SPP Southwest Power Pool

Impact Study Addendum for Generation Interconnection Request GEN–2005–017

SPP Tariff Studies
(#GEN-2005-017)

November 2007

Executive Summary

<OMITTED TEXT> (Customer) requested interconnection of a 340MW wind farm within the control area of Southwestern Public Service Company (d/b/a Xcel Energy) (SPS). The plant site is located in Sherman County, Texas along the Potter-Finney 345kV transmission line. The proposed method of interconnection is to build a new 345kV switching station that interconnects into the Potter-Finney 345kV line. The proposed in-service date is December 31, 2007.

The Facility Study determined the requirements to interconnect the 340MW of generation is a new 345kV ring bus substation located on the Potter-Finney 345kV line. The station will have terminals to the south (Potter), north (Finney or prior queued wind farms), and to the Customer facility. The Customer will be required to install 83Mvar of capacitors within their interconnection facilities. The Customer will be responsible for paying for the installation of a 345kV line reactor on the line to the north. Depending upon the status of the prior queued wind farms, the Customer could be required to pay for the installation of a 345kV line reactor and for a 345kV, 80Mvar static var compensator (SVC) at the Customer substation.

After the Facility Study was completed, SPP has revisited the stability study that was conducted by ABB Consulting for the Impact Study. An additional scenario was examined that was left out of the original Impact Study. This scenario included the Lamar DC Tie importing its full capacity of 210MW into the Eastern Interconnection from the Western Interconnection. The transient overvoltage analysis that was conducted by Shawnee Power Consulting did not need to be revised.

Results of this Impact Re-Study have determined that the SVC previously proposed to be located at GEN-2002-008 switching station on the 115kV bus should now be located at the GEN-2005-017 switching station. This SVC should be sized at +80/-0 Mvar.

In addition, the General Electric turbines to be purchased by the Customer shall be purchased with the manufacturer's optional +/-90% power factor capability as well as with the manufacturer's LVRT II package for low voltage ride through.

The total minimum cost for building the SPS's portion of the 345kV ring bus substation required for stand alone interconnection can be found in Table 3 of this Study and is a minimum of $9,801,000. For more detail, refer to the original Facility Study for this request. This cost is dependent upon the status of the two prior queued interconnection projects on the Potter – Finney 345kV line.

The required interconnection costs listed in Table 3 do not include all 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.

Introduction

<OMITTED TEXT> (Customer) requested interconnection of a 340MW wind farm within the control area of Southwestern Public Service Company (d/b/a Xcel Energy) (SPS). The plant site is located in Sherman County, Texas along the Potter-Finney 345kV transmission line. The proposed method of interconnection is to build a new 345kV switching station that interconnects into the Potter-Finney 345kV line. The proposed in-service date is December 31, 2007. An additional scenario has been added to the Impact Study and has triggered additional upgrades.

Interconnection Facilities

The Facility Study for this request can be found at

http://sppoasis.spp.org/documents/swpp/transmission/studies/files/2005_Generation_Studies/GEN-2005-017FS.pdf

The requirements for interconnection of the 340MW wind farm consist of building a new 345kV ring bus with three terminals, one each to Potter County Interchange, Finney County Interchange (or a prior queued wind farm), and one to the Customer wind farm. This station will be constructed, owned, and maintained by SPS. The Customer's facility will consist of a 345kV line that will connect the 345kV switching station to a 345/115/34.5kV substation to built, owned, and maintained by the Customer. The Customer 345/115/34.5kV substation will have two 345/34.5kV substation transformers and a 345/115kV transformer. Each of the two 345/34.5kV transformers will collect the energy from approximately eighty-six (86) General Electric 1.5MW wind turbines for a total power output of 129MW for each transformer. The 345/115kV transformer will connect to a 115kV line that will interconnect into a second Customer substation with a 115/34.5kV transformer. The second Customer substation will collect the energy from fifty-three (53) General Electric 1.5MW wind turbines for a total output of 79.5MW. The wind farm will have a total output of 339MW.

Due to reactive power losses on the wind turbine collector system and reactive losses due to the 345kV line reactors that are required for the project, the Customer will be required to install 83Mvar of capacitors within their facilities. Each of the 345/34.5kV transformers will be required to have a staged 34.5kV, 30Mvar capacitor bank on the 34.5kV bus of each transformer. At the 115/34.5kV transformer station, the Customer will be required to install a 115kV, 23Mvar capacitor bank on the 115kV bus.

There are two previous queued requests that have requested interconnection along the Potter-Finney 345kV line. The requests are GEN-2002-008 and GEN-2003-013. GEN-2002-008 is north of the study project (toward Finney). GEN-2003-013 is north of GEN-2002-008. As of the writing of this study, both of these requests have executed Interconnection Agreements. Recently, GEN-2002-008 has come out of suspension. GEN-2003-013 is currently in suspension. The Facilities required by this request will depend upon the status of the two prior queued projects.

The 345kV switching station will also include a 345kV line reactor on the terminal looking toward GEN-2002-008 (Finney). The size of this line reactor is determined by whether the two prior queued projects come off of suspension. These costs can be seen in Table 1.

If both prior queued request come off of suspension and are eventually built, combined with this request there will be over 770MW of wind generation on the 345kV line section between Potter and Finney. There will also be over 200MVar of line reactors on this line section. Due to these considerations, a static var compensator device (SVC) will be required by the Customer to be installed at the Customer's 345kV substation. This is a change from the original Impact Study that placed this SVC at the switching station for GEN-2002-008. This device is necessary to prevent possible voltage collapse for an outage of the 345kV line from wind farm – Potter 345kV. This SVC device will be constructed, owned, and maintained by the Customer. This SVC device has been sized at 80Mvar and will be placed on the 345kV bus at the Customer switching station

In addition to the SVC at the Customer substation, the Customer will be required to pay for the installation of two (2) 34.5kV, 16Mvar capacitor banks at the switching station for GEN-2003-013. These cap banks are necessary to prevent voltage collapse for an outage of the 345kV line from Finney to Holcomb. These banks will be installed and owned by the GEN-2003-013 interconnection customer and will be the cost responsibility of the Customer of this request.

This SVC device and additional capacitor banks will be required if the GEN-2002-008 and GEN-2003-013 generation interconnection request are both built in addition to the study project.

Table 1: Scenarios for GEN-2005-017

Scenario	Line Reactors/ Static Var Compensators to be Installed	Approx. Cost to Customer
GEN-2002-008 and GEN-2003-013 come off of suspension and are both built	• 25 MVAR Line Reactor to be installed at GEN-2005-017 • Two (2) 34.5kV, 16Mvar capacitor banks to be installed at GEN-2003-013 • 345kV, +80/-0 Mvar Static Var Compensator to be installed at GEN-2005-017	$2,991,252 $500,000 Customer to determine
GEN-2002-008 comes off suspension; GEN-2003-013 does not	• 27 MVar Line Reactor to be installed at GEN-2005-017 • 50 MVar Line Reactor to be installed at GEN-2002-008	$2,991,252 $3,392,164
GEN-2003-013 comes off suspension; GEN-2002-008 does not	• 30 Mvar Line Reactor to be installed at GEN-2005-017 • 27Mvar Line Reactor to be installed at GEN-2003-013	$3,124,889
GEN-2002-008 and GEN-2003-013 both do not come off suspension	• 75 Mvar Line Reactor to be installed at GEN-2005-017	$3,793,075

The total cost for building a new 345kV Switching Station (not including the Line Reactor and SVC costs above) are given in the Facility Study for this request and are repeated in Table 2 and 3. The costs do not include the line reactor/SVC costs in Table 1. These costs do include Customer facilities up to the point of interconnection.

Table 2: Direct Assignment Facilities

Description	Estimated Cost
Customer – 345-115-34.5kV Substation facilities including two 34.5kV 30MVAR and one 115kV 23MVAR capacitor bank.	*
Customer – 345kV line between Customer substation and new SPS switching station.	*
Customer – 345kV, 80MVAR SVC at the Customer substation	*
Additional 345kV circuit breaker in Customer substation per the original Facility Study	*
Customer - Right-of-Way for Customer Substation & Line.	
3rd Party GI Customer – Two (2) 34.5kV, 16MVar capacitor banks at the switching station for GEN-2003-013	$500,000
Total	*

Note: *Estimates of cost to be determined by Customer.

Table 3: Required Interconnection Network Upgrade Facilities

Project	Description	Estimated Cost
	Stand-alone Network Upgrade	
1	Ring Bus, 345 kV	$ 5,075,689
2	Right-of-Way Cost (station land, surveying, etc.)	$ 100,000
	Subtotal:	**$ 5,175,689**
	Network Upgrade	
3	Relay Modifications, Potter County and Finney Station	$ 240,000
4	345 kV Transmission Line Work	$ 304,401
5	75 MVAR Line Reactor (**Default from Table 1**)	$ 3,793,075
	Subtotal:	**$ 4,337,476**
	Transmission Owner's Interconnection Facilities[1] (at the Requester's Expense)	
6	Communications[2]	See footnote
7	Remote Terminal Unit (RTU)	$ 54,120
8	Revenue metering	$ 234,000
	Subtotal:	**$ 288,120**
	Total Cost:	$ 9,801,285

[1] This is a direct assigned cost to the Requester.
[2] It is the Requester's responsibility to provide both the data circuit and both dial-up telephone circuits

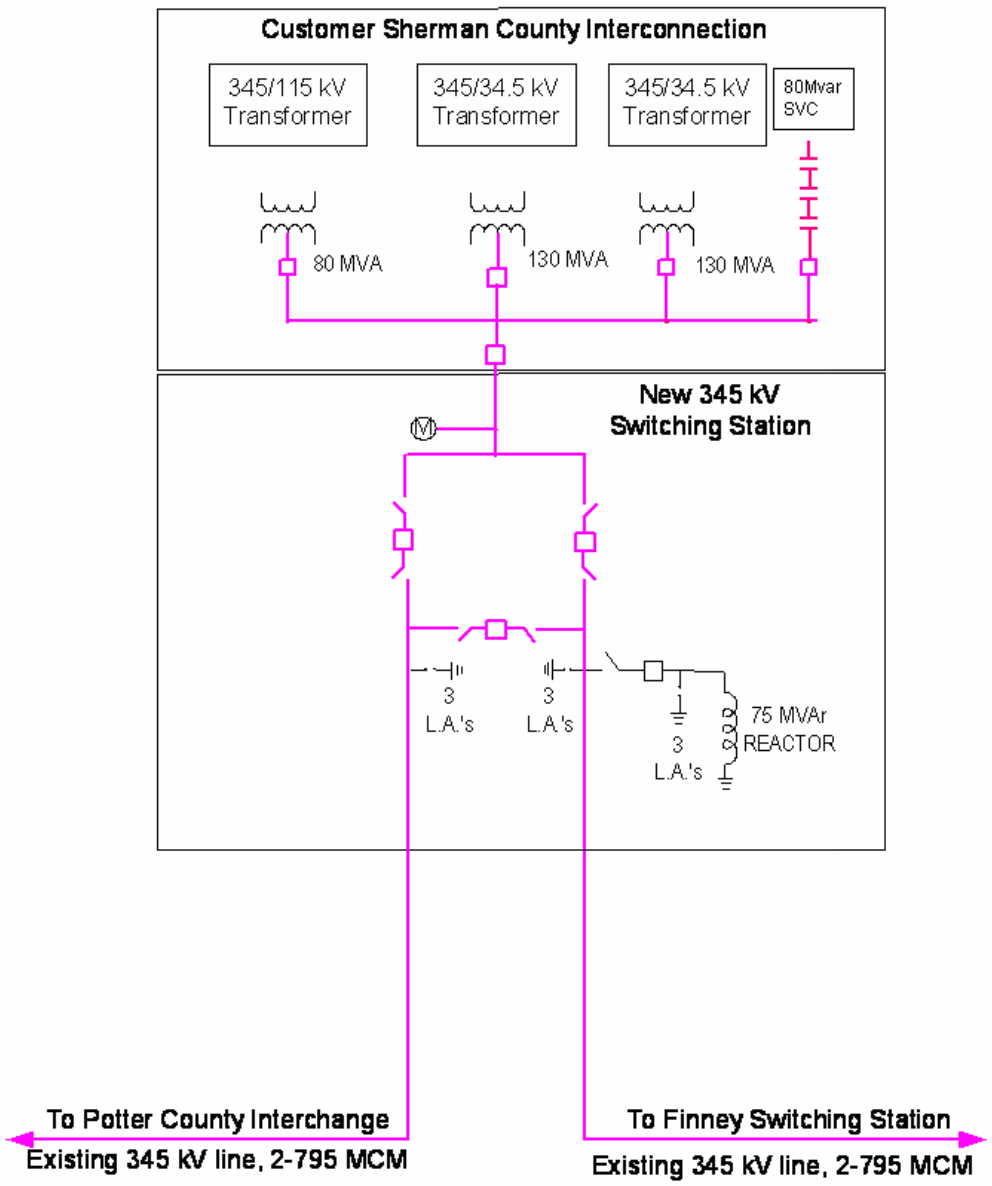

Figure 1. – Interconnection Facilities

Dynamic Stability Analysis

The Dynamic Stability Study was revisited after the Facility Study and looked at the possibility of all wind farms in the queue on the Potter – Finney 345kV line would be in service while the Lamar DC tie was importing 210MW into the Eastern Interconnection. The Customer's requested General Electric wind turbines were continued to be studied using parameters of the original Impact Study were used. Please see the original Impact Study for details. The original Impact Study can be found at

http://sppoasis.spp.org/documents/swpp/transmission/studies/files/2005_Generation_Studies/GEN-2005-017_is%20_2_.pdf

The 2007 series of stability models was used for this study as opposed to the 2006 series of models being used for the original study. Using the previous designed configuration (50Mvar SVC at GEN-2002-008), the system was found to be unstable for one contingency. The results of the stability Study are shown in Table 4.

Table 4. Stability Study Results for GEN-2005-017
(Original Configuration)

	FAULT DESCRIPTION	08WP
1	a. Apply 3-phase fault at the Holcomb bus (531449). b. Clear fault after 3 cycles by removing the line from Holcomb – Finney (531449 – 523853).	Unstable
2	a. Apply 1-phase fault at the Holcomb bus (531449). b. Clear fault after 3 cycles by tripping one phase on the line from Holcomb – Finney 345kV (531449-523853). c. Wait 30 cycles, and then re-close the phase in (b) into the fault. d. Apply fault for 3 cycles, then trip the line in (b).	Stable
3	a. Apply 3-phase fault at the Potter bus (523961). b. Clear fault after 3 cycles by removing the line from Potter – GEN-2005-017 (523961 – 51700).	Stable
4	a. Apply 1-phase fault at the Potter bus (523961). b. Clear fault after 3 cycles by removing the line from Potter – GEN-2005-017 (523961 – 51700). c. Wait 30 cycles, and then re-close the line in (b) d. Apply fault for 3 cycles, then trip the line	Stable
5	c. Apply 3-phase fault at the GEN-2005-017 bus (51700). d. Clear fault after 3 cycles by removing the line from Potter – GEN-2005-017 (523961 – 51700).	Stable
6	a. Apply 1-phase fault at the GEN-2005-017 bus (51700). b. Clear fault after 3 cycles by removing the line from Potter – GEN-2005-017 (523961 – 51700). c. Wait 30 cycles, and then re-close the line in (b) d. Apply fault for 3 cycles, then trip the line	Stable

Through several iterations of analysis it was determined that reactive compensation would be better utilized by placing the reactive compensation at GEN-2005-017 and GEN-2003-013, which were roughly at the 1/3 and 2/3 points of the line rather than at GEN-2002-008, which was roughly in the middle of the line.

The final determination was made to move the SVC that was originally placed at GEN-2002-008 to the Customer substation, GEN-2005-017. The SVC should be placed on the 345kV bus as the Customer wind turbines and capacitor banks are already placed on 34.5kV and 115kV buses. In addition, static capacitor banks should be installed at the switching station for GEN-2003-013. These banks should be sized at 32Mvar total capacitance. By placing the capacitor banks at GEN-2003-013, it allows the GE turbines at this wind farm to use their dynamic reactive capability only in the case of a severe contingency.

In addition, the GE turbines to be purchased by the Customer should be purchased with the manufacturer's option of 90% lagging / leading power factor option.

Once these changes were made, all contingencies were found to be stable. Please see Table 5 below.

Table 5. Stability Study Results for GEN-2005-017
(New Configuration)

	FAULT DESCRIPTION	08WP	12SP
1	a. Apply 3-phase fault at the Holcomb bus (531449). b. Clear fault after 3 cycles by removing the line from Holcomb – Finney (531449 – 523853).	Stable	Stable
2	a. Apply 1-phase fault at the Holcomb bus (531449). b. Clear fault after 3 cycles by tripping one phase on the line from Holcomb – Finney 345kV (531449-523853). c. Wait 30 cycles, and then re-close the phase in (b) into the fault. d. Apply fault for 3 cycles, then trip the line in (b).	Stable	Stable
3	a. Apply 3-phase fault at the Potter bus (523961). b. Clear fault after 3 cycles by removing the line from Potter – GEN-2005-017 (523961 – 51700).	Stable	Stable
4	a. Apply 1-phase fault at the Potter bus (523961). b. Clear fault after 3 cycles by removing the line from Potter – GEN-2005-017 (523961 – 51700). c. Wait 30 cycles, and then re-close the line in (b) d. Apply fault for 3 cycles, then trip the line	Stable	Stable
5	a. Apply 3-phase fault at the GEN-2005-017 bus (51700). b. Clear fault after 3 cycles by removing the line from Potter – GEN-2005-017 (523961 – 51700).	Stable	Stable
6	a. Apply 1-phase fault at the GEN-2005-017 bus (51700). b. Clear fault after 3 cycles by removing the line from Potter – GEN-2005-017 (523961 – 51700). c. Wait 30 cycles, and then re-close the line in (b) d. Apply fault for 3 cycles, then trip the line	Stable	Stable

As stated earlier, the SVC device and the capacitors at the switching station for GEN-2003-013 are necessary if GEN-2002-008 and GEN-2003-013 both come off of suspension and no additional transmission facilities are constructed.

If additional transmission facilities are added to points along the Potter-Finney 345kV transmission line, this Impact Study may need to be revised.

Conclusion

The minimum cost of interconnecting the Customer's interconnection request is estimated at $9,801,000 (not including possible additional costs for capacitors and SVCs) for SPS's interconnection Network Upgrade facilities listed in Table 3. At this time, the cost estimates for other Direct Assignment facilities including those in Table 2 have not been defined by the Customer.

The Customer is required to install 83Mvar of capacitors within their interconnection facilities.

Based on this additional Stability Study and upon the status of the prior queued projects on the Potter-Finney 345kV line, the Customer will be responsible for paying for facilities that will be constructed in the prior queued project's switching station. See Table 1. These facilities include, but are not limited to the addition of a 345kV, 80Mvar SVC at the Customer 345kV bus and the addition of 32Mvar of capacitor banks on the 34.5kV bus at the switching station for GEN-2003-013.

In addition, the Customer will be required to purchase the General Electric wind turbines with the manufacturer's optional +/-90% power factor option.

The required interconnection costs listed in this Study do not include all 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.