (539664) 115kV line, near GEN-2001-039A.	Stable	Stable
57.	FLT57-1PH	*Single phase fault and sequence like previous*	Stable	Stable

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.

Two fault contingencies were developed to verify that the wind farm will remain on line when the POI voltage is drawn down to 0.0 pu. These contingencies are shown in Table 4.

Table 4: LVRT Fault Contingencies

Cont. Name	Description
FLT50-3PH	3 phase fault on the GEN-2001-039A (579025) to Fort Dodge (539671) 115kV line, near GEN-2001-039A. a. Apply fault at the GEN-2001-039A 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.
FLT56-3PH	3 phase fault on the GEN-2001-039A (579025) to Greenburg (539664) 115kV line, near GEN-2001-039A. a. Apply fault at the GEN-2001-039A 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.

The project wind farm remained online for the fault contingencies described in this section and for all the fault contingencies described in Table 1. GEN-2001-039A is found to be in compliance with FERC Order #661A.

5.0 Power Factor Analysis

The objective of this task is to quantify the power factor at the point of interconnection for the wind farm during base case and system contingencies. SPP transmission planning practice requires interconnecting generation projects to maintain the power factor (pf) at the Point of Interconnection (POI) near unity for system intact conditions and within +/- 0.95 pf for post-contingency conditions. This is analyzed by having the wind farm maintain a prescribed voltage schedule at the point of interconnection of 1.0 p.u. voltage, or if the pre-project voltage is higher than 1.0 p.u., to maintain the pre-project voltage schedule.

5.1 Approach

The study project was turned off during the power factor analysis. The wind farm was then replaced by a generator modeled at the POI with the same real power (MW) capability as the project wind farm and open limits for the reactive power set points (Mvar). The generator was set to hold the POI scheduled bus voltage. Contingencies from the three-phase fault definitions shown in Table 5 were then applied and the reactive power required to maintain the bus voltage was recorded.

The pre-project voltage at the POI (Bus 579025) for the summer peak conditions was 0.9992 p.u. and for the winter peak conditions was 1.0106 p.u. Therefore, the scheduled voltage for the POI was set to 1.00 p.u. for summer and 1.0106 p.u.for the winter peak conditions.

5.2 Results

The power factor was calculated for summer and winter peak conditions. Table 5 shows the power factor results for GEN-2001-039A (104.0 MW). Note that a negative Q (Mvar) output illustrates that the generator is absorbing reactive power from the system, implying a leading power factor; a positive Q (Mvar) illustrates that the generator is supplying reactive power to the system, implying a lagging power factor.

Table 5: Power Factor Analysis

Contingency	Summer			Winter		
(Pgen=104.0MW)	**MVAR**	**PF**		**MVAR**	**PF**	
System Intact	-11.20	0.994	Leading	-8.50	0.997	Leading
GEN-2001-039A to Greenburg 115kV	-11.80	0.994	Leading	-14.50	0.990	Leading
GEN-2001-039A to Fort Dodge 115kV	-10.00	0.995	Leading	-9.30	0.996	Leading
Fort Dodge to DCBeef 115kV	-7.40	0.997	Leading	-4.50	0.999	Leading
Fort Dodge to N. Fort Dodge 115kV	-10.50	0.995	Leading	-4.40	0.999	Leading
Fort Dodge to GEN-2008-079 Tap 115kV	-12.00	0.993	Leading	-9.00	0.996	Leading
Greenburg to Sun City 115kV	-19.50	0.983	Leading	-21.90	0.979	Leading
Sawyer to Medicine Lodge 115kV	-25.10	0.972	Leading	-17.60	0.986	Leading
GEN-2008-079 Tap to Cudahy 115kV	6.80	0.998	Lagging	12.40	0.993	Lagging
N. Fort Dodge to Spearville 115kV	21.90	0.979	Lagging	34.90	0.948	Lagging
Medicine Lodge 115/138kV Transformer	-1.10	1.000	Leading	-4.30	0.999	Leading
Spearville 115/230kV Transformer	20.40	0.981	Lagging	34.00	0.950	Lagging

Notes:

1. Lagging is when the generating plant is supplying reactive power to the transmission grid. In this situation, the alternating current sinusoid "lags" behind the alternating voltage sinusoid, meaning that the current peaks shortly after the voltage.
2. Leading is when the generating plant is taking reactive power from the transmission grid. In this situation, the alternating current sinusoid "leads" the alternating voltage sinusoid, meaning that the current peaks shortly before the voltage.

6.0 Conclusion

<OMITTED TEXT> (Customer) has requested an impact restudy under the Southwest Power Pool Open Access Transmission Tariff (OATT) for the interconnection of 105.0 MW of wind generation within the balancing authority of Mid-Kansas Electric Company (MKEC) in Kiowa County, Kansas. The proposed point of interconnection is a new MKEC 115kV substation located on the Fort Dodge to Greensburg 115kV transmission line. The wind farm facility had been previously studied using the Clipper C93G1 2.5MW wind turbines. In this impact restudy the Interconnection Customer has requested a change in wind turbine generators to the GE xle 1.6MW machines.

The stability analysis results show that, for both the Near Term cases and the Far Term cases (see Far Term report in Appendix B), the wind generation facility and the transmission system remain stable for all contingencies studied when using the GE xle 1.6MW wind turbine generators. Also, GEN-2001-039A is found to be in compliance with FERC Order #661A.

A power factor analysis was performed for both the Near Term and the Far Term cases. The facility will be required to maintain a 95% lagging (providing vars) and 95% leading (absorbing vars) power factor at the point of interconnection.

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: SAMPLE PLOTS for Near Term Cases

2010 SERIES MDWG WITH 2009 SERIES ERAG MMWG
2011 SUMMER MDWG WITH 2011 SUMMER MMWG; FOR DYN; RED DYN

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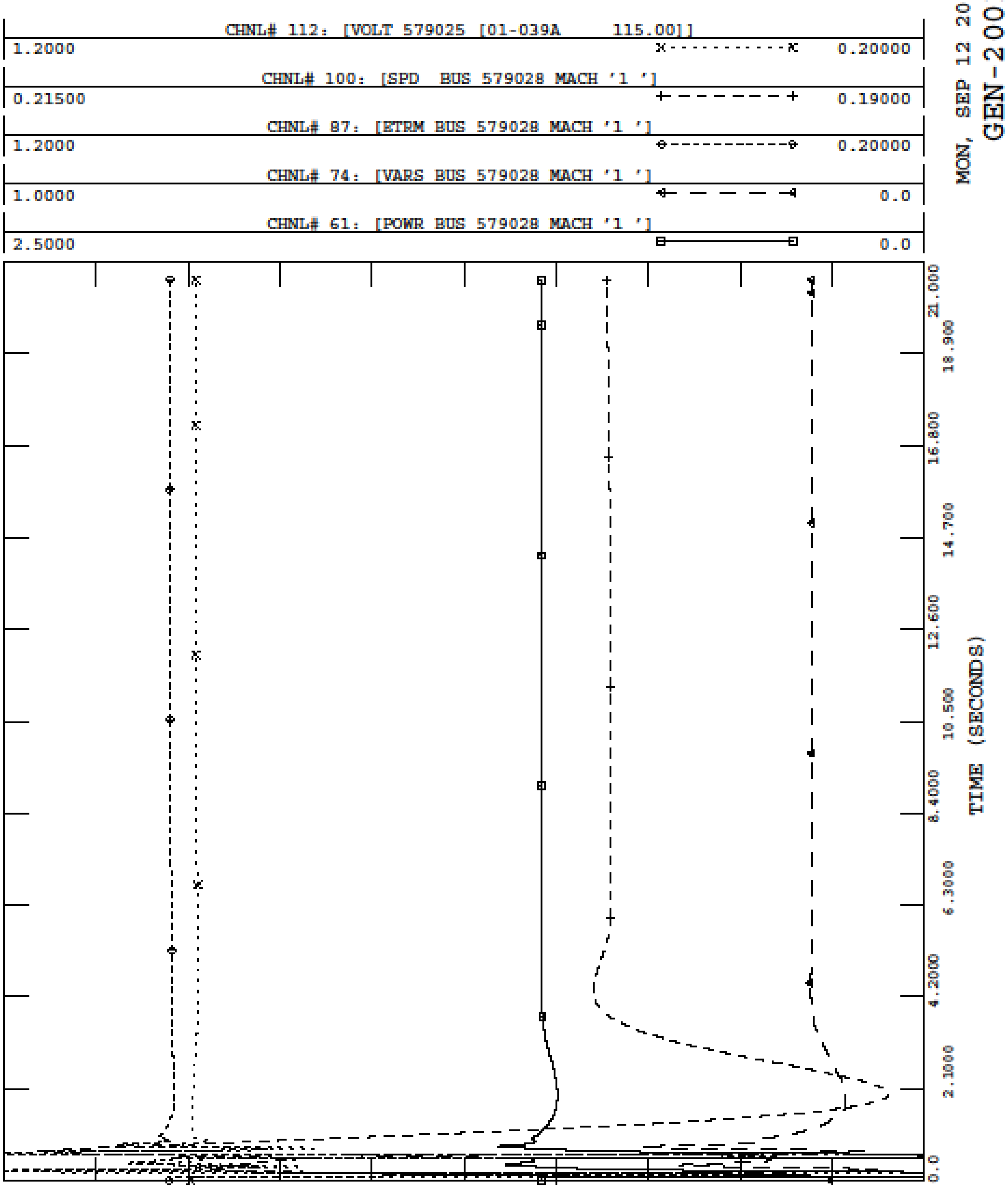

2010 SERIES MDWG WITH 2009 SERIES ERAG MMWG
2011 SUMMER MDWG WITH 2011 SUMMER MMWG; FOR DYN; RED DYN

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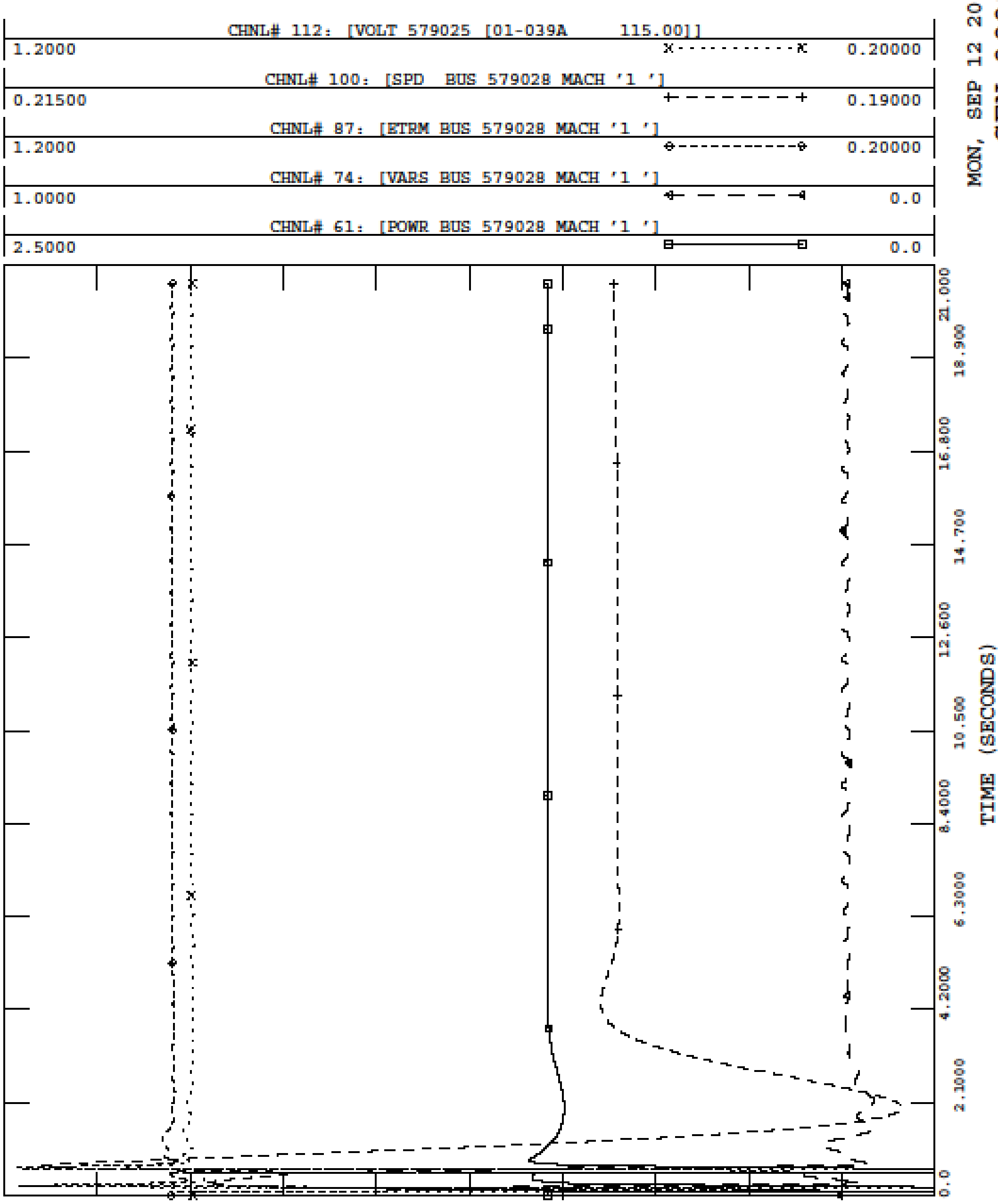
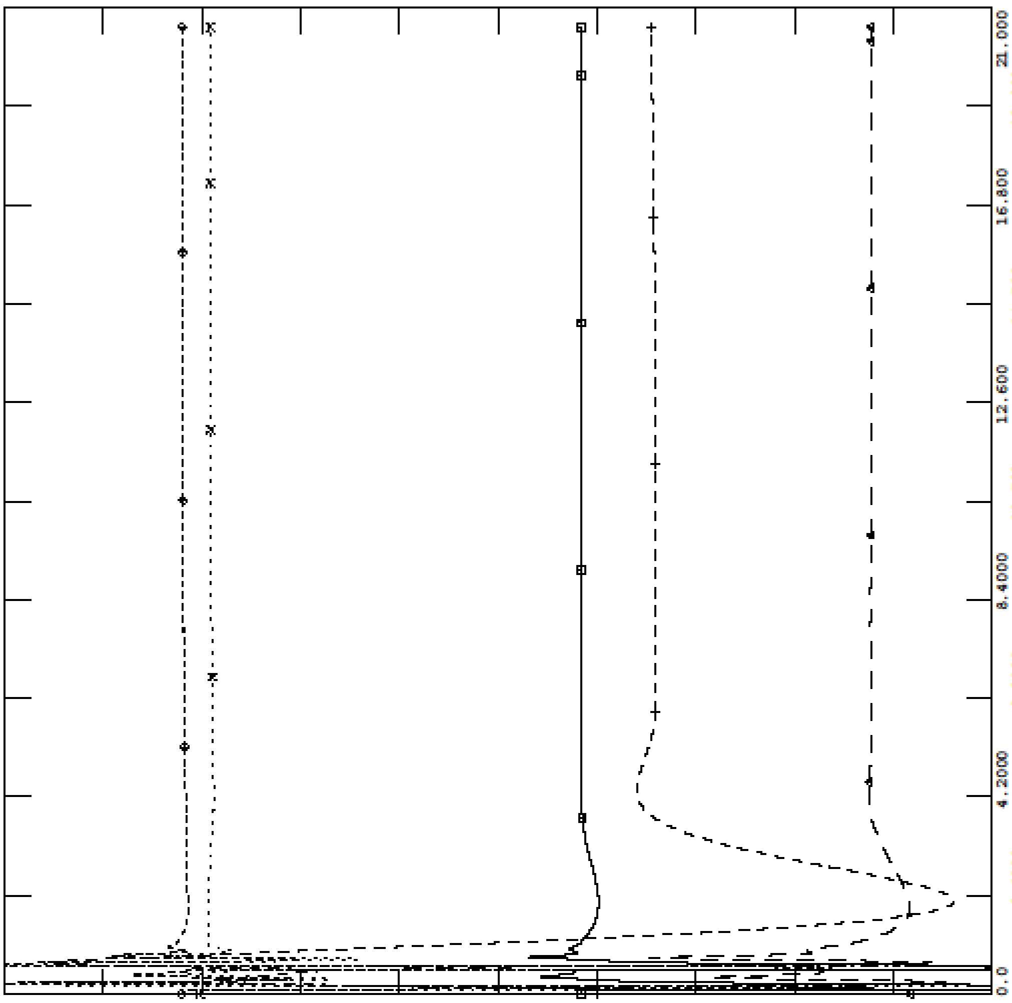
MON, SEP 12 2011 11:44
GEN-2001-039A



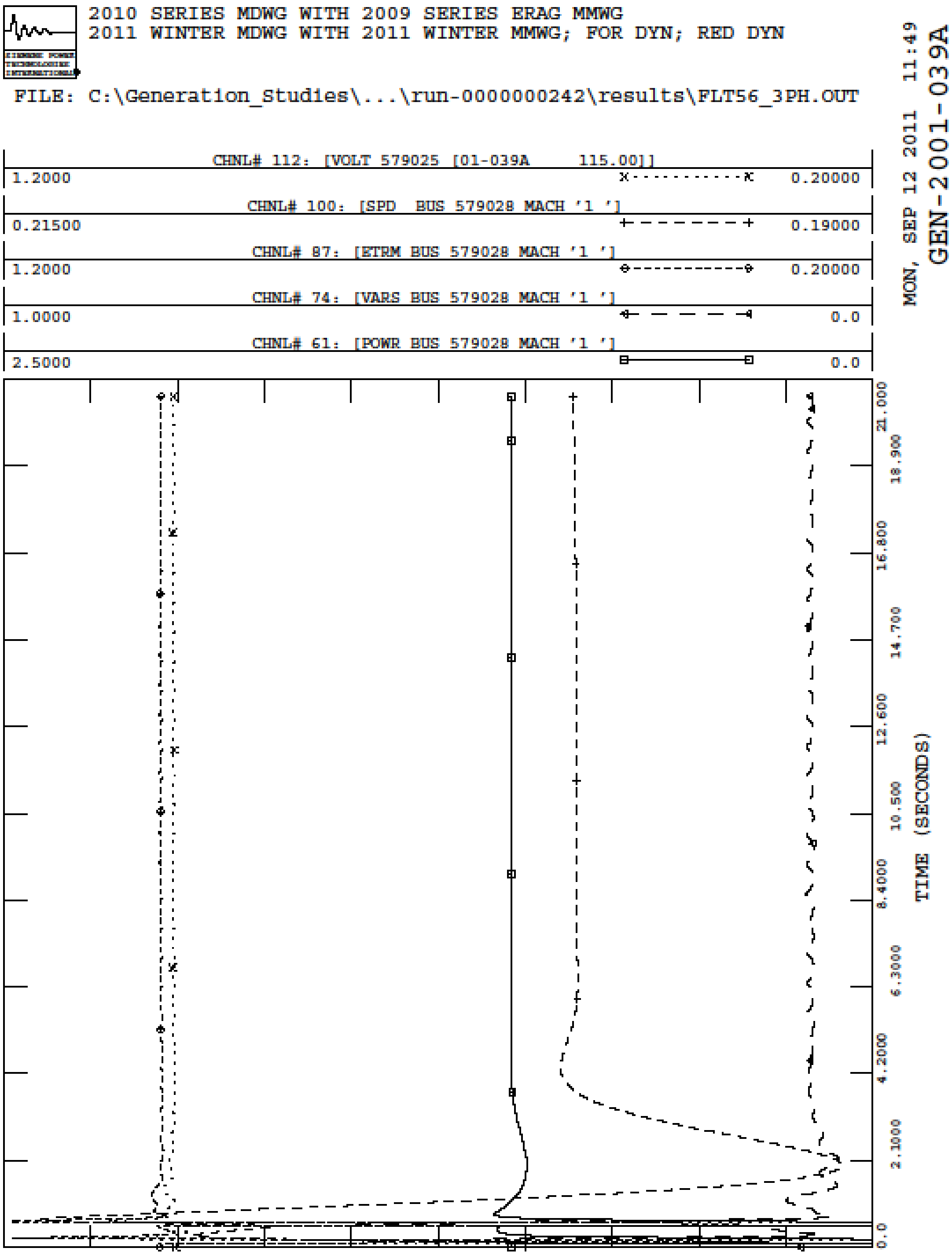
2010 SERIES MDWG WITH 2009 SERIES ERAG MMWG
2011 WINTER MDWG WITH 2011 WINTER MMWG; FOR DYN; RED DYN

FILE: C:\Generation_Studies\...\run-0000000242\results\FLT50_3PH.OUT

CHNL# 112: [VOLT 579025 [01-039A 115.00]]		
1.2000	x-----------x	0.20000
CHNL# 100: [SPD BUS 579028 MACH '1 ']		
0.21500	+-------+	0.19000
CHNL# 87: [ETRM BUS 579028 MACH '1 ']		
1.2000	◇-----------◇	0.20000
CHNL# 74: [VARS BUS 579028 MACH '1 ']		
1.0000	◁— — — —◁	0.0
CHNL# 61: [POWR BUS 579028 MACH '1 ']		
2.5000	□————□	0.0



MON, SEP 12 2011 11:52
GEN-2001-039A


2010 SERIES MDWG WITH 2009 SERIES ERAG MMWG
2011 WINTER MDWG WITH 2011 WINTER MMWG; FOR DYN; RED DYN
FILE: C:\Generation_Studies\...\run-0000000242\results\FLT56_3PH.OUT
CHNL# 112: [VOLT 579025 [01-039A 115.00]]
1.2000
0.20000
CHNL# 100: [SPD BUS 579028 MACH '1 ']
0.21500
0.19000
CHNL# 87: [ETRM BUS 579028 MACH '1 ']
1.2000
0.20000
CHNL# 74: [VARS BUS 579028 MACH '1 ']
1.0000
0.0
CHNL# 61: [POWR BUS 579028 MACH '1 ']
2.5000
0.0
MON, SEP 12 2011 11:49
GEN-2001-039A
0.0
2.1000
4.2000
6.3000
8.4000
10.500
12.600
14.700
16.800
18.900
21.000
TIME (SECONDS)

APPENDIX B: FAR TERM STUDY (Transmission System Conditions Beyond December 31, 2014)

SPP GEN-2001-039A Impact Restudy

Final Report for

Southwest Power Pool

Prepared by:
Excel Engineering, Inc.

August 31, 2011

Principal Contributor:

Shu Liu, P.E.
William Quaintance, P.E.

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0. Certification

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the Laws of the State of **Kansas**.

William Quaintance
Kansas License Number: 20756

Excel Engineering, Inc.
Kansas License Number: 1611

1. Background and Scope

The GEN-2001-039A Impact Restudy is a generation interconnection study performed by Excel Engineering, Inc. for its non-affiliated client, Southwest Power Pool (SPP). Its purpose is to study the impacts of interconnecting the project shown in Table 1-1. The in-service date assumed for the generation addition was 2011.

Table 1-1. Interconnection Requests Evaluated in this Study

Request	Size (MW)	Wind Turbine Model	Point of Interconnection	POI Bus	Gen Buses
GEN-2001-039A	104	GE 1.6MW	Tap on Fort Dodge (539671) – Greensburg (539664) 115kV line	579025	579028

The prior-queued requests shown in Table 1-2 were included in this study and dispatched at 100% of rated capacity.

The study included stability analysis of the proposed interconnection request. Contingencies that resulted in a prior-queued project tripping off-line, if any, were re-run with the prior-queued project's voltage and frequency tripping disabled. A power factor analysis was performed for the wind farm in Table 1-1.

ATC (Available Transfer Capability) studies were not performed as part of this study. These studies will be required at the time transmission service is actually requested. Additional transmission upgrades may be required based on that analysis.

Study assumptions in general have been based on Excel's knowledge of the electric power system and on the specific information and data provided by SPP. The accuracy of the conclusions contained within this study is sensitive to the assumptions made with respect to generation additions and transmission improvements being contemplated. Changes in the assumptions of the timing of other generation additions or transmission improvements will affect this study's conclusions.

Table 1-2. Nearby Interconnection Requests Already in the Queue

Request	Size	Wind Turbine Model	Point of Interconnection	POI Bus	Gen Buses
GEN-2002-025A	150.0	GE 1.5 MW	Spearville 230kV	539695	562102
GEN-2004-014	154.5	GE 1.5 MW	Spearville 230kV	539695	562701
GEN-2005-012	250.7	Siemens 2.3MW	Spearville 345kV	531469	561803 561805
GEN-2006-006	205.5	GE 1.5 MW	Spearville 345kV	531469	562704
GEN-2006-021	100.0	Clipper 2.5MW	Tap on Harper – Medicine Lodge 138kV line	539638	579142
GEN-2006-022	150.0	Clipper 2.5MW	Pratt 115kV	539687	579146
GEN-2007-038	200.0	Clipper 2.5MW	Spearville 345kV	531469	579277 579278
GEN-2008-018	405.0	GE 1.5 MW	2008-018POI 345kV	531010	579430 579431
GEN-2007-040	200.1	Siemens 2.3MW	Tap on Holcomb – Spearville 345kV line	531000	579288
GEN-2008-079	99.5	GE 1.6 MW	Tap on Cudahy – Judson Large 115kV line	573029	573023 573025
GEN-2008-124	200.1	Siemens 2.3MW	Spearville 345kV	531469	579483 579485
GEN-2010-009	165.6	Siemens SWT 2.3MW	Tap on Holcomb – Spearville 345kV line	531000	575124
GEN-2010-015	200.1	Siemens SWT 2.3MW	Spearville 345kV	531469	576300 576310
GEN-2010-016	199.8	Vestas V90 1.8MW	Tap on Spearville – Post Rock 345kV line	576704	576700

2. Executive Summary

The GEN-2001-039A Impact Restudy evaluated the impacts of interconnecting the Table 1-1 study projects to the SPP transmission system.

No stability problems were found during summer or winter peak conditions due to the addition of this project.

Power factor requirements for the study projects are listed in Table 4-2.

With the assumptions described in this report, the study project should be able to connect without causing any stability problems on the SPP transmission grid.

Any change in system or wind farm models or assumptions could change these results.

3. Study Development and Assumptions

3.1 Simulation Tools

The Siemens Power Technologies, Inc. PSS/E power system simulation program Version 30.3.3 was used in this study.

3.2 Models Used

SPP provided its latest stability database cases for both summer and winter peak seasons.

The model included the study and prior-queued projects.

Power flow one-line diagram of the study project in summer peak conditions is shown in Figure 3-1. As the figure shows, the wind farm model includes explicit representation of the radial transmission line, the substation transformer(s) from transmission voltage to 34.5kV. The remainder of each wind farm is represented by one or more lumped equivalents including a generator, a step-up transformer, and a collector system impedance.

Steady-state and dynamic model data for the study plant are given in Appendix D.

No special modeling is required of line relays in these cases, except for the special modeling related to the wind-turbine tripping.

3.3 Monitored Facilities

All generators and transmission buses in Areas 520, 524, 525, 526, 531, 534, 536, 539, and 541 were monitored.

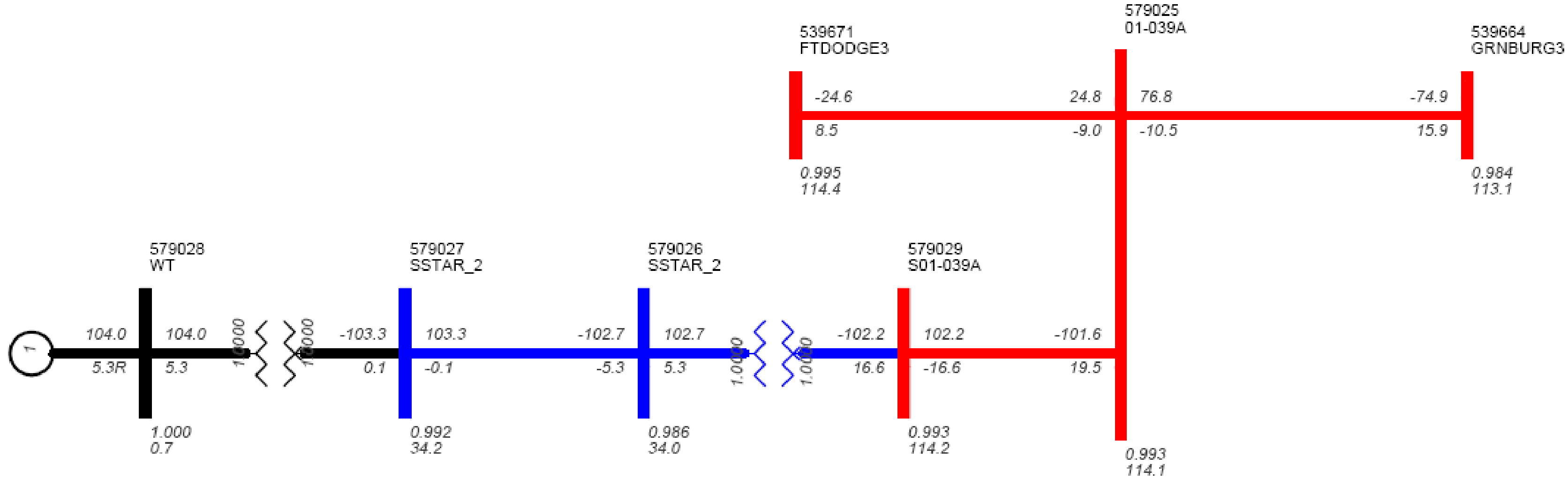

Figure 3-1. Power Flow One-line for GEN-2001-039A and adjacent equipment

3.4 Performance Criteria

Wind generators must comply with FERC Order 661A on low voltage ride through for wind farms. Therefore, the wind generators should not trip off line for faults for under voltage relay actuation. If a wind generator trips off line, an appropriately sized SVC or STATCOM device may need to be specified to keep the wind generator on-line for the fault. SPP was consulted to determine if the addition of an SVC or STATCOM is warranted for the specific condition.

Contingencies that resulted in a prior-queued project tripping off-line, if any, were re-run with the prior-queued project's voltage and frequency tripping disabled to check for stability issues.

3.5 Performance Evaluation Methods

A power factor analysis was performed for all study projects that are wind farms. The power factor analysis consisted of modeling a var generator in each wind farm holding a voltage schedule at the POI. The voltage schedule was set to the higher of the voltage with the wind farm off-line or 1.0 per unit.

If the required power factor at the POI is beyond the capability of the studied wind turbines, then capacitor banks would be considered. Factors used in sizing capacitor banks would include two requirements of FERC Order 661A: the ability of the wind farm to ride through low voltage with and without capacitor banks and the ability of the wind farm to recover to pre-fault voltage. If a wind generator trips on high voltage, a leading power factor may be required.

ATC studies were not performed as part of this study. These studies will be required at the time transmission service is actually requested. Additional transmission facilities may be required based on subsequent ATC analysis.

Stability analysis was performed for the proposed interconnection request. Faults were simulated on transmission lines at the POIs and on other nearby transmission equipment. The faults in Table 3-1 were run for each case (three phase and single phase as noted).

Table 3-1. Fault Definitions for GEN-2001-039A Impact Restudy

Cont. No.	Contingency Name	Description
1	FLT01-3PH	3 phase fault on the 01-039A (579025) to GRNBURG (539664) 115kV line, near 01-039A. a. Apply fault at the 01-039A 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.
2	FLT02-1PH	*Single phase fault and sequence like previous*
3	FLT03-3PH	3 phase fault on the 01-039A (579025) to FTDODGE (539671) 115kV line, near 01-039A. a. Apply fault at the 01-039A 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	FLT04-1PH	*Single phase fault and sequence like previous*
5	FLT05-3PH	3 phase fault on the FTDODGE (539671) to DCBEEF (539645) 115kV line, near FTDODGE. a. Apply fault at the FTDODGE115kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
6	FLT06-1PH	*Single phase fault and sequence like previous*
7	FLT07-3PH	3 phase fault on the FTDODGE (539671) to NFTDODG (539771) CKT 2 115kV line, near FTDODGE. a. Apply fault at the FTDODGE115kV 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.
8	FLT08-1PH	*Single phase fault and sequence like previous*
9	FLT09-3PH	3 phase fault on the FTDODGE (539671) to G08-079-TAP (573029) 115kV line, near FTDODGE. a. Apply fault at the FTDODGE115kV 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 GRNBURG (539664) to SUNCITY (539697) 115kV line, near GRNBURG. a. Apply fault at the GRNBURG 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.
12	FLT12-1PH	*Single phase fault and sequence like previous*
13	FLT13-3PH	3 phase fault on the SAWYER (539649) to MED-LDG (539673) 115kV line, near GRNBURG. a. Apply fault at the GRNBURG 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.
14	FLT14-1PH	*Single phase fault and sequence like previous*

Cont. No.	Contingency Name	Description
15	FLT15-3PH	3 phase fault on the G08-079-TAP (573029) to CUDAHY (539659) 115kV line, near G08-079-TAP. a. Apply fault at the G08-079-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.
16	FLT16-1PH	*Single phase fault and sequence like previous*
17	FLT17-3PH	3 phase fault on the NFTDODG (539771) to SPEARVL (539694) CKT2 115kV line, near NFTDODG. a. Apply fault at the NFTDODG 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.
18	FLT18-1PH	*Single phase fault and sequence like previous*
19	FLT19-3H	3 phase fault on the MED-LDG 115kV (539673) to 138kV (539674) transformer, near the 115 kV bus. a. Apply fault at the MED-LDG 115kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
20	FLT20-3PH	3 phase fault on the SPEARVL 115kV (539694) to 230kV (539695) transformer, near the 115 kV bus. a. Apply fault at the SPEARVL 115kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
21	FLT21-3PH	3 phase fault on the SPEARVL 115kV (539694) to 345kV (531469) transformer, near the 115 kV bus. a. Apply fault at the SPEARVL 115kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
22	FLT22-3PH	3 phase fault on the MED-LDG 138kV (539674) to 345kV (765342) transformer, near the 138kV bus. a. Apply fault at the MED-LDG 138kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.

4. Results and Observations

4.1 Stability Analysis Results

Table 4-1 summarizes the results. Figure 4-1 through Figure 4-2 show representative summer peak season plots for faults at the POI's of the study project. Complete sets of plots for both summer and winter peak seasons for each fault are included in Appendices A and B.

The system remains stable for all simulated faults. The study project and the prior-queued projects stay on-line and are stable for all simulated faults.

Table 4-1. Summary of Stability Results

Cont. No.	Cont. Name	Description	Summer Peak Results	Winter Peak Results
1	FLT01-3PH	3 phase fault on the 01-039A (579025) to GRNBURG (539664) 115kV line, near 01-039A.	OK	OK
2	FLT02-1PH	*Single phase fault and sequence like previous*	OK	OK
3	FLT03-3PH	3 phase fault on the 01-039A (579025) to FTDODGE (539671) 115kV line, near 01-039A.	OK	OK
4	FLT04-1PH	*Single phase fault and sequence like previous*	OK	OK
5	FLT05-3PH	3 phase fault on the FTDODGE (539671) to DCBEEF (539645) 115kV line, near FTDODGE.	OK	OK
6	FLT06-1PH	*Single phase fault and sequence like previous*	OK	OK
7	FLT07-3PH	3 phase fault on the FTDODGE (539671) to NFTDODG (539771) CKT 2 115kV line, near FTDODGE.	OK	OK
8	FLT08-1PH	*Single phase fault and sequence like previous*	OK	OK
9	FLT09-3PH	3 phase fault on the FTDODGE (539671) to G08-079-TAP (573029) 115kV line, near FTDODGE.	OK	OK
10	FLT10-1PH	*Single phase fault and sequence like previous*	OK	OK
11	FLT11-3PH	3 phase fault on the GRNBURG (539664) to SUNCITY (539697) 115kV line, near GRNBURG.	OK	OK
12	FLT12-1PH	*Single phase fault and sequence like previous*	OK	OK
13	FLT13-3PH	3 phase fault on the SAWYER (539649) to MED-LDG (539673) 115kV line, near GRNBURG.	OK	OK
14	FLT14-1PH	*Single phase fault and sequence like previous*	OK	OK
15	FLT15-3PH	3 phase fault on the G08-079-TAP (573029) to CUDAHY (539659) 115kV line, near G08-079-TAP.	OK	OK
16	FLT16-1PH	*Single phase fault and sequence like previous*	OK	OK
17	FLT17-3PH	3 phase fault on the NFTDODG (539771) to SPEARVL (539694) CKT2 115kV line, near NFTDODG.	OK	OK
18	FLT18-1PH	*Single phase fault and sequence like previous*	OK	OK

Cont. No.	Cont. Name	Description	Summer Peak Results	Winter Peak Results
19	FLT19-3H	3 phase fault on the MED-LDG 115kV (539673) to 138kV (539674) transformer, near the 115 kV bus.	OK	OK
20	FLT20-3PH	3 phase fault on the SPEARVL 115kV (539694) to 230kV (539695) transformer, near the 115 kV bus.	OK	OK
21	FLT21-3PH	3 phase fault on the SPEARVL 115kV (539694) to 345kV (531469) transformer, near the 115 kV bus.	OK	OK
22	FLT22-3PH	3 phase fault on the MED-LDG 138kV (539674) to 345kV (765342) transformer, near the 138kV bus.	OK	OK

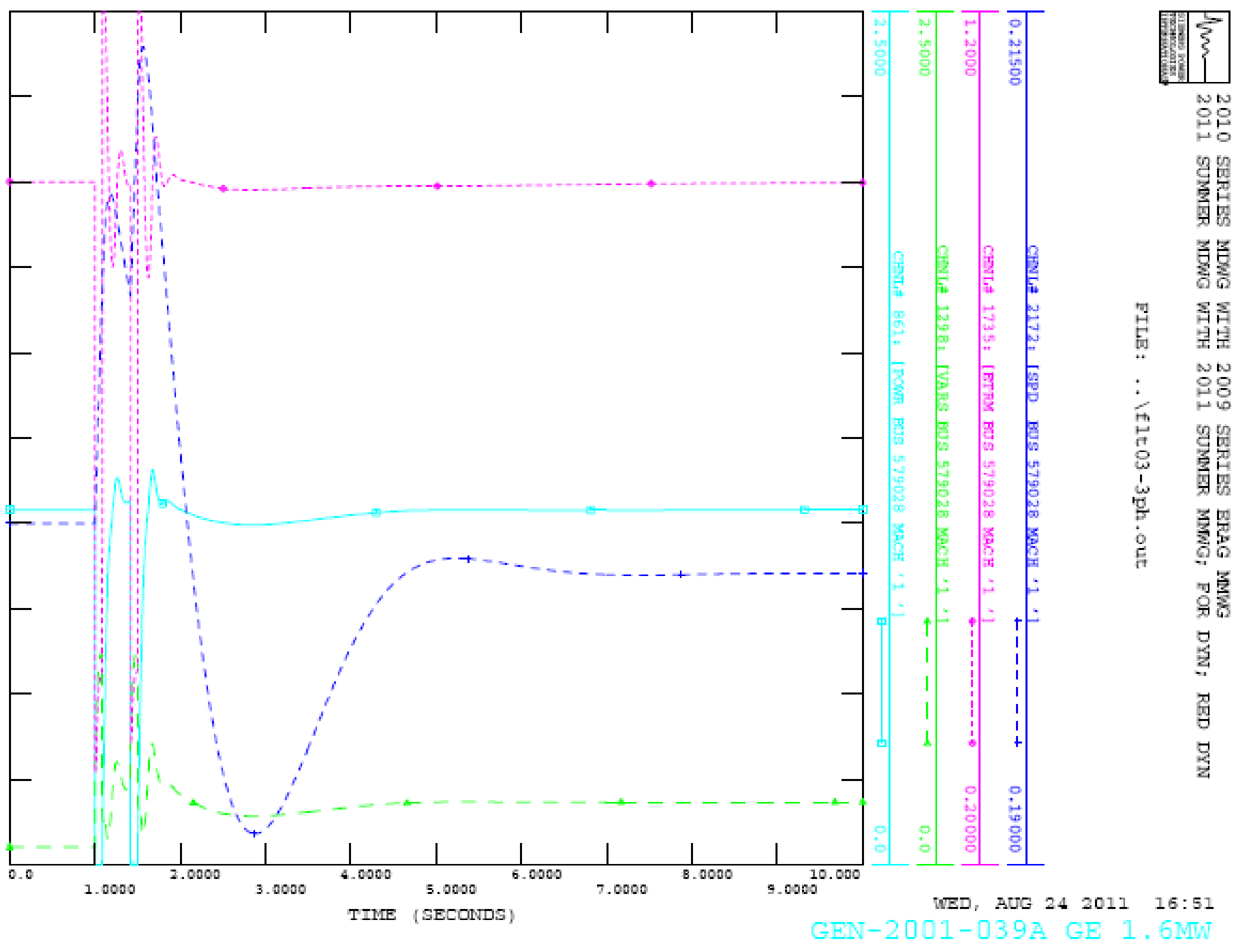

Figure 4-1. GEN-2001-039A Plot for Fault 3 – 3-Phase fault on the GEN-2001-039A Tap to FTDODGE 115kV line, near GEN-2001-039A Tap

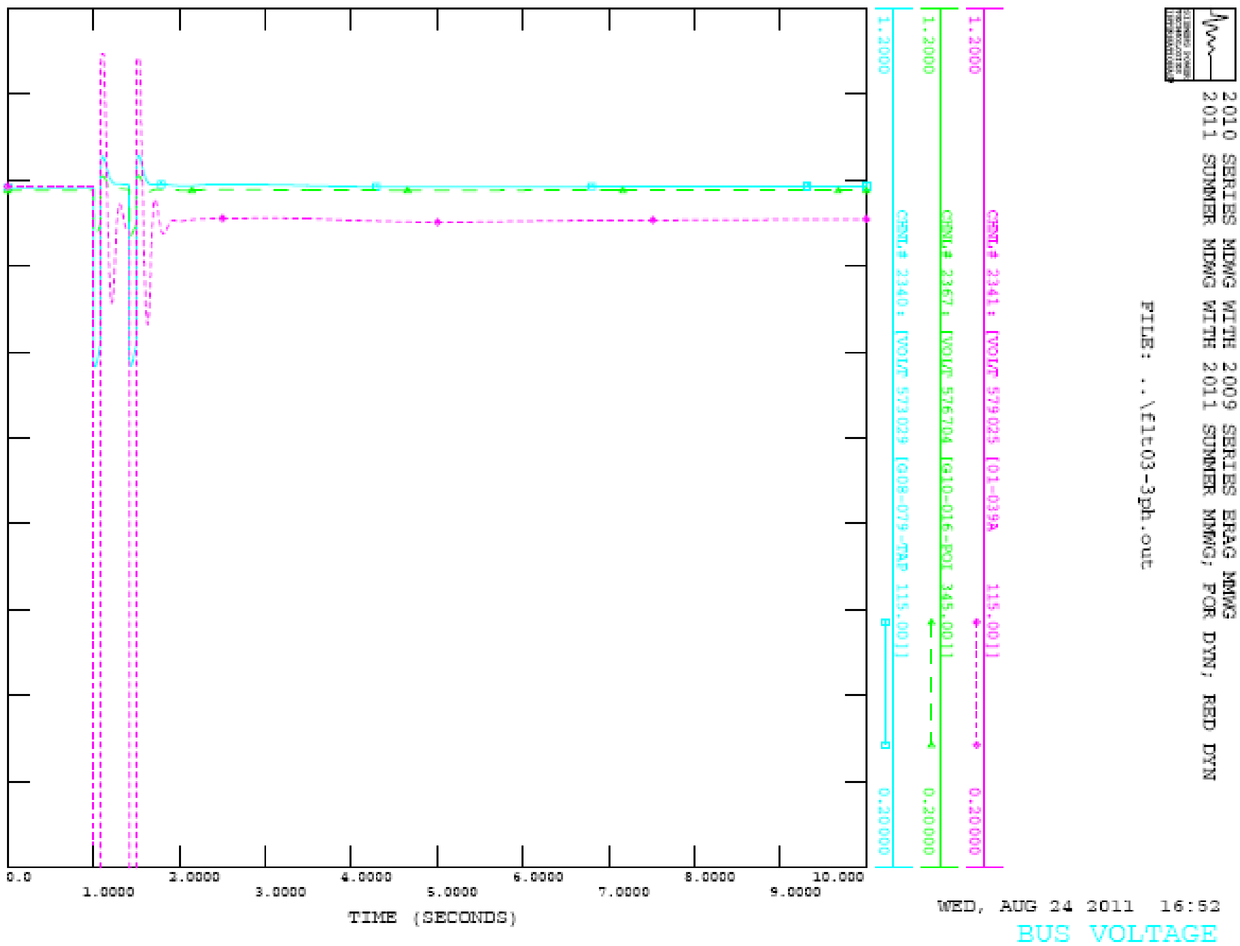

Figure 4-2. POI Voltages for Fault 3 – 3-Phase fault on the GEN-2001-039A Tap to FTDODGE 115kV line, near GEN-2001-039A Tap

4.2 Power Factor Requirements

All stability faults were tested as power flow contingencies to determine the power factor requirements for the wind farm study projects to maintain scheduled voltage at their respective points of interconnection (POI). The voltage schedules are set equal to the voltages at the POIs before the projects are added, with a minimum of 1.0 per unit. Fictitious reactive power sources were added to the study projects to maintain scheduled voltage during all studied contingencies. The MW and Mvar injections from the study projects at the POIs were recorded and the resulting power factors were calculated for all contingencies for summer peak and winter peak cases. The most leading and most lagging power factors determine the minimum power factor range capability that the study projects must install before commercial operation.

If more than one study project shared a single POI, the projects were grouped together and a common power factor requirement was determined for those study projects. This ensures that none of the study projects is required to provide more or less than its fair share of the reactive power requirements at a single POI. *Prior-queued* projects at the same POI, if any, were not grouped with the study projects because their interconnection requirements were determined in previous studies. The voltage schedules of prior-queued and study projects at the same POI were coordinated.

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 4-2 below. These are only the minimum power factor ranges based on steady-state analysis.

The full details for each contingency in summer and winter peak cases are given in Appendix C.

Table 4-2. Power Factor Requirements [1]

Request	Size (MW)	Generator Model	Point of Interconnection	Study PF Requirement	
				Lagging [2]	Leading [3]
GEN-2001-039A	104	GE 1.6MW	Tap on Fort Dodge – Greensburg 115kV line	1.000	0.980

Notes:

1. For each plant, 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.
2. Lagging is when the generating plant is supplying reactive power to the transmission grid. In this situation, the alternating current sinusoid “lags” behind the alternating voltage sinusoid, meaning that the current peaks shortly after the voltage.
3. Leading is when the generating plant is taking reactive power from the transmission grid. In this situation, the alternating current sinusoid “leads” the alternating voltage sinusoid, meaning that the current peaks shortly before the voltage.

5. Conclusions

The GEN-2001-039A Impact Restudy evaluated the impacts of interconnecting the project shown below.

Table 5-1. Interconnection Requests Evaluated in this Study

Request	Size (MW)	Wind Turbine Model	Point of Interconnection	POI Bus	Gen Buses
GEN-2001-039A	104	GE 1.6MW	Tap on Fort Dodge (539671) – Greensburg (539664) 115kV line	579025	579028

No stability problems were found during summer or winter peak conditions due to the addition of this project.

Final power factor for the study projects are listed in Table 4-2.

With the assumptions described in this report, the study project should be able to connect without causing any stability problems on the SPP transmission grid.

Any change in system or wind farm models or assumptions could change these results.

Appendix A –Summer Peak Plots

See attachments.

Appendix B –Winter Peak Plots

See attachments.

Appendix C – Power Factor Details

See attachment.

Appendix D – Project Model Data

See attachment.