Southwest Power Pool

Addendum to Facility Study for Generation Interconnection Request GEN – 2002 – 008

SPP Coordinated Planning
(#GEN-2002-008)

October 2004

Summary

Xcel Energy performed the following study at the request of the Southwest Power Pool (SPP) for SPP Generation Interconnection request Gen-2002-008. The request for interconnection was placed with SPP in accordance SPP's Open Access Transmission Tariff, which covers new generation interconnections on SPP's transmission system.

Pursuant to the tariff, Xcel Energy was asked to perform a detailed Electromagnetic Transient Program analysis. This study determined the transmission line reactor sizes required to accommodate the Generation Interconnection Gen-2002-008. These reactor sizes will be used to when performing the Electromagnetic Transient Program analysis. Xcel Energy contracted with Shaw Power Technologies Inc. (Shaw PTI) to complete this sizing analysis since Shaw PTI had accomplished the Impact study. The Electromagnetic Transient Program analysis when completed will satisfy the Facility Study Agreement executed by the Customer and SPP.

ADDENDUM:

FACILITY STUDY FOR
>TEXT OMITTED<
(Transmission Line Reactor Requirements)

SPP #GEN-2002-008

October 18, 2004

Xcel Energy Services, Inc.
Transmission Planning

Introduction

This study report is to address results of a transmission line reactor study used to determined the type of line reactors required on the existing Southwestern Public Service (SPS) 345kV transmission circuit J03, which may be needed to accommodate the generator interconnection request #GEN-2002-008. The system impact study report recently completed for this wind farm project by Power Technologies, Inc. (PTI) does not indicate whether transmission line reactors might be required. Thus this study was conducted to determine the exact size and location of the line reactors for the interconnection of this wind farm. Additionally, since the existing transmission circuit already had line reactors at both Potter County and Finney, it was necessary to check if indeed line reactors would be required due to the power factor characteristic of most wind farms.

This study uses two Southwest Power Pool (SPP) 2004 series power flow models, a 2005 April Minimum and a 2005 Summer Peak model with emphasis placed on the 2005 April Minimum Model. The 2005 Summer Peak Model was considered since the April minimum model showed no power flowing into or out of the west through the Lamar HVDC converter. The 2005 summer model does show 105 MW into the SPP region and voltage effects as a result of the additional power flow needed to be addressed.

Study

In both power flow models existing transmission line reactors in-service during this study included the Potter County reactor (75 MVAr, Fixed), the Finney reactors (50 MVAr fixed, 50 MVAr switched) and the Lamar switched reactor (50 MVAr). Additionally, a 25 MVAr reactor on the tertiary bus of the 345/230kV autotransformer at Potter County was also in-service and an additional 25 MVAr was available. A simplified one-line diagram of the transmission circuit J03 that includes the new switching station and resulting line sections from the proposed transmission tap is included in Figure 1.

This study involved opening transmission line breakers at each end of the new line sections, to determine bus voltage behavior on all the buses between Potter County and Lamar as a result of power flows and Ferranti effects. The tables in Appendix A show the bus voltages for each case studied with the respective switching station breakers opened. The scenarios studied included load flow cases with the wind farm at zero output and with the wind farm at full output, Table 1 below defines the load flow cases with the wind farm's operational status.

Table 1, Cases Studied Showing Wind Farm's Status

Case Number	Status
05AP(GP)-41008-0010.sav	OFF
05AP(GP)-41008-0020.sav	At full output
05SP(J03)-41008-0010.sav	OFF
05SP(J03)-41008-0020.sav	At full output

Results

The results of this study indicate that the highest bus voltages on circuit J03 will occur during periods of light load. These observations were taken from the April minimum case and were reinforced by the summer peak case, although the bus voltages were not as high as in the summer peak case. The location showing the highest bus voltage was at the Finney switching station and the new switching station for the April Minimum case with all the generation off-line. The bus voltage at both Finney and the #GEN-2002-008 switching station, during periods of light load, reached the value of 1.068 pu of nominal when breakers OR70–OR65 at Finney were open. The opening of this breaker raised the voltage 6.1% as a result of the Ferranti effect. Table 2 through Table 5 in Appendix A show the bus voltages along the 345kV transmission system between Potter County Interchange and the Lamar Switching Station for the different switching scenarios considered. Additionally, the underground 34.5 kV collection system of the wind farm was not considered in this study. This results in the possibility of obtaining slightly higher voltages if the wind farm is generating little to no power due to the high reactance of underground cables, which are typically used in wind farm collection systems.

Although the voltage was not excessively high, a line reactor on the line between this new switching station and the Finney switching would help suppress the voltage in the event it is needed during line switching. Since a 50 MVAr line reactor is already installed at Finney, the location chosen for the addition of new 25 MVAr line reactor was at the new switching station as shown in Figure 1. As expected the 25 MVAr reactor helped suppress voltages at all the bus locations along the transmission circuit J03, and the results are shown in both Table 6 and Table 7.

Another consideration was placing the 25 MVAr reactor on the tertiary of the 345/115kV autotransformer at the switching station. However the possibility could pose a potential problem if the autotransformer is out of service when the line needs to be switched. Thus this consideration was not studied since it could render the reactor unavailable when called upon.

Conclusions

Based on the outcome of this study it is determined that the addition of a 25 MVAr reactor at the proposed location, as shown in Figure 1, benefits bus voltages during periods of light load. However, considering that the bus voltages were not excessively high it is recommended that no transmission line reactors be installed.

Cost Estimates

Since the conclusions indicated that the need for line reactors was not necessary, a cost adjust has been made to the estimate provided in the facility study for the generator interconnection request, #GEN-2002-008, completed September 16, 2004. The cost of item 1 in Table 1 of the facility study, labeled *"Required Interconnection Projects"*, needs to be modified to show the elimination of the line reactors. The new cost for the construction of the 345kV ring bus is $ 3,565,921.

Appendix A

2005 April Minimum Load Flow Cases

Table 2, Case 05AP(GP)-41008-0010.sav

	Highest Switching Station Bus Voltages Observed			
OPEN Breaker(s)	Lamar	Finney	#GEN-2002-008	Potter
system intact	1.003	1.007	1.032	1.005
OR90–OR70	1.043	1.047	1.056	1.015
OR70–OR65	0.995	1.068	1.068	1.020
D–E	1.005	1.009	1.040	1.003
D–F	1.005	1.009	1.040	1.003
2R05	1.007	1.011	1.047	1.030

Table 3, Case 05AP(GP)-41008-0020.sav

	Highest Switching Station Bus Voltages Observed			
OPEN Breaker(s)	Lamar	Finney	#GEN-2002-008	Potter
system intact	1.002	1.006	1.029	0.998
OR90–OR70	1.035	1.038	1.047	1.004
OR70–OR65	0.995	1.059	1.060	1.008
D–E	1.005	1.009	1.040	0.992
D–F	0.997	1.001	1.033	1.001
2R05	0.999	1.002	1.040	1.023

2005 Summer Peak Load Flow Cases

Table 4, Case 05SP(J03)-41008-0010.sav

	Highest Switching Station Bus Voltages Observed			
OPEN Breaker(s)	Lamar	Finney	#GEN-2002-008	Potter
system intact	1.014	1.014	1.029	0.999
OR90–OR70	1.036	1.036	1.044	1.005
OR70–OR65	1.008	1.061	1.062	1.013
D–E	1.019	1.019	1.051	0.997
D–F	1.019	1.019	1.051	0.997
2R05	1.021	1.021	1.058	1.040

Table 5, Case 05SP(J03)-41008-0020.sav

	Highest Switching Station Bus Voltages Observed			
OPEN Breaker(s)	Lamar	Finney	#GEN-2002-008	Potter
system intact	1.013	1.013	1.023	0.989
OR90–OR70	1.013	1.013	1.021	0.986
OR70–OR65	1.008	1.056	1.056	1.005
D–E	1.019	1.019	1.051	0.988
D–F	1.009	1.009	1.042	0.997
2R05	1.012	1.011	1.050	1.032

Load Flow Cases With A 25 MVAr Reactor At The #GEN-2002-008 Switching Station

Table 6, Case 05AP(GP)-41008-001A.sav [1]

	Highest Switching Station Bus Voltages Observed			
OPEN Breaker(s)	Lamar	Finney	#GEN-2002-008	Potter
system intact	1.000	1.004	1.021	1.001
OR90–OR70	1.022	1.025	1.034	1.007
OR70–OR65	0.995	1.045	1.046	1.011
D–E	1.000	1.003	1.025	1.003
D–F	1.000	1.003	1.025	1.003
2R05	1.001	1.005	1.025	1.008

Table 7, Case 05SP(J03)-41008-001A.sav [2]

	Highest Switching Station Bus Voltages Observed			
OPEN Breaker(s)	Lamar	Finney	#GEN-2002-008	Potter
system intact	1.011	1.011	1.018	0.995
OR90–OR70	1.014	1.014	1.022	0.997
OR70–OR65	1.008	1.039	1.039	1.005
D–E	1.014	1.014	1.029	0.997
D–F	1.014	1.014	1.029	0.997
2R05	1.016	1.015	1.036	1.018

[1] Re-run of case 05AP(GP)-41008-0010.sav with a 25 MVAr line reactor at the proposed location shown in Figure 1.
[2] Re-run of case 05SP(J03)-41008-0010.sav with a 25 MVAr line reactor at the proposed location shown in Figure 1.

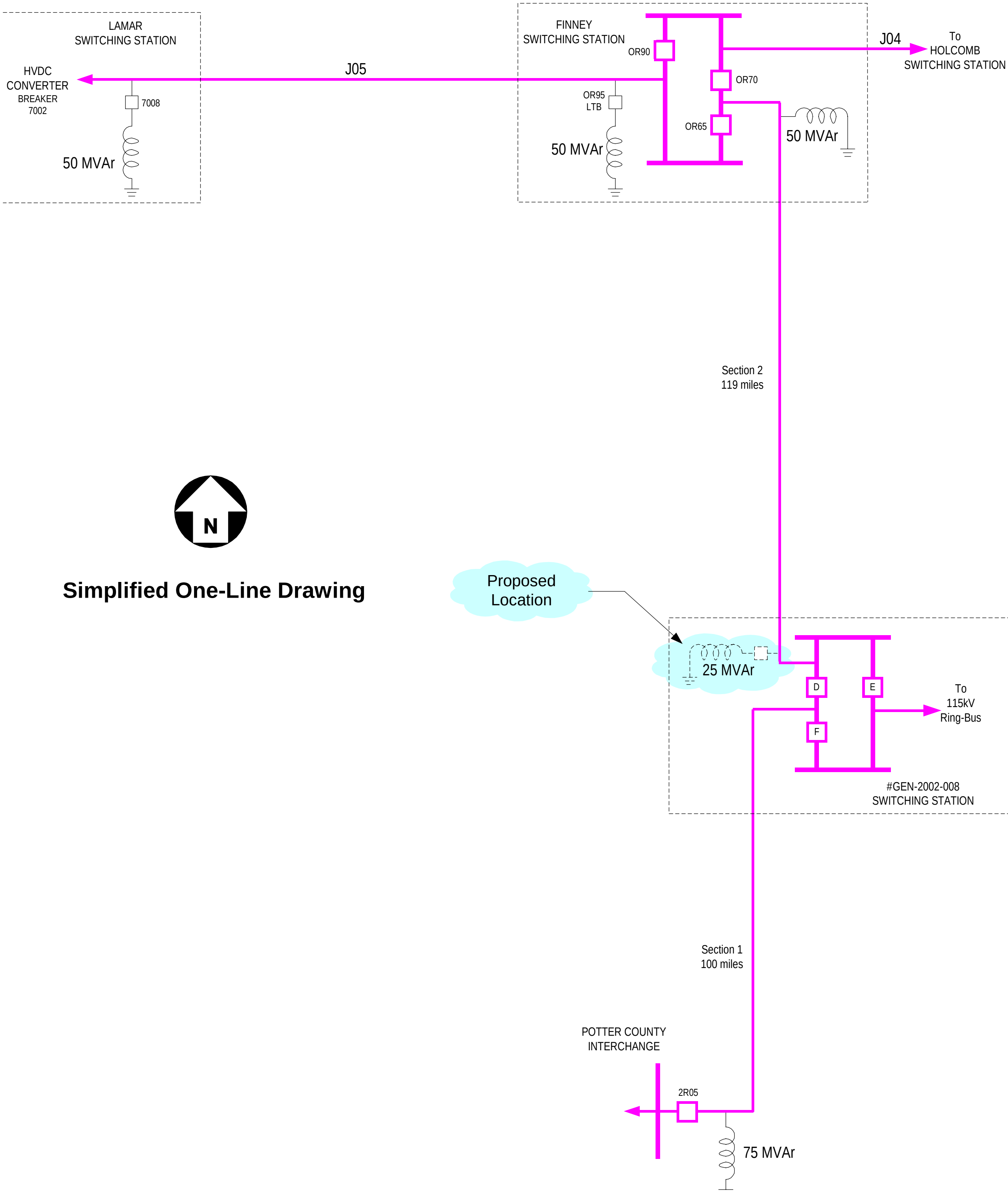

Figure 1, Potter-Lamar 345kV Transmission