Southwest Power Pool

GEN-2009-020
Impact Restudy

SPP Generation
Interconnection Studies

GEN-2009-020

February 2011

Executive Summary

This report contains the findings of a restudy of GEN-2009-020. The GEN-2009-020 interconnection request was studied as part of the DISIS-2010-001 Definitive Impact Study, Cluster Group #11, which was originally posted in July 2010. A subsequent restudy was posted 1/31/2011. The original report showed that GEN-2009-020 will require a +/- 15 Mvar Static Var Compensator. With the power factor requirements, and all network upgrades in service, all interconnection request in Group 11 will meet FERC Order #661A low voltage ride through (LVRT) requirements and the transmission system will remain stable. The final PF requirements of the original report at the point of interconnection were 1.0 (Lagging) and 0.98 (Leading).

This restudy was performed solely to evaluate the effects of a turbine manufacturer change of switching wind turbine manufacturers from Vestas (V90-1.8MW) for 48.6MW to GE (1.6MW) for 49.6MW. The requested In-Service Date is 12/31/2011. This study looked at interconnection at Balzine (530585) – Nekoma (530564) 69kV (Bus 575040) with and interconnection injection of 49.6MW. The restudy results for the final PF requirements at the point of interconnection are 0.999 (Lagging) and 0.977 (Leading) with no additional power factor compensation required.

The findings of the restudy show that for no stability problems were found during summer or winter peak conditions due to the addition of these generators.

Power factor requirements were determined as shown in Table 4-2 of the report below. However, any change in wind turbine model or controls could change the results.

With the assumptions outlined in this report, GEN-2009-020 should be able to reliably connect to the SPP transmission grid.

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.

SPP GEN-2009-020 Restudy

Draft Report for

Southwest Power Pool

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February 8, 2011

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TABLE OF CONTENTS

List of Figures

List of Tables

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 Registration Number: 20756

Excel Engineering, Inc.
Kansas Authorization Number: 1611

1. Background and Scope

The GEN-2009-020 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

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2009-020	49.6	GE 1.6MW	Balzine (530585) – Nekoma (530564) 69kV (Bus 575040)

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

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

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2003-006A	200	Vestas V90 3.0MW	Elm Creek 230kV (539639)
GEN-2003-019	250	GE 1.5MW	Smoky Hills 230kV (530592)
GEN-2006-031	75	Gas	Knoll 115kV (530561)
GEN-2006-032	200	Gamesa 2.0MW	South Hays 230kV (530582)
GEN-2008-092	200	GE 1.5MW	Knoll 230kV (530558)
GEN-2009-011	50	Gamesa 2.0MW	Tap Plainville (539686) – Phillipsburg (539685) 115kV. (Bus 570911)
GEN-2009-008	199.5	GE 1.5MW	South Hays (530582) 230kV
GEN-2009-040	73.8	Vestas V90 1.8MW	Smittyville (533338) – Knob Hill (533332) 115kV (Bus 560287)

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 other generation additions and transmission improvements being contemplated by other entities. Changes in the assumptions of the timing of other generation additions or transmission improvements will affect this study's conclusions.

2. Executive Summary

The GEN-2009-020 Restudy evaluated the impacts of interconnecting the project to the SPP electric system with GE 1.6 MW wind turbines.

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

Power factor requirements were determined as shown in Table 4-2. However, any change in wind turbine model or controls could change the results.

With the assumptions outlined in this report, GEN-2009-020 should be able to reliably connect to the SPP transmission grid.

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. In this study, PSS/E model for the study plant was developed and included in the power flow case and the dynamics database. Power flow and dynamic model data for the study plants are provided in Appendix D.

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

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 in Areas 520, 524, 525, 526, 531, 534, 536, 539, 544, 640, 645, and 650 were monitored.

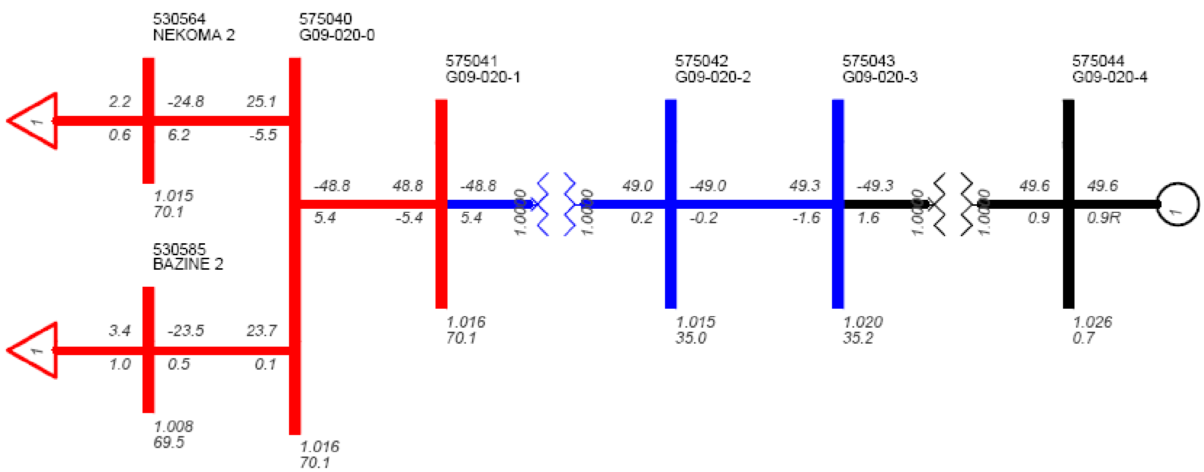

Figure 3-1. Power Flow One-line for GEN-2009-020 and adjacent equipment (SP)

3.4 Performance Criteria

The wind generators must comply with FERC Order 661A on low voltage ride through for wind farms. Therefore, the wind generators must not trip off line for faults at the Point of Interconnection. 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

Since the interconnection request is a wind project, a power factor analysis was performed. The power factor analysis consisted of modeling a var generator in the wind farm holding a voltage schedule at the POI. The voltage schedule was set equal 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 DISIS-2010-001 Group 3

Cont. No.	Cont. Name	Description
1	FLT01-3PH	3 phase fault on the Setab 345kV (531465) to 115kV (531464) transformer, near the 345 kV bus. a. Apply fault at the Setab 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
2	FLT02-3PH	3 phase fault on the Mingo (531451) to Red Willow (640325) 345kV line, near Mingo. a. Apply fault at the Mingo 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
3	FLT03-1PH	Single phase fault on the line in previous fault. a. Apply fault. 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	FLT04-3PH	3 phase fault on the Mingo 345kV (531451) to 115kV (531429) transformer, near the 345 kV bus. a. Apply fault at the Mingo 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
5	FLT05-3PH	3 phase fault on the Post Rock (530583) to Gen-2010-016 (576704) 345kV line, near Post Rock. a. Apply fault at the Post Rock 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
6	FLT06-1PH	Single phase fault on the line in previous fault. a. Apply fault. 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.
7	FLT07-3PH	3 phase fault on the Post Rock (530583) to Axtell (640065) 345kV line, near Post Rock. a. Apply fault at the Post Rock 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
8	FLT08-1PH	Single phase fault on the line in previous fault. a. Apply fault. 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.
9	FLT09-3PH	3 phase fault on the Knoll (530558) to Smoky Hills (530592) 230kV line, near Smoky Hills.. a. Apply fault at the Smoky Hills 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 Post Rock (530584) to South Hays (530582) 230kV line, near Post Rock. a. Apply fault at the Post Rock 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*

Cont. No.	Cont. Name	Description
13	FLT13-3PH	3 phase fault on the Post Rock (530584) to Knoll (530558) 230kV line, near Post Rock. a. Apply fault at the Post Rock 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 Post Rock 345kV (530583) to 230kV (530584) transformer, near the 345kV bus. a. Apply fault at the Post Rock 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
16	FLT16-3PH	3 phase fault on one circuit of the Knoll 230kV (530558) to 115kV (530561) transformer, near the 230kV bus. a. Apply fault at the Knoll 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
17	FLT17-3PH	3 phase fault on the Knoll (530561) to Saline (530551) 115kV line, near Knoll. a. Apply fault at the Knoll 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 Knoll (530561) to Redline (530605) 115kV line, near Knoll. a. Apply fault at the Knoll 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 South Hays (530582) to Mullergren (539679) 230kV line, near South Hays. a. Apply fault at the South Hays 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.
22	FLT22-1PH	*Single phase fault and sequence like previous*
23	FLT23-3PH	3 phase fault on the Knoll (530561) to N Hays (530581) 115kV line, near Knoll. a. Apply fault at the Knoll 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.
24	FLT24-1PH	*Single phase fault and sequence like previous*
25	FLT25-3PH	3 phase fault on the Pioneer Tap (539642) to Mullergren (539678) 115kV line, near Pioneer Tap. a. Apply fault at the Pioneer 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*

Cont. No.	Cont. Name	Description
27	FLT27-3PH	3 phase fault on the Post Rock 345kV (530583) to 230kV (530584) transformer, near the 230kV bus. a. Apply fault at the Post Rock 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
29	FLT29-3PH	3 phase fault on the Heizer (530563) 69kV – Heizer (530601) 115kV transformer on the 115kV bus a. Apply fault at the Heizer 115 kV bus b. Clear fault after 5 cycles by tripping the faulted line.
30	FLT30-3PH	3 phase fault on one circuit of the Heizer (530601) 115kV – Mullergren (539679) 230kV transformer on the 115kV bus a. Apply fault at the Heizer 115 kV bus b. Clear fault after 5 cycles by tripping the faulted line.
31	FLT31-3PH	3 phase fault on the Mullergren (539679) 230kV – Great Bend (539678) 115kV transformer on the 230kV bus a. Apply fault at the Mullergren 230 kV bus b. Clear fault after 5 cycles by tripping the faulted line.
32	FLT32-3PH	3 phase fault on the S. Hays (530582) 230kV – S. Hays (530553) 115kV transformer on the 115kV bus a. Apply fault at the S. Hays 115 kV bus b. Clear fault after 5 cycles by tripping the faulted line.
33	FLT33-3PH	3 phase fault on the Concordia (539657) 115kV – Concordia (532658) 230kV transformer on the 230kV bus a. Apply fault at the Concordia 230kV bus b. Clear fault after 5 cycles by tripping the faulted line.
34	FLT34-3PH	3 phase fault on the Mullergren (539679) – 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.
35	FLT35-1PH	*Single phase fault and sequence like previous*
36	FLT36-3PH	3 phase fault on the Mullergren (539679) – Spearville (539695) 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.
37	FLT37-1PH	*Single phase fault and sequence like previous*
38	FLT38-3PH	3 phase fault on the Graham (531386) – Beach Station (530557) 115kV line, near Graham. a. Apply fault at the Graham 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.
39	FLT39-1PH	*Single phase fault and sequence like previous*
40	FLT40-3PH	3 phase fault on the Hoxie (530556) – Beach Station (530557) 115kV line, near Hoxie. a. Apply fault at the Hoxie 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.

Cont. No.	Cont. Name	Description
41	FLT41-1PH	*Single phase fault and sequence like previous*
42	FLT42-3PH	3 phase fault on the GEN-2009-020 (575040) – Bazine (530585) 69kV line, near GEN-2009-020. a. Apply fault at the GEN-2009-020 69kV 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.
43	FLT43-1PH	*Single phase fault and sequence like previous*
44	FLT44-3PH	3 phase fault on the GEN-2009-020 (575040) – Nekoma (530564) 69kV line, near GEN-2009-020. a. Apply fault at the GEN-2009-020 69kV 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.
45	FLT45-1PH	*Single phase fault and sequence like previous*

4. Results and Observations

4.1 Stability Analysis Results

All faults were run for both summer and winter peak conditions. If a previously-queued generator tripped for any of these faults, the voltage and frequency tripping was disabled, and the fault was re-run to check for system stability.

Table 4-1 summarizes the overall results for all faults run. Figure 4-1 and Figure 4-2 show representative summer peak season plots for faults at the POI for 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.

4.2 Generator Performance

In the initial study, prior-queued project GEN-2006-032 tripped due to high voltage following faults 7, 11, 13, 16, 21, and 27. By adjusting the substation transformer tap to set steady state generator bus voltage to a lower level (1.024pu in SP Case, 0.998pu in WP Case), this plant stays on-line and is stable for all simulated faults. Figure 4-3 and Figure 4-4 show generator behaviors following fault 11 before and after adjusting the tap.

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 Setab 345kV (531465) to 115kV (531464) transformer, near the 345 kV bus.	OK	OK
2	FLT02-3PH	3 phase fault on the Mingo (531451) to Red Willow (640325) 345kV line, near Mingo.	OK	OK
3	FLT03-1PH	Single phase fault on the line in previous fault.	OK	OK
4	FLT04-3PH	3 phase fault on the Mingo 345kV (531451) to 115kV (531429) transformer, near the 345 kV bus.	OK	OK
5	FLT05-3PH	3 phase fault on the Post Rock (530583) to Gen-2010-016 (576704) 345kV line, near Post Rock.	OK	OK
6	FLT06-1PH	Single phase fault on the line in previous fault.	OK	OK
7	FLT07-3PH	3 phase fault on the Post Rock (530583) to Axtell (640065) 345kV line, near Post Rock.	OK	OK
8	FLT08-1PH	Single phase fault on the line in previous fault.	OK	OK
9	FLT09-3PH	3 phase fault on the Knoll (530558) to Smoky Hills (530592) 230kV line, near Smoky Hills..	OK	OK
10	FLT10-1PH	*Single phase fault and sequence like previous*	OK	OK
11	FLT11-3PH	3 phase fault on the Post Rock (530584) to South Hays (530582) 230kV line, near Post Rock.	OK	OK
12	FLT12-1PH	*Single phase fault and sequence like previous*	OK	OK
13	FLT13-3PH	3 phase fault on the Post Rock (530584) to Knoll (530558) 230kV line, near Post Rock.	OK	OK
14	FLT14-1PH	*Single phase fault and sequence like previous*	OK	OK
15	FLT15-3PH	3 phase fault on the Post Rock 345kV (530583) to 230kV (530584) transformer, near the 345kV bus.	OK	OK
16	FLT16-3PH	3 phase fault on one circuit of the Knoll 230kV (530558) to 115kV (530561) transformer, near the 230kV bus.	OK	OK
17	FLT17-3PH	3 phase fault on the Knoll (530561) to Saline (530551) 115kV line, near Knoll.	OK	OK
18	FLT18-1PH	*Single phase fault and sequence like previous*	OK	OK
19	FLT19-3PH	3 phase fault on the Knoll (530561) to Redline (530605) 115kV line, near Knoll.	OK	OK
20	FLT20-1PH	*Single phase fault and sequence like previous*	OK	OK
21	FLT21-3PH	3 phase fault on the South Hays (530582) to Mullergren (539679) 230kV line, near South Hays.	OK	OK
22	FLT22-1PH	*Single phase fault and sequence like previous*	OK	OK
23	FLT23-3PH	3 phase fault on the Knoll (530561) to N Hays (530581) 115kV line, near Knoll.	OK	OK
24	FLT24-1PH	*Single phase fault and sequence like previous*	OK	OK

Cont. No.	Cont. Name	Description	Summer Peak Results	Winter Peak Results
25	FLT25-3PH	3 phase fault on the Pioneer Tap (539642) to Mullergren (539678) 115kV line, near Pioneer Tap.	OK	OK
26	FLT26-1PH	*Single phase fault and sequence like previous*	OK	OK
27	FLT27-3PH	3 phase fault on the Post Rock 345kV (530583) to 230kV (530584) autotransformer on the 230kV bus (530583)	OK	OK
29	FLT29-3PH	3 phase fault on the Heizer (530563) 69kV – Heizer (530601) 115kV transformer on the 115kV bus	OK	OK
30	FLT30-3PH	3 phase fault on one circuit of the Heizer (530601) 115kV – Mullergren (539679) 230kV transformer on the 115kV bus	OK	OK
31	FLT31-3PH	3 phase fault on the Mullergren (539679) 230kV – Great Bend (539678) 115kV transformer on the 230kV bus	OK	OK
32	FLT32-3PH	3 phase fault on the S. Hays (530582) 230kV – S. Hays (530553) 115kV transformer on the 115kV bus	OK	OK
33	FLT33-3PH	3 phase fault on the Concordia (539657) 115kV – Concordia (532658) 230kV transformer on the 230kV bus	OK	OK
34	FLT34-3PH	3 phase fault on the Mullergren (539679) – Circle (532871) 230kV line, near Mullergren.	OK	OK
35	FLT35-1PH	*Single phase fault and sequence like previous*	OK	OK
36	FLT36-3PH	3 phase fault on the Mullergren (539679) – Spearville (539695) 230kV line, near Mullergren.	OK	OK
37	FLT37-1PH	*Single phase fault and sequence like previous*	OK	OK
38	FLT38-3PH	3 phase fault on the Graham (531386) – Beach Station (530557) 115kV line, near Graham.	OK	OK
39	FLT39-1PH	*Single phase fault and sequence like previous*	OK	OK
40	FLT40-3PH	3 phase fault on the Hoxie (530556) – Beach Station (530557) 115kV line, near Hoxie.	OK	OK
41	FLT41-1PH	*Single phase fault and sequence like previous*	OK	OK
42	FLT42-3PH	3 phase fault on the GEN-2009-020 (575040) – Bazine (530585) 69kV line, near GEN-2009-020.	OK	OK
43	FLT43-1PH	*Single phase fault and sequence like previous*	OK	OK
44	FLT44-3PH	3 phase fault on the GEN-2009-020 (575040) – Nekoma (530564) 69kV line, near GEN-2009-020.	OK	OK
45	FLT45-1PH	*Single phase fault and sequence like previous*	OK	OK

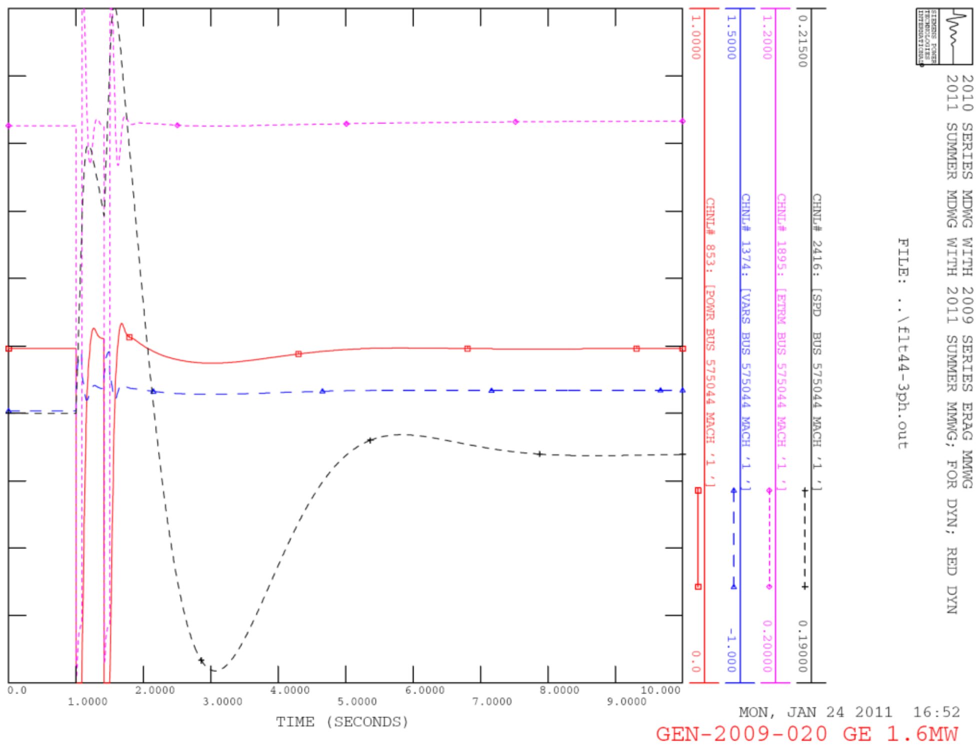

Figure 4-1. GEN-2009-020 Plot for Fault 44 – 3-Phase Fault on the GEN-2009-020 (575040) – Nekoma (530564) 69kV line, near GEN-2009-020

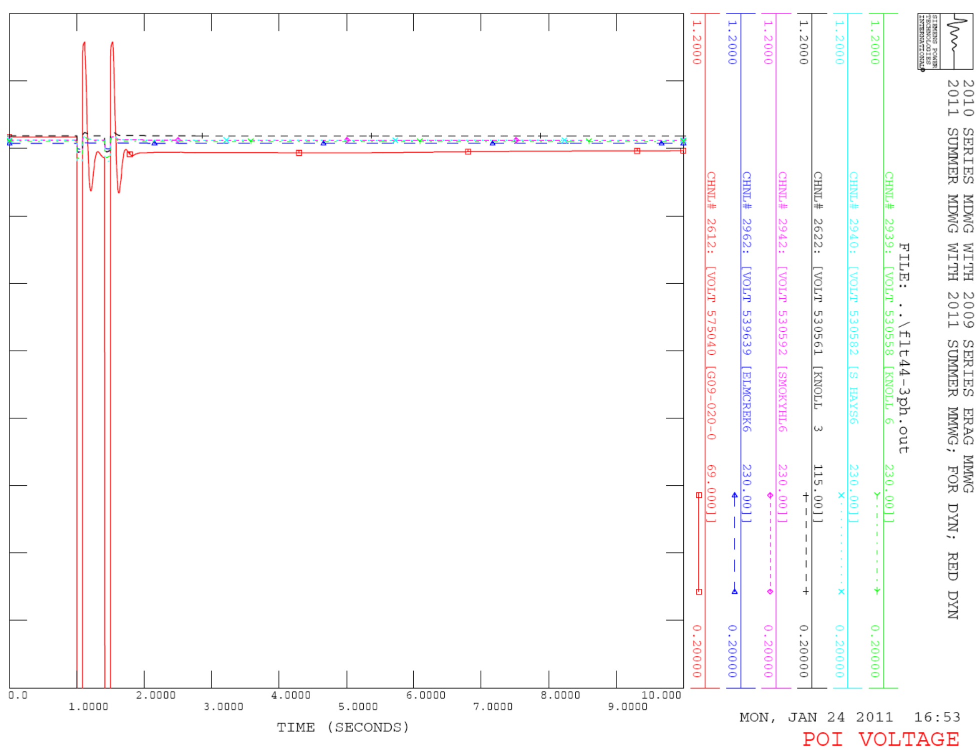

Figure 4-2. POI Voltage Plot for Fault 44 – 3-Phase Fault on the GEN-2009-020 (575040) – Nekoma (530564) 69kV line, near GEN-2009-020

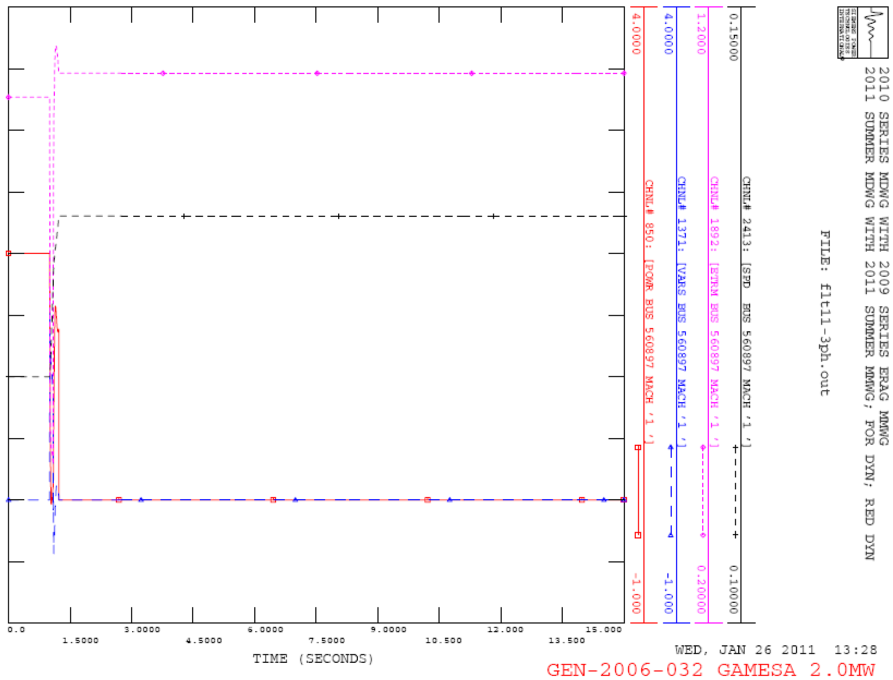

Figure 4-3. GEN-2006-032 Plot for Fault 11 – 3-Phase Fault on the Post Rock (530584) – South Hays (530582) 230kV line, near Post Rock (Steady State Generator Bus Voltage = 1.054pu)

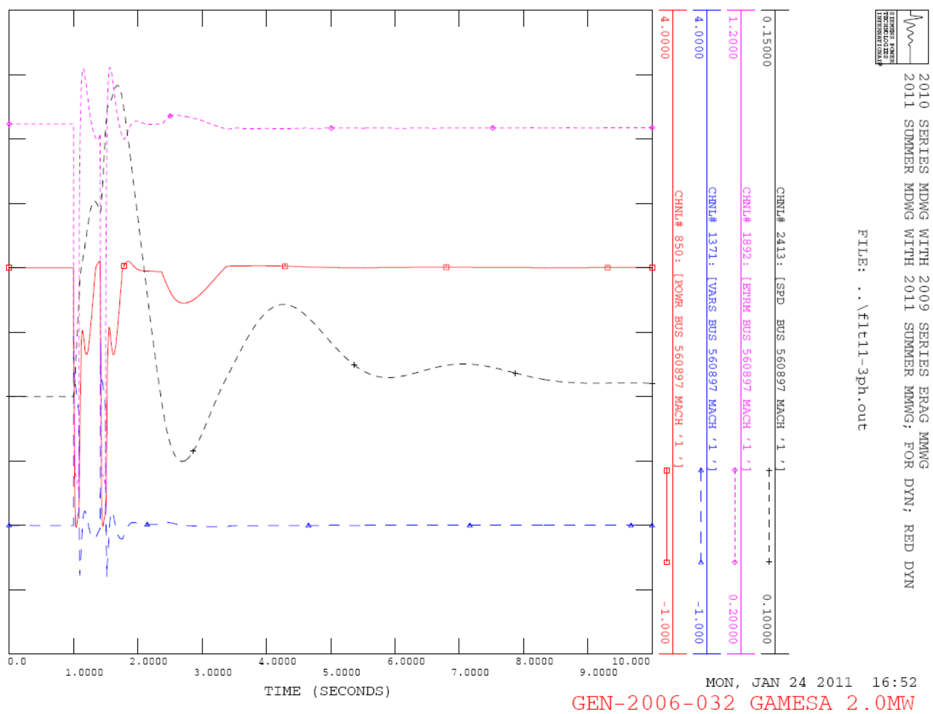

Figure 4-4. GEN-2006-032 Plot for Fault 11 – 3-Phase Fault on the Post Rock (530584) – South Hays (530582) 230kV line, near Post Rock (Steady State Generator Bus Voltage = 1.024pu)

4.3 Power Factor Requirements

All stability faults were tested as power flow contingencies to determine the power factor requirements for the wind farm study project to maintain scheduled voltage at its respective points of interconnection (POI). The voltage schedule is set equal to the voltage at the POI before the project is added, with a minimum of 1.0 per unit. Fictitious reactive power sources were added to the study project 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 (none in this case), 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 voltages 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 was less than 0.95 lagging, then the requirement was set to 0.95 lagging. This limit was not reached for the study project. Much greater reactive power supply would be needed to meet the voltage schedules under some contingencies, but only 0.95 lagging will be required. The limit for leading power factor requirement is also 0.95, and this limit was not reached for the study project. If the project never operated leading under any contingency, then the leading requirement is set to 1.0. Similar for lagging.

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. A project developer may install more capability than this if desired.

The study plant must install sufficient reactive power resources to meet these requirements listed in Table 4-2. The following method is used to decide if a study project needs to install additional capacitors:

1. Use the power flow case with fictitious reactive power sources added
2. Apply the contingency to cause the lowest reactive power flow from POI to the study project (leading is positive, lagging is negative)
3. If the study plant could provide enough reactive power to meet the power factor requirement, no additional capacitor is needed.
   If the study plant could not provide enough reactive power to meet the power factor requirement, the size of the additional capacitor was determined.

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	Final PF Requirement		Estimated Capacitor Requirements (Mvar)
				Lagging [2]	Leading [3]	
GEN-2009-020	49.6	GE 1.6MW	Balzine (530585) – Nekoma (530564) 69kV (Bus 575040)	0.999	0.977	0

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 wind farm. The power factor capability at the POI includes the net effect of the wind turbine generators, transformer and collector 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-2009-020 Restudy evaluated the impacts of interconnecting the project shown below.

Table 5-1. Interconnection Requests Evaluated

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2009-020	49.6	GE 1.6MW	Balzine (530585) – Nekoma (530564) 69kV (Bus 575040)

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

Power factor requirements were determined as shown in Table 4-2. However, any change in wind turbine model or controls could change the results.

With the assumptions outlined in this report, GEN-2009-020 should be able to reliably connect to the SPP transmission grid.

Appendix A – Summer Peak Plots

See attachment.

Appendix B – Winter Peak Plots

See attachment.

Appendix C – Power Factor Details

See attachment.

Appendix D – Project Model Data

See attachment.