Southwest Power Pool

Definitive Interconnection System Impact Re-Study For Generation Interconnection Request GEN-2008-016

SPP Generation Interconnection

(#GEN-2008-016)

October *2011*

Executive Summary

<OMITTED TEXT> (Customer) has requested interconnection under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnection of 248 MW of wind generation within the balancing authority of Southwestern Public Service Company (SPS) in Lynn County, Texas. The generation interconnection request is part of the ICS-2008-001 cluster study. During the performance of the Facility Study, it was determined by the Transmission Owner and Interconnection Customer that system expectations in the area of the Grassland 230kV substation have become largely altered. This restudy is being conducted to evaluate interconnection required system upgrades as a result of modifications to the nearby system.

The wind generation facility was studied with one hundred thirty-eight (138) Vestas V90 1.8 MW wind turbine generators. This Impact study addresses the thermal loading and dynamic stability effects of interconnecting the plant to the rest of the SPS transmission system.

Power flow analysis has indicated that with system upgrades, the customer's wind facility can interconnect its full 248 MW of generation capacity into the SPS transmission system. Due to changes in the system configuration near Grassland, a new 230kV line from Wolfforth-Grassland 230kV is now required. The previously assigned Grassland Autotransformer upgrade is no longer required. Powerflow analysis was based on both summer and winter peak conditions and light loading cases.

The power factor requirements for GEN-2008-016 are +/-95% at the POI per FERC and SPP Tariff requirements.

The stability study results show that with the required network upgrades, the transmission system remains stable for all simulated contingencies and conditions studied for the Customer facility.

Two seasonal base cases were used in the study to analyze the stability impacts of the proposed generation facility. The cases studied were modified 2011 summer peak and 2011 winter peak cases that were adjusted to reflect system conditions at the requested in-service date. Each case was modified to include prior queued projects that are listed in the body of the report. Fifty-nine (59) contingencies were identified for use in this study. The Vestas V90 1.8 MW wind turbines were modeled using information provided by the Customer.

The cost to interconnect is estimated at $34,046,367.

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 interconnection under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnection of 248 MW of wind generation within the balancing authority of Southwestern Public Service Company (SPS) in Lynn County, Texas. The generation interconnection request is part of the ICS-2008-001 cluster study. During the performance of the Facility Study, it was determined by the Transmission Owner and Interconnection Customer that system expectations in the area of the Grassland 230kV substation have become largely altered. This restudy is being conducted to evaluate interconnection required system upgrades as a result of modifications to the nearby system.

This Impact study addresses the thermal loading and dynamic stability effects of interconnecting the plant to the rest of the SPS transmission system. Two seasonal base cases were used in the study to analyze the stability impacts of the proposed generation facility. The cases studied were modified 2011 summer peak and 2011 winter peak cases that were adjusted to reflect system conditions at the requested in-service date. Each case was modified to include prior queued projects that are listed in the body of the report. Thirty-nine (39) contingencies were identified for use in this study. The Vestas V90 1.8 MW wind turbines were modeled using information provided by the Customer.

2.0 Purpose

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

1. are directly interconnected to the Transmission System;
2. are interconnected to Affected Systems and may have an impact on the Interconnection Request;
3. have a pending higher queued Interconnection Request to interconnect to the Transmission System; or
4. have no Queue Position but have executed an LGIA or requested that an unexecuted LGIA be filed with FERC.

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

Nothing in this 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 a pair of equivalent wind turbine generators of 122.4 MW and 124.2 MW output. The wind turbines are connected to equivalent 0.69/34.5KV generator step units (GSU). The high side of each GSU is connected to a 34.5/230kV substation transformer. A 230kV transmission line connects the Customer’s substation to the Point of Interconnection (POI).

3.2 Interconnection Facility and Network Upgrades

The POI will be at the SPS Grassland 230kV Interchange. Figure 1 shows the facility and proposed POI.

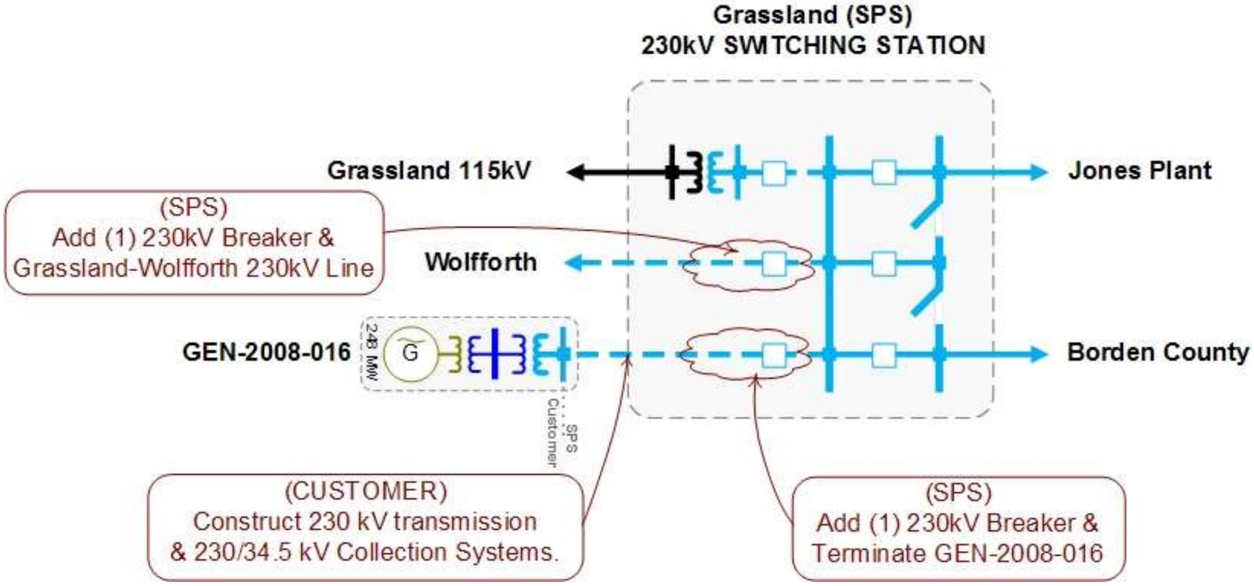

Figure 1: GEN-2008-016 Facility and Proposed Interconnection Configuration

Powerflow analysis, described in the next section, determined that additional network upgrades are required for interconnection. These upgrades include a new 230kV transmission line from Grassland to Wolfforth of approximately 45 miles in length.

Total interconnection costs are estimated in Table 1.

Table 1: Interconnection Costs for GEN-2008-016

Facility	Costs
Grassland Substation – Install 230kV line terminal for interconnection of generating facility (Transmission Owner Interconnection Facility)	$895,022
Grassland Substation – RTU (Network Upgrades	$ 51,345
Grassland Substation – Install 230kV line terminal for interconnecting 45 mile line to Wolfforth (Network Upgrades)	$800,000
Wolfforth Substation – Install 230kV line terminal for interconnecting 45 mile line to Grassland (Network Upgrades)	$800,000
Wolfforth-Grassland 230kV transmission line	$31,500,000
Total	**$34,046,367**

4.0 Power Flow Analysis

A powerflow analysis was conducted for the Interconnection Customer's facility using modified versions of the 2011 spring peak, 2011 summer and winter peak and the 2016 summer and winter peak models. The output of the Interconnection Customer's facility was offset in each model by a reduction in output of existing online SPP generation. This method allows the request to be studied as an Energy Resource (ER) Interconnection Request. The available seasonal models used were through the 2016 Summer Peak.

The Southwest Power Pool (SPP) Criteria states that:

> "The transmission system of the SPP region shall be planned and constructed so that the contingencies as set forth in the Criteria will meet the applicable NERC Reliability Standards for transmission planning. All

MDWG power flow models shall be tested to verify compliance with the System Performance Standards from NERC Table 1 – Category A."

The ACCC function of PSS/E was used to simulate single contingencies in portions of or all of the control area of SPS and other control areas within SPP and the resulting scenarios analyzed. This satisfies the "more probable" contingency testing criteria mandated by NERC and the SPP criteria.

Interconnection Upgrades are identified as constraints that have at least a 20% impact on the constraint from the generator being studied. The ACCC analysis indicates that GEN-2008-016 as studied as part of the ICS-2008-001 cluster can interconnect 100 MW to the SPS transmission system without causing additional interconnection upgrades. A new Wolfforth – Grassland 230kV transmission line is required for interconnection of the full 248 MW request. These analysis results are listed in Table 2. The following network upgrades were assumed to be in service in this analysis.

1. Woodward – Tuco 345kV transmission line
2. Hitchland – Woodward double circuit 345kV transmission line
3. Wolfforth – Grassland 230kV transmission line[1]
4. All other network upgrades listed in ICS-2008-001-4 on page 6 located at SPP.org > Engineering >Tariff Studies > Generation Interconnection > 2008_Impact_Studies

[1] This upgrade was not applied in scenario 0 shown in Table 2.

Table 2: ACCC Analysis for GEN-2008-016 Interconnecting 248 MW of Wind Generation

GROUP	SCENARIO	SEASON	SOURCE	DIRECTION	MONTCOMMONNAME	RATEA	RATEB	TDF	TC% LOADING	CONTNAME	Interconnection Available prior to Grassland-Wolfforth Upgrade
00G08_016	0	11SP	G08_016	'FROM->TO'	'GRASSLAND INTERCHANGE 230/115KV TRANSFORMER CKT 1'	100	115	0.63123	179.4147	'GRASSLAND INTERCHANGE - Jones Station Bus#2 230KV CKT 1'	100MW
00G08_016	0	16SP	G08_016	'FROM->TO'	'GRASSLAND INTERCHANGE 230/115KV TRANSFORMER CKT 1'	100	115	0.58928	179.1018	'GRASSLAND INTERCHANGE - Jones Station Bus#2 230KV CKT 1'	
06G08_016	0	11G	G08_016	'FROM->TO'	'GRASSLAND INTERCHANGE 230/115KV TRANSFORMER CKT 1'	100	115	0.62974	154.8785	'GRASSLAND INTERCHANGE - Jones Station Bus#2 230KV CKT 1'	
00G08_016	0	11WP	G08_016	'FROM->TO'	'GRASSLAND INTERCHANGE 230/115KV TRANSFORMER CKT 1'	100	125	0.62984	148.6127	'GRASSLAND INTERCHANGE - Jones Station Bus#2 230KV CKT 1'	
00G08_016	0	16WP	G08_016	'FROM->TO'	'GRASSLAND INTERCHANGE 230/115KV TRANSFORMER CKT 1'	100	125	0.58809	143.2519	'GRASSLAND INTERCHANGE - Jones Station Bus#2 230KV CKT 1'	
6	0	11G	G08_016	'FROM->TO'	'GRASSLAND INTERCHANGE 230/115KV TRANSFORMER CKT 1'	100	115	0.63096	125.2641	'GRASSLAND INTERCHANGE - Jones Station Bus#2 230KV CKT 1'	
06G08_016	0	11G	G08_016	'FROM->TO'	'GRASSLAND INTERCHANGE - LYNN COUNTY INTERCHANGE 115KV CKT 1'	159	160	0.62797	120.552	'GRASSLAND INTERCHANGE - Jones Station Bus#2 230KV CKT 1'	
06G08_016	0	11G	G08_016	'FROM->TO'	'LYNN COUNTY INTERCHANGE - SOUTH PLAINS REC-WOODROW INTERCHANGE 115KV CKT 1'	159	160	0.62797	104.605	'GRASSLAND INTERCHANGE - Jones Station Bus#2 230KV CKT 1'	
00G08_016	0	11SP	G08_016	'FROM->TO'	'GRASSLAND INTERCHANGE - LYNN COUNTY INTERCHANGE 115KV CKT 1'	159	160	0.63107	103.033	'GRASSLAND INTERCHANGE - Jones Station Bus#2 230KV CKT 1'	
00G08_016	0	16SP	G08_016	'FROM->TO'	'Jones Station Bus#2 - LUBBOCK SOUTH INTERCHANGE 230KV CKT 2'	319	351	0.25105	102.9391	'JONES STATION - LUBBOCK SOUTH INTERCHANGE 230KV CKT 1'	
6	0	11G	G08_016	'FROM->TO'	'GRASSLAND INTERCHANGE - LYNN COUNTY INTERCHANGE 115KV CKT 1'	159	160	0.62923	100	'GRASSLAND INTERCHANGE - Jones Station Bus#2 230KV CKT 1'	

5.0 Power Factor Analysis

The power factor requirements for GEN-2008-016 are +/-95% at the POI per FERC and SPP Tariff requirements. Additionally, this power factor range was found to be sufficient to maintain the voltage schedule at the POI as indicated below in Table 3.

Table 3: Power Factor Requirements at POI

Contingency	Summer (248.4 MW @ 1.0 Vp.u.)			Winter (248.4 MW @ 1.0 Vp.u.)		
	MVAR	PF	Type	MVAR	PF	Type
Pre Contingency	-11.6	0.9989	Lagging	-2.8	0.9999	Lagging
Grassland (526677) to Jones Bus 2 (526338) 230kV line	-8.5	0.9994	Lagging	16.9	0.9977	Leading
Grassland (526677) to Borden (526830) 230kV line	-24.5	0.9952	Lagging	-20.0	0.9968	Lagging
Grassland (526677) to Wolfforth (526525) 230kV line	5.1	0.9998	Leading	10.2	0.9992	Leading
Grassland 230kV (526677) to 115kV (526676) transformer	-12.5	0.9987	Lagging	-4.4	0.9998	Lagging
Borden 230kV (526830) to Vealmoor 138kV (522896) transformer	-8.3	0.9994	Lagging	-3.8	0.9999	Lagging
Grassland (526676) to Lynn Co. (526656) 115kV line	-25.0	0.9950	Lagging	-16.2	0.9979	Lagging
Lynn Co 115kV (526656) to 69kV (526655) transformer	-12.7	0.9987	Lagging	-3.1	0.9999	Lagging
Lynn Co. (526656) to Woodrow (526602) 115kV line	-25.7	0.9947	Lagging	-17.8	0.9974	Lagging
Woodrow (526602) to Lubbock S. (526268) 115kV line	-40.0	0.9873	Lagging	-27.6	0.9939	Lagging
Lubbock S. (526268) to Lubbock E. (526598) 115kV line	-10.5	0.9991	Lagging	-3.2	0.9999	Lagging
Lubbock S. (526268) to Allen (526213) 115kV line	-11.6	0.9989	Lagging	-3.3	0.9999	Lagging
Lubbock S. 115kV (526268) to 69kV (526267) transformer	-11.6	0.9989	Lagging	-2.8	0.9999	Lagging
Lubbock S. 230kV (526269) to 115kV (526268) transformer	-23.2	0.9957	Lagging	-9.7	0.9992	Lagging
Lubbock S. (526269) to LP-Southeast (522861) 230kV line	-10.9	0.9990	Lagging	-2.3	1.0000	Lagging
Wolfforth (526525) to Lubbock S. (526269) 230kV line	-24.0	0.9954	Lagging	-14.5	0.9983	Lagging
Wolfforth (526525) to Sundown (526435) 230kV line	-9.4	0.9993	Lagging	0.8	1.0000	Leading
Wolfforth 230kV (526525) to 115kV (526524) transformer	-2.1	1.0000	Lagging	5.1	0.9998	Leading
Lubbock E. (526298) to Crosby (525926) 115kV line	-10.8	0.9991	Lagging	-2.6	0.9999	Lagging
Lubbock E. 230kV (526299) to 115kV (526298) transformer	-14.3	0.9983	Lagging	-4.5	0.9998	Lagging
Jones Bus 2 (526338) to Lubbock S. (526269) 230kV line	-14.6	0.9983	Lagging	-4.2	0.9999	Lagging
Jones Bus 2 (526338) to Lubbock E. (526299) 230kV line	-15.0	0.9982	Lagging	-5.2	0.9998	Lagging
Lubbock E. (526299) to LP-Wadsworth (522888) 230kV line	-12.3	0.9988	Lagging	-3.2	0.9999	Lagging
Jones Bus 2 (526338) to LP-Holly (522870) 230kV line	-13.2	0.9986	Lagging	-4.0	0.9999	Lagging
Jones Bus 2 (526338) to Jones Bus 1 (526337) 230kV line	-11.8	0.9989	Lagging	-2.7	0.9999	Lagging
Jones Bus 1 (526337) to Lubbock S. (526269) 230kV line	-14.6	0.9983	Lagging	-4.2	0.9999	Lagging
Jones Bus 1 (526337) to Tuco (525830) 230kV line	-11.0	0.9990	Lagging	-2.6	0.9999	Lagging
Tuco (525830) to Swisher (525213) 230kV line	-11.7	0.9989	Lagging	-2.8	0.9999	Lagging
Tuco (525830) to Tolk E. (525524) 230kV line	-17.0	0.9977	Lagging	-7.9	0.9995	Lagging

Contingency	Summer (248.4 MW @ 1.0 Vp.u.)			Winter (248.4 MW @ 1.0 Vp.u.)		
	MVAR	PF	Type	MVAR	PF	Type
Tuco (525830) to Carlisle (526161) 230kV line	-14.0	0.9984	Lagging	-5.1	0.9998	Lagging
Tuco 230kV (525830) to 345kV (525832) transformer	-11.6	0.9989	Lagging	-2.6	0.9999	Lagging
Tuco (525832) to Border (525835) 345kV line	-11.4	0.9989	Lagging	-1.8	1.0000	Lagging
Tuco (525832) to GEN-2008-014 Tap (560813) 345kV line	-11.7	0.9989	Lagging	-2.0	1.0000	Lagging
GEN-2005-017 Tap (579118) to Hitchland (523097) 345kV line	-12.4	0.9988	Lagging	-3.8	0.9999	Lagging

6.0 Stability Analysis

6.1 Contingencies Simulated

Fifty-nine (59) contingencies were considered for the transient stability simulations. These contingencies included three phase and single phase transmission line faults and transformer 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 below in Table 4.

Table 4: Fault Definitions

Cont. No.	Cont. Name	Description
1	FLT_GRASSLAND_JONES BUS26_230kV_3PH	3 phase fault on the Grassland (526677) to Jones Bus 2 (526338) 230kV line, near Grassland. a. Apply fault at the Grassland 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.
2	FLT_GRASSLAND_JONES BUS26_230kV_1PH	*Single phase fault and sequence like previous*
3	FLT_GRASSLAND_BORD EN_230kV_3PH	3 phase fault on the Grassland (526677) to Borden (526830) 230kV line, near Grassland. a. Apply fault at the Grassland 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.
4	FLT_GRASSLAND_BORD EN_230kV_1PH	*Single phase fault and sequence like previous*

Cont. No.	Cont. Name	Description
5	FLT_GRASSLAND_WOLFFORTH6_230kV_3PH	3 phase fault on the Grassland (526677) to Wolfforth (526525) 230kV line, near Grassland. a. Apply fault at the Grassland 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.
6	FLT_GRASSLAND_GRASSLAND3_230_115kV_3PH	3 phase fault on the Grassland 230kV (526677) to 115kV (526676) transformer, near the 230kV bus. a. Apply fault at the Grassland 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
7	FLT_BORDEN_CRVEALMOOR4_230_138kV_3PH	3 phase fault on the Borden 230kV (526830) to Vealmoor 138kV (522896) transformer, near the 230kV bus. a. Apply fault at the Borden 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
8	FLT_GRASSLAND3_LYNNCNTY3_115kV_3PH	3 phase fault on the Grassland (526676) to Lynn Co. (526656) 115kV line, near Grassland. a. Apply fault at the Grassland 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.
9	FLT_GRASSLAND3_LYNNCNTY3_115kV_1PH	*Single phase fault and sequence like previous*
10	FLT_LYNNCNTY3_LYNNCNTY2_115_69kV_3PH	3 phase fault on the Lynn Co 115kV (526656) to 69kV (526655) transformer, near the 115kV bus. a. Apply fault at the Lynn Co. 115kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
11	FLT_LYNNCNTY3_SPWOODROW3_115kV_3PH	3 phase fault on the Lynn Co. (526656) to Woodrow (526602) 115kV line, near Lynn Co. a. Apply fault at the Lynn Co. 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	FLT_LYNNCNTY3_SPWOODROW3_115kV_1PH	*Single phase fault and sequence like previous*
13	FLT_SPWOODROW3_LBBCKSTH3_115kV_3PH	3 phase fault on the Woodrow (526602) to Lubbock S. (526268) 115kV line, near Woodrow. a. Apply fault at the Woodrow 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	FLT_SPWOODROW3_LBBCKSTH3_115kV_1PH	*Single phase fault and sequence like previous*

Cont. No.	Cont. Name	Description
15	FLT_LBBCKSTH3_LUBBCKEST3_115kV_3PH	3 phase fault on the Lubbock S. (526268) to Lubbock E. (526598) 115kV line, near Lubbock S. a. Apply fault at the Lubbock S. 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	FLT_LBBCKSTH3_LUBBCKEST3_115kV_1PH	*Single phase fault and sequence like previous*
17	FLT_LBBCKSTH3_ALLEN3_115kV_3PH	3 phase fault on the Lubbock S. (526268) to Allen (526213) 115kV line, near Lubbock S. a. Apply fault at the Lubbock S. 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	FLT_LBBCKSTH3_ALLEN3_115kV_1PH	*Single phase fault and sequence like previous*
19	FLT_LBBCKSTH3_SPWOODROW3_115kV_3PH	3 phase fault on the Lubbock S. (526268) to Woodrow (526602) 115kV line, near Lubbock S. a. Apply fault at the Lubbock S. 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	FLT_LBBCKSTH3_SPWOODROW3_115kV_1PH	*Single phase fault and sequence like previous*
21	FLT_LBBCKSTH3_LBBCKSTH2_115_69kV_3PH	3 phase fault on the Lubbock S. 115kV (526268) to 69kV (526267) transformer, near the 115kV bus. a. Apply fault at the Lubbock S. 115kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
22	FLT_LUBBCKSTH6_LBBCKSTH3_230_115kV_3PH	3 phase fault on the Lubbock S. 230kV (526269) to 115kV (526268) transformer, near the 230kV bus. a. Apply fault at the Lubbock S. 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
23	FLT_LUBBCKSTH6_LPSOUTHEST6_230kV_3PH	3 phase fault on the Lubbock S. (526269) to LP-Southeast (522861) 230kV line, near Lubbock S. a. Apply fault at the Lubbock S. 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.
24	FLT_LUBBCKSTH6_LPSOUTHEST6_230kV_1PH	*Single phase fault and sequence like previous*
25	FLT_WOLFFORTH6_LUBBCKSTH6_230kV_3PH	3 phase fault on the Wolfforth (526525) to Lubbock S. (526269) 230kV line, near Wolfforth. a. Apply fault at the Wolfforth 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.

Cont. No.	Cont. Name	Description
26	FLT_WOLFFORTH6_LUBBCKSTH6_230kV_1PH	*Single phase fault and sequence like previous*
27	FLT_WOLFFORTH6_SUNDOWN6_230kV_3PH	3 phase fault on the Wolfforth (526525) to Sundown (526435) 230kV line, near Wolfforth. a. Apply fault at the Wolfforth 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.
28	FLT_WOLFFORTH6_SUNDOWN6_230kV_1PH	*Single phase fault and sequence like previous*
29	FLT_WOLFFORTH6_WOLFFORTH3_230_115kV_3PH	3 phase fault on the Wolfforth 230kV (526525) to 115kV (526524) transformer, near the 230kV bus. a. Apply fault at the Wolfforth 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
30	FLT_LUBBCKEST3_CROSBY3_115kV_3PH	3 phase fault on the Lubbock E. (526298) to Crosby (525926) 115kV line, near Lubbock E. a. Apply fault at the Lubbock E. 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.
31	FLT_LUBBCKEST3_CROSBY3_115kV_1PH	*Single phase fault and sequence like previous*
32	FLT_LUBBCKEST6_LUBBCKEST3_230_115kV_3PH	3 phase fault on the Lubbock E. 230kV (526299) to 115kV (526298) transformer, near the 230kV bus. a. Apply fault at the Lubbock E. 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
33	FLT_JONESBUS26_LUBBCKSTH6_230kV_3PH	3 phase fault on the Jones Bus 2 (526338) to Lubbock S. (526269) 230kV line, near Jones Bus 2. a. Apply fault at the Jones Bus 2 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.
34	FLT_JONESBUS26_LUBBCKSTH6_230kV_1PH	*Single phase fault and sequence like previous*
35	FLT_JONESBUS26_LUBBCKEST6_230kV_3PH	3 phase fault on the Jones Bus 2 (526338) to Lubbock E. (526299) 230kV line, near Jones Bus 2. a. Apply fault at the Jones Bus 2 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.
36	FLT_JONESBUS26_LUBBCKEST6_230kV_1PH	*Single phase fault and sequence like previous*

Cont. No.	Cont. Name	Description
37	FLT_LUBBCKEST6_LPWADSWRTH6_230kV_3PH	3 phase fault on the Lubbock E. (526299) to LP-Wadsworth (522888) 230kV line, near Lubbock E. a. Apply fault at the Lubbock E. 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.
38	FLT_LUBBCKEST6_LPWADSWRTH6_230kV_1PH	*Single phase fault and sequence like previous*
39	FLT_JONESBUS26_LPHOLLY6_230kV_3PH	3 phase fault on the Jones Bus 2 (526338) to LP-Holly (522870) 230kV line, near Jones Bus 2. a. Apply fault at the Jones Bus 2 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	FLT_JONESBUS26_LPHOLLY6_230kV_1PH	*Single phase fault and sequence like previous*
41	FLT_JONESBUS26_JONESBUS16_230kV_3PH	3 phase fault on the Jones Bus 2 (526338) to Jones Bus 1 (526337) 230kV line, near Jones Bus 2. a. Apply fault at the Jones Bus 2 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	FLT_JONESBUS26_JONESBUS16_230kV_1PH	*Single phase fault and sequence like previous*
43	FLT_JONESBUS16_LUBBCKSTH6_230kV_3PH	3 phase fault on the Jones Bus 1 (526337) to Lubbock S. (526269) 230kV line, near Jones Bus 1. a. Apply fault at the Jones Bus 1 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.
44	FLT_JONESBUS16_LUBBCKSTH6_230kV_1PH	*Single phase fault and sequence like previous*
45	FLT_JONESBUS16_TUCOINT6_230kV_3PH	3 phase fault on the Jones Bus 1 (526337) to Tuco (525830) 230kV line, near Jones Bus 1. a. Apply fault at the Jones Bus 1 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.
46	FLT_JONESBUS16_TUCOINT6_230kV_1PH	*Single phase fault and sequence like previous*
47	FLT_TUCOINT6_SWISHER6_230kV_3PH	3 phase fault on the Tuco (525830) to Swisher (525213) 230kV line, near Tuco. a. Apply fault at the Tuco 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.

Cont. No.	Cont. Name	Description
48	FLT_TUCOINT6_SWISHER6_230kV_1PH	*Single phase fault and sequence like previous*
49	FLT_TUCOINT6_TOLKEAST6_230kV_3PH	3 phase fault on the Tuco (525830) to Tolk E. (525524) 230kV line, near Tuco. a. Apply fault at the Tuco 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.
50	FLT_TUCOINT6_TOLKEAST6_230kV_1PH	*Single phase fault and sequence like previous*
51	FLT_TUCOINT6_CARLISLE6_230kV_3PH	3 phase fault on the Tuco (525830) to Carlisle (526161) 230kV line, near Tuco. a. Apply fault at the Tuco 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.
52	FLT_TUCOINT6_CARLISLE6_230kV_1PH	*Single phase fault and sequence like previous*
53	FLT_TUCOINT6_TUCOINT7_230_345kV_3PH	3 phase fault on the Tuco 230kV (525830) to 345kV (525832) transformer, near the 230kV bus. a. Apply fault at the Tuco 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
54	FLT_TUCOINT7_BORDER7_345kV_3PH	3 phase fault on the Tuco (525832) to Border (525835) 345kV line, near Tuco. a. Apply fault at the Tuco 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	FLT_TUCOINT7_BORDER7_345kV_1PH	*Single phase fault and sequence like previous*
56	FLT_TUCOINT7_G08014_345kV_3PH	3 phase fault on the Tuco (525832) to GEN-2008-014 Tap (560813) 345kV line, near Tuco. a. Apply fault at the Tuco 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.
57	FLT_TUCOINT7_G08014_345kV_1PH	*Single phase fault and sequence like previous*
58	FLT_2005017_HITCHLAND7_345kV_3PH	3 phase fault on the GEN-2005-017 Tap (579118) to Hitchland (523097) 345kV line, near GEN-2005-017 Tap. a. Apply fault at the GEN-2005-017 Tap 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.
59	FLT_2005017_HITCHLAND7_345kV_1PH	*Single phase fault and sequence like previous*

6.2 Further Model Preparation

The base cases contain all higher or equally queued projects as described in ICS-2008-001-4.

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.

6.3 Results

Results of the stability analysis are summarized in Table 5. The results indicate that for all contingencies studied the transmission system remains stable with the inclusion of equally or higher queued projects listed in ICS-2008-001-4.

Table 5: Results of Simulated Contingencies

Cont. No.	Cont. Name	Description	2011 Summer	2011 Winter
1	FLT_GRASSLAND_JONESBUS26_230kV_3PH	3 phase fault on the Grassland (526677) to Jones Bus 2 (526338) 230kV line, near Grassland.	Stable	Stable
2	FLT_GRASSLAND_JONESBUS26_230kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
3	FLT_GRASSLAND_BORDEN_230kV_3PH	3 phase fault on the Grassland (526677) to Borden (526830) 230kV line, near Grassland.	Stable	Stable
4	FLT_GRASSLAND_BORDEN_230kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
5	FLT_GRASSLAND_WOLFFORTH6_230kV_3PH	3 phase fault on the Grassland (526677) to Wolfforth (526525) 230kV line, near Grassland.	Stable	Stable
6	FLT_GRASSLAND_GRASSLAND3_230_115kV_3PH	3 phase fault on the Grassland 230kV (526677) to 115kV (526676) transformer, near the 230kV bus.	Stable	Stable
7	FLT_BORDEN_CRVEALMOOR4_230_138kV_3PH	3 phase fault on the Borden 230kV (526830) to Vealmoor 138kV (522896) transformer, near the 230kV bus.	Stable	Stable
8	FLT_GRASSLAND3_LYNNCNTY3_115kV_3PH	3 phase fault on the Grassland (526676) to Lynn Co. (526656) 115kV line, near Grassland.	Stable	Stable
9	FLT_GRASSLAND3_LYNNCNTY3_115kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
10	FLT_LYNNCNTY3_LYNNCNTY2_115_69kV_3PH	3 phase fault on the Lynn Co 115kV (526656) to 69kV (526655) transformer, near the 115kV bus.	Stable	Stable
11	FLT_LYNNCNTY3_SPWOODROW3_115kV_3PH	3 phase fault on the Lynn Co. (526656) to Woodrow (526602) 115kV line, near Lynn Co.	Stable	Stable
12	FLT_LYNNCNTY3_SPWOODROW3_115kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
13	FLT_SPWOODROW3_LBBCKSTH3_115kV_3PH	3 phase fault on the Woodrow (526602) to Lubbock S. (526268) 115kV line, near Woodrow.	Stable	Stable

Cont. No.	Cont. Name	Description	2011 Summer	2011 Winter
14	FLT_SPWOODROW3_LBBCKSTH3_115kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
15	FLT_LBBCKSTH3_LUBBCKEST3_115kV_3PH	3 phase fault on the Lubbock S. (526268) to Lubbock E. (526598) 115kV line, near Lubbock S.	Stable	Stable
16	FLT_LBBCKSTH3_LUBBCKEST3_115kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
17	FLT_LBBCKSTH3_ALLEN3_115kV_3PH	3 phase fault on the Lubbock S. (526268) to Allen (526213) 115kV line, near Lubbock S.	Stable	Stable
18	FLT_LBBCKSTH3_ALLEN3_115kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
19	FLT_LBBCKSTH3_SPWOODROW3_115kV_3PH	3 phase fault on the Lubbock S. (526268) to Woodrow (526602) 115kV line, near Lubbock S.	Stable	Stable
20	FLT_LBBCKSTH3_SPWOODROW3_115kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
21	FLT_LBBCKSTH3_LBBCKSTH2_115_69kV_3PH	3 phase fault on the Lubbock S. 115kV (526268) to 69kV (526267) transformer, near the 115kV bus.	Stable	Stable
22	FLT_LUBBCKSTH6_LBBCKSTH3_230_115kV_3PH	3 phase fault on the Lubbock S. 230kV (526269) to 115kV (526268) transformer, near the 230kV bus.	Stable	Stable
23	FLT_LUBBCKSTH6_LPSOUTHEST6_230kV_3PH	3 phase fault on the Lubbock S. (526269) to LP-Southeast (522861) 230kV line, near Lubbock S.	Stable	Stable
24	FLT_LUBBCKSTH6_LPSOUTHEST6_230kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
25	FLT_WOLFFORTH6_LUBBCKSTH6_230kV_3PH	3 phase fault on the Wolfforth (526525) to Lubbock S. (526269) 230kV line, near Wolfforth.	Stable	Stable
26	FLT_WOLFFORTH6_LUBBCKSTH6_230kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
27	FLT_WOLFFORTH6_SUNDOWN6_230kV_3PH	3 phase fault on the Wolfforth (526525) to Sundown (526435) 230kV line, near Wolfforth.	Stable	Stable
28	FLT_WOLFFORTH6_SUNDOWN6_230kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
29	FLT_WOLFFORTH6_WOLFFORTH3_230_115kV_3PH	3 phase fault on the Wolfforth 230kV (526525) to 115kV (526524) transformer, near the 230kV bus.	Stable	Stable
30	FLT_LUBBCKEST3_CROSBY3_115kV_3PH	3 phase fault on the Lubbock E. (526298) to Crosby (525926) 115kV line, near Lubbock E.	Stable	Stable
31	FLT_LUBBCKEST3_CROSBY3_115kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
32	FLT_LUBBCKEST6_LUBBCKEST3_230_115kV_3PH	3 phase fault on the Lubbock E. 230kV (526299) to 115kV (526298) transformer, near the 230kV bus.	Stable	Stable
33	FLT_JONESBUS26_LUBBCKSTH6_230kV_3PH	3 phase fault on the Jones Bus 2 (526338) to Lubbock S. (526269) 230kV line, near Jones Bus 2.	Stable	Stable
34	FLT_JONESBUS26_LUBBCKSTH6_230kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable

Cont. No.	Cont. Name	Description	2011 Summer	2011 Winter
35	FLT_JONESBUS26_LUBBCKEST6_230kV_3PH	3 phase fault on the Jones Bus 2 (526338) to Lubbock E. (526299) 230kV line, near Jones Bus 2.	Stable	Stable
36	FLT_JONESBUS26_LUBBCKEST6_230kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
37	FLT_LUBBCKEST6_LPWADSWRTH6_230kV_3PH	3 phase fault on the Lubbock E. (526299) to LP-Wadsworth (522888) 230kV line, near Lubbock E.	Stable	Stable
38	FLT_LUBBCKEST6_LPWADSWRTH6_230kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
39	FLT_JONESBUS26_LPHOLLY6_230kV_3PH	3 phase fault on the Jones Bus 2 (526338) to LP-Holly (522870) 230kV line, near Jones Bus 2.	Stable	Stable
40	FLT_JONESBUS26_LPHOLLY6_230kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
41	FLT_JONESBUS26_JONESBUS16_230kV_3PH	3 phase fault on the Jones Bus 2 (526338) to Jones Bus 1 (526337) 230kV line, near Jones Bus 2.	Stable	Stable
42	FLT_JONESBUS26_JONESBUS16_230kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
43	FLT_JONESBUS16_LUBBCKSTH6_230kV_3PH	3 phase fault on the Jones Bus 1 (526337) to Lubbock S. (526269) 230kV line, near Jones Bus 1.	Stable	Stable
44	FLT_JONESBUS16_LUBBCKSTH6_230kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
45	FLT_JONESBUS16_TUCOINT6_230kV_3PH	3 phase fault on the Jones Bus 1 (526337) to Tuco (525830) 230kV line, near Jones Bus 1.	Stable	Stable
46	FLT_JONESBUS16_TUCOINT6_230kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
47	FLT_TUCOINT6_SWISHER6_230kV_3PH	3 phase fault on the Tuco (525830) to Swisher (525213) 230kV line, near Tuco.	Stable	Stable
48	FLT_TUCOINT6_SWISHER6_230kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
49	FLT_TUCOINT6_TOLKEAST6_230kV_3PH	3 phase fault on the Tuco (525830) to Tolk E. (525524) 230kV line, near Tuco.	Stable	Stable
50	FLT_TUCOINT6_TOLKEAST6_230kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
51	FLT_TUCOINT6_CARLISLE6_230kV_3PH	3 phase fault on the Tuco (525830) to Carlisle (526161) 230kV line, near Tuco.	Stable	Stable
52	FLT_TUCOINT6_CARLISLE6_230kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
53	FLT_TUCOINT6_TUCOINT7_230_345kV_3PH	3 phase fault on the Tuco 230kV (525830) to 345kV (525832) transformer, near the 230kV bus.	Stable	Stable
54	FLT_TUCOINT7_BORDER7_345kV_3PH	3 phase fault on the Tuco (525832) to Border (525835) 345kV line, near Tuco.	Stable	Stable
55	FLT_TUCOINT7_BORDER7_345kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable

Cont. No.	Cont. Name	Description	2011 Summer	2011 Winter
56	FLT_TUCOINT7_G08014_345 kV_3PH	3 phase fault on the Tuco (525832) to GEN-2008-014 Tap (560813) 345kV line, near Tuco.	Stable	Stable
57	FLT_TUCOINT7_G08014_345 kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable
58	FLT_2005017_HITCHLAND7_ 345kV_3PH	3 phase fault on the GEN-2005-017 Tap (579118) to Hitchland (523097) 345kV line, near GEN-2005-017 Tap.	Stable	Stable
59	FLT_2005017_HITCHLAND7_ 345kV_1PH	*Single phase fault and sequence like previous*	Stable	Stable

6.4 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.

Four fault contingency 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 6.

Table 6: LVRT Fault Contingencies

Cont. Name	Description
FLT_GRASSLAND_JONESBUS26_230kV_3PH	3 phase fault on the Grassland (526677) to Jones Bus 2 (526338) 230kV line, near Grassland. a. Apply fault at the Grassland 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.
FLT_GRASSLAND_BORDEN_230kV_3PH	3 phase fault on the Grassland (526677) to Borden (526830) 230kV line, near Grassland. a. Apply fault at the Grassland 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.
FLT_GRASSLAND_WOLFFORTH6_230kV_3PH	3 phase fault on the Grassland (526677) to Wolfforth (526525) 230kV line, near Grassland. a. Apply fault at the Grassland 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.
FLT_GRASSLAND_GRASSLAND3_230_115kV_3PH	3 phase fault on the Grassland 230kV (526677) to 115kV (526676) transformer, near the 230kV bus. a. Apply fault at the Grassland 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.

The project wind farm remained online for the fault contingencies described in this section and for all the fault contingencies described in Section 6.1; GEN-2008-016 is found to be in compliance with FERC Order #661A.

7.0 Conclusion

<OMITTED TEXT> (Customer) has requested a Definitive Interconnection System Impact Study for interconnection service of 248 MW of wind generation within the balancing authority of Southwestern Public Service Company (SPS) in Lynn County, Texas.

With the inclusion of system upgrades identified in this report, including a new Wolfforth – Grassland 230kV transmission line, the customer's wind facility can interconnect its full 248 MW of generation capacity at the SPS Grassland 230kV substation. Interconnection capacity is limited to 100 MW until the new Wolfforth – Grassland 230kV transmission line is placed in-service.

The power factor requirements for GEN-2008-016 are +/-95% at the POI per FERC and SPP Tariff requirements.

The results of this study show that the wind generation facility and the transmission system remain stable for all contingencies studied. Also, GEN-2008-016 is found to be in compliance with FERC Order #661A

The estimated costs for interconnection facilities are estimated at $34,046,367.

These 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.