Southwest Power Pool

Impact Restudy For Generation Interconnection Request GEN-2006-045

SPP Generation Interconnection

(#GEN-2006-045)

September 2011

Executive Summary

This report contains the findings of an impact restudy of GEN-2006-045. The interconnection customer requested a restudy due to a change in the wind turbine generator manufacturer.

The initial GEN-2006-045 impact study was completed and posted in October 2007. In that study the project was analyzed using Suzlon S88 2.1MW wind turbine generators. The first impact study showed that for both GEN-2006-039 and GEN-2006-045 to be interconnected required network upgrades in addition to the interconnection substation.

This restudy evaluated the effects on the stability of the transmission system as a result of changing the generators from the Suzlon S88 2.1MW wind turbine generators to the Sinovel SL1500 1.5MW wind turbine generators.

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 did not have the additional network upgrades described in the first impact study. This set of cases is referred to as the Near Term cases and is applicable due to the status of GEN-2006-039. The prior queued project GEN-2006-039 was not included since it is currently on suspension.

The second set of cases consisted of a modified 2011 summer peak case and a modified 2011 winter peak case that included the network upgrades as described in the first impact study. This set of cases is referred to as the Far Term cases. This set of cases assumes that prior queued project GEN-2006-039 will come out of suspension and complete its project.

The findings of this restudy is that for both the Near Term and the Far Term cases the transmission system remains stable for the use of the Sinovel SL1500 1.5MW wind turbine generators in the GEN-2006-045 interconnection project.

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.

With the assumptions outlined in this report, GEN-2006-045 can interconnect its generating facility using the Sinovel wind generators.

The Interconnection Agreement for GEN-2006-045 will need to be modified to reflect the results of this study.

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.

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Southwest Power Pool, Inc. (SPP)

GEN-2006-045 Impact Re-Study Analysis

Final Report

PXE-0508
Revision #01

September 2011

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EXECUTIVE SUMMARY

SPP requested an Interconnection System Impact Re-study. The Interconnection System Impact Re-study required a Power Factor Analysis and a Stability Analysis detailing the impacts of the interconnecting project as shown in Table ES-1.

Table ES-1
Interconnection Project Evaluated

Request	Size (MW)	Turbine Model	Point of Interconnection (POI)
GEN-2006-045	240	Sinovel SL 1500 1.5 MW	Buffalo Lake 230 kV (560009)

SUMMARY OF POWER FACTOR ANALYSIS

Power Factor Analysis shows that GEN-2006-045 has a power factor range of 0.9944 lagging (supplying) to 0.9981 leading (absorbing) for the Far Term Cases and a power factor range of 0.9850 to 0.9982 leading (absorbing) for the Near Term Cases.

SUMMARY OF STABILITY ANALYSIS

The Stability Analysis determined that no wind turbine tripping or system instability occurs from interconnecting GEN-2006-045 at 100% output for both the Far Term cases and the Near Term cases.

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SECTION 1: OBJECTIVES

The objective of this report is to provide Southwest Power Pool, Inc. (SPP) with the deliverables for the "GEN-2006-045 Impact Restudy-01." SPP requested an Interconnection System Impact Restudy for GEN-2006-045, which requires a Power Factor Analysis, a Stability Analysis, and an Impact Study Report.

SECTION 2: BACKGROUND

The Siemens Power Technologies, Inc. PSS/E power system simulation program Version 30.3.3 was used for this study. SPP provided the stability database cases for summer peak and winter peak seasons for Far[1][2] and Near[3][4] Term cases and a list of contingencies to be examined. The model includes the study project and the previously queued projects as listed in Table 2-1 and Table 2-2, respectively. Refer to Appendix A for the steady-state and dynamic model data for the study project. A power flow one-line diagram of GEN-2006-045 interconnection project is shown in Figure 2-1 (Far Term) and Figure 2-2 (Near Term).

The Power Factor analysis will determine the power factor at the point of interconnection for the wind interconnection project for pre-contingency and post-contingency conditions. Table 2-3 and Table 2-4 lists the contingencies developed from the three-phase fault definitions provided in the Group's interconnection impact study request for Far Term cases and Near Term cases, respectively.

The Stability Analysis will determine the impacts of the new interconnecting project on the stability and voltage recovery of the nearby system and the ability of the interconnecting project to meet FERC Order 661A. If problems with stability or voltage recovery are identified, the need for reactive compensation or system upgrades will be investigated. Three-phase and single-phase faults will be examined as listed in Table 2-3 and Table 2-4.

[1] *MDWG_2010_2011SP_DISIS-2010-001-3-G5.sav – Far Term summer peak filename.*

[2] *MDWG_2010_2011WP_DISIS-2010-001-3-G5.sav – Far Term winter peak filename.*

[3] NT-*MDWG_2010_2011SP_DISIS-2010-001-3-G5.sav – Near Term summer peak filename.*

[4] NT-*MDWG_2010_2011WP_DISIS-2010-001-3-G5.sav – Near Term winter peak filename.*

Table 2-1
Interconnection Project Evaluated

Request	Size (MW)	Turbine Model	Point of Interconnection (POI)
GEN-2006-045	240	Sinovel SL 1500 1.5 MW	Buffalo Lake 230 kV (560009)

Table 2-2
Previously Queued Nearby Interconnection Projects Included

Request	Size (MW)	Turbine Model	Point of Interconnection (POI)
GEN-2002-022	240	Siemens 2.3 MW	Bushland 230 kV (524267)
GEN-2006-039[1]	400	Clipper 2.5 MW	Buffalo Lake 230 kV (560009)
GEN-2006-047[1]	240	Suzlon 2.1 MW	Buffalo Lake 230 kV (560009)
GEN-2007-002	160	Steam Turbine	Grapevine 115 kV (523770)
GEN-2007-048	400	Furhlander	Amarillo South - Swisher 230 kV line (525228)
GEN-2008-051	322	Siemens 2.3 MW	Potter 345 kV (523961)
GEN-2008-088	50.6	Siemens SWT 2.3 MW	Vega 69 kV (523888)

[1]This project is not in the near term stability database cases

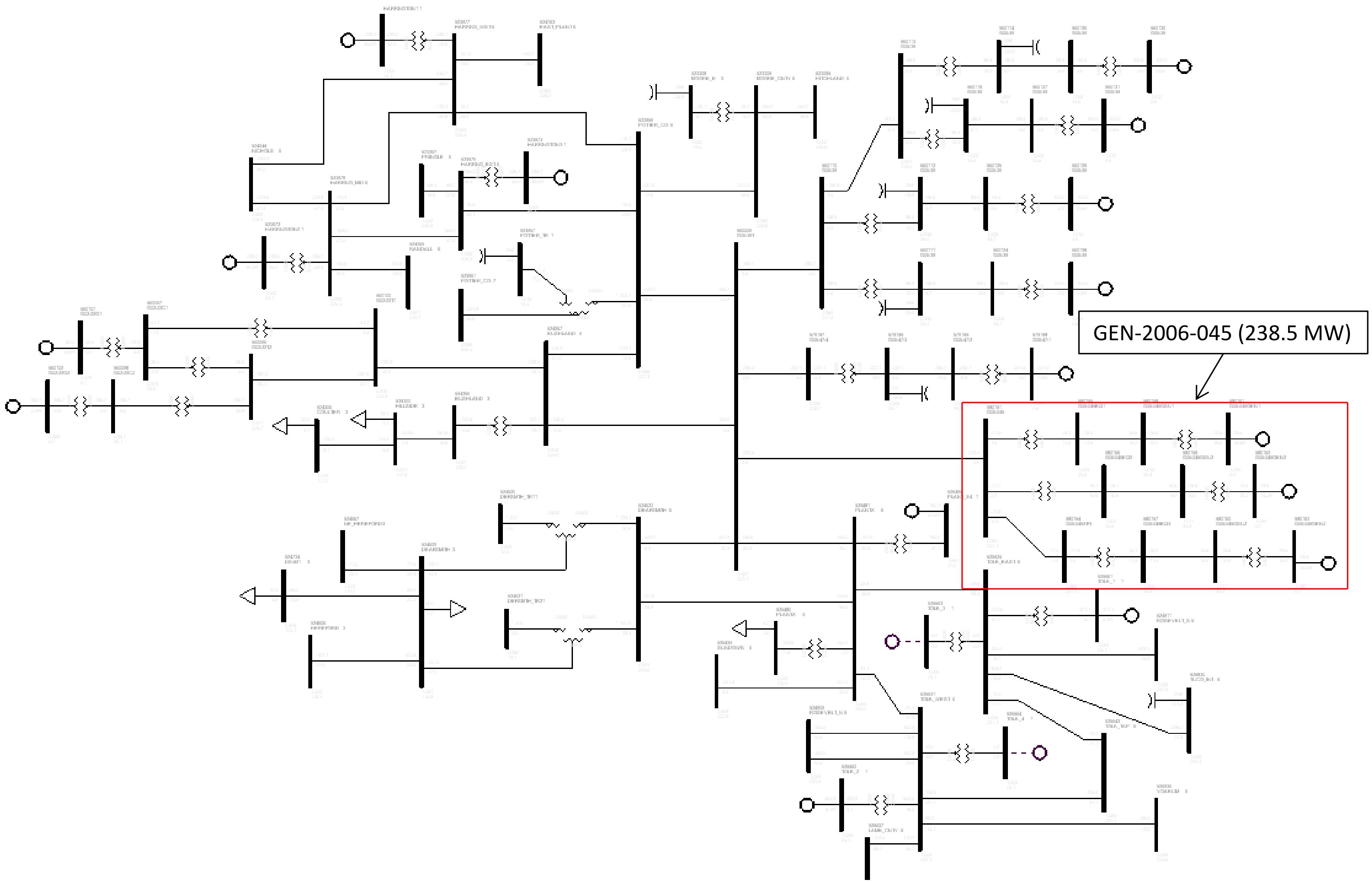

Figure 2-1. Power flow one-line diagram for Far Term cases for interconnection project GEN-2006-045.

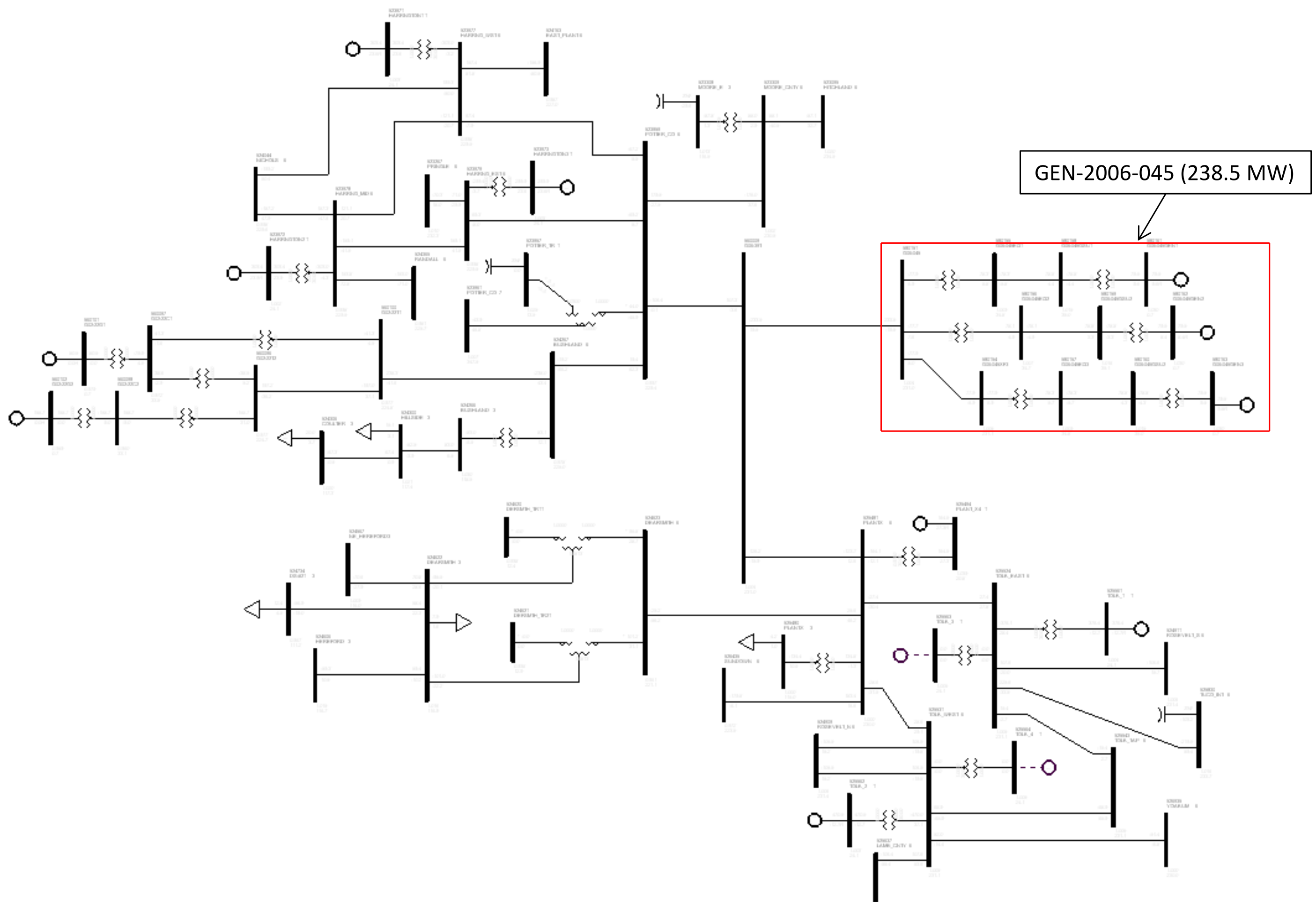

Figure 2-2. Power flow one-line diagram for Near Term cases for interconnection project GEN-2006-045.

Table 2-3
Case List with Contingency Description for Far Term Cases

Ref. No.	Case Name	Description
1	FLT01-3PH	3 phase fault on the G06-039T (560009) to Potter Co (523959) 230 kV Ckt 1, near G06-039T. a. Apply fault at G06-039T 230 kV 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 G06-039T (560009) to Bushland (524267) 230 kV Ckt 1, near G06-039T. a. Apply fault at G06-039T 230 kV 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 G06-039T (560009) to Deafsmith (524623) 230 kV Ckt 1, near G06-039T. a. Apply fault at G06-039T 230 kV 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 G06-039T (560009) to PlantX (525481) 230 kV Ckt 1, near G06-039T. a. Apply fault at G06-039T 230 kV 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 Bushland (524267) to Potter Co (523959) 230 kV Ckt 1, near Bushland. a. Apply fault at Bushland 230 kV 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 Potter Co (523959) to Moore Cnty (523309) 230 kV Ckt 1, near Potter Co. a. Apply fault at Potter Co 230 kV 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 Potter Co (523959) to Harng Wst (523977) 230 kV Ckt 2, near Potter Co. a. Apply fault at Potter Co 230 kV 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*

Table 2-3 (continued)
Case List with Contingency Description for Far Term Cases

Ref. No.	Case Name	Description
15	FLT15-3PH	3 phase fault on the Potter Co (523959) to Harng Est (523979) 230 kV Ckt 1, near Potter Co. a. Apply fault at Potter Co 230 kV 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 Deafsmith (524623) to PlantX (525481) 230 kV Ckt 1, near Deafsmith. a. Apply fault at Deafsmith 230 kV 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 PlantX (525481) to Tolk East (525524) 230 kV Ckt 2, near PlantX. a. Apply fault at PlantX 230 kV 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 PlantX (525481) to Tolk West (525531) 230 kV Ckt 1, near PlantX. a. Apply fault at PlantX 230 kV 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 PlantX (525481) to Sundown (526435) 230 kV Ckt 1, near PlantX. a. Apply fault at PlantX 230 kV 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 Bushland 230 kV (524267) to 115 kV (524266) Transformer Ckt 1, near 230 kV bus. a. Apply fault at the Bushland 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
26	FLT26-3PH	3 phase fault on the Potter Co 230 kV (523959) to 345 kV (523961) Transformer Ckt 1, near 230 kV bus. a. Apply fault at the Potter Co 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
27	FLT27-3PH	3 phase fault on the Deafsmith 230 kV (524623) to 115 kV (524622) Transformer Ckt 2, near 230 kV bus. a. Apply fault at the Deafsmith 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
28	FLT28-3PH	3 phase fault on the PlantX 230 kV (525481) to 115 kV (525480) Transformer Ckt 1, near 230 kV bus. a. Apply fault at the PlantX 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Table 2-4

Case List with Contingency Description for Near Term Cases

Ref. No.	Case Name	Description
1	FLT01-3PH	3 phase fault on the G06-039T (560009) to Potter Co (523959) 230 kV Ckt 1, near G06-039T.
		a. Apply fault at G06-039T 230 kV 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 G06-039T (560009) to PlantX (525481) 230 kV Ckt 1, near G06-039T.
		a. Apply fault at G06-039T 230 kV 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*

SECTION 3: 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.

3.1 Far Term Cases

Approach

Both winter peak and summer peak power flows provided by SPP were examined prior to the Power Factor Analysis to ensure they contained the proposed study project modeled at 100% of the nameplate rating and any previously queued projects listed in Table 2-2. There was no suspect power flow data in the study area. The proposed study project and previous queued projects at the point of interconnection were turned off during the power factor analysis. The wind farms were then replaced by a generator modeled at the POI with the same real power (MW) capability as the wind farms 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 provided in Table 2-3 were then applied and the reactive power required to maintain the bus voltage was recorded.

The study project (GEN-2006-045) and two previous queued projects (GEN-2006-039 and GEN-2006-047) share the same POI (Bus 560009). These projects were disabled and two generators were placed at the POI, one was modeled with PGEN = 238.5 MW (GEN-2006-045), QMin = -9999 Mvar, and QMax = 9999 Mvar and the other generator was modeled with PGEN = 641.5 MW (GEN-2006-039 and GEN-2006-047), QMin = -9999 Mvar, and QMax = 9999 Mvar. All buses and transformers connected from the POI to the corresponding generators were disabled. The pre-project voltage at the POI (Bus 560009) for the summer peak conditions is 0.9874 p.u. and for the winter peak conditions is 0.9853 p.u.. Therefore, the scheduled voltage for the POI was set to 1.00 p.u. for summer and winter peak conditions.

Results

The power factor was calculated for summer and winter peak conditions. Table 3.1-1 shows the power factor results for GEN-2006-045 (238.5 MW). Note that a positive Q (Mvar) output illustrates that the generator is absorbing reactive power from the system, implying a leading power factor; a negative Q (Mvar) illustrates that the generator is supplying reactive power to the system, implying a lagging power factor.

Table 3.1-1
GEN-2006-045 - Far Term Cases (P_{GEN} = 238.5 MW)

Ref. No.	Summer Peak			Winter Peak		
	Power Factor		Q** (MVAR)	Power Factor		Q** (MVAR)
Base	0.9985	Lagging	-13.05	0.9985	Leading	13.18
1	0.9977	Lagging	-16.23	0.9987	Leading	12.16
3	0.9994	Lagging	-8.37	0.9981	Leading	14.63
5	0.9991	Lagging	-10.05	0.9999	Lagging	-3.59
7	0.9959	Lagging	-21.74	0.9998	Leading	4.27
9	0.9944	Lagging	-25.43	0.9999	Leading	3.80
11	0.9978	Lagging	-15.80	0.9985	Leading	12.88
13	0.9982	Lagging	-14.30	0.9991	Leading	10.09
15	0.9982	Lagging	-14.34	0.9991	Leading	9.97
17	0.9954	Lagging	-22.96	0.9997	Leading	6.24
19	0.9985	Lagging	-13.06	0.9986	Leading	12.67
21	0.9985	Lagging	-13.06	0.9986	Leading	12.67
23	0.9984	Lagging	-13.47	0.9988	Leading	11.52
25	0.9991	Lagging	-9.99	0.9983	Leading	14.04
26	0.9974	Lagging	-17.29	0.9989	Leading	11.13
27	0.9984	Lagging	-13.35	0.9991	Leading	10.25
28	0.9982	Lagging	-14.42	0.9990	Leading	10.62

*The scheduled voltage for the POI (Buffalo Lake 230 kV) was 1.00 p.u. for summer and winter peak conditions

**A positive Q (Mvar) output illustrates the generator is absorbing Mvars from the system, which implies a leading power factor; negative Q (Mvar) output shows the generator is supplying Mvars to the system implying a lagging power factor.

Summary

Power Factor Analysis shows that GEN-2006-045 has a power factor range of 0.9944 lagging (supplying) to 0.9981 leading (absorbing) for the Far Term Cases.

3.2 Near Term Cases

Approach

Both winter peak and summer peak power flows provided by SPP were examined prior to the Power Factor Analysis to ensure they contained the proposed study project modeled at 100% of the nameplate rating and any previously queued projects listed in Table 2-2. There was no suspect power flow data in the study area. The proposed study project at the point of interconnection was turned off during the power factor analysis. The wind farm was then replaced by a generator modeled at the wind farm's high voltage bus with the same real power (MW) capability as the 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 provided in Table 2-3 were then applied and the reactive power required to maintain the bus voltage was recorded.

The study project (GEN-2006-045) was disabled and a generator was placed at the POI (Bus 560009). The generator was modeled with PGEN = 238.5 MW, QMin = -9999 Mvar, and QMax = 9999 Mvar. All buses and transformers connected from the POI to the GEN-2006-045 wind generators were disabled. The pre-project voltage at the POI (Bus 560009) for the summer peak conditions is 1.0045 p.u. and for the winter peak conditions is 0.9987 p.u.. Therefore, the scheduled voltage for the POI was set to 1.0045 p.u. for summer peak conditions and 1.00 p.u. for winter peak conditions.

Results

The power factor was calculated for summer and winter peak conditions. Table 3.2-1 shows the power factor results for GEN-2006-045 (238.5 MW). Note that a positive Q (Mvar) output illustrates that the generator is absorbing reactive power from the system, implying a leading power factor; a negative Q (Mvar) illustrates that the generator is supplying reactive power to the system, implying a lagging power factor.

Table 3.2-1

GEN-2006-045 - Near Term Cases (P_{GEN} = 238.5 MW)

Ref. No.	Summer Peak			Winter Peak		
	Power Factor		Q** (MVAR)	Power Factor		Q** (MVAR)
Base	0.9916	Leading	31.20	0.9850	Leading	41.75
1	0.9982	Leading	14.17	0.9959	Leading	21.63
3	-	-	-	-	-	-
5	-	-	-	-	-	-
7	0.9981	Leading	14.53	0.9973	Leading	17.53
9	0.9865	Leading	39.53	0.9857	Leading	40.76
11	0.9936	Leading	27.15	0.9858	Leading	40.67
13	0.9920	Leading	30.31	0.9862	Leading	40.10
15	0.9920	Leading	30.29	0.9862	Leading	40.05
17	0.9945	Leading	25.20	0.9856	Leading	40.90
19	0.9915	Leading	31.26	0.9850	Leading	41.84
21	0.9915	Leading	31.25	0.9850	Leading	41.84
23	0.9913	Leading	31.75	0.9858	Leading	40.59
25	0.9910	Leading	32.25	0.9851	Leading	41.68
26	0.9956	Leading	22.33	0.9870	Leading	38.90
27	0.9915	Leading	31.35	0.9852	Leading	41.53
28	0.9913	Leading	31.63	0.9855	Leading	41.05

*The scheduled voltage for the POI (Buffalo Lake 230 kV) was 1.00 p.u. for summer and winter peak conditions

**A positive Q (Mvar) output illustrates the generator is absorbing Mvars from the system, which implies a leading power factor; negative Q (Mvar) output shows the generator is supplying Mvars to the system implying a lagging power factor.

<u>Summary</u>

Power Factor Analysis shows that GEN-2006-045 has a power factor range of 0.9850 to 0.9982 leading (absorbing) for the Near Term Cases.

3.3 Overall Summary

Power Factor Analysis shows that GEN-2006-045 has a power factor range of 0.9944 lagging (supplying) to 0.9981 leading (absorbing) for the Far Term Cases and a power factor range of 0.9850 to 0.9982 leading (absorbing) for the Near Term Cases.

SECTION 4: STABILITY ANALYSIS

The objective of the stability analysis was to determine the impacts of the new wind farm on the stability and voltage recovery on the SPP transmission system. If problems with stability or voltage recovery were identified the need for reactive compensation or system upgrades were investigated.

4.1 Far Term Cases

Approach

Both winter peak and summer peak power flows provided by SPP were examined prior to the Stability Analysis to ensure they contained the proposed study project modeled at 100% of the nameplate rating and any previously queued projects listed in Table 2-2. There was no suspect power flow data in the study area. The dynamic datasets were also verified and stable initial system conditions (i.e., “flat lines”) were achieved. Three-phase and single line-to-ground faults listed in Table 2-3 were examined. Single-phase fault impedances were calculated to result in a voltage of approximately 60% of the pre-fault voltage. Refer to Table 4.1-1 for a list of the calculated single-phase fault impedances used for the this analysis

Table 4.1-1
Calculated Single-Phase Fault Impedances for Far Term Cases

Ref. No.	Casename	Single-Phase Fault Impedance (MVA)	
		Summer Peak	Winter Peak
2	FLT02-1PH	-3250	-3250
4	FLT04-1PH	-3250	-3250
6	FLT06-1PH	-3250	-3250
8	FLT08-1PH	-3250	-3250
10	FLT10-1PH	-2750	-2750
12	FLT12-1PH	-5250	-5000
14	FLT14-1PH	-5250	-5000
16	FLT16-1PH	-5250	-5000
18	FLT18-1PH	-2500	-2500
20	FLT20-1PH	-5500	-5000
22	FLT22-1PH	-5500	-5000
24	FLT24-1PH	-5500	-5000

Bus voltages and previously queued generation in the study area were monitored in addition to the bus voltages in the following areas:

- 520 AEPW
- 524 OKGE
- 525 WFEC
- 526 SPS
- 531 MIDW
- 534 SUNC
- 536 WERE

The results of the analysis determined if reactive compensation or system upgrades were required to obtain acceptable system performance. If additional reactive compensation was required, the size, type, and location were determined. The proposed reactive reinforcements would ensure the wind farm meets FERC Order 661A low voltage requirements and return the wind farm to its pre-disturbance operating voltage. If the results indicated the need for fast responding reactive support, dynamic support such as an SVC or STATCOM was investigated. If tripping of the prior queued projects was observed during the stability analysis (for under/over voltage or under/over frequency) the simulations were re-ran with the prior queued project's voltage and frequency tripping disabled. If stability problems were identified, the maximum acceptable generation level for the GEN-2006-045 to operate without causing any stability problems was quantified. Stability analysis results indicated that GEN-2006-045 can interconnect at 100% output for all Far Term contingencies.

Results

Refer to Table 4.1-2 for a summary of the Stability Analysis results for Far Term cases. The initial simulations were run for summer and winter peak conditions and all contingencies remained stable. Figure 4.1-1 shows the response of the GEN-2006-045 (GEN 1) generator during a three-phase fault on the Buffalo Lake to Bushland 230 kV line (FLT03-3PH) during winter peak conditions. Figure 4.1-2 shows selected bus voltages in the study area during FLT03-3PH which is a representative case for the "worst" delayed voltage recovery. Figure 4.1-3 shows the response of the GEN-2006-045 (GEN 1) generator during a three-phase fault on the Bushland to Potter Co. 230 kV line (FLT09-3PH) during winter peak conditions. Figure 4.1-4 shows selected bus voltages in the study area during FLT09-3PH which is a representative case for the "most severe" voltage dip.

Table 4.1-2
Stability Analysis Summary of Results for Far Term Cases

Ref. No.	Casename	Summer		Winter	
		Stable?	Acceptable Voltages?	Stable?	Acceptable Voltages?
1	FLT01-3PH	Stable	Yes	Stable	Yes
2	FLT02-1PH	Stable	Yes	Stable	Yes
3	FLT03-3PH	Stable	Yes	Stable	Yes
4	FLT04-1PH	Stable	Yes	Stable	Yes
5	FLT05-3PH	Stable	Yes	Stable	Yes
6	FLT06-1PH	Stable	Yes	Stable	Yes
7	FLT07-3PH	Stable	Yes	Stable	Yes
8	FLT08-1PH	Stable	Yes	Stable	Yes
9	FLT09-3PH	Stable	Yes	Stable	Yes
10	FLT10-1PH	Stable	Yes	Stable	Yes
11	FLT11-3PH	Stable	Yes	Stable	Yes
12	FLT12-1PH	Stable	Yes	Stable	Yes
13	FLT13-3PH	Stable	Yes	Stable	Yes
14	FLT14-1PH	Stable	Yes	Stable	Yes
15	FLT15-3PH	Stable	Yes	Stable	Yes
16	FLT16-1PH	Stable	Yes	Stable	Yes
17	FLT17-3PH	Stable	Yes	Stable	Yes
18	FLT18-1PH	Stable	Yes	Stable	Yes
19	FLT19-3PH	Stable	Yes	Stable	Yes
20	FLT20-1PH	Stable	Yes	Stable	Yes
21	FLT21-3PH	Stable	Yes	Stable	Yes
22	FLT22-1PH	Stable	Yes	Stable	Yes
23	FLT23-3PH	Stable	Yes	Stable	Yes
24	FLT24-1PH	Stable	Yes	Stable	Yes
25	FLT25-3PH	Stable	Yes	Stable	Yes
26	FLT26-3PH	Stable	Yes	Stable	Yes
27	FLT27-3PH	Stable	Yes	Stable	Yes
28	FLT28-3PH	Stable	Yes	Stable	Yes

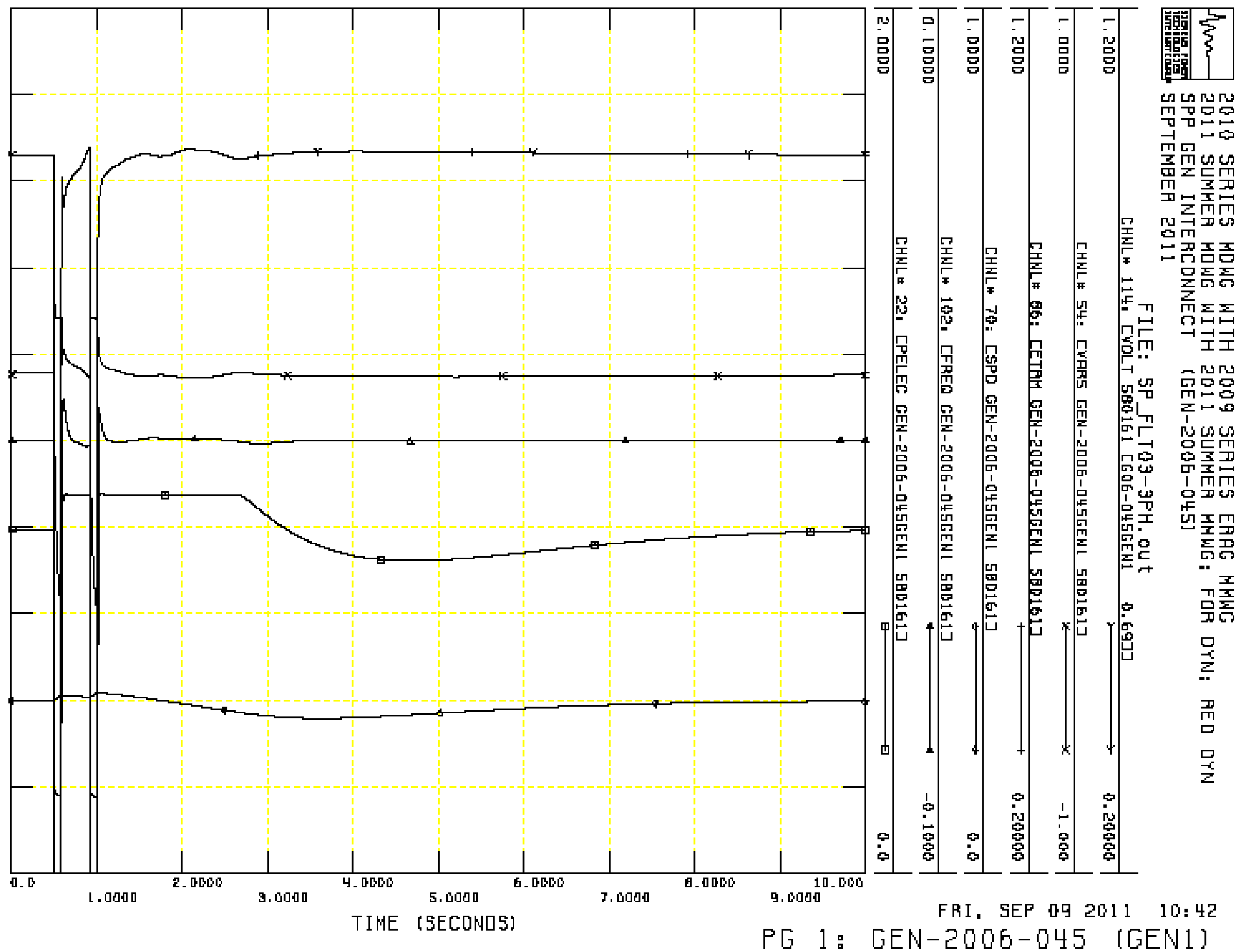

Figure 4.1-1. Response of GEN-2006-045 project during case FLT03-3PH for winter peak conditions for the Far Term case.

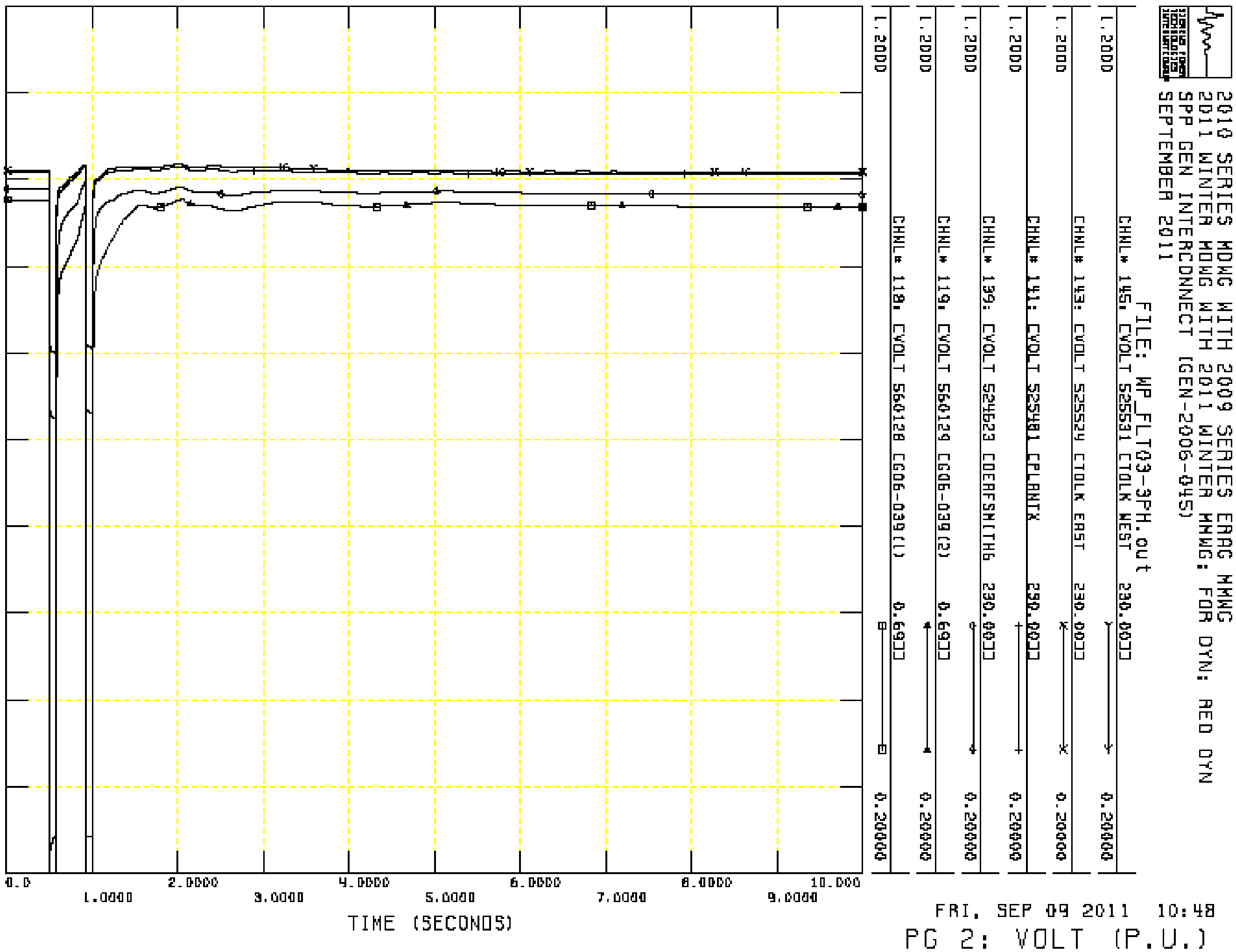

Figure 4.1-2. Response of selected area bus voltages for case FLT03-3PH for winter peak conditions for the Far Term case.

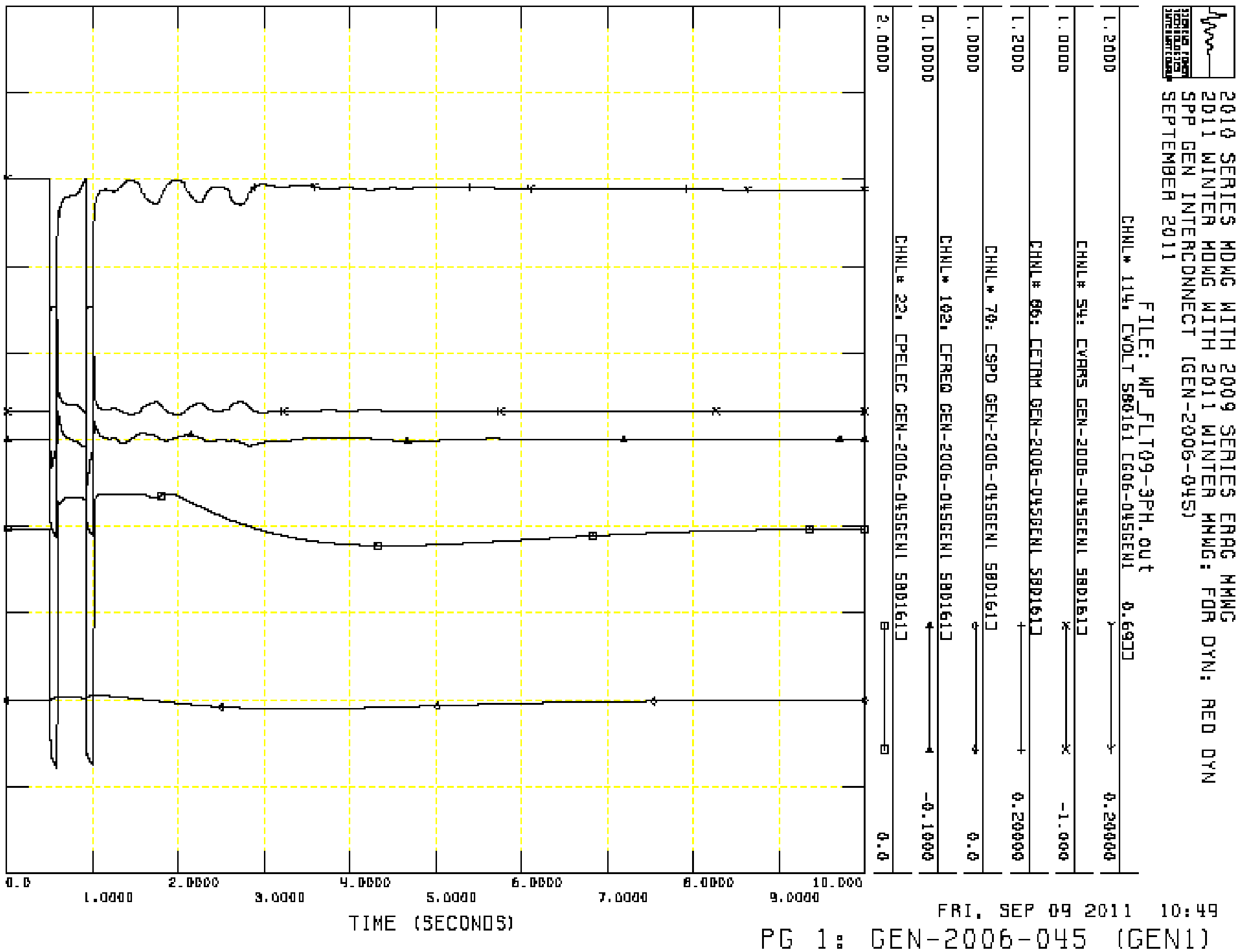

Figure 4.1-3. Response of GEN-2006-045 project during case FLT09-3PH for winter peak conditions for the Far Term case.

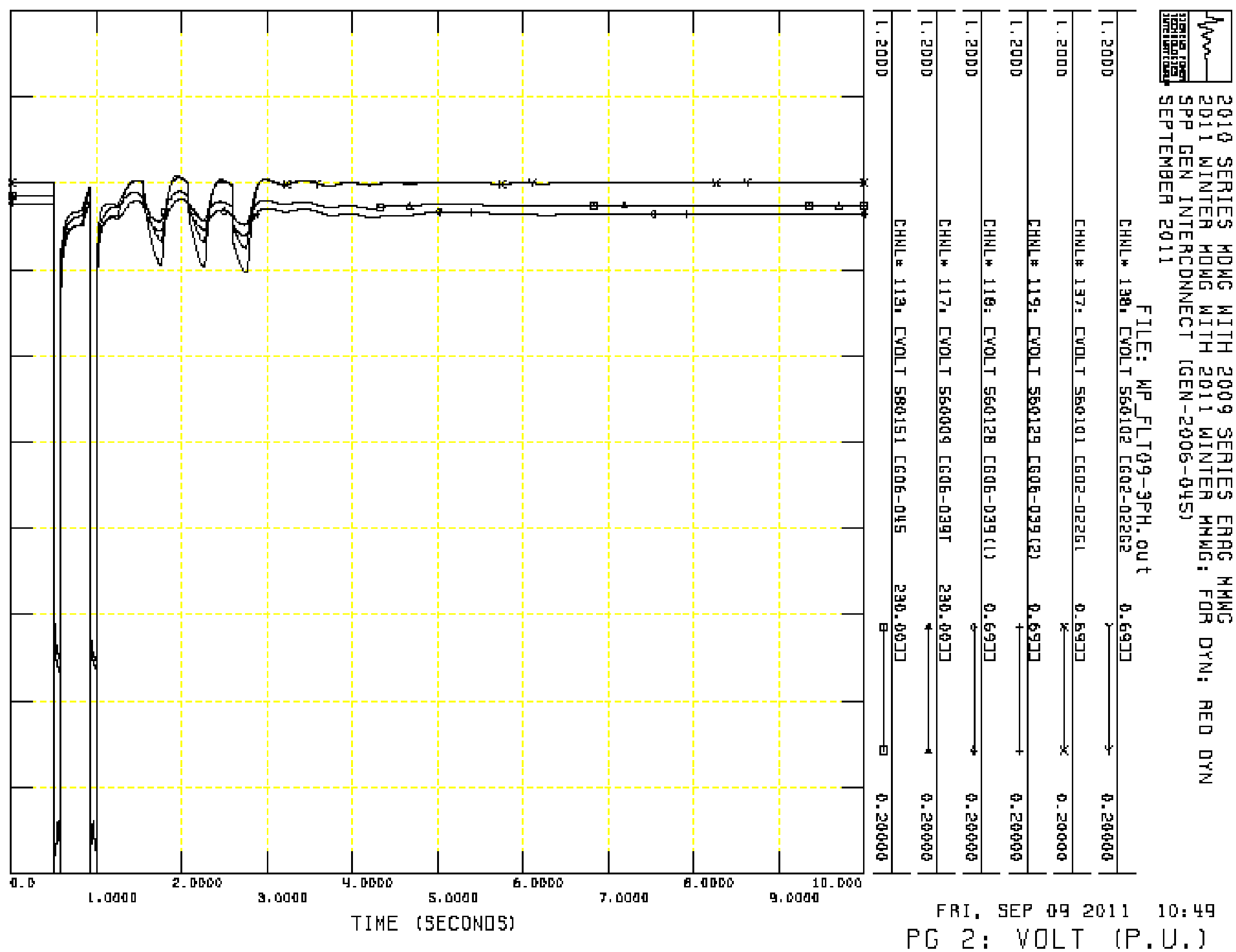

Figure 4.1-4. Response of selected area bus voltages for case FLT09-3PH for winter peak conditions for the Far Term case.

Summary

The stability analysis determined that no wind generator tripping or system instability occurs by interconnecting GEN-2006-045 project at 100% output. Refer to Appendix B and Appendix C for the stability plots of the study area and nearby system's bus voltage and generator's response during the disturbance for the summer peak and winter peak conditions, respectively.

4.2 Near Term Cases

Approach

Both winter peak and summer peak power flows provided by SPP were examined prior to the Stability Analysis to ensure they contained the proposed study project modeled at 100% of the nameplate rating and any previously queued projects listed in Table 2-2. There was no suspect power flow data in the study area. The dynamic datasets were also verified and stable initial system conditions (i.e., "flat lines") were achieved. Three-phase and single line-to-ground faults listed in Table 2-3 were examined. Single-phase fault impedances were calculated to result in a voltage of approximately 60% of the pre-fault voltage. Refer to Table 4.2-1 for a list of the calculated single-phase fault impedances used for the this analysis

Table 4.2-1
Calculated Single-Phase Fault Impedances for Near Term Cases

Ref. No.	Casename	Single-Phase Fault Impedance (MVA)	
		Summer Peak	Winter Peak
2	FLT02-1PH	-1750	-1750
4	FLT04-1PH	-1750	-1750

Bus voltages and previously queued generation in the study area were monitored in addition to the bus voltages in the following areas:

- 520 AEPW
- 524 OKGE
- 525 WFEC
- 526 SPS
- 531 MIDW
- 534 SUNC
- 536 WERE

The results of the analysis determined if reactive compensation or system upgrades were required to obtain acceptable system performance. If additional reactive compensation was required, the size, type, and location were determined. The proposed reactive reinforcements would ensure the wind farm meets FERC Order 661A low voltage requirements and return the wind farm to its pre-disturbance operating voltage. If the results indicated the need for fast responding reactive support, dynamic support such as an SVC or STATCOM was investigated. If tripping of the prior queued projects was observed during the stability analysis (for under/over voltage or under/over frequency) the simulations were re-ran with the prior queued project's voltage and frequency tripping disabled. If stability problems were identified, the maximum acceptable generation level for the GEN-2006-045 to operate without causing any stability problems was quantified. Stability analysis results indicated that GEN-2006-045 can interconnect at 100% output for all Far Term contingencies.

Results

Refer to Table 4.2-2 for a summary of the Stability Analysis results for Near Term cases. The initial simulations were run for summer and winter peak conditions and all contingencies remained stable. Figure 4.2-1 shows the response of the GEN-2006-045 (GEN 1) generator during a three-phase fault on the Buffalo Lake to Potter Co. 230 kV line (FLT01-3PH) during winter peak conditions. Figure 4.2-2 shows selected bus voltages in the study area during FLT01-3PH which is a representative case for the "worst" voltage recovery.

Table 4.2-2
Stability Analysis Summary of Results for Near Term Cases

Ref. No.	Casename	Summer		Winter	
		Stable?	Acceptable Voltages?	Stable?	Acceptable Voltages?
1	FLT01-3PH	Stable	Yes	Stable	Yes
2	FLT02-1PH	Stable	Yes	Stable	Yes
3	FLT03-3PH	Stable	Yes	Stable	Yes
4	FLT04-1PH	Stable	Yes	Stable	Yes

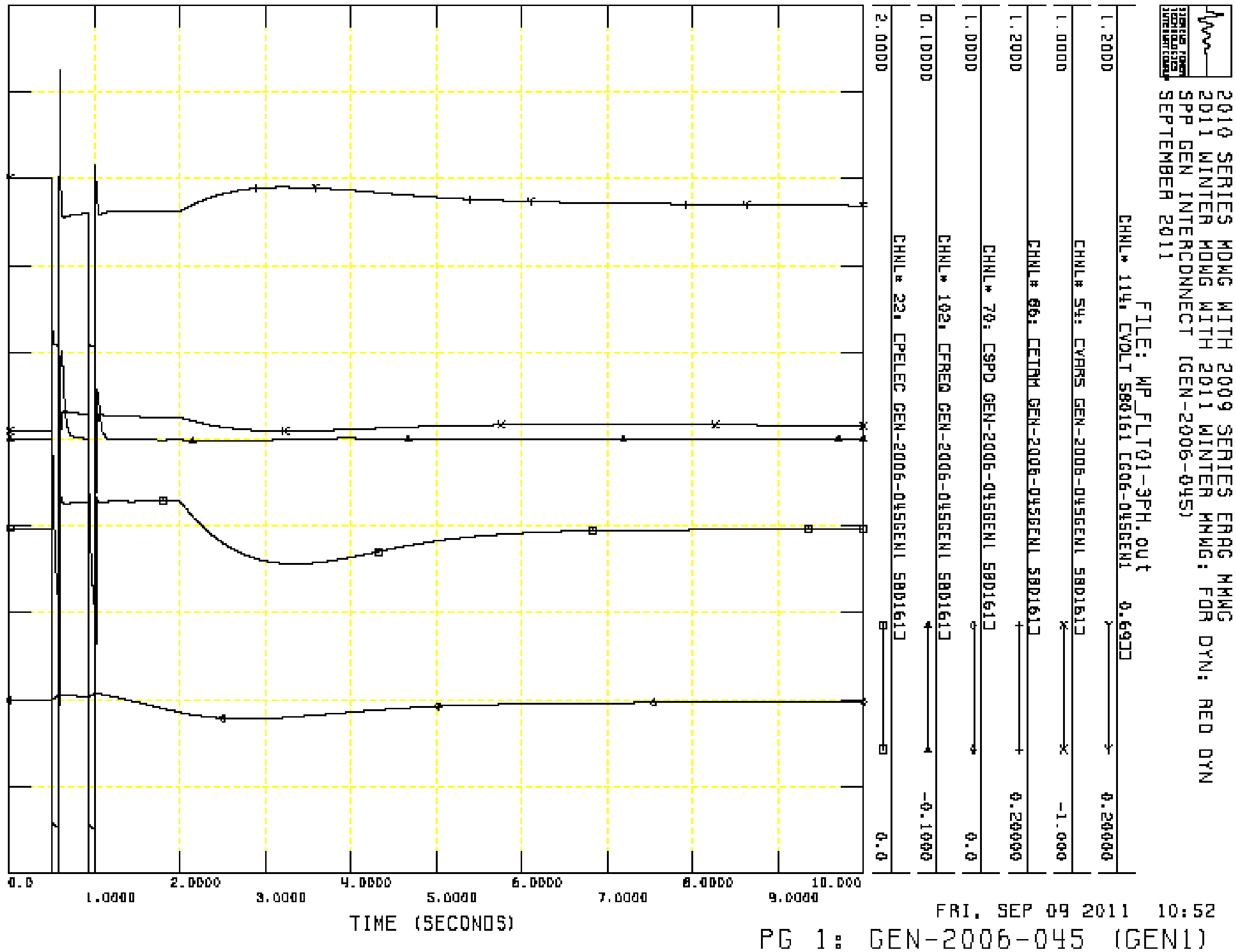

Figure 4.2-1. Response of GEN-2006-045 project during case FLT01-3PH for winter peak conditions for the Near Term case.

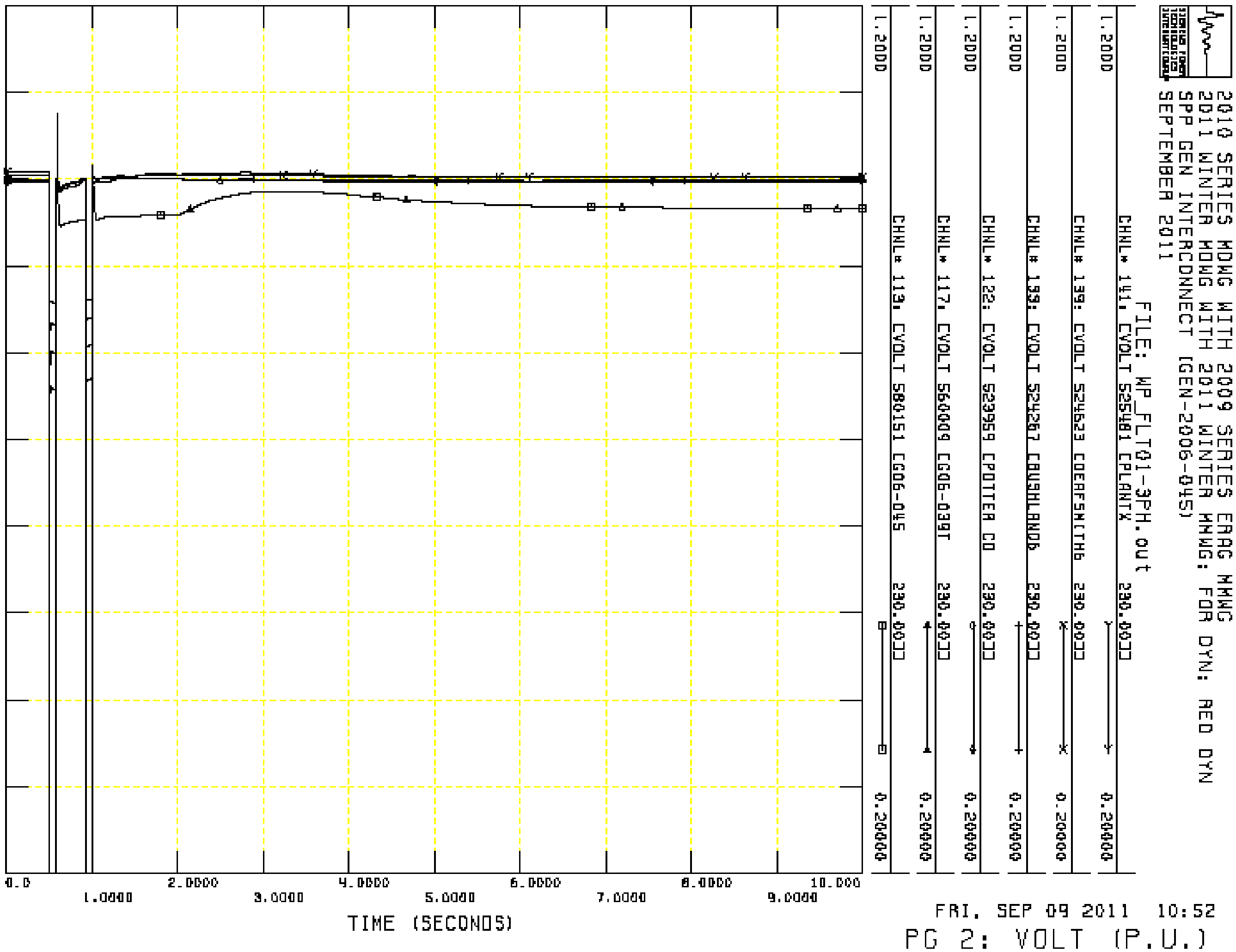

Figure 4.2-2. Response of selected area bus voltages for case FLT01-3PH for winter peak conditions for the Near Term case.

Summary

The stability analysis determined that no wind generator tripping or system instability occurs by interconnecting GEN-2006-045 project at 100% output. Refer to Appendix D and Appendix E for the stability plots of the study area and nearby system's bus voltage and generator's response during the disturbance for the summer peak and winter peak conditions, respectively.

4.3 Overall Summary

The stability analysis determined that no wind generator tripping or system instability occurs by interconnecting the GEN-2006-045 project at 100% output for both the Far Term cases and Near Term cases. Refer to Appendix B and Appendix C for the Far Term stability plots of the study area and nearby system's bus voltage and generator's response during the disturbance for the summer peak and winter peak conditions, respectively. Refer to Appendix D and Appendix E for the Near Term stability plots of the study area and nearby system's bus voltage and generator's response during the disturbance for the summer peak and winter peak conditions, respectively.

SECTION 5: CONCLUSIONS

Power Factor Analysis

Power Factor Analysis shows that GEN-2006-045 has a power factor range of 0.9944 lagging (supplying) to 0.9981 leading (absorbing) for the Far Term Cases and a power factor range of 0.9850 to 0.9982 leading (absorbing) for the Near Term Cases.

Stability Analysis

The Stability Analysis determined that no wind turbine tripping or system instability occurs from interconnecting GEN-2006-045 at 100% output for both the Far Term cases and the Near Term cases.