Southwest Power Pool

Impact Study For Generation Interconnection Request GEN-2006-018

SPP Tariff Studies

(#GEN-2006-018)

March 2010

Executive Summary

<OMITTED TEXT> (Customer) has requested an Impact Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnection of approximately 170 MW of natural gas powered synchronous generation within the control area of Xcel Energy (SPS) in Hale County, Texas. The facility will consist of eighteen (18) separate machines. The interconnection request was previously studied with one (1) 170 MW combustion turbine.

The following study was conducted by Excel Engineering. The stability study shows that the interconnection of the proposed project does not have any adverse impact on the system stability in the SPP area.

The interconnection customer must complete a restudy of the harmonics interaction study that was conducted for the Facility Study before the interconnection agreement can be amended to reflect this change in technology.

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.

SPP GEN-2006-018 Impact Study

Draft Report for

Southwest Power Pool

Prepared by:
Excel Engineering, Inc.

March 5, 2010

Principal Contributors:

Shu Liu, P.E.
William Quaintance, P.E.

TABLE OF CONTENTS

List of Figures

List of Tables

0. Certification

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the Laws of the State of **Arkansas**.

William Quaintance
Arkansas Registration Number 13865

1. Background and Scope

The GEN-2006-018 Impact Study is a generation interconnection study performed by Excel Engineering, Inc. for its non-affiliated client, Southwest Power Pool (SPP). Its purpose is to study the impacts of interconnecting the project shown in Table 1-1. The in-service date assumed for the generation addition was 2010.

Table 1-1. Interconnection Requests Evaluated

Request	Size (MW)	Generator Design	Point of Interconnection
GEN-2006-018	168.1	18 Natural Gas Generators	Tuco 230kV (525830)

All prior-queued requests located in control area 526 were included in this study.

This study is primarily a stability analysis for the proposed interconnection request. Contingencies that resulted in a prior-queued generation tripping off-line, if any, were re-run with the prior-queued project's voltage and frequency tripping disabled. Since the interconnection request in this group was not a wind project, a power factor analysis was NOT performed.

ATC (Available Transfer Capability) studies were not performed as part of this study. These studies will be required at the time transmission service is actually requested. Additional transmission upgrades may be required based on that analysis.

Study assumptions in general have been based on Excel's knowledge of the electric power system and on the specific information and data provided by SPP. The accuracy of the conclusions contained within this study is sensitive to the assumptions made with respect to other generation additions and transmission improvements being contemplated by other entities. Changes in the assumptions of the timing of other generation additions or transmission improvements will affect this study's conclusions.

2. Executive Summary

The GEN-2006-018 Impact Study evaluated the impacts of interconnecting project GEN-2006-018 to the SPP electric system.

No stability problems were found during summer or winter peak conditions due to the addition of these generators. A number of faults were tested with the Tuco SVC out of service, and no problems were found.

The standard power factor requirement for the synchronous generators of GEN-2006-018 is 0.95 leading to 0.95 lagging at the POI.

With the assumptions described in this report, GEN-2006-018 should be able to connect without causing any stability problems on the SPP transmission grid.

3. Study Development and Assumptions

3.1 Simulation Tools

The Siemens Power Technologies, Inc. PSS/E power system simulation program Version 30.3.3 was used in this study.

3.2 Models Used

SPP provided its latest stability database cases for both summer and winter peak seasons. The study plant's PSS/E model was developed in this study and was included in the power flow case and the dynamics database. The project was dispatched against SPP generation. Power flow and dynamic model data for the study plants are provided in Appendix D.

A power flow one-line diagram of the study project in summer peak conditions is shown in Figure 3-1. As the figure shows, the plant model includes three two-winding transformers that connect the units to the 230 kV system. Each transformer has six generators connected to the secondary winding. A zero impedance 230 kV line connects the plant substation to the Tuco 230 kV bus.

Figure 3-2 shows the location of the study project on the transmission system. The green ellipse indicates the study project point of interconnection (POI). The green X's indicate the fault locations examined in this study. Red transmission lines are nominally 345 kV and blue lines are 230 kV.

No special modeling is required of line relays in these cases, except for the special modeling related to the wind-turbine tripping.

3.3 Monitored Facilities

All generators in Areas 526 were monitored.

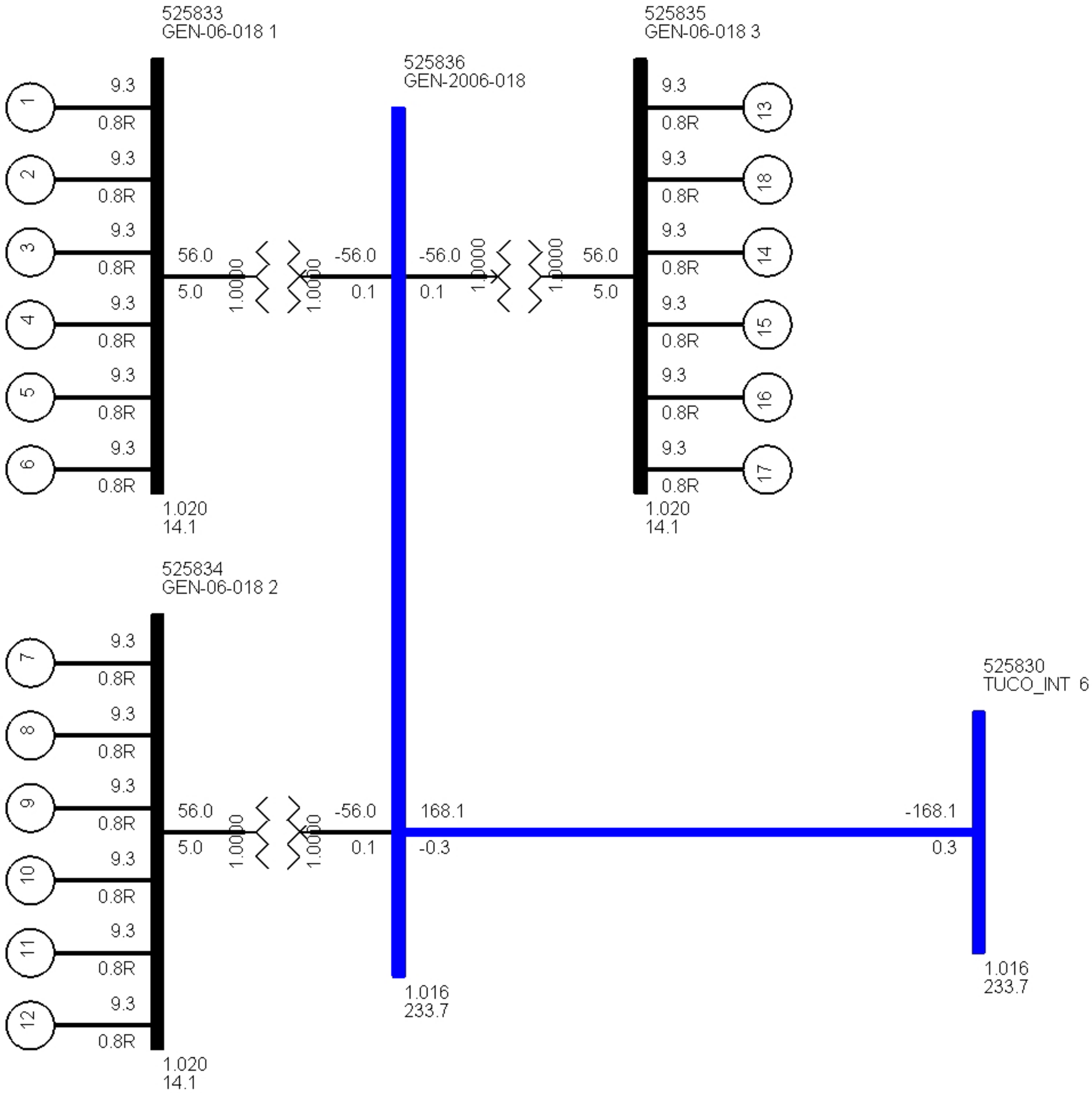

Figure 3-1. Power Flow One-line for GEN-2006-018 and adjacent equipment (SP)

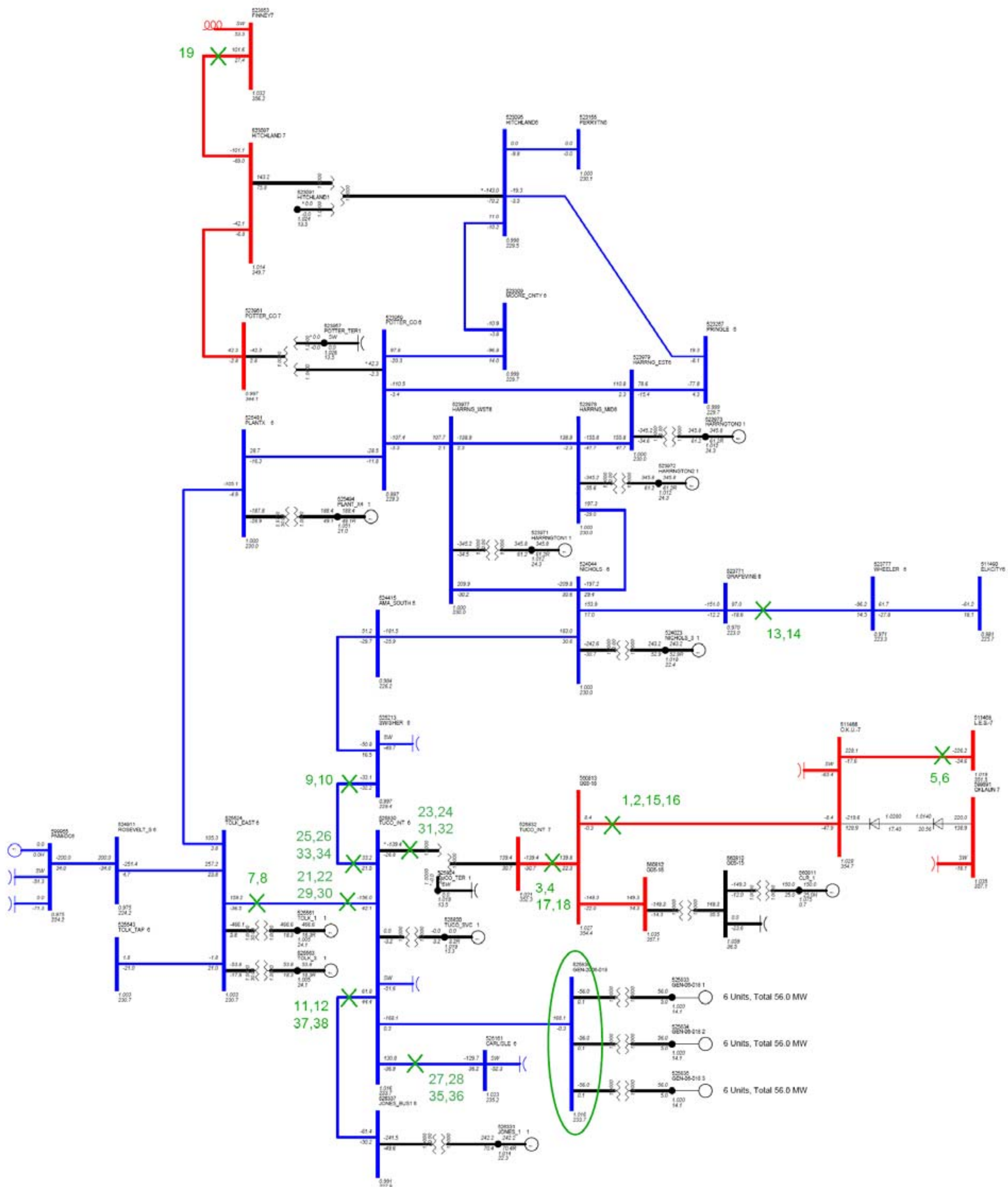

Figure 3-2. Transmission System near GEN-2006-018 (SP)

3.4 Performance Criteria

GEN-2006-018 does not include wind turbines, so the low voltage ride through standard of FERC Order 661A does not apply. GEN-2006-018 use synchronous generators, which typically do not have the under-voltage tripping issues that wind turbines do. Remaining on-line and stable following transmission network faults is required of all generation.

Contingencies that resulted in a prior-queued project tripping off-line, if any, were re-run with the prior-queued project's voltage and frequency tripping disabled to check for stability issues.

3.5 Performance Evaluation Methods

Since the interconnection request is not a wind project, a power factor analysis was NOT performed.

Stability analysis was performed for the proposed interconnection request. Faults were simulated on transmission lines at the POIs and on other nearby transmission equipment. The faults in Table 3-1 were run for each case (three phase and single phase as noted).

Table 3-1. Fault Definitions for GEN-2006-018

Cont. No.	Contingency Name	Description
1	FLT13PH	Three phase fault on the Oklaunion to the GEN-2005-015 Wind Farm Switching Station 345kV line, near the Wind Farm. a. Apply fault at the Wind Farm Switching Station 345kV bus. b. Clear Fault after 4 cycles by removing the 345kV line from the Wind Farm to Oklaunion and removing the line reactor from service. c. Wait 30 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 4 cycles, then trip the line in (b) and remove fault.
2	FLT21PH	*Single phase fault and sequence like Cont. No. 1*
3	FLT33PH	Three phase fault on the Wind Farm Switching Station to Tuco 345 kV line, near Tuco. a. Apply fault at the Tuco 345kV bus. b. Clear fault after 5 cycles by removing the 345kV line from Tuco to the Wind Farm Switching Station and the Tuco 345/230kV autotransformer. c. Wait 30 cycles, and then re-close the line and autotransformer in (b) into the fault. d. Leave fault on for 5 cycles, then trip the line and autotransformer in (b) and remove fault.
4	FLT41PH	*Single phase fault and sequence like Cont. No. 3*

Cont. No.	Contingency Name	Description
5	FLT53PH	Three phase fault on the Oklaunion to Lawton Eastside 345V line, near Lawton East Side. a. Apply Fault at the Lawton East Side bus. b. Trip the line after 2.5 cycles by removing the line from Oklaunion to Lawton ES and the Oklaunion HVDC tie, and remove the fault. c. Wait 30 cycles, and then re-close the line in (b) into the fault. d. Leave fault on for 2.5 cycles, then trip the line in (b) and remove fault.
6	FLT61PH	*Single phase fault and sequence like Cont. No. 5*
7	FLT73PH	Three phase fault on the Tuco to Tolk 230kV line near Tolk. a. Apply fault at the Tolk 230 kV bus. b. Clear fault after 5 cycles by tripping the 230kV line from Tolk to Tuco. (No reclose).
8	FLT81PH	*Single phase fault and sequence like Cont. No. 7*
9	FLT93PH	Three phase fault on the Tuco to Swisher 230kV line, near Swisher. a. Apply fault at the Swisher 230kV bus. b. Clear fault after 5 cycles by tripping the 230kV line from Swisher to Tuco. 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	FLT101PH	*Single phase fault and sequence like Cont. No. 9*
11	FLT113PH	Three phase fault on the Tuco to Jones 230kV line near Tuco. a. Apply fault at the Tuco 230kV bus. b. Clear fault after 5 cycles by tripping the 230kV line from Tuco to Jones (no reclose)
12	FLT121PH	*Single phase fault and sequence like Cont. No. 11*
13	FLT133PH	Three phase fault on the Grapevine to Elk City 230kV line near Grapevine. a. Apply fault at the Grapevine 230kV bus. b. Clear fault after 5 cycles by tripping the 230kV line from Grapevine to Elk City. c. Wait 20 cycles, and then re-close line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
14	FLT141PH	*Single phase fault and sequence like Cont. No. 13*
15	FLT153PH	With the Tuco SVC out of service, repeat Contingency #1
16	FLT161PH	*Single phase fault and sequence like Cont. No. 15*
17	FLT173PH	With the Tuco SVC out of service, repeat Contingency #3
18	FLT181PH	*Single phase fault and sequence like Cont. No. 17*
19	FLT193PH	Three phase fault on the Finney to Hitchland 345kV line near Finney a. Apply fault at the Finney 345kV bus. b. Clear fault after 3.5 cycles by removing the line from GEN-2003-013 Wind Farm to Finney (no reclose).
21	FLT213PH	Three phase fault on the Tuco to Tolk 230kV line near Tuco. a. Apply fault at the Tuco 230 kV bus. b. Clear fault after 5 cycles by tripping the 230kV line from Tuco to Tolk. (No reclose).
22	FLT221PH	*Single phase fault and sequence like Cont. No. 21*

Cont. No.	Contingency Name	Description
23	FLT233PH	Three phase fault on the Tuco 345/230 kV transformer, near Tuco 230 kV. a. Apply fault at the Tuco 230kV bus. b. Clear fault after 5 cycles by removing the Tuco 345/230kV autotransformer.
24	FLT241PH	*Single phase fault and sequence like Cont. No. 23*
25	FLT253PH	Three phase fault on the Tuco to Swisher 230kV line, near Tuco. a. Apply fault at the Tuco 230kV bus. b. Clear fault after 5 cycles by tripping the 230kV line from Tuco to Swisher. 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	FLT261PH	*Single phase fault and sequence like Cont. No. 25*
27	FLT273PH	Three phase fault on the Tuco to CarlIsle 230kV line, near Tuco. a. Apply fault at the Tuco 230kV bus. b. Clear fault after 5 cycles by tripping the 230kV line from Tuco to CarlIsle. 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	FLT281PH	*Single phase fault and sequence like Cont. No. 27*
29	FLT293PH	With the Tuco SVC out of service, repeat Contingency #21
30	FLT301PH	*Single phase fault and sequence like Cont. No. 29*
31	FLT313PH	With the Tuco SVC out of service, repeat Contingency #23
32	FLT321PH	*Single phase fault and sequence like Cont. No. 31*
33	FLT333PH	With the Tuco SVC out of service, repeat Contingency #25
34	FLT341PH	*Single phase fault and sequence like Cont. No. 33*
35	FLT353PH	With the Tuco SVC out of service, repeat Contingency #27
36	FLT361PH	*Single phase fault and sequence like Cont. No. 35*
37	FLT373PH	With the Tuco SVC out of service, repeat Contingency #11
38	FLT381PH	*Single phase fault and sequence like Cont. No. 37*

4. Results and Observations

4.1 Stability Analysis Results

All faults were run for both summer and winter peak conditions. If a previously-queued generator tripped for any of these faults, the voltage and frequency tripping was disabled, and the fault was re-run to check for system stability. No tripping occurred in this study.

Table 4-1 summarizes the overall results for all faults run. Figure 4-1 and Figure 4-2 show representative summer peak season plots for faults at the POI of the study project. Complete sets of plots for both summer and winter peak seasons for each fault are included in Appendices A and B.

The system remains stable for all simulated faults. The study project stays on-line and stable for all simulated faults.

Table 4-1. Summary of Stability Results

Cont. No.	Contingency Name	Description	Summer Peak Results	Winter Peak Results
1	FLT13PH	Three phase fault on the Oklaunion to the GEN-2005-015 Wind Farm Switching Station 345kV line, near the Wind Farm.	OK	OK
2	FLT21PH	*Single phase fault and sequence like Cont. No. 1*	OK	OK
3	FLT33PH	Three phase fault on the Wind Farm Switching Station to Tuco 345 kV line, near Tuco.	OK	OK
4	FLT41PH	*Single phase fault and sequence like Cont. No. 3*	OK	OK
5	FLT53PH	Three phase fault on the Oklaunion to Lawton Eastside 345V line, near Lawton East Side.	OK	OK
6	FLT61PH	*Single phase fault and sequence like Cont. No. 5*	OK	OK
7	FLT73PH	Three phase fault on the Tuco to Tolk 230kV line near Tolk.	OK	OK
8	FLT81PH	*Single phase fault and sequence like Cont. No. 7*	OK	OK
9	FLT93PH	Three phase fault on the Tuco to Swisher 230kV line, near Swisher.	OK	OK
10	FLT101PH	*Single phase fault and sequence like Cont. No. 9*	OK	OK
11	FLT113PH	Three phase fault on the Tuco to Jones 230kV line near Tuco.	OK	OK
12	FLT121PH	*Single phase fault and sequence like Cont. No. 11*	OK	OK
13	FLT133PH	Three phase fault on the Grapevine to Elk City 230kV line near Grapevine.	OK	OK
14	FLT141PH	*Single phase fault and sequence like Cont. No. 13*	OK	OK
15	FLT153PH	With the Tuco SVC out of service, repeat Contingency #1	OK	OK
16	FLT161PH	*Single phase fault and sequence like Cont. No. 15*	OK	OK
17	FLT173PH	With the Tuco SVC out of service, repeat Contingency #3	OK	OK
18	FLT181PH	*Single phase fault and sequence like Cont. No. 17*	OK	OK

Cont. No.	Contingency Name	Description	Summer Peak Results	Winter Peak Results
19	FLT193PH	Three phase fault on the Finney to Hitchland 345kV line near Finney	OK	OK
21	FLT213PH	Three phase fault on the Tuco to Tolk 230kV line near Tuco.	OK	OK
22	FLT221PH	*Single phase fault and sequence like Cont. No. 21*	OK	OK
23	FLT233PH	Three phase fault on the Tuco 345/230 kV transformer, near Tuco 230 kV.	OK	OK
24	FLT241PH	*Single phase fault and sequence like Cont. No. 23*	OK	OK
25	FLT253PH	Three phase fault on the Tuco to Swisher 230kV line, near Tuco.	OK	OK
26	FLT261PH	*Single phase fault and sequence like Cont. No. 25*	OK	OK
27	FLT273PH	Three phase fault on the Tuco to CarlIsle 230kV line, near Tuco.	OK	OK
28	FLT281PH	*Single phase fault and sequence like Cont. No. 27*	OK	OK
29	FLT293PH	With the Tuco SVC out of service, repeat Contingency #21	OK	OK
30	FLT301PH	*Single phase fault and sequence like Cont. No. 29*	OK	OK
31	FLT313PH	With the Tuco SVC out of service, repeat Contingency #23	OK	OK
32	FLT321PH	*Single phase fault and sequence like Cont. No. 31*	OK	OK
33	FLT333PH	With the Tuco SVC out of service, repeat Contingency #25	OK	OK
34	FLT341PH	*Single phase fault and sequence like Cont. No. 33*	OK	OK
35	FLT353PH	With the Tuco SVC out of service, repeat Contingency #27	OK	OK
36	FLT361PH	*Single phase fault and sequence like Cont. No. 35*	OK	OK
37	FLT373PH	With the Tuco SVC out of service, repeat Contingency #11	OK	OK
38	FLT381PH	*Single phase fault and sequence like Cont. No. 37*	OK	OK

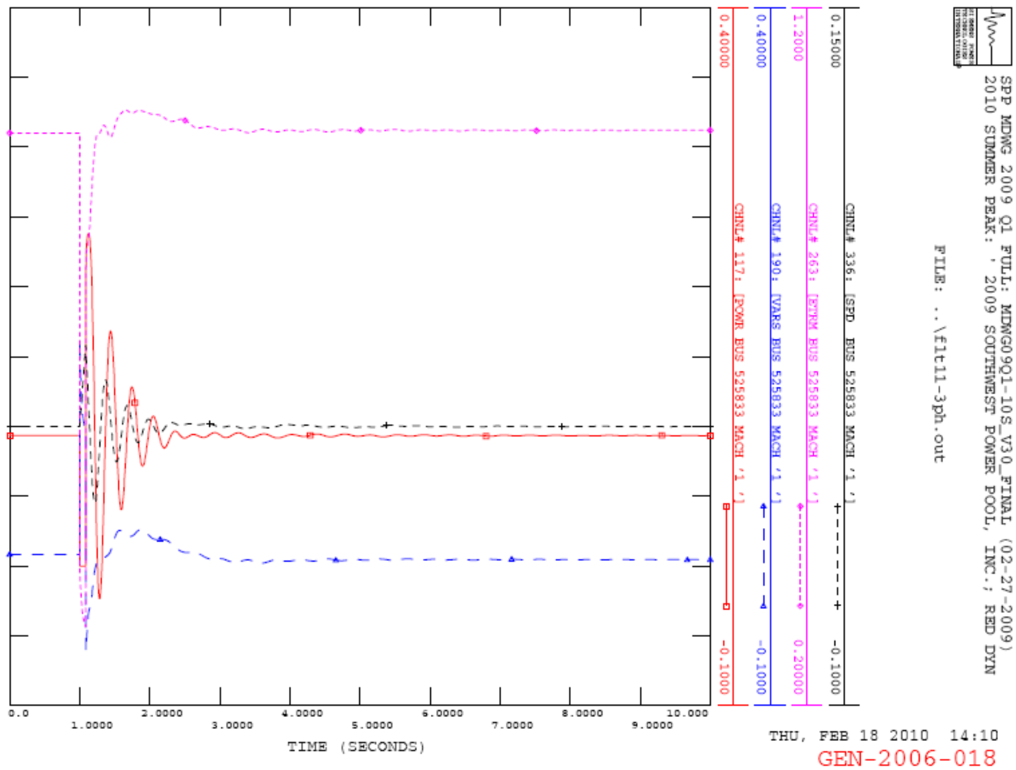

Figure 4-1. GEN-2006-018 Plot for Fault 11 – 3-Phase Fault on the Tuco to Jones 230 kV line, near Tuco

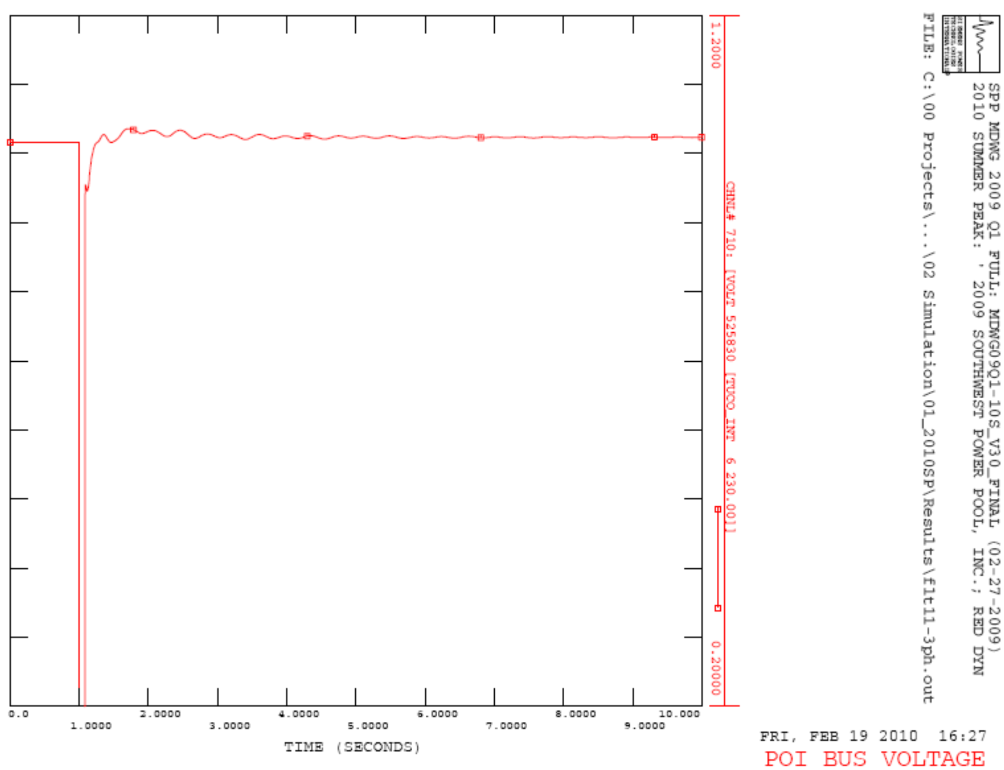

Figure 4-2. POI Voltage Plot for Fault 11 – 3-Phase Fault on the Tuco to Jones 230 kV line, near Tuco

4.2 Generator Performance

The study project performs well for all faults.

The prior-queued project Jones generators shows lightly damped oscillations in many of the disturbances. See for example the plot for fault 11 in Figure 4-3 below. These oscillations are not due to the addition of the study project GEN-2006-018.

Prior-queued project GEN-2005-015 shows high post-contingency voltages on both generator bus and its 345kV POI bus following faults 3, 4, 5, and 6. GEN-2005-015 has no voltage control capability in the model. These high voltages are not due to the addition of the study project GEN-2006-018.

The other prior-queued projects perform well for all faults, with no tripping evident.

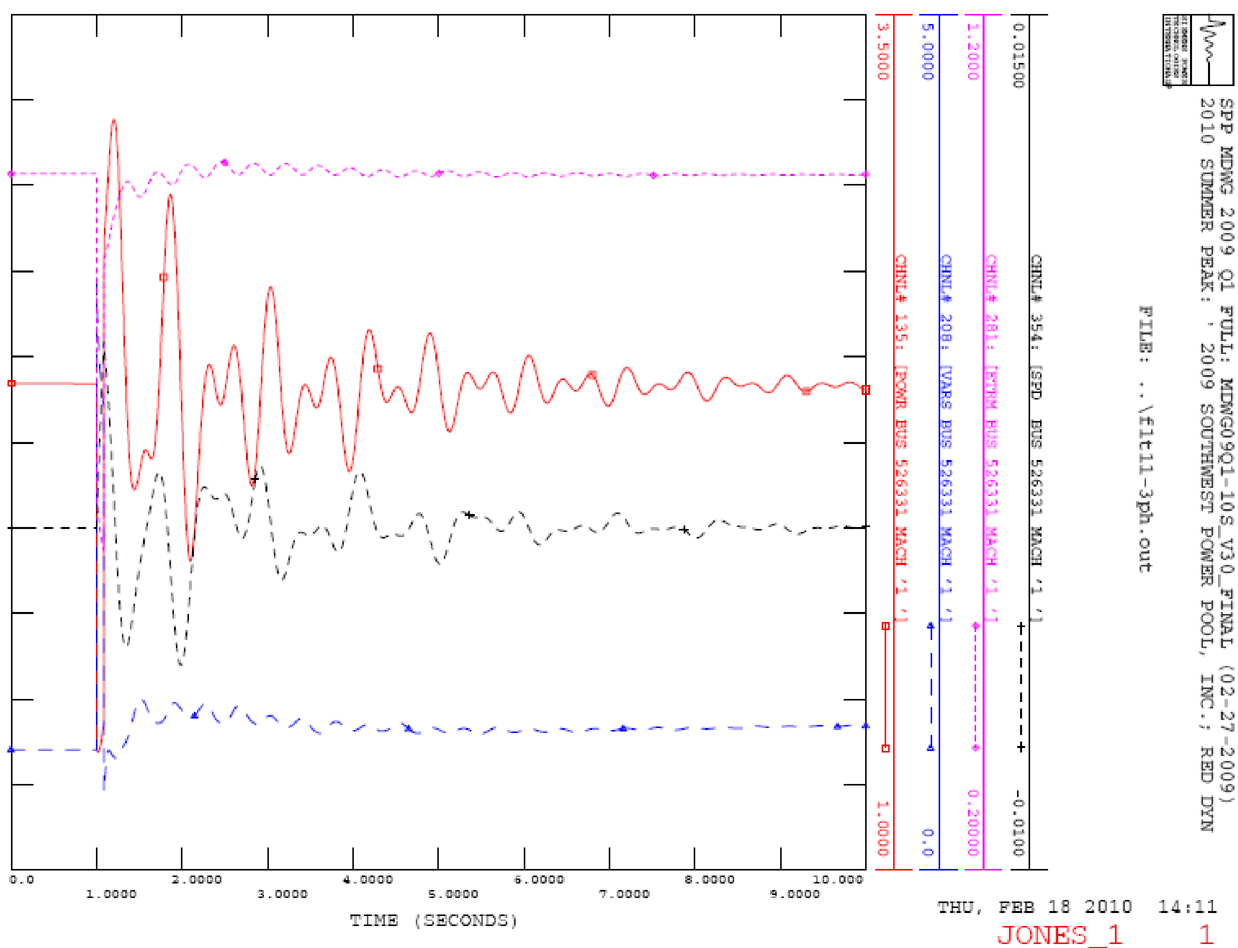

Figure 4-3. Jones Generator Plot for Fault 11 – 3-Phase Fault on the Tuco to Jones 230 kV line, near Tuco

4.3 Power Factor Requirements

The study project is not a wind farm, so no power factor test was performed.

The standard requirement for synchronous generators such as those in GEN-2006-018 is 0.95 lagging to 0.95 leading at the POI.

The final power factor requirements are shown in Table 4-2 below. These are only the minimum power factor ranges. A project developer may install more capability than this if desired.

Table 4-2. Power Factor Requirements [1]

Project	MW	POI	Final PF Requirement	
			Lagging [2]	Leading [3]
GEN-2006-018	168.1	Tuco 230kV (525830)	0.950	0.950

Notes:
1. For each plant, the table shows the minimum required power factor capability at the point of interconnection that must be designed and installed with the wind farm. The power factor capability at the POI includes the net effect of the wind turbine generators, transformer and collector line impedances, and any reactive compensation devices installed on the plant side of the meter. Installing more capability than the minimum requirement is acceptable.
2. Lagging is when the generating plant is supplying reactive power to the transmission grid. In this situation, the alternating current sinusoid “lags” behind the alternating voltage sinusoid, meaning that the current peaks shortly after the voltage.
3. Leading is when the generating plant is taking reactive power from the transmission grid. In this situation, the alternating current sinusoid “leads” the alternating voltage sinusoid, meaning that the current peaks shortly before the voltage.

5. Conclusions

The GEN-2006-018 Impact Study evaluated the impacts of interconnecting the project shown below.

Table 5-1. Interconnection Requests Evaluated

Request	Size (MW)	Generator Design	Point of Interconnection
GEN-2006-018	168.1	18 Natural Gas Generators	Tuco 230kV (525830)

No stability problems were found during summer or winter peak conditions due to the addition of these generators. A number of faults were tested with the Tuco SVC out of service, and no problems were found.

The standard power factor requirement for the synchronous generators of GEN-2006-018 is 0.95 leading to 0.95 lagging at the POI.

With the assumptions described in this report, GEN-2006-018 should be able to connect without causing any stability problems on the SPP transmission grid.

Appendix A – Summer Peak Plots

See attachment.

Appendix B – Winter Peak Plots

See attachment.

Appendix C – Power Factor Details

None required because the study project is not a wind farm.

Appendix D – Project Model Data

See attachment.