Southwest Power Pool

GEN-2008-018 Impact Restudy for Generator Modification (Turbine Change)

SPP Generation
Interconnection Studies

GEN-2008-018

June 2013

Executive Summary

This document reports on the findings of a restudy for the GEN-2008-018 interconnection request. The interconnection customer has requested this restudy to determine the effects of changing wind turbine generators from the previously studied GE 1.5MW wind turbine generators to the GE1.85MW wind turbine generators.

In this restudy the project uses two hundred nineteen (219) GE 1.85MW wind turbine generators for an aggregate power of 405.15MW and is located in Finney County, Kansas. The interconnection request shows that the GE 1.85MW wind turbine generators will have the optional +/-0.90 power factor capabilities installed.

The restudy showed that no stability problems were found during the summer or the winter peak conditions as a result of changing to the GE 1.85MW wind turbine generators. Additionally, the project wind farm was found to stay connected during the contingencies that were studied and, therefore, will meet the Low Voltage Ride Through (LVRT) requirements of FERC Order #661A.

A power factor analysis was performed in this study. The facility will be required to maintain a 95% lagging (providing VARs) and 95% leading (absorbing VARs) power factor at the point of interconnection. Additionally, GEN-2008-018 is required to install capacitor banks (40MVAR) on its 34.5kV bus and reactor banks (55MVAR) on its 345kV bus in addition to its generator reactive capability (+/-0.90 power factor).

A Limited Operation Study was performed at the Customer's request to determine the operating limit before the Finney-Holcomb 345kV circuit #2 can be completed. Analysis has determined that to avoid potential voltage collapse, the GEN-2008-018 Generator can interconnect a maximum of 350MW before the Finney-Holcomb 345kV line can be completed.

It should be noted that although this study analyzed many of the most probable contingencies, it is not an all-inclusive list that can account for every operational situation. Additionally, the generator[s] may not be able to inject any power onto the Transmission System due to constraints that fall below the threshold of mitigation for a Generator Interconnection request. Because of this, it is likely that the **Customer[s] may be required to reduce their generation output to 0 MW under certain system conditions** to allow system operators to maintain the reliability of the transmission network.

With the assumptions outlined in this report and with all the required network upgrades from the GEN-2008-018 GIA in place, GEN-2008-018 should be able to reliably interconnect to the SPP transmission grid.

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

1.0 Introduction

The interconnection customer has requested this restudy to determine the effects of changing wind turbine generators from the previously studied GE 1.5MW wind turbine generators to the GE1.85MW wind turbine generators.

In this study SPP monitored the generators and transmission lines in Areas 520, 524, 525, 526, 531, 534, 536, 640, 645, 650, and 652.

2.0 Purpose

The purpose of this impact restudy is to evaluate the effects of using GE 1.85MW wind turbine generators on the reliability of the Transmission System.

3.0 Facilities

3.1 Customer Facility

With two hundred-nineteen (219) GE 1.85MW wind turbine generators, the project has a maximum power output of 405.15MW. Figure 1 shows the facility one-line drawing.

3.2 Interconnection Facility

The point of interconnection (POI) is the SPS Finney 345kV substation located in Finney County, Kansas (see Figure 1).

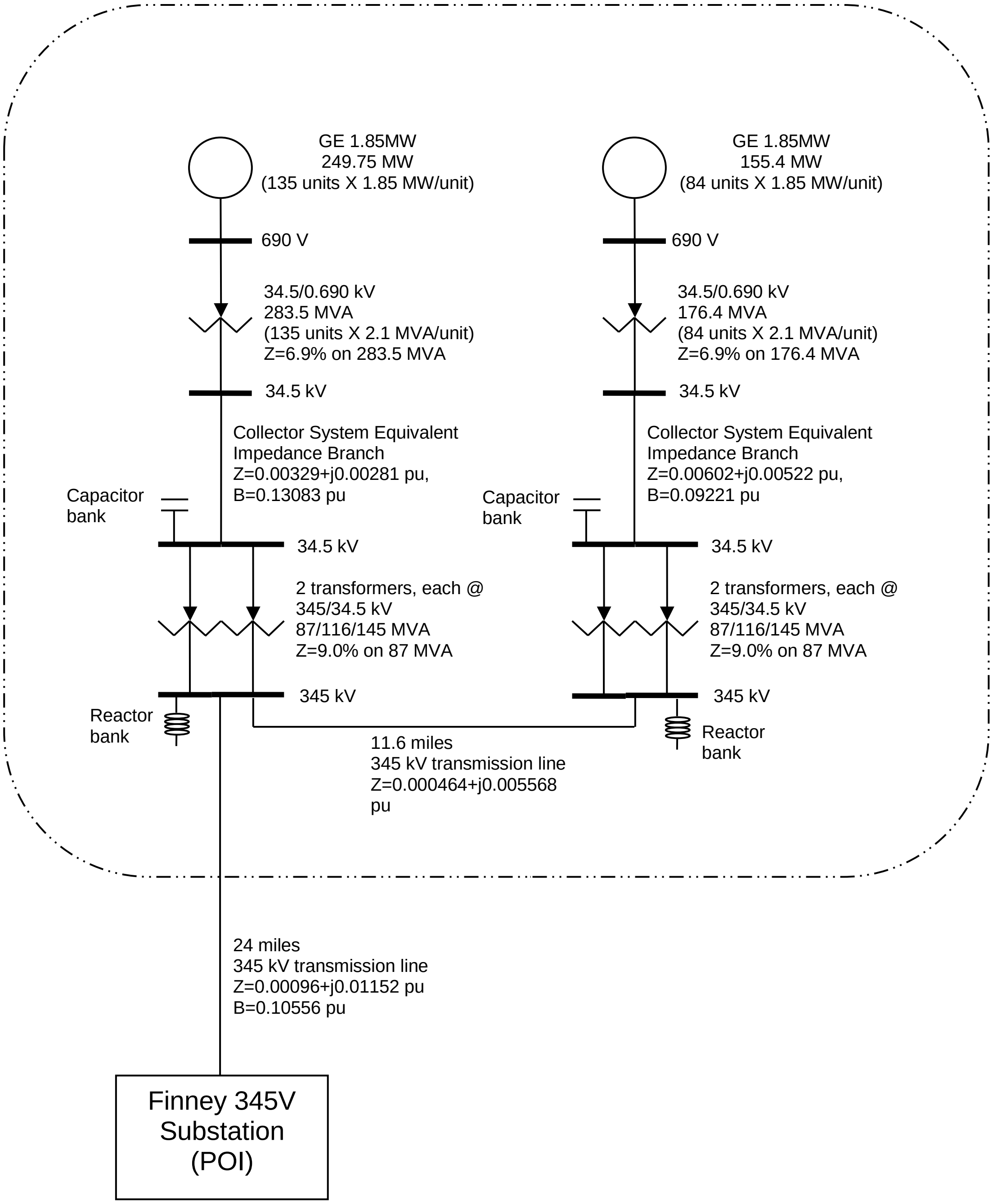

Figure 1: GEN-2008-018 Facility One-line Diagram

4.0 Stability Study Criteria

FERC Order 661A Low Voltage Ride-Through Provisions (LVRT), which went into effect January 1, 2006, requires that wind generating plants remain in-service during 3-phase faults at the point of interconnection. This order may require a Static VAR Compensator (SVC) or STATCOM device be specified at the Customer facility to keep the wind generator on-line for the fault. Dynamic Stability studies performed as part of the System Impact Study will provide additional guidance as to whether the reactive compensation can be static or a portion must be dynamic (such as a SVC or STATCOM).

5.0 Model Development

Transient stability analysis was performed using modified versions of the 2012 series of Model Development Working Group (MDWG) dynamic study models representing two geographical study areas or groups within the SPP footprint:

1. Hitchland area (Group 2)
2. Spearville area (Group 3)

Each group contains the 2014 (summer and winter) seasonal models or cases. The cases are then adapted to resemble the power flow study cases with regards to prior queued generation requests and topology. Finally the prior queued and study generation is dispatched into the SPP footprint. Initial simulations are then carried out for a no-disturbance run of twenty (20) seconds to verify the numerical stability of the model.

Siemens PSS/E Version 32.1 was the software tool used to perform the impact restudy. For simulation purposes, the Customer's facility was simplified by using the equivalent model of the wind farm as shown in Figure 1. The data used to develop the equivalent wind farm model were supplied by the Customer.

The Customer also supplied the PSS/E Version 32.1 stability models for the GE 1.85MW wind turbine generators. The GE's reactive power capability is +/-0.90.

Prior queued requests were included in the saved cases. The prior queued requests are shown in Table 1.

Table 1: Prior Queued Projects

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2001-039A	104	GE 1.6MW	Shooting Star 115kV (539763)
GEN-2002-008	240	GE 1.5MW	Hitchland 345kV (523097)
GEN-2002-009	79.8	Suzlon 2.1MW	Hansford 115kV (523195)
GEN-2002-025A	150	GE 1.5 MW	Spearville 230kV (539695)
GEN-2003-020	159	GE 1.5 MW	Carson Co. 115kV (523924)
GEN-2004-014	154.5	GE 1.5 MW	Spearville 230kV (539695)

Table 1: Prior Queued Projects

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2005-012	250.7	Siemens 2.3MW	Spearville 345kV (531469)
GEN-2006-006	205.5	GE 1.5 MW	Spearville 345kV (531469)
GEN-2006-020	20	D8.2 2.0MW	Tap on Hitchland – Sherman Tap 115kV line (560200)
GEN-2006-021	100	Clipper 2.5MW	Flat Ridge 138kV (539638)
GEN-2006-022	150	Clipper 2.5MW	Pratt 115kV (539687)
GEN-2006-044	370	DeWind D9.2 2.0MW	Hitchland 345kV (523097)
GEN-2007-038	200	Clipper 2.5MW	Spearville 345kV (531469)
GEN-2007-040	200.1	Siemens 2.3MW	Buckner 345kV (531501)
GEN-2007-046	199.5	GE 1.5MW	Hitchland 115kV (523093)
GEN-2007-057	34.5	GE 1.5MW	Moore Co. East 115kV (523308)
GEN-2008-047	300	GE 1.5MW	Tap on Hitchland to Woodward 345kV line (580500)
GEN-2008-079	98.9	Siemens 2.3MW	Tap on Cudahy – Fort Dodge 115kV line (560229)
GEN-2008-124	200.1	Siemens 2.3MW	Spearville 345kV (531469)
GEN-2010-001	300	Suzlon 2.1MW	Tap on Hitchland to Woodward 345kV line (580500)
GEN-2010-009	165.6	Siemens 2.3MW	Buckner 345kV (531501)
GEN-2010-014	358.8	Siemens SWT 2.3MW	Hitchland 345kV (523097)
GEN-2010-015	200.1	Siemens 2.3MW	Spearville 345kV (531469)
GEN-2010-045	197.8	Siemens 2.3MW	Buckner 345kV (531501)

6.0 Stability Study Analysis

Fifty (50) contingencies were considered for the transient stability simulations in this scenario. 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. The faults were simulated on both the summer peak and the winter peak models.

Table 2: Contingency List

Cont. No.	Cont. Name	Description
1	FLT01_3PH	3 phase fault on Finney 345kV Bus 523853 to Hitchland 345kV Bus 523097 CKT 1, near Finney. a. Apply fault at the Finney 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
2	FLT02_1PH	*Single phase fault and sequence like previous*
3	FLT03_1PH	3 phase fault on Finney 345kV Bus 523853 to Lamar 345kV Bus 599950 CKT 1, near Finney. a. Apply fault at the Finney 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
4	FLT04_1PH	*Single phase fault and sequence like previous*
5	FLT05_3PH	3 phase fault on Finney 345kV Bus 523853 to Holcomb 345kV Bus 531449 CKT 1, near Finney. a. Apply fault at the Finney 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
6	FLT06_1PH	*Single phase fault and sequence like previous*
7	FLT07_3PH	3 phase fault on Holcomb 345kV Bus 531449 to Setab 345kV Bus 531465 CKT 1, near Holcomb. a. Apply fault at the Holcomb 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
8	FLT08_1PH	*Single phase fault and sequence like previous*
9	FLT09_3PH	3 phase fault on Holcomb 345kV Bus 531449 to Buckner 345kV Bus 531501 CKT 1, near Holcomb. a. Apply fault at the Holcomb 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
10	FLT10_1PH	*Single phase fault and sequence like previous*
11	FLT11_3PH	3 phase fault on Hitchland 345kV Bus 523097 to Potter County 345kV Bus 523961 CKT 1, near Hitchland. a. Apply fault at the Hitchland 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.
12	FLT12_1PH	*Single phase fault and sequence like previous*
13	FLT13_3PH	3 phase fault on Hitchland 345kV Bus 523097 to Beaver County 345kV Bus 580500 CKT 1, near Hitchland. a. Apply fault at the Hitchland 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.
14	FLT14_1PH	*Single phase fault and sequence like previous*

Table 2: Contingency List

Cont. No.	Cont. Name	Description
15	FLT15_3PH	3 phase fault on Setab 345kV Bus 531465 to Mingo 345kV Bus 531451 CKT 1, near Setab. a. Apply fault at the Setab 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
16	FLT16_1PH	*Single phase fault and sequence like previous*
17	FLT17_3PH	3 phase fault on Buckner 345kV Bus 531501 to Spearville 345kV Bus 531469 CKT 1, near Buckner. a. Apply fault at the Buckner 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.
18	FLT18_1PH	*Single phase fault and sequence like previous*
19	FLT19_3PH	3 phase fault on Spearville 345kV Bus 531469 to Clark County 345kV Bus 539800 CKT 1, near Spearville. a. Apply fault at the Spearville 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.
20	FLT20_1PH	*Single phase fault and sequence like previous*
21	FLT21_3PH	3 phase fault on Spearville 345kV Bus 531469 to Ironwood 345kV Bus 539803 CKT 1, near Spearville. a. Apply fault at the Spearville 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.
22	FLT22_1PH	*Single phase fault and sequence like previous*
23	FLT23_3PH	3 phase fault on Spearville 345kV Bus 531469 to GEN11-017 345kV Bus 560242 CKT 1, near Spearville. a. Apply fault at the Spearville 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.
24	FLT24_1PH	*Single phase fault and sequence like previous*
25	FLT25_3PH	3 phase fault on Clark County 345kV Bus 539800 to Thistle 345kV Bus 539801 CKT 1, near Clark County. a. Apply fault at the Clark County 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.
26	FLT26_1PH	*Single phase fault and sequence like previous*
27	FLT27_3PH	3 phase fault on Thistle 345kV Bus 539801 to Woodward 345kV Bus 515375 CKT 1, near Thistle. a. Apply fault at the Thistle 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.
28	FLT28_1PH	*Single phase fault and sequence like previous*

Table 2: Contingency List

Cont. No.	Cont. Name	Description
29	FLT29_3PH	3 phase fault on Woodward 345kV Bus 515375 to Beaver County 345kV Bus 580500 CKT 1, near Woodward. a. Apply fault at the Woodward 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
30	FLT30_1PH	*Single phase fault and sequence like previous*
31	FLT31_3PH	3 phase fault on Holcomb 115kV Bus 531448 to Jones 115kV Bus 531379 CKT 1, near Holcomb. a. Apply fault at the Holcomb 115kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
32	FLT32_1PH	*Single phase fault and sequence like previous*
33	FLT33_3PH	3 phase fault on Holcomb 115kV Bus 531448 to Plymell 115kV Bus 531393 CKT 1, near Holcomb. a. Apply fault at the Holcomb 115kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
34	FLT34_1PH	*Single phase fault and sequence like previous*
35	FLT35_3PH	3 phase fault on Holcomb 115kV Bus 531448 to Fletcher 115kV Bus 531420 CKT 1, near Holcomb. a. Apply fault at the Holcomb 115kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
36	FLT36_1PH	*Single phase fault and sequence like previous*
37	FLT37_3PH	3 phase fault on Holcomb 115kV Bus 531448 to Garden City 115kV Bus 531445 CKT 1, near Holcomb. a. Apply fault at the Holcomb 115kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
38	FLT38_1PH	*Single phase fault and sequence like previous*
39	FLT39_3PH	3 phase fault on the Spearville 230kV Bus 539695 to Great Bend 230kV Bus 539679 CKT 1, near Spearville. a. Apply fault at the Spearville 230kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
40	FLT40_1PH	*Single phase fault and sequence like previous*
41	FLT41_3PH	3 phase fault on the Scott City 115kV Bus 531433 to Pile 115kV Bus 531432 CKT 1, near Scott City. a. Apply fault at the Scott City 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.
42	FLT42_3PH	*Single phase fault and sequence like previous*

Table 2: Contingency List

Cont. No.	Cont. Name	Description
43	FLT43_3PH	3 phase fault on the Holcomb 345kV Bus 531449 to Holcomb 230kv Bus 531448 to Holcomb 13.8kVkV Bus 531450 CKT 1, near Holcomb 345kV. a. Apply fault at the Holcomb 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
44	FLT44_3PH	3 phase fault on the Hitchland 345kV Bus 523097 to Hitchland 230kV Bus 523095 to Hitchland 13.8kVkV Bus 523094 CKT 2, near Hitchland 345kV. a. Apply fault at the Hitchland 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
45	FLT45_3PH	3 phase fault on the Setab 345kV Bus 531465 to Setab 115kv Bus 531464 to Setab 13.8kVkV Bus 531259 CKT 1, near Setab 345kV. a. Apply fault at the Setab 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
46	FLT46_3PH	3 phase fault on the Spearville 230kV Bus 539695 to Spearville 115kv Bus 539694 to Spearville 13.8kV Bus 539935 CKT 1, near Spearville 230kV. a. Apply fault at the Spearville 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
47	FLT47_3PH	3 phase fault on the Spearville 345kV Bus 531469 to Spearville 230kV Bus 539695 to Spearville 13.8kV Bus 531468 CKT 1, near Spearville 345kV. a. Apply fault at the Spearville 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
48	FLT48_3PH	3 phase fault on Hitchland 345kV Bus 523097 to Beaver County 345kV Bus 580500 CKT 2, near Hitchland. a. Apply fault at the Hitchland 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.
49	FLT49_3PH	3 phase fault on Thistle 345kV Bus 539801 to Woodward 345kV Bus 515375 CKT 2, near Thistle. a. Apply fault at the Thistle 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.
50	FLT50_3PH	3 phase fault on Woodward 345kV Bus 515375 to Beaver County 345kV Bus 580500 CKT 2, near Woodward. a. Apply fault at the Woodward 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.

7.0 Simulation Results

All faults were run for both summer and winter cases, and no tripping occurred in this study. Table 3 summarizes the results for all faults. Complete sets of plots for summer and winter cases are available on request.

Based on the dynamic results and with all network upgrades in service, GEN-2008-018 did not cause any stability problems and remained stable for all faults studied. Additionally, the project wind farm was found to stay connected during the contingencies that were studied and therefore, meet the Low Voltage Ride Through (LVRT) requirements of FERC Order #661A.

Table 3: Contingency Simulation Results

No.	Cont. Name	Description	Group 2 – Hitchland Area		Group 3 – Spearville Area	
			Summer	Winter	Summer	Winter
1	FLT01_3PH	3 phase fault on Finney 345kV Bus 523853 to Hitchland 345kV Bus 523097 CKT 1, near Finney.	Stable	Stable	Stable	Stable
2	FLT02_1PH	*Single phase fault and sequence like previous*	Stable	Stable	Stable	Stable
3	FLT03_1PH	3 phase fault on Finney 345kV Bus 523853 to Lamar 345kV Bus 599950 CKT 1, near Finney.	Stable	Stable	Stable	Stable
4	FLT04_1PH	*Single phase fault and sequence like previous*	Stable	Stable	Stable	Stable
5	FLT05_3PH	3 phase fault on Finney 345kV Bus 523853 to Holcomb 345kV Bus 531449 CKT 1, near Finney.	Stable	Stable	Stable	Stable
6	FLT06_1PH	*Single phase fault and sequence like previous*	Stable	Stable	Stable	Stable
7	FLT07_3PH	3 phase fault on Holcomb 345kV Bus 531449 to Setab 345kV Bus 531465 CKT 1, near Holcomb.	Stable	Stable	Stable	Stable
8	FLT08_1PH	*Single phase fault and sequence like previous*	Stable	Stable	Stable	Stable
9	FLT09_3PH	3 phase fault on Holcomb 345kV Bus 531449 to Buckner 345kV Bus 531501 CKT 1, near Holcomb.	Stable	Stable	Stable	Stable
10	FLT10_1PH	*Single phase fault and sequence like previous*	Stable	Stable	Stable	Stable
11	FLT11_3PH	3 phase fault on Hitchland 345kV Bus 523097 to Potter County 345kV Bus 523961 CKT 1, near Hitchland.	Stable	Stable	Stable	Stable
12	FLT12_1PH	*Single phase fault and sequence like previous*	Stable	Stable	Stable	Stable
13	FLT13_3PH	3 phase fault on Hitchland 345kV Bus 523097 to Beaver County 345kV Bus 580500 CKT 1, near Hitchland.	Stable	Stable	Stable	Stable
14	FLT14_1PH	*Single phase fault and sequence like previous*	Stable	Stable	Stable	Stable
15	FLT15_3PH	3 phase fault on Setab 345kV Bus 531465 to Mingo 345kV Bus 531451 CKT 1, near Setab. a. Apply fault at the Setab 345kV bus.	Stable	Stable	Stable	Stable
16	FLT16_1PH	*Single phase fault and sequence like previous*	Stable	Stable	Stable	Stable
17	FLT17_3PH	3 phase fault on Buckner 345kV Bus 531501 to Spearville 345kV Bus 531469 CKT 1, near Buckner.	Stable	Stable	Stable	Stable
18	FLT18_1PH	*Single phase fault and sequence like previous*	Stable	Stable	Stable	Stable
19	FLT19_3PH	3 phase fault on Spearville 345kV Bus 531469 to Clark County 345kV Bus 539800 CKT 1, near Spearville.	Stable	Stable	Stable	Stable
20	FLT20_1PH	*Single phase fault and sequence like previous*	Stable	Stable	Stable	Stable
21	FLT21_3PH	3 phase fault on Spearville 345kV Bus 531469 to Ironwood 345kV Bus 539803 CKT 1, near Spearville.	Stable	Stable	Stable	Stable

Table 3: Contingency Simulation Results

No.	Cont. Name	Description	Group 2 – Hitchland Area		Group 3 – Spearville Area	
			Summer	Winter	Summer	Winter
22	FLT22_1PH	*Single phase fault and sequence like previous*	Stable	Stable	Stable	Stable
23	FLT23_3PH	3 phase fault on Spearville 345kV Bus 531469 to GEN11-017 345kV Bus 560242 CKT 1, near Spearville.	Stable	Stable	Stable	Stable
24	FLT24_1PH	*Single phase fault and sequence like previous*	Stable	Stable	Stable	Stable
25	FLT25_3PH	3 phase fault on Clark County 345kV Bus 539800 to Thistle 345kV Bus 539801 CKT 1, near Clark County.	Stable	Stable	Stable	Stable
26	FLT26_1PH	*Single phase fault and sequence like previous*	Stable	Stable	Stable	Stable
27	FLT27_3PH	3 phase fault on Thistle 345kV Bus 539801 to Woodward 345kV Bus 515375 CKT 1, near Thistle.	Stable	Stable	Stable	Stable
28	FLT28_1PH	*Single phase fault and sequence like previous*	Stable	Stable	Stable	Stable
29	FLT29_3PH	3 phase fault on Woodward 345kV Bus 515375 to Beaver County 345kV Bus 580500 CKT 1, near Woodward.	Stable	Stable	Stable	Stable
30	FLT30_1PH	*Single phase fault and sequence like previous*	Stable	Stable	Stable	Stable
31	FLT31_3PH	3 phase fault on Holcomb 115kV Bus 531448 to Jones 115kV Bus 531379 CKT 1, near Holcomb	Stable	Stable	Stable	Stable
32	FLT32_1PH	*Single phase fault and sequence like previous*	Stable	Stable	Stable	Stable
33	FLT33_3PH	3 phase fault on Holcomb 115kV Bus 531448 to Plymell 115kV Bus 531393 CKT 1, near Holcomb.	Stable	Stable	Stable	Stable
34	FLT34_1PH	*Single phase fault and sequence like previous*	Stable	Stable	Stable	Stable
35	FLT35_3PH	3 phase fault on Holcomb 115kV Bus 531448 to Fletcher 115kV Bus 531420 CKT 1, near Holcomb.	Stable	Stable	Stable	Stable
36	FLT36_1PH	*Single phase fault and sequence like previous*	Stable	Stable	Stable	Stable
37	FLT37_3PH	3 phase fault on Holcomb 115kV Bus 531448 to Garden City 115kV Bus 531445 CKT 1, near Holcomb.	Stable	Stable	Stable	Stable
38	FLT38_1PH	*Single phase fault and sequence like previous*	Stable	Stable	Stable	Stable
39	FLT39_3PH	3 phase fault on the Spearville 230kV Bus 539695 to Great Bend 230kV Bus 539679 CKT 1, near Spearville.	Stable	Stable	Stable	Stable
40	FLT40_1PH	*Single phase fault and sequence like previous*	Stable	Stable	Stable	Stable
41	FLT41_3PH	3 phase fault on the Scott City 115kV Bus 531433 to Pile 115kV Bus 531432 CKT 1, near Scott City.	Stable	Stable	Stable	Stable
42	FLT42_3PH	*Single phase fault and sequence like previous*	Stable	Stable	Stable	Stable
43	FLT43_3PH	3 phase fault on the Holcomb 345kV Bus 531449 to Holcomb 230kv Bus 531448 to Holcomb 13.8kVkV Bus 531450 CKT 1, near Holcomb 345kV.	Stable	Stable	Stable	Stable

Table 3: Contingency Simulation Results

No.	Cont. Name	Description	Group 2 – Hitchland Area Summer	Group 2 – Hitchland Area Winter	Group 3 – Spearville Area Summer	Group 3 – Spearville Area Winter
44	FLT44_3PH	3 phase fault on the Hitchland 345kV Bus 523097 to Hitchland 230kV Bus 523095 to Hitchland 13.8kVkV Bus 523094 CKT 2, near Hitchland 345kV.	Stable	Stable	Stable	Stable
45	FLT45_3PH	3 phase fault on the Setab 345kV Bus 531465 to Setab 115kv Bus 531464 to Setab 13.8kVkV Bus 531259 CKT 1, near Setab 345kV.	Stable	Stable	Stable	Stable
46	FLT46_3PH	3 phase fault on the Spearville 230kV Bus 539695 to Spearville 115kv Bus 539694 to Spearville 13.8kV Bus 539935 CKT 1, near Spearville 230kV.	Stable	Stable	Stable	Stable
47	FLT47_3PH	3 phase fault on the Spearville 345kV Bus 531469 to Spearville 230kV Bus 539695 to Spearville 13.8kV Bus 531468 CKT 1, near Spearville 345kV.	Stable	Stable	Stable	Stable
48	FLT48_3PH	3 phase fault on Hitchland 345kV Bus 523097 to Beaver County 345kV Bus 580500 CKT 2, near Hitchland. a. Apply fault at the Hitchland 345kV bus.	Stable	Stable	Stable	Stable
49	FLT49_3PH	3 phase fault on Thistle 345kV Bus 539801 to Woodward 345kV Bus 515375 CKT 2, near Thistle. a. Apply fault at the Thistle 345kV bus.	Stable	Stable	Stable	Stable
50	FLT50_3PH	3 phase fault on Woodward 345kV Bus 515375 to Beaver County 345kV Bus 580500 CKT 2, near Woodward. a. Apply fault at the Woodward 345kV bus.	Stable	Stable	Stable	Stable

8.0 <u>Power Factor Analysis</u>

A power factor analysis was performed in this study. Table 4 shows the power factor of the customer facility at the POI for various contingencies. The facility will be required to maintain a 95% lagging (providing VARs) and 95% leading (absorbing VARs) power factor at the point of interconnection.

The power factor analysis was also used for reactor sizing. In order to perform this analysis the request and equivalent transmission lines and collectors systems were modeled using specifications provided by the Customer. The cases are modeled such that the generation and capacitor banks are switched out of service, but the wind farm's transmission subsystem (345kV and 34.5kV) remains in-service. The charging from these open-ended transmission facilities is then monitored for reactive power injections into the POI.

Analysis shows that the approximate amount of charging provided by the GEN-2008-018 subsystem is 55 Mvars. It is recommended that the Customer install at least 55 Mvars of reactors at the 345kV bus of its generation facility (on the high side of its substation transformers) to compensate for this injection into the transmission system. See Figure 2: Reactor One-line Diagram.

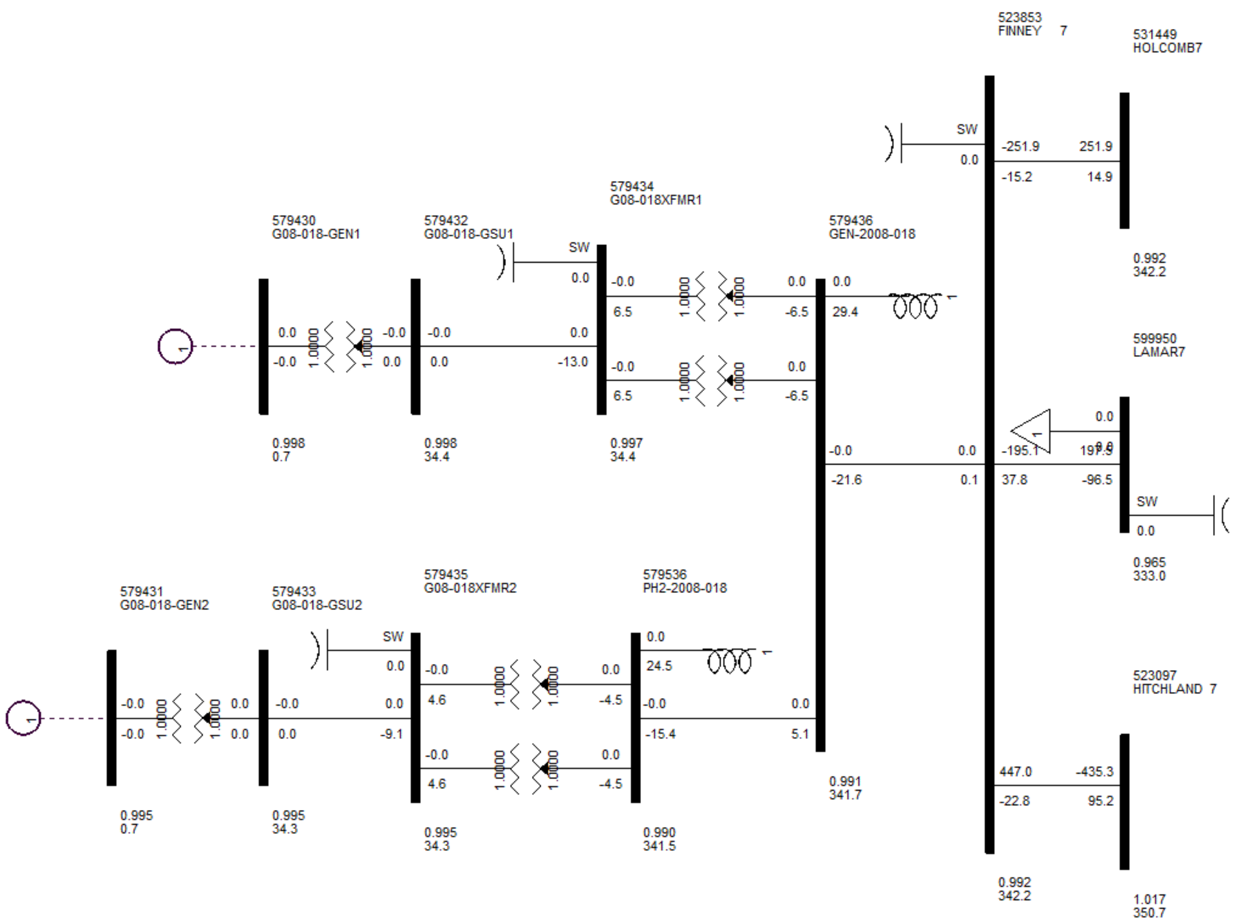

Figure 2: Reactor One-line Diagram

Table 4: Power Factor Analysis

Bus 523853 (POI) voltage: 1.01588 PU (Summer) /1.01089 PU (Winter)	Group 2 – Hitchland Area							
CONTINGENCY	**MW (Summer)**	**MVAR (Summer)**	**PF (Summer)**		**MW (Winter)**	**MVAR (Winter)**	**PF (Winter)**	
No contingency	405.1	29.8	0.998	LAG	405.1	40.2	0.996	LAG
FINNEY7 345KV BUS 523853 TO HITCHLAND7 345KV BUS 523097 CKT 1	405.1	-33.2	0.998	LEAD	405.1	-13.5	1.000	LEAD
FINNEY7 345KV BUS 523853 TO LAMAR7 345KV BUS 599950 CKT 1	405.1	-8.6	1.000	LEAD	405.1	-7.0	1.000	LEAD
FINNEY7 345KV BUS 523853 TO HOLCOMB7 345KV BUS 531449 CKT 1	405.1	207.4	0.912	LAG	405.1	205.5	0.911	LAG
HOLCOMB7 345KV BUS 531449 TO SETAB7 345KV BUS 531465 CKT 1	405.1	52.6	0.993	LAG	405.1	123.6	0.962	LAG
HOLCOMB7 345KV BUS 531449 TO BUCKNER7 345KV BUS 531501 CKT 1	405.1	117.6	0.963	LAG	405.1	118.4	0.964	LAG
HITCHLAND 345KV BUS 523097 TO POTTER COUNTY 345KV BUS 523961 CKT 1	405.1	46.6	0.995	LAG	405.1	61.8	0.991	LAG
HITCHLAND 345KV BUS 523097 TO BEAVER COUNTY 345KV BUS 580500 CKT 1	405.1	33.5	0.997	LAG	405.1	42.5	0.995	LAG
SETAB 345KV BUS 531465 TO MINGO 345KV BUS 531451 CKT 1	405.1	94.6	0.975	LAG	405.1	105.5	0.971	LAG
BUCKNER 345KV BUS 531501 TO SPEARVILLE 345KV BUS 531469 CKT 1	405.1	80.0	0.983	LAG	405.1	73.6	0.986	LAG
SPEARVILLE 345KV BUS 531469 TO CLARK COUNTY 345KV BUS 539800 CKT 1	405.1	35.3	0.997	LAG	405.1	43.2	0.995	LAG
SPEARVILLE 345KV BUS 531469 TO IRONWOOD 345KV BUS 539803 CKT 1	405.1	30.5	0.998	LAG	405.1	37.6	0.996	LAG
SPEARVILLE 345KV BUS 531469 TO GEN11-017 345KV BUS 560242 CKT 1	405.1	25.6	0.998	LAG	405.1	38.3	0.996	LAG
CLARK COUNTY 345KV BUS 539800 TO THISTLE 345KV BUS 539801 CKT 1	405.1	32.1	0.997	LAG	405.1	44.6	0.995	LAG
THISTLE 345KV BUS 539801 TO WOODWARD 345KV BUS 515375 CKT 1	405.1	52.7	0.992	LAG	405.1	63.8	0.990	LAG
WOODWARD 345KV BUS 515375 TO BEAVER COUNTY 345KV BUS 580500 CKT 1	405.1	93.4	0.978	LAG	405.1	100.1	0.972	LAG
HOLCOMB7 115KV BUS 531448 TO JONES 115KV BUS 531379 CKT 1	405.1	31.4	0.997	LAG	405.1	42.0	0.996	LAG

Table 4: Power Factor Analysis

Bus 523853 (POI) voltage: 1.01588 PU (Summer) /1.01089 PU (Winter)	Group 2 – Hitchland Area							
CONTINGENCY	**MW (Summer)**	**MVAR (Summer)**	**PF (Summer)**		**MW (Winter)**	**MVAR (Winter)**	**PF (Winter)**	
HOLCOMB7 115KV BUS 531448 TO PLYMELL 115KV BUS 531393 CKT 1	405.1	41.1	0.995	LAG	405.1	44.6	0.995	LAG
HOLCOMB7 115KV BUS 531448 TO FLETCHER 115KV BUS 531420 CKT 1	405.1	34.8	0.997	LAG	405.1	41.3	0.996	LAG
HOLCOMB7 115KV BUS 531448 TO GARDEN CITY 115KV BUS 531445 CKT 1	405.1	30.9	0.997	LAG	405.1	43.2	0.995	LAG
SPEARVILLE 230KV BUS 539695 TO GREAT BEND 230KV BUS 539679 CKT 1	405.1	29.9	0.998	LAG	405.1	40.6	0.996	LAG
SCOTT CITY 115KV BUS 531433 TO PILE 115KV BUS 531432 CKT 1	405.1	29.8	0.998	LAG	405.1	36.7	0.997	LAG
THREEWINDING FROM HOLCOMB7 345KV BUS 531449 TO HOLCOMB 230KV BUS 531448 TO HOLCOMB 13.8KV BUS 531450 CKT 1	405.1	12.1	1.000	LAG	405.1	-43.3	0.991	LEAD
THREEWINDING FROM HITCHLAND 345KV BUS 523097 TO HITCHLAND 230KV BUS 523095 TO HITCHLAND 13.8KV BUS 523094 CKT 2	405.1	30.3	0.998	LAG	405.1	40.9	0.996	LAG
THREEWINDING FROM SETAB 345KV BUS 531465 TO SETAB 115KV BUS 531464 TO SETAB 13.8KV BUS 531259 CKT 1	405.1	20.1	0.999	LAG	405.1	34.6	0.997	LAG
THREEWINDING FROM SPEARVILLE 230KV BUS 539695 TO SPEARVILLE 115KV BUS 539694 TO SPEARVILLE 13.8KV BUS 539935 CKT 1	405.1	29.9	0.998	LAG	405.1	40.2	0.996	LAG
THREEWINDING FROM SPEARVILLE 345KV BUS 531469 TO SPEARVILLE 230KV BUS 539695 TO SPEARVILLE 13.8KV BUS 531468 CKT 1	405.1	29.1	0.998	LAG	405.1	41.0	0.996	LAG

Table 4: Power Factor Analysis

Bus 523853 (POI) voltage: 1.0029 PU (Summer) /1.00 PU (Winter)	Group 3 – Spearville Area							
CONTINGENCY	**MW (Summer)**	**MVAR (Summer)**	**PF (Summer)**		**MW (Winter)**	**MVAR (Winter)**	**PF (Winter)**	
No contingency	405.1	52.9	0.992	LAG	405.1	130.7	0.952	LAG
FINNEY7 345KV BUS 523853 TO HITCHLAND7 345KV BUS 523097 CKT 1	405.1	130.9	0.952	LAG	405.1	185.2	0.909	LAG
FINNEY7 345KV BUS 523853 TO LAMAR7 345KV BUS 599950 CKT 1	405.1	-5.5	1.000	LEAD	405.1	60.2	0.989	LAG
FINNEY7 345KV BUS 523853 TO HOLCOMB7 345KV BUS 531449 CKT 1	405.1	70.3	0.985	LAG	405.1	72.6	0.984	LAG
HOLCOMB7 345KV BUS 531449 TO SETAB7 345KV BUS 531465 CKT 1	405.1	101.7	0.970	LAG	405.1	197.8	0.899	LAG
HOLCOMB7 345KV BUS 531449 TO BUCKNER7 345KV BUS 531501 CKT 1	405.1	9.9	1.000	LAG	405.1	58.1	0.990	LAG
HITCHLAND 345KV BUS 523097 TO POTTER COUNTY 345KV BUS 523961 CKT 1	405.1	58.8	0.990	LAG	405.1	136.7	0.948	LAG
HITCHLAND 345KV BUS 523097 TO BEAVER COUNTY 345KV BUS 580500 CKT 1	405.1	48.3	0.993	LAG	405.1	124.0	0.956	LAG
SETAB 345KV BUS 531465 TO MINGO 345KV BUS 531451 CKT 1	405.1	138.4	0.946	LAG	405.1	215.4	0.883	LAG
BUCKNER 345KV BUS 531501 TO SPEARVILLE 345KV BUS 531469 CKT 1	405.1	195.8	0.900	LAG	405.1	236.0	0.864	LAG
SPEARVILLE 345KV BUS 531469 TO CLARK COUNTY 345KV BUS 539800 CKT 1	405.1	88.5	0.977	LAG	405.1	157.8	0.932	LAG
SPEARVILLE 345KV BUS 531469 TO IRONWOOD 345KV BUS 539803 CKT 1	405.1	82.6	0.980	LAG	405.1	151.3	0.937	LAG
SPEARVILLE 345KV BUS 531469 TO GEN11-017 345KV BUS 560242 CKT 1	405.1	127.6	0.954	LAG	405.1	185.4	0.909	LAG
CLARK COUNTY 345KV BUS 539800 TO THISTLE 345KV BUS 539801 CKT 1	405.1	121.3	0.958	LAG	405.1	190.2	0.905	LAG
THISTLE 345KV BUS 539801 TO WOODWARD 345KV BUS 515375 CKT 1	405.1	66.8	0.987	LAG	405.1	131.5	0.951	LAG
WOODWARD 345KV BUS 515375 TO BEAVER COUNTY	405.1	54.7	0.991	LAG	405.1	130.6	0.952	LAG

Table 4: Power Factor Analysis

Bus 523853 (POI) voltage: 1.0029 PU (Summer) /1.00 PU (Winter)	Group 3 – Spearville Area							
CONTINGENCY	**MW (Summer)**	**MVAR (Summer)**	**PF (Summer)**		**MW (Winter)**	**MVAR (Winter)**	**PF (Winter)**	
345KV BUS 580500 CKT 1								
HOLCOMB7 115KV BUS 531448 TO JONES 115KV BUS 531379 CKT 1	405.1	54.8	0.991	LAG	405.1	132.8	0.950	LAG
HOLCOMB7 115KV BUS 531448 TO PLYMELL 115KV BUS 531393 CKT 1	405.1	55.6	0.991	LAG	405.1	130.7	0.952	LAG
HOLCOMB7 115KV BUS 531448 TO FLETCHER 115KV BUS 531420 CKT 1	405.1	59.4	0.989	LAG	405.1	130.5	0.952	LAG
HOLCOMB7 115KV BUS 531448 TO GARDEN CITY 115KV BUS 531445 CKT 1	405.1	53.9	0.991	LAG	405.1	134.2	0.949	LAG
SPEARVILLE 230KV BUS 539695 TO GREAT BEND 230KV BUS 539679 CKT 1	405.1	86.2	0.978	LAG	405.1	153.3	0.935	LAG
SCOTT CITY 115KV BUS 531433 TO PILE 115KV BUS 531432 CKT 1	405.1	56.1	0.991	LAG	405.1	129.6	0.952	LAG
THREEWINDING FROM HOLCOMB7 345KV BUS 531449 TO HOLCOMB 230KV BUS 531448 TO HOLCOMB 13.8KV BUS 531450 CKT 1	405.1	74.9	0.983	LAG	405.1	75.9	0.983	LAG
THREEWINDING FROM HITCHLAND 345KV BUS 523097 TO HITCHLAND 230KV BUS 523095 TO HITCHLAND 13.8KV BUS 523094 CKT 2	405.1	53.8	0.991	LAG	405.1	131.9	0.951	LAG
THREEWINDING FROM SETAB 345KV BUS 531465 TO SETAB 115KV BUS 531464 TO SETAB 13.8KV BUS 531259 CKT 1	405.1	45.4	0.994	LAG	405.1	129.3	0.953	LAG
THREEWINDING FROM SPEARVILLE 230KV BUS 539695 TO SPEARVILLE 115KV BUS 539694 TO SPEARVILLE 13.8KV BUS 539935 CKT 1	405.1	53.0	0.992	LAG	405.1	130.7	0.952	LAG
THREEWINDING FROM SPEARVILLE 345KV BUS 531469 TO SPEARVILLE 230KV BUS 539695 TO SPEARVILLE 13.8KV BUS 531468 CKT 1	405.1	53.0	0.992	LAG	405.1	131.9	0.951	LAG

Lowest leading power factor
Lowest lagging power factor

9.0 Limited Operation before Finney-Holcomb 345kV circuit #2

Additionally, the Customer requested a Limited Operation Study to be performed for the latest configuration of the wind farm to determine the maximum amount of generation that can be interconnected prior to the completion of the Finney-Holcomb 345kV transmission line.

The configuration provided by the Customer for GEN-2008-018 was used to represent GEN-2008-018 into the study models. An outage of the Finney-Holcomb 345kV line was simulated until a converged powerflow solution was obtained.

Season	Monitored Element	Contingency	Max MW Available
Spring	Non-Converged	Finney-Holcomb	350MW

In no way does this study guarantee operation for all periods of time. It should be noted that although this study analyzed many of the most probable contingencies, it is not an all-inclusive list and cannot account for every operational situation. Because of this, it is likely that the **Customer[s] may be required to reduce their generation output to 0 MW** under certain system conditions to allow system operators to maintain the reliability of the transmission network.

10.0 Conclusion

The findings of the restudy show that no stability problems were observed during the summer or the winter peak conditions due to the use of the GE 1.85MW wind turbine generators. Additionally, the project wind farm was found to stay connected during the contingencies that were studied and therefore, meet the Low Voltage Ride Through (LVRT) requirements of FERC Order #661A.

A power factor analysis was performed in this study. The facility will be required to maintain a 95% lagging (providing VARs) and 95% leading (absorbing VARs) power factor at the point of interconnection. Additionally, GEN-2008-018 is required to install capacitor banks (40MVAR) and reactor banks (55MVAR) in addition to its generator reactive capability (+/-0.90 power factor).

A Limited Operation Study was performed at the Customer's request to determine the operating limit before the Finney-Holcomb 345kV circuit #2 can be completed. Analysis has determined to avoid potential voltage collapse, the GEN-2008-018 Generator can interconnect a maximum of 350MW before the Finney-Holcomb 345kV line can be completed.

With the assumptions outlined in this report and with all required network upgrades from the GEN-2008-018 GIA in place, GEN-2008-018 with the wind turbine generators described in the study should be able to reliably interconnect to the SPP transmission grid.