Southwest Power Pool

GEN-2010-040
Impact Restudy #2

SPP Generation
Interconnection Studies

GEN-2010-040

March 2012

Executive Summary

The Generation Interconnection Customer has requested a generator interconnection through the Southwest Power Pool (SPP) Tariff. A Definitive Interconnection System Impact Study (SPP Definitive Impact Study DISIS 2010-002, posted January 31, 2011) has been completed for the Customer's generator interconnection project, GEN-2010-040. Subsequent to the completion of DISIS-2010-002, the customer requested an impact restudy due to a change in the wind turbine generator (wtg) from Suzlon to REpower wtg's. This study was completed and posted as GEN-2010-040 Impact Restudy, dated November 2011. A second restudy has been requested by the Customer to study the effects of using a mixture of wtg's from REpower and Mitsubishi. This document reports the observations and conclusions of the study.

The project has a maximum power output of 300MW and is to be located in Canadian County Oklahoma. The project has two 34.5/345kV substation transformers that will connect to the Customer's 345kV transmission line to the Point of Interconnection (POI), the Cimarron 345kV Substation. One substation transformer will be fed by a collector subsystem that contains seventy-three (73) REpower MM92 2.05MW wtg's. The other substation transformer will be fed by a collector subsystem that contains sixty-two (62) Mitsubishi MWT102 2.4MW wtg's. The total power output of will be 298.5MW

The restudy was done with two scenarios. The first scenario represents the SPP network topology as of December 31, 2012. The second scenario represents the SPP network topology as of December 31, 2014.

The findings of the restudy show that no stability problems were found during the summer or the winter peak conditions for both scenarios due to the use of the REpower MM92 2.05MW and the Mitsubishi MWT 102 2.4MW wtg's. Additionally, the project wind farm was found to stay connected during the contingencies that were studied, meeting the Low Voltage Ride Through (LVRT) requirements of FERC Order #661A.

A power factor analysis was performed. The facility will be required to maintain a 95% lagging (providing VARs) and 95% leading (absorbing VARs) power factor a the point of interconnection. Analysis showed that even with the reactive capabilities of the wtg's that approximately 35MVARs of additional capacitors are needed to meet 0.95 lagging (providing VARs) at the POI.

With the assumptions outlined in this report, GEN-2010-040 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 Generation Interconnection Customer has requested a generator interconnection through the Southwest Power Pool (SPP) Tariff. A Definitive Interconnection System Impact Study (SPP Definitive Impact Study DISIS 2010-002, posted January 31, 2011) has been completed for the Customer's generator interconnection project, GEN-2010-040. Subsequent to the completion of DISIS-2010-002, the customer requested an impact restudy due to a change in the wind turbine generator (wtg) from Suzlon to REpower wtg's. This study was completed and posted as GEN-2010-040 Impact Restudy, dated November 2011. A second restudy has been requested by the Customer to study the effects of using a mixture of wtg's from REpower and Mitsubishi.

The project has a maximum power output of 300MW and is to be located in Canadian County Oklahoma. The project has two 34.5/345kV substation transformers that will connect to the Customer's 345kV transmission line to the Point of Interconnection (POI), the Cimarron 345kV Substation. One substation transformer will be fed by a collector subsystem that contains seventy-three (73) REpower MM92 2.05MW wtg's. The other substation transformer will be fed by a collector subsystem that contains sixty-two (62) Mitsubishi MWT102 2.4MW wtg's. The total power output of will be 298.5MW

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

2.0 Purpose

The purpose of this impact restudy is to evaluate the effects of using Mitsubishi wtg'g in place of a portion of the previously studied REpower wtg's on the reliability of the Transmission System.

3.0 Facilities

3.1 Customer Facility

The project has a maximum power output of 300MW and is to be located in Canadian County Oklahoma. The project has two 34.5/345kV substation transformers that will connect to the Customer's 345kV transmission line to the Point of Interconnection (POI), the Cimarron 345kV Substation. One substation transformer will be fed by a collector subsystem that contains seventy-three (73) REpower MM92 2.05MW wtg's. The other substation transformer will be fed by a collector subsystem that contains sixty-two (62) Mitsubishi MWT102 2.4MW wtg's. The total power output will be 298.5MW.

3.2 Interconnection Facility

Figure 1 shows the interconnection facility for GEN-2010-040.

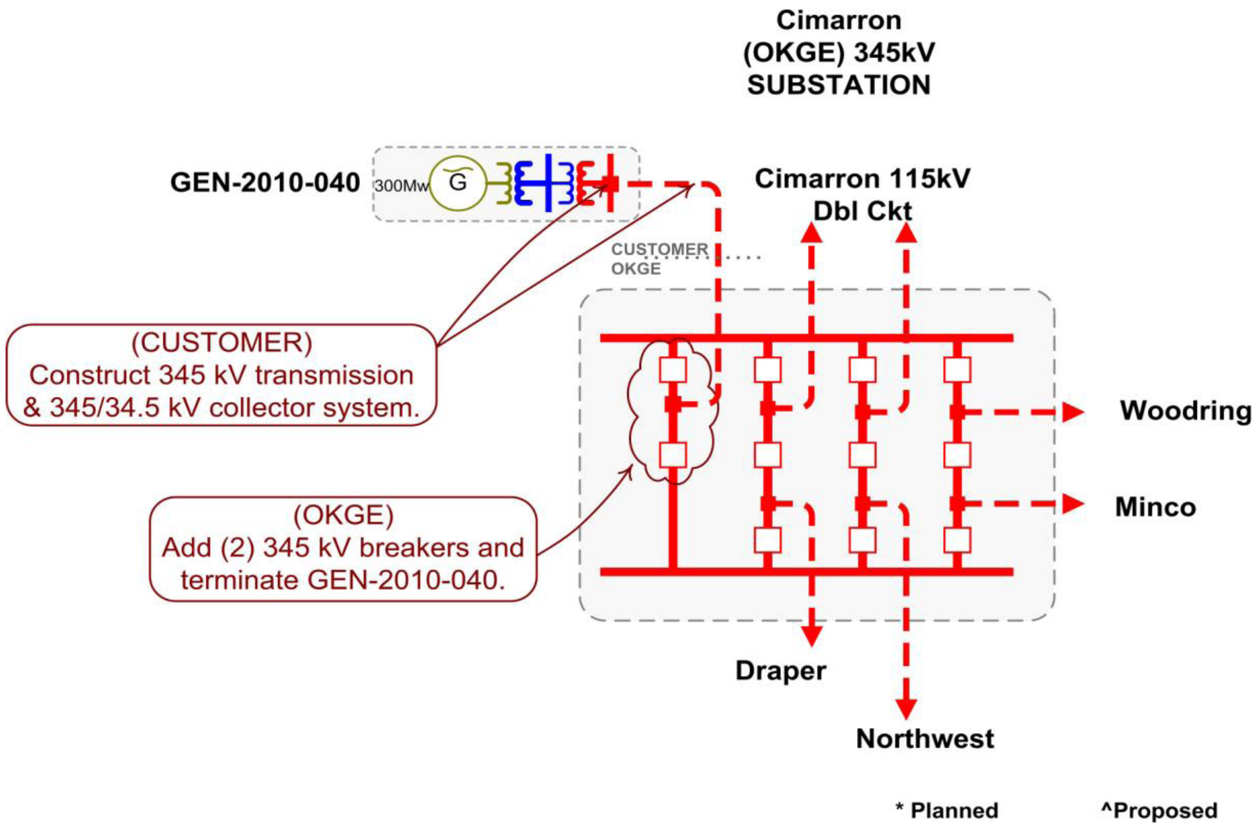

Figure 1: GEN-2010-040 POI One-line Diagram

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

Siemens PSS/E Version 30.3.3 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 2. The data used to develop the equivalent wind farm model was supplied by the Customer.

The Customer also supplied the PSS/E Version 30.3.3 stability models for the Mitsubishi MWT102 2.4MW wtg's and the REpower MM92 2.05MW wtg's. Both the Mitsubishi and the REpower wtg's have reactive power capabilities. The Mitsubishi's reactive power capability is +0.95 to -0.90 PF and the REpower's reactive power capability is +0.95 to -0.95 PF.

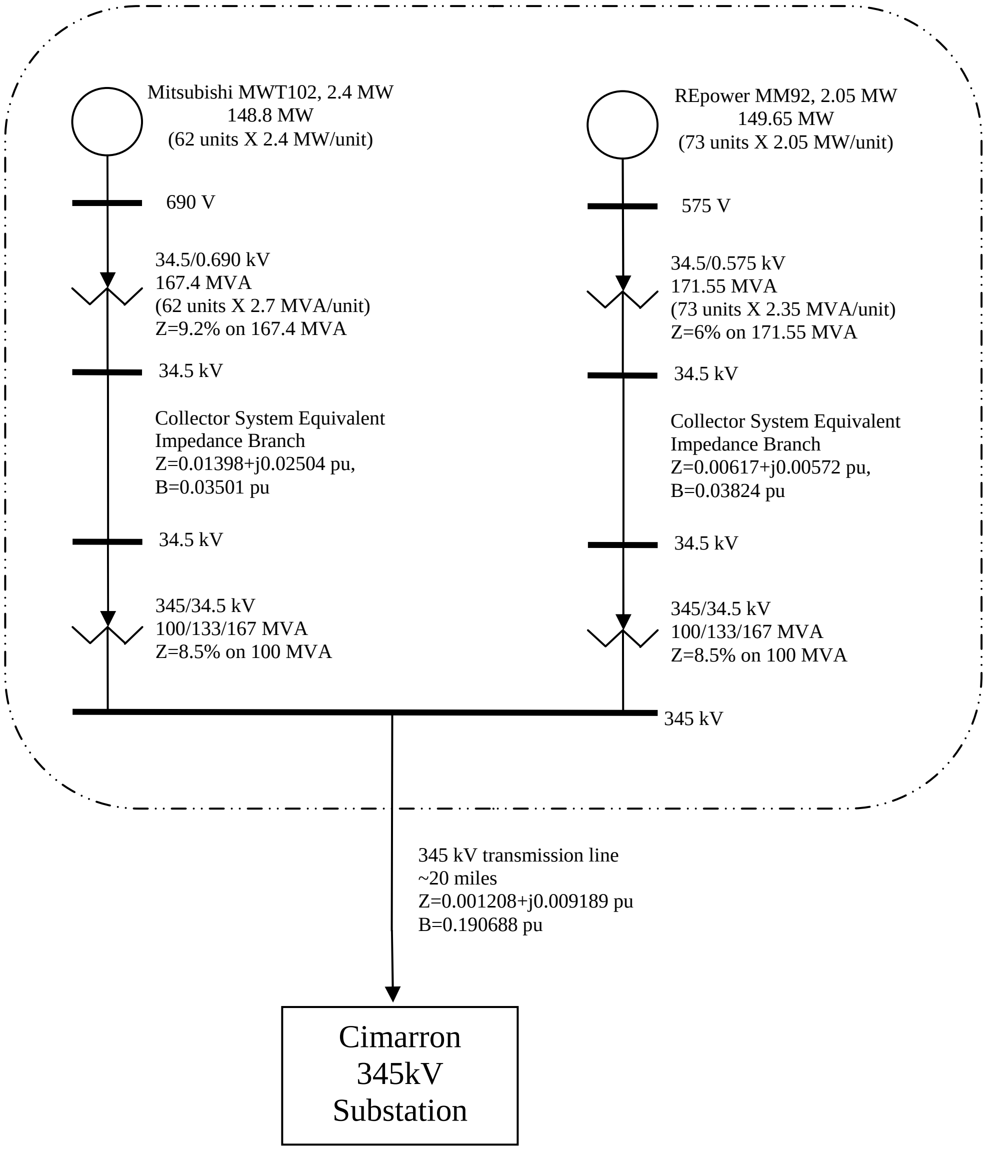

Figure 2: GEN-2010-040 Facility One-line Diagram

Two sets of power flow cases were used for this study. Each set consists of a summer case and a winter case. The first set (Scenario 1) represents the SPP network as of December 31, 2012. The second set (Scenario 2) represents the SPP network as of December 31, 2014. The upgrades that are significant in Scenario 2 are as follows:

1. Woodward to Thistle – double circuit 345kV

2. Woodward to Hitchland – double circuit 345kV
3. Spearville to Clark – double circuit 345kV
4. Woodward to Border to Tuco – single circuit 345kV
5. Tatonga-Matthewson-Cimarron 345kV double circuit

Prior queued requests were included in the saved cases. The prior queued requests are shown in Table 1. Additional prior queued projects were added for the 2014 scenario which created a direct connection from Cimarron to Tatonga.

Request	Size (MW)	Wind Turbine Model	Point of Interconnection
Blue Canyon I	74	CIMTR	Washita 138kV (521089)
Blue Canyon II (GEN-2003-004)	151	Vestas V80	Washita 138kV (521089)
Weatherford	147	G.E. 1.5MW	Weatherford 138kV (511506)
GEN-2003-005	100	G.E. 1.6MW	Tap on the Anadarko – Paradise 138kV line (521129)
GEN-2006-002	101	G.E. 1.5 & 1.6MW	Sweetwater 230kV (511541)
GEN-2006-035	224	Gamesa	Sweetwater 230kV (511541)
GEN-2006-043	98.9	Siemens 2.3MW	Sweetwater 230kV (511541)
GEN-2007-032	150	Acciona 1.5MW	Tap on the Clinton Jct. – Clinton 138kV line (560939)
GEN-2007-043	200	GE 1.6MW	Cimarron-Anadarko 345kV line
GEN-2007-052	150	Gas Turbine	Anadarko 138kV (520814)
GEN-2008-023	150	G.E. 1.6MW	Hobart Junction 138kV (511463)
GEN-2009-016	100.8	G.E. 1.6MW	Falcon Road 138KV (511511)
GEN-2008-037	100.8	Vestas V90 1.8MW	Tap on the Washita – Blue Canyon 138kV line (Bus 573570)
GEN-2010-012	65	Clipper 2.5MW	Brantley 138kV (520832)
GEN-2001-014	94.5	Suzlon 2.1MW	Fort Supply 138kV (520920)
GEN-2001-037	102	GE 1.5MW	Woodward-Mooreland 138kV (515785)
GEN-2005-005	120	SMK 223	Moorland – Woodward 138kV (515785)
GEN-2005-008	120	GE 1.5MW	Woodward 138kV (514785)
GEN-2006-024S	18.9	Suzlon 2.1MW	Buffalo Bear 69kV (521120)
GEN-2006-046	132	Mitsubishi 2.4MW	Dewey 138kV (514787)
GEN-2007-006	161.7	Suzlon 2.1MW	Roman Nose 138kV (514823)
GEN-2007-021	200	GE 1.6MW	Tatonga 345kV (515407)
GEN-2007-044	299.2	GE 1.6MW	Tatonga 345kV (515407)
GEN-2007-050	175.2	Siemens 2.3MW	Woodward 138kV (515376)
GEN-2007-051	199.5	GE 1.5MW	Mooreland 138kV (520999)
GEN-2007-062	765	GE 1.5MW	Woodward 345kV (515375)
GEN-2008-003	101.2	Siemens 2.3MW	Woodward 138kV (515376)
GEN-2008-019	300	Mitsubishi 2.4MW	Tatonga 345kV (515407)

GEN-2008-029	250.5	GE 1.5MW	Woodward 138kV (515376)
GEN-2008-044	197.8	Siemens SWT 2.3MW	Tatonga 345kV (515407)
GEN-2010-011	29.7	Siemens SWT 2.3MW	Addition to Gen-2008-044 34.5kV bus (576503)
GEN-2011-007	250	RePower 2.05MW	Mathewson 345kV (560368)
GEN-2011-019	299	Siemens 2.3MW	Woodward 345kV (515375)
GEN-2011-020	299	Siemens 2.3MW	Woodward 345kV (515375)
GEN-2011-024	299	Siemens 2.3MW	Tatonga 345kV (515407)
GEN-2011-051	104.4	Vestas V90 1.8MW	Woodward – Tatonga 345kV (562075)
GEN-2011-054	299	Siemens 2.3MW	Cimarron 345kV (514901)

Table 1: Prior Queued Request Table

6.0 <u>Stability Study Analysis (Scenario 1)</u>

Forty-eight (48) 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 afault 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. The faults were simulated on both the summer peak and the winter peak models.

Cont. No.	Cont. Name	Description
1	FLT01-3PH	3 phase fault on Cimarron 345KV Bus 514901 to Gen2007-043 345KV Bus 210431 CKT 1, near Cimarron. a. Apply fault at the Cimarron 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	FLT03-3PH	3 phase fault on the Cimarron 345KV Bus 514901 to Northwest 345KV Bus 514880 CKT 1, near Cimarron. a. Apply fault at the Cimarron 345KV. 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*

Cont. No.	Cont. Name	Description
5	FLT05-3PH	3 phase fault on the Cimarron 345KV Bus 514901 to Draper 345KV Bus 514934 CKT 1, near Cimarron. a. Apply fault at the Cimarron 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 the Cimarron 345KV Bus 514901 to Woodring 345KV Bus 514715 CKT 1, near Cimarron. a. Apply fault at the Cimarron 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 the Northwest 345KV Bus 514880 to SpringCreek 345KV Bus 514881 CKT 1, near Northwest. a. Apply fault at the Northwest 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 the Northwest 345KV Bus 514880 to Arcadia 345KV Bus 514908 CKT 1, near Northwest. a. Apply fault at the Northwest 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 the Northwest 345KV Bus 514880 to Tatonga 345KV Bus 515407 CKT 1,near Northwest a. Apply fault at the Northwest 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*
15	FLT15-3PH	3 phase fault on the Woodring 345KV Bus 514715 to G0813T 345KV Bus 210130 CKT 1, near Woodring. a. Apply fault at the Woodring 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 the Woodring 345KV Bus 514715 to Sooner 345KV Bus 514803 CKT 1, near Woodring. a. Apply fault at the Woodring 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*

Cont. No.	Cont. Name	Description
19	FLT19-3PH	3 phase fault on the Draper 345KV Bus 514934 to Seminole 345KV Bus 515045 CKT 1, near Draper. a. Apply fault at the Draper 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 the Gen2007-043 345KV Bus 210431 to Gracemont 345KV Bus 515800 CKT 1, near Gen2007-043. a. Apply fault at the Gen2007-043 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 the Gracemont 345KV Bus 515800 to LES 345KV Bus 511468 CKT 1, near Gracemont. a. Apply fault at the Gracemont 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 the Tatonga 345KV Bus 515407 to Woodword 345KV Bus 515375 CKT 1, near Tatonga. a. Apply fault at the Tatonga 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 the Spring Creek 345KV Bus 514881 to Sooner 345KV Bus 514803 CKT 1, near Spring Creek. a. Apply fault at the Spring Creek 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*
29	FLT29-3PH	3 phase fault on the Arcadia 345KV Bus 514908 to HorseshoeLake 345KV Bus 514943 CKT 1, near Arcadia. a. Apply fault at the Arcadia 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 the Horseshoe Lake 345KV Bus 514943 to Seminole 345KV Bus 515045 CKT 1, near Horseshoe Lake. a. Apply fault at the Horseshoe Lake 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.
32	FLT32-1PH	*Single phase fault and sequence like previous*

Cont. No.	Cont. Name	Description
33	FLT33-3PH	3 phase fault on the Cimarron 138KV Bus 514898 to Tuttle Conoco Tap 138KV Bus 511425 CKT 1, near Cimarron. a. Apply fault at the Cimarron 138KV 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 the Cimarron 138KV Bus 514898 to El Reno 138KV Bus 514819 CKT 1, near Cimarron. a. Apply fault at the Cimarron 138KV 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 the Cimarron 138KV Bus 514898 to Jensen Tap 138KV Bus 514820 CKT 1, near Cimarron. a. Apply fault at the Cimarron 138KV. 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 Cimarron 138KV Bus 514898 to Haymaker 138KV Bus 514863 CKT 1, near Cimarron. a. Apply fault at the Cimarron 138KV 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 Cimarron 138KV Bus 514898 to Czech Hall 130KV Bus 514894 CKT 1, near Cimarron. a. Apply fault at the Cimarron 138KV 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	FLT42-1PH	*Single phase fault and sequence like previous*
43	FLT43-3PH	3 phase fault on the Cimarron 138KV Bus 514898 to Sara 138KV Bus 514895 CKT 1, near Cimarron. a. Apply fault at the Cimarron 138KV 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	FLT44-1PH	*Single phase fault and sequence like previous*
45	FLT45-3PH	3 phase fault on the Cimarron 138KV Bus 514898 to Cimarron 345KV Bus 514901 to Cimarron 13.8KV Bus 515714 CKT 1, near Cimarron 138kV. a. Apply fault at the Cimarron 138kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
46	FLT46-3PH	3 phase fault on the Northwest 138KV Bus 514879 to Northwest 345KV Bus 514880 to Northwest 13.8KV Bus 515742 CKT 1, near the Northwest 138kV. a. Apply fault at the Northwest 138KV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.

Cont. No.	Cont. Name	Description
47	FLT47-3PH	3 phase fault on the Woodring 138KV Bus 514714 to Woodring 345KV Bus 514715 to Woodring 13.8KV Bus 515770 CKT 1, near Woodring 138kV. a. Apply fault at the Woodring 138KV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
48	FLT48-3PH	3 phase fault on the Draper 138KV Bus 514933 to Draper 345KV Bus 514934 to Draper 13.8KV Bus 515720 CKT 1, near Draper 138kV. a. Apply fault at Draper 138KV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.

Table 2: Contingency List (Scenario 1)

7.0 Simulation Results (Scenario 1)

All faults were run for both summer and winter cases, 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, with all network upgrades in service, GEN-2010-040 did not cause any stability problems and remained stable for all faults studied.

No.	Cont. Name	Description	Summer	Winter
1	FLT01-3PH	Cimarron 345KV Bus 514901 to Gen2007-043 345KV Bus 210431 CKT 1, near Cimarron.	Stable	Stable
2	FLT02-1PH	*Single phase fault and sequence like previous*	Stable	Stable
3	FLT03-3PH	Cimarron 345KV Bus 514901 to Northwest 345KV Bus 514880 CKT 1, near Cimarron.	Stable	Stable
4	FLT04-1PH	*Single phase fault and sequence like previous*	Stable	Stable
5	FLT05-3PH	Cimarron 345KV Bus 514901 to Draper 345KV Bus 514934 CKT 1, near Cimarron.	Stable	Stable
6	FLT06-1PH	*Single phase fault and sequence like previous*	Stable	Stable
7	FLT07-3PH	Cimarron 345KV Bus 514901 to Woodring 345KV Bus 514715 CKT 1, near Cimarron.	Stable	Stable
8	FLT08-1PH	*Single phase fault and sequence like previous*	Stable	Stable
9	FLT09-3PH	Northwest 345KV Bus 514880 to SpringCreek 345KV Bus 514881 CKT 1, near Northwest.	Stable	Stable
10	FLT10-1PH	*Single phase fault and sequence like previous*	Stable	Stable
11	FLT11-3PH	Northwest 345KV Bus 514880 to Arcadia 345KV Bus 514908 CKT 1, near Northwest.	Stable	Stable
12	FLT12-1PH	*Single phase fault and sequence like previous*	Stable	Stable
13	FLT13-3PH	Northwest 345KV Bus 514880 to Tatonga 345KV Bus 515407 CKT 1,near Northwest.	Stable	Stable
14	FLT14-1PH	*Single phase fault and sequence like previous*	Stable	Stable
15	FLT15-3PH	Woodring 345KV Bus 514715 to G0813T 345KV Bus 210130 CKT 1, near Woodring.	Stable	Stable
16	FLT16-1PH	*Single phase fault and sequence like previous*	Stable	Stable

No.	Cont. Name	Description	Summer	Winter
17	FLT17-3PH	Woodring 345KV Bus 514715 to Sooner 345KV Bus 514803 CKT 1, near Woodring.	Stable	Stable
18	FLT18-1PH	*Single phase fault and sequence like previous*	Stable	Stable
19	FLT19-3PH	Draper 345KV Bus 514934 to Seminole 345KV Bus 515045 CKT 1, near Draper.	Stable	Stable
20	FLT20-1PH	*Single phase fault and sequence like previous*	Stable	Stable
21	FLT21-3PH	Gen2007-043 345KV Bus 210431 to Gracemont 345KV Bus 515800 CKT 1, near Gen2007-043.	Stable	Stable
22	FLT22-1PH	*Single phase fault and sequence like previous*	Stable	Stable
23	FLT23-3PH	Gracemont 345KV Bus 515800 to LES 345KV Bus 511468 CKT 1, near Gracemont.	Stable	Stable
24	FLT24-1PH	*Single phase fault and sequence like previous*	Stable	Stable
25	FLT25-3PH	Tatonga 345KV Bus 515407 to Woodword 345KV Bus 515375 CKT 1, near Tatonga.	Stable	Stable
26	FLT26-1PH	*Single phase fault and sequence like previous*	Stable	Stable
27	FLT27-3PH	Spring Creek 345KV Bus 514881 to Sooner 345KV Bus 514803 CKT 1, near Spring Creek.	Stable	Stable
28	FLT28-1PH	*Single phase fault and sequence like previous*	Stable	Stable
29	FLT29-3PH	Arcadia 345KV Bus 514908 to HorseshoeLake 345KV Bus 514943 CKT 1, near Arcadia.	Stable	Stable
30	FLT30-1PH	*Single phase fault and sequence like previous*	Stable	Stable
31	FLT31-3PH	Horseshoe Lake 345KV Bus 514943 to Seminole 345KV Bus 515045 CKT 1, near Horseshoe Lake.	Stable	Stable
32	FLT32-1PH	*Single phase fault and sequence like previous*	Stable	Stable
33	FLT33-3PH	Cimarron 138KV Bus 514898 to Tuttle Conoco Tap 138KV Bus 511425 CKT 1, near Cimarron.	Stable	Stable
34	FLT34-1PH	*Single phase fault and sequence like previous*	Stable	Stable
35	FLT35-3PH	Cimarron 138KV Bus 514898 to El Reno 138KV Bus 514819 CKT 1, near Cimarron.	Stable	Stable
36	FLT36-1PH	*Single phase fault and sequence like previous*	Stable	Stable
37	FLT37-3PH	Cimarron 138KV Bus 514898 to Jensen Tap 138KV Bus 514820 CKT 1, near Cimarron.	Stable	Stable
38	FLT38-1PH	*Single phase fault and sequence like previous*	Stable	Stable
39	FLT39-3PH	Cimarron 138KV Bus 514898 to Haymaker 138KV Bus 514863 CKT 1, near Cimarron.	Stable	Stable
40	FLT40-1PH	*Single phase fault and sequence like previous*	Stable	Stable
41	FLT41-3PH	Cimarron 138KV Bus 514898 to Czech Hall 130KV Bus 514894 CKT 1, near Cimarron.	Stable	Stable
42	FLT42-1PH	*Single phase fault and sequence like previous*	Stable	Stable
43	FLT43-3PH	Cimarron 138KV Bus 514898 to Sara 138KV Bus 514895 CKT 1, near Cimarron.	Stable	Stable
44	FLT44-1PH	*Single phase fault and sequence like previous*	Stable	Stable
45	FLT45-3PH	Cimarron 138KV Bus 514898 to Cimarron 345KV Bus 514901 to Cimarron 13.8KV Bus 515714 CKT 1, near Cimarron 138kV.	Stable	Stable
46	FLT46-3PH	Northwest 138KV Bus 514879 to Northwest 345KV Bus 514880 to Northwest 13.8KV Bus 515742 CKT 1, near the Northwest 138kV.	Stable	Stable
47	FLT47-3PH	Woodring 138KV Bus 514714 to Woodring 345KV Bus 514715 to Woodring 13.8KV Bus 515770 CKT 1, near Woodring 138kV.	Stable	Stable

No.	Cont. Name	Description	Summer	Winter
48	FLT48-3PH	Draper 138KV Bus 514933 to Draper 345KV Bus 514934 to Draper 13.8KV Bus 515720 CKT 1, near Draper 138kV.	Stable	Stable

Table 3: Contingency Simulation Results (Scenario 1)

8.0 Power Factor Analysis (Scenario 1)

A power factor analysis was performed by substituting a VAR generator for the Customer project at the POI. (The Customer project was disconnected from the POI.) The power output of the VAR generator was set to 298.5MW, the total maximum of the wind farm. The voltage schedule of the VAR generator was set to 1.00 per unit. The analysis was done for both the summer and winter cases. The contingencies and results are shown in Tables 4.

The analysis showed that even with the reactive capabilities of the wtg's that approximately 35MVARs of additional capacitors are needed to meet 0.95 lagging (providing VARs) at the POI. This analysis was done by setting the wtg's to their maximum lagging (providing VARs) and then their maximum leading (absorbing VARs) capability and observing the generated power and reactive power at the POI.

Bus 514901 (POI) voltage: 1.00 PU (S) /1.00 PU (W)	GEN-2010-040 (POI at Cimarron 345kV, Bus 514901)							
CONTINGENCY	**MW (S)**	**MVAR (S)**	**PF (S)**		**MW (W)**	**MVAR (W)**	**PF (W)**	
No contingency	298.5	128.0	0.919	LAG	298.5	177.3	0.860	LAG
Cimarron 345KV Bus 514901 to Gen2007043 345KV Bus 210431 CKT 1	298.5	140.6	0.905	LAG	298.5	139.1	0.906	LAG
Cimarron 345KV Bus 514901 to Northwest 345KV Bus 514880 CKT 1	298.5	143.4	0.901	LAG	298.5	171.1	0.868	LAG
Cimarron 345KV Bus 514901 to Draper 345KV Bus 514934 CKT 1	298.5	129.3	0.918	LAG	298.5	206.0	0.823	LAG
Cimarron 345KV Bus 514901 to Woodring 345KV Bus 514715 CKT 1	298.5	200.4	0.830	LAG	298.5	262.8	**0.751**	LAG
Northwest 345KV Bus 514880 to SpringCreek 345KV Bus 514881 CKT 1	298.5	213.0	0.814	LAG	298.5	206.7	0.822	LAG
Northwest 345KV Bus 514880 to Arcadia 345KV Bus 514908 CKT 1	298.5	121.9	0.926	LAG	298.5	181.2	0.855	LAG
Northwest 345KV Bus 514880 to Tatonga 345KV Bus 515407 CKT 1	298.5	194.2	0.838	LAG	298.5	259.4	0.755	LAG
Woodring 345KV Bus 514715 to G0813T 345KV Bus 210130 CKT 1	298.5	158.5	0.883	LAG	298.5	200.6	0.830	LAG
Woodring 345KV Bus 514715 to Sooner 345KV Bus 514803 CKT 1	298.5	131.7	0.915	LAG	298.5	168.7	0.871	LAG
Draper 345KV Bus 514934 to Seminole 345KV Bus 515045 CKT 1	298.5	160.4	0.881	LAG	298.5	199.6	0.831	LAG
Gen2007043 345KV Bus 210431 to Gracemont 345KV Bus 515800 CKT 1	298.5	123.7	0.924	LAG	298.5	92.4	0.955	LAG
Gracemont 345KV Bus 515800 to LES 345KV Bus 511468 CKT 1	298.5	141.7	0.903	LAG	298.5	126.1	0.921	LAG
Tatonga 345KV Bus 515407 to Woodword 345KV Bus 515375 CKT 1	298.5	157.0	0.885	LAG	298.5	206.0	0.823	LAG
SpringCreek 345KV Bus 514881 to Sooner 345KV Bus 514803 CKT 1	298.5	153.1	0.890	LAG	298.5	206.7	0.822	LAG
Arcadia 345KV Bus 514908 to HorseshoeLake 345KV Bus 514943 CKT 1	298.5	132.3	0.914	LAG	298.5	172.8	0.865	LAG
HorseshoeLake 345KV Bus 514943 to Seminole 345KV Bus 515045 CKT 1	298.5	131.6	0.915	LAG	298.5	179.2	0.857	LAG
Cimarron 138KV Bus 514898 to TuttleConocoTap 138KV Bus 511425 CKT 1	298.5	124.9	0.922	LAG	298.5	179.7	0.857	LAG
Cimarron 138KV Bus 514898 to ElReno 138KV Bus 514819	298.5	121.9	0.926	LAG	298.5	175.3	0.862	LAG

Bus 514901 (POI) voltage: 1.00 PU (S) /1.00 PU (W)	GEN-2010-040 (POI at Cimarron 345kV, Bus 514901)							
CONTINGENCY	**MW (S)**	**MVAR (S)**	**PF (S)**		**MW (W)**	**MVAR (W)**	**PF (W)**	
CKT 1								
Cimarron 138KV Bus 514898 to JensenTap 138KV Bus 514820 CKT 1	298.5	121.1	0.927	LAG	298.5	175.0	0.863	LAG
Cimarron 138KV Bus 514898 to Haymaker 138KV Bus 514863 CKT 1	298.5	129.9	0.917	LAG	298.5	183.0	0.853	LAG
Cimarron 138KV Bus 514898 to CzechHall 130KV Bus 514894 CKT 1	298.5	117.5	0.931	LAG	298.5	189.3	0.844	LAG
Cimarron 138KV Bus 514898 to Sara 138KV Bus 514895 CKT 1	298.5	120.5	0.927	LAG	298.5	179.6	0.857	LAG
Cimarron 138KV Bus 514898 to Cimarron 345KV Bus 514901 to Cimarron 13.8KV Bus 515714 CKT 1	298.5	76.5	0.969	LAG	298.5	112.6	0.936	LAG
Northwest 138KV Bus 514879 to Northwest 345KV Bus 514880 to Northwest 13.8KV Bus 515742 CKT 1	298.5	122.6	0.925	LAG	298.5	155.6	0.887	LAG
Woodring 138KV Bus 514714 to Woodring 345KV Bus 514715 to Woodring 13.8KV Bus 515770 CKT 1	298.5	117.1	0.931	LAG	298.5	175.1	0.863	LAG
Draper 138KV Bus 514933 to Draper 345KV Bus 514934 to Draper 13.8KV Bus 515720 CKT 1	298.5	126.2	0.921	LAG	298.5	167.1	0.873	LAG

NOTE: No contingency produced a Leading PF

0.751 indicates the smallest Lagging PF

(S) - Summer Case
(W) - Winter Case

LAG - Generating facility providing VARS to network
LEAD - Generating facility absorbing VARS from network

Table 4: GEN-2010-040 Power Factor Table (Scenario 1)

9.0 Stability Study Analysis (Scenario 2)

Fifty-five (55) contingencies were considered for the transient stability simulations for this scenario. This scenario has more contingencies than the first scenario because of network upgrades in the vicinity of the POI. These contingencies included three phase faults and single phase line faults at locations defined by SPP. Single-phase line faults were simulated by applying afault 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 5 below. The faults were simulated on both the summer peak and the winter peak models.

Cont. No.	Cont. Name	Description
1	FLT01-3PH	3 phase fault on Cimarron 345KV Bus 514901 to Minco 345KV Bus 514801 CKT 1, near Cimarron. a. Apply fault at the Cimarron 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	FLT03-3PH	3 phase fault on the Cimarron 345KV Bus 514901 to Northwest 345KV Bus 514880 CKT 1, near Cimarron. a. Apply fault at the Cimarron 345KV. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
4	FLT04-1PH	*Single phase fault and sequence like previous*
5	FLT05-3PH	3 phase fault on the Cimarron 345KV Bus 514901 to Draper 345KV Bus 514934 CKT 1, near Cimarron. a. Apply fault at the Cimarron 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 the Cimarron 345KV Bus 514901 to Mathewson 345KV Bus 560368 CKT 1, near Cimarron a. Apply fault at the Cimarron 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 the Northwest 345KV Bus 514880 to SpringCreek 345KV Bus 514881 CKT 1, near Northwest. a. Apply fault at the Northwest 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*

Cont. No.	Cont. Name	Description
11	FLT11-3PH	3 phase fault on the Northwest 345KV Bus 514880 to Arcadia 345KV Bus 514908 CKT 1, near Northwest. a. Apply fault at the Northwest 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 the Northwest 345KV Bus 514880 to Mathewson 345KV Bus 560368 CKT 1, near Northwest. a. Apply fault at the Northwest 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*
15	FLT15-3PH	3 phase fault on the Mathewson 345KV Bus 560368 to Tatonga 345KV Bus 515407 CKT 1, near Mathewson. a. Apply fault at the Mathewson 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 the Mathewson 345KV Bus 560368 to Woodring 345KV Bus 514715 CKT 1, near Mathewson. a. Apply fault at the Mathewson 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 Woodring 345KV Bus 514715 to G0813POI 345KV Bus 579406 CKT 1, near Woodring. a. Apply fault at the Woodring 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 the Woodring 345KV Bus 514715 to Sooner 345KV Bus 514803 CKT 1, near Woodring. a. Apply fault at the Woodring 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 the Draper 345KV Bus 514934 to Seminole 345KV Bus 515045 CKT 1, near Draper. a. Apply fault at the Draper 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*

Cont. No.	Cont. Name	Description
25	FLT25-3PH	3 phase fault on the Minco 345KV Bus 514801 to Gracemont 345KV Bus 515800 CKT 1, near Minco a. Apply fault at the Minco 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 the Gracemont 345KV Bus 515800 to LES 345KV Bus 511468 CKT 1, near Gracemont. a. Apply fault at the Gracemont 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*
29	FLT29-3PH	3 phase fault on the Tatonga 345KV Bus 515407 to G11051Tap 345KV Bus 562075 CKT 1, near Tatonga. a. Apply fault at the Tatonga 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 the Spring Creek 345KV Bus 514881 to Sooner 345KV Bus 514803 CKT 1, near Spring Creek. a. Apply fault at the Spring Creek 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.
32	FLT32-1PH	*Single phase fault and sequence like previous*
33	FLT33-3PH	3 phase fault on the Arcadia 345KV Bus 514908 to HorseshoeLake 345KV Bus 514943 CKT 1, near Arcadia. a. Apply fault at the Arcadia 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.
34	FLT34-1PH	*Single phase fault and sequence like previous*
35	FLT35-3PH	3 phase fault on the Horseshoe Lake 345KV Bus 514943 to Seminole 345KV Bus 515045 CKT 1, near Horseshoe Lake. a. Apply fault at the Horseshoe Lake 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.
36	FLT36-1PH	*Single phase fault and sequence like previous*
37	FLT37-3PH	3 phase fault on the Cimarron 138KV Bus 514898 to Tuttle Conoco Tap 138KV Bus 511425 CKT 1, near Cimarron. a. Apply fault at the Cimarron 138KV 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*

Cont. No.	Cont. Name	Description
39	FLT39-3PH	3 phase fault on the Cimarron 138KV Bus 514898 to El Reno 138KV Bus 514819 CKT 1, near Cimarron. a. Apply fault at the Cimarron 138KV 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 Cimarron 138KV Bus 514898 to Jensen Tap 138KV Bus 514820 CKT 1, near Cimarron. a. Apply fault at the Cimarron 138KV. 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	FLT42-1PH	*Single phase fault and sequence like previous*
43	FLT43-3PH	3 phase fault on the Cimarron 138KV Bus 514898 to Haymaker 138KV Bus 514863 CKT 1, near Cimarron. a. Apply fault at the Cimarron 138KV 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	FLT44-1PH	*Single phase fault and sequence like previous*
45	FLT45-3PH	3 phase fault on the Cimarron 138KV Bus 514898 to Czech Hall 130KV Bus 514894 CKT 1, near Cimarron. a. Apply fault at the Cimarron 138KV 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	FLT46-1PH	*Single phase fault and sequence like previous*
47	FLT47-3PH	3 phase fault on the Cimarron 138KV Bus 514898 to Sara 138KV Bus 514895 CKT 1, near Cimarron. a. Apply fault at the Cimarron 138KV 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.
48	FLT48-1PH	*Single phase fault and sequence like previous*
49	FLT49-3PH	3 phase fault on the Cimarron 138KV Bus 514898 to Cimarron 345KV Bus 514901 to Cimarron 13.8KV Bus 515714 CKT 1, near Cimarron 138kV. a. Apply fault at the Cimarron 138kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
50	FLT50-3PH	3 phase fault on the Northwest 138KV Bus 514879 to Northwest 345KV Bus 514880 to Northwest 13.8KV Bus 515742 CKT 1, near the Northwest 138kV. a. Apply fault at the Northwest 138KV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
51	FLT51-3PH	3 phase fault on the Woodring 138KV Bus 514714 to Woodring 345KV Bus 514715 to Woodring 13.8KV Bus 515770 CKT 1, near Woodring 138kV. a. Apply fault at the Woodring 138KV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
52	FLT52-3PH	3 phase fault on the Draper 138KV Bus 514933 to Draper 345KV Bus 514934 to Draper 13.8KV Bus 515720 CKT 1, near Draper 138kV. a. Apply fault at Draper 138KV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.

Cont. No.	Cont. Name	Description
53	FLT53-3PH	3 phase fault on the Cimarron 345KV Bus 514901 to Draper 345KV Bus 514934 CKT 1 and CKT 2, near Cimarron. a. Apply fault at the Cimarron 345KV bus. b. Clear fault after 5 cycles by tripping the faulted lines (CKT 1 and CKT 2). c. Wait 20 cycles, and then re-close the lines in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the lines in (b) and remove fault.
54	FLT54-3PH	3 phase fault on the Mathewson 345KV Bus 560368 to Tatonga 345KV Bus 515407 CKT 1 and CKT 2, near Mathewson. a. Apply fault at the Mathewson 345KV bus. b. Clear fault after 5 cycles by tripping the faulted lines (CKT 1 and CKT 2). c. Wait 20 cycles, and then re-close the lines in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the lines in (b) and remove fault.
55	FLT55-3PH	3 phase fault on the Tatonga 345KV Bus 515407 to G11051Tap 345KV Bus 562075 CKT 1 and CKT 2, near Tatonga. a. Apply fault at the Tatonga 345KV bus. b. Clear fault after 5 cycles by tripping the faulted lines (CKT 1 and CKT 2). c. Wait 20 cycles, and then re-close the lines in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the lines in (b) and remove fault.

Table 5: Contingency List (Scenario 2)

10.0 Simulation Results (Scenario 2)

All faults were run for both summer and winter cases, no tripping occurred in this study.

Table 6 summarizes the results for all faults. Complete sets of plots for summer and winter cases are available on request.

Based on the dynamic results, with all network upgrades in service, GEN-2010-040 did not cause any stability problems and remained stable for all faults studied.

No.	Cont. Name	Description	Summer	Winter
1	FLT01-3PH	Cimarron 345KV Bus 514901 to Gen2007-043 345KV Bus 210431 CKT 1, near Cimarron.	Stable	Stable
2	FLT02-1PH	*Single phase fault and sequence like previous*	Stable	Stable
3	FLT03-3PH	Cimarron 345KV Bus 514901 to Northwest 345KV Bus 514880 CKT 1, near Cimarron.	Stable	Stable
4	FLT04-1PH	*Single phase fault and sequence like previous*	Stable	Stable
5	FLT05-3PH	Cimarron 345KV Bus 514901 to Draper 345KV Bus 514934 CKT 1, near Cimarron.	Stable	Stable
6	FLT06-1PH	*Single phase fault and sequence like previous*	Stable	Stable
7	FLT07-3PH	Cimarron 345KV Bus 514901 to Woodring 345KV Bus 514715 CKT 1, near Cimarron.	Stable	Stable
8	FLT08-1PH	*Single phase fault and sequence like previous*	Stable	Stable

No.	Cont. Name	Description	Summer	Winter
9	FLT09-3PH	Northwest 345KV Bus 514880 to SpringCreek 345KV Bus 514881 CKT 1, near Northwest.	Stable	Stable
10	FLT10-1PH	*Single phase fault and sequence like previous*	Stable	Stable
11	FLT11-3PH	Northwest 345KV Bus 514880 to Arcadia 345KV Bus 514908 CKT 1, near Northwest.	Stable	Stable
12	FLT12-1PH	*Single phase fault and sequence like previous*	Stable	Stable
13	FLT13-3PH	Northwest 345KV Bus 514880 to Tatonga 345KV Bus 515407 CKT 1,near Northwest.	Stable	Stable
14	FLT14-1PH	*Single phase fault and sequence like previous*	Stable	Stable
15	FLT15-3PH	Woodring 345KV Bus 514715 to G0813T 345KV Bus 210130 CKT 1, near Woodring.	Stable	Stable
16	FLT16-1PH	*Single phase fault and sequence like previous*	Stable	Stable
17	FLT17-3PH	Woodring 345KV Bus 514715 to Sooner 345KV Bus 514803 CKT 1, near Woodring.	Stable	Stable
18	FLT18-1PH	*Single phase fault and sequence like previous*	Stable	Stable
19	FLT19-3PH	Draper 345KV Bus 514934 to Seminole 345KV Bus 515045 CKT 1, near Draper.	Stable	Stable
20	FLT20-1PH	*Single phase fault and sequence like previous*	Stable	Stable
21	FLT21-3PH	Gen2007-043 345KV Bus 210431 to Gracemont 345KV Bus 515800 CKT 1, near Gen2007-043.	Stable	Stable
22	FLT22-1PH	*Single phase fault and sequence like previous*	Stable	Stable
23	FLT23-3PH	Gracemont 345KV Bus 515800 to LES 345KV Bus 511468 CKT 1, near Gracemont.	Stable	Stable
24	FLT24-1PH	*Single phase fault and sequence like previous*	Stable	Stable
25	FLT25-3PH	Tatonga 345KV Bus 515407 to Woodword 345KV Bus 515375 CKT 1, near Tatonga.	Stable	Stable
26	FLT26-1PH	*Single phase fault and sequence like previous*	Stable	Stable
27	FLT27-3PH	Spring Creek 345KV Bus 514881 to Sooner 345KV Bus 514803 CKT 1, near Spring Creek.	Stable	Stable
28	FLT28-1PH	*Single phase fault and sequence like previous*	Stable	Stable
29	FLT29-3PH	Arcadia 345KV Bus 514908 to HorseshoeLake 345KV Bus 514943 CKT 1, near Arcadia.	Stable	Stable
30	FLT30-1PH	*Single phase fault and sequence like previous*	Stable	Stable
31	FLT31-3PH	Horseshoe Lake 345KV Bus 514943 to Seminole 345KV Bus 515045 CKT 1, near Horseshoe Lake.	Stable	Stable
32	FLT32-1PH	*Single phase fault and sequence like previous*	Stable	Stable
33	FLT33-3PH	Cimarron 138KV Bus 514898 to Tuttle Conoco Tap 138KV Bus 511425 CKT 1, near Cimarron.	Stable	Stable
34	FLT34-1PH	*Single phase fault and sequence like previous*	Stable	Stable
35	FLT35-3PH	Cimarron 138KV Bus 514898 to El Reno 138KV Bus 514819 CKT 1, near Cimarron.	Stable	Stable
36	FLT36-1PH	*Single phase fault and sequence like previous*	Stable	Stable
37	FLT37-3PH	Cimarron 138KV Bus 514898 to Jensen Tap 138KV Bus 514820 CKT 1, near Cimarron.	Stable	Stable
38	FLT38-1PH	*Single phase fault and sequence like previous*	Stable	Stable
39	FLT39-3PH	Cimarron 138KV Bus 514898 to Haymaker 138KV Bus 514863 CKT 1, near Cimarron.	Stable	Stable
40	FLT40-1PH	*Single phase fault and sequence like previous*	Stable	Stable
41	FLT41-3PH	Cimarron 138KV Bus 514898 to Czech Hall 130KV Bus 514894 CKT 1, near Cimarron.	Stable	Stable
42	FLT42-1PH	*Single phase fault and sequence like previous*	Stable	Stable

No.	Cont. Name	Description	Summer	Winter
43	FLT43-3PH	Cimarron 138KV Bus 514898 to Sara 138KV Bus 514895 CKT 1, near Cimarron.	Stable	Stable
44	FLT44-1PH	*Single phase fault and sequence like previous*	Stable	Stable
45	FLT45-3PH	Cimarron 138KV Bus 514898 to Cimarron 345KV Bus 514901 to Cimarron 13.8KV Bus 515714 CKT 1, near Cimarron 138kV.	Stable	Stable
46	FLT46-3PH	Northwest 138KV Bus 514879 to Northwest 345KV Bus 514880 to Northwest 13.8KV Bus 515742 CKT 1, near the Northwest 138kV.	Stable	Stable
47	FLT47-3PH	Woodring 138KV Bus 514714 to Woodring 345KV Bus 514715 to Woodring 13.8KV Bus 515770 CKT 1, near Woodring 138kV.	Stable	Stable
48	FLT48-3PH	Draper 138KV Bus 514933 to Draper 345KV Bus 514934 to Draper 13.8KV Bus 515720 CKT 1, near Draper 138kV.	Stable	Stable

Table 6: Contingency Simulation Results (Scenario 2)

11.0 Power Factor Analysis (Scenario 2)

A power factor analysis was performed by substituting a VAR generator for the Customer project at the POI. (The Customer project was disconnected from the POI.) The power output of the VAR generator was set to 298.5MW, the total maximum of the wind farm. The voltage schedule of the VAR generator was set to 1.00 per unit. The analysis was done for both the summer and winter cases. The contingencies and results are shown in Tables 7.

The analysis showed that even with the reactive capabilities of the wtg's that approximately 35MVARs of additional capacitors are needed to meet 0.95 lagging (providing VARs) at the POI. This analysis was done by setting the wtg's to their maximum lagging (providing VARs) and then their maximum leading (absorbing VARs) capability and observing the generated power and reactive power at the POI.

Bus 514901 (POI) voltage: 1.000 PU (S) / 1.000PU (W)	GEN-2010-040 (POI at Cimarron 345kV, Bus 514901)							
CONTINGENCY	**MW (S)**	**MVAR (S)**	**PF (S)**		**MW (W)**	**MVAR (W)**	**PF (W)**	
No contingency	298.5	123.2	0.924	LAG	298.5	227.5	0.795	LAG
Cimarron 345KV Bus 514901 TO Minco 345KV Bus 514801 CKT 1	298.5	167.8	0.872	LAG	298.5	259.6	0.755	LAG
Cimarron 345KV Bus 514901 to Northwest 345KV Bus 514880 CKT 1	298.5	116.2	0.932	LAG	298.5	203.6	0.826	LAG
Cimarron 345KV Bus 514901 to Draper 345KV Bus 514934 CKT 1	298.5	143.2	0.902	LAG	298.5	251.5	0.765	LAG
Cimarron 345KV Bus 514901 TO Mathewson 345KV Bus 560368 CKT 1	298.5	123.2	0.924	LAG	298.5	220.3	0.805	LAG
Northwest 345KV Bus 514880 to SpringCreek 345KV Bus 514881 CKT 1	298.5	174.5	0.863	LAG	298.5	253.2	0.763	LAG
Northwest 345KV Bus 514880 to Arcadia 345KV Bus 514908 CKT 1	298.5	141.0	0.904	LAG	298.5	263.0	0.750	LAG
Northwest 345KV Bus 514880 TO Mathewson 345KV Bus 560368 CKT 1	298.5	169.9	0.869	LAG	298.5	281.5	0.728	LAG
Mathewson 345KV Bus 560368 TO Tatonga 345KV Bus 515407 CKT 1	298.5	154.2	0.888	LAG	298.5	263.6	0.750	LAG
Mathewson 345KV Bus 560368 TO Woodring 345KV Bus 514715 CKT 1	298.5	184.5	0.851	LAG	298.5	302.5	**0.702**	LAG
Woodring 345KV Bus 514715 TO G0813POI 345KV Bus 579406 CKT 1	298.5	137.5	0.908	LAG	298.5	244.8	0.773	LAG
Woodring 345KV Bus 514715 to Sooner 345KV Bus 514803 CKT 1	298.5	135.9	0.910	LAG	298.5	242.6	0.776	LAG
Draper 345KV Bus 514934 to Seminole 345KV Bus 515045 CKT 1	298.5	137.7	0.908	LAG	298.5	241.9	0.777	LAG
Minco 345KV Bus 514801 TO Gracemont 345KV Bus 515800 CKT 1	298.5	133.8	0.913	LAG	298.5	237.5	0.783	LAG
Gracemont 345KV Bus 515800 to LES 345KV Bus 511468 CKT 1	298.5	117.0	0.931	LAG	298.5	217.0	0.809	LAG
Tatonga 345KV Bus 515407 TO G11051Tap 345KV Bus 562075 CKT 1	298.5	115.9	0.932	LAG	298.5	216.5	0.809	LAG
SpringCreek 345KV Bus 514881 to Sooner 345KV Bus 514803 CKT 1	298.5	138.4	0.907	LAG	298.5	251.0	0.765	LAG
Arcadia 345KV Bus 514908 to HorseshoeLake 345KV Bus 514943 CKT 1	298.5	129.8	0.917	LAG	298.5	237.1	0.783	LAG
HorseshoeLake 345KV Bus 514943 to Seminole 345KV Bus 515045 CKT 1	298.5	129.3	0.918	LAG	298.5	236.7	0.784	LAG
Cimarron 138KV Bus 514898 to TuttleConocoTap 138KV Bus 511425 CKT 1	298.5	113.9	0.934	LAG	298.5	221.3	0.803	LAG
Cimarron 138KV Bus 514898 to ElReno 138KV Bus 514819 CKT	298.5	119.9	0.928	LAG	298.5	225.6	0.798	LAG

Bus 514901 (POI) voltage: 1.000 PU (S) / 1.000PU (W)	GEN-2010-040 (POI at Cimarron 345kV, Bus 514901)							
CONTINGENCY	**MW (S)**	**MVAR (S)**	**PF (S)**		**MW (W)**	**MVAR (W)**	**PF (W)**	
1								
Cimarron 138KV Bus 514898 to JensenTap 138KV Bus 514820 CKT 1	298.5	119.6	0.928	LAG	298.5	224.7	0.799	LAG
Cimarron 138KV Bus 514898 to Haymaker 138KV Bus 514863 CKT 1	298.5	124.2	0.923	LAG	298.5	227.3	0.796	LAG
Cimarron 138KV Bus 514898 to CzechHall 130KV Bus 514894 CKT 1	298.5	123.4	0.924	LAG	298.5	224.8	0.799	LAG
Cimarron 138KV Bus 514898 to Sara 138KV Bus 514895 CKT 1	298.5	120.2	0.928	LAG	298.5	227.7	0.795	LAG
Cimarron 138KV Bus 514898 to Cimarron 345KV Bus 514901 to Cimarron 13.8KV Bus 515714 CKT 1	298.5	107.3	0.941	LAG	298.5	210.0	0.818	LAG
Northwest 138KV Bus 514879 to Northwest 345KV Bus 514880 to Northwest 13.8KV Bus 515742 CKT 1	298.5	125.9	0.921	LAG	298.5	220.7	0.804	LAG
Woodring 138KV Bus 514714 to Woodring 345KV Bus 514715 to Woodring 13.8KV Bus 515770 CKT 1	298.5	120.1	0.928	LAG	298.5	225.1	0.798	LAG
Draper 138KV Bus 514933 to Draper 345KV Bus 514934 to Draper 13.8KV Bus 515720 CKT 1	298.5	121.9	0.926	LAG	298.5	222.6	0.802	LAG

NOTE: No contingency produced a Leading PF

0.702 indicates the smallest Lagging PF

(S) - Summer Case
(W) - Winter Case

LAG - Generating facility providing VARS to network
LEAD - Generating facility absorbing VARS from network

Table 7: GEN-2010-040 Power Factor Table (Scenario 2)

12.0 Conclusion

The findings of the restudy show that no stability problems were found during the summer or the winter peak conditions for both scenarios due to the use of the REpower MM92 2.05MW and the Mitsubishi MWT 102 2.4MW wtg's. Additionally, the project wind farm was found to stay connected during the contingencies that were studied, meeting the Low Voltage Ride Through (LVRT) requirements of FERC Order #661A.

A power factor analysis was performed. The facility will be required to maintain a 95% lagging (providing VARs) and 95% leading (absorbing VARs) power factor a the point of interconnection. Analysis show that even with the reactive capabilities of the wtg's that approximately 35MVARs of additional capacitors are needed to meet 0.95 lagging (providing VARs) at the POI.

With the assumptions outlined in this report, GEN-2010-040 with the wtg's described in the study should be able to reliably interconnect to the SPP transmission grid.