



***Generation Interconnection  
Study for  
<OMITTED TEXT>***

***SPP Coordinated Planning  
(#GEN-2001-013)  
(#GEN-2001-014)***

**November, 2001**

## **Executive Summary**

<OMITTED TEXT> has requested a Generation Interconnection Study for interconnection of two different wind facilities in Harper County, Oklahoma. The first facility is rated at 96 MW and is located at a location named Sleeping Bear. The second location is rated at 25.5 MW and is located at the South Buffalo site. The requested point of interconnection for Sleeping Bear is near the Western Farmers Electric Cooperative (WFEC) Fort Supply 138kV substation. The interconnection point for the South Buffalo project is near the WFEC Buffalo 69kV substation. The projected in-service date of the facility is October 2002.

Dynamic stability analysis indicates the Sleeping Bear Facility is unstable under a single contingency outage scenario ((outage of the Fort Supply-Iodine (Mooreland) 138kV transmission line)) for its full output without new system reinforcements. Further dynamic stability analysis indicated that for the previous mentioned contingency, the output of the Sleeping Bear facility must be limited to 75 MW without system reinforcements. The South Buffalo facility full output of 25.5 MW was not limited by stability considerations.

Powerflow analysis indicates with local utilities serving their native load, the addition of the South Buffalo facility does not cause any additional overloads in the local northwest Oklahoma area. However, the output of the Sleeping Bear facility is further limited by the previously mentioned Fort Supply-Iodine 138kV line outage. When this outage occurs, all of the Sleeping Bear facility's output is delivered through the Fort Supply 138/69kV autotransformer, which has an emergency rating of 70 MVA. Therefore, the output of the Sleeping Bear facility is limited to 70 MW for powerflow. This study does not serve as an ATC study of available transmission capacity. The customer must request transmission service through the SPP OASIS in order to operate the facility.

There are two options for interconnecting the Sleeping Bear project. The first option consists of building a new WFEC substation at the <OMITTED TEXT> site. This cost of this option is \$1,510,000 and has a lead-time of 12 months. The second option consists of building a four mile 138kV line from Sleeping Bear to Fort Supply and modifying Fort Supply substation. This option costs \$1,866,000 and has a 12 month lead-time.

The South Buffalo project may be interconnected at a cost of \$900,000. The interconnection of the South Buffalo project consists of building a new WFEC 69kV substation near the project on the Buffalo-Fort Supply 69kV line. This project has a lead-time of 12 months.

## Introduction

<OMITTED TEXT> requested interconnection for a 96MW generating facility consisting of (77) 1.5 MW wind turbines produced by Enron. The Facility is located in northwestern Oklahoma in Harper County, Oklahoma and is named Sleeping Bear. The proposed method of interconnection is to interconnect into the 138kV substation bus at Fort Supply.

<OMITTED TEXT> also requested interconnection for a 25.5 MW generating facility consisting of (17) 1.5 MW wind turbines produced by Enron. The 25.5 MW project is also located in Harper County, Oklahoma and is called South Buffalo. The proposed method of interconnection is to build a substation on the WFEF Buffalo-Fort Supply 69kV transmission line approximately four (4) miles south of the Buffalo substation.

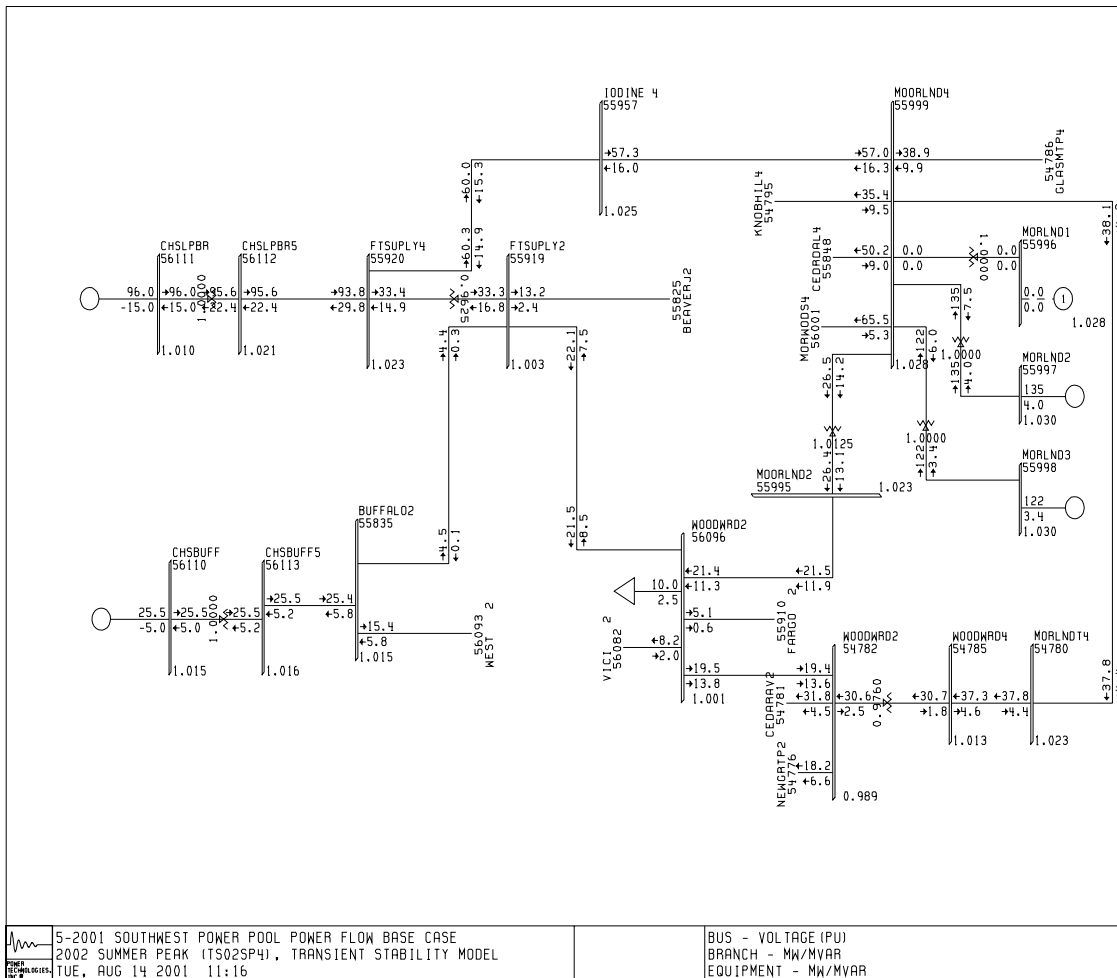


Figure 1. Transmission System in northwestern Oklahoma

The System Impact Study investigates the effect of the new generation on system performance during normal and contingency conditions. For purposes of this study, the power was absorbed into the system by lowering generation in Western Farmers Electric Cooperative system at Hugo Power Station and Anadarko Power Station.

The study investigated the plant's response in steady-state contingency, dynamic stability, and short circuit analysis.

The steady-state contingency analysis considers the impact of the new generation on transmission facility loading and transmission bus voltages for outages of transmission lines, autotransformers, and generators.

Stability analysis shows the effect of the new generation on the transient stability of WFEC and any surrounding utility generators. Transient stability is concerned with the recovery from faults on the transmission system that are in close proximity to generating facilities.

Short circuit analysis determines the whether the interruption capabilities of existing circuit breakers are exceeded with the addition of the new generation.

### **Steady State Analysis**

A steady state analysis was conducted for the facility. The steady-state analysis considers the impact of transfer on transmission line loadings for local area of the <OMITTED TEXT> facilities. This study does not take into account ATC analysis, which is performed when a customer requests transmission service on Southwest Power Pool's OASIS. A modified version of the 01 Series Southwest Power Pool 2004 summer peak base case was used for this study. The modified model includes transmission transactions that have been confirmed on Southwest Power Pool's OASIS since the release of the last model.

The analysis of the <OMITTED TEXT> Sleeping Bear facility shows that the proposed location cannot handle the full 96MW of output under single contingency situations of the Fort Supply 138kV bus without system upgrades. The Fort Supply 138kV bus has two points of interconnection. One is the 138kV line to Mooreland power station and the second is the autotransformer to the 69kV system. For an outage of the 138kV line to Mooreland, the entire plant output is directed through the 138/69kV autotransformer at Fort Supply, which is rated at 70 MVA normal and emergency. This caused an overload of 141% of the Fort Supply's autotransformer emergency rating. The Fort Supply-Woodward 69kV line, which has an emergency rating of 61 MVA, also loads to 124% of its emergency rating for the outage of the Fort Supply-Mooreland 138kV line.

The Sleeping Bear facility's output should be reduced to 70MW to alleviate overloading the Fort Supply autotransformer.

Analysis of the <OMITTED TEXT> South Buffalo 25.5 MW facility shows no overloads resulting from the addition of the generation.

Overloaded facilities are shown below in Table 1. With reduced output of the Sleeping Bear Facility, no new overloads or voltage violations were observed for the addition of the Customer generation in the local area. To obtain ATC values, the Customer shall request transmission service on the Southwest Power Pool OASIS.

**Table 1. – Facility Overloads caused by  
<OMITTED TEXT> Generation (CE) at full output**

Owner	Branch over 100% Rate B	Rate B (MVA)	% Loading before CE	% Loading After CE	Outaged Branch Causing Overload
WFEC	Fort Supply 138/69kV autotransformer	70	0	141	Fort Supply-Iodine 138kV
WFEC	Fort Supply-Woodward 69kV	61	32	124	Fort Supply-Iodine 138kV

**Table 2. – Facility Overloads caused by <OMITTED TEXT> Generation  
(CE) (reduce Sleeping Bear output to 70MW)**

Owner	Branch over 100% Rate B	Rate B (MVA)	% Loading before CE	% Loading After CE	Outaged Branch Causing Overload
	None				

Powerflow Analysis Methodology

The Southwest Power Pool (SPP) criteria state that the following conditions be met in order to maintain a reliable and stable system.

- 1) More probable contingency testing .... must conclude that
  - a) All facility loadings are within their emergency ratings and all voltages are within their emergency limits (0.90-1.05 per unit) and
  - b) Facility loadings can be returned to their normal limits within four hours
  
- 2) Less probable contingency testing ... shall conclude that

- a) Neither uncontrolled islanding, nor uncontrolled loss of large amounts of load will result.

More probable contingency testing is defined as losing any single piece of equipment or multi-circuit transmission lines. Less probable contingency testing involves the loss of any two critical pieces of equipment such as 345kV autotransformers and generating units or the loss of critical transmission lines in the same right-of-way.

The 01 Series Southwest Power Pool 2004 summer peak base case was used to model the transmission network and system loads

Using the created models and the ACCC function of PSS/E, single contingencies in the western Oklahoma zones of WFEC and Oklahoma Gas & Electric were analyzed.

### **Transient Stability Analysis**

Transient stability analysis was performed by Asea Brown Boveri (ABB) of Raleigh, North Carolina to verify dynamic system response to disturbances on the transmission system using the 2002 summer peak model. The Enron turbine machine data was supplied by <OMITTED TEXT> .

The Sleeping Bear substation consists of a 138kV bus with terminals to the Sleeping Bear facility and one each to Fort Supply 138kV substation and Iodine 138kV substation. 3 phase faults were simulated to each of these transmission lines and were cleared using a 5 cycle clearing time.

For a 3-phase fault on the Sleeping Bear-Iodine 138kV line cleared in 5 cycles by tripping the line, the Sleeping Bear generators are unstable. Further stability analysis reveals that the facility's output must be reduced to 75MW in order to maintain stability of the units.

Early conversations with <OMITTED TEXT> indicated that the customer did not wish to pursue system reinforcements that would alleviate instability of the Sleeping Bear turbines. Therefore, the interconnection agreement for the Sleeping Bear facility can allow for an interconnection of 70 MW because of the emergency limit of the Fort Supply autotransformer.

Stability analysis did not indicate any stability related problems with the South Buffalo 25.5 MW facility. The South Buffalo may be interconnected at the requested output of 25.5 MW.

The entire stability study from ABB is available upon request.

## **Short Circuit Analysis**

WFEC completed a short circuit study of the area to determine the impacts of the addition of the<OMITTED TEXT> facilities. Results showed there were no impacts due to the wind facilities that would cause any equipment to be replaced.

## **Facility Analysis**

Sleeping Bear - <OMITTED TEXT> supplied a one-line diagram with their proposed facility configuration. The wind turbines generating voltage is stepped up to 34.5kV distribution voltage system, which is terminated into the <OMITTED TEXT> Sleeping Bear substation. At the Sleeping Bear substation, Customer will provide a 138/34.5kV transformer to step the voltage up to WFEC transmission voltage. This station is approximately four miles from WFEC Fort Supply substation and is very near the Fort Supply-Mooreland transmission line.

WFEC has proposed two options for interconnecting into the Fort Supply 138kV substation. The first option consists of building a 3-breaker 138kV ring bus substation adjacent to the Customer substation. This substation will have terminals for lines to Fort Supply and Mooreland and for the Customer transformer. The existing WFEC transmission line will be split and brought into and dead-ended in the new substation. Additional relay modifications will be required at Mooreland and Fort Supply substations. The 138kV ring bus station will be built and owned by WFEC. The land for the substation shall be provided by <OMITTED TEXT> and deeded to WFEC. This option is estimated to cost \$1,510,000 and has a project lead time of 12 months.

WFEC's second proposed option for interconnecting the Sleeping Bear facility is to add a new line terminal at WFEC's Fort Supply substation. The addition of the terminal would include two (2) 138kV circuit breakers. A four mile, 138kV, 795MCM ACSR transmission line would be constructed from the Fort Supply substation to the proposed<OMITTED TEXT> substation. This option is estimated to cost \$1,190,000 for the substation work and \$676,000 for the transmission work for a total cost of \$1,866,000. This option also has a lead time of 12 months.

One-line configurations are shown in Appendix A. Sleeping Bear facility cost options are listed in Table 3.

**Table 3. – Sleeping Bear Facility Costs**

<b>Facility Option</b>	<b>Cost</b>	<b>Lead Time</b>
Option #1 – Build new substation	\$1,510,000	12 months
Option #2 – Modify Fort Supply substation and build new line	\$1,866,000	12 months

South Buffalo – <OMITTED TEXT> also supplied a one-line of the South Buffalo project. The configuration is similar to the Sleeping Bear facility except that the transmission voltage is 69kV to match the voltage at the WFECC Buffalo substation.

WFECC proposes to build a 2-breaker 69kV substation four miles south of Buffalo in the Fort Supply-Buffalo 69kV line. The station will have a single 69kV bus with a breaker on each terminal. Terminals will exist for lines to Buffalo and Fort Supply and for the <OMITTED TEXT> 69/34.5kV transformer. The circuit breaker supplied by <OMITTED TEXT> will be used for transformer and facility terminal relaying. Relay modifications will be necessary at Fort Supply and Buffalo substations. WFECC will build an own the new substation. Property for the station will be supplied by <OMITTED TEXT> and will be deeded to WFECC. Estimated cost of this work is \$900,000 and has a 12 month lead-time.

The one-line configuration is shown in Appendix A. The South Buffalo project cost is listed in Table 4.

**Table 4. – South Buffalo Facility Costs**

<b>Facility</b>	<b>Cost</b>	<b>Lead Time</b>
Build new substation four miles south of Buffalo	900,000	12 months



## **Conclusions**

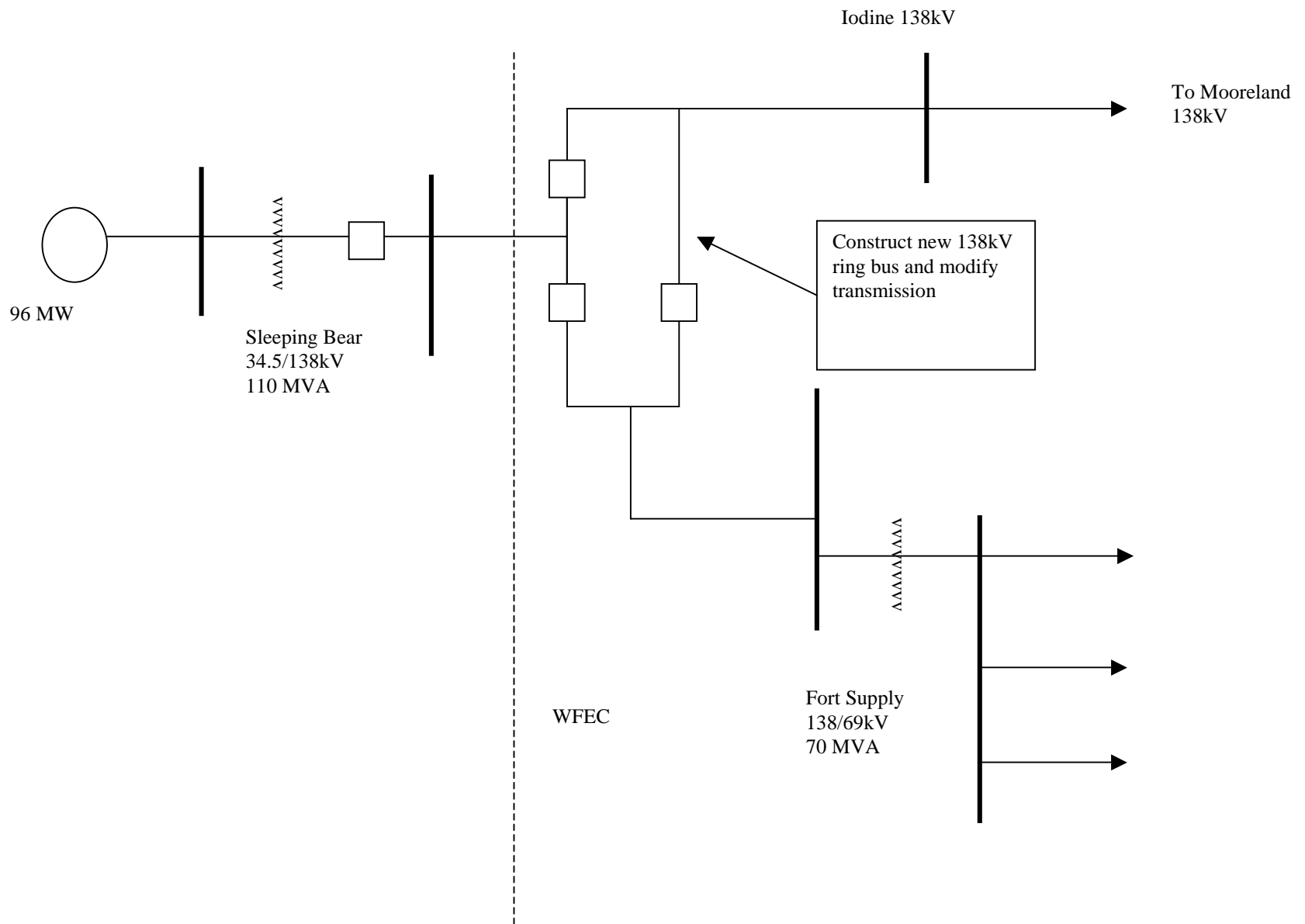
The <OMITTED TEXT> South Buffalo facility may be interconnected into the Western Farmers Electric Cooperative system at 25.5 MW without any system reinforcements. Without system reinforcements, the output of the <OMITTED TEXT>

Sleeping Bear facility is limited to 75 MW due to the instability caused by a 3 phase fault that causes the outage of the Sleeping Bear(Fort Supply)-Iodine 138kV line and is further limited to 70 MW due to the emergency rating of the Fort Supply autotransformer.

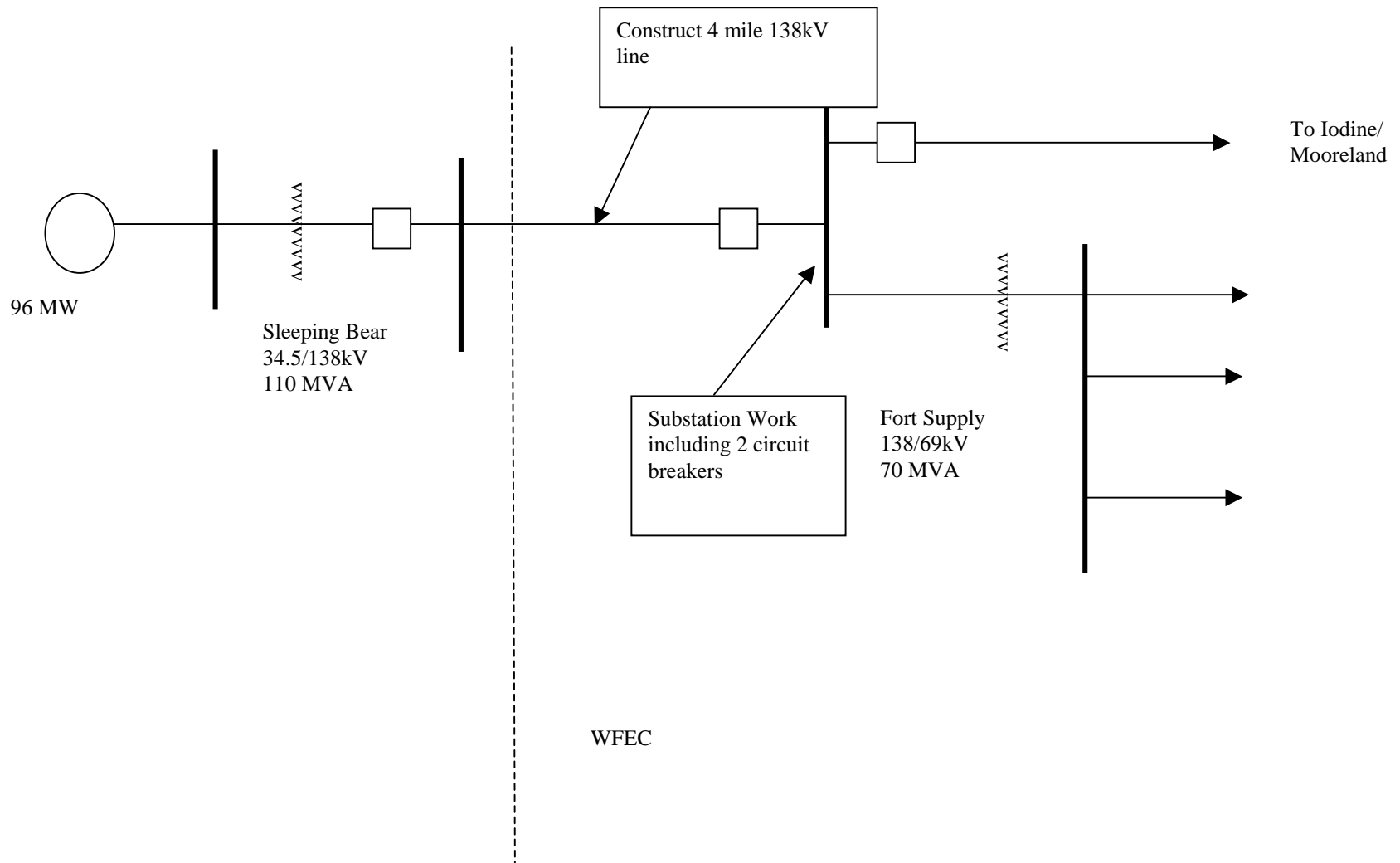
The South Buffalo Facility can be interconnected for 25.5 MW to the WFEC transmission system at its full output for a cost of \$900,000 and the facilities have a 12 month lead time. The Sleeping Bear facility can be interconnected at an output level of 70 MW for a cost of \$1,510,000 for the option of a new WFEC substation or at a cost \$1,866,000 for the option of building a new transmission line.

The costs do not include any costs associated with the deliverability of the energy to final customers. These costs are determined by separate studies if <OMITTED TEXT> requests transmission service on Southwest Power Pool's OASIS.

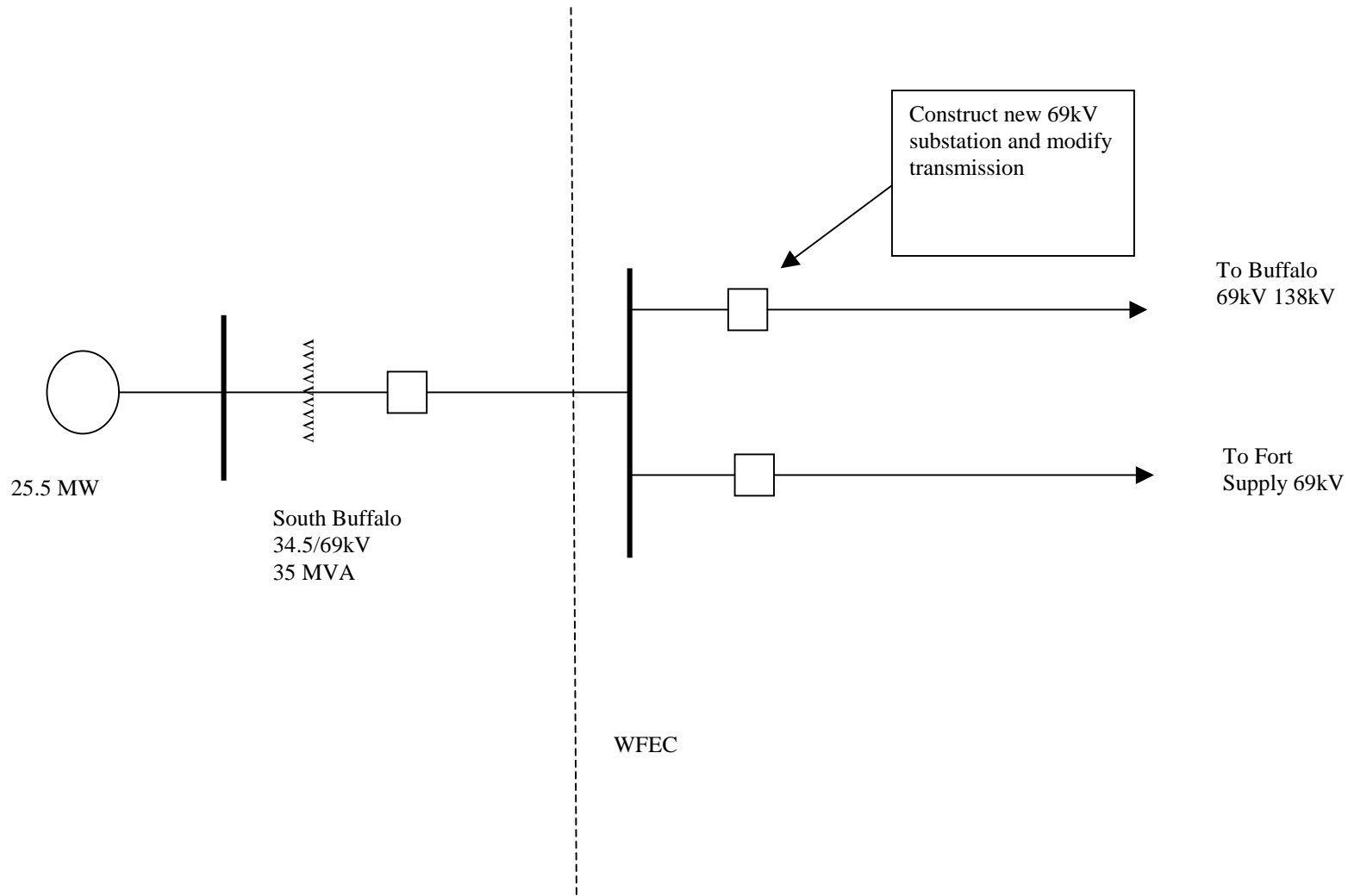
## **APPENDIX A. – ONE-LINE CONFIGURATIONS**



**Figure A-1. – Sleeping Bear Interconnection Option #1**



**Figure A-2. – Sleeping Bear Interconnection Option #2**



**Figure A-3. – South Buffalo Interconnection**