Impact Study for Generation Interconnection Request

GEN-2006-049

February, 2012
Generation Interconnection

Southwest Power Pool

Executive Summary

The following Impact Study has been performed under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnection of 400 MW of wind generation within the balancing authority of Southwestern Public Service (SPS) in Stevens County, Oklahoma. This Impact Study was performed to determine the impacts of the withdrawal of higher queued interconnection customers to the interconnection of the generating facility to the transmission system.

A power flow analysis shows that the Customer's wind facility can interconnect 400 MW of generation with transmission upgrades. Upgrades required include the Hitchland – Moore County 230kV transmission line. Power flow analysis was based on both summer and winter peak conditions and light loading cases.

The wind generation facility was studied as a 399 MW generator with a total of two hundred sixty-six (266) 1.5MW GE turbine generators. This Impact study addresses the dynamic stability effects of interconnecting the plant to the rest of the SPS transmission system. Two seasonal base cases were used in the study to analyze the stability impacts of the proposed generation facility. Each case was modified to include prior queued projects that are listed in the body of the report. Eighteen (18) contingencies were identified for use in this study. The GE 1.5 MW wind turbines were modeled using information provided by the Customer. The results of a stability analysis determined that for the addition of the GEN-2006-049 interconnection request, it will be necessary to add a second 345kV circuit from Finney to Holcomb. After adding the new line, the transmission system was found to remain stable for both summer and winter peak conditions. With only one circuit from Finney to Holcomb, potential instability was observed during the fault applied at Finney opening the line to Holcomb subsequently.

The cost to interconnect the GEN-2006-049 interconnection request is estimated at $22,490,606.

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.

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Introduction

The following Impact Study has been performed under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnection of 400 MW of wind generation within the balancing authority of Southwestern Public Service (SPS) in Stevens County, Texas. This Impact Study was performed to determine the impacts of the withdrawal of higher queued interconnection customers to the interconnection of the generating facility to the transmission system

The wind generation facility was studied as a 399 MW request with a total of with two hundred sixty-six (266) GE 1.5 MW wind turbine generators. Two seasonal base cases were used in the study to analyze the stability impacts of the proposed generation facility. The cases studied were modified versions of the 2012 summer peak and 2012 winter peak to reflect the system conditions at the requested in-service date. Each case was modified to include prior queued projects that are listed in the body of the report. Eighteen (18) contingencies were identified for this study.

Purpose

The purpose of this Impact Study is to evaluate the impact of the proposed interconnection on the reliability of the Transmission System for the withdrawal of higher queued request GEN-2005-017. 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 original 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 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.

Facilities

Generating Facility

The project was modeled with the existing plant as an equivalent wind turbine generator of 400 MW output. The wind turbine is connected to one equivalent 0.69/34.5KV generator step unit (GSU). The high side of the GSU is connected to one 34.5/345kV substation transformer. A 345kV transmission line connects the Customer's substation transformer to the POI.

Interconnection Facility

The Point of Interconnection will be at a new 345kV switching station to be located in Stevens County, Kansas. Figure 1 shows a one-line illustration of the facility and the POI. Figure 2 shows a one-line bus interconnection of the Point of Interconnection.

Costs to interconnect are listed in Table 1.

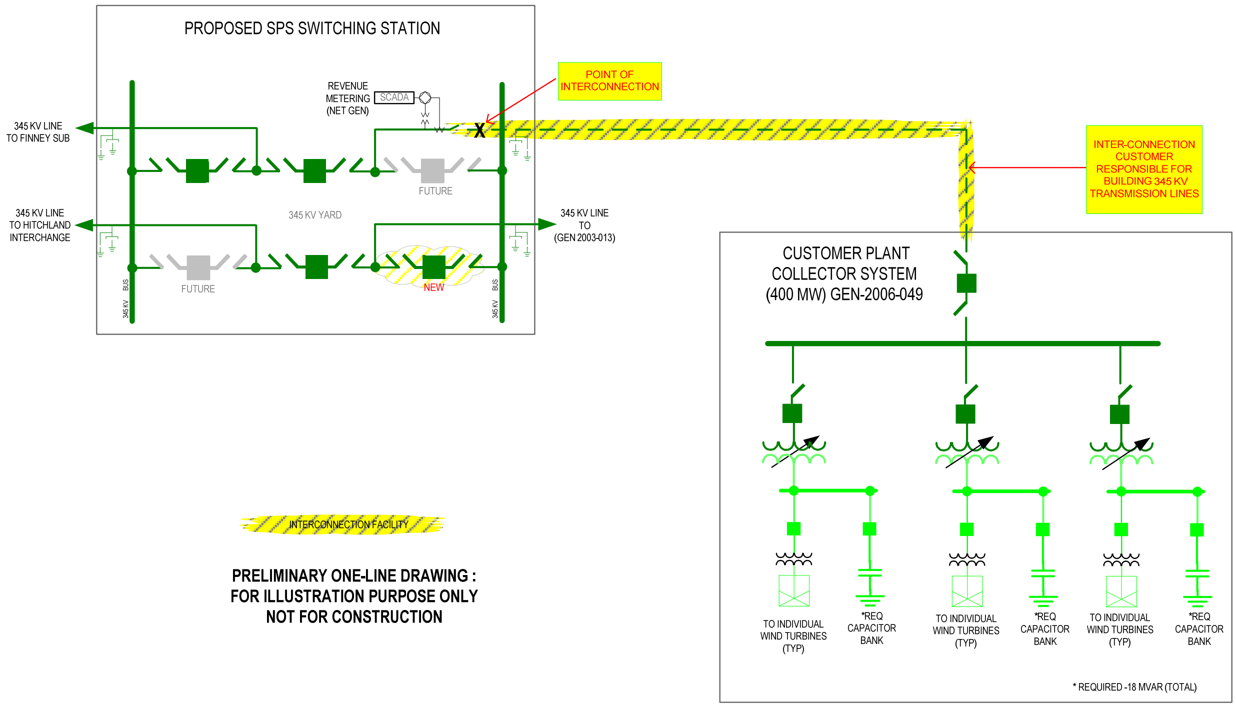

Figure 1: *GEN-2006-049*
Facility and Proposed Interconnection Configuration

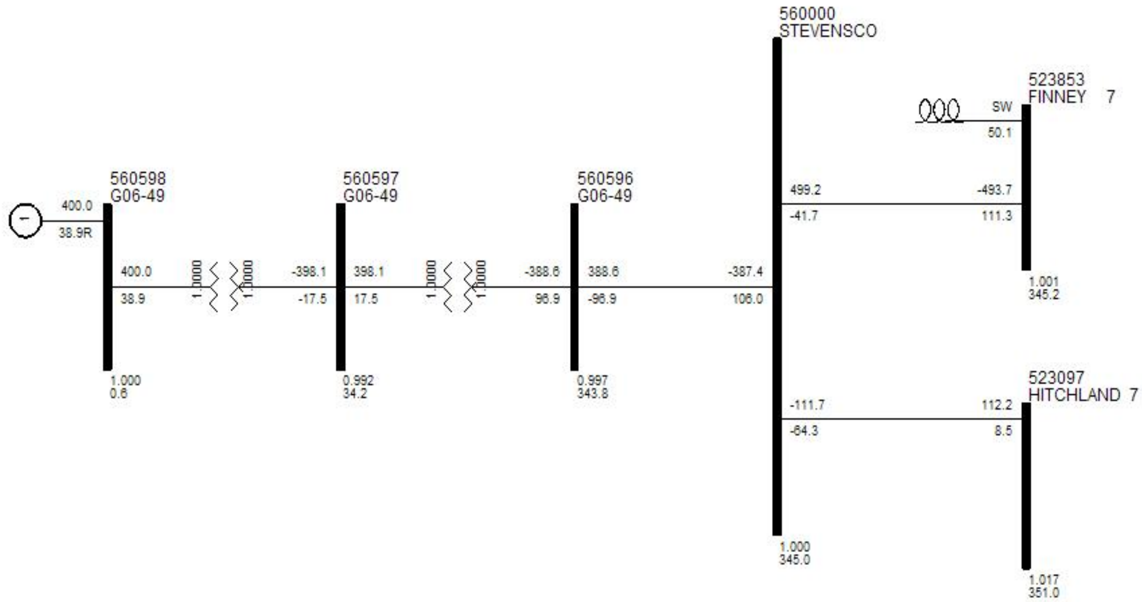

Figure 2: *GEN-2006-049 Bus Interconnection*

Table 1. Updated GEN-2006-049 Interconnection Costs

Facility	**Estimated Cost**
Stevens County 345kV Interchange Substation – Construct three breaker 345kV ring bus substation. Includes relay changeouts at Hitchland and Finney	$9,083,161
Finney Substation – Changeout 345kV line reactor on the Hitchland 345kV terminal from a 50Mvar to a 30Mvar.	$2,900,000
Finney Substation – Add 345kV line terminal for transmission line to Holcomb	$3,628,035
Finney – Holcomb 345kV transmission line – Construct approximately 1 mile of transmission	$1,879,410
Holcomb Substation (SUNC) – Add 345kV line terminal for transmission line to Finney. Includes two 345kV breakers and additional rung for ring bus.	$5,000,000
Total Estimated Facilities	**$22,490,606**

Power flow Analysis

A power flow analysis was conducted for the Interconnection Customer's facility using a modified version of the 2012 spring, 2012 summer and winter, and 2017 summer and winter seasonal models. The output of the Interconnection Customer's facility was offset in the model by a reduction in output of existing online SPP generation. This method allows the request to be studied as an Energy Resource (ERIS) Interconnection Request. This analysis was conducted assuming that previous queued requests listed in Table 3 were in-service.

The Southwest Power Pool (SPP) Criteria states that:

> "The transmission system of the SPP region shall be planned and constructed so that the contingencies as set forth in the Criteria will meet the applicable NERC Reliability Standards for transmission planning. All MDWG power flow models shall be tested to verify compliance with the System Performance Standards from NERC Table 1 – Category A."

The ACCC function of PSS/E was used to simulate single contingencies in portions of or all of the control area of SPP and other control areas within SPP and the resulting data analyzed. This satisfies the "more probable" contingency testing criteria mandated by NERC and the SPP criteria.

The ACCC analysis indicates that the Customer's project can interconnect 400 MW of generation with transmission upgrades. The results listed can be mitigated by the completion of the Hitchland-Moore County 230kV transmission line due to be completed in 2012.

***Table 1**: ACCC Analysis for GEN-2006-049*

SEASON	SOURCE	DIRECTION	MONTCOMMONNAME	RATEA	RATEB	TDF	TC%LOADING	CONTNAME
12G	G06_049	FROM->TO	HITCHLAND INTERCHANGE (H TP80148301) 230/115/13.2KV TRANSFORMER CKT 1	250	250	0.24853	105.4233	Hitchland Interchange - POTTER COUNTY INTERCHANGE 345KV CKT 1
12G	G06_049	FROM->TO	HITCHLAND INTERCHANGE (H TP80148301) 230/115/13.2KV TRANSFORMER CKT 1	250	250	0.24853	103.5089	Hitchland Interchange - POTTER COUNTY INTERCHANGE 345KV CKT 1
12G	G06_049	FROM->TO	HITCHLAND INTERCHANGE (H TP80148301) 230/115/13.2KV TRANSFORMER CKT 1	250	250	0.24853	105.4555	POTTER COUNTY INTERCHANGE (WAUK 90343-A) 345/230/13.2KV TRANSFORMER CKT 1
12G	G06_049	FROM->TO	HITCHLAND INTERCHANGE (H TP80148301) 230/115/13.2KV TRANSFORMER CKT 1	250	250	0.24853	103.5176	POTTER COUNTY INTERCHANGE (WAUK 90343-A) 345/230/13.2KV TRANSFORMER CKT 1

Stability Analysis

Executive Summary

A transient stability study has been performed by Southwest Power Pool (SPP) to evaluate the interconnection requests in the Southwestern Public Service Company (SPS) area, to re-evaluate the dynamic stability of the system due to withdrawn of the prior queued request GEN-2005-017.

The GEN-2006-049 restudy has five (5) prior queued interconnection requests in the SPS area. The interconnection requests include GEN-2002-008, GEN-2002-009, GEN-2003-020, GEN-2006-020 and GEN-2006-044. The interconnection requests in the SPS area total 1268.3 MW.

The results of a stability analysis determined that for the addition of the GEN-2006-049 interconnection request, it will be necessary to add a second circuit from Finney to Holcomb 345kV. After adding the new line, the transmission system was found to remain stable for both summer and winter peak conditions. With only one circuit from Finney to Holcomb, potential instability was observed during the fault applied at Finney opening the line to Holcomb subsequently. With network upgrades in service, the GEN-2006-049 project was found to stay connected during the contingencies that were studied, meeting the Low Voltage Ride Through (LVRT) requirements of FERC Order #661A.

Should any previously queued projects that were included in this study withdraw from the queue, then this System Impact Study may have to be revised to determine the impacts of this Interconnection Customer's project on transmission facilities.

Introduction

A transient stability study has been performed by Southwest Power Pool (SPP) to evaluate the interconnection requests in the Southwestern Public Service Company (SPS) area, to re-evaluate the dynamic stability of the system due to withdrawn of the prior queued request GEN-2005-017 (339 MW).

The GEN-2006-049 restudy has five (5) prior queued interconnection requests in the SPS area. The interconnection requests include GEN-2002-008, GEN-2002-009, GEN-2003-020, GEN-2006-020 and GEN-2006-044. The interconnection requests in the SPS area total 1268.3 MW.

Two seasonal base cases were used in the study to analyze the stability impacts of the proposed generation facility. A 2011 summer peak case and a 2011 winter peak case which were both modified to include the prior queued projects shown in Table 3.

Purpose

The purpose of this Impact Study is to re-evaluate the impact of the proposed interconnection on the reliability of the Transmission System. Table 3 below lists the requests that were analyzed in this study.

***Table 3**: GEN-2006-049 Impact Study Request Table*

Request	MW
GEN-2002-008	240
GEN-2002-009	79.8
GEN-2003-020	159
GEN-2006-020	20
GEN-2006-044	370.5

Should any previously queued projects that were included in this study withdraw, then this GEN-2006-049 Impact Study may require a re-study of this request at the expense of the customer.

Facilities

Generating Facility

Table 4 lists the point of interconnection and machines used in this impact study to simulate the contingencies.

***Table 4**: Point of Interconnection and machine type*

Request	Turbine	Point of Interconnection
GEN-2002-008	GE 1.5	Hitchland 345 kV (523097)
GEN-2002-009	Suzlon 2.1	Hansford 115 kV (523195)
GEN-2003-020	GE 1.5/ GE 1.6	Martin 115 kV (523928)
GEN-2006-020	Dewind 2.0	DWS Frisco 115 kV (523160)
GEN-2006-044	Dewind 2.0	Hitchland 345kV (523097)
GEN-2006-049	GE 1.5	Stevens 345kV (560029)

Stability Study Criteria

Contingencies Simulated

Eighteen (18) contingencies were considered for the transient stability simulations. The faults that were defined and simulated are listed in Table 5. These contingencies included three phase faults and single phase line faults at locations defined by SPP. Single-phase line faults were simulated by applying fault impedance to the positive sequence network at the fault location to represent the effect of the negative and zero sequence networks on the positive sequence network. The fault impedance was computed to give a positive sequence voltage at the specified fault location of approximately 60% of pre-fault voltage. This method is in agreement with SPP current practice.

***Table 5**: Contingencies Evaluated*

Cont. No.	Cont. Name	Description
1	FLT1_3PH	3 phase fault on the Stevens (560029) to Hitchland (523097) 345kV line, near Stevens. a. Apply fault at the Stevens 345 kV 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	FLT2_1PH	*Single phase fault and sequence like previous*
3	FLT3_3PH	3 phase fault on the Hitchland (523097) to Potter (523961) 345kV line, near Hitchland. a. Apply fault at the Hitchland 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
4	FLT4_1PH	*Single phase fault and sequence like previous*
5	FLT5_3PH	3 phase fault on the Hitchland 230/345 kV autotransformer near 230kV bus. a. Apply fault at the Hitchland 230kV bus (523095). b. Clear fault after 5 cycles by tripping the faulted transformer.
6	FLT6_3PH	3 phase fault on the Hitchland 230/345 kV autotransformer near 345kV bus. a. Apply fault at the Hitchland 345kV bus (523097). b. Clear fault after 5 cycles by tripping the faulted transformer.
7	FLT7_3PH	3 phase fault on the Potter 230/345 kV autotransformer near 345kV bus. a. Apply fault at the Potter 345kV bus (523961). b. Clear fault after 5 cycles by tripping the faulted transformer.
8	FLT8_3PH	3 phase fault on the Finney (523853) to Holcomb (531449) 345kV line, near Finney. a. Apply fault at the Finney 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
9	FLT9_1PH	*Single phase fault and sequence like previous*
10	FLT10_3PH	3 phase fault on the Spearville 230/345 kV autotransformer near 345kV bus. a. Apply fault at the Spearville 345kV bus (531469). b. Clear fault after 5 cycles by tripping the faulted transformer.
11	FLT11_3PH	3 phase fault on the Holcomb (531449) to Spearville (531469) 345kV line, near Holcomb. a. Apply fault at the Holcomb 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
12	FLT12_1PH	*Single phase fault and sequence like previous*
13	FLT13_3PH	3 phase fault on the Holcomb (531449) to Setab (531465) 345kV line, near Holcomb. a. Apply fault at the Holcomb 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
14	FLT14_1PH	*Single phase fault and sequence like previous*

Cont. No.	Cont. Name	Description
15	FLT15-3PH	3 phase fault on the Hitchland (523097) to Stevens (560029) 345kV line, near Hitchland. a. Apply fault at the Stevens 345 kV 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 Stevens (560029) to Finney (523853) 345kV line, near Stevens. a. Apply fault at the Stevens 345 kV 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*

Further Model Preparation

The base cases contain prior queued projects as shown in Table 3. All prior queued projects are dispatched at 100% nameplate.

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

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

Results

Results of the stability analysis are summarized in Table 6. The results indicate that the transmission system is stable for all contingencies tested summer and winter cases.

***Table 6**: Results of Simulated Contingencies*

Cont. No.	Cont. Name	Description	Summer	Winter
1	FLT1_3PH	3 phase fault on the Stevens (560029) to Hitchland (523097) 345kV line, near Stevens. a. Apply fault at the Stevens 345 kV 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.	Stable	Stable
2	FLT2_1PH	*Single phase fault and sequence like previous*	Stable	Stable

Cont. No.	Cont. Name	Description	Summer	Winter
3	FLT3_3PH	3 phase fault on the Hitchland (523097) to Potter (523961) 345kV line, near Hitchland. a. Apply fault at the Hitchland 345 kV 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.	Stable	Stable
4	FL4_1PH	*Single phase fault and sequence like previous*	Stable	Stable
5	FLT5_3PH	3 phase fault on the Hitchland 230/345 kV autotransformer near 230kV bus. a. Apply fault at the Hitchland 230kV bus (523095). b. Clear fault after 5 cycles by tripping the faulted transformer.	Stable	Stable
6	FLT6_3PH	3 phase fault on the Hitchland 230/345 kV autotransformer near 345kV bus. a. Apply fault at the Hitchland 345kV bus (523097). b. Clear fault after 5 cycles by tripping the faulted transformer.	Stable	Stable
7	FL7_3PH	3 phase fault on the Potter 230/345 kV autotransformer near 345kV bus. a. Apply fault at the Potter 345kV bus (523961). b. Clear fault after 5 cycles by tripping the faulted transformer.	Stable	Stable
8	FLT8_3PH	3 phase fault on the Finney (523853) to Holcomb (531449) 345kV line, near Finney. a. Apply fault at the Finney 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	Unstable	Unstable
8	FLT8_3PH (Add 2nd Finney-Holcomb 345kV)	3 phase fault on the Finney (523853) to Holcomb (531449) 345kV line, near Finney. a. Apply fault at the Finney 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	Stable	Stable
9	FLT9_1PH	*Single phase fault and sequence like previous*	Stable	Stable
10	FLT10_3PH	3 phase fault on the Spearville 230/345 kV autotransformer near 345kV bus. a. Apply fault at the Spearville 345kV bus (531469). b. Clear fault after 5 cycles by tripping the faulted transformer.	Stable	Stable
11	FLT11_3PH	3 phase fault on the Holcomb (531449) to Spearville (531469) 345kV line, near Holcomb. a. Apply fault at the Holcomb 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	Stable	Stable
12	FLT12_1PH	*Single phase fault and sequence like previous*	Stable	Stable
13	FLT13_3PH	3 phase fault on the Holcomb (531449) to Setab (531465) 345kV line, near Holcomb. a. Apply fault at the Holcomb 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	Stable	Stable
14	FLT14_1PH	*Single phase fault and sequence like previous*	Stable	Stable
15	FLT15_3PH	3 phase fault on the Hitchland (523097) to Stevens (560029) 345kV line, near Hitchland. a. Apply fault at the HItchland 345 kV 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.	Stable	Stable
16	FLT16_1PH	*Single phase fault and sequence like previous*	Stable	Stable
17	FLT17_3PH	3 phase fault on the Stevens (560029) to Finney (523853) 345kV line, near Stevens. a. Apply fault at the Stevens 345 kV 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.	Stable	Stable

Cont. No.	Cont. Name	Description	Summer	Winter
18	FLT18_1PH	*Single phase fault and sequence like previous*	Stable	Stable

FERC LVRT Compliance

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 that draw the voltage down at the POI to 0.0 pu.

Conclusion

A Impact Study has been performed by Southwest Power Pool (SPP) to evaluate the interconnection requests in the Southwestern Public Service Company (SPS) area, to re-evaluate the dynamic stability of the system due to withdrawn of the prior queued request GEN-2005-017 (339 MW).

The GEN-2006-049 restudy has five (5) prior queued interconnection requests in the SPS area. The interconnection requests include GEN-2002-008, GEN-2002-009, GEN-2003-020, GEN-2006-020 and GEN-2006-044. The interconnection requests in the SPS area total 1268.3 MW.

The results of a stability analysis determined that for the addition of the GEN-2006-049 interconnection request, it will be necessary to add a second circuit from Finney to Holcomb 345kV. After adding the new line, the transmission system was found to remain stable for both summer and winter peak conditions. With only one circuit from Finney to Holcomb, potential instability was observed during the fault applied at Finney opening the line to Holcomb subsequently. With network upgrades in service, the GEN-2006-049 project was found to stay connected during the contingencies that were studied, meeting the Low Voltage Ride Through (LVRT) requirements of FERC Order #661A.

The cost to interconnect the GEN-2006-049 interconnection request is estimated at $22,490,606.

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.

All plots are available on request.