Southwest Power Pool

Limited Operational Impact Study For Generation Interconnection Request GEN-2009-020

SPP Generation Interconnection

(#GEN-2009-020)

May 2011

Executive Summary

<OMITTED TEXT> (Customer) has requested a Limited Operation Impact Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnection of 49.6 MW of wind generation within the balancing authority of Midwest Energy (MIDW) in Rush County, Kansas. Customer has requested this Limited Operation Interconnection Study (LOIS) to determine the impacts of interconnecting its generating facility to the transmission system before all required Network Upgrades identified in the DISIS-2010-001-1 Impact Re-Study can be placed into service. Limited Operation Studies are conducted under GIA Section 5.9.

This study assumed that only the higher queued projects identified in Table 3 of this study might go into service before the completion of all Network Upgrades identified in DISIS-2010-001-1. If any additional generation projects not identified in Table 3 but with queue priority equal to or over GEN-2009-020 request to go into commercial operation before all Network Upgrades identified through the DISIS-2010-001-1 study process as required, then this study must be conducted again to determine whether sufficient limited interconnection capacity exists to interconnect the GEN-2009-020 interconnection request in addition to all higher priority requests in operation or pending operation. These projects are listed in Table 4.

A power flow analysis showed that the Customer's wind facility can interconnect its full 49.6 MW of generation on its requested in-service date of December 31, 2011, subject to construction time constraints of the interconnection substation. Power flow analysis was based on both summer and winter peak conditions and light loading cases.

The wind generation facility was studied with thirty-one (31) G.E. 1.6 MW wind turbine generators. This Impact study addresses the dynamic stability effects of interconnecting the plant to the rest of the MIDW transmission system for the system condition as it will be on December 31, 2011. 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-six (36) contingencies were identified for use in this study. The G.E. 1.6 MW wind turbines were modeled using information provided by the Customer.

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

1.0 Introduction

<OMITTED TEXT> (Customer) has requested an Impact Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnection of 49.6 MW of wind generation within the balancing authority of Midwest Energy (MIDW) in Rush County, Kansas. Customer has requested this Limited Operation Interconnection Study (LOIS) to determine the impacts of interconnecting its generating facility to the transmission system before all required Network Upgrades identified in the DISIS-2010-001-1 Impact Study can be placed into service. Limited Operation Studies are conducted under GIA Section 5.9.

This Impact study addresses the dynamic stability effects of interconnecting the plant to the rest of the MIDW transmission system for the system condition as it will be on December 31, 2011. The wind generation facility was studied with thirty-one (31) G.E. 1.6 MW wind turbine. Two seasonal base cases were used in the study to analyze the stability impacts of the proposed generation facility. The cases studied were modified versions of the 2011 summer peak and 2011 winter peak to reflect the system conditions at the requested in-service date. Each case was modified to include prior queued projects that are listed in the body of the report. Thirty-six (36) contingencies were identified for this study.

2.0 Purpose

The purpose of this Limited Operation Interconnection Study (LOIS) is to evaluate the impact of the proposed interconnection on the reliability of the Transmission System. The LOIS 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 LOIS is commenced:

a) are directly interconnected to the Transmission System;
b) are interconnected to Affected Systems and may have an impact on the Interconnection Request;
c) have a pending higher queued Interconnection Request to interconnect to the Transmission System listed in Table 3; or
d) have no Queue Position but have executed an LGIA or requested that an unexecuted LGIA be filed with FERC.

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

Nothing in this System Impact Study constitutes a request for transmission service or confers upon the Interconnection Customer any right to receive transmission service.

3.0 Facilities

3.1 Generating Facility

The project was modeled as an equivalent wind turbine generator of 49.6 MW output. The wind turbine is connected to an equivalent 0.69/34.5KV generator step unit (GSU). The high side of the GSU is connected to the 34.5/69kV substation transformer. A 69kV transmission line connects the Customer's substation transformer to the POI.

3.2 Interconnection Facility

The Point of Interconnection will be at a tap on the Transmission Owners Nekoma-Balzine 69kV transmission line. **Figure 1** shows the proposed POI. Figure 2 shows the Point of Interconnection.

Cost to interconnect on a Limited basis is estimated at $1,800,000.

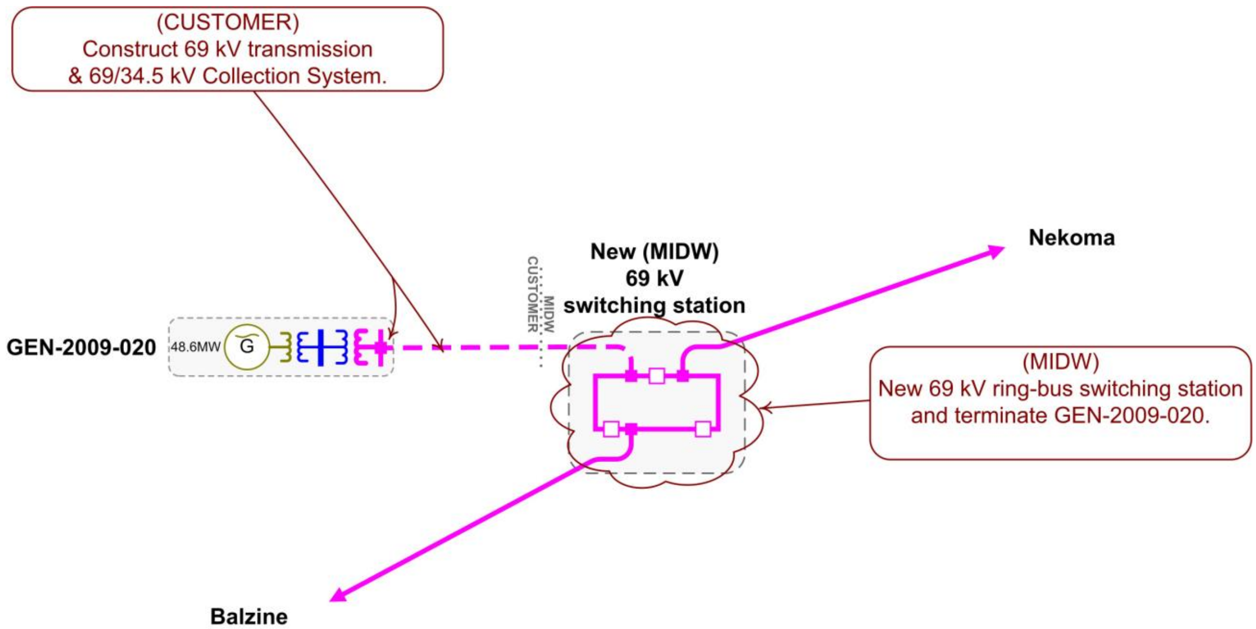

Figure 1: GEN-2009-020 Facility and Proposed Interconnection Configuration

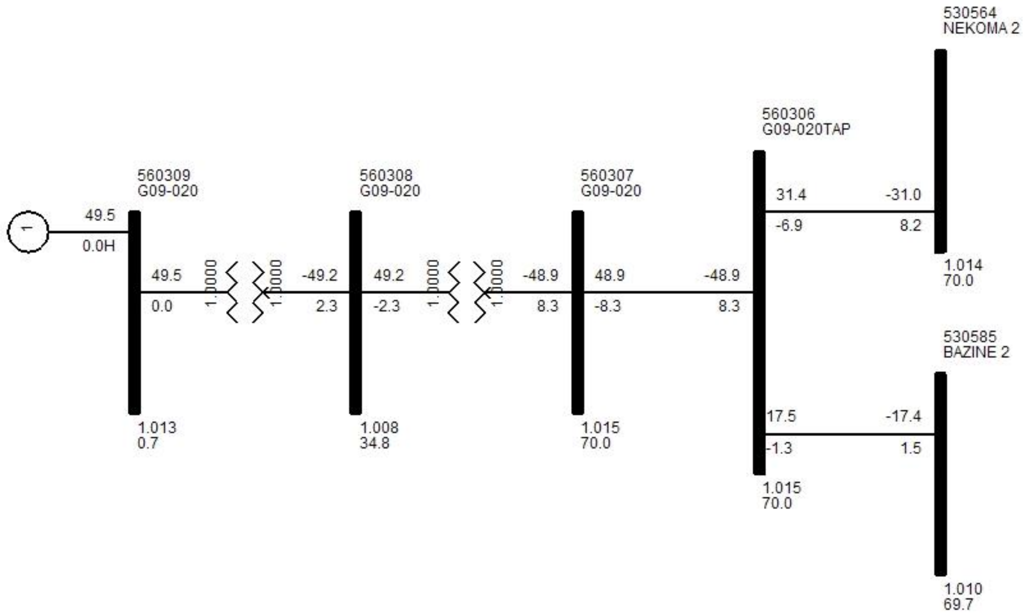

Figure 2: GEN-2009-020 Bus Interconnection

4.0 Power Flow Analysis

A power flow analysis was conducted for the Interconnection Customer's facility using a modified version of the 2011 spring, 2012 summer, and 2012 winter seasonal models. The output of the Interconnection Customer's facility was offset in the model by a reduction in output of existing online SPP generation. This method allows the request to be studied as an Energy Resource (ERIS) Interconnection Request. This analysis was conducted assuming that previous queued requests listed in Table 3 were in-service.

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 MIDW and other control areas within SPP and the resulting data analyzed. This satisfies the "more probable" contingency testing criteria mandated by NERC and the SPP criteria.

Higher queued projects listed in Table 4 were not modeled as in service. If any of these come in service, this study will need to be performed again to determine if any limited interconnection service is available.

The ACCC analysis indicates that as a result of the Customer's project at full nameplate power the MIDW transmission system will not experience thermal overloads as shown in**Error! Reference source not found.**.

Table 1: ACCC Analysis

SEASON	SOURCE	DIRECTION	MONTCOMMONNAME	RATEA	RATEB	TDF	TC%LOADING	MW Available	CONTNAME
			None						

5.0 Stability Analysis

5.1 Contingencies Simulated

Thirty-six (36) contingencies were considered for the transient stability simulations. These contingencies included three phase faults and single phase line faults at locations defined by SPP. Single-phase line faults were simulated by applying a fault impedance to the positive sequence network at the fault location to represent the effect of the negative and zero sequence networks on the positive sequence network. The fault impedance was computed to give a positive sequence voltage at the specified fault location of approximately 60% of pre-fault voltage. This method is in agreement with SPP current practice.

The faults that were defined and simulated are listed in Table 2 below.

Table 2: Contingencies Evaluated

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	FLT03-3PH	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	FLT04-1PH	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	FLT05-3PH	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	FLT07-3PH	3 phase fault on the Smoky Hills (530592) to Knoll (530558) 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.
6	FLT08-1PH	*Single phase fault and sequence like previous*
7	FLT09-3PH	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.
8	FLT11-3PH	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.
9	FLT12-1PH	*Single phase fault and sequence like previous*
10	FLT13-3PH	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.
11	FLT14-1PH	*Single phase fault and sequence like previous*

Cont. No.	Cont. Name	Description
12	FLT15-3PH	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.
13	FLT16-1PH	*Single phase fault and sequence like previous*
14	FLT17-3PH	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.
15	FLT18-1PH	*Single phase fault and sequence like previous*
16	FLT19-3PH	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.
17	FLT20-1PH	*Single phase fault and sequence like previous*
18	FLT21-3PH	3 phase fault on the Nekoma (530564) 69kV – Nekoma (530608) 115kV autotransformer on the 115kV bus a. Apply fault at the Nekoma 115 kV bus b. Clear fault after 5 cycles by tripping the faulted line.
19	FLT23-3PH	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.
20	FLT25-3PH	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.
21	FLT27-3PH	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.
22	FLT29-3PH	3 phase fault on the Concordia (539657) 115kV – Concordia 539658) 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.
23	FLT31-3PH	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.
24	FLT32-1PH	*Single phase fault and sequence like previous*
25	FLT33-3PH	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.
26	FLT34-1PH	*Single phase fault and sequence like previous*

Cont. No.	Cont. Name	Description
27	FLT35-3PH	3 phase fault on the Beach Station (530557) – Redline (530605) 115kV line, near Beach Station. a. Apply fault at the Beach Station 115kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
28	FLT36-1PH	*Single phase fault and sequence like previous*
29	FLT37-3PH	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.
30	FLT38-1PH	*Single phase fault and sequence like previous*
31	FLT39-3PH	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.
32	FLT40-1PH	*Single phase fault and sequence like previous*
33	FLT41-3PH	3 phase fault on the GEN-2009-020-POI (579040) – Nekoma (530564) 69kV line, near GEN-2009-020-POI. a. Apply fault at the GEN-2009-020-POI 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.
34	FLT42-1PH	*Single phase fault and sequence like previous*
35	FLT43-3PH	3 phase fault on the GEN-2009-020-POI (575040) – Balzine (530585) 69kV line, near GEN-2009-020-POI. a. Apply fault at the GEN-2009-020-POI 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.
36	FLT44-1PH	*Single phase fault and sequence like previous*

5.2 <u>Further Model Preparation</u>

The base cases contain prior queued projects as shown in Table 3.

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

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

Table 3: Prior Queued Projects Included

Project	MW
Montezuma	110
GEN-2001-039A	105
GEN-2002-025A	150
GEN-2003-006A	200
GEN-2003-019	250
GEN-2004-014	154
GEN-2005-012	160
GEN-2006-031	75
GEN-2007-040	200
GEN-2008-079	100
GEN-2009-011	50

The projects listed in Table 4 are higher or equally queued projects that are <u>not</u> included in this analysis. If any of these projects come into service, this study will need to be re-performed to determine if any limited capacity is available.

Table 4: Prior Queued Projects Not Included

Project	MW
GEN-2005-012	90
GEN-2006-032	200
GEN-2006-006	205
GEN-2007-038	200
GEN-2008-018	405
GEN-2008-092	201
GEN-2008-124	200
GEN-2009-008	200
GEN-2009-062	115
GEN-2010-009	166
GEN-2010-015	200
GEN-2010-016	200

5.3 Results

Results of the stability analysis are summarized in Table 5. The results indicate that for all contingencies studied the transmission system remains stable.

Table 5: Results of Simulated Contingencies

Cont. No.	Cont. Name	Description	2011 Summer	2011 Winter
1	FLT01-3PH	3 phase fault on the Setab 345kV (531465) to 115kV (531464) transformer, near the 345 kV bus.	Stable	Stable
2	FLT03-3PH	3 phase fault on the Mingo (531451) to Red Willow (640325) 345kV line, near Mingo.	Stable	Stable
3	FLT04-1PH	Single phase fault on the line in previous fault.	Stable	Stable
4	FLT05-3PH	3 phase fault on the Mingo 345kV (531451) to 115kV (531429) transformer, near the 345 kV bus.	Stable	Stable
5	FLT07-3PH	3 phase fault on the Smoky Hills (530592) to Knoll (530558) 230kV line, near Smoky Hills.	Stable	Stable
6	FLT08-1PH	*Single phase fault and sequence like previous*	Stable	Stable
7	FLT09-3PH	3 phase fault on one circuit of the Knoll 230kV (530558) to 115kV (530561) transformer, near the 230kV bus.	Stable	Stable
8	FLT11-3PH	3 phase fault on the Knoll (530561) to Saline (530551) 115kV line, near Knoll.	Stable	Stable
9	FLT12-1PH	*Single phase fault and sequence like previous*	Stable	Stable
10	FLT13-3PH	3 phase fault on the Knoll (530561) to Redline (530605) 115kV line, near Knoll.	Stable	Stable
11	FLT14-1PH	*Single phase fault and sequence like previous*	Stable	Stable
12	FLT15-3PH	3 phase fault on the South Hays (530582) to Mullergren (539679) 230kV line, near South Hays.	Stable	Stable
13	FLT16-1PH	*Single phase fault and sequence like previous*	Stable	Stable
14	FLT17-3PH	3 phase fault on the Knoll (530561) to N Hays (530581) 115kV line, near Knoll.	Stable	Stable
15	FLT18-1PH	*Single phase fault and sequence like previous*	Stable	Stable
16	FLT19-3PH	3 phase fault on the Pioneer Tap (539642) to Mullergren (539678) 115kV line, near Pioneer Tap.	Stable	Stable
17	FLT20-1PH	*Single phase fault and sequence like previous*	Stable	Stable
18	FLT21-3PH	3 phase fault on the Nekoma (530564) 69kV – Nekoma (530608) 115kV autotransformer on the 115kV bus.	Stable	Stable
19	FLT23-3PH	3 phase fault on the Heizer (530563) 69kV – Heizer (530601) 115kV transformer on the 115kV bus	Stable	Stable
20	FLT25-3PH	3 phase fault on one circuit of the Heizer (530601) 115kV – Mullergren (539679) 230kV transformer on the 115kV bus	Stable	Stable
21	FLT27-3PH	3 phase fault on the S. Hays (530582) 230kV – S. Hays (530553) 115kV transformer on the 115kV bus	Stable	Stable
22	FLT29-3PH	3 phase fault on the Concordia (539657) 115kV – Concordia 539658) 230kV transformer on the 230kV bus	Stable	Stable
23	FLT31-3PH	3 phase fault on the Mullergren (539679) – Circle (532871) 230kV line, near Mullergren.	Stable	Stable

Cont. No.	Cont. Name	Description	2011 Summer	2011 Winter
24	FLT32-1PH	*Single phase fault and sequence like previous*	Stable	Stable
25	FLT33-3PH	3 phase fault on the Mullergren (539679) – Spearville (539695) 230kV line, near Mullergren.	Stable	Stable
26	FLT34-1PH	*Single phase fault and sequence like previous*	Stable	Stable
27	FLT35-3PH	3 phase fault on the Beach Station (530557) – Redline (530605) 115kV line, near Beach Station.	Stable	Stable
28	FLT36-1PH	*Single phase fault and sequence like previous*	Stable	Stable
29	FLT37-3PH	3 phase fault on the Graham (531386) – Beach Station (530557) 115kV line, near Graham.	Stable	Stable
30	FLT38-1PH	*Single phase fault and sequence like previous*	Stable	Stable
31	FLT39-3PH	3 phase fault on the Hoxie (530556) – Beach Station (530557) 115kV line, near Hoxie.	Stable	Stable
32	FLT40-1PH	*Single phase fault and sequence like previous*	Stable	Stable
33	FLT41-3PH	3 phase fault on the GEN-2009-020-POI (579040) – Nekoma (530564) 69kV line, near GEN-2009-020-POI.	Stable	Stable
34	FLT42-1PH	*Single phase fault and sequence like previous*	Stable	Stable
35	FLT43-3PH	3 phase fault on the GEN-2009-020-POI (575040) – Balzine (530585) 69kV line, near GEN-2009-020-POI.	Stable	Stable
36	FLT44-1PH	*Single phase fault and sequence like previous*	Stable	Stable

5.4 FERC LVRT Compliance

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

Two fault contingencies were developed to verify that the wind farm will remain on line when the POI voltage is drawn down to 0.0 pu. These contingencies are shown in Table 6.

Table 6: LVRT Fault Contingencies

Cont. Name	Description
FLT41-3PH	3 phase fault on the GEN-2009-020-POI (579040) – Nekoma (530564) 69kV line, near GEN-2009-020-POI. a. Apply fault at the GEN-2009-020-POI 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.
FLT43-3PH	3 phase fault on the GEN-2009-020-POI (575040) – Balzine (530585) 69kV line, near GEN-2009-020-POI. a. Apply fault at the GEN-2009-020-POI 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.

The project wind farm remained online for the fault contingencies described in this section and for all the fault contingencies described in section 6.2. GEN-2009-020 is found to be in compliance with FERC Order #661A.

6.0 <u>Conclusion</u>

<OMITTED TEXT> (Customer) has requested an Limited Operation Impact Study for limited interconnection service of 49.6 MW of wind generation within the balancing authority of Midwest Energy (MIDW) in Rush County, Kansas, , in accordance with the Article 5.9 of the Standard Generation Interconnection Agreement (GIA) in the SPP OATT.

The results of this study show that the wind generation facility and the transmission system remain stable for all contingencies studied. Also, GEN-2009-020 is found to be in compliance with FERC Order #661A.

The projects listed in Table 4 are higher or equally queued projects that are not included in this analysis. If any of these projects come into service, this study will need to be re-performed to determine if any limited capacity is available.

A power flow analysis showed that the Customer's wind facility can interconnect its full 49.6 MW request at its in-service date of December 31, 2011, subject to construction time constraints of building the interconnection substation.

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