Southwest Power Pool

Interim Operational Impact Study For Generation Interconnection Request GEN-2007-050

SPP Tariff Studies

(#GEN-2007-050)

September 2009

Executive Summary

<OMITTED TEXT> (Customer) has requested an Impact Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnection of 170.2 MW of wind generation within the control area of Oklahoma Gas and Electric (OKGE) in Woodward County, Oklahoma. SPP has completed the Impact Study as part of the cluster study ICS-2008-001 and is currently performing a restudy to account for withdrawn queue positions. SPP may not be able to complete all interconnection studies required under the OATT in time to begin construction to meet the Customer's in service date of December 31, 2010. Therefore, Customer has requested this Interim Operation Impact Study (IOIS) to determine the impacts of interconnecting its generating facility to the transmission system before all required Network Upgrades identified in the Impact Cluster Study (ICS-2008-001) are able to be placed into service. SPP announced it would conduct such studies for interested interconnection customers in an OASIS posting on March 6, 2009.

This study is intended only as an Interim Operation Study that will be used in order to tender an Interim Interconnection Agreement to the Customer for Interim Interconnection Service. If an Interim Interconnection Agreement is not executed with the Customer, this study will be invalid. If an Interim Interconnection Agreement is executed with the Customer, this study will be considered invalid upon termination of such Interim Interconnection Agreement.

This study assumed that only the projects identified in Table 1 of this study may go into service before the completion of all Network Upgrades identified in ICS-2008-001. If any additional generation projects that are not identified in Table 1 and are queued higher than the GEN-2007-050 request to go into commercial operation before such time that all required Network Upgrades identified through the Cluster Interconnection Study process, this study must be conducted again to determine whether sufficient interim interconnection capacity exists to interconnect the GEN-2007-050 interconnection request. If sufficient interim interconnection capacity does not exist, the Interconnection Customer may be disconnected from the Transmission System.

Two seasonal base cases were used in the study to analyze the stability impacts of the proposed generation facility. The cases studied were a modified 2010 summer peak and 2010 winter peak that included the projects shown in Table 1. Also, each case was modified to include a 345 kV transmission line from Woodward to Northwest scheduled to be in service March 1, 2010. Forty-two (42) contingencies were identified for use in this study. The Siemens SMK-2.3-93 2.3 MW wind turbines were modeled using information provided by the manufacturer.

ABB Power Systems Division was contracted by SPP to conduct the stability study. The stability study (the ABB report is found in Appendix A) shows that with the Customer requested Siemens wind turbines the transmission system remains stable for all simulated contingencies and both system conditions studied. If the Customer does not use the Siemens SMK-2.3-93 2.3 MW, this IOIS will be considered invalid and the Customer will not be allowed to interconnect on an interim basis. The study results show that, with the Siemens turbines, the wind farm will meet FERC Order #661A's Low Voltage Ride Through (LVRT) provisions. The Customer's windfarm is required to maintain +/- 0.95 power factor at the point of interconnection (POI) for any system condition.

The estimates of costs for network upgrades and the interconnection facilities for interim operation will be estimated by the Transmission Owner on an expedited basis to meet the Customer's in service date. The Customer will also be required to provide security in the amount of $18,744,000 per the Impact Cluster Study (ICS-2008-001). This amount of security will be adjusted as the GEN-2007-050 interconnection request advances through the Cluster interconnection process as stated in SPP's OASIS posting.

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

1.0 Introduction

<OMITTED TEXT> (Customer) has requested an Impact Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnection of 170.2MW of wind generation within the control area of Oklahoma Gas and Electric (OKGE) in Woodward County, Oklahoma. As the interconnection studies for this request may not be complete to start construction meet the Customer's requested in service date of December 31, 2010, the Customer has requested that SPP conduct an Interim Operational Impact Study (IOIS) to determine if the generating facility can be interconnected in an interim manner before all Network Upgrades identified in the Impact Cluster Study (ICS-2008-001) are placed in service. SPP announced it would conduct such studies for interested interconnection customers in an OASIS posting on March 6, 2009.

The wind powered generation facility was studied with seventy-four (74) individual Siemens SMK-2.3-93 2.3 MW wind turbines. The requested in-service date for the 170.2 MW facility is December 31, 2010. ABB Power Systems Division was contracted by SPP to conduct the impact study. ABB issued a report of its impact study which is included as Appendix A to this document.

Two seasonal base cases were used in the study to analyze the stability impacts of the proposed generation facility. A 2010 summer peak case and a 2010 winter peak case were modified to include the projects shown in Table 1. Also, each case was modified to include a 345 kV transmission line from Woodward to Northwest that is scheduled to be in service by March1, 2010. Forty-two (42) contingencies were identified for this study. The Siemens SMK-2.3-93 2.3 MW wind turbines were modeled using information provided by the manufacturer.

2.0 Purpose

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

a) are directly interconnected to the Transmission System;
b) are interconnected to Affected Systems and may have an impact on the Interconnection Request;
c) have a pending higher queued Interconnection Request to interconnect to the Transmission System listed in Table 1
d) have had an Interim Operational Impact Study already performed (these projects also listed in Table 1); or
e) have no Queue Position but have executed an LGIA or requested that an unexecuted LGIA be filed with FERC.

Any changes to these assumptions, for example, one or more of the previously queued projects not included in this study signing an interconnection agreement or the Woodward-Northwest 345 kV transmission line is not in service by March 1, 2009, may require a re-study of this request at the expense of the customer. If such a subsequent study shows that interconnection capacity is not available, the Customer may not be allowed to interconnect or may be required to disconnect from the Transmission System if applicable.

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

Project	MW
GEN-2001-014	96
GEN-2001-037	103
GEN-2002-005	120
GEN-2005-008	130
GEN-2006-046	130
GEN-2007-006	160
GEN-2008-003	101

Table 1: Study Modeled Projects

3.0 Facilities

3.1 Generating Facility

For a description of the generating facility see the ABB report in the appendix.

3.2 Interconnection Facility

The point of interconnection (POI) will be at the new OKGE 138 kV switching station located just west of the existing Woodward 138 kV District Substation. Figure 1 shows the proposed POI. OKGE is currently building the new Woodward EHV 138kV substation as part of its construction plans. The customer intends to interconnect into the new Woodward EHV 138 kV substation.

Cost to interconnect on an interim basis is estimated at **$1,250,000**.

The customer's latest estimate for cost responsibility for Interconnection Service is given in the Impact Cluster Study (ICS-2008-001) at **$18,744,000**. The customer will be required to provide security in this amount to move forward into an Interim Interconnection Agreement.

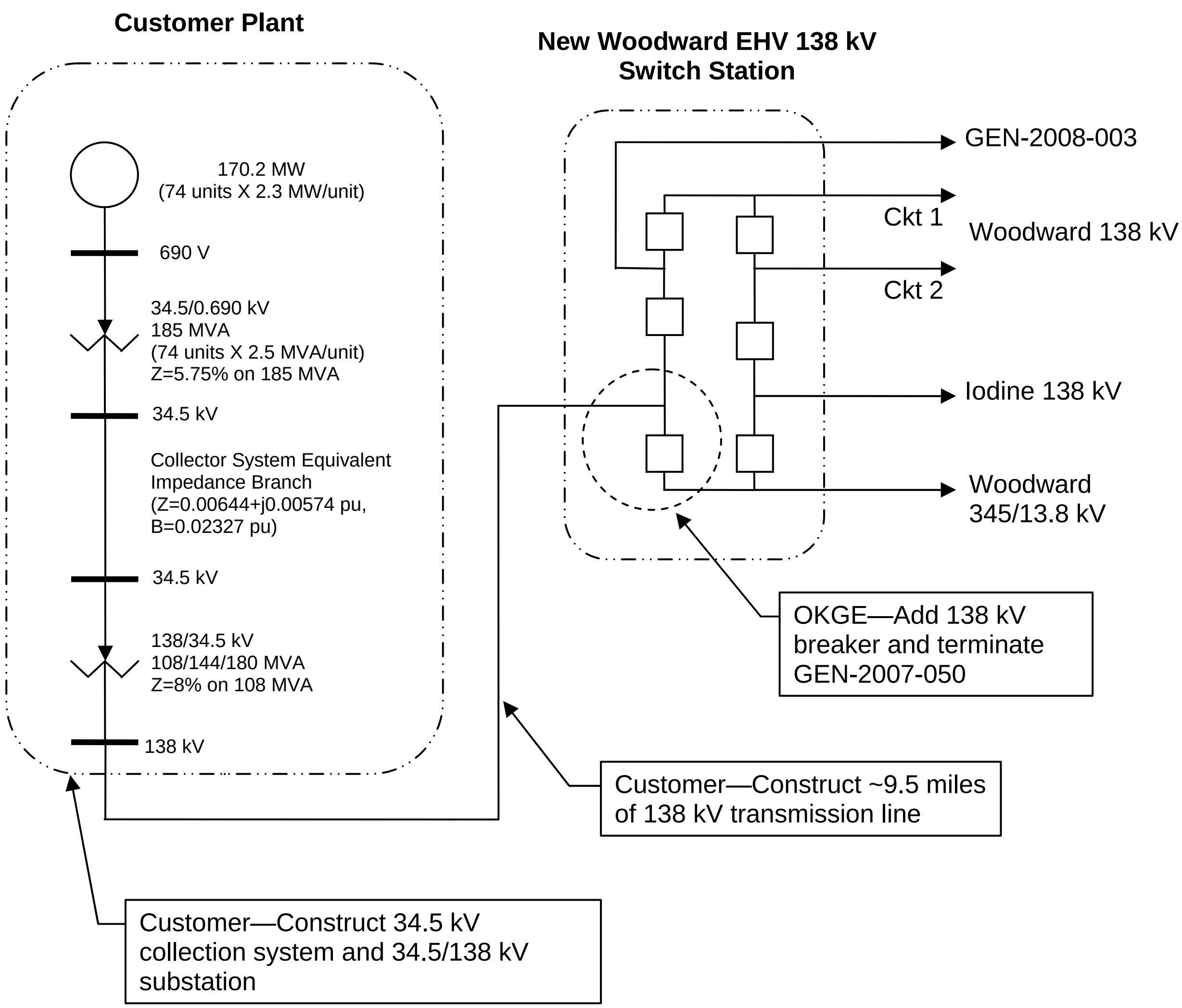

Figure 1: GEN-2007-050 Facility and Proposed Interconnection Configuration

3.3 Power Factor Requirements

The Customer's windfarm is required to maintain +/- 0.95 power factor at the POI for any system condition. See the ABB report for detailed power factor analysis.

4.0 Conclusion

<OMITTED TEXT> (Customer) has requested an Interim Operation Impact Study for interim interconnection service of 170.2 MW of wind generation within the control area of Oklahoma Gas and Electric (OKGE) in Woodward County, Oklahoma, in accordance with the OASIS posting made by SPP on March 6, 2009. The wind powered generation facility was studied with seventy-four (74) individual Siemens SMK-2.3-93 2.3 MW wind turbines

The results of this study show that the wind farm and the transmission system remain stable for all contingencies studied. The Customer's windfarm is required to maintain +/-0.95 power factor at the POI. Additionally, the stability study results show that the wind farm will meet FERC Order #661A's Low Voltage Ride Through (LVRT) provisions.

The estimates of costs for network upgrades and the interconnection facilities are found in the Impact Cluster Study, ICS-2008-001, posted July 1, 2009. The Customer is required to provide security in the amount of $18,744,000 to move forward into an Interim Interconnection Agreement. Failure by the Customer to provide the security in this amount in accordance with the Interim Interconnection will cause this Interim Operation Impact Study and the Interim Interconnection Agreement to become invalid.

This study assumed that only the projects identified in Table 1 of this study may go into service before the completion of all Network Upgrades identified in ICS-2008-001. If any additional generation projects that are not identified in Table 1 and are queued higher than the GEN-2007-050 request to go into commercial operation before such time that all required Network Upgrades identified through the Cluster Interconnection Study process, this study must be conducted again to determine whether sufficient interim interconnection capacity exists to interconnect the GEN-2007-050 interconnection request. If sufficient interim interconnection capacity does not exist, the Interconnection Customer may be disconnected from the Transmission System.

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

APPENDIX A.

ABB Report for System Impact Study GEN-2007-050

POWER SYSTEMS DIVISION
GRID SYSTEMS CONSULTING

System Impact Study for GEN-2007-050

FINAL REPORT

REPORT NO.: 2009-E3393-R1
Issued On: September 10, 2009
Revised ON: September 23, 2009

Prepared for:
Southwest Power Pool, Inc.

ABB Inc.
Power Systems Division
Grid Systems Consulting
940 Main Campus Drive, Suite 300
Raleigh, NC 27606

Legal Notice

This document, prepared by ABB Inc., is an account of work sponsored by Southwest Power Pool, Inc. (SPP). Neither SPP nor ABB Inc, nor any person or persons acting on behalf of either party: (i) makes any warranty or representation, expressed or implied, with respect to the use of any information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights, or (ii) assumes any liabilities with respect to the use of or for damages resulting from the use of any information, apparatus, method, or process disclosed in this document.

ABB Inc – Grid Systems Consulting

Technical Report

Southwest Power Pool, Inc.	**No.** 2009-E3393-R1	
System Impact Study for GEN-2007-050	Date: 09/23/09	# Pages 33

Author(s):	**Reviewed by:**	**Approved by:**
Trinadh Dwibhashyam	Amit Kekare	Willie Wong

Executive Summary

Southwest Power Pool, Inc. (SPP) has commissioned ABB Inc. to perform a system impact study for GEN-2007-050, a wind-based generation of 170.2 MW on the SPP system. The proposed wind farm is located in Woodward, Oklahoma.

Request	Size	Wind Turbine Model	Point of Interconnection	County
GEN-07-050	170.2	Siemens 2.3 MW	Woodward EHV 138 kV (#515376)	Woodward, Oklahoma

The main objectives of this study were

1) To determine the need of reactive power compensation, if any, for the proposed wind farm
2) To determine the impact of proposed GEN-07-050 (170.2 MW) generation on system stability and the nearby transmission system and generating stations.
3) To validate the compliance with FERC LVRT requirement for the wind farm.

To achieve these objectives the following analyses were performed on the 2010 Summer Peak and 2010 Winter Peak system conditions with GEN-2007-050 in-service

- Power factor analysis for the selected contingencies.
- Transient stability analysis under various local and regional contingencies.
- LVRT performance under selected contingencies near POI.

Assumptions

1. The following prior queued projects were included in the powerflow cases provided by SPP.
   - GEN-2001-014 – 96 MW, Suzzlon turbines, Ft. Supply 138 kV (520920)
   - GEN-2001-037 – 103 MW, GE turbines, Woodward/Mooreland 138 kV (515785)
   - GEN-2002-005 – 120 MW, Acciona turbines, Elk City/ Morewood 138 kV (200)
   - GEN-2005-008 – 130 MW, GE turbines, Woodward 138 kV (514785)
   - GEN-2006-046 – 130 MW, Mitsubishi turbines, Taloga 138 kV (521065)

- GEN-2007-006 – 160 MW, Suzzlon turbines, Watonga 138 kV (515799)
- GEN-2008-003 – 101 MW, Siemens turbines, Woodward EHV 138 kV (515376)

2. The study assumes that the Woodward – Northwest 345 kV line in-service (scheduled completion March 2010).

Following is the summary of study findings:

Power factor analysis
SPP requires that the Customer's wind farm maintain +/- 0.95 power factor at the POI for any system condition. An analysis was conducted to determine whether the proposed GEN-2007-050 project has sufficient reactive power capability to meet the power factor criteria.

Stability Analysis
The stability analysis was performed to determine the impact, if any, of the proposed GEN-2007-050 project on the stability of the SPP system. The system was found to be STABLE following all 3-phase faults and single-line-to-ground (SLG) faults with line reclosing and delayed clearing.

FERC Order 661A Compliance
Selected faults were simulated at the Point of Interconnection (POI) of the proposed GEN-2007-050 wind farm to determine the compliance with FERC 661 – A post-transition period LVRT standard. The results indicated that the proposed project meets the FERC LVRT requirement for wind farms.

Based on the results of the analysis, it can be concluded that the proposed GEN-2007-050 doesn't adversely impact the stability of the Transmission System in the local area

The results of this analysis are based on available data and assumptions made at the time of conducting this study. If any of the data and/or assumptions made in developing the study model change, the results provided in this report may not apply and additional analysis may be required.

Rev No.	Revision Description	Date	Authored by	Reviewed by	Approved by
0	Draft Report	09/10/09	Trinadh	A. Kekare	
1	Updated per SPP comments	09/23/09	Trinadh	A. Kekare	
DISTRIBUTION: Ray Offenbacker – Southwest Power Pool, Inc.					

TABLE OF CONTENTS

1 INTRODUCTION

Southwest Power Pool, Inc. (SPP) has commissioned ABB Inc. to perform a system impact study for GEN-07-050, a wind-based generation of 170.2 MW on the SPP system. The proposed wind farm is located in Woodward, Oklahoma. Figure 1-1 shows the locations of GEN-2007-050 with proposed 170.2 MW generation.

The study evaluated the impact of the GEN-2007-050 project on the stability of the SPP system. The scope of this study was limited to the transient stability analysis.

The main objectives of this study were

1) To determine the need of reactive power compensation, if any, for the proposed wind farms
2) To determine the impact of proposed GEN-2007-050 (170.2 MW) generation on system stability and the nearby transmission system and generating stations.
3) To validate the compliance with FERC LVRT requirement for the wind farm.

To achieve these objectives the following analyses were performed on the 2010 Summer Peak and 2010 Winter Peak system conditions with GEN-2007-050 in-service

- Power factor analysis for the selected contingencies.
- Transient stability analysis under various local and regional contingencies.
- LVRT performance under selected contingencies near POI.

The study was performed on 2010 Summer Peak and winter peak cases, provided by SPP. This report documents the methods, analysis and results of the system impact study.

Table 1-1: GEN-2007-050 Project

Request	Size	Wind Turbine Model	Point of Interconnection	County
GEN-07-050	170.2	Siemens 2.3 MW	Woodward EHV 138 kV (#515376)	Woodward, Oklahoma

1.1 REPORT ORGANIZATION

This report is organized as follows:

Section 2: Description of proposed GEN-07-050 project
Section 3: Study methodology
Section 4: Model Development
Section 5: Power Factor Analysis Results
Section 6: Stability Analysis Results
Section 7: Conclusions

The detailed study results are compiled in separate Appendices.

Figure 1-1 GEN-2007-050 Project location

2 DESCRIPTION OF GEN-2007-050

The details of load flow and dynamic data for the GEN-2007-050 wind farm projects are included in the Appendix A.

- Wind farm rating: 170.2 MW
- Interconnection:

  Voltage: 138 kV

  Location: Woodward EHV substation. The windfarm will be connected to the proposed POI via 9.5 miles 138 kV line.

  Transformer: One (1) step-up transformer connecting to the 138 kV

  MVA: 108/144/180 MVA

  Voltage: 138/34.5/13.2 kV

  Z: 11 % on 108 MVA

- Wind Turbines:

  Number: Seventy Four (74)

  Manufacturer: Siemens

  Type: Doubly-fed induction generator (DFIG)

Machine Terminal voltage: 0.69 kV

  Rated Power: 2.3 MW

  Frequency: 60 Hz

  Generator Step-up Transformer

  MVA: 2.5
  High voltage: 34.5 kV,
  Low voltage: 0.69 kV
  Z: 5.75% on 2.5 MVA

- Reactive Power Capability: 0.9 lagging/ 0.9 leading
- Fault Ride-through: Manufacturer’s default ride-through capability was modeled
- PSSE Model Used SMK203_model

3 STUDY METHODOLOGY

3.1 POWER FACTOR ANALYSIS

The purpose of the power factor analysis was to determine whether the range of power factor the GEN-2007-050 wind farm must provide to maintain an acceptable voltage schedule at the point of interconnection. FERC Order #661A requires wind farms to be able to meet a +/-0.95 power factor towards this requirement.

Following steps were taken to perform the power factor analysis:

- A VAR generator with large capacity (+/- 9999 Mvar) was modeled at the POI of the subject wind farm. The VAR generator was set to hold the POI voltage consistent with the voltage schedule in the provided base case. The reactive power capability of the wind farm was set to zero.
- A list of selected contingencies in the vicinity of the subject wind farm project was simulated. The results were used to identify the most-limiting contingency from steady state voltage and power factor perspective.
- If the required reactive power support, to maintain an acceptable power factor at the POI, was found to be beyond the capability of proposed windfarm then the additional reactive power compensation (e.g. shunt capacitor banks) was considered.

It is important to note that the reactive power compensation identified in this analysis was primarily to meet steady state criteria. The need for dynamic reactive power support, if any, will be determined during transient stability analysis.

3.2 TRANSIENT STABILITY ANALYSIS

The purpose of the transient stability analysis was to determine the impact, if any, of the GEN-2007-050 wind farm project on the system stability and the nearby transmission system and generating stations.

Using Planning Standards approved by NERC, the following stability definition was applied in the Transient Stability Analysis:

“Power system stability is defined as that condition in which the differences of the angular positions of synchronous machine rotors become constant following an aperiodic system disturbance.”

Stability analysis was performed using Siemens-PTI’s PSS/E^{TM} dynamics program V30.3.2. Three-phase and single-line-to-ground (SLG) faults were simulated for the specified duration and synchronous machine rotor angles and wind turbine generator speeds were monitored to check whether synchronism is maintained following fault removal.

For three-phase faults, a fault admittance of –j2E9 was used (essentially infinite admittance or zero impedance). The PSS/E dynamics program only simulates the positive sequence network. Unbalanced faults (like single-phase line faults) involve the positive, negative, and zero sequence networks. For unbalanced faults, the equivalent fault admittance was inserted in the PSS/E positive sequence model between the faulted bus and ground to simulate the effect of the negative and zero sequence networks. For a single-line-to-ground (SLG) fault, the fault admittance equals the inverse of the sum of the positive, negative and zero sequence Thevenin impedances at the faulted bus. Since PSS/E inherently models the positive sequence fault impedance, the sum of the negative and zero sequence Thevenin impedances needs to be added and entered as the fault impedance at the faulted bus. The fault impedance was estimated to give a positive sequence voltage at the fault location of approximately 60% of pre-fault voltage, which is a typical value.

Another important aspect of the stability analysis was to determine the ability of the wind generators to stay connected to the grid during disturbances. This is primarily determined by their low-voltage ride-through capabilities – or lack thereof – as represented in the models by low-voltage trip settings. The Federal Energy Regulatory Commission (FERC) Post-transition period LVRT standard for Interconnection of Wind generating plants includes a Low Voltage Ride Through (LVRT) requirement. The key features of LVRT requirements are:

- A wind generating plant must remain in-service during three-phase faults with normal clearing (maximum 9 cycles) and single-line-to-ground faults with delayed clearing, and have subsequent post-fault recovery to pre-fault voltage unless the clearing of the fault effectively disconnects the generator from the system.
- The maximum clearing time the wind generating plant shall be required to withstand a three-phase fault shall be 9 cycles after which, if the fault remains following the location-specific normal clearing time for three-phase faults, the wind generating plant may disconnect from the transmission system. A wind generating plant shall remain interconnected during such a fault on transmission system for a voltage level as low as zero volts, as measured at the high voltage side of the GSU connected at POI.

These criteria were used to evaluate the LVRT capability of the GEN-07-050 Project.

4 MODEL DEVELOPMENT

Two power flow cases dispatched against the proposed project GEN-2007-050 – “BASE_GEN-2007-050_10SP.sav” and “BASE_GEN-2007-050_10WP.sav” – representing the 2010 Summer Peak and Winter Peak conditions were provided by SPP.

1. The following prior queued projects were included in the powerflow cases provided by SPP.
    - GEN-2001-014 – 96 MW, Suzzlon turbines, Ft. Supply 138 kV (520920)
    - GEN-2001-037 – 103 MW, GE turbines, Woodward/Mooreland 138 kV (515785)
    - GEN-2002-005 – 120 MW, Acciona turbines, Elk City/ Morewood 138 kV (200)
    - GEN-2005-008 – 130 MW, GE turbines, Woodward 138 kV (514785)
    - GEN-2006-046 – 130 MW, Mitsubishi turbines, Taloga 138 kV (521065)
    - GEN-2007-006 – 160 MW, Suzzlon turbines, Watonga 138 kV (515799)
    - GEN-2008-003 – 101 MW, Siemens turbines, Woodward EHV 138 kV (515376)
2. The study assumes that the Woodward – Northwest 345 kV line in-service (scheduled completion March 2010).

4.1 MODEL DEVELOPMENT FOR GEN-2007-050

The details of the GEN-2007-050 wind farm project are provided in section 2. The proposed GEN-2007-050 wind farm (170.2 MW) will be comprised of seventy four (74) Siemens 2.3 MW doubly fed induction generators (DFIG).

The proposed wind farm was modeled by using a single equivalent wind turbine-generator. The wind turbine generator was modeled to maintain power factor near to unity at POI. A lumped equivalent of generator step-up transformer (GSU) was modeled connecting the single equivalent generators to the equivalent collector system at 34.5 kV. The equivalent collector system impedance was calculated based on the information provided by SPP. The collector system was connected to 138 kV through a 34.5/138/13.2 kV transmission step-up transformer. The proposed windfarm was connected to the 138 kV POI through 9.5 miles 138 kV line. Figure 4-1 shows the one-line diagram for the equivalent modeling.

Thus two power flow cases including the GEN-2007-050 were established and named as ‘POST_GEN-2007-050_10SP.sav’ (2010 summer peak) and POST_GEN-2007-050_10WP.sav’ (2010 winter peak).

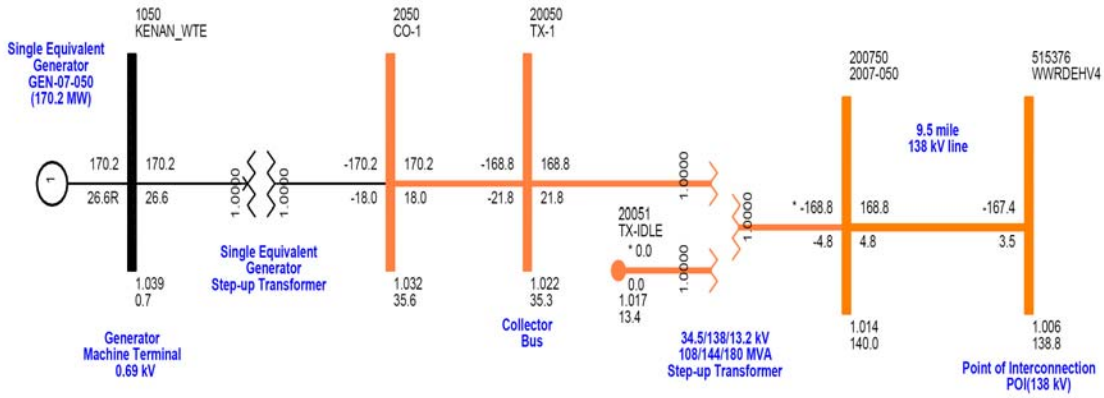

Figure 4-1: one-line diagram for GEN-2007-050 project

Figure 4-2 and Figure 4-3 show the one-line diagram in the local area of GEN-2007-050 before and after GEN-07-050 for 2010 summer peak. Figure 4-4 and Figure 4-5 depict the 2010 winter peak system before and after GEN-2007-050.

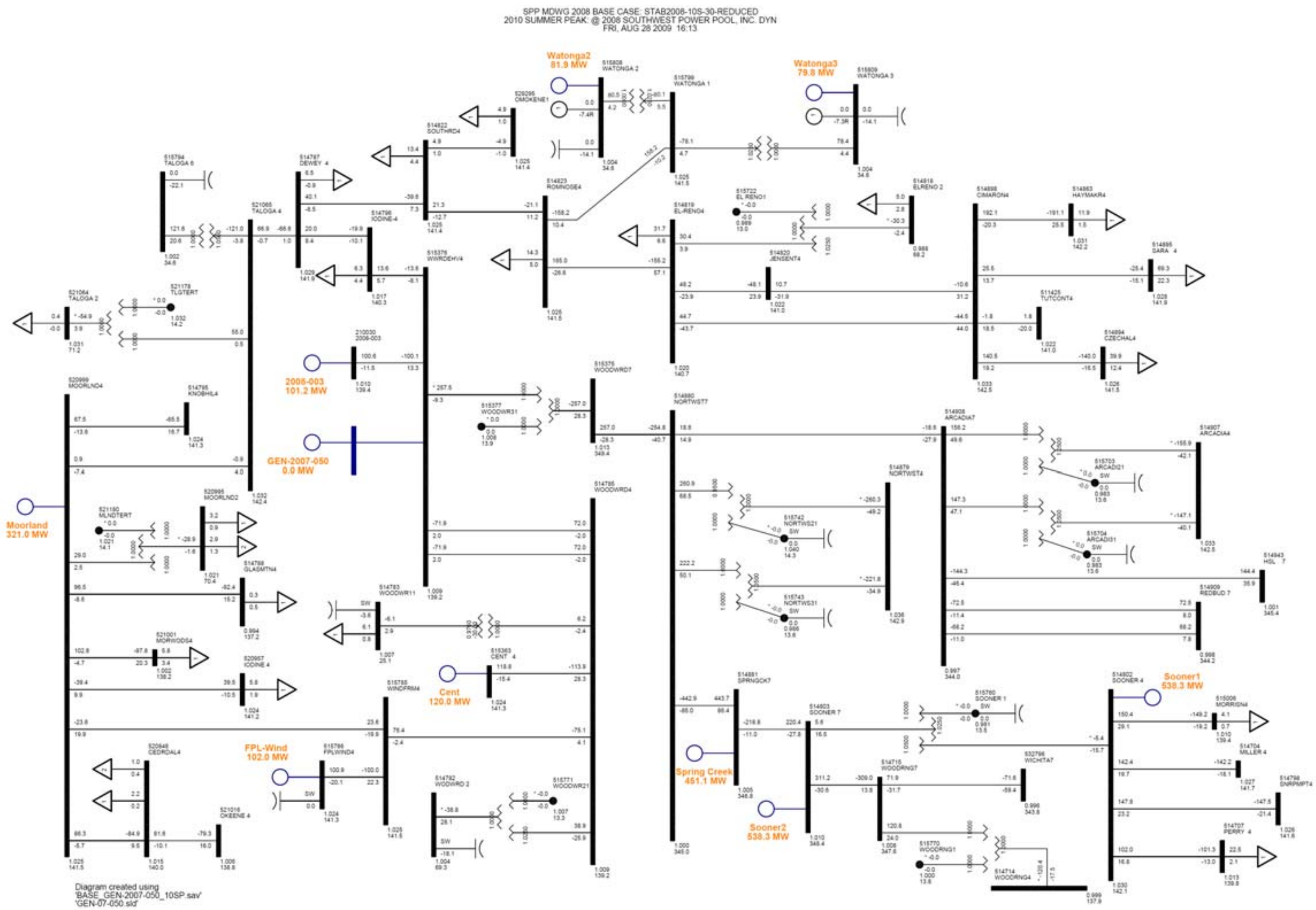

Figure 4-2 One-line Diagram of the local area <u>without</u> GEN-07-050 (2010 Summer Peak)

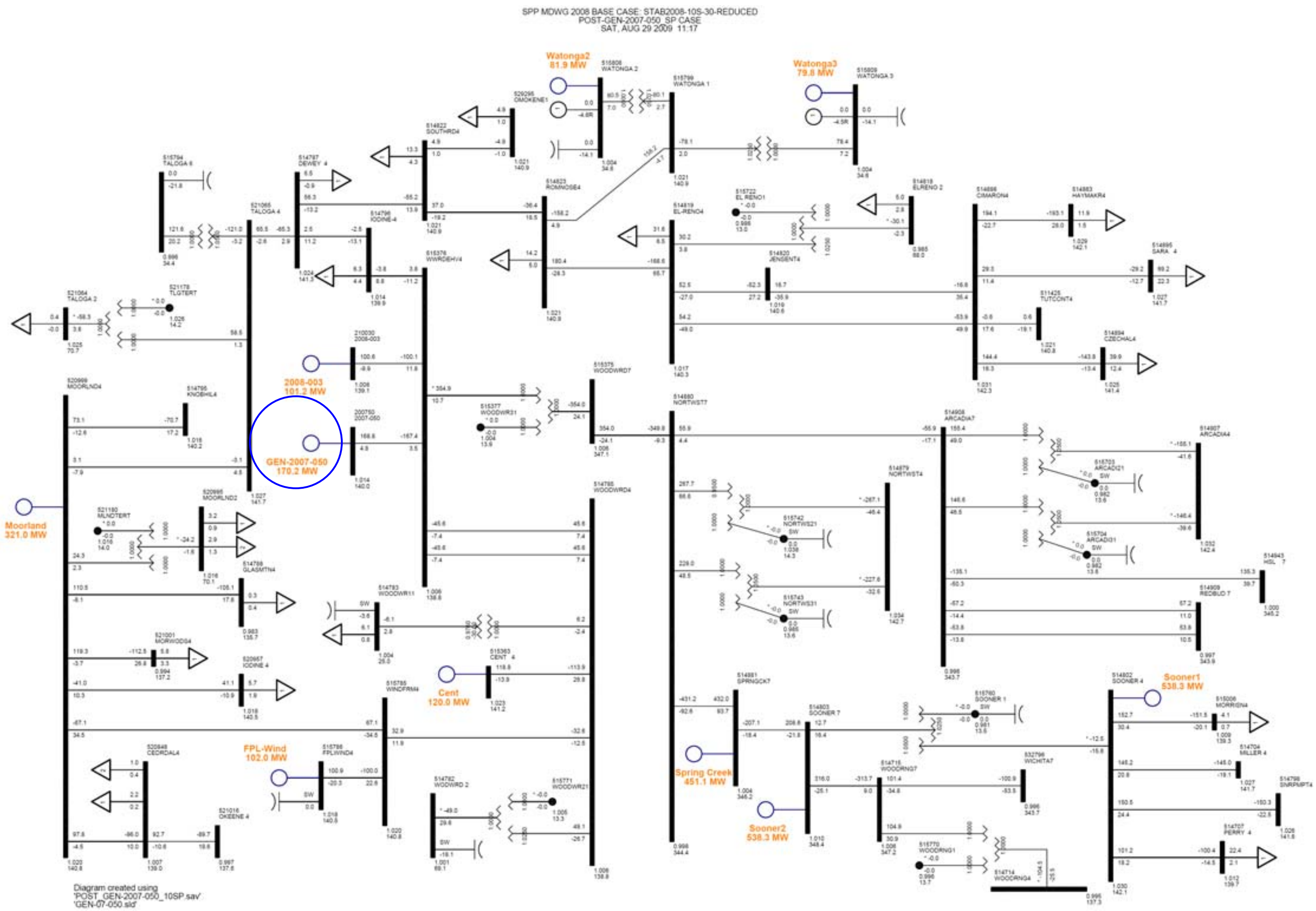

Figure 4-3 One-line Diagram of the local area <u>with</u> GEN-07-050 (2010 Summer Peak)

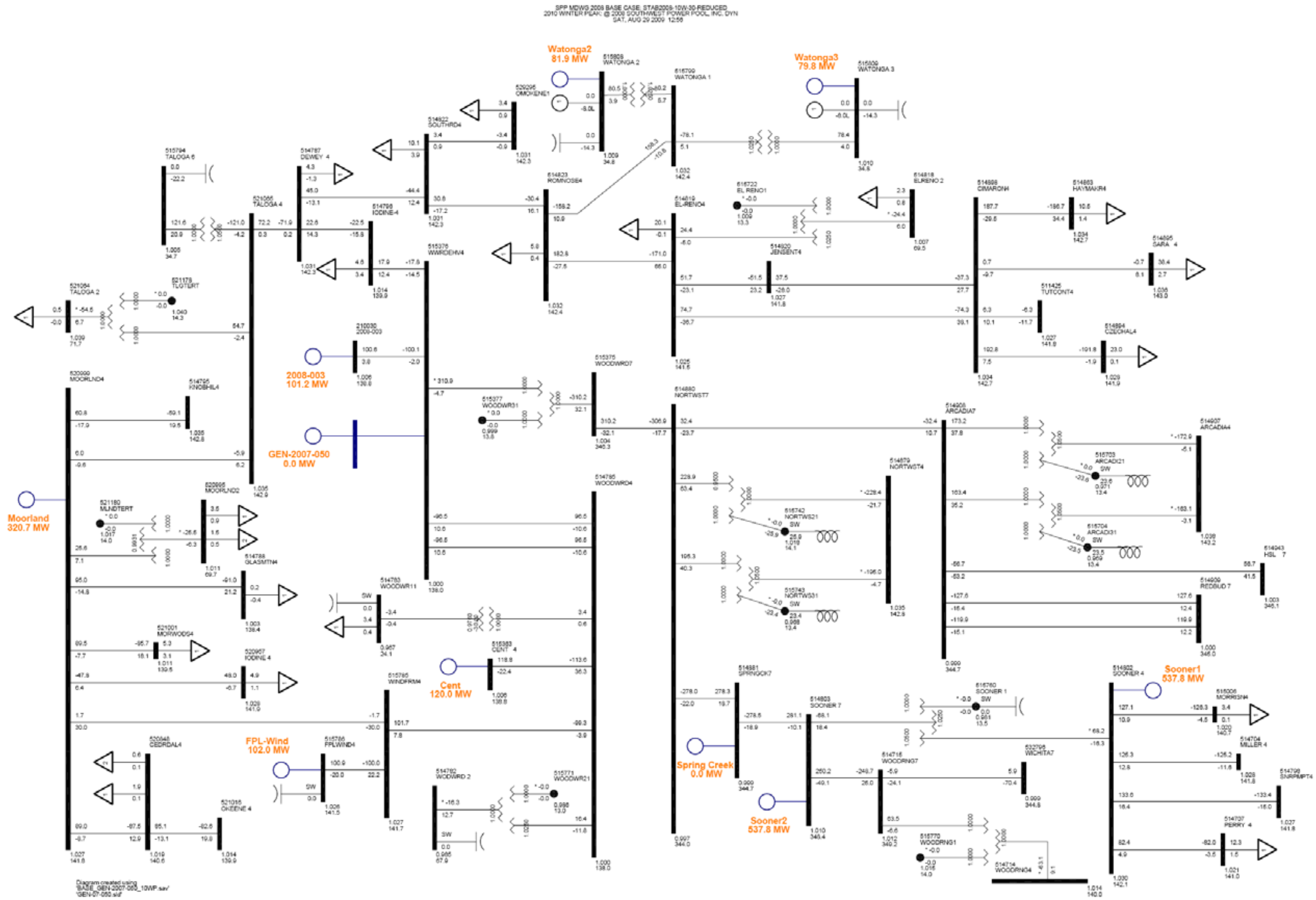

Figure 4-4 One-line Diagram of the local area <u>without</u> GEN-07-050 (2010 Winter Peak)

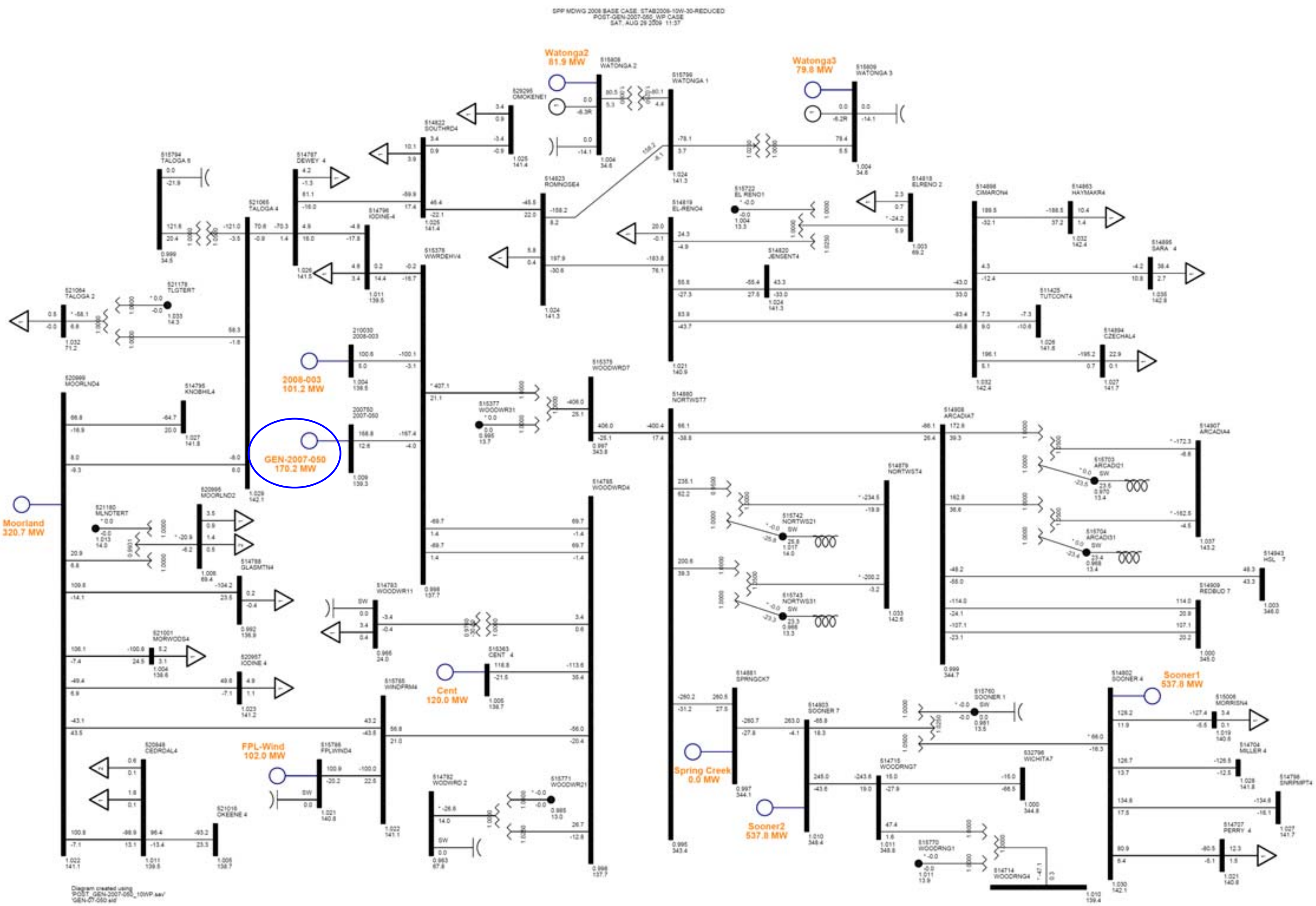

Figure 4-5 One-line Diagram of the local area with GEN-07-050 (2010 Winter Peak)

5 POWER FACTOR ANALYSIS RESULTS

Table 5-1 lists the contingencies simulated for Power Factor analysis.

Table 5-1: List of contingencies simulated for Power Factor Analysis

Contingency Name	Contingency Description
CONT_01	Woodward (515375) to Northwest (514880) 345kV line
CONT_02	Woodward 345kV (515375) to 138kV (515376) transformer
CONT_03	Wichita (532796) to Woodring (514715) 345kV line
CONT_04	Woodring (514715) to Sooner (514803) 345kV line
CONT_05	Cimarron (514901) to Draper (514934) 345kV line
CONT_06	Northwest (514880) to Arcadia (514908) 345kV line
CONT_07	Northwest (514880) to Spring Creek (514881) 345kV line
CONT_08	Northwest (514880) to Cimarron (514901) 345kV line
CONT_09	Northwest 345kV (514880) to 138kV (514879) transformer
CONT_10	Woodward EHV 138kV (515376) to 345kV (515375) transformer
CONT_11	Woodward EHV (515376) to Iodine (514796) 138kV line
CONT_12	FPLWind4 (515786) to Windfarm4 (515785) 138kV line
CONT_13	Windfarm4 (515785) to Woodward (514785) 138kV line
CONT_14	Mooreland (520999) to Glass Mountain (514788) 138kV line
CONT_15	Mooreland (520999) to Cedardale (520848) 138kV line
CONT_16	Mooreland (520999) to Morewood (521001) 138kV line
CONT_17	Mooreland (520999) to Taloga (521065) 138kV line
CONT_18	Taloga 138kV (521065) to 69kV (521064) transformer
CONT_19	Dewey (514787) to Taloga (521065) 138kV line
CONT_20	Dewey (514787) to Southard (514822) 138 kV line
CONT_21	El Reno (514819) to Roman Nose (514823) 138kV line

The proposed GEN-2007-050 windfarm (170.2 MW) will be comprised of Siemens 2.3 MW wind turbine generators. These wind turbine generators are doubly fed induction generators (DFIG) with a reactive power capability of +/- 0.90 p.f. The wind turbine generators were modeled in voltage control mode.

Next, as described in section 3.1, the VAR generator was modeled at POI. The VAR generator was set to hold the 138 kV POI voltage consistent with the pre-contingency voltage schedule. The reactive power capability of the wind farm was set to zero.

The contingencies from Table 5-1 were simulated on 2010 summer peak and 2010 winter peak system conditions. Per SPP's request power factor at the POI was calculated by considering a common interconnection for GEN-2007-050 and GEN-2008-003 project to determine the marginal power factor requirement for interconnections at the Woodward 138kV bus. Table 5-2 and Table 5-3 list the active power, reactive power and the power factor at the POI following the simulated contingencies for summer peak and winter peak conditions respectively.

Table 5-2 VAR generator output at the GEN-2007-050 POI (2010 summer peak)

Contingency	Real Power at POI 138 kV (MW)			Reactive Power at POI 138 kV (Mvar)				Effective Power factor at the POI
	From GEN-2007-050	From GEN-2008-003	Total MW	From GEN-2007-050	From GEN-2008-003	VAR Gen output	Total Mvar	
BASECASE	167.3	100.1	267.4	31.8	11.8	-28.3	15.3	0.99837
CONT_01	167.3	100.1	267.4	31.8	11.8	-21.1	22.5	0.99648
CONT_02	167.3	100.1	267.4	31.8	11.8	-17.9	25.7	0.99541
CONT_03	167.3	100.1	267.4	31.8	11.8	-29.5	14.1	0.99861
CONT_04	167.3	100.1	267.4	31.8	11.8	-29.8	13.8	0.99867
CONT_05	167.3	100.1	267.4	31.8	11.8	-29.2	14.4	0.99855
CONT_06	167.3	100.1	267.4	31.8	11.8	-27	16.6	0.99808
CONT_07	167.3	100.1	267.4	31.8	11.8	-54	-10.4	0.99924
CONT_08	167.3	100.1	267.4	31.8	11.8	-23.3	20.3	0.99713
CONT_09	167.3	100.1	267.4	31.8	11.8	-24.1	19.5	0.99735
CONT_10	167.3	100.1	267.4	31.8	11.8	-17.9	25.7	0.99541
CONT_11	167.3	100.1	267.4	31.8	11.8	-36.6	7	0.99966
CONT_12	167.3	100.1	267.4	31.8	11.8	-3.4	40.2	0.98889
CONT_13	167.3	100.1	267.4	31.8	11.8	-39.2	4.4	0.99986
CONT_14	167.3	100.1	267.4	31.8	11.8	-57.8	-14.2	0.99859
CONT_15	167.3	100.1	267.4	31.8	11.8	-53.5	-9.9	0.99932
CONT_16	167.3	100.1	267.4	31.8	11.8	-66.8	-23.2	0.99626
CONT_17	167.3	100.1	267.4	31.8	11.8	-28.7	14.9	0.99845
CONT_18	167.3	100.1	267.4	31.8	11.8	-33.5	10.1	0.99929
CONT_19	167.3	100.1	267.4	31.8	11.8	-41.8	1.8	0.99998
CONT_20	167.3	100.1	267.4	31.8	11.8	-48.7	-5.1	0.99982
CONT_21	167.3	100.1	267.4	31.8	11.8	-120.1	-76.5	0.96143

**The reactive power capability of the GEN-2007-050 wind farm was set to unity p.f at machine terminal (i.e Qmax=Qmin=Qgen= 0 Mvar).

Table 5-3 VAR generator output at the GEN-07-0250 POI (2010 winter peak)

Contingency	Real Power at POI 138 kV (MW)			Reactive Power at POI 138 kV (Mvar)				Effective Power factor
	From GEN-2007-050	From GEN-2008-003	Total MW	From GEN-2007-050	From GEN-2008-003	VAR Gen output	Total Mvar	
BASECASE	167.2	100.1	267.3	32.6	-3.1	-36.6	-7.1	0.99965
CONT_01	167.2	100.1	267.3	32.6	-3.1	-43.4	-13.9	0.99865
CONT_02	167.2	100.1	267.3	32.6	-3.1	-40.1	-10.6	0.99921
CONT_03	167.2	100.1	267.3	32.6	-3.1	-37.5	-8	0.99955
CONT_04	167.2	100.1	267.3	32.6	-3.1	-36.1	-6.6	0.99970
CONT_05	167.2	100.1	267.3	32.6	-3.1	-38.5	-9	0.99943
CONT_06	167.2	100.1	267.3	32.6	-3.1	-39.2	-9.7	0.99934

Contingency	Real Power at POI 138 kV (MW)			Reactive Power at POI 138 kV (Mvar)				Effective Power factor
	From GEN-2007-050	From GEN-2008-003	Total MW	From GEN-2007-050	From GEN-2008-003	VAR Gen output	Total Mvar	
CONT_07	167.2	100.1	267.3	32.6	-3.1	-49.1	-19.6	0.99732
CONT_08	167.2	100.1	267.3	32.6	-3.1	-35	-5.5	0.99979
CONT_09	167.2	100.1	267.3	32.6	-3.1	-31.9	-2.4	0.99996
CONT_10	167.2	100.1	267.3	32.6	-3.1	-40.1	-10.6	0.99921
CONT_11	167.2	100.1	267.3	32.6	-3.1	-49	-19.5	0.99735
CONT_12	167.2	100.1	267.3	32.6	-3.1	-2.5	27	0.99494
CONT_13	167.2	100.1	267.3	32.6	-3.1	-54.1	-24.6	0.99579
CONT_14	167.2	100.1	267.3	32.6	-3.1	-69.8	-40.3	0.98882
CONT_15	167.2	100.1	267.3	32.6	-3.1	-64.5	-35	0.99154
CONT_16	167.2	100.1	267.3	32.6	-3.1	-75.1	-45.6	0.98576
CONT_17	167.2	100.1	267.3	32.6	-3.1	-37.4	-7.9	0.99956
CONT_18	167.2	100.1	267.3	32.6	-3.1	-42.3	-12.8	0.99886
CONT_19	167.2	100.1	267.3	32.6	-3.1	-51.5	-22	0.99663
CONT_20	167.2	100.1	267.3	32.6	-3.1	-60.8	-31.3	0.99321
CONT_21	167.2	100.1	267.3	32.6	-3.1	-140.5	-111	**0.92354**

**The reactive power capability of the wind farm was set to unity p.f at machine terminal (i.e Qmax=Qmin=Qgen= 0 Mvar).

The results indicated that the *CONT_21*: loss of El Reno – Roman Nose 138 kV line will yield the maximum reactive power output from the VAR generator at POI following interconnection of GEN-2007-050 project.

In addition to the above analysis, the list of contingencies was repeated without the VAR generator at the POI. The voltage at the POI was monitored. The results of the contingency analysis are included in Appendix B. The *CONT_21*: Loss of El Reno – Roman Nose 138 kV line resulted in lowest voltage at POI in post-contingency conditions in both summer peak and winter peak system conditions.

The analysis shows that a 0.92 power factor is required to maintain the voltage at the POI. FERC Order #661A limits a wind farm's requirement to maintain power factor at the POI to +/- 0.95 power factor.

6 STABILITY ANALYSIS RESULTS

Stability simulations were performed to examine the transient behavior of the GEN-2007-050 project and impact of the proposed addition of generation on the SPP system. A number of three-phase and single phase faults with re-closing were simulated. The fault clearing times and re-closing times used for the simulations are given in Table 6-1.

Table 6-1: Fault Clearing Times

Faulted bus kV level	Normal Clearing	Time before reclosing
345	5 cycles	20 cycles
138	5 cycles	20 cycles

Table 6-2 lists all the faults simulated for transient stability analysis.

Twenty one (21) three phase and twenty one (21) single-line-to-ground faults with re-closing were simulated. For all cases analyzed, the initial disturbance was applied at t = 0.1 seconds. The breaker clearing was applied at the appropriate time following this fault inception.

Table 6-2 List of Simulated Faults for GEN-2007-050 SIS

Cont. No.	Description
1	3 phase fault on the Woodward (515375) to Northwest (514880) 345kV line, 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.
2	Single phase fault and sequence like previous
3	3 phase fault on the Woodward 345kV (515375) to 138kV (515376) transformer, near the 345 kV bus. a. Apply fault at the Woodward 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
4	Single phase fault and sequence like previous
5	3 phase fault on the Wichita (532796) to Woodring (514715) 345kV line, near Wichita. a. Apply fault at the Wichita 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	Single phase fault and sequence like previous
7	3 phase fault on the Woodring (514715) to Sooner (514803) 345kV line, 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.
8	Single phase fault and sequence like previous

Cont. No.	Description
9	3 phase fault on the Cimarron (514901) to Draper (514934) 345kV line, 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.
10	Single phase fault and sequence like previous
11	3 phase fault on the Northwest (514880) to Arcadia (514908) 345kV line, 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	Single phase fault and sequence like previous
13	3 phase fault on the Northwest (514880) to Spring Creek (514881) 345kV line, 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	Single phase fault and sequence like previous
15	3 phase fault on the Northwest (514880) to Cimarron (514901) 345kV line, 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.
16	Single phase fault and sequence like previous
17	3 phase fault on Northwest 345kV (514880) to 138kV (514879) transformer T2, near the 345 kV bus. a. Apply fault at the Northwest 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
18	Single phase fault and sequence like previous
19	3 phase fault on the Woodward EHV 138kV (515376) to 345kV (515375) transformer, near the 138kV bus. a. Apply fault at the Woodward 138kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
20	Single phase fault and sequence like previous
21	3 phase fault on the Woodward EHV (515376) to Iodine (514796) 138kV line, near Woodward EHV. a. Apply fault at the Woodward EHV 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.
22	Single phase fault and sequence like previous
23	3 phase fault on the FPLWind4 (515786) Windfarm4 (515785) 138kV line, near FPLWind4 a. Apply fault at the FPLWind4 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.
24	Single phase fault and sequence like previous

Cont. No.	Description
25	3 phase fault on the Windfarm4 (515785) to Woodward (514785) 138kV line, near Windfarm4. a. Apply fault at the Windfarm4 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.
26	Single phase fault and sequence like previous
27	3 phase fault on the Mooreland (520999) to Glass Mountain (514788) 138kV line, near Mooreland. a. Apply fault at the Mooreland 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.
28	Single phase fault and sequence like previous
29	3 phase fault on the Mooreland (520999) to Cedardale (520848) 138kV line, near Mooreland. a. Apply fault at the Mooreland 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.
30	Single phase fault and sequence like previous
31	3 phase fault on the Mooreland (520999) to Morewood (521001) 138kV line, near Mooreland. a. Apply fault at the Mooreland 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.
32	Single phase fault and sequence like previous
33	3 phase fault on the Mooreland (520999) to Taloga (521065) 138kV line, near Mooreland. a. Apply fault at the Mooreland 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	Single phase fault and sequence like previous
35	3 phase fault on the Taloga 138kV (521065) to 69kV (521064) transformer, near the 138kV bus. a. Apply fault at the Taloga 138kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
36	Single phase fault and sequence like previous
37	3 phase fault on the Dewey (514787) to Taloga (521065) 138kV line, near Dewey. a. Apply fault at the Dewey 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	Single phase fault and sequence like previous
39	3 phase fault on the Dewey (514787) to Southard (514822) 138kV line, near Dewey. a. Apply fault at the Dewey 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.

Cont. No.	Description
40	Single phase fault and sequence like previous
41	3 phase fault on El Reno (514819) to Roman Nose (514823) 138kV line, near El Reno. a. Apply fault at the El Reno 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	Single phase fault and sequence like previous

** Following loss of FPLWind4 – Windfarm4 138 kV line the FPL windfarm will be islanded. Hence, FPL wind farm was tripped following the fault.

Table 6-3 summarizes the stability analysis results for 2010 summer peak and 2010 winter peak system conditions.

The system was stable following all simulated 3-Phase and single-phase faults. Also, no undervoltage tripping of any other windfarms in the system was observed following the simulated faults. The stability plots for the transient stability analysis are included in Appendix C for reference.

Table 6-3 Results of stability analysis

FAULT	2010 Summer Peak			2010 Winter Peak		
	Pre-Project	Post-Project		Pre-Project	Post-Project	
		Stable?	Acceptable Voltages?		Stable?	Acceptable Voltages?
FLT_1_3PH	---	STABLE	YES	---	STABLE	YES
FLT_2_1PH	---	STABLE	YES	---	STABLE	YES
FLT_3_3PH	---	STABLE	YES	---	STABLE	YES
FLT_4_1PH	---	STABLE	YES	---	STABLE	YES
FLT_5_3PH	---	STABLE	YES	---	STABLE	YES
FLT_6_1PH	---	STABLE	YES	---	STABLE	YES
FLT_7_3PH	---	STABLE	YES	---	STABLE	YES
FLT_8_1PH	---	STABLE	YES	---	STABLE	YES
FLT_9_3PH	---	STABLE	YES	---	STABLE	YES
FLT_10_1PH	---	STABLE	YES	---	STABLE	YES
FLT_11_3PH	---	STABLE	YES	---	STABLE	YES
FLT_12_1PH	---	STABLE	YES	---	STABLE	YES
FLT_13_3PH	---	STABLE	YES	---	STABLE	YES
FLT_14_1PH	---	STABLE	YES	---	STABLE	YES
FLT_15_3PH	---	STABLE	YES	---	STABLE	YES
FLT_16_1PH	---	STABLE	YES	---	STABLE	YES
FLT_17_3PH	---	STABLE	YES	---	STABLE	YES
FLT_18_1PH	---	STABLE	YES	---	STABLE	YES
FLT_19_3PH	---	STABLE	YES	---	STABLE	YES

FAULT	2010 Summer Peak			2010 Winter Peak		
	Pre-Project	Post-Project		Pre-Project	Post-Project	
		Stable?	Acceptable Voltages?		Stable?	Acceptable Voltages?
FLT_20_1PH	---	STABLE	YES	---	STABLE	YES
FLT_21_3PH	---	STABLE	YES	---	STABLE	YES
FLT_22_1PH	---	STABLE	YES	---	STABLE	YES
FLT_23_3PH	---	STABLE	YES	---	STABLE	YES
FLT_24_1PH	---	STABLE	YES	---	STABLE	YES
FLT_25_3PH	---	STABLE	YES	---	STABLE	YES
FLT_26_1PH	---	STABLE	YES	---	STABLE	YES
FLT_27_3PH	---	STABLE	YES	---	STABLE	YES
FLT_28_1PH	---	STABLE	YES	---	STABLE	YES
FLT_29_3PH	---	STABLE	YES	---	STABLE	YES
FLT_30_1PH	---	STABLE	YES	---	STABLE	YES
FLT_31_3PH	---	STABLE	YES	---	STABLE	YES
FLT_32_1PH	---	STABLE	YES	---	STABLE	YES
FLT_33_3PH	---	STABLE	YES	---	STABLE	YES
FLT_34_1PH	---	STABLE	YES	---	STABLE	YES
FLT_35_3PH	---	STABLE	YES	---	STABLE	YES
FLT_36_1PH	---	STABLE	YES	---	STABLE	YES
FLT_37_3PH	---	STABLE	YES	---	STABLE	YES
FLT_38_1PH	---	STABLE	YES	---	STABLE	YES
FLT_39_3PH	---	STABLE	YES	---	STABLE	YES
FLT_40_1PH	---	STABLE	YES	---	STABLE	YES
FLT_41_3PH	---	STABLE	YES	---	STABLE	YES
FLT_42_1PH	---	STABLE	YES	---	STABLE	YES

6.1 FERC LVRT COMPLIANCE

As explained in section 2, the proposed project was modeled with the low voltage ride through capacity. To determine the compliance of the subject wind farm project total of three (3) faults were simulated. Faults were simulated at the POI of wind farm project and normally cleared by tripping one transmission element at a time. Table 6-4 lists the faults simulated for LVRT analysis.

Table 6-4: List of faults for FERC LVRT compliance

Fault Name	Description
FLT_19_3PH_LVRT	3 phase fault on the Woodward EHV 138kV (515376) to 345kV (515375) transformer, near the 138kV bus. a. Apply fault at the Woodward 138kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
FLT_21_3PH_LVRT	3 phase fault on the Woodward EHV (515376) to Iodine (514796) 138kV line, near Woodward EHV. a. Apply fault at the Woodward EHV 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT_WWRD1_3PH_LVRT	3 phase fault on the Woodward EHV (515376) to Woodward (514785) 138kV line, near Woodward EHV. a. Apply fault at the Woodward EHV 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

The results of the simulations indicated that the wind farm project GEN-2007-050 meet the FERC LVRT criteria for the interconnection of the windfarm generation (FERC Order 661 – A).

The results of the FERC LVRT compliance are included in Appendix D for reference.

7 CONCLUSIONS

The main objectives of this study were

1) To determine the need of reactive power compensation, if any, for the proposed wind farms
2) To determine the impact of proposed GEN-07-050 (170.2 MW) generation on system stability and the nearby transmission system and generating stations.
3) To validate the compliance with FERC LVRT requirement for the wind farm.

The study was performed on 2010 Summer Peak and winter peak cases, provided by SPP.

To achieve these objective the following analyses were performed on the 2010 Summer Peak and 2010 winter peak system conditions with GEN-2007-050 projects in-service

- o Power factor Analysis for the selected contingencies.
- o Transient Stability analysis under various local and regional contingencies.
- o LVRT performance under selected contingencies near POI.

Assumptions

1. The following prior queued projects were included in the powerflow cases provided by SPP.
   - GEN-2001-014 – 96 MW, Suzzlon turbines, Ft. Supply 138 kV (520920)
   - GEN-2001-037 – 103 MW, GE turbines, Woodward/Mooreland 138 kV (515785)
   - GEN-2002-005 – 120 MW, Acciona turbines, Elk City/ Morewood 138 kV (200)
   - GEN-2005-008 – 130 MW, GE turbines, Woodward 138 kV (514785)
   - GEN-2006-046 – 130 MW, Mitsubishi turbines, Taloga 138 kV (521065)
   - GEN-2007-006 – 160 MW, Suzzlon turbines, Watonga 138 kV (515799)
   - GEN-2008-003 – 101 MW, Siemens turbines, Woodward EHV 138 kV (515376)
2. The study assumes that the Woodward – Northwest 345 kV line in-service (scheduled completion March 2010).

Following is the summary of study findings:

Power factor analysis

SPP requires that the Customer's wind farm maintain +/- 0.95 power factor at the POI for any system condition. An analysis was conducted to determine whether the proposed GEN-2007-050 project has sufficient reactive power capability to meet the power factor criteria.

Stability Analysis

The stability analysis was performed to determine the impact, if any, of the proposed GEN-2007-050 project on the stability of the SPP system. The system was found to be STABLE following all 3-phase faults and single-line-to-ground (SLG) faults with line reclosing and delayed clearing.

FERC Order 661A Compliance

Selected faults were simulated at the Point of Interconnection (POI) of the proposed GEN-2007-050 wind farm to determine the compliance with FERC 661 – A post-transition period LVRT standard. The results indicated that the proposed project meets the FERC LVRT requirement for wind farms.

Based on the results of the analysis, it can be concluded that the proposed GEN-2007-050 doesn't adversely impact the stability of the transmission System in the local area

The results of this analysis are based on available data and assumptions made at the time of conducting this study. If any of the data and/or assumptions made in developing the study model change, the results provided in this report may not apply and additional analysis may be required.

APPENDIX A LOAD FLOW AND STABILITY DATA IN PSSE FORMAT FOR GEN-2007-050

Loadflow Data

```
1050,   'KENAN_WTE  ',    0.69, 2,    0.000,    0.000,  524,  1311, 1.00000,   0.0000,
1
2050,   'CO-1'       ,    34.5, 1,    0.000,    0.000,  524,  1311, 1.00000,   0.0000,
1
20050,  'TX-1'       ,    34.5, 1,    0.000,    0.000,  524,  1311, 1.00000,   0.0000,
1
200750, '2007-050'   ,   138.0, 1,    0.000,    0.000,  524,  1311, 1.00000,   0.0000,
1
20051,  'TX-IDLE'    ,    13.2, 1,    0.000,    0.000,  524,  1311, 1.00000,   0.0000,
1
0 / END OF BUS DATA, BEGIN LOAD DATA
0 / END OF LOAD DATA, BEGIN GENERATOR DATA
1050,'1 ',  170.200,   0.000,   82.000,  -82.000,1.03200,2050,  170.2000,   0.0000,
0.6415,   0.00000,   0.00000,1.00000,1,  100.0,  170.200,   0.000,   1,1.0000
0 / END OF GENERATOR DATA, BEGIN BRANCH DATA
2050    20050 '1 ' 0.005171 0.005321 0.049287    170   170  170 0 0 0 0 1 0.0 1 1.0000
200750 515376 '1 ' 0.004990 0.034380 0.011238    170   170  170 0 0 0 0 1 0.0 1 1.0000
0 / END OF BRANCH DATA, BEGIN TRANSFORMER DATA
1050,2050,     0,'1 ',1,2,1,   0.00000,   0.00000,2,'            ',1,   1,1.0000
   0.0000,   0.0575,   185.00
1.00000,   0.000,   0.000,  185.00,  185.00,  185.00, 0,      0, 1.0500, 0.9500, 1.0500,
0.9500, 3, 0, 0.00000, 0.00000
1.00000,   0.000
20050 200750 20051 '1 ' 1 2 1 0.0 0 1 '        ' 1 1 1.0
   0.0000 0.1100 180 0.0000 0.000 100 0.00000 0.0 100 1.0 0.0
1.00000 0.000 0.000 0.0000 0.000 0.0 0 0 1.025 0.75 1.025 0.75 2 0 0.0 0.0
1.00000 0.000 0.000 0.0000 0.000 0.0
1.00000 0.000 0.000 0.0000 0.000 0.0
0 / END OF TRANSFORMER DATA, BEGIN AREA DATA
0 / END OF AREA DATA, BEGIN TWO-TERMINAL DC DATA
0 / END OF TWO-TERMINAL DC DATA, BEGIN VSC DC LINE DATA
0 / END OF VSC DC LINE DATA, BEGIN SWITCHED SHUNT DATA
0 / END OF SWITCHED SHUNT DATA, BEGIN IMPEDANCE CORRECTION DATA
0 / END OF IMPEDANCE CORRECTION DATA, BEGIN MULTI-TERMINAL DC DATA
0 / END OF MULTI-TERMINAL DC DATA, BEGIN MULTI-SECTION LINE DATA
0 / END OF MULTI-SECTION LINE DATA, BEGIN ZONE DATA
0 / END OF ZONE DATA, BEGIN INTER-AREA TRANSFER DATA
0 / END OF INTER-AREA TRANSFER DATA, BEGIN OWNER DATA
0 / END OF OWNER DATA, BEGIN FACTS DEVICE DATA
0 / END OF FACTS DEVICE DATA
```

Dynamics Data

```
SPP MDWG 2008 BASE CASE: STAB2008-10S-30-REDUCED
 2010 SUMMER PEAK: @ 2008 SOUTHWEST POWER POOL, INC. DYN

 PLANT MODELS

 REPORT FOR ALL MODELS                  BUS 1050 [KENAN_WTE   0.6900] MODELS
 MODEL BUILD NUMBER =         1


  ** SMK203 **  BUS   MACH     C O N S     S T A T E S     V A R S     I C O N S
             1050   1    *****-*****   38900-38918   10708-10785   5793- 5803

    MBASE    RSOURCE     XSOURCE     |VTERM|       P_LF        Q_LF
  170.200    0.000000    0.641500    1.038698    1.000000    0.156212
```

APPENDIX B Results of Power Factor Analysis

APPENDIX B.1 GEN-2007-050 POI voltages without VAR generator

Contingency	Contingency Description	GEN-07-050 POI VOLTAGES (#515376)	
		Summer Peak	Winter Peak
CONT_01	Woodward (515375) to Northwest (514880) 345kV line	1.00924	0.9936
CONT_02	Woodward 345kV (515375) to 138kV (515376) transformer	1.01041	0.9958
CONT_03	Wichita (532796) to Woodring (514715) 345kV line	1.00566	0.9979
CONT_04	Woodring (514715) to Sooner (514803) 345kV line	1.00557	0.9982
CONT_05	Cimarron (514901) to Draper (514934) 345kV line	1.00571	0.9977
CONT_06	Northwest (514880) to Arcadia (514908) 345kV line	1.0062	0.9975
CONT_07	Northwest (514880) to Spring Creek (514881) 345kV line	1.00015	0.9952
CONT_08	Northwest (514880) to Cimarron (514901) 345kV line	1.00704	0.9984
CONT_09	Northwest 345kV (514880) to 138kV (514879) transformer	1.00685	0.9992
CONT_10	Woodward EHV 138kV (515376) to 345kV (515375) transformer	1.01041	0.9958
CONT_11	Woodward EHV (515376) to Iodine (514796) 138kV line	1.00397	0.9951
CONT_12	FPLWind4 (515786) to Windfarm4 (515785) 138kV line	1.0129	1.0059
CONT_13	Windfarm4 (515785) to Woodward (514785) 138kV line	1.00282	0.9930
CONT_14	Mooreland (520999) to Glass Mountain (514788) 138kV line	0.99926	0.9904
CONT_15	Mooreland (520999) to Cedardale (520848) 138kV line	1.00025	0.9917
CONT_16	Mooreland (520999) to Morewood (521001) 138kV line	0.99716	0.9891
CONT_17	Mooreland (520999) to Taloga (521065) 138kV line	1.00582	0.9979
CONT_18	Taloga 138kV (521065) to 69kV (521064) transformer	1.00476	0.9968
CONT_19	Dewey (514787) to Taloga (521065) 138kV line	1.00289	0.9947
CONT_20	Dewey (514787) to Southard (514822) 138 kV line	1.00119	0.9923
CONT_21	El Reno (514819) to Roman Nose (514823) 138kV line	**0.98482**	**0.9728**

APPENDIX B.2 Power factor at GEN-2007-050 POI with the VAR generator

Summer Peak

Contingency	Real Power at POI 138 kV (MW)			Reactive Power at POI 138 kV (Mvar)				Effective Power factor
	From GEN-2007-050	From GEN-2008-003	Total MW	From GEN-2007-050	From GEN-2008-003	VAR Gen output	Total Mvar	
BASECASE	167.3	100.1	267.4	31.8	11.8	-28.3	15.3	0.99837
CONT_01	167.3	100.1	267.4	31.8	11.8	-21.1	22.5	0.99648
CONT_02	167.3	100.1	267.4	31.8	11.8	-17.9	25.7	0.99541
CONT_03	167.3	100.1	267.4	31.8	11.8	-29.5	14.1	0.99861
CONT_04	167.3	100.1	267.4	31.8	11.8	-29.8	13.8	0.99867
CONT_05	167.3	100.1	267.4	31.8	11.8	-29.2	14.4	0.99855
CONT_06	167.3	100.1	267.4	31.8	11.8	-27	16.6	0.99808
CONT_07	167.3	100.1	267.4	31.8	11.8	-54	-10.4	0.99924
CONT_08	167.3	100.1	267.4	31.8	11.8	-23.3	20.3	0.99713
CONT_09	167.3	100.1	267.4	31.8	11.8	-24.1	19.5	0.99735
CONT_10	167.3	100.1	267.4	31.8	11.8	-17.9	25.7	0.99541
CONT_11	167.3	100.1	267.4	31.8	11.8	-36.6	7	0.99966
CONT_12	167.3	100.1	267.4	31.8	11.8	-3.4	40.2	0.98889
CONT_13	167.3	100.1	267.4	31.8	11.8	-39.2	4.4	0.99986
CONT_14	167.3	100.1	267.4	31.8	11.8	-57.8	-14.2	0.99859
CONT_15	167.3	100.1	267.4	31.8	11.8	-53.5	-9.9	0.99932
CONT_16	167.3	100.1	267.4	31.8	11.8	-66.8	-23.2	0.99626
CONT_17	167.3	100.1	267.4	31.8	11.8	-28.7	14.9	0.99845
CONT_18	167.3	100.1	267.4	31.8	11.8	-33.5	10.1	0.99929
CONT_19	167.3	100.1	267.4	31.8	11.8	-41.8	1.8	0.99998
CONT_20	167.3	100.1	267.4	31.8	11.8	-48.7	-5.1	0.99982
CONT_21	167.3	100.1	267.4	31.8	11.8	**-120.1**	-76.5	0.96143

Winter Peak

Contingency	Real Power at POI 138 kV (MW)			Reactive Power at POI 138 kV (Mvar)				Effective Power factor
	From GEN-2007-050	From GEN-2008-003	Total MW	From GEN-2007-050	From GEN-2008-003	VAR Gen output	Total Mvar	
BASECASE	167.2	100.1	267.3	32.6	-3.1	-36.6	-7.1	0.99965
CONT_01	167.2	100.1	267.3	32.6	-3.1	-43.4	-13.9	0.99865
CONT_02	167.2	100.1	267.3	32.6	-3.1	-40.1	-10.6	0.99921
CONT_03	167.2	100.1	267.3	32.6	-3.1	-37.5	-8	0.99955
CONT_04	167.2	100.1	267.3	32.6	-3.1	-36.1	-6.6	0.99970
CONT_05	167.2	100.1	267.3	32.6	-3.1	-38.5	-9	0.99943
CONT_06	167.2	100.1	267.3	32.6	-3.1	-39.2	-9.7	0.99934
CONT_07	167.2	100.1	267.3	32.6	-3.1	-49.1	-19.6	0.99732
CONT_08	167.2	100.1	267.3	32.6	-3.1	-35	-5.5	0.99979
CONT_09	167.2	100.1	267.3	32.6	-3.1	-31.9	-2.4	0.99996
CONT_10	167.2	100.1	267.3	32.6	-3.1	-40.1	-10.6	0.99921
CONT_11	167.2	100.1	267.3	32.6	-3.1	-49	-19.5	0.99735
CONT_12	167.2	100.1	267.3	32.6	-3.1	-2.5	27	0.99494
CONT_13	167.2	100.1	267.3	32.6	-3.1	-54.1	-24.6	0.99579
CONT_14	167.2	100.1	267.3	32.6	-3.1	-69.8	-40.3	0.98882
CONT_15	167.2	100.1	267.3	32.6	-3.1	-64.5	-35	0.99154
CONT_16	167.2	100.1	267.3	32.6	-3.1	-75.1	-45.6	0.98576
CONT_17	167.2	100.1	267.3	32.6	-3.1	-37.4	-7.9	0.99956
CONT_18	167.2	100.1	267.3	32.6	-3.1	-42.3	-12.8	0.99886
CONT_19	167.2	100.1	267.3	32.6	-3.1	-51.5	-22	0.99663
CONT_20	167.2	100.1	267.3	32.6	-3.1	-60.8	-31.3	0.99321
CONT_21	167.2	100.1	267.3	32.6	-3.1	**-140.5**	-111	0.92354

APPENDIX C PLOTS FOR STABILITY SIMULATIONS

APPENDIX D PLOTS FOR LVRT SIMULATIONS