SPP Southwest Power Pool

Facility Study for Generation Interconnection Request GEN–2006–043

SPP Tariff Studies
(#GEN-2006-043)

June 2008

Executive Summary

<OMITTED TEXT> (Customer) has requested a Facility Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnection of 300 MW of wind generation within the control area of American Electric Power West (AEPW) in Roger Mills County, Oklahoma. The Facility Study has been conducted by AEP and follows this summary.

In the original Impact Study posted in October 2007, the Customer was given the option of lowering the queue position to 126 MW or pursue the 300 MW queue position with the construction of a 345kV transmission line. The Customer opted to pursue the 126 MW option.

The Impact Study has been re-evaluated taking into account a voltage stability analysis to prevent voltage collapse in the event that the Customer generation and all previous queued generation goes into service without going through the transmission service queue.

The Impact Study re-evaluation has determined that the queue position will need to be further reduced to 99 MW. This will bring the total of the GEN-2006-043, GEN-2006-035, and GEN-2006-002 generation projects to 473 MW. Currently, GEN-2006-002 has a signed LGIA that is on suspension. GEN-2006-035 does not currently have a signed LGIA.

If the Customer wishes to interconnect more than 99 MW, a new 345kV line as described in the original Impact Study will need to be constructed and paid for by the Customer.

The Impact Study shows that the Customer will be required to provide 95% leading/lagging power factor at the point of interconnection. This will require additional capacitor devices as the GE turbines can only provide 95% power factor at the generator terminals.

The restudy of the Impact Study follows the Facility Study portion of this report.

Affected System Facilities

Southwestern Public Service (d/b/a Xcel Energy) (SPS) was asked to perform short circuit analysis on its transmission system to determine if any transmission facilities were affected by the addition of GEN-2006-043. No SPS facilities were deemed to be affected by the addition of GEN-2006-043.

Western Farmers Electric Cooperative (WFEC) was asked to perform short circuit analysis on its transmission system to determine if any transmission facilities were affected by the addition of GEN-2006-043. No WFEC facilities were deemed to be affected by the addition of GEN-2006-043.

Generation Interconnection Facilities Study

For

GEN-2006-043

American Electric Power

Southwest Transmission Planning

March 2008

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Introduction

The Southwest Power Pool (SPP) has requested a Facility Study for interconnecting a 99 MW wind farm power plant in Roger Mills County, Oklahoma. The proposed in-service date is December 2008.

The purpose of this study is to identify the facilities and their costs that are needed to interconnect the new generation with AEP's 230 kV transmission system. This facilities study is done in conjunction with SPP Feasibility and Impact Studies for Generation Interconnection Request GEN-2006-043

The interconnection point for the new generation will be a new 230 kV substation built on AEP's portion of the Elk City to Grapevine (SPS) 230 kV tie line. AEP will build a new 3 breaker ring bus 230 kV substation to accommodate the new interconnection. The new AEP station will include a Control House with available room for all metering, protection and SCADA systems needed for the interconnection. If this request and both GEN-2006-002 and GEN-2006-035 interconnect into the substation, a fourth and fifth ring bus terminal will be required. Currently, GEN-2006-002 has a signed LGIA that is on suspension.

A detailed description of all costs associated with the construction of this interconnection is shown in Tables 1 and 2.

Interconnection Facilities (See Figures 1 and 2)

The customer requested interconnection to a point on the Elk City – Grapevine 230 kV transmission line at a point in northwest Beckham County, Oklahoma. This point is also the point of interconnection for prior queued requests in the SPP queue. Requests GEN-2006-002 and GEN-2006-035 have also requested interconnection into a new substation in northwest Beckham County, Oklahoma on the Elk City – Grapevine 230 kV transmission line.

To meet the requirements for interconnection of the 99 MW wind farm, AEP will build a new 3 breaker ring bus 230 kV substation in the existing Elk City – Grapevine 230 kV transmission line, which is jointly owned by AEP and SPS. The new AEP station will include a Control House with available room for all metering, protection and SCADA systems needed for the interconnection. If this request and both GEN-2006-002 and GEN-2006-035 interconnect into the substation, a fourth and fifth ring bus terminal will be required.

230 kV Substation

A new 230 kV ring bus substation will be built on the Elk City to Grapevine (SPS) tie line for the generation interconnection. This substation will consist of three 230 kV circuit breakers and associated equipment. If this request and both GEN-2006-002 and GEN-2006-035 interconnect into the substation, a fourth and fifth ring bus terminal will be required. A 230 kV line will be required to connect the generators to the 230 kV bus. See Figure 1 for details.

The design and construction of the new substation will meet all AEP specifications for stations. Bus work and disconnect switches will be designed to accommodate the loading requirements, and circuit breakers will be rated to ensure adequate load and fault interrupting capability. Metering equipment will be installed to monitor the plant output and will meet the required accuracy specifications. The interconnect metering now located at Elk City will be moved to the new substation for the Grapevine line. AEP will own, operate and maintain the substation.

Short Circuit Fault Duty Evaluation

AEP conducted a short circuit fault duty evaluation for impacts that could be contributed to the new generator. Due to Southwestern Public Service Company (SPS) & Western Farmers Electric Cooperative (WFEC) having transmission facilities in close proximity to the new 230 kV substation, SPS and WFEC also conducted a short circuit fault duty evaluation for the request.

It is standard practice for AEP to recommend replacing a circuit breaker when the current through the breaker for a fault exceeds 100% of its interrupting rating with recloser de-rating applied, as determined by the ANSI/IEEE C37.5-1979, C37.010-1979 & C37.04-1979 breaker rating methods.

In the AEP system, no breakers were found to exceed their interrupting capability after the addition of the 99 MW of wind farm generation and related facilities.

SPS found no breakers that needed replacing, due to the new generation, on the SPS system.

WFEC found no breakers that needed replacing, due to the new generation, on the WFEC system.

Therefore there is no short circuit upgrade costs associated with the Gen-2006-043 interconnection.

Interconnection Costs

Listed below are the costs associated with interconnecting the 99 MW wind farm generation facility to the AEP transmission system.

Table 1: Required Interconnection Facilities
(Assuming prior queued project withdraws)

SYSTEM IMPROVEMENT	COST (2004 DOLLARS)
New 3 breaker 230 kV ring bus substation. Including all metering, protection, and SCADA	$5,148,000
Replace line panel and carrier equipment at Elk City 230 kV substation	$350,000
TRANSMISSION INTERCONNECTION FACILITY TOTAL COSTS	**$5,498,000**

Table 2: Required Interconnection Facilities
(Assuming prior queued projects stays in the queue)

SYSTEM IMPROVEMENT	COST (2004 DOLLARS)
Add 230 kV terminal to the ring bus station built for request GEN-2006-043	$1,203,000
TRANSMISSION INTERCONNECTION FACILITY TOTAL COSTS	**$1,203,000**

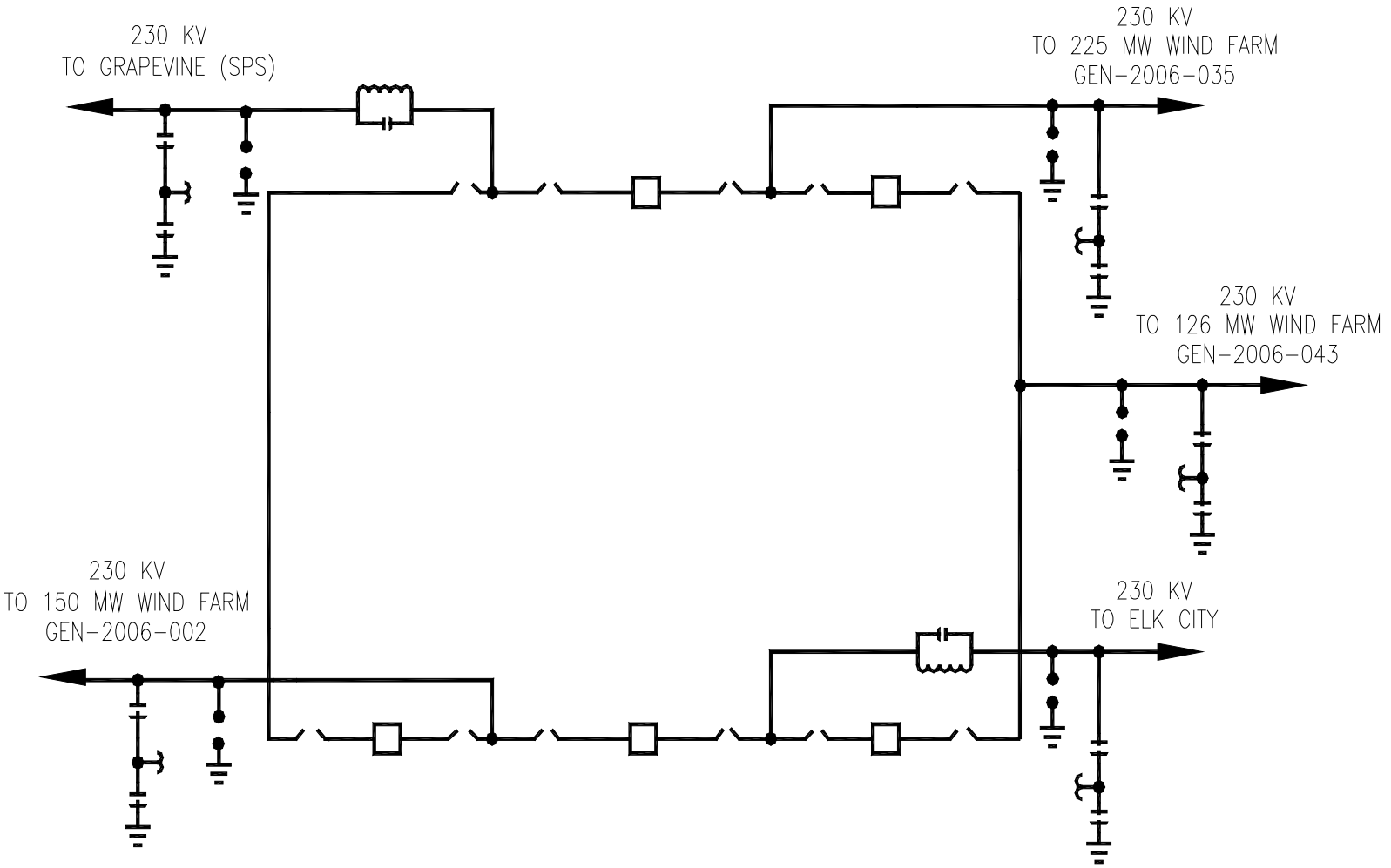

FIGURE 1
NEW 230 KV SUBSTATION FOR INTERCONNECTION

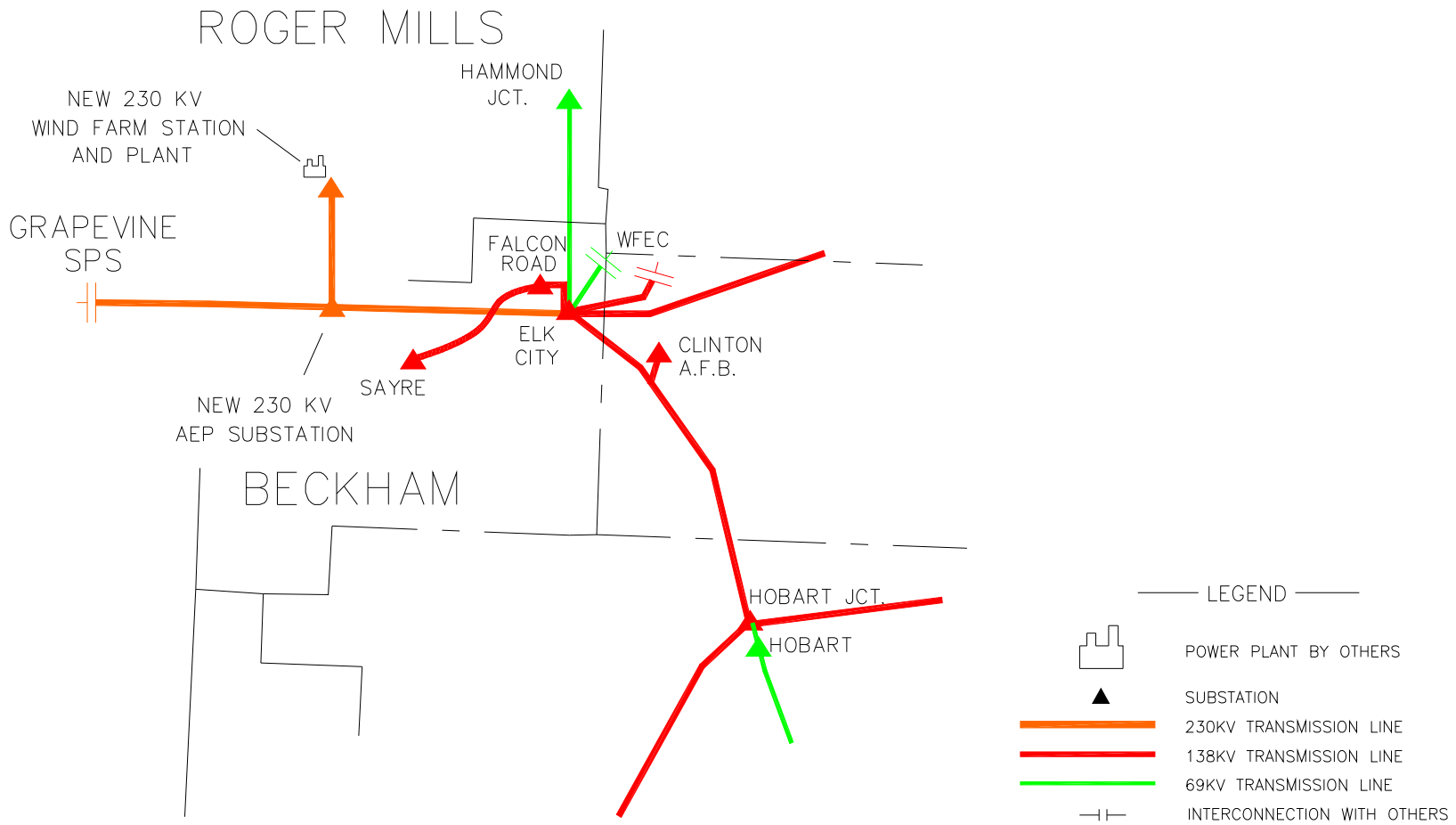

FIGURE 2 ELK CITY AREA TRANSMISSION MAP

ATTACHEMENT 1. IMPACT RESTUDY

Executive Summary

<OMITTED TEXT> (Customer) has requested an Impact Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnection of 300 MW of wind generation within the control area of American Electric Power West (AEPW) in Roger Mills County, Oklahoma. The Customer has proposed an in-service date in two phases - Phase I: August 1, 2008 and Phase II: December 1, 2008. This Impact study addresses the dynamic stability effects of interconnecting the plant to the rest of the AEPW transmission system as well as addressing the need for reactive compensation required by the wind farm because of the use of the GE turbines.

Two seasonal base cases were used in the study to analyze the stability impacts of the proposed generation facility. The cases studied were the 2008 winter peak and 2012 summer peak. Each case was modified to include prior queued projects that are listed in the body of the report. Seventeen contingencies were simulated in each case. The GE 1.5s wind turbines were modeled using information provided by the manufacturer.

Due to voltage stability concerns, the Customer will be required to lower the queue position of this interconnection request to 99MW. If the Customer wishes to interconnect more than 99MW, then additional transmission lines as described in the original Impact Study will need to be constructed.

Due to voltage stability concerns, the Customer will be required to maintain a power factor of +/- 95% leading/lagging at the point of interconnection. The GE turbines typically have a +/- 95% power factor capability at the generator turbine. Therefore, the Customer will be required to install additional capacitor banks within its substation in order to meet the power factor requirement at the point of interconnection. Otherwise, the Customer may choose to purchase the GE turbines with the manufacturer's optional +/- 90% power factor option.

Further Stability study results show that in order for the wind farm to meet FERC Order #661A's Low Voltage Ride Through (LVRT) provisions, the Customer shall purchase the GE turbines with the LVRT II low voltage ride through package available from the manufacturer.

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 300 MW of wind generation within the control area of AEPW in Roger Mills County, Oklahoma. The wind powered generation facility was studied with 200 individual General Electric (GE) 1.5 MW wind turbines. The requested in-service date for the 300 MW facility is August 1, 2008 for Phase I and December 1, 2008 for Phase II. This Impact study addresses the dynamic stability effects of interconnecting the plant to the rest of the AEPW transmission system as well as addressing the need for reactive compensation required by the wind farm because of the use of the GE turbines.

2.0 Purpose

The purpose of the Interconnection System Impact Study is to evaluate the impact of the proposed interconnection on the reliability of the Transmission System. The Impact Study considers the Base Case as well as all Generating Facilities (and with respect to (b) below, any identified Network Upgrades associated with such higher queued interconnection) that, on the date the Interconnection System Impact Study 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; or
d) have no Queue Position but have executed an LGIA or requested that an unexecuted LGIA be filed with FERC.

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

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

3.0 Facilities

3.1 Generating Facility

The Customer supplied drawings that showed the generating facility to be divided into two systems – a West Collector System and an East Collector System. The East Collector System consisted of 106 GE 1.5 MW Wind Turbine Generators (WTG) and the West Collector System consisted of 109 GE 1.5 MW WTG's. The total power if all generators were on line would be 322.5 MW. Since the queue position is only 300 MW, for this impact study the power output was limited to 300 MW by removing 15 wind turbines. Each collector system was limited to 150 MW of generation (100 wind turbines) (see Figure 1). The following wind turbines were not used in the study:

1. East Collector System – E066-E071 (6 wind turbines)
2. West Collector System – W004-W012 (9 wind turbines)

The generating facility was studied with the assumption that it would be using GE 1.5s Wind Turbine Generators. The nameplate rating of each turbine is 1.5 MW (1500 kW)

with a machine base of 1667 kVA. The turbine output voltage is 575 V. The GE turbines utilize a doubly fed induction-generator with a wound rotor and slip rings. The generator synchronous speed is 1200 rpm, and a variable frequency power converter tied to the generator rotor allows the generator to operate at speeds ranging from 800 rpm to 1600 rpm. Nominal speed at 1.5 MW power output is 1440 rpm and the maximum allowable non-operating rotational speed is 1680 rpm. The power converter allows the generator to produce power at a power factor of 0.9 lagging to 0.95 leading. The power factor is settable at each WTG or by the Plant SCADA system.

This study was performed using the latest GE Standard Voltage and Frequency Settings with Fault Ride Through modeling stability package available from PTI.

Each wind turbine will feed into a 0.575/34.5 kV GSU rated at 1750 kVA. Impedance for the GSU is 5.75%.

The impedance for each of the 34.5/230 kV transformers is 9.0% on a 100 MVA OA Base with a top rating of 167 MVA.

3.2 Interconnection Facilities

Please see the Facility Study for GEN-2006-043 posted in May 2008 for the Transmission Owner facilities.

4.0 Voltage Stability Analysis

The original Impact Study determined there were issues due to the addition of GEN-2006-043. The problems were encountered for an outage of both 230kV lines at the point of interconnection. These problems were due both to the size of the original request (300MW) bus also because of two prior queued projects at the same point of interconnection.

Considering the ability that generators now have to not obtain any sort of transmission service and generate directly into the system, and the large overloads that were being observed on the 230kV line. For this analysis the Customer's wind farm and previous wind farms were modeled with both the GEN-2006-035 and GEN-2006-043 wind farms capable of having +/- 95% power factor capability.

Using the P-V analysis tool available in PSS/E, it was found that the maximum transfer available from the point of interconnection without voltage collapse is approximately 128 MW for the outage of the wind farm – Elk City 230kV transmission line. Voltage collapse occurs at the Grapevine substation at 90% voltage.

In order to protect against voltage collapse with all previous queued projects in service, the maximum allowable interconnection without system improvements will be 99 MW. This amount allows for a margin of voltage reliability. It also should be noted that the Rate B of the Wind Farm – Grapevine line will be loaded up to 441MVA for this situation, which is approximately 113% of Rate B for the 795 MCM conductor for this line and 125% of Rate B for the limiting element, which is a line trap.

Any additional increase in the interconnection for this facility will require the addition of new transmission lines as described in the original Impact Study.

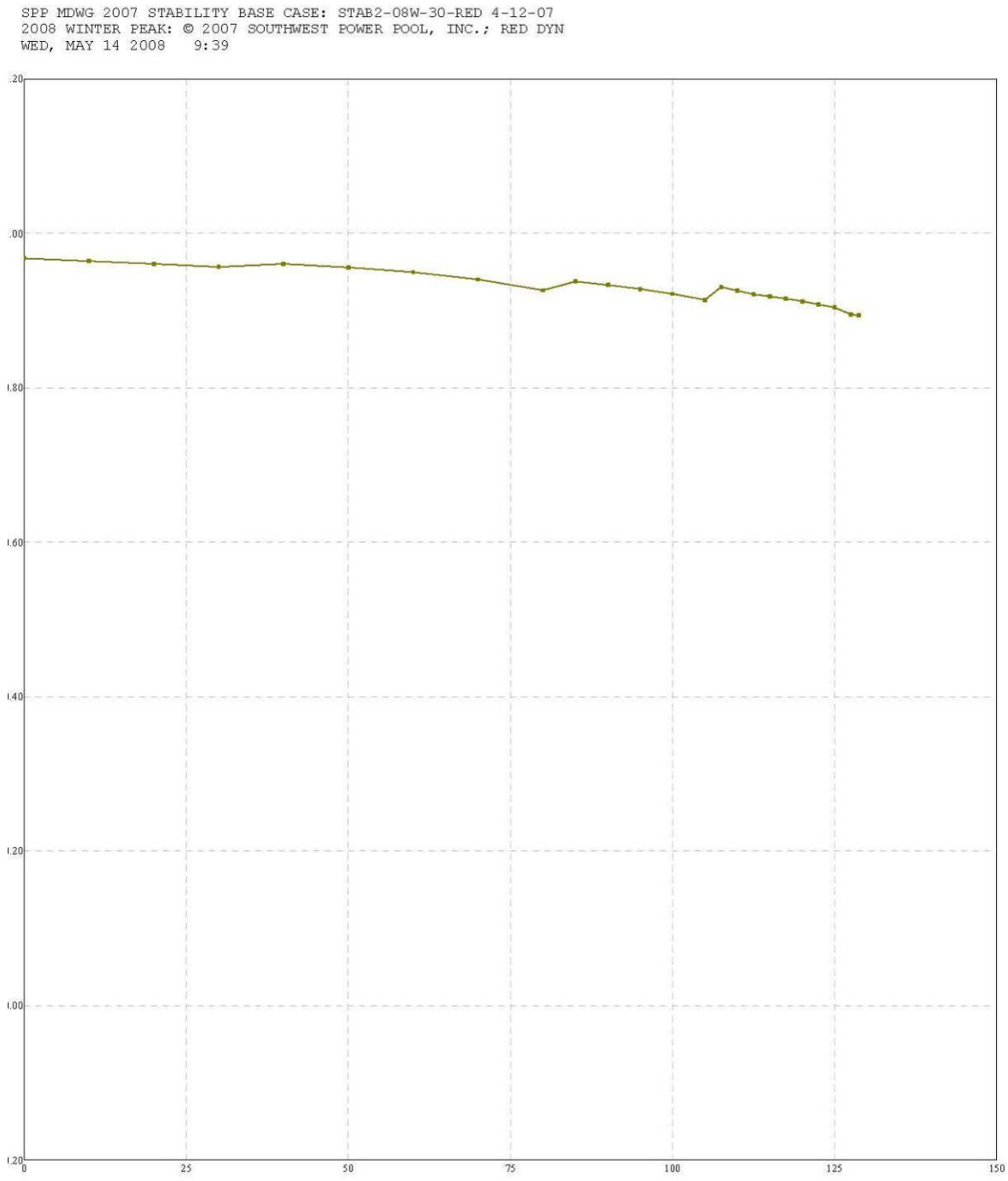

Figure 1. P-V Analysis for the outage of the Wind Farm – Stateline 230kV (Voltage at Grapevine)

5.0 Power Factor Requirements

The most critical outages for the GEN-2006-043 wind farm are determined to be the outages at the point of interconnection. To avoid voltage collapse at 99MW, the wind farm is required to supply 30 Mvar at the point of interconnection. This will require the addition of either capacitor banks or the GE turbines should be purchased with the optional +/- 90% power factor option. The table below shows the power factor requirements for the wind farm.

SEASON	CONTINGENCY	PF @POI	PF	MW @POI	Mvars @POI
12SP	NONE	0.986	Lag	98.4	16.2
12SP	Wind Farm – Elk City	0.943	Lag	98.2	34.6
12SP	Wind Farm - Stateline	0.943	Lag	98.3	34.9

Table. 1. Power Factor Requirements for GEN-2006-043

6.0 Stability Analysis

The Dynamic stability analysis was conducted using the parameters of the original Impact Study for interconnection of 99 MW. GEN-2006-002 and GEN-2006-035 were studied with Gamesa 2.0 MW wind turbines. All parameters and contingencies from the original Impact Study were used in the restudy of the stability analysis. The stability analysis showed that with GEN-2006-035 and GEN-2006-043 meeting the required +/- 95% power factor requirements, the wind farms will stay on line and the transmission system will remain stable.

In Figure 2 below, the outage of the wind farm to Elk City is taken without the addition of any capacitors. The result is that GEN-2006-043 stays on line, but GEN-2006-035 and GEN-2006-002 trip off line. This was not the case in the pre-project case, so the addition of GEN-2006-043 at 99MW is causing the problem.

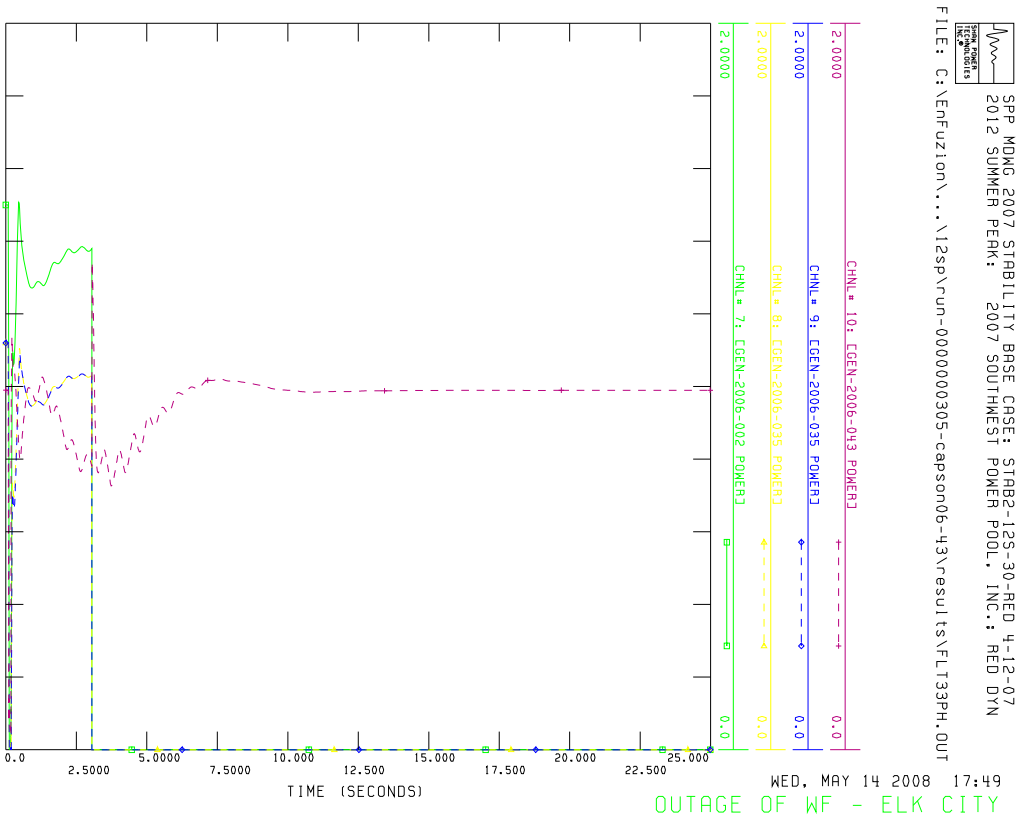

Figure 2. Outage of Wind Farm – Elk City 230kV
(no capacitors)

In Figure 3 below, the same outage is taken with the addition of a 20 Mvar capacitor at the 230kV bus of the Customer wind farm. The result is that all wind farms stay on line.

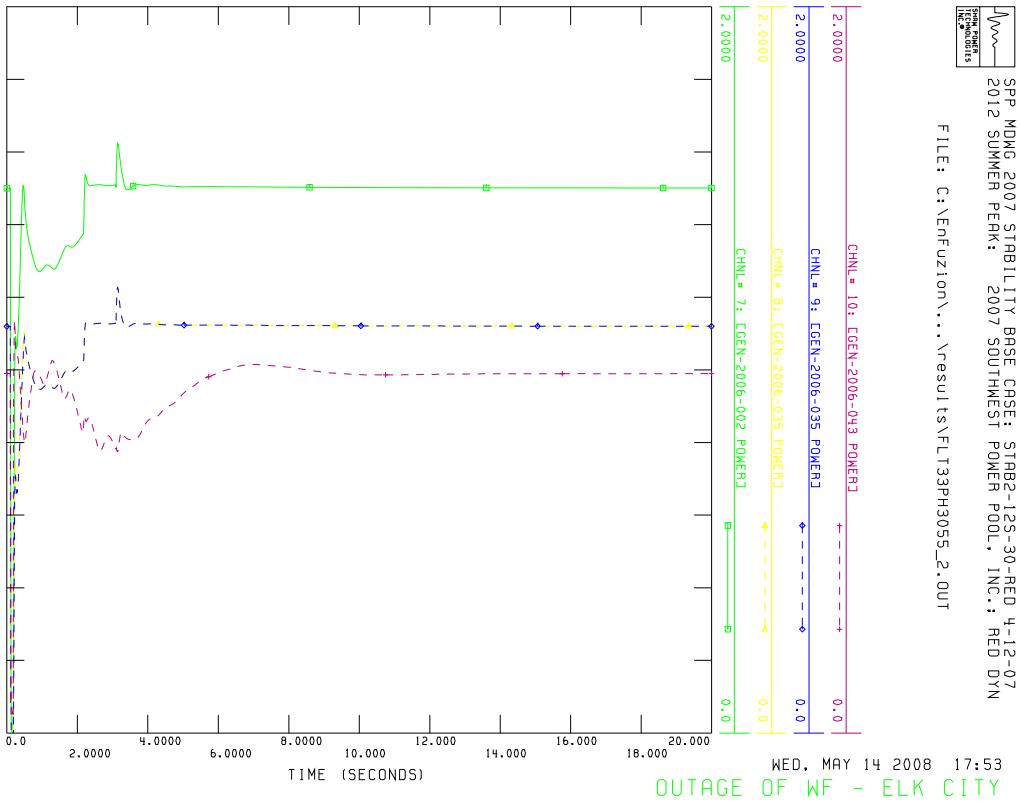

Figure 3. Outage of Wind Farm – Elk City 230kV (with additional capacitors)

The original Impact Study can be consulted for all details of the Stability analysis.

7.0 Conclusion

This study has indicated that the highest amount of generation that can be installed at the GEN-2006-043 site with previous queued projects in service is 99 MW. The Customer will be required to meet the +/- 95% power factor requirement at the point of interconnection.