SPP Southwest Power Pool

Impact Study For Generation Interconnection Request GEN-2006-019

SPP Tariff Studies

(#GEN-2006-019)

February, 2007

Executive Summary

<OMITTED TEXT> (Customer) has requested a Feasibility/Impact Study for the purpose of interconnecting 275 MW net generation into the facilities of City Utilities of Springfield (SPRM), in Greene County, Missouri. The proposed coal fired steam turbine has a proposed point of interconnection at the 161kV bus of SPRM's Southwest Power Station. The proposed in-service date is October 1, 2010.

Power flow analysis has indicated that for the powerflow cases studied, it is possible to interconnect the 275MW of generation with transmission system reinforcements within the local transmission systems.

The requirements for interconnection consist of expanding the existing 161kV bus at Southwest Power Station and adding a new 161kV line terminal. The total cost for expanding the bus and adding the terminal, the required interconnection facility, is estimated at $3,200,000. Other Network Constraints in the SPRM and Westar transmission systems that may be verified with a transmission service request and associated studies are listed in Table 3. These Network Constraints are in the local area of the new generation when this generation is sunk throughout the SPP footprint for the Energy Resource (ER) Interconnection request. With a defined source and sink in a Transmission Service Request (TSR), this list of Network Constraints will be refined and expanded to account for all Network Upgrade requirements. This cost does not include building any Customer facilities beyond the point of interconnection. This cost does not include any facilities that may be necessary due to short circuit fault duty considerations. These facilities will be identified in the Facility Study if the Customer executes a Facility Study Agreement.

In Table 4, a value of Available Transfer Capability (ATC) associated with each overloaded facility is included. These values may be used by the Customer for future analyses including the determination of lower generation capacity levels that may be installed. When transmission service associated with this interconnection is evaluated, the loading of the facilities listed in this table may be greater due to higher priority reservations. If the loading of a facility is higher, the level of ATC will be lower. These contingency analyses will have to be re-evaluated as part of a transmission service request.

A dynamic stability study was conducted by Pterra Consulting (Pterra) in Albany, New York. Stability studies showed no problems associated with interconnecting the requested generation. The entire study can be found in Attachment 1.

There are several other proposed generation additions in the general area of the Customer's facility. It was assumed in this preliminary analysis that these other projects within the local area will be in service. Those previously queued projects that have advanced to nearly complete phases were included in this Feasibility/Impact Study. In the event that another request for a generation interconnection with a higher priority withdraws, then this request may have to be re-evaluated to determine the local Network Constraints.

The required interconnection costs listed in Table 2 and other upgrades associated with Network Constraints listed in Table 3 do not include all costs associated with the deliverability of the energy to final customers. These costs are determined by separate studies if the Customer requests transmission service through Southwest Power Pool's OASIS.

Introduction

<OMITTED TEXT> (Customer) has requested an Impact Study for the purpose of interconnecting a 275MW coal-fired steam turbine into the facilities of City Utilities of Springfield (SPRM). The plant site is located in Greene County, Missouri at the existing Southwest Power Station, which is owned by SPRM. The proposed method of interconnection is to add a new terminal at the 161kV bus at Southwest Station. The proposed in service date for the generation is October 1, 2010.

Interconnection Facilities

The primary objective of this study is to identify the system problems associated with connecting the plant to the area transmission system. The Feasibility and other subsequent Interconnection Studies are designed to identify attachment facilities, Network Upgrades and other direct assignment facilities needed to accept power into the grid at the interconnection receipt point.

The Customer's generator, per documentation provided by the Customer will be 21kV, 370MVA machine with approximate power capabilities of 300MW and auxiliary load of approximately 25MW. The Customer's GSU high side will interconnect at 161kV at the Southwest Power Station owned by SPRM. The requirements for interconnection consist of expanding the existing 161kV bus at Southwest Power Station to accommodate the new generating unit and adding a new 161kV terminal.

The total cost for expanding the 161kV bus and adding a new 161kV terminal into the Southwest Power Station and miscellaneous transmission construction, the required interconnection facility, is estimated at $3,200,000. These estimates will be refined during the development of the Facility study based on the final designs. This cost does not include building the 161kV facilities from the Customer substation into the SPRM Southwest Power Station 161kV bus. The Customer is responsible for these 161kV facilities up to the point of interconnection. This cost also does not include the Customer's 161kV step-down substation, which should be determined by the Customer.

The costs of interconnecting the facility to the SPRM transmission system are listed in Table 1 & 2. **These costs do not include any cost that might be associated with short circuit study results**. These costs will be determined when and if a Facility Study is conducted.

Other Network Constraints in the SPRM and Westar transmission systems that were identified are listed in Table 3.

A preliminary one-line drawing of the interconnection and direct assigned facilities are shown in Figure 1.

Table 1: Direct Assignment Facilities

Facility	ESTIMATED COST (2007 DOLLARS)
Customer – 161kV Step-down Facilities	*
Customer – 161kV facilities between Customer Step-down facility and Southwest Power Station	*
Customer - Right-of-Way for Customer facilities.	*
Total	*****

Note: *Estimates of cost to be determined by Customer.

Table 2: Required Interconnection Network Upgrade Facilities

Facility	ESTIMATED COST (2007 DOLLARS)
SPRM – Expand the 161kV bus and add a 161kV line terminal to Southwest Power Station	$3,200,000
Total	**$3,200,000**

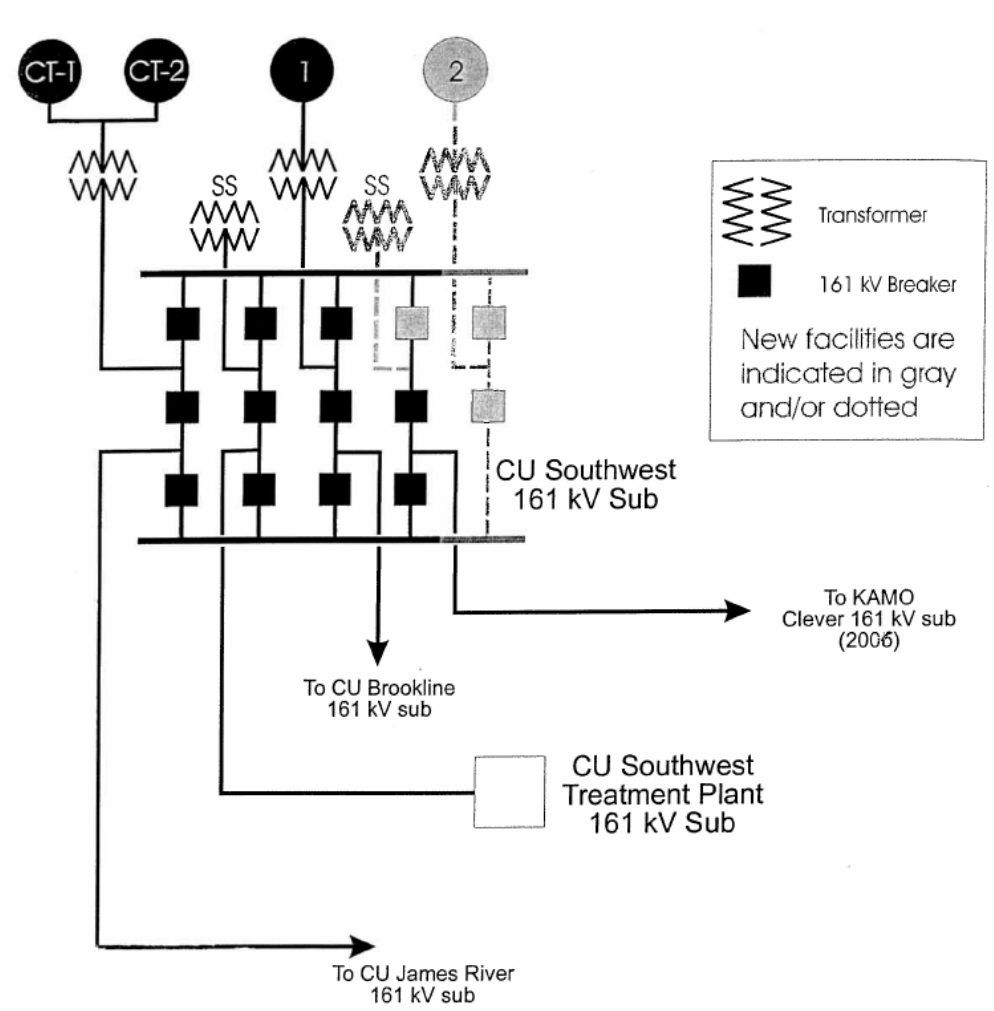

Figure 1: Proposed Interconnection
(Final substation design to be determined)

Powerflow Analysis

A powerflow analysis was conducted for the facility using modified versions of the 2011 Summer and Winter Peak, and 2016 Summer Peak models. The output of the Customer's facility was offset in each model by a reduction in output of existing online SPP generation. This method allows the request to be studied as an Energy Resource (ER) Interconnection request. The proposed in-service date of the generation is October 1, 2010. The available seasonal models used were through the 2016 Summer Peak of which is the end of the current SPP planning horizon.

The analysis of the Customer's project indicates that, given the requested generation level of 275MW and location, additional criteria violations will occur on the existing SPRM and Westar transmission systems under steady state and contingency conditions in the peak seasons.

In Table 4, a value of Available Transfer Capability (ATC) associated with each overloaded facility is included. These values may be used by the Customer to determine lower generation capacity levels that may be installed. When transmission service associated with this interconnection is evaluated, the loading of the facilities listed in this table may be greater due to higher priority reservations. When a facility is overloaded for more than one contingency, only the highest loading on the facility for each season is included in the table.

There are several other proposed generation additions in the general area of the Customer's facility. These local projects that were previously queued were assumed to be in service in this Feasibility Study. Those local projects that were previously queued and have advanced to nearly complete phases were included in this Feasibility Study.

Powerflow Analysis Methodology

The Southwest Power Pool (SPP) criteria states that: "The transmission system of the SPP region shall be planned and constructed so that the contingencies as set forth in the Criteria will meet the applicable *NERC Planning Standards* for System Adequacy and Security – Transmission System Table l hereafter referred to as NERC Table l) and its applicable standards and measurements".

Using the created models and the ACCC function of PSS\E, single contingencies in portions or all of the modeled areas of SPRM, Grand River Dam Authority (GRDA), Independence (INDN), Empire District (EMDE), American Electric Power West, Westar, Kansas City Power & Light, Missouri Public Service, Southwestern Power Administration (SWPA), and others were applied and the resulting scenarios analyzed. This satisfies the 'more probable' contingency testing criteria mandated by NERC and the SPP criteria.

Table 3: Network Constraints

OWNER	NETWORK CONSTRAINT
SPRM	'BATTLEFIELD - SOUTHWEST DISPOSAL 161KV CKT 1'
SPRM	'BROOKLINE - JUNCTION 161KV CKT 1'
SPRM	'BROOKLINE - SOUTHWEST 161KV CKT 1'
WESTAR	'EDWARDSVILLE (EDWRDV4X) 161/115/12.47KV TRANSFORMER CKT 1'
WESTAR	'JARBALO JUNCTION SWITCHING STATION - STRANGER CREEK 115KV CKT 1'
WESTAR	'MOCKINGBIRD HILL SWITCHING STATION - STULL SWITCHING STATION 115KV CKT 1'
SPRM	'SOUTHWEST - SOUTHWEST DISPOSAL 161KV CKT 1'
WESTAR	'STULL SWITCHING STATION - TECUMSEH HILL 115KV CKT 1'

Table 4: Contingency Analysis

ELEMENT	SEASON	RATE (MVA)	LOADING (%)	ATC (MW)	CONTINGENCY
2011 SUMMER PEAK					
'JARBALO JUNCTION SWITCHING STATION - STRANGER CREEK 115KV CKT 1'	11sp	240	108.8	0	'ARNOLD - STRANGER CREEK 115KV CKT 1'
'STULL SWITCHING STATION - TECUMSEH HILL 115KV CKT 1'	11sp	92	108.7	88	'STRANGER CREEK (STRNGR1X) 345/115/14.4KV TRANSFORMER CKT 1'
'BROOKLINE - SOUTHWEST 161KV CKT 1'	11sp	358	114.8	203	'SOUTHWEST - SOUTHWEST DISPOSAL 161KV CKT 1'
'SOUTHWEST - SOUTHWEST DISPOSAL 161KV CKT 1'	11sp	358	110.7	218	'BROOKLINE - SOUTHWEST 161KV CKT 1'
'BATTLEFIELD - SOUTHWEST DISPOSAL 161KV CKT 1'	11sp	358	109.4	225	'BROOKLINE - SOUTHWEST 161KV CKT 1'
'MOCKINGBIRD HILL SWITCHING STATION - STULL SWITCHING STATION 115KV CKT 1'	11sp	92	102.2	227	'STRANGER CREEK (STRNGR1X) 345/115/14.4KV TRANSFORMER CKT 1'
2016 SUMMER PEAK					
'BROOKLINE - JUNCTION 161KV CKT 1'	16sp	358	107.1	0	'BATTLEFIELD - MAIN 161KV CKT 1'
'JARBALO JUNCTION SWITCHING STATION - STRANGER CREEK 115KV CKT 1'	16sp	240	120.9	0	'ARNOLD - STRANGER CREEK 115KV CKT 1'
'MOCKINGBIRD HILL SWITCHING STATION - STULL SWITCHING STATION 115KV CKT 1'	16sp	92	117.5	0	'STRANGER CREEK (STRNGR1X) 345/115/14.4KV TRANSFORMER CKT 1'
'STULL SWITCHING STATION - TECUMSEH HILL 115KV CKT 1'	16sp	92	124.9	0	'STRANGER CREEK (STRNGR1X) 345/115/14.4KV TRANSFORMER CKT 1'
'EDWARDSVILLE (EDWRDV4X) 161/115/12.47KV TRANSFORMER CKT 1'	16sp	185	101.5	181	'STRANGER CREEK (STRNGR1X) 345/115/14.4KV TRANSFORMER CKT 1'

Note: When transmission service associated with this interconnection is evaluated, the loading of the facilities listed in this table may be greater due to higher priority reservations. If the loading of a facility is higher, the level of ATC will be lower.

Dynamic Stability Analysis

A dynamic stability analysis was conducted by Pterra Consulting (Pterra) in Albany, New York for this generation interconnection request. The analysis revealed no stability issues associated with this generation interconnection request. The entire study can be found in Attachment 1.

Conclusion

The minimum cost of interconnecting the Customer project is estimated at $3,200,000 for SPRM's Transmission Owner interconnection facilities and network upgrades listed in Table 2 excluding upgrades of other transmission facilities by SPRM and WESTAR in Table 3 of which are Network Constraints. At this time, the cost estimates for Direct Assignment facilities including those in Table 1 have not all been defined by the Customer.

In Table 4, a value of Available Transfer Capability (ATC) associated with each overloaded facility is included. These values may be used by the Customer to determine lower generation capacity levels that may be installed. When transmission service associated with this interconnection is evaluated, the loading of the facilities listed in this table may be greater due to higher priority reservations. These contingency analyses will have to be re-evaluated as part of a transmission service request.

Dynamic Stability Analysis shows that the interconnection of the proposed generation request will pose no adverse reliability conditions to the transmission system.

These interconnection costs do not include any cost that may be associated with short circuit analysis. A short circuit study will be performed if the Customer executes a Facility Study Agreement.

The required interconnection costs listed in Table 2 and other upgrades associated with Network Constraints listed in Table 3 and Table 4 do not include all costs associated with the deliverability of the energy to final customers. These costs are determined by separate studies if the Customer requests transmission service through Southwest Power Pool's OASIS.

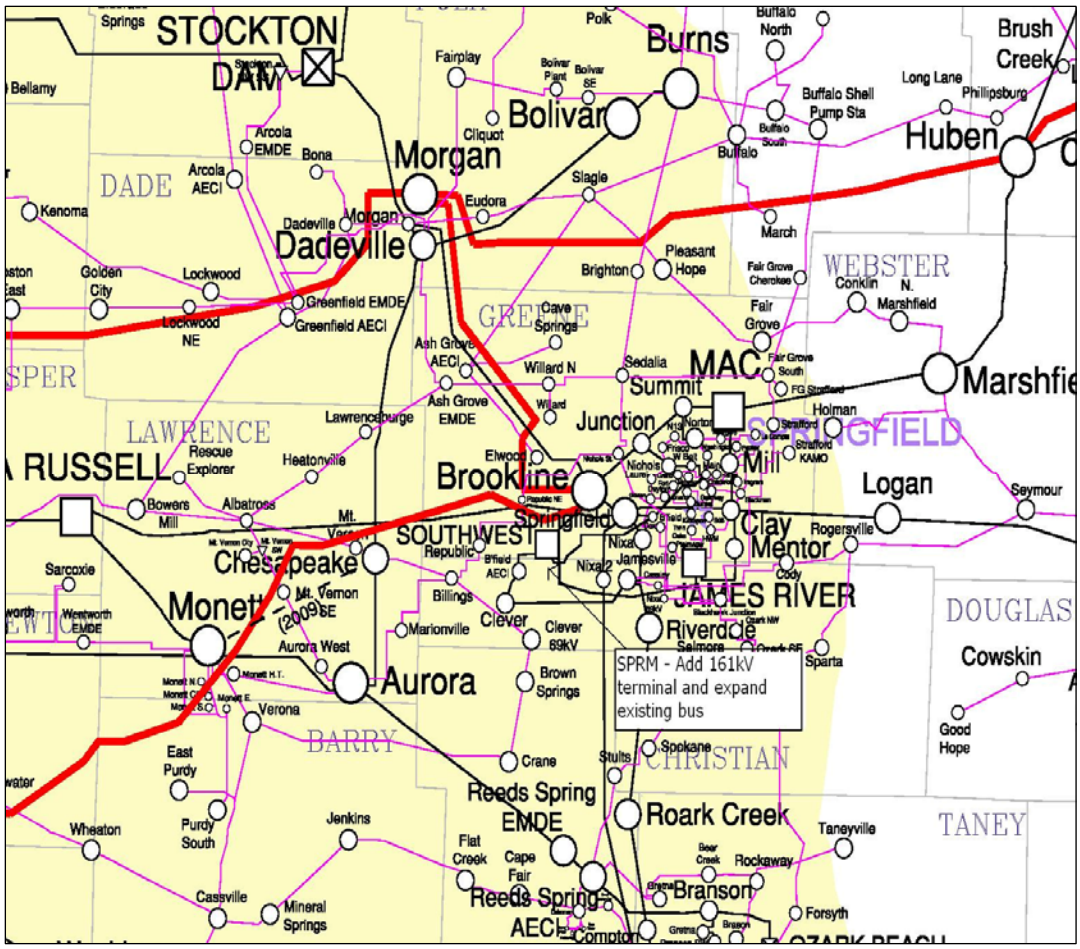

Figure 2: Map of the Local Area

ATTACHMENT 1.

STABILITY STUDY

Pterra Consulting

Report No. R104-07

"Impact Study for Generation Interconnection Request GEN-2006-019"

Submitted to

The Southwest Power Pool

January 2007

4 Automation Lane, Ste.250, Albany, NY 12205 Tel: 518-724-3832 Web: www.pterra.us

Report No. R104-07

"Impact Study for Generation Interconnection Request GEN-2006-019"

1. Executive Summary

This report presents the stability simulation findings of the impact study of a proposed interconnection (Gen-2006-019). The analysis was conducted through the Southwest Power Pool Tariff for a 161 kV interconnection for a coal fired steam turbine nominally rated at 275MW in Greene County, Missouri. The steam turbine will be interconnected into the existing Southwest Power Station substation owned by City Utilities of Springfield (SPRM).

Two base cases each comprising of a power flow and corresponding dynamics database for 2011 summer and 2007 winter were provided by SPP. Transient stability simulations were conducted with the proposed steam turbine in service with a full output of 275 MW. In order to integrate the proposed 275 MW steam turbine in SPP system, the existing generation in the SPP footprint was re-dispatched as provided by SPP.

Twenty (20) disturbances were considered for the transient stability simulations which included 3-phase faults, as well as, 1-phase to ground faults, at the locations defined by SPP. 1-phase faults were simulated by applying a fault impedance to the positive sequence network at the fault location, representing 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.

For both peak summer and winter loading conditions, the simulations conducted in the study showed stable response for the studied disturbances. All oscillations were well damped. The study finds that the proposed 275 MW steam turbine project shows stable performance of SPP system for the contingencies tested on the supplied base cases.

2. Introduction

2.1 Project Overview

The proposed 275 MW steam turbine would be interconnected into the existing Southwest Power Station 161 kV substation. A new position in the existing substation will be installed. Figure 1 shows the interconnection diagram of the proposed GEN-2006-019 project to the 161 kV transmission system.

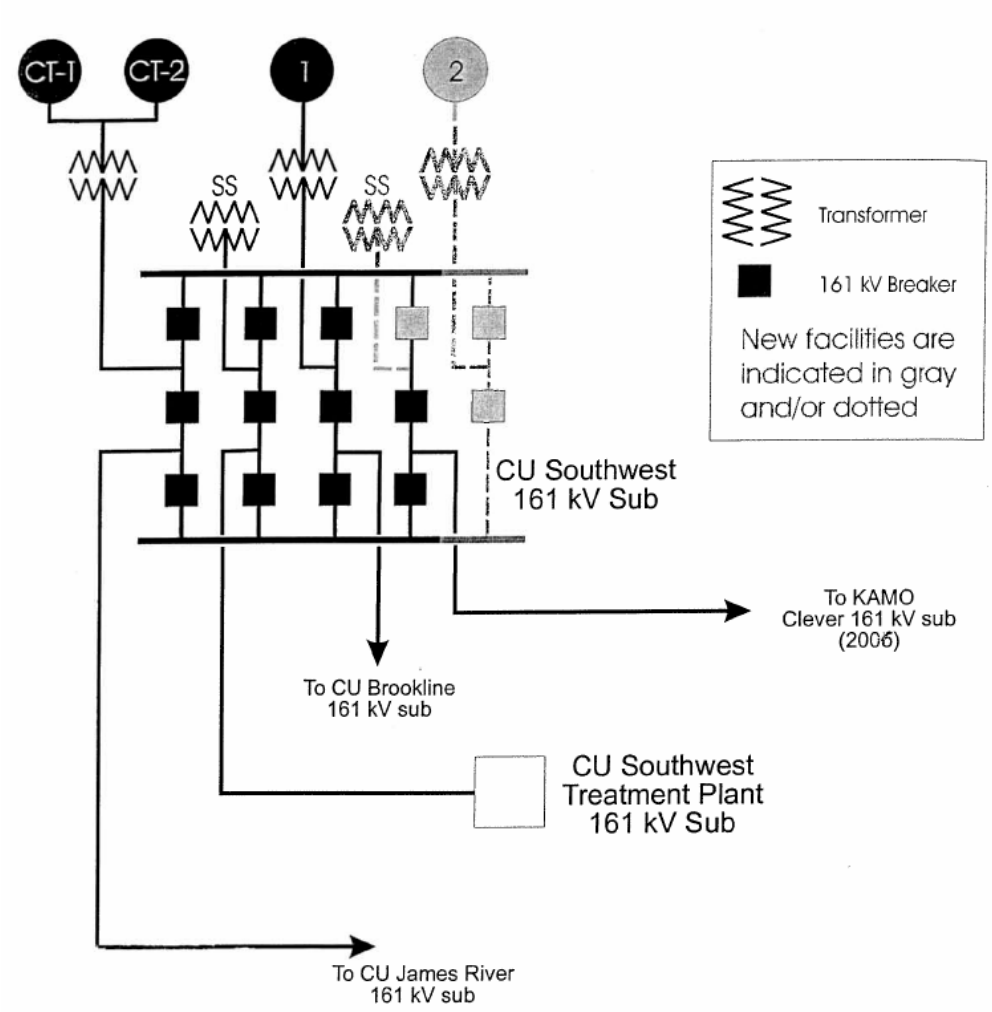

Figure 1. Interconnection Plan for GEN-2006-019 to the 161 kV System

In order to integrate the proposed 275 MW steam turbine in SPP system, generation with the SPP footprint is displaced.

Table 1 shows the reactive capability of the proposed 275 MW steam turbine.

Table. 1 Generator Reactive Capability

Plant Output Limit	P_{GEN}	Min. Reactive Power	Max. Reactive Power
Gen 2006-019	275 MW	-90.4[(1)] MVAR	170.4[(2)] MVAR

(1) Based on 0.95 power factor (under-excited)
(2) Based on 0.85 power factor (over-excited)

Two base cases each comprising of a power flow and corresponding dynamics database for 2011 summer and 2007 winter were provided by SPP. The base cases contain two (2) prior queued projects in the base case. The projects are as follows;

a. GEN-2001-024 – 510/540MW consisting of six combustion turbines
b. GEN-2004-017 – 250MW combined cycle plant

2.2 Objective

The objective of the study is to determine the impact on system stability of connecting the proposed 275 MW steam turbine to SPP's 161 kV transmission system.

3. Stability Analysis

3.1 Modeling of the 275 MW Steam Turbine

The proposed 275 MW steam turbine and its step-up (GSU) transformer in the load flow case were modeled.

3.2 Assumptions

The following assumptions were adopted for the study:

1. A generic dynamic model for the generator excitation system was used with typical values. The model used is the standard IEEET1 excitation system model.
2. A generic dynamic model for the turbine speed governor was used with typical values. The model used is the standard IEEEG1 speed governor model.
3. As for the machine model, the round rotor generator model with quadratic saturation was used. SPP provided the generator data used for that model.
4. Generation units in areas 520, 544, 523, 524, 545, and 546 in addition to the prior queued projects were monitored during the stability simulations.

3.3 Disturbances Simulated

Twenty (20) disturbances were considered for the transient stability simulations which included three phase faults, as well as single phase line faults, at the locations defined by SPP. 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.

Table 2. List of Contingencies

Fault #	Fault Description
FLT_1_3PH	Three Phase fault at Southwest Power Station (SWPS) on the SWPS-SWDisposal 161kV line (#59954-59960)
FLT_2_1PH	Single Phase fault same as above
FLT_3_3PH	Three Phase fault at Brookline on the SWPS – Brookline 161kV line (#59969-59954)
FLT_4_1PH	Single Phase fault same as above
FLT_5_3PH	Three Phase fault at the line midpoint on the SWPS – James River Power Station 161kV line (#59954-59961)
FLT_6_1PH	Single Phase fault same as above
FLT_7_3PH	Three Phase fault at Battlefield on the SWDisposal – Battlefield 161kV line (#59960-59959)
FLT_8_1PH	Single Phase fault same as above
FLT_9_3PH	Three Phase fault at Brookline on the Brookline – Flint Creek 345kV line (#53140-59481-59984)
FLT_10_1PH	Single Phase fault same as above
FLT_11_3PH	Three Phase fault at Main on the Battlefield – Main 161kV line (#59958-59959)

Fault #	Fault Description
FLT_12_1PH	Single Phase fault same as above
FLT_13_3PH	Three Phase fault at Brookline on the Brookline – Morgan 161kV line (#59969-96101)
FLT_14_1PH	Single Phase fault same as above
FLT_15_3PH	Three Phase fault at Brookline on the Brookline – Junction 161kV line (#59969-59955)
FLT_16_1PH	Single Phase fault same as above
FLT_17	Trip SWPS unit #1
FLT_18	Trip Customer plant (SWPS unit #2)
FLT_19_3PH	Three Phase fault at SWPS on the SWPS – Battlefield 161kV line (#59954-96661)
FLT_20_1PH	Single Phase fault same as above

For all disturbances except disturbances FLT_17 and FLT_18, the faults are cleared after 5 cycles followed by 20 cycles time delay before a re-closing of 5 cycles and lockout. For disturbances FLT_17 and FLT_18, the faults are cleared after 3.5 cycles with no re-closing.

3.4 Simulation Results

Simulations were performed with a 0.1-second steady-state run followed by the appropriate disturbance as described in Table 2. Simulations were run for a minimum 10-second duration to confirm proper machine damping. Based on the obtained simulation results, the system remained stable for all the simulated faults with the proposed 275 MW steam turbine project in service. All oscillations were well damped. The study finds that the proposed 275 MW steam turbine project, on the basis of base cases, modeling assumptions described within this report, and for the tested contingencies (on the supplied base cases) show stable performance of SPP system.

For the two base cases studied a complete set of the transient stability plots for rotor angle, speed, frequency, and voltages for the monitored buses in SPP for the simulated (20) disturbances with the proposed 275 MW steam turbine in service, are in an electronic format on the accompanying CD.

For both peak summer and winter loading conditions, the simulations conducted in the study showed stable response for the studied disturbances. All oscillations were well damped. The study finds that the proposed 275 MW steam turbine project shows stable performance of SPP system for the contingencies tested on the supplied base cases.

4. Conclusion

The stability simulation findings of the impact study of a proposed interconnection (Gen-2003-019) were presented in this report. The analysis was conducted through the Southwest Power Pool Tariff for a 161 kV interconnection for a coal fired steam turbine nominally rated at 275MW in Greene County, Missouri. The steam turbine will be interconnected into the existing Southwest Power Station owned by City Utilities of Springfield (SPRM).

Two base cases each comprising of a power flow and corresponding dynamics database for 2011 summer and 2007 winter were provided by SPP. Transient stability simulations were conducted with the proposed steam turbine in service with a full output of 275 MW. In order to integrate the proposed 275 MW steam turbine in SPP system, the existing generation in the SPP footprint was re-dispatched as provided by SPP.

Twenty (20) disturbances were considered for the transient stability simulations which included 3-phase faults, as well as, 1-phase to ground faults, at the locations defined by SPP.

For both peak summer and winter loading conditions, the simulations conducted in the study showed stable response for the studied disturbances. All oscillations were well damped. The study finds that the proposed 275 MW steam turbine project shows stable performance of SPP system for the contingencies tested on the supplied base cases.