FEASIBILITY STUDY

[redacted] WIND PROJECT
150 MW GENERATION INTERCONNECTION
INTO THE LARAMIE RIVER STATION-STORY 345 KV

INTERCONNECTION CUSTOMER:
[redacted]

FINAL

04\25\08

Basin Electric Power Cooperative
Transmission Services

0.0 Executive Summary

This is the feasibility study for [redacted] Large Generator Interconnection request for 150 MW of wind generation into the Missouri Basin Power Project (MBPP) System. The proposed project is located approximately 8 miles east of Chugwater in Goshen County, Wyoming. The point of interconnection is on the LRS-Story 345 kV line.

The study is performed as described in the Interconnection Feasibility Study Agreement dated March 14, 2008. The "Interconnection Customer" is [redacted]. The "Transmission Provider" is Basin Electric Power Cooperative, as the operating agent for the MBPP System and administrator of the Basin Electric Power Cooperative West (BEPW) tariff. The Interconnection Customer requested that Network Resource Interconnection Service be studied, with the option for Energy Resource Interconnection. At this time a Transmission Service Request has not been submitted to the Transmission Provider, and there is no firm available transmission capacity on the MBPP System. The request for generation interconnection service in and of itself does not convey any right to deliver electricity to any specific customer or Point of Delivery. The Interconnection Customer has indicated interest in marketing the power in the Public Service of Colorado service area. For this reason the feasibility study analysis is performed on a summer peak load case with stressed TOT3 conditions.

The results indicate that the interconnection of the [redacted] Wind project overloads the LRS-Ault 345 kV line at a lower TOT3 transfer level then the existing rating. The overload can be eliminated by upgrading the terminal equipment on the LRS-Ault 345 kV line. The approximate cost for the upgraded equipment is $100,000. This cost estimate does not include installation costs, or owner's overhead. The generation interconnection into the LRS-Story 345 kV line also increased the loading on the LRS 345\230 kV transformer. This impact could be eliminated with an additional LRS 345\230 kV transformer, or by interconnecting the project at the LRS 230 kV bus. A second LRS 345\230 kV transformer would cost approximately $4.2 million. This cost estimate is for the transformer only and does not include the required substation upgrades, installation costs, or owner's overhead. In addition to these upgrades the remaining 22 TOT3 generation scenarios will need to be studied, as part of the future System Impact Study, to determine if any additional transmission upgrades are required to maintain the existing TOT3 transfer capabilities.

1.0 Introduction

[redacted] ("Interconnect Customer") has proposed the [redacted] Wind Generation Project. The [redacted] Wind project would utilize sixty of Clipper Windpower's Liberty series C93 2.5 MW generators for a total of 150 MW of wind generation. The Interconnect Customer proposes to interconnect into the Missouri Basin Power Project (MBPP) transmission system, for which Basin Electric ("Transmission Provider") is the operating agent. The point of interconnection is 15 miles south of the MBPP Laramie River Station (LRS) on the existing LRS-Story 345 kV line. The project site is approximately 8 miles east of Chugwater, in Goshen County, WY, and is located adjacent to the LRS-Story 345 kV line. The Feasibility Study Agreement for the Large Generator Interconnect request was received on March 14, 2008. The project in service date is October 1, 2012.

2.0 Study Scope

The study will determine the impacts of generation interconnection request by analyzing the transmission system both pre- and post- interconnection of the [redacted] Wind project. The study will include power flow, dynamic stability, and short circuit analysis at peak summer loads and TOT3 stressed.

The proposed point of interconnection for the project is directly north of WECC Path 36, or commonly known as TOT3. TOT3 defines the power transfer from southern Wyoming into northern Colorado.

TOT3 is defined as the combined north to south flow on the following lines:

- Laramie River-Ault 345 kV
- Laramie River-Story 345 kV
- Archer-Ault 230 kV
- Sidney-N. Yuma 230 kV
- Cheyenne-Ault 230 kV
- Cheyenne-Ault 115 kV
- Sidney-Peetz 115 kV

The transfer capabilities across TOT3 is dependant on the power schedule on the Stegall and Sidney DC ties, and the generation levels at the Laramie River Station, Pawnee, and Colorado Power Project (Brush) generation units. There are a total of 24 points on the TOT3 generation matrix. The scope of this study is to determine the impacts due to the interconnection of the [redacted] Wind project at two of the 24 generation points and at the same TOT3 transfer. This study will include the generation scenario that allows for the maximum TOT3 transfer, that being 1680 MW. This generation point includes LRS=1140 MW, Pawnee=777 MW, CPP=66 MW, and the Sidney and Stegall DC ties scheduled at 300 MW E-W. The 1680 MW rating is a result of the LRS-Story 345 kV outage and LRS-Ault 345 kV line loading to its limit. The second scenario that will be analyzed has the same LRS, Pawnee, CPP generation, but the DC ties are scheduled W-E.

Western Area Power Administration (WAPA) is in Phase 3 of WECC Path Rating Process to increase the TOT3 capabilities to 1680 MW. Their Miracle Mile Project includes upgrading one of the Miracle Mile-Cheyenne 115 kV lines to 230 kV, and a new Cheyenne-Ault 230 kV line. This study will include WAPA's Miracle Mile Project.

First the benchmark results will be determined by increasing the TOT3 north to south transfers and simulating area n-1 outages until the existing TOT3 limit is determined. Then the [redacted] Wind Project will be interconnected and generation north and south of TOT3 will be adjusted to achieve the same TOT3 transfer. The same n-1 outages will be simulated and the results will be compared to determine the interconnection impacts.

The analysis is performed according to NERC/WECC requirements and includes system intact and contingent (n-1) analysis. Transmission facilities 69 kV and higher are monitored in the study area. PSSE version 29.4 is used.

3.0 Base Case

This study will utilize the heavy summer base case that WAPA created for accrediting their Miracle Mile Project through the WECC Path Rating Process. This 2010 HS case was originally created for the Wyoming Joint Queue Study. WAPA has updated this case and it has been reviewed by members of their Peer Review Group to ensure accurate representation of regional area loads, resources, and transmission system configurations.

4.0 Modeling

The [redacted] Wind project is modeled with an equivalent generator model provided by [redacted]. The sixty 2.5 MW Liberty wind turbine generators are modeled as a single 150 MW 0.69 kV generator with the power factor fixed at .99 overexcited. The project is modeled at 100% of nameplate capacity. A single 0.69\34.5 kV GSU transformer is modeled with an impedance of 5.79% on a 175 MVA base. The 34.5\345 kV transformer is modeled with an impedance of 10% on a 175 MVA base. At the point of interconnection on the LRS-Story 345 kV a three breaker ring substation is modeled with a fault clearing time of 4 cycles.

5.0 Performance Criteria

System Normal (NERC/WECC Category A):
All bus voltages are within 0.95-1.05 per unit. All line and transformer loading is less than 100% of continuous rating.

Outage Conditions (NERC/WECC Category B, C, and D):

Steady State:
All bus voltages are within 0.90-1.10 per unit. All line and transformer loading is less than 100% of continuous rating or an established emergency rating. Solution calculation disables automatic transformer tap changing. Automatic shunt device switching is disabled.

Transient Stability:
First swing bus voltage dip is greater than 0.70 pu, generator rotor angles remain in synchronism and positive system damping occurs.

6.0 Steady State Powerflow Analysis Results

The purpose of steady state powerflow analysis is to determine the impacts that the [redacted] Wind project has on the transmission system during peak load and high TOT3 north-south transfers. System intact and contingency (n-1) analysis is provided. The forced outage list and powerflow summary reports are provided in Appendix A.

Currently the Laramie River Station has a generation restriction of 680 MW during the outage of either the LRS 345 kV lines. This is to protect the LRS 345\230 kV transformer in the event the second LRS 345 kV line is removed from service. Previous operational experience has also demonstrated that during periods of low TOT3 transfer and generation outages north of the Laramie River Station, the LRS 345\230 kV transformer can also become overloaded causing a LRS generation curtailment. The interconnection of the [redacted] Wind project on the LRS-Story 345 kV would agitate these transformer overloads. Initial system intact analysis of the loading on the LRS 345\230 kV transformer indicates that the 150 MW [redacted] Wind project increases the loading on the LRS transformer by approximately 65 MVA, or 10% of is rating. A second LRS 345\230 kV transformer or interconnection of this project at the LRS 230 kV substation would relieve this loading. A second LRS 345\230 kV transformer would cost approximately $4.2 million. This cost estimate is for the transformer only and does not include the required substation upgrades, installation, or owner's overhead.

6.1 DC Ties East to West

6.1.1 Existing System

The current TOT3 rating with LRS=1140 MW, Pawnee=777 MW, CPP=66 MW, and DC ties east to west is determined by the following:

Case Name	Forced Outage	Limiting Facility	Overload	TOT3
A1A45	LRS-Story 345 kV	LRS-Ault 345 kV	100.7 % of 956 MVA	1680

6.1.2 150 MW [redacted] Wind Project

The same scenario is created with the addition of the [redacted] Wind project at 150 MW and TOT3 at 1680.

Case Name	Forced Outage	Limiting Facility	Overload	TOT3
A2A40	[redacted]Wnd-Story 345 kV	LRS-Ault 345 kV	104.1 % of 956 MVA	1680

It is concluded that with TOT3 transfers constant at 1680 MW, a 150 MW [redacted] Wind project would increase the LRS-Ault 345 kV line loading by 34 MVA, or 3.6% of its 956 MVA rating. The LRS-Ault 345 kV overload can be eliminated by upgrading the terminal equipment on the LRS-Ault 345 kV line. Preliminary investigation indicates that the PLC wave traps and line disconnects on both ends of the line would require upgrading. With the upgraded equipment the line rating would be raised to 1200 MVA. The approximate cost for the upgraded equipment is $100,000. This estimate does not include installation costs, or owner's overhead.

6.2 DC Ties West to East

6.2.1 Existing System

The current TOT3 limit with LRS=1140 MW, Pawnee=777 MW, CPP=66 MW, and DC ties 300 MW W-E is determined by the loading on the Gering-McGrew 115 kV line during the Stegall-Sidney 230 kV outage.

Case Name	Forced Outage	Limiting Facility	Overload	TOT3
A1C38	Stegall-Sidney 230 kV	Gering-McGrew 115 kV	99.5% of 109 MVA	1146

It is also observed that the loading on the LRS-Stegall 230 kV, during the LRS-Ault 345 kV outage, is 103% of its 478 MVA rating. This is within its emergency rating of 117%, or 560 MVA.

6.2.2 150 MW [redacted] Wind Project

The same scenario is created with the addition of the [redacted] Wind project at 150 MW and TOT3 at 1150 MW. The loading on the Gering-McGrew 115 kV line is relieved with the addition of the 150 MW [redacted] Wind project. During the LRS-Ault 345 kV outage the loading on the LRS-Stegall 230 kV line and the LRS 345\230 kV transformer increases.

Case Name	Forced Outage	Limiting Facility	Overload	TOT3
A2C32	LRS-Ault 345 kV	LRS-Stegall 230 kV	112.2% of 478 MVA	1150
		LRS 345\230 kV	104.6% of 600 MVA	

The LRS-Stegall 230 kV loading is within its emergency rating 117%, or 560 MVA. The loading on the LRS 345\230 kV transformer is also within its emergency rating of 120%, or 720 MVA. It is concluded that at this TOT3 generation point the interconnection of the 150 MW [redacted] Wind Project meets study criteria.

7.0 Transient Stability Analysis Results

The heavy summer transient stability analysis is performed at the same TOT3 generation points and TOT3 flows as the steady state analysis.

LRS=1140, Pawnee=777, CPP=66, DC Ties=300 E-W, TOT3=1680
LRS=1140, Pawnee=777, CPP=66, DC Ties=300 W-E, TOT3=1146

The transient stability analysis includes the following disturbances:

#1 - 4 cycle 3-phase fault at the Laramie River 345 kV bus and loss of the LRS-Ault 345 kV line
#2 - 4 cycle 3-phase fault at the Laramie River 345 kV bus and loss of the LRS-Story 345 kV line (pre-interconnection of [redacted] Wind)
#3 - 4 cycle 3-phase fault at the Laramie River 345 kV bus and loss of the LRS-[redacted] Wind 345 kV line (post-interconnection of [redacted] Wind)
#4 - 4 cycle 3-phase fault at the [redacted] Wind 345 kV bus and loss of the [redacted] Wind-LRS 345 kV line (post-interconnection of [redacted] Wind)
#5 - 4 cycle 3-phase fault at the [redacted] Wind 345 kV bus and loss of the [redacted] Wind-Story 345 kV line (post-interconnection of [redacted] Wind)

The transient stability plots and summaries are provided in Appendix B.

7.1 DC Ties East to West

7.1.1 Existing System

The disturbance list is simulated with LRS=1140 MW, Pawnee=777 MW, CPP=66 MW, DC ties=300 MW E-W, and TOT3 at 1680 MW. The existing system satisfies study criteria.

Fault	Min. Voltage Dip
#1	BRIDGEPT115. = 0.7442
#2	BRIDGEPT115. = 0.8426
#3	N\A
#4	N\A
#5	N\A

7.1.2 150 MW [redacted] Wind Project

The same scenario is created with the addition of the [redacted] Wind project at 150 MW and TOT3 at 1680.

Fault	Min. Voltage Dip
#1	BRIDGEPT115. = 0.7240
#2	N\A
#3	SKYLINE 115. = 0.8862
#4	SKYLINE 115. = 0.9147
#5	BRIDGEPT115. = 0.8833

The stability margin is reduced due to the addition of the 150 MW [redacted] Wind Project, but study criteria is satisfied.

7.2 DC Ties West to East

7.2.1 Existing System

The disturbance list is simulated with LRS=1140 MW, Pawnee=777 MW, CPP=66 MW, DC ties=300 MW W-E, and TOT3 at 1146 MW. The existing system meets study criteria.

Fault	Min. Voltage Dip
#1	HAXTUN 115. = 0.8119
#2	BRIDGEPT115. = 0.8781
#3	N\A
#4	N\A
#5	N\A

7.2.2 150 MW [redacted] Wind Project

The same scenario is created with the addition of the [redacted] Wind project at 150 MW and TOT3 at 1150 MW.

Fault	Min. Voltage Dip
#1	HAXTUN 115. = 0.7961
#2	N\A
#3	LAR.RIVR345. = 0.9010
#4	BRIDGEPT115. = 0.9408
#5	BRIDGEPT115. = 0.9136

At this TOT3 generation point study criteria is satisfied with the addition of the 150 MW [redacted] Wind Project.

8.0 Short Circuit Analysis

Short circuit analysis is performed on the LRS 345 kV and the [redacted] Wind 345 kV buses. The analysis indicates the following short circuit currents:

Fault	Fault Current
LRS 345 kV 3-phase	14,000 amps
LRS 345 kV SLG	17,000 amps
[redacted] Wind 345 kV 3-phase	9,500 amps
[redacted] Wind 345 kV SLG	8,200 amps

The Clipper Windpower Liberty series wind turbines utilize power electronics to convert the variable wind power to the electrical output power. The power inverters are current limiting and therefore have negligible contributions to the fault currents. Existing equipment at the LRS 345 kV substation can accommodate these fault currents.

9.0 Conclusions

This analysis considers the interconnection of the [redacted] Wind project into the LRS-Story 345 kV line on the MBPP transmission system. Steady state and transient stability analysis is performed on two of the 24 points of the TOT3 generation matrix. As the interconnection study proceeds with the System Impact Study, all 24 TOT3 generation points will need to be studied to see how the interconnection of the [redacted] Wind project affects each of these TOT3 limits and to ensure that the existing TOT3 transfer rights are not affected.

The results for the two TOT3 generation points that were studied indicate that the interconnection of the 150 MW [redacted] Wind project decreases the TOT3 transfer capabilities. This is due to the increased loading of the LRS-Ault 345 kV line during the outage of the LRS-Story 345 kV line. The LRS-Ault line rating can be increased by upgrading the terminal equipment. The approximate cost for the upgraded equipment is $100,000. This cost estimate does not include installation costs, or owner's overhead.

The interconnection of the [redacted] Wind project into the LRS-Story 345 kV line would increase the loading on the LRS 345\230 kV transformer. Initial system intact analysis of the loading on the LRS 345\230 kV transformer indicates that the [redacted] Wind project increases the loading on the transformer by approximately 65 MVA, or 10% of its rating. To eliminate this impact a second LRS 345\230 kV transformer could be installed, or the project could be interconnected into the LRS 230 kV system. A second LRS 345\230 kV transformer would cost approximately $4.2 million. This cost estimate is for the transformer only and does not include the required substation upgrades, installation costs, and owner's overhead.

The Interconnection Customer has not submitted a Transmission Service Request to the Transmission Provider. The request for generation interconnection service in and of itself does not convey any right to deliver electricity to any specific customer or Point of Delivery. Before proceeding with the System Impact Study the Interconnecting Customer may want to consider submitting a Transmission Service Request as no firm transmission capacity is available on the BEPW tariff.