Wind Generation Interconnection Feasibility Study

For

>Omitted Text<

150 MW of Wind Energy
Near Guymon, Oklahoma
SPP #GEN-2002-006

Transmission Planning & Asset Management
Xcel Energy

September 20, 2002

Introduction

>Omitted Text< proposes to build a 150 MW wind-farm to be located in Texas County, Oklahoma east of Guymon. The wind-farm will be comprised of (100) 1.5 MW GE/Enron wind turbines. The planned in service date for the 150 MW wind-farm is by June 30, 2005.

The location of the proposed 150 MW wind-farm is approximately 3 miles east of Guymon, Oklahoma. Please see Figure 1 of Appendix A, illustrating the location of the >Omitted Text< wind-farm.

The areas described in the interconnection request are two noncontiguous areas that are approximately 2.3 miles north of an existing SPS 115 kV transmission available for interconnection. The 115 kV line that is routed through the described area is a tie line to another utility and is not available for interconnection. Two alternative interconnections were considered.

Interconnection Options

This study determined the feasibility of interconnecting the 150 MW wind-farm to the SPS transmission with two available interconnection options. The first interconnection option considered in this study required constructing 6.5 miles of 115 kV transmission line tying the wind farm directly to the Texas County Interchange. The second interconnection option considered would require 2.3 miles of 115 kV transmission to tie the wind farm to the existing 115 kV transmission line between Texas County Interchange and Cole Interchange with a 3-breaker interconnection facility. Please see Figures 2 & 3 of Appendix A for illustrations of the interconnection options.

This study did not examine any transfer capability issues that may be caused by the interconnection of the 150 MW wind-farm. Such studies would be part of >Omitted Text< 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 2005 summer peak, 2005 winter peak, and 2004 spring load conditions. To create a 2006 spring (light-load) model, the SPP model for the 2004 spring was used to represent the expected 2006 spring light load conditions.

Due to the inductive electrical characteristics of the wind turbines, the >Omitted Text< >Omitted Text<wind farm was modeled at a constant 0.98 lagging power factor, (absorbing approximately 0.2 MVAR from the transmission grid for each MW generated). This assumes that the reactive power requirements of the wind-farm will be no worse. Typically, it is required of generating facilities to fully compensate for, or put back on the transmission system, the reactive power

consumed by their plant. Therefore a 32 MVAR capacitor bank was modeled on the wind farms 34.5 kV bus

There was no impedance information provided for the proposed 34.5/115 kV transformer. This transformer could be a low impedance autotransformer or a higher impedance 2-winding transformer. Therefore, 7% impedance on the 130 MVA base rating of the transformer was modeled.

<u>Study Method</u>

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.

Powerflow studies without the >Omitted Text< wind-farm were used to determine the existing or expected conditions. These conditions were considered the reference or “base case” conditions for which comparisons would be made. Then the proposed 150 MW 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 the >Omitted Text< wind-farm. 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 the >Omitted Text< wind-farm. Thus, if a transmission element overload is caused by the new wind-farm, >Omitted Text< is responsible for the costs to mitigate the overload.

Case models were developed for the two interconnection options and evaluated. These case models reflect the anticipated 2005 and 2006 seasonal load conditions. Please see the case model descriptions in Appendix B of this report.

<u>Power Flow Results</u>

The results of the powerflow studies for each case evaluated indicate that the 150 MW interconnection of the >Omitted Text< wind-farm will not cause any adverse loading or voltage problems for system intact conditions with either option. However, system intact power flow results do not indicate the adverse impacts caused by the added facilities due to single contingency outages.

Comparative Contingency Study Results

Throughout the single contingency studies of both interconnection options the >Omitted Text< wind farm was left at its full generating capacity of 150 MW at a constant 0.98 lagging power factor with a 32 MVAR capacitor bank modeled on the 34.5 kV bus. This did not vary from the case models of either interconnection option, or seasonal model.

Single contingency analysis of option 1 cases revealed interconnecting the 150 MW wind farm directly to Texas County Interchange created no new contingency overloads. However, manual manipulation of area capacitor banks at Texas County Interchange and Cole Interchange was necessary to prevent voltage levels from rising or falling below acceptable levels. No improvements to the existing transmission were required to resolve initial voltage problems.

Similar results were found for interconnection option 2. Single contingency analysis of option 2 cases revealed that no new contingency overloads were created by interconnecting the 150 MW wind farm by tapping into the 115 kV line between Texas County Interchange and Cole Interchange. However, with the exception of one contingency, the same manipulation of the capacitor banks at Texas County and Cole interchanges was necessary to prevent voltages above or below acceptable levels.

With the Option 2 interconnection, the contingency loss of the 115 kV line from Texas County to TC-Guymon substation was unresolved with the wind farm generating at 150 MW. Under this contingency condition, the wind farm would be left on the end of a long radial line, which would cause extreme low voltage conditions at the wind farm and TC-Guymon substation. Under this contingency condition, the wind farm would be limited to approximately 1/3 of its capacity (~50 MW).

Interconnection Requirements, Cost, and Construction Schedule

The following is the cost estimate summaries of the interconnection options do not include the costs for reactive power compensation, which may be necessary to control voltage levels in the area due to the variability of the wind farms output. Such equipment costs would be the requester’s responsibility.

Option 1 Interconnection:

Additional 115kv Line GCB at Texas County Interchange with protective relaying and metering.	$ 460,523
6.5 mi. 115 kV line construction to Texas Co with H-frame construction, 397.5 MCM ACSR conductor, steel corners and dead-ends.	$ 950,000
Right-of-Way for 6.5 Miles 115 kV line.	$ 100,750
Estimated Grand Total for Option 1	$ 1,511,273

Option 2 Interconnection:

115 kV 3-breaker ring interconnection facility including modifications to existing protective relaying and additional metering.	$ 995,216
2.3 mi. 115 kV line construction to Interconnection Facility with H-frame construction, 397.5 MCM ACSR conductor, steel corners and dead-ends.	$ 360,000
Right-of-Way for 2.3 Miles 115 kV line.	$ 35,650
Right-of-Way for Interconnection Facility.	$ 20,000
Estimated Grand Total for Option 2	$ 1,410,866

For both interconnection options, the estimated lead time required is 14 months. Preliminary one-line diagrams of the interconnection options may be seen in Figures 2 & 3 of Appendix A.

Conclusion

The >Omitted Text< 150 MW wind farm may be interconnected with either option to the Xcel Energy transmission system without system improvements provided adequate reactive power compensation is included in their facility to keep voltage levels at an acceptable level through the entire range of their generation capacity. Due to the variability of the wind farm's generation output, this may require a static-var-compensation (SVC) unit with both inductive and capacitive compensation.

Option 1 interconnection of the150 MW wind farm directly to Texas County Interchange will provide better transmission access without generation limitations due to single contingency outages. The cost to interconnect the wind farm directly to Texas County Interchange is estimated at $ 1,511,273.

Option 2 interconnection which ties the wind farm to the 115 kV line between Texas County and Cole interchanges will have a constrained generation levels at approximately 50 MW with the contingency loss of the 115 kV line toward Texas County Interchange. The cost for this interconnection option is estimated at $ 1,410,866.

This study has shown that the proposed >Omitted Text< 150 MW wind-farm would be a viable source of wind generation on the Xcel Energy transmission system with either interconnection option. However, Xcel Energy recommends interconnecting the 150 MW wind farm directly to Texas County Interchange as in Option 1 for its better transmission access without generation curtailment due to single contingency conditions.

Appendix A

>Omitted Text<

Wind Farm Location

And

Interconnection Options

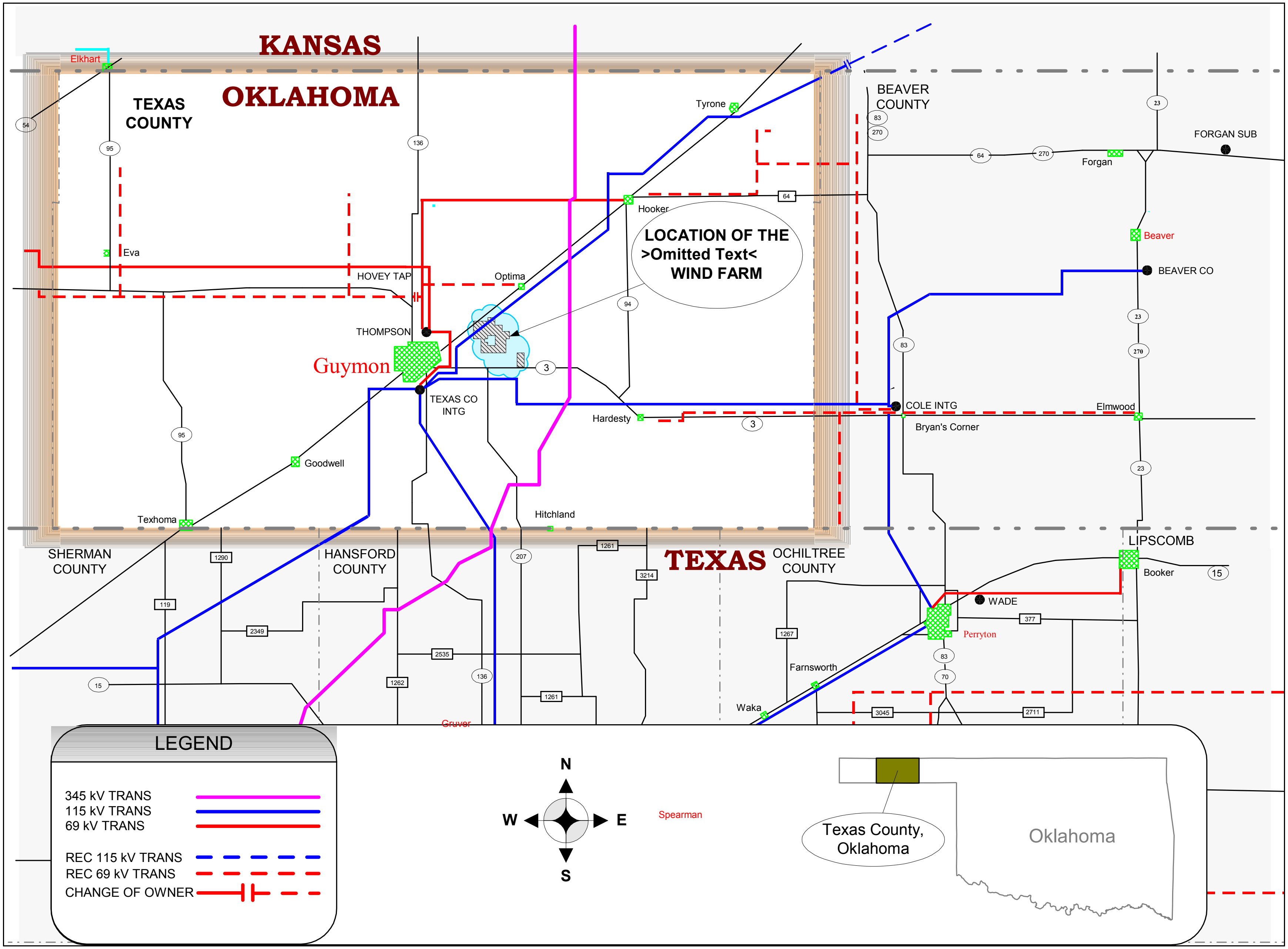

Figure 1 >Omitted Text< Wind Farm Location

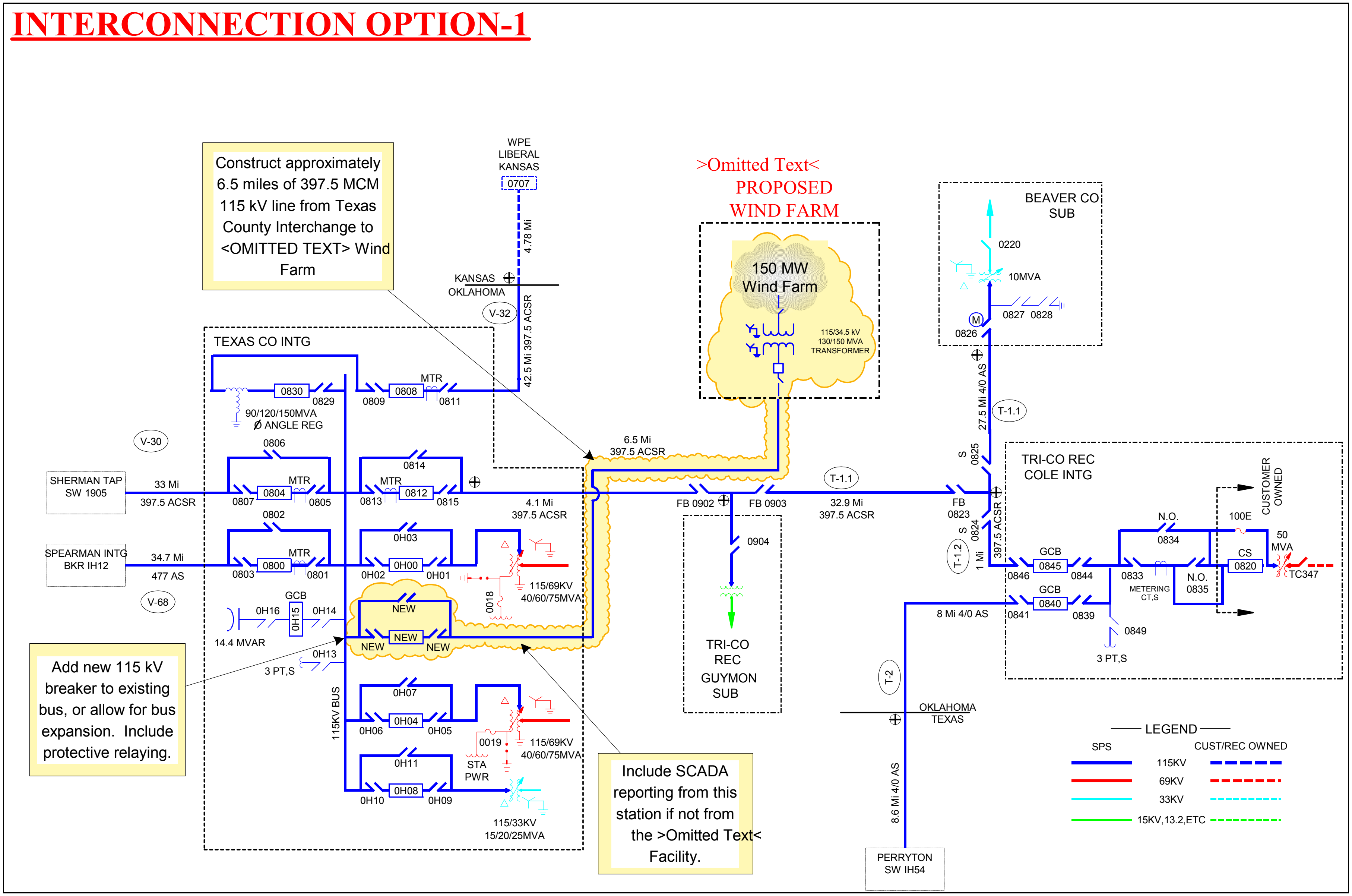

Figure 2: Option 1 Interconnection

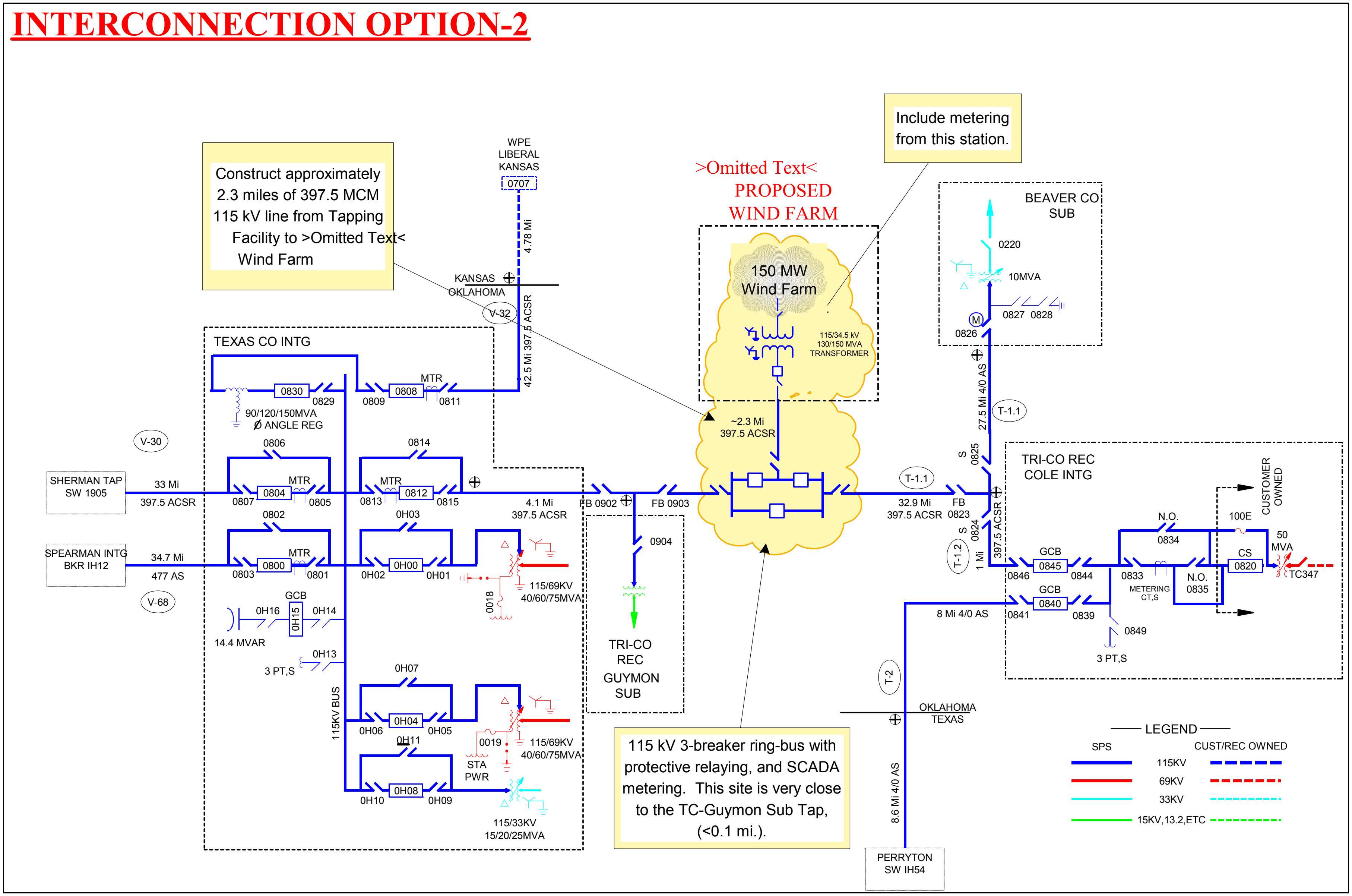

Figure 3: Option 2 Interconnection