



***Facility Study
For
Generation Interconnection
Request
GEN-2004-014***

SPP Tariff Studies

(#GEN-2004-014)

June 2007

Executive Summary

<OMITTED TEXT> (Customer) has requested a Facility Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnection of a 154 MW wind powered generation facility in Ford County, Kansas to the transmission system of Sunflower Electric Power Corporation (SUNC). The wind powered generation facility was studied with seventy-seven (77) individual Gamesa G87 2.0 MW wind turbines. The original requested in-service date for the 154MW facility is December 1, 2005.

The generation facility was originally studied to interconnect into the Midwest Energy transmission system at North Kinsley 115kV substation. The Feasibility and Impact Studies analyzed the facility to also have a connection to the Spearville-Mullergren 230kV transmission line utilizing two 230/115kV autotransformers at a new substation near North Kinsley.

During the process of conducting the Facility Study, it was determined that this interconnection may be problematic. It calls for the transmission interconnection of two different control areas within SPP. An interconnection such as this is required by the SPP tariff to go through the SPP Transmission Working Group (TWG) for approval.

Through a series of discussions with the Customer, it was decided that a substitute interconnection point could be studied to be interconnected to the Spearville 230kV bus, which is electrically very similar to the original configuration, and the connection to Midwest Energy would be omitted. However, the stability analysis conducted has shown that the transmission system will not be stable for certain contingencies for this configuration. Therefore, it is recommended to use the substitute interconnection point at Spearville and to build a new 115kV line from Spearville to Midwest Energy's North Kinsley substation. This is a less costly option earlier proposed which called for a new substation with two 230/115kV autotransformers on the Spearville-Mullergren 230kV line.

Because this interconnection will still include a connection between Sunflower and Midwest Energy, the SPP TWG will have the opportunity to review and approve this interconnection configuration. If this configuration does not meet TWG approval, the GEN-2004-014 interconnection 154MW may be need to be lowered to accommodate the existing Spearville infrastructure.

The need for the Spearville to North Kinsley 115kV line may be deferred in certain cases. If the current queue of wind farms requesting interconnection at Spearville do not go into service, this line may not be necessary for interconnection. For this reason, it will depend on the timing of both this request and other requests in the Spearville area as to when this line will be necessary. It may be possible that funds appropriated to build the Spearville – North Kinsley 115kV line may be better allocated to fund 345kV expansions alternatives such as part of the proposed 'X' plan (Spearville-Mooreland 345kV).

The costs for the Interconnection Facilities to be constructed, owned, and maintained by Midwest Electric Cooperative is \$1,715,000. The cost of the Interconnection Facilities to be constructed, owned, and maintained by Sunflower is \$7,503,000. The

time to construct the facilities is approximately 18 months and will be refined during the Milestone negotiation process during the 60 day Interconnection Agreement negotiation period between the Customer and the Transmission Owner.

These costs could change pending the completion of a short circuit study by Midwest Energy to determine the impacts of the Spearville-N Kinsley 115kV line addition.

A 34.5kV, 18 Mvar capacitor bank will be required by the Customer to be installed in the Customer substation for reactive compensation of the wind farm turbines, collector circuits, and associated transformers. The Customer will also be required to install a 34.5kV, +/- 12MVA STATCOM device for voltage regulation of the wind farm.

Introduction

<OMITTED TEXT> (Customer) has requested a Facility Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnecting a 154 MW wind powered generation facility in Ford County, Kansas to the transmission system of Sunflower Electric Power Corporation. The wind powered generation facility studied was proposed to comprise of seventy-seven (77) Gamesa G87 2.0 MW wind turbines. The original requested in-service date for the facility is December 1, 2005 and is not feasible. The wind powered generation facility will interconnect into the 230kV bus at Sunflower/Mid Kansas Electric Spearville substation.

The Impact Study has also been conducted again in part due to a change to the interconnection configuration.

1.0 Project Location and Existing Facilities

The project is located in Ford County, Kansas, a few miles east of the Spearville 345/230/115kV substation. The point of interconnection originally requested was the North Kinsley substation that is owned by Midwest Energy. The Feasibility and Impact Study analyzed this interconnection point and determined an additional transmission tie was necessary to the transmission system previously owned by Aquila and now owned by Sunflower.

After several series of meetings between Southwest Power Pool, affected Transmission Owners, and the Customer, it was determined that a substitute interconnection would be studied, interconnecting into the Spearville 230kV substation.

In able to maintain a stable transmission system with all previous queued wind farms in service, a 115kV transmission line connecting Spearville to North Kinsley will still be necessary. This interconnection will be contingent upon review and approval from the Southwest Power Pool Transmission Working Group (TWG).

If at the time the wind generators go in service, all previous queued generators are not in service, the need for this line could be deferred to a later date.

3.0 Interconnection Facilities

All required interconnection facilities are tabulated in Table 1 and are shown in Figure 1.

3.1 Spearville Substation - The Customer will be interconnecting into the Spearville 230kV substation owned by Sunflower. The Customer will build a short 230kV line from their wind farm facilities to the Spearville substation. A 115kV terminal will be added for a new 115kV line to Midwest Energy's North Kinsley substation.

The costs for the substation work at Spearville is estimated below

- Installing 230kV line terminal including one (1) 230kV circuit breaker, three (3) 230kV disconnect switches and associated structural steel, foundations, and associated equipment
- | | |
|----------|------------|
| Subtotal | \$ 800,000 |
|----------|------------|
- Installing 115kV line terminal including two 115kV circuit breakers, associated disconnect switches, structural steel, foundations, and associated equipment
- | | |
|------------------------------------|--------------------|
| Subtotal | <u>\$ 453,000</u> |
| Total Spearville Substation | \$1,253,000 |

3.2 Spearville – North Kinsley 115kV Transmission – To interconnect the Customer interconnection request will require the construction of approximate 25 mile long transmission line from Spearville to Midwest Energy’s North Kinsley substation. The cost of the 115kV transmission line has been estimated to cost approximately \$250,000 per mile.

The costs of the Spearville – Kinsley 115kV line is below.

- Construct approximately 25 miles of 115kV transmission line from Spearville – North Kinsley substation.
- | | |
|--------------------------------------|--------------------|
| Total 115kV Transmission Line | \$6,250,000 |
|--------------------------------------|--------------------|

3.3 North Kinsley 115kV substation – The interconnection will call for Midwest Energy to build a substation adjacent to the existing North Kinsley substation. A two breaker 115kV bus substation will be built, owned, and maintained by Midwest Energy. The 115kV bus will have terminals to the existing North Kinsley substation and Spearville substation

The costs of the Midwest Energy Facilities are detailed below

- Two breaker 115kV substation
 - R/W
- | | |
|---------------------------------------|--------------------|
| | \$1,700,000 |
| | <u>\$ 15,000</u> |
| Total North Kinsley Substation | \$1,715,000 |

Table 1: Required Interconnection Facilities

Project	Description	Estimated Cost
Interconnection Facilities - Midwest Electric		
1	115kV Ring-Bus Switching Station	\$ 1,700,000
3	Right-Of-Way ¹	\$ 15,000
Subtotal:		\$1,715,000
Interconnection Facilities – Sunflower Electric		
4	Spearville Substation	\$ 1,253,000
5	Spearville – North Kinsley 230kV Transmission Line	\$6,250,000
Subtotal:		\$7,503,000
Total Cost:		\$9,218,000

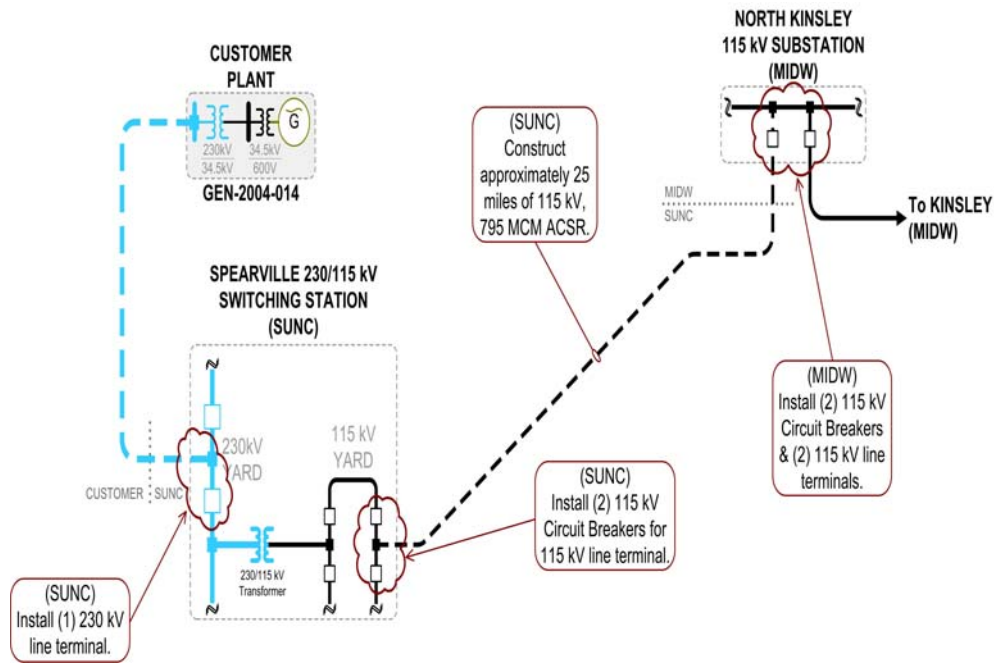


Figure 1. Interconnection Configuration

3.4 Customer Facilities

- 3.4.1 34.5kV Capacitor Bank** – To maintain a unity power factor at the wind farm interconnection point, the Customer will be required to install a 34.5kV, 18 Mvar capacitor bank on the 34.5kV bus of the Customer 230/34.5kV substation.
- 3.4.2 STATCOM Device** – To maintain acceptable voltage regulation and to maintain system reliability and stability, the Customer will be required install a STATCOM device on the 34.5kV bus of its 230/34.5kV substation. This device shall have a continuous rating of +/-12MVA

4.0 Stability Analysis

4.1 Objective

The objective of the stability study is to determine the impact on system stability of connecting the proposed GEN-2004-014 wind farm to SPP's transmission system.

4.2 The Wind Generating Facility

The rated output of the generation facility is 154MW, comprised of seventy-seven (77) Gamesa G87 wind turbines. The base voltage of the Gamesa turbine is 690 V, and a generator step up transformer (GSU) of 2500kVA connects each unit to the high side of 34.5kV. The rated power output of each turbine is 2.0 MW while the actual power output depends on the wind. In performing a system impact study, the wind farm generation from the study customer and previously queued customers is dispatched into the SPP footprint.

The Customer's substation will contain a 230/34.5kV, 100/133/167 MVA transformer and appropriate 230kV and 34.5kV switching equipment. The Customer substation will contain 18Mvar of 34.5kV capacitors and a 34.5kV, +/-12MVA STATCOM device.

4.3 Interconnection Configuration

The substitute interconnection configuration studied required an interconnection the wind farm into the Spearville 230kV substation bus. .

4.4 Contingencies Simulated

Fourteen (14) contingencies were considered for this transient stability study. These contingencies included three phase faults, as well as single phase line faults were simulated. Single-phase line faults were simulated by applying a fault impedance to the positive sequence network at the fault location to represent the

effect of the negative and zero sequence networks on the positive sequence network. The fault impedance was computed to give a positive sequence voltage at the specified fault location of approximately 60% of pre-fault voltage. This method is in agreement with SPP current practice.

The faults that were defined and simulated are listed in Table 2.

4.5 Results

Results are summarized in Table 2.

The “Spearville area transmission system” has four transmission lines linking it to the rest of the electrical system. There is a 345kV line to the west, a 230kV line to the northeast, a 115kV line to the east, and a 115kV line to the southwest.

It was found that with GEN-2004-014 in service, for loss of the Spearville – Holcomb 345kV line, certain system instabilities would possibly occur at the several wind farms that have presently requested interconnection into the “Spearville area transmission system”.

To alleviate the system instabilities, it will be necessary to add back in the previously studied connection between the “Spearville area transmission system” and the Midwest Energy North Kinsley 115kV substation.

The previous configuration called for a new substation to be built near the North Kinsley with two 230/115kV autotransformers. A 115kV substation would have to be built with terminals to the wind farm and to North Kinsley. A 230kV substation would have to be built with terminals to Spearville and Mullergen.

A second autotransformer is already proposed to be added at Spearville by the summer of 2008. Under this proposed configuration, a 115kV line, approximately 25 miles in length will be built from Spearville to the North Kinsley substation.

With the addition of the new line from Spearville to North Kinsley, the proposed generators can be interconnected at Spearville.

Table 2. Contingencies Evaluated

	Contingency	Description	Winter Peak	Winter Peak -no trip	Winter Peak (with Kinsley)	Winter Peak -no trip (with Kinsley 115kV)	Summer Peak	Summer Peak -no trip	Summer Peak (with Kinsley 115kV)	Summer Peak -no trip (with Kinsley 115kV)
1	FLT13PH	3 phase fault on the Spearville to Holcomb 345 kV line, near Spearville.	Stable WF trip**	Unstable	Stable WF trip**	Stable	Stable WF trip**	Unstable	Stable WF trip**	Stable
2	FLT21PH	<i>Single phase fault and sequence like Cont. No. 1</i>	Stable WF trip**	Unstable	Stable WF trip**	Stable	Stable WF trip**	Unstable	Stable WF trip**	Stable
3	FLT33PH	3 phase fault on the Spearville – Mullergren 230kV line near Spearville.	Stable WF trip**	Stable	Stable WF trip**	Stable	Stable WF trip**	Stable	Stable WF trip**	Stable
4	FLT41PH	<i>Single phase fault and sequence like Cont. No. 3</i>	Stable	Stable	Stable	Stable	Stable WF trip**	Stable	Stable WF trip**	Stable
5	FLT53PH	3-phase fault at Greenburg – Sun City 115kV line near Greenburg	*	*	Stable	Stable	*	*	Stable	Stable
6	FLT61PH	<i>Single phase fault and sequence like Cont. No. 5</i>	*	*	Stable	Stable	*	*	Stable	Stable
7	F10SLG	SLG fault at Mullergren on 230 kV line to Spearville, Breaker failure at Mullergren, [CB6012]	*	*	Stable WF trip**	Stable	*	*	Stable WF trip**	Stable
8	F133PH	3-phase fault at North Judson Large on 115 kV line to Spearville	*	*	Stable WF trip**	Stable	*	*	Stable WF trip**	Stable
9	F073PH	3-phase fault at North Judson Large on 115 kV line to Spearville	*	*	Stable WF trip**	Stable	*	*	Stable WF trip**	Stable
10	F14SLG	SLG fault at North Judson Large on 115 kV line to Spearville Breaker failure at North Judson Large, [CB3071]	*	*	Stable WF trip**	Stable	*	*	Stable WF trip**	Stable
11	FLT153PH	3 Phase fault at Judson Large on 115 kV line to	*	*	Stable WF	Stable	*	*	Stable WF	Stable

	Contingency	Description	Winter Peak	Winter Peak -no trip	Winter Peak (with Kinsley)	Winter Peak –no trip (with Kinsley 115kV)	Summer Peak	Summer Peak –no trip	Summer Peak (with Kinsley 115kV)	Summer Peak –no trip (with Kinsley 115kV)
		GEN-2001-039A Tap			trip**				trip**	
12	FLT16SLG	SLG fault at Judson Large on 115 kV line to GEN-2001-039A Tap - Breaker failure at Judson Large, [CB3629]	*	*	Stable WF trip**	Stable	*	*	Stable WF trip**	Stable
13	FLT173PH	3 Phase fault at GEN-2001-039A 115 kV line to Greenburg Tap	*	*	Stable WF trip**	Stable	*	*	Stable WF trip**	Stable
14	FLT18SLG	Single Phase fault at GEN-2001-039A 115 kV line to Greenburg – Breaker failure at GEN-2001-039A	*	*	Stable WF trip**	Stable	*	*	Stable WF trip**	Stable

*Contingency not simulated due to earlier encountered instabilities

** Either the study wind farm or a previously queued wind farm tripped due to low or high voltage. When this occurs, contingencies are run with all tripping disable to assure of system stability.

5.0 Conclusion

The GEN-2004-014 generation interconnection request for 154MW may be interconnected into the SPP transmission system with system reinforcements. If all previously queued generation requests go into service without transmission system reinforcements for transmission service, the GEN-2004-014 interconnection request will be required to pay for the construction of a twenty-five (25) mile, 115kV transmission line to be built from the SUNC Spearville substation to the Midwest Energy North Kinsley substation. This construction will include 115kV terminals at both Spearville and North Kinsley substations.

This transmission interconnection between SUNC and MIDW will need to undergo review by the SPP Transmission Working Group. If this interconnection is not approved by the TWG, the GEN-2004-014 interconnection request 154MW could be lowered to accommodate the existing transmission infrastructure at Spearville substation.

If all previous queued wind farms do not go into service, the need for this line may be reviewed and deferred until such time as it is necessary.

The total costs to accommodate this generation interconnection request include Sunflower facility network upgrade costs of \$7,503,000 and Midwest Energy facility costs of \$1,715,000. These costs could change pending the completion of a short circuit study on the Midwest Energy system.