FEASIBILITY STUDY OF
SOUTHWESTERN PUBLIC SERVICE COMPANY'S
2003 RENEWABLE ENERGY RFP

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Transmission Planning

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Executive Summary

This report summarizes the results of the Feasibility Study involving bidders in the Southwestern Public Service Company's (SPS) 2003 Renewable Energy Request for Proposals (RFP). The results of this study indicate the required transmission system reinforcements for four different renewable energy portfolios comprised of candidates taken from the list of bidders in the SPS RFP. Each portfolio is comprised of proposed renewable energy sources located within the SPS control area, as required by the SPS RFP.

The sequential numbering of the four portfolios has no significance, and they are numbered A, B, C and D within this report. The MW size for each of the portfolios studied is 400.5 MW, 400 MW, 398.7 MW and 465.9 MW, respectively.

Powerflow analysis has indicated that transmission system reinforcements will be required for the four renewable energy portfolios. The cost required for all necessary transmission system reinforcements for the different portfolios vary, with one portfolio totaling $63,653,063. The estimated completion time for the construction of all the transmission system reinforcements will typically be 36 months.

A detailed list of required transmission system reinforcements for the respective portfolios is listed in Table 1, along with the estimated cost of each item. These cost figures are for transmission system reinforcements necessary to mitigate both voltage and thermal violations. Additionally, Table 2 shows the estimated cost numbers for the respective portfolios with and without prior transmission service requests, for the powerflow models considered. Once the selection of the winning portfolio is determined, the list of system reinforcements noted in Table 1 will undergo further powerflow analysis along with transient stability analysis to determine any additional requirements.

Cost numbers have not been provided for network upgrades related to generator interconnections because not all of the bidders have completed the required generation interconnection process through the Southwest Power Pool (SPP). Those costs will be added on top of the cost provided, but are very bidder-specific.

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Introduction

The primary objective of this Feasibility Study is to determine the necessary requirements for the network transmission service of the four respective renewable energy portfolios. The study addresses major system impacts associated with the transmission of power from these portfolios. These renewable energy portfolios are comprised of different project sites that may or may not employ similar wind turbine technology currently available to the public, while others may employ no wind energy as the main source of fuel for the generation of electric power. While some wind turbines may feature individual characteristics specific to geographical location and desired performance, the individual evaluation of each project site was not within the scope of this study. This study evaluated the system impacts caused by each individual portfolio as a whole, and in no way serves to establish impacts specifically attributed to a particular project site. Any impacts as a result of the Southwest Power Pool generator interconnection process are not tabulated as part of this report since not all the bidders have completed that process.

Each portfolio consists of energy generated from some type of a renewable resource interconnecting to the SPS transmission system. Some of these generating facilities have undergone, or are pending interconnection evaluation within the Southwest Power Pool interconnection queue to determine the necessary requirements for interconnection to the SPS transmission grid. The descriptions of the four portfolios evaluated in this study are briefly described below.

Portfolio A

This portfolio is comprised of three different project sites located in the states of Texas, Kansas and New Mexico. The Texas site is for 160 MW of wind-generated power interconnecting to the 230kV bus at Bushland Interchange. An additional 160.5 MW of wind-generated power will interconnect to the 345kV transmission circuit between Potter County Interchange and Finney Switching Station east of Hugoton, Kansas. Finally, the third project site in New Mexico is an 80 MW interconnection to the 230kV circuit between Oasis Interchange and Chaves County. The combined output of these project sites as it pertains to this specific portfolio is 400.5 MW.

Portfolio B

The second portfolio is for three different project sites. The first project site located in Carson County, Texas will interconnect 160 MW to the 230kV transmission circuit between Nichols Station and Grapevine Interchange. The second project site is for 160.5 MW interconnecting to the 345kV transmission circuit between Potter County Interchange and Finney Switching Station east of Hugoton, Kansas. The last project site is being developed in Oklahoma and will interconnect 79.5 MW of wind-generated electric power at Texas County Interchange near Guymon. The combined output of these sites is for 400.0 MW of wind-generated electric power.

Portfolio C

Portfolio C, with its four project sites, has a combined output of 398.7 MW of wind-generated electric power and is located in the states of Oklahoma and Texas. The first project site is in Oklahoma and will interconnect 79.5 MW of wind-generated power at Texas County Interchange near Guymon. The next three project sites are all located in the Texas panhandle at Carson County (80 MW), Bushland Interchange (160 MW), and Conway Substation (79.2 MW). These three Texas sites will interconnect to the transmission system at 230kV for both the Carson County and Bushland site and at 115kV for the site at the Conway Substation.

Portfolio D

The last portfolio that is considered in this study is for 465.9 MW of electric power. The Texas project site with 160 MW of wind-generated electric energy will interconnect to the 230kV bus at Bushland Interchange. In Kansas, east of Hugoton, the 345kV transmission line between Potter County and Finney Switching Station is the interconnection for this project site with a nominal output of 160.5 MW. Finally, the last two project sites are in New Mexico. The first interconnects to the 230kV circuit between Oasis Interchange and Chaves County with an output of 120 MW of wind power. The other generation source is from a biomass plant that is proposing interconnection to the 230kV Roosevelt County Interchange and has an output of 25.4 MW.

Study Approach

This Feasibility Study uses the 2004 Southwest Power Pool series models, comprised of the 2007 and the 2010 Summer Peak models. The 2007 Summer Peak cases were studied with and without prior transmission service requests, while the 2010 Summer Peak cases included prior transmission service requests. Both the 2007 and 2010 Summer Peak models include the renewable resources of the White Deer Wind Farm located in White Deer, TX and the Cielo Caprock Wind Farm, just south of Tucumcari, NM. To allow for the Portfolio generation into the SPS transmission grid, the existing SPS generation was re-dispatched in accordance with the guidelines set forth by the combined efforts of the SPP, Xcel Energy Marketing and Transmission Planning. No other generation interconnection requests presently in the SPP study queue, other than those with these portfolios, are included in the generation patterns of this study.

This powerflow study was performed using the Power Technologies, Inc. (PTI) Power System Simulator/Engineering (PSS/E) release 29.4.0 program and contains a steady-state analysis using AC Contingency Checking (ACCC) with a Fixed Slope Decoupled Newton–Raphson (FDNS) solution. Voltage limit checks are set in accordance with existing planning criteria, which states that for system intact conditions bus voltages must be maintained between 0.95 – 1.05 per-unit of their nominal value. Under single element contingencies, the voltages are allowed to deviate between 0.90 – 1.10 per-unit of their nominal value. The thermal limit checks are comprised of both an A and B seasonal rating. The A-rating is for system intact conditions, while the B-rating is an emergency rating for single element contingencies.

Results

The contingency analysis performed was for single contingencies looking only at the SPS control area. The SPP footprint will be considered during later studies, when the final network designation of generation is made and a formal request for network transmission service is received.

The power output for each of the respective project sites was set with the directions specified by the requestor of this study, however none of the projects sites have a specified power factor. In this study, the generator power factor for each of the project sites was set to approximately 98% leading (absorbing) which are typical values observed from other wind energy generating facilities.

During the course of this study thermal overloads observed on the SPS transmission system were prevalent in each of the Portfolios studied. The most recurrent violation in this study was the thermal overload of the Nichols 230/115kV autotransformers. The number of occurrences are too numerous to mention; however this thermal overload is a direct result of the displaced Nichols generation, which is displaced by the new renewable energy resources located throughout the SPS control area. In order to mitigate this violation, the most practical solution is to upgrade both autotransformers to allow for the re-dispatch of the Nichols generators.

The loss of one Tolk generator is also a contingency of concern. During this contingency the flow of power into the SPS control area through the tie-lines located in the northern and eastern portions of the SPS transmission system is greatly increased. The increase in powerflow through these tie-lines increases to the point that voltage collapse is evident in the transmission network in the northern portion of the SPS transmission system. This problem is also evident during the loss of the eastern tie-line (345kV line from TUCO Interchange to O.K.U. Interchange) between SPS and Public Service Company of Oklahoma (PSO). In some contingencies a powerflow solution could not be obtained since the existing transmission network was incapable of delivering the power from the northern portion of the SPS system to the south. The solution to these violations is the construction of a new 345kV transmission line from Potter County Interchange to the Tolk Station. This solution provides additional relief to the northern portion of the transmission system for the loss of an eastern tie-line and will support the southern part of the system during the loss of a Tolk generator and the eastern tie-line between TUCO and O.K.U.

The other violation of concern is the lack of reactive power in much of the SPS transmission system. This is a direct result of the fact that the induction type generators cannot supply any of the dynamic VArs that were previously supplied to the transmission system by the displaced SPS generation. These induction type generators, instead of producing VArs, typically operate at a leading power factor and absorb VArs from the transmission system, further depleting the VAr resources that are required to maintain acceptable voltage values and provide dynamic support. So the net result is that the transmission system is left to provide lagging VArs to account for the leading characteristic of these induction type generators. Therefore the most efficient solution is to add additional bus shunts to the transmission system at the location that will both provide acceptable voltage levels and provide the necessary reinforcements that allow for the interconnection of these project sites during single element contingencies. The locations where shunt capacitor banks are proposed are noted in Table 1 below. A transient stability analysis performed during a System Impact Study (SIS), as part of the SPP generator interconnection process, will determine if additional banks may be required. Finally, the SIS study may also determine a need to replace some of these shunt capacitors with dynamic type devices capable of providing dynamic VAr support during system disturbances.

Cost Estimates

This study does not intend to address the necessary cost estimates specific to the interconnection of the individual project sites that make up the various portfolios. It is assumed that the projects sites have gone or will go through the SPP interconnection process where the interconnection cost for each specific project site will be determined.

The items listed below in Table 1 are the necessary transmission system reinforcements for the interconnection of the respective portfolios. Included in the table, beneath each portfolio name, are markers ("o", "x" and "+") indicating the system reinforcements required for the specific portfolio in each of the powerflow models studied. The markers give an indication as to whether the portfolio was studied with or without prior transmission service requests. The cost figure for each individual system reinforcement is listed in Table 1.

Table 1, Itemized Cost Estimates of Required System Reinforcements [1]

		Portfolio			
Required Transmission System Reinforcement	Estimated Cost	A	B	C	D
New 345kV Transmission Line, Potter County–Tolk Station (122 mi)	$ 24,762,036	+	ox+	+	+
ROW: 345kV Line, Potter County–Tolk Station	$ 9,981,818	+	ox+	+	+
Substation Upgrades, Potter County–Tolk Station 345kV Line	$ 3,150,000	+	ox+	+	+
Line Reactors, Potter County–Tolk Station 345kV Line	$ 3,000,000	+	ox+	+	+
New 230kV Transmission Line, Harrington – Nichols (1 mi)	$ 484,114	ox+			ox+
ROW: 230kV Line, Harrington – Nichols	$ 30,000	ox+			ox+
Substation Upgrades, Harrington–Nichols 230kV Line	$ 520,568	ox+			ox+
New 115kV Transmission Line, Bushland Int. – NE Hereford Int. (40 mi)	$ 4,415,546	ox+	ox+	ox+	ox+
ROW: 115kV Line, Bushland Int. – NE Hereford Int.	$ 2,666,667	ox+	ox+	ox+	ox+
Substation Upgrades, Bushland Int.–NE Hereford 115kV Line	$ 1,073,000	ox+	ox+	ox+	ox+
Upgrade Both Nichols Station 230/115kV autotransformers	$ 3,990,391	ox+	ox+	ox+	ox+
Upgrade Bushland 230/115kV autotransformer	$ 2,063,546			+	
New 115/69kV autotransformer, NE Hereford Int.	$ 1,930,605	ox+	ox+	ox+	
New 345/230kV autotransformer, Potter County Int.	$ 6,858,000	o	o		o
New 28.8 MVAr Bus Shunt, Chaves County Int. 230kV	$ 700,000	+	+	+	
New 28.8 MVAr Bus Shunt, Chaves County Int. 115kV	$ 600,000			+	o
New 28.8 MVAr Bus Shunt, Oasis Int. 115kV	$ 600,000	ox+	ox+	ox+	ox+
New 28.8 MVAr Bus Shunt, Pecos Int. 115kV	$ 600,000	ox+	ox+	ox+	x+
Move 28.8 MVAr Bus Shunt, From Bushland to Deaf Smith Int. 115kV	$ 650,000	x		x+	x
New 28.8 MVAr Bus Shunt, Grapevine Int. 115kV	$ 625,000		ox+		
New 7.2 MVAr Bus Shunt, Dexter Int. 69kV	$ 375,000			+	

[1] o - Item required in 2007 Summer Peak Model **without** Prior Transmission Service Requests.
x - Item required in 2007 Summer Peak Model **with** Prior Transmission Service Requests.
+ - Item required in 2010 Summer Peak Model **with** Prior Transmission Service Requests.

The ROW cost numbers shown in Table 1 includes all monies required for the purchase of land necessary for the new transmission line, all necessary surveying, environmental studies, archeological studies and any damages to facilities during the construction of the transmission line. Additionally, and for discussion purposes only, one may assume that the approximate cost to interconnect of one of these portfolios is approximately $12,000,000. The exact interconnection cost figure for each project site, and hence each portfolio, will be determined once each project site completes the SPP interconnection process.

Table 2 below shows the total estimated cost for the transmission system reinforcements for each of the respective portfolios. The estimated cost is with and without prior transmission service requests for the powerflow models studied. All estimated cost figures were provided by the various engineering departments and will be fine-tuned during any subsequent studies. As a result of the large number of generation patterns, any changes made to the generation pattern used in these models could yield different transmission system reinforcements. Additional generation patterns could also be considered however these will have to be considered in subsequent studies, as well.

Table 2, Total Estimated Portfolio Cost [2]

	o	x	+
Portfolio A	$ 23,168,891	$ 16,960,891	$ 57,904,745
Portfolio B	$ 63,653,063	$ 56,795,063	$ 57,495,063
Portfolio C	$ 15,276,209	$ 15,926,209	$ 60,558,609
Portfolio D	$ 21,238,286	$ 15,030,286	$ 55,274,140

Depending on the portfolio, the construction of a new transmission line connecting the north-south interface of the SPS control area will be required by 2010. This line is needed to allow the transfer of power between the SPS north and south regions, under different generation patterns, regardless of the portfolio chosen. The line will also serve to provide much needed support during the loss of a major tie-line and the loss of a major generating plant.

[2] See footnote 1

Engineering and Construction

Table 3 below shows the approximate time frame that is expected for the completion of system reinforcements that are required to interconnect each portfolio for the different powerflow cases studied. In addition to engineering and construction, the construction of new transmission lines involves the approval of a Certificate of Convenience and Necessity (CCN). Although the filing process for a CCN is done concurrently with the engineering process, construction cannot begin until the CCN is approved by the respective state utility commission. It is anticipated that a CCN filing could take anywhere from 1½ to 2½ years depending on the complexity of the filing.

Table 3, Estimated Engineering and Construction Time [3]

		Portfolio			
Required Transmission System Reinforcement	Estimate Construction Time	A	B	C	D
New 345kV Transmission Line, Potter County–Tolk Station (122 mi)	36 months	+	ox+	+	+
ROW: 345kV Line, Potter County–Tolk Station		+	ox+	+	+
Substation Upgrades, Potter County–Tolk Station 345kV Line		+	ox+	+	+
Line Reactors, Potter County–Tolk Station 345kV Line		+	ox+	+	+
New 230kV Transmission Line, Harrington – Nichols (1 mi)	10 months	ox+			ox+
ROW: 230kV Line, Harrington – Nichols		ox+			ox+
Substation Upgrades, Harrington–Nichols 230kV Line		ox+			ox+
New 115kV Transmission Line, Bushland Int. – NE Hereford Int. (40 mi)	30 months	ox+	ox+	ox+	ox+
ROW: 115kV Line, Bushland Int. – NE Hereford Int.		ox+	ox+	ox+	ox+
Substation Upgrades, Bushland Int.–NE Hereford 115kV Line		ox+	ox+	ox+	ox+
Upgrade Both Nichols Station 230/115kV autotransformers	16 months	ox+	ox+	ox+	ox+
Upgrade Bushland 230/115kV autotransformer	16 months			+	
New 115/69kV autotransformer, NE Hereford Int.	12 months	ox+	ox+	ox+	
New 345/230kV autotransformer, Potter County Int.	20 months	o	o		o
New 28.8 MVAr Bus Shunt, Chaves County Int. 230kV	10 months	+	+	+	
New 28.8 MVAr Bus Shunt, Chaves County Int. 115kV	10 months			+	o
New 28.8 MVAr Bus Shunt, Oasis Int. 115kV	9 months	ox+	ox+	ox+	ox+
New 28.8 MVAr Bus Shunt, Pecos Int. 115kV	9 months	ox+	ox+	ox+	x+
Move 28.8 MVAr Bus Shunt, From Bushland to Deaf Smith Int. 115kV	9 months	x		x+	x
New 28.8 MVAr Bus Shunt, Grapevine Int. 115kV	9 months		ox+		
New 7.2 MVAr Bus Shunt, Dexter Int. 69kV	9 months			+	

[3] See footnote one

Conclusions

Regardless of the renewable energy portfolio chosen, the construction of transmission system reinforcements will be required for network transmission service. Furthermore, Portfolio C shows the greatest increases in power flows on the north-south interface lines, thus placing the greatest strain on these transmission lines during system intact conditions.

Recommendations

This study report is provided to outline the system reinforcements that will be required for each respective portfolio and to serve as additional guidance for the evaluation of each portfolio, by some party other than the Transmission Planning group. A recommendation as to the best performing portfolio was not within the scope of this study and as such, no recommendation of this type will be made.