Wind Generation Interconnection Feasibility Study

For

Customer

50 to 600 MW of Wind Energy
Near Melrose, New Mexico
SPP #GEN-2001-033

Transmission Reliability & Assessment
Xcel Energy

November 2, 2001

Introduction

Customer has requested a generator interconnection for a new wind farm to be located near Clovis, New Mexico. Customer requests Interconnection on the 230 kV transmission line that passes south of Melrose, New Mexico. This transmission line is 97.7 miles in length and terminates at the Oasis and Chavez County Interchanges. Customer plans to have the first wind turbine units installed by June of 2002, with the balance of the units installed by December 15, 2002. Depending upon the capacity of the existing transmission system, Customer plans to install up to 600 MW of wind generation.

This study determined the feasibility of the interconnection site and the level of acceptable generation that could be put on existing transmission facilities without causing an adverse impact. Alternative interconnections were not considered. This study did not examine any transfer capability issues that may be caused by the interconnection of the Customer generation. Such studies would be part of Customer's transmission service request, not part of this interconnection feasibility study.

Assumptions

The transmission models used for this study were the SPP system models for the 2002 and 2004 summer peak conditions. The loads on the 2004 summer model were scaled back by 3% to represent the expected 2003 summer conditions. A previous study had determined that the Potter County – Frio Draw 345 kV line and its associated 230 kV terminations in the Clovis, New Mexico area would not be needed prior to the interconnection in 2003.

A customer has made a request for 550 MW combined-cycle-turbine generation to be interconnected in the Clovis, New Mexico area. This request was made prior to the request made by Customer. Therefore the 2003 summer model had to include the 550 MW generation facilities. Powerflow and contingency analysis of these models determined the results of this feasibility study.

The Customer generation facilities were modeled at or near unity power factor. This assumes that an equal amount reactive power required by the wind generation facility will be compensated for, or put back on the transmission system.

Study Method

Powerflow and contingency studies were performed using the Power System Analysis Program (PSS/E) developed by Power Technologies, Inc. This program has the capability of doing powerflow simulations, short circuit studies, stability studies, and contingency studies.

Existing and expected conditions were determined by powerflow studies on system models that did not did not include the generation from Customer These conditions were considered the reference or "base case" conditions for which comparisons would be made. Then various levels of wind generation were modeled to determine the system intact powerflow changes to the SPS transmission system.

Single contingency studies were performed with and without the added generation from Customer This type of study involves modeling the outage of each transmission element in the vicinity of the proposed interconnection one at a time and observing any overload or voltage problem created by the outage. Then, comparisons were made between the case models with and without the added generation from Customer's facilities. Thus, if a transmission element overload is caused by the new resource, Customer is responsible for the costs to mitigate the overload.

To determine the level of acceptable wind generation that would not cause an adverse impact to the SPS transmission, a combination of powerflow and comparative-contingency studies were performed using the SPP 2002 and the scaled back 2004 summer peak models. These studies were performed with and without the additional wind generation from Customer Several cases were modeled and evaluated. Please see the case model descriptions in Appendix B of this report.

Power Flow Results

System intact powerflow results indicate that in 2002, 500 MW of wind generation from Customer will cause the 230 kV transmission line from the interconnection point towards Oasis Interchange to overload by 101.7% of its normal rating. In 2003 the 550 MW plant will be in service. The power generation from this plant will help balance the flow on the 230 kV interconnection lines to Customer facility, thereby increasing the acceptable level of generation from Customer to just under 550 MW. At 550 MW supplied by Customer, the 230 kV transmission lines connecting the 550 MW plant to the Roosevelt County Interchange will overload to 104%, and the voltage level at Chavez County Interchange will drop below an acceptable level for continued operations (below 0.95 per unit).

However, system intact power flow results do not indicate the adverse impacts caused by the added facilities due to single contingency outages. The results from the single contingency analysis indicated adverse impacts to the SPS transmission occur at a lower level of generation from Customer's interconnection.

<u>Comparative Contingency Study Results</u>

The contingency studies comparing before and after the interconnection of the Customer facilities indicate that the critical contingency is the loss of the 230 kV transmission line between the interconnection point and the Oasis Interchange. This contingency will require a great deal of reactive power compensation to maintain adequate voltage levels for continued operation. At approximately 250 MW of wind generation, service from the Customer facility could be sustained or restored after this loss. Results of the comparative-contingency studies for the 2002 cases are summarized in Table 1 below.

Table 1: Comparative Contingency Results for 2002 Cases

MW	Contingency	Voltage	Pre-Cont	Post-Cont. No Generator	Post-Cont. With Generator
100	Customer – Oasis Int. 230 kV	Customer	0.964	0.984	0.989
200	Customer – Oasis Int. 230 kV	Customer	0.968	0.982	0.937
250	Customer – Oasis Int. 230 kV	Customer	0.975	0.982	0.912
260	Customer – Oasis Int. 230 kV	Customer	0.975	0.982	0.895
300	Customer – Oasis Int. 230 kV	Customer	0.977	0.982	Divergent Case

The values under the "MW" heading are the generation level of the Customer facility; under the heading "Pre-Cont." is the per unit voltage before the contingency event; under the heading "Post-Cont. No Generator" are the per unit voltages with wind generation tripped off; and under the heading "Post-Cont. With Generator" are the per unit voltage if generation is restored to the pre-contingency levels. The "Divergent Case" at the 300 MW level indicates that with the 230 kV line from Customer to the Oasis Interchange out of service, the program used in this study could not resolve the extreme low voltage conditions with the Customer facility at 300 MW of generation.

By 2003 summer, single contingency conditions change to reduce the level of acceptable generation from the Customer facility. Table 2 illustrates the new single contingency problem with the Customer facility generating at 200 MW.

Table 2 2003 Summer Single Contingency Conditions		
Contingency (Outage)	Limiting Element	Overload, Under Voltage
230 kV line from Customer – Oasis Interchange	230 kV Bus @ Customer	0.8707 p.u.
230 kV line from Clovis – Roosevelt Interchange, ckt-1	230 kV line from Clovis – Roosevelt Interchange, ckt-2	103.9%
230 kV line from Clovis – Roosevelt Interchange, ckt-2	230 kV line from Clovis – Roosevelt Interchange, ckt-1	103.9%

By 2003 summer, single contingency conditions change such that a single contingency outage of either one of the 230 kV lines between the 550 MW generator and the Roosevelt Interchange will cause the other to overload to 103.4% when the Customer facility is generating at 200 MW. With the loss of the 230 kV line from Customer facility to Oasis Interchange, voltage conditions at Customer are below acceptable operating levels. The wind generation from Customer would have to be limited to 185 MW & unity power factor to mitigate these conditions.

Interconnection Requirements, Cost, and Construction Schedule

The cost estimates for the interconnection adding the Customer facility to Southwestern's system are contained in Appendix D along with a one-line diagram of the construction required. The cost estimates assume that Customer will terminate their facilities at the 230 kV level, no more than two spans away from the existing 230 kV transmission line ROW.

Conclusion

This study has shown that with the proposed interconnection, the Customer proposal is a viable source of wind generation on the SPS transmission system for less than 500 MW in 2002 and less than 550 MW in 2003 for system intact conditions. However, under single contingency conditions, the acceptable wind generation from Customer is no more than 250 MW in 2002, and no more than 185 MW in 2003 when the 550 MW combined cycle plant is in service. To increase the acceptable level of generation from Customer under single contingency conditions, additional transmission facilities would have to be constructed, or greater reactive power compensation installed.

Appendix

Powerflow Case Model Descriptions

Case Model Descriptions

The following is a brief description of the model changes between cases used in this study.

2002 Base Case: #02SP-000

- This base case models the existing transmission with only the planned improvements scheduled to be complete before the 2002 summer season. This case was used for comparative purposes.

Case: #02SP-010:

- This case modeled the interconnection of the Customer generators interconnected to the 230 kV transmission line approximately 10 miles west of the Oasis Interchange.
- The SPS system slack-generator at Tolk Station was allowed to slack back from 503.9 MW to 399.1 MW.
- The generation of the Customer farm was modeled at 100 MW at unity power factor.

Case: #02SP-011

- This case was modeled essentially the same as Case # 02SP-010 where the interconnection point to the SPS transmission remained the same, and the slack-generator at Tolk Station again balanced to 296.0 MW.
- The generation of the Customer farm was modeled at 200 MW at unity power factor.

Case: #02SP-011A

- This case was modeled essentially the same as Case # 02SP-010 where the interconnection point to the SPS transmission remained the same, and the slack-generator at Tolk Station again balanced to 245.1 MW.
- The generation of the Customer farm was modeled at 250 MW at unity power factor.

Case: #02SP-011B

- This case was modeled essentially the same as Case # 02SP-010 where the interconnection point to the SPS transmission remained the same, and the slack-generator at Tolk Station again balanced to 234.8 MW.
- The generation of the Customer farm was modeled at 260 MW at unity power factor.

Case: #02SP-012

- This case was a test model essentially the same as Case # 02SP-010 where the interconnection point to the SPS transmission remained the same, and the slack-generator at Tolk Station again balanced to 194.2 MW.
- The generation of the Customer farm was modeled at 300 MW at unity power factor.

2003 Base Case: #03SP-000

- This base case models the expected interconnection of the 550 MW generating plant near Clovis, New Mexico on the existing transmission. Only those planned improvements scheduled to be complete before the 2003 summer season have been included. This case was used for comparative purposes.
- The SPS system slack-generator at Tolk Station was settled to 348.1 MW after the 550 MW plant was in service.
- The generation of the Customer farm was modeled at 260 MW at unity power factor.

Case: #03SP-020

- The Customer facility was modeled the same as the 2002 cases where the interconnection point to the SPS transmission remained the same, and the slack-generator at Tolk Station again balanced to 248.1 MW.
- The generation of the Customer farm was modeled at 100 MW and power factor at 0.98 lagging.

Case: #03SP-021

- The Customer facility was modeled the same as the 2002 cases where the interconnection point to the SPS transmission remained the same, and the slack-generator at Tolk Station again balanced to 149.2 MW.
- The generation of the Customer farm was modeled at 200 MW and power factor at 0.95 lagging to test the voltage level sensitivity to reactive power requirements of the Customer facility.

Case: #03SP-021A

- The Customer facility was modeled the same as the 2002 cases where the interconnection point to the SPS transmission remained the same, and the slack-generator at Tolk Station again balanced to 149.2 MW.
- The generation of the Customer farm was modeled at 200 MW and power factor corrected to 0.98 lagging.

Case: #03SP-021B

- The Customer facility was modeled the same as the 2002 cases where the interconnection point to the SPS transmission remained the same, and the slack-generator at Tolk Station again balanced to 248.1 MW.
- The generation of the Customer farm was modeled at 200 MW and power factor at 0.95 lagging.
- A SVC (Static VAR Compensator) modeled at the Chavez Co. 230 kV bus to test the compensation level needed to keep the local bus voltage levels at an acceptable level. At Steady State, SVC = 45.5 MVAR capacitive, with the Critical Contingency loss of the 230 kV line from Customer to Oasis, SVC = 127.3 MVAR capacitive, voltage level at Customer still at 0.8844 per unit.

Case: #03SP-021C

- The Customer facility was modeled the same as the 2002 cases where the interconnection point to the SPS transmission remained the same, and the slack-generator at Tolk Station again balanced to 248.1 MW.
- The generation of the Customer farm was modeled at 200 MW and power factor at 0.95 lagging.
- The 230 kV line from the Customer facility to Chavez County Interchange was modeled as having 30% series compensation. This was done to relieve the reactive power requirements needed to get the steady state and contingency powerflows to Chavez County without overloading the 550 MW plant interconnection to Roosevelt Interchange. The series compensation of this line does relieve the contingency overloads of the 230 kV lines between the 550 MW plant and Roosevelt Interchange. However, with this line compensated, the Critical Contingency loss of the 230 kV line from Customer to Oasis leaves the voltage level at Customer still at 0.8025 per unit.

Case: #03SP-022

- The Customer facility was modeled the same as the 2002 cases where the interconnection point to the SPS transmission remained the same, and the slack-generator at Tolk Station again balanced to 248.1 MW.
- The generation of the Customer farm was modeled at 185 MW and power factor at unity.

This case model mitigated the contingency overloads and low voltage conditions. This case was used to determine the 2003 summer post contingency recovery level of generation.

Appendix

Estimated Costs

Scoping Estimate

A "Scoping Estimate" is provided by Xcel Energy for the convenience of the requesting entity (Requester). It is produced before engineering design has been completed. Xcel Energy will make every effort to produce a representative estimate that incorporates as many project-specific factors as possible. However, a Scoping Estimate is generally based on typical conditions encountered on past construction projects and uses historical cost data from other Xcel Energy projects which may or may not be directly comparable. A Scoping Estimate will only give a broad-based estimate of the possible costs that may be incurred during a potential construction project. Xcel Energy will not proceed to construction based on a Scoping Estimate. If a Requester wants a more definitive estimate of the cost of a project, an "Engineering Estimate" should be requested.

This form will be provided to the Requester prior to completion of the Scoping Estimate so that the Requester can verify the Project Scope and Assumptions information, below. Once the estimate is complete, Xcel Energy will fill in the "Estimated Costs" space at the bottom, and provide a copy of this form to the Requester.

Requester Name _Customer_______ Phone
Address __
To generate this Scoping Estimate, Requester agrees to pay Xcel Energy : $ Paid to SPP
Requester: __________N/A____10/30/01__________
Signature *Date*

The Requester should review the information detailed below and notify Xcel Energy in writing as soon as possible if any of these assumptions are incorrect.

Project Information:
Name: _Customer Wind Farm _______________________
Location: _
Scope: _1. 230 kV interconnection facility at project location.

Project Assumptions: include conditions and requirements set by Xcel Energy and responsibilities of Xcel Energy, and, as appropriate, the Requester. Attach additional pages if more room is needed.
__Customer will interconnect at a single 230 kV interconnection facility to the SPS transmission system. All required reactive power compensation will be provided by Customer on their energy collection network prior to the 230 kV interconnection.

Scoping Estimate of Costs by Xcel Energy: _**$1,832,635.28**_____________

Xcel Energy ____
Print Name

____
Signature *Date*

Scoping Estimate

A "Scoping Estimate" is provided by Xcel Energy for the convenience of the requesting entity (Requester). It is produced before engineering design has been completed. Xcel Energy will make every effort to produce a representative estimate that incorporates as many project-specific factors as possible. However, a Scoping Estimate is generally based on typical conditions encountered on past construction projects and uses historical cost data from other Xcel Energy projects which may or may not be directly comparable. A Scoping Estimate will only give a broad-based estimate of the possible costs that may be incurred during a potential construction project. Xcel Energy will not proceed to construction based on a Scoping Estimate. If a Requester wants a more definitive estimate of the cost of a project, an "Engineering Estimate" should be requested.

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Requester Name _Customer_______ Phone ___
Address __

To generate this Scoping Estimate, Requester agrees to pay Xcel Energy : $ Paid to SPP
Requester: _________N/A____10/30/01__________
Signature *Date*

The Requester should review the information detailed below and notify Xcel Energy in writing as soon as possible if any of these assumptions are incorrect.

Project Information:
Name: _Customer Wind Farm______________________
Location: _ _____________________
Scope: _1. Oasis – Chavez 230 kV line construction in and out of interconnection facility with 795 MCM lines.

Project Assumptions: include conditions and requirements set by Xcel Energy and responsibilities of Xcel Energy, and, as appropriate, the Requester. Attach additional pages if more room is needed.
__ Customer will interconnect at a single 230 kV interconnection facility to the SPS transmission system.

Scoping Estimate of Costs by Xcel Energy: _**$ 499,170**____

Xcel Energy ____
Print Name

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Signature *Date*

CUSTOMER 230 KV INTERCONNECTION					
Description	**QTY.**	**Cost each**	**Cost total**	**MH each**	**MH total**
230 KV Line Terminal Structures with relays	3	$281,245.51	$843,736.53	1,100	3,300
230 KV Breaker Installation	3	$257,838.47	$773,515.41	800	2,400
230 KV Customer Isolation	1	$86,334.08	$86,334.08	400	400
Control House	1	$129,049.27	$129,049.27	650	650
TOTALS			**$1,832,635.28**		**6,750**
Transmission					
New installation			$488,493.00		74
Removal			$10,677.00		12
Total			**$499,170.00**		**86**
Estimated Grand Total			**$2,331,805.28**		**6,836**
Note: Man-hour estimates are for construction only. Material & equipment lead times are not included. Construction duration will vary with the crew size allotted. 230 kV breaker lead-time may vary up to 40 weeks after placement of purchase-order.					