Impact Study For Generation Interconnection Request GEN-2002-005

SPP Tariff Studies

(#GEN-2002-005)

March 2008

Summary

Pursuant to the tariff and at the request of the Southwest Power Pool (SPP), Black & Veatch performed the following Impact Study to satisfy the Impact Study Agreement executed by the requesting Customer and SPP for SPP Generation Interconnection request #GEN-2002-005. GEN-2002-005 has an executed Interconnection Agreement that has been on suspension until recently. The Customer has asked to evaluate the use of Acciona 1.5MW wind turbines for use at the facility.

Interconnection Facilities

The Impact Study has determined that by using the Customer requested Acciona 1.5 MW wind turbines, which can hold a voltage schedule in a power factor range of 0.95 leading to 0.95 lagging, that no additional capacitor banks are required for the interconnection of the wind farm.The Impact Study has determined that if the Customer uses the studied Acciona 1.5MW wind turbines, that no SVC or STATCOM device will be required for interconnection. The wind farm will comply with FERC Order #661A low voltage ride through provisions if the Acciona turbines are used.

Powerflow Analysis

The powerflow analysis was performed again as an informational tool for the Customer. The analysis was performed on the 2008 winter peak, 2009 summer peak, and 2012 summer peak. SPP transmission scenario 0 powerflow models were used. Added into the models were wind farms that are currently in service in the area. These include the following projects listed in Table 1.

Table 1. Projects in Powerflow Study

Queue Number	Status	MW
GEN-2001-014	In Service	94
GEN-2003-020/GEN-2004-020	In Service	147
GEN-2001-026	In Service	74
GEN-2003-004/GEN-2004-023/GEN-2005-003	In Service	151
GEN-2001-037	In Service	102

The results are shown on the next page on Table 2.

SEASON	OVERLOADED ELEMENT	RATING (MVA)	LOADING (%)	ATC (MW)	CONTINGENCY
09SP	FLETCHER TAP - LAWTON EASTSIDE 138KV CKT 1	143	104	0	ELGIN JUNCTION - SOUTHWESTERN STATION 138KV CKT 1
09SP	GLASS MOUNTAIN - MOORELAND 138KV CKT 1	124	105	31	2002-05T - ELK CITY 138KV CKT 1
09SP	2002-05T - ELK CITY 138KV CKT 1	130	130	66	BASE CASE
12SP	2002-05T - ELK CITY 138KV CKT 1	130	134	59	BASE CASE
12SP	GLASS MOUNTAIN - MOORELAND 138KV CKT 1	124	101	114	2002-05T - ELK CITY 138KV CKT 1

IMPACT STUDY FOR SPP GENERATION QUEUE POSITION GEN-2002-005

SOUTHWEST POWER POOL (SPP)
March 10, 2008

Final Report

By

BLACK & VEATCH

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EXECUTIVE SUMMARY

A transient stability study was performed for Southwest Power Pool (SPP) Interconnection Queue Position GEN-2002-005 as part of the System Impact Study. The Interconnection Queue Position GEN-2002-005 is a wind farm of 114 MW capacity proposed to be interconnected at a new substation on the Moorewood Switch – Elk City 138kV transmission line. This portion of the line is owned by Western Farmers Electric Cooperative (WFEC).

Transient Stability studies were conducted with the full output of 114 MW (100%). The wind farm was considered to contain Acciona 1.5 MW turbines.

The 2012 summer peak load flow case and 2008 winter peak load flow case together with the SPP MDWG 2007 stability model were used as the base case for the transient stability analysis. The study was performed using PTI's PSS/E program, which is an industry-wide accepted power system simulation program. The wind farm was modeled using the Acciona wind turbine models provided by the customer.

Transient Stability studies were conducted with the GEN-2002-005 output at 114 MW (100%) for two scenarios, i.e., (i) summer peak load and (ii) winter peak load. Sixteen (16) contingencies were considered for each of the scenarios.

GEN-2002-005 generators were found to stay connected to the grid for all the contingencies that were studied.

The study has not indicated any angular or voltage instability problem due to addition of GEN-2002-005 for the contingencies analyzed in both the scenarios.

If any previously queued projects that were included in this study drop out then this System Impact Study may have to be revised to determine the impacts of this Interconnection Customer's project on SPS transmission facilities.

1. INTRODUCTION

This report discusses the results of a transient stability study performed for Southwest Power Pool (SPP) Interconnection Queue Position GEN-2002-005.

The Interconnection Queue Position GEN-2002-005 is a wind farm of 114 MW capacity proposed to be interconnected at a new substation on the Moorewood Switch – Elk City 138 kV transmission line owned by WFEC. The system one line diagram of the area near the Queue Position GEN-2002-005 is shown below.

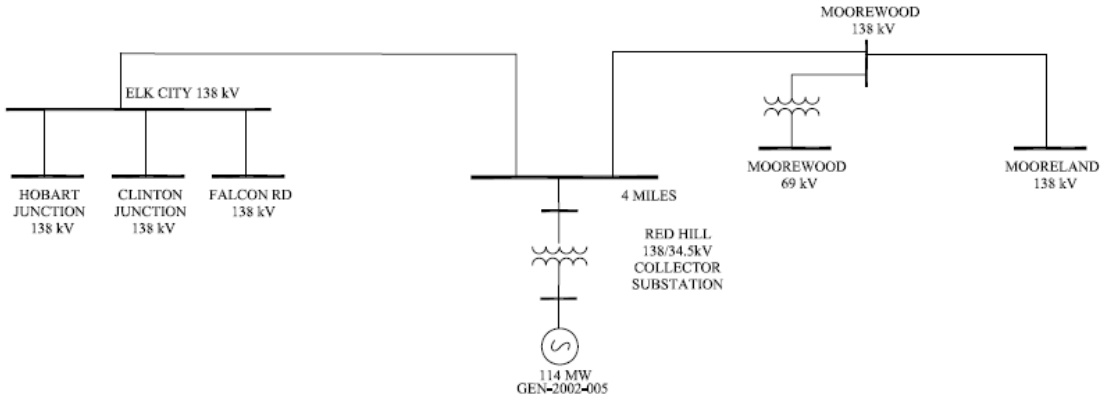

Figure 1: System One Line Diagram near GEN-2002-005

Transient Stability studies were conducted with the full output of 114 MW (100%). The wind farm was considered to contain Acciona -1.5 MW wind turbines in the study.

2. STABILITY STUDY CRITERIA

The 2012 summer peak load flow and 2008 winter peak load flow cases together with the SPP MDWG 2007 stability model were used as the base case for the transient stability analysis. These models were provided by SPP.

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 difference of the angular positions of synchronous machine rotor becomes constant following an aperiodic system disturbance.”

Disturbances such as three phase and single phase line faults were simulated for a specified duration and the synchronous machine rotor angles were monitored for their synchronism following the fault removal.

The ability of the wind generators to stay connected to the grid during the disturbances and during the fault recovery was also monitored.

3. SIMULATION CASES

Transient Stability studies were conducted with the GEN-2002-005 output at 114 MW for (i) 2012 summer peak and (ii) 2008 winter peak load flow cases.

Table 1 indicates the contingencies which were studied for each of the two cases.

Fault	Fault Definition
FLT13PH	Three phase fault on Wind Farm tap to Moorewood Switch 138 kV line, near Wind Farm, with one shot reclosing after 20 cycles.
FLT21PH	Single phase fault on Wind Farm tap to Moorewood Switch 138 kV line, near Wind Farm, with one shot reclosing after 20 cycles.
FLT33PH	Three phase fault on Wind Farm tap to Elk City 138 kV line, near Wind Farm, with one shot reclosing after 20 cycles.
FLT41PH	Single phase fault on Wind Farm tap to Elk City 138 kV line, near Wind Farm, with one shot reclosing after 20 cycles.
FLT53PH	Three phase fault on Elk City to Clinton Junction 138 kV line, near Clinton Junction, with one shot reclosing after 20 cycles.
FLT61PH	Single phase fault on Elk City to Clinton Junction 138 kV line, near Clinton Junction, with one shot reclosing after 20 cycles.
FLT73PH	Three phase fault on Elk City to Hobart Junction 138 kV line, near Hobart Junction, with one shot reclosing after 20 cycles.
FLT81PH	Single phase fault on Elk City to Hobart Junction 138 kV line, near Hobart Junction, with one shot reclosing after 20 cycles.
FLT93PH	Three phase fault on the 230kV side of Elk City Autotransformer.
FLT101PH	Single phase fault on the 230kV side of Elk City Autotransformer.
FLT113PH	Three phase fault on the 138kV side of Elk City Autotransformer.
FLT121PH	Single phase fault on the 138kV side of Elk City Autotransformer.
FLT133PH	Three phase fault on the 138kV side of Moorewood

	Autotransformer.
FLT141PH	Single phase fault on the 138kV side of Moorewood Autotransformer.
FLT153PH	Three phase fault on Mooreland to Taloga 138 kV line, near Taloga, with one shot reclosing after 20 cycles.
FLT161PH	Single phase fault on Mooreland to Taloga 138 kV line, near Taloga, with one shot reclosing after 20 cycles.

Table 1: Study Cases

In all of the simulations, the fault duration was considered to be 5 cycles. One shot re-closing into the fault was also considered in the study with the re-closure dead time of 20 cycles.

4. SIMULATION MODEL

The customer requested to use Acciona Wind turbine (AW 1500) for the System Impact Study. The Acciona turbines are a double fed induction generator with the stator winding connected directly to the grid and the rotor winding connected to the grid through a bidirectional power electronic converter. The following are the main electrical parameters of the Acciona 1.5 MW wind turbine.

Rated Power : 1.5 MW
Operating Nominal Voltage : 12 kV
Operating Power Factor : 0.95 Lead to 0.95 Lag.

The models of the Wind Farm equipment such as generators, transformers and cables were added to the base case for the purpose of this study. The equivalent generators of the wind farm were based on the number of collector circuits shown on the Customer provided single line diagram. Figure 2 shows the one line diagram of GEN-2002-005 modeled.

Table 2 shows the number of Acciona 1.5 MW wind generators modeled as equivalents at each collector buses of the wind farm.

Collector Bus	**No. of generators aggregated**
Circuit 1	11
Circuit 2	11
Circuit 3	10
Circuit 4	9
Circuit 5	13
Circuit 6	11
Circuit 7	12

Table 2: Equivalent Generators with Acciona -1.5 MW Turbines

The Customer provided the wind turbine feeder conductor types, lengths and impedance values. Table 3 indicates the transmission line parameters, as provided by the Customer, were used in the model for the underground lines within the Wind Farm.

Conductor Size	Resistance (Ohms per 1000 ft)	Reactance (Ohms per 1000 ft)
1/0 AWG	0.212	0.053
4/0 AWG	0.106	0.047
500 Kcmil	0.048	0.042
1000 Kcmil	0.028	0.037

Table 3: Cable impedance per 1000 feet

The PSS/E model for Acciona wind turbines was provided by the customer.

The base case power flow diagram for the project GEN-2002-005 is shown in Figure 2. A prior queued project, GEN-2001-014, was also included in the study model.

5. STUDY ASSUMPTIONS

The following assumptions were made in the Study:

1. The wind speed over the entire wind farm was assumed to be uniform and constant during the study period.
2. From the wind turbine data sheets the protection settings were used as and are shown in Table 5.
3. The other generators in the SPP control area were scaled down to accommodate the new generation as indicated in Table 4.

Scenario	Generation within SPP	
	Summer	Winter
With the Gen-2006-038	41,103 MW	28,220 MW
Without the Gen-2006-038	40,989 MW	28,106 MW

Table 4: SPP Dispatches

Protective Function	Protection Setting	Time Delay
Over Frequency	63.0 Hz	5 seconds
Under Frequency	57.0 Hz	5 seconds
Under Voltage	15%	0.5 seconds
Under Voltage	80%	1 second
Under Voltage	85%	15.0 second
Under Voltage	90%	210.0 seconds
Over Voltage	110%	5.0 second
Over Voltage	120%	0.1 seconds

Table 5: Protective Functions and Settings for Acciona 1.5 MW Turbines

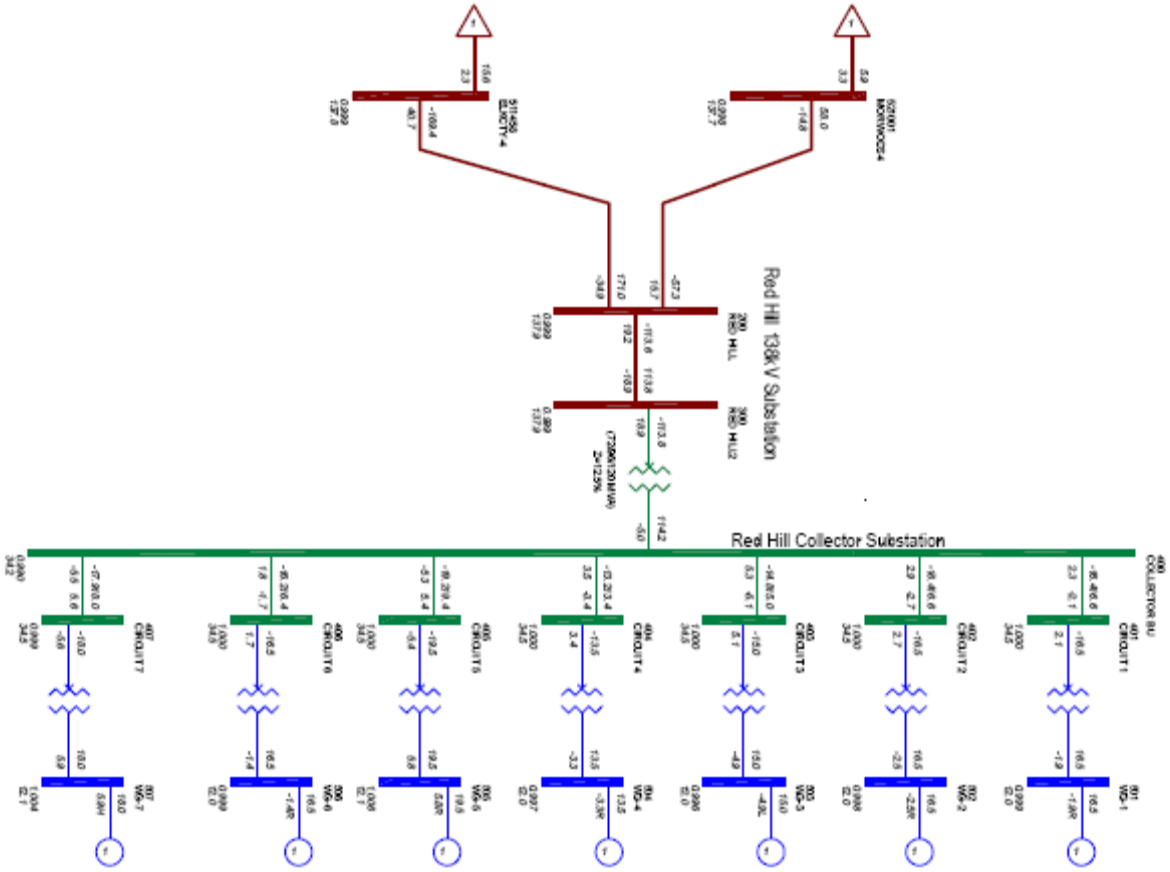

Figure 2: 100% Power Flow Base Case for GEN-2002-005

6. SIMULATION RESULTS

Initial simulation was carried out without any disturbance to verify the numerical stability of the model and was confirmed to be stable.

It was noticed that the Accionia machines were tripped on over voltage caused by the voltage spikes during switching. It was also established that these spikes were due to modeling inaccuracies and hence the over voltage protections were disabled in the subsequent simulations.

Table 6 provides the summary of the stability studies for GEN-2002-005.

GEN-2002-005 generators were found to stay connected to the grid for all the contingencies that were studied.

Fault Number	Summer Load	Winter Load
FLT13PH	- -	- -
FLT21PH	- -	- -
FLT33PH	- -	- -
FLT41PH	- -	- -
FLT53PH	- -	- -
FLT61PH	- -	- -
FLT73PH	- -	- -
FLT81PH	- -	- -
FLT93PH	- -	- -
FLT101PH	- -	- -
FLT113PH	- -	- -
FLT121PH	- -	- -
FLT133PH	- -	- -
FLT141PH	- -	- -
FLT153PH	- -	- -
FLT161PH	- -	- -

UV : GEN-2002-005 Tripped due to low voltage
OV : GEN-2002-005 Tripped due to high voltage
UF : Tripped due to low frequency
OF : Tripped due to high frequency
PQ : Prior Queued Projects Tripped
S : Stability issues encountered
- - : Gen-2002-005 Wind Farm did not trip

Table 6: Stability Study Results Summary

Figure 3 shows the system response for the contingency FLT13PH.

7. SUMMARY

A transient stability analysis was conducted for the SPP Interconnection Generation Queue Position GEN-2002-005 consisting of Acciona 1.5 MW wind turbines, with the wind farm aggregate output of 114 MW. The study was conducted for two different power flow scenarios, i.e., one for summer peak and one for winter peak.

The study has not indicated any angular or voltage instability problem due to the addition of GEN-2002-005 for the contingencies analyzed in both the scenarios.

Disclaimer

If any previously queued projects that were included in this study drop out, then this System Impact Study may have to be revised to determine the impacts of this Interconnection Customer's project on SPS transmission facilities. Since this is also a preliminary System Impact Study, not all previously queued projects were assumed to be in service in this System Impact Study. If any of those projects are constructed, then this System Impact Study may have to be revised to determine the impacts of this Interconnection Customer's project on SPS transmission facilities. In accordance with FERC and SPP procedures, the study cost for restudy shall be borne by the Interconnection Customer.

Figure 3 : System Responses with 100% output of GEN-2002-005 for FLT13PH

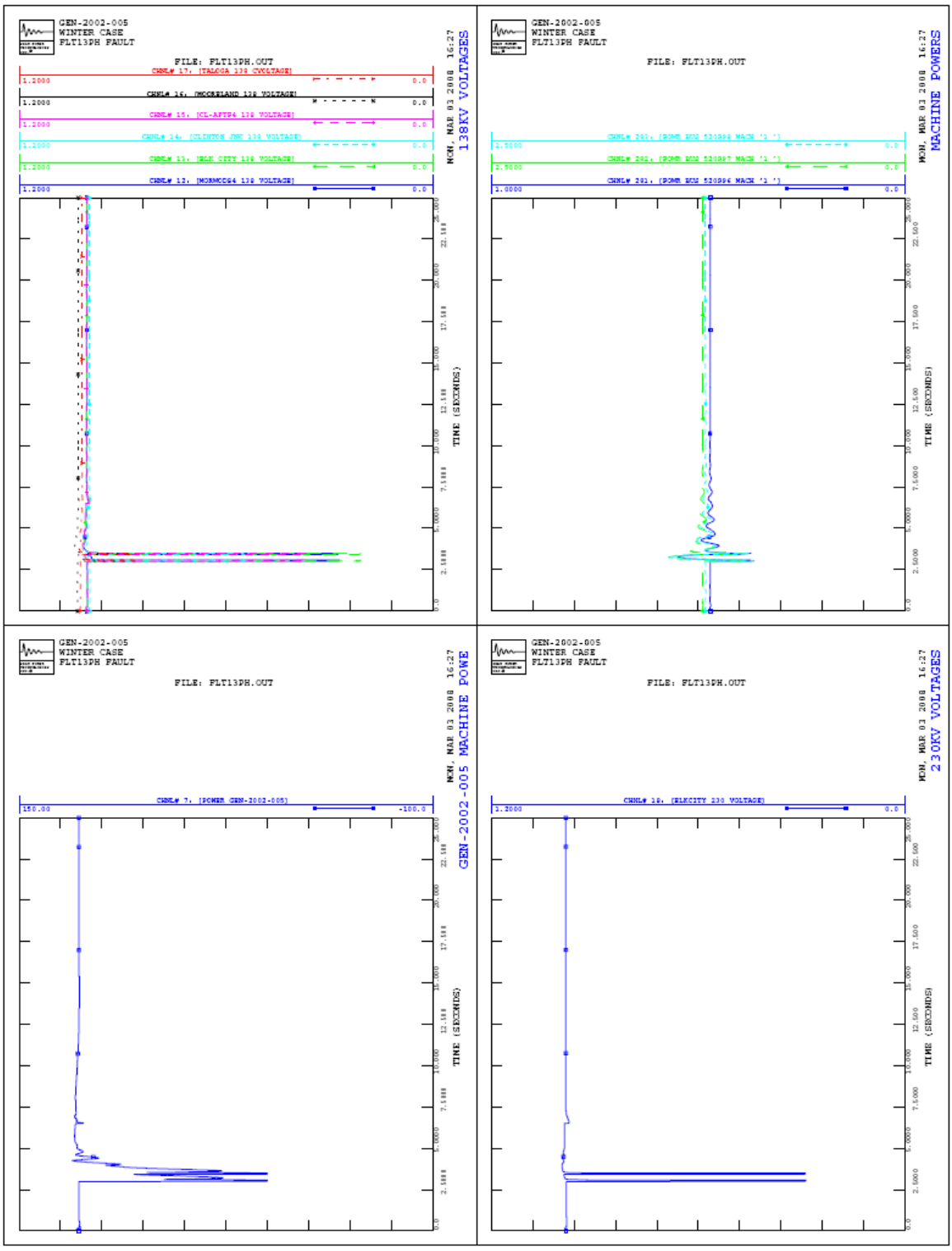

Figure 3 : System Responses with 100% output of GEN-2002-005 for FLT13PH (Cont'd)