



***Impact Study for Generation
Interconnection Request
GEN-2006-010***

***SPP Tariff Studies
(#GEN-2006-010)***

January 25, 2007

Executive Summary

<OMITTED TEXT> (Customer) has requested an Impact Study for the purpose of interconnecting a 610/620MW (summer/winter net rating) coal-fired steam turbine/generator within the control area of American Electric Power West (AEPW). The plant site is located in Hempstead County, Arkansas near the Okay-McNabb 115kV transmission line, which is owned by AEPW. The requested method of interconnection is to build a new station to interconnect into the Okay-McNabb 115kV transmission line. The proposed in service date is June 1, 2011.

Power flow analysis has indicated that for the powerflow cases studied, it is possible to interconnect the 610/620MW of generation with transmission system reinforcements within the local transmission systems.

The requirements to interconnect the 610/620MW of generation consist of building a 138/115kV switchyard at the proposed plant site, building a new 138kV line to Sugar Hill substation, building a new 138kV line to Southeast Texarkana substation, and converting the existing 115kV line from the interconnection point to Patterson to 138kV. Also included is a 115kV terminal to McNabb. These facilities are detailed in Table 2. The total minimum cost for interconnecting the plant is \$92,850,000. Other Network Constraints in the AEPW, Southwestern Power Administration (SWPA), and Southwestern Public Service (SPS) 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. These costs do not include the building of the 138kV lines/buswork from the Customer' facilities into the 138/115kV switchyard.

Preliminary Results from the current Aggregate Transmission Service Impact Study, SPP-2006-AG3-ASIS, indicate the need for additional facilities for full energy delivery from this plant. These preliminary results indicate the need for building an additional transmission line from the plant to Northwest Texarkana. This line will be built and operated at 345kV. Also included is substation work at the GEN-2006-010 facility which includes building a 345kV switchyard and a 345/138kV autotransformer. These additional facilities are priced at approximately \$55,400,000 and would be priced out in more detail in a Transmission Service 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.

A Stability Study was conducted by ABB Power Systems Division Grid Systems Consulting in Raleigh, North Carolina for this generation interconnection request. The Stability study determined that the interconnection configuration described above is adequate to maintain

generator stability and transmission system stability and reliability. The entire ABB study can be found in Attachment 1.

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 610/620MW (summer/winter net rating) coal-fired steam turbine within the control area of American Electric Power West (AEPW). The plant site is located in Hempstead County, Arkansas near the Okay-McNabb 115kV transmission line, which is owned by AEPW. The requested method of interconnection is to build a new station to interconnect into the Okay-McNabb 115kV transmission line. The proposed in service date is June 1, 2011.

Interconnection Facilities

The primary objective of this study is to identify the system problems associated with connecting the plant into the area transmission system. The Impact 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.

Facilities Needed Solely for Interconnection

The Customer's Interconnection Facilities will consist of the 610/620MW (net summer/winter rating) coal fired steam turbine/generator and a 23/138kV GSU rated at 800MVA. The GSU will interconnect into the Transmission Owner's Interconnection Facilities and Network Upgrades described below. For more detail of the Customer's facilities, please see the stability study in Attachment 1, Section 2.2.

The Customer's request was to interconnect into the Okay-McNabb 115kV transmission line in Hempstead County. However, the local area does not presently have adequate transmission infrastructure necessary to accommodate the 610/620 MW coal fired power plant. The Okay-McNabb line is rated 150/174MVA normal/emergency. Through stability analysis, several iterations of incremental facilities were tested to determine the minimum interconnection configuration. It was determined that two new transmission outlets were required to make the plant meet dynamic stability criteria in addition to converting one of the existing outlets (Okay or McNabb) to 138kV and rebuilding with a larger conductor and. The stability study determined that the minimum interconnection configuration that could accept the power from the requested generation would consist of the following facilities.

- 138kV switchyard at the GEN-2006-010 generator facility. This switchyard will have a minimum of seven terminals. The terminals will house lines that will go to the following -
 - Three (3) terminals to the GEN-2006-010 GSU, RAT, and coal handling facility
 - 138kV terminal for line to Okay-Ashdown REC-Patterson
 - 138/115kV autotransformers to be relocated from Patterson substation
 - 138kV terminal for line to Sugar Hill substation
 - 138kV terminal for line to Southeast Texarkana substation

- 115kV switchyard at the GEN-2006-010 generator. This switchyard will contain the following
 - 115kV line terminal to McNabb/Fulton/Couch(Entergy)

- Autotransformer relocated from Patterson
- New 138kV, 1590 MCM ACSR transmission line to Sugar Hill substation. This line is approximately 23 miles in length.
 - Add new 138kV line terminal including two circuit breakers at Sugar Hill substation
- New 138kV, 1590 MCM ACSR transmission line to Southeast Texarkana substation. This line is approximately 26 miles in length.
 - Add new 138kV terminal including two 138kV circuit breakers to Southeast Texarkana substation
- Convert the 115kV line from GEN-2006-010-Okay-Ashdown REC-Patterson to 138kV
 - Add 138kV terminal and rebuild Patterson 138kV substation to breaker-and-a-half bus configuration
 - Convert Okay substation to 138kV – Replace 115/69kV autotransformer with 138/69kV autotransformer.
 - Convert Ashdown REC substation to 138kV

For more information on how the minimum interconnection configuration was determined, please see the ABB Stability Study in Attachment 1, Section 2.3. The configuration chosen is Configuration #7.

The total cost for building the minimum Interconnection Network Upgrade Facilities is \$92,850,000. These costs are detailed below in Table 2. These costs do not include Customer facilities up to the point of interconnection which are partially shown in Table 1. These costs do not include the costs associated with short circuit analysis. Short circuit analysis will be conducted if the Customer chooses to continue on with the request into a Facility Study.

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

Need for Additional Transmission Reinforcements for Energy Delivery

The powerflow analysis described in the next section indicates while the minimum interconnection facilities listed in Table 2 will allow the plant to interconnect, additional transmission reinforcements will be necessary for delivery of the full output from the facility.

Multiple transmission service requests (TSRs) have been made for this facility on the SPP OASIS and are currently being evaluated in the TSR Aggregate Study SPP-2006-AG3. SPP-2006-AG3-ASIS was posted on SPP's OASIS on December 8, 2006. The Aggregate Facility Study, SPP-2006-AG3-AFS is expected to be posted the third week of January, 2007.

SPP-2006-AG3-AFS is expected to indicate preliminary results for delivering approximately 620MW to designated loads will include the need for additional facilities.

These additional facilities include but are not limited to -

- New 345kV, 2-795MCM ACSR line from GEN-2006-010 to Northwest Texarkana substation. This line is approximately thirty-three (33) miles in length and will cost approximately \$46,200,000.
- Add a 345kV switchyard and 345/138kV autotransformer to the GEN-2006-010 facility for an additional \$8,200,000.
- Add 345kV terminal at Northwest Texarkana substation for an additional \$1,600,000.
- Subtotal for partial Additional Facilities - \$56,000,000

These facilities will be priced out as part of the requesting Customer’s TSR and will continue to be modified as the request continues through the TSR process into a Facility Study. These additional facilities may or may not be eligible for base plan funding to the requesting party(ies).

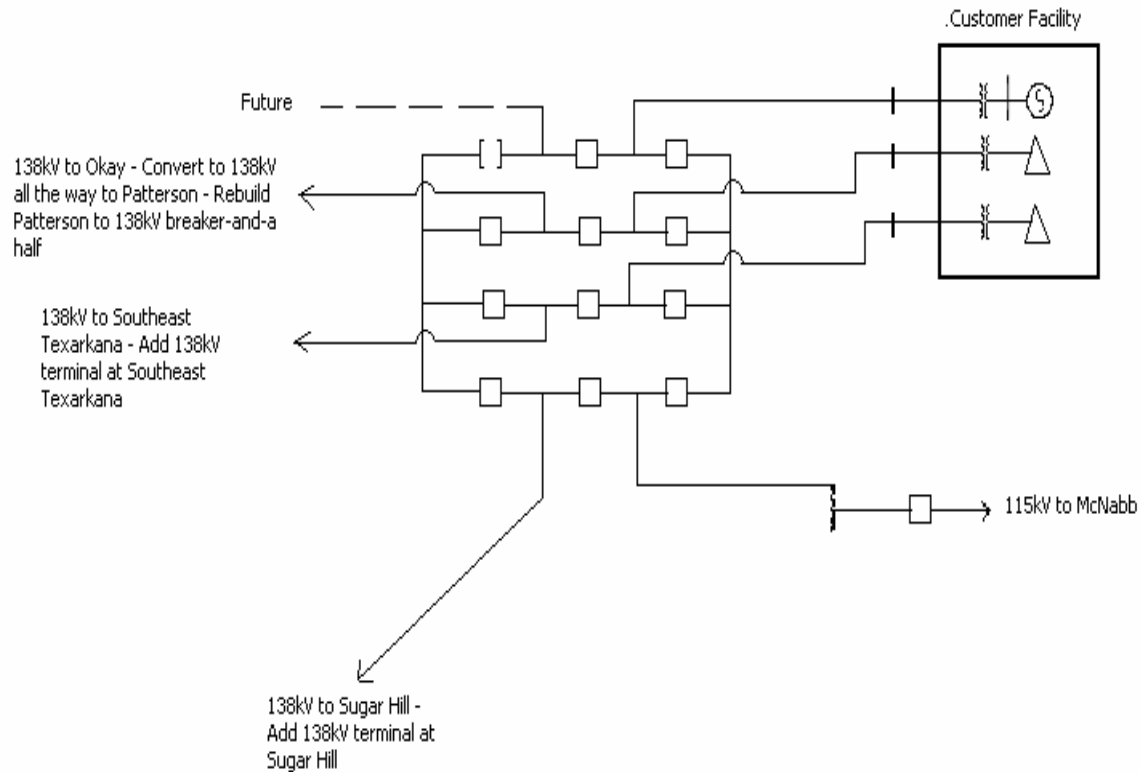
Table 1: Direct Assignment Facilities

Facility	ESTIMATED COST (2006 DOLLARS)
Customer – 23/138kV Substation facilities including Customer’s generator, GSU and associated equipment up to the point of change of ownership	*
Customer – 138kV line between Customer facilities and the new AEPW 138/115kV switching station	
Customer - Right-of-Way for Customer Substation & Line.	
Total	*

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

Table 2: Required Interconnection Network Upgrade Facilities

Facility	ESTIMATED COST (2006 DOLLARS)
AEPW – GEN-2006-010 138/115kV switchyard. Will include eleven (11) 138kV breakers, one (1) 115kV breaker, and the 138/115kV autotransformers relocated from Patterson	\$7,000,000
AEPW – Sugar Hill 138kV substation – Add one (1) 138kV terminal including two (2) 138kV circuit breakers	\$1,300,000
AEPW – Southeast Texarkana 138kV substation – Add one (1) 138kV terminal including two (2) 138kV circuit breakers.	\$1,200,000
AEPW – Patterson 138kV Substation – Install six (6) 138kV circuit breakers to convert the station to breaker–and–a-half scheme. Replace one 138kV breaker, remove the 138/15kV autotransformers to GEN-2006-010 station	\$5,200,000
AEPW – Okay substation – Replace three (3) single phase 115/69kV autotransformers with one (1) 90 MVA, three-phase 138/69kV autotransformer and convert high side to 138kV	\$3,000,000
AEPW – Build new GEN-2006-010 – Sugar Hill 138kV transmission line with 1590 MCM ACSR (approx. 23 miles)	\$20,700,000
AEPW – Build new GEN-2006-010 – Southeast Texarkana 138kV transmission line with 1590 MCM ACSR (approx. 26 miles)	\$23,400,000
AEPW - Build new 138 kV line section (operated at 115 kV) from Hempstead substation to the Okay-Hope 115 kV transmission line (1.5 miles of 1590 ACSR) to form a Hempstead-Hope 115 kV line.	\$1,500,000
AEPW - Build new 1.5 mile, 1590 ACSR, 138 kV line section from Hempstead substation to the Okay-Hope 115 kV transmission line and rebuild 12 miles of existing line to Okay Substation to 138 kV, 1590 ACSR, to form a Hempstead-Okay 138 kV line.	\$12,150,000
Convert the Okay-Patterson 115 kV line to 138 kV and reconductor with 1590 ACSR, 19 miles	\$17,100,000
Ashdown REC (AECC delivery point), Replace switches 6276 and 6277 with 3000 A, 138 kV switches and replace the conductor between them with 1590 ACSR	\$300,000
Total	\$92,850,000



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

Powerflow Analysis

A powerflow analysis was conducted for the generation interconnection request assuming the facilities in Table 2 are in service. The analysis used 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 June 1, 2011. 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 610/620MW and location, additional criteria violations will occur on the existing AEPW, SWPA, and SPS transmission systems under steady state and contingency conditions in the peak seasons. These Network Constraints are shown in Table 3.

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.

TSR Powerflow Analysis

This powerflow analysis indicates that while the minimum interconnection facilities listed in Table 2 will allow the plant to interconnect, additional transmission reinforcements will be necessary for delivery of the full output from the Facility. As discussed in the Facilities Section, multiple Transmission Service Requests (TSRs) are being evaluated for service from this Facility. Preliminary results from SPP-2006-AG3-ASIS posted on December 8, 2006 show the need for additional facilities.

Powerflow 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 I hereafter referred to as NERC Table I) 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 control areas of AEPW, Entergy, CLECO, WFEC, and SWPA control areas were applied and the resulting scenarios analyzed. This satisfies the 'more probable' contingency testing criteria mandated by NERC and the SPP criteria.

Dynamic Stability Analysis

A stability study was performed by ABB in Raleigh, NC for this generation request. That study is appended to this study as Attachment 1. Through several iterations and by studying many different configurations, the study determined the minimum interconnection configuration allowable for this generation interconnection request. The study analyzed two different configurations that met stability criteria. Both configurations included four outlets from the Facility, Configuration #4 and Configuration #7. For both configurations, it was determined the unit will not lose synchronism with the remainder of the transmission system and the transmission system will remain stable with the addition of the proposed generation. Configuration #7 was chosen due to shorter line lengths and lower costs.

The entire study can be found in Attachment 1.

Table 3. Network Constraints

OWNER	NETWORK CONSTRAINT
AEP	'ASHDOWN WEST REC - CRAIG JUNCTION 138KV CKT 1'
AEP	'BETHEL - BROKEN BOW 138KV CKT 1'
AEP	'BETHEL - NASHOBA 138KV CKT 1'
SWPA-AEP	'BROWN - RUSSETT 138KV CKT 1'
SWPA	'CLARKSVILLE - DARDANELLE 161KV CKT 1'
AEP	'CLAYTON - NASHOBA 138KV CKT 1'
AEP	'CLAYTON - SARDIS 138KV CKT 1'
WERE	'JARBALO JUNCTION SWITCHING STATION - STRANGER CREEK 115KV CKT 1'
AEP	'LONE OAK - SARDIS 138KV CKT 1'
AEP	'MIDWAY REC - NASHVILLE 69KV CKT 1'
AEP	'OKAY - TOLLETTE 69KV CKT 1'
AEP	'OKAY (OKAY) 138/69/13.8KV TRANSFORMER CKT 1'
AEP	'SE TEXARKANA - TEXARKANA PLANT 69KV CKT 1'
AEP	'SE TEXARKANA (SETEXARK) 138/69/13.2KV TRANSFORMER CKT 1'
AEP	'SUGAR HILL (SUGAR HL) 138/69/12.47KV TRANSFORMER CKT 1'
SPS	'TUCO INTERCHANGE (TUCO XX4) 345/230/13.2KV TRANSFORMER CKT 1'

Table 4. Contingency Analysis

ELEMENT	SEASON	RATE (MVA)	LOADING (%)	ATC (MW)	CONTINGENCY	
2011 SUMMER PEAK						
'TUCO INTERCHANGE (TUCO XX4) 345/230/13.2KV TRANSFORMER CKT 1'	11sp	560	108.3	60		'GEN:51442 1'
'BETHEL - BROKEN BOW 138KV CKT 1'	11sp	107	136.7	79		'PITTSBURG - VALLIANT 345KV CKT 1'
'BETHEL - NASHOBA 138KV CKT 1'	11sp	107	131.3	155		'PITTSBURG - VALLIANT 345KV CKT 1'
'OKAY (OKAY) 138/69/13.8KV TRANSFORMER CKT 1'	11sp	66	128.3	169		'ASHDOWN REC (MILLWOOD) - OKAY 138KV CKT 1'
'CLAYTON - NASHOBA 138KV CKT 1'	11sp	107	129.8	178		'PITTSBURG - VALLIANT 345KV CKT 1'
'CLAYTON - SARDIS 138KV CKT 1'	11sp	107	126.7	222		'PITTSBURG - VALLIANT 345KV CKT 1'
'SE TEXARKANA - TEXARKANA PLANT 69KV CKT 1'	11sp	90	119.0	267		'BASE CASE'
'LONE OAK - SARDIS 138KV CKT 1'	11sp	107	123.5	268		'PITTSBURG - VALLIANT 345KV CKT 1'
'SE TEXARKANA - TEXARKANA PLANT 69KV CKT 1'	11sp	121	114.5	349		'SUGAR HILL (SUGAR HL) 138/69/12.47KV TRANSFORMER CKT 1'
'BETHEL - BROKEN BOW 138KV CKT 1'	11sp	88	111.3	389		'BASE CASE'
'OKAY - TOLLETTE 69KV CKT 1'	11sp	72	110.4	430		'ASHDOWN REC (MILLWOOD) - OKAY 138KV CKT 1'
'CLARKSVILLE - DARDANELLE 161KV CKT 1'	11sp	189	102.7	470		'ARKANSAS NUCLEAR ONE 500 - FT SMITH 500KV CKT 1'
'BETHEL - NASHOBA 138KV CKT 1'	11sp	88	105.0	512		'BASE CASE'
'ASHDOWN WEST REC - CRAIG JUNCTION 138KV CKT 1'	11sp	235	104.3	546		'LYDIA - VALLIANT 345KV CKT 1'
'CLAYTON - NASHOBA 138KV CKT 1'	11sp	88	103.0	551		'BASE CASE'
'SUGAR HILL (SUGAR HL) 138/69/12.47KV TRANSFORMER CKT 1'	11sp	147	101.1	587		'SE TEXARKANA (SETEXARK) 138/69/13.2KV TRANSFORMER CKT 1'
2011 WINTER PEAK						
'BETHEL - BROKEN BOW 138KV CKT 1'	11wp	107	121.6	300		'PITTSBURG - VALLIANT 345KV CKT 1'
'BETHEL - NASHOBA 138KV CKT 1'	11wp	107	116.9	368		'PITTSBURG - VALLIANT 345KV CKT 1'
'CLAYTON - NASHOBA 138KV CKT 1'	11wp	107	115.4	389		'PITTSBURG - VALLIANT 345KV CKT 1'
'OKAY (OKAY) 138/69/13.8KV TRANSFORMER CKT 1'	11wp	66	114.3	394		'ASHDOWN REC (MILLWOOD) - OKAY 138KV CKT 1'
'CLAYTON - SARDIS 138KV CKT 1'	11wp	107	113.2	420		'PITTSBURG - VALLIANT 345KV CKT 1'
'LONE OAK - SARDIS 138KV CKT 1'	11wp	107	110.4	461		'PITTSBURG - VALLIANT 345KV CKT 1'

Table 4. Contingency Analysis

ELEMENT	SEASON	RATE (MVA)	LOADING (%)	ATC (MW)	CONTINGENCY
'BROWN - RUSSETT 138KV CKT 1'	11wp	96	100.1	607	'BROWN - BROWN 138KV CKT 1'
2016 SUMMER PEAK					
'TUCO INTERCHANGE (TUCO XX4) 345/230/13.2KV TRANSFORMER CKT 1'	16sp	560	120.9	0	'GEN:51973 1'
'OKAY (OKAY) 138/69/13.8KV TRANSFORMER CKT 1'	16sp	66	137.7	21	'ASHDOWN REC (MILLWOOD) - OKAY 138KV CKT 1'
'BETHEL - BROKEN BOW 138KV CKT 1'	16sp	107	138.7	55	'PITTSBURG - VALLIANT 345KV CKT 1'
'BETHEL - NASHOBA 138KV CKT 1'	16sp	107	133.1	133	'PITTSBURG - VALLIANT 345KV CKT 1'
'SE TEXARKANA - TEXARKANA PLANT 69KV CKT 1'	16sp	90	125.1	133	'BASE CASE'
'CLAYTON - NASHOBA 138KV CKT 1'	16sp	107	131.5	156	'PITTSBURG - VALLIANT 345KV CKT 1'
'CLAYTON - SARDIS 138KV CKT 1'	16sp	107	128.2	203	'PITTSBURG - VALLIANT 345KV CKT 1'
'SE TEXARKANA - TEXARKANA PLANT 69KV CKT 1'	16sp	121	120.7	222	'SUGAR HILL (SUGAR HL) 138/69/12.47KV TRANSFORMER CKT 1'
'BETHEL - BROKEN BOW 138KV CKT 1'	16sp	88	119.4	225	'BASE CASE'
'LONE OAK - SARDIS 138KV CKT 1'	16sp	107	124.8	252	'PITTSBURG - VALLIANT 345KV CKT 1'
'OKAY - TOLLETTE 69KV CKT 1'	16sp	72	118.0	299	'ASHDOWN REC (MILLWOOD) - OKAY 138KV CKT 1'
'BETHEL - NASHOBA 138KV CKT 1'	16sp	88	112.9	353	'BASE CASE'
'CLAYTON - NASHOBA 138KV CKT 1'	16sp	88	111.0	391	'BASE CASE'
'OKAY (OKAY) 138/69/13.8KV TRANSFORMER CKT 1'	16sp	60	111.2	405	'BASE CASE'
'CLAYTON - SARDIS 138KV CKT 1'	16sp	88	107.1	470	'BASE CASE'
'SUGAR HILL (SUGAR HL) 138/69/12.47KV TRANSFORMER CKT 1'	16sp	147	106.3	475	'SE TEXARKANA (SETEXARK) 138/69/13.2KV TRANSFORMER CKT 1'
'LONE OAK - SARDIS 138KV CKT 1'	16sp	88	103.0	550	'BASE CASE'
'ASHDOWN WEST REC - CRAIG JUNCTION 138KV CKT 1'	16sp	235	103.2	563	'LYDIA - VALLIANT 345KV CKT 1'
'SE TEXARKANA (SETEXARK) 138/69/13.2KV TRANSFORMER CKT 1'	16sp	146	101.4	579	'SUGAR HILL (SUGAR HL) 138/69/12.47KV TRANSFORMER CKT 1'
'MIDWAY REC - NASHVILLE 69KV CKT 1'	16sp	69	102.0	584	'ASHDOWN REC (MILLWOOD) - OKAY 138KV CKT 1'
'JARBALO JUNCTION SWITCHING STATION - STRANGER CREEK 115KV CKT 1'	16sp	240	111.9	603	'GEN:56663 1'

Table 4. Contingency Analysis

ELEMENT	SEASON	RATE (MVA)	LOADING (%)	ATC (MW)	CONTINGENCY

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.

Conclusion

The minimum cost of interconnecting the Customer's interconnection request is estimated at \$92,850,000 for AEP's interconnection Network Upgrade facilities listed in Table 2. At this time, the cost estimates for other Direct Assignment facilities including those in Table 1 have not been defined by the Customer. As stated earlier, the local projects that were previously queued are assumed to be in service in this Impact Study.

A stability study was conducted by ABB for this request. For the interconnection configuration recommended by the study, the generator and the system remain stable for all contingencies.

These interconnection costs do not include any cost that may be associated with short circuit analysis. A short circuit study will be conducted if the Customer signs 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 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.

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.

ATTACHMENT 1.
STABILITY STUDY



**POWER SYSTEMS DIVISION
GRID SYSTEMS CONSULTING**

**IMPACT STUDY FOR GENERATION
INTERCONNECTION REQUEST
GEN-2006-010**

Final REPORT

REPORT NO.: 2006-11393-R2
Issued: January 25, 2007

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Executive Summary

Southwest Power Pool (SPP) has commissioned ABB to perform a Generation Interconnection Impact study of a coal fired steam turbine power plant with power output rated 610 MW (summer) / 620 MW (winter) in Hempstead County, Arkansas. The coal plant will be interconnected into the existing Okay-McNab 115 kV line in the control area of American Electric Power West (AEPW), with several possible transmission upgrade configurations.

The recommended configuration for clearly maintaining stability is Configuration 7. This Configuration includes two new 138 kV lines from GEN-2006-010 (one to Sugar Hill and one to SE Texarkana) and the uprating of the GEN-2006-010 – Okay – Ashdown – Patterson 115 kV line to 138 kV.

Configuration 6, which does not include the new line to SE Texarkana, is not recommended because of poorly damped oscillations following Fault 9, and the sensitivity of this configuration to changes in generation dispatch and future line impedances.

The results of this analysis are based on available data and assumptions made at the time of conducting this study. If any of the data and/or assumptions made in developing the study model change, the results provided in this report may not apply.

Rev No.	Revision Description	Date	Authored by	Reviewed by	Approved by
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DISTRIBUTION:

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1 INTRODUCTION

Southwest Power Pool (SPP) has commissioned ABB Inc., to perform a Generation Interconnection Impact study of a coal fired steam turbine power plant with power output rated 610 MW (summer) / 620 MW (winter) in Hempstead County, Arkansas. The coal plant will be interconnected into the existing Okay-McNab 115 kV line in the control area of American Electric Power West (AEPW). Figure 1-1 shows the point of interconnection for the GEN-2006-010.



Figure 1-1: GEN-2006-010 Point of Interconnection

The objective of this impact study is to find the minimum configuration necessary to interconnect the power plant with the primary criteria being stability of the steam turbine. The study is performed on two system scenarios: 2007 Winter Peak and the 2011 Summer Peak.

The initial interconnection configuration will be in the existing Okay-McNab 115 kV transmission line in the AEP control area. The generation from the power plant will be dispatched into the AEPW control area. Incremental interconnection configurations to be evaluated in this impact study will be as follows:

- Configuration 1 – This corresponds to the initial interconnection configuration which will require the addition of a 138 / 115 kV 650 MVA autotransformer.
- Configuration 2 – Configuration 1 plus the addition of a 138 kV, 1590 MCM ACSR transmission line from the GEN-2006-010 138 kV bus to Northwest

Texarkana 138 kV bus (#53300). A 138 / 115 kV 650 MVA autotransformer will be modeled in this configuration.

- Configuration 3 – Configuration 2 except that the 115 kV line from GEN-2006-010 to Okay (#53303) to Ashdown REC (#53225) to Patterson (#53305) will be converted to 138 kV, 1590 MCM ACSR. A smaller 138 / 115 kV autotransformer (150 MVA) will be modeled in this configuration.
- Configuration 4 – Configuration 3 with the addition of a 138 kV line from GEN-2006-010 to Sugar Hill (#53323)
- Configuration 5 – Additional configuration involving 345 kV as needed.
- Configuration 6 – Configuration 4 with the removal of 138 kV transmission line from the GEN-2006-010 138 kV bus to Northwest Texarkana 138 kV bus (#53300).
- Configuration 7 – Configuration 6 with the addition of a 138 kV line from GEN-2006-010 to SE Texarkana (#53320).

The proposed interconnection configurations are illustrated in Figure 1-2 through Figure 1-7 respectively.

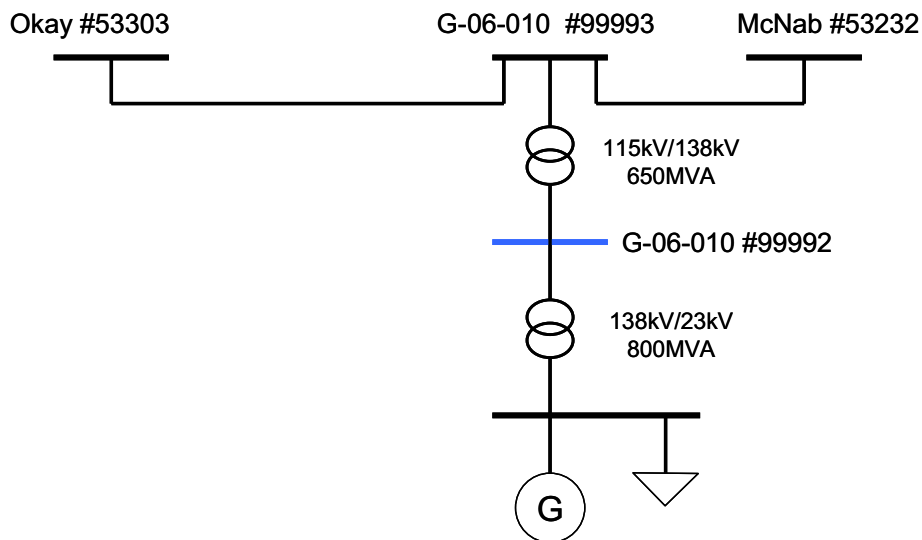


Figure 1-2 Interconnection Configuration 1 for the Proposed Project

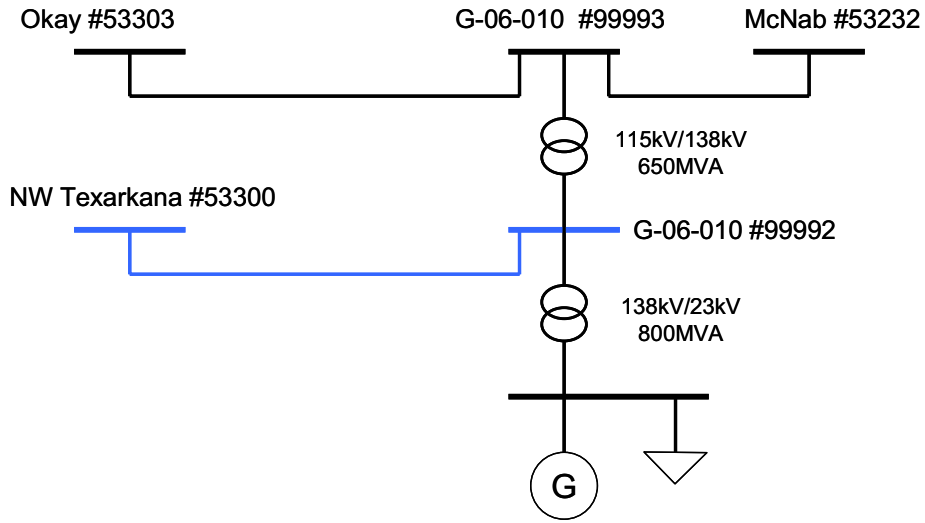


Figure 1-3 Interconnection Configuration 2 for the Proposed Project

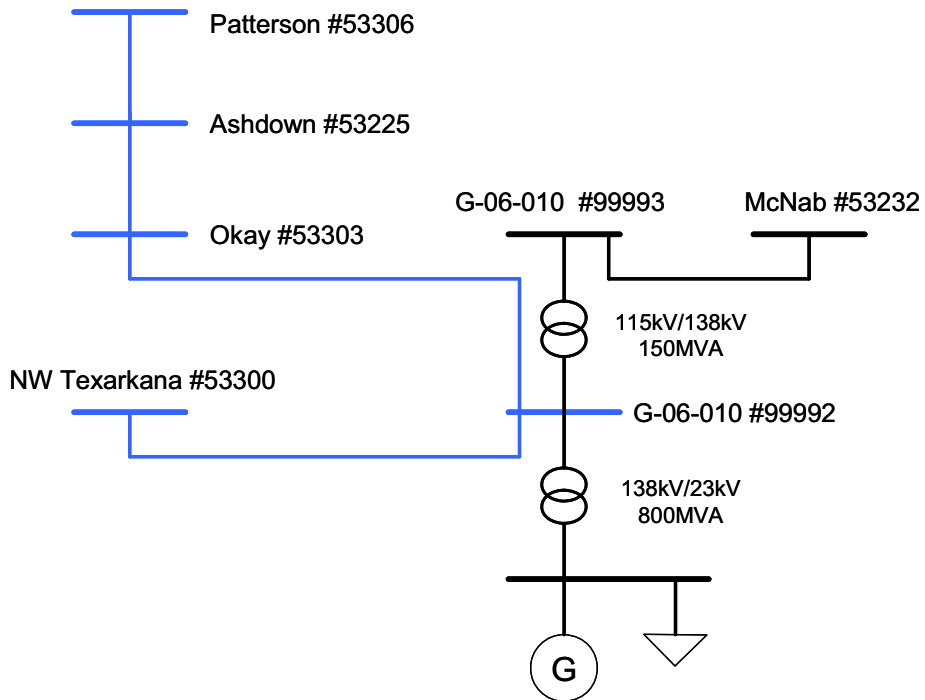


Figure 1-4 Interconnection Configuration 3 for the Proposed Project

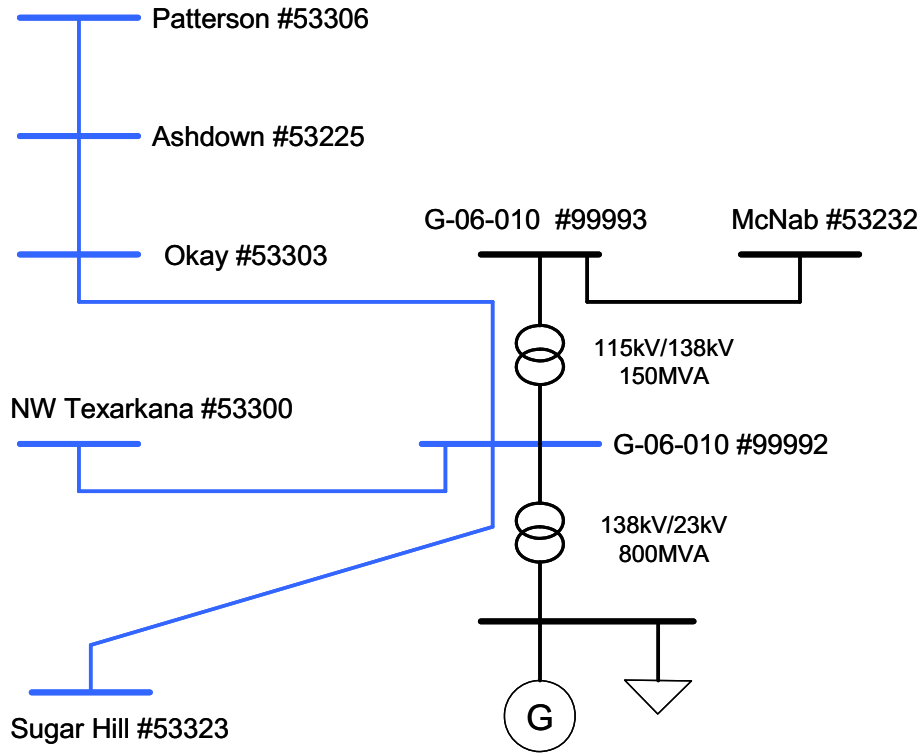


Figure 1-5 Interconnection Configuration 4 for the Proposed Project

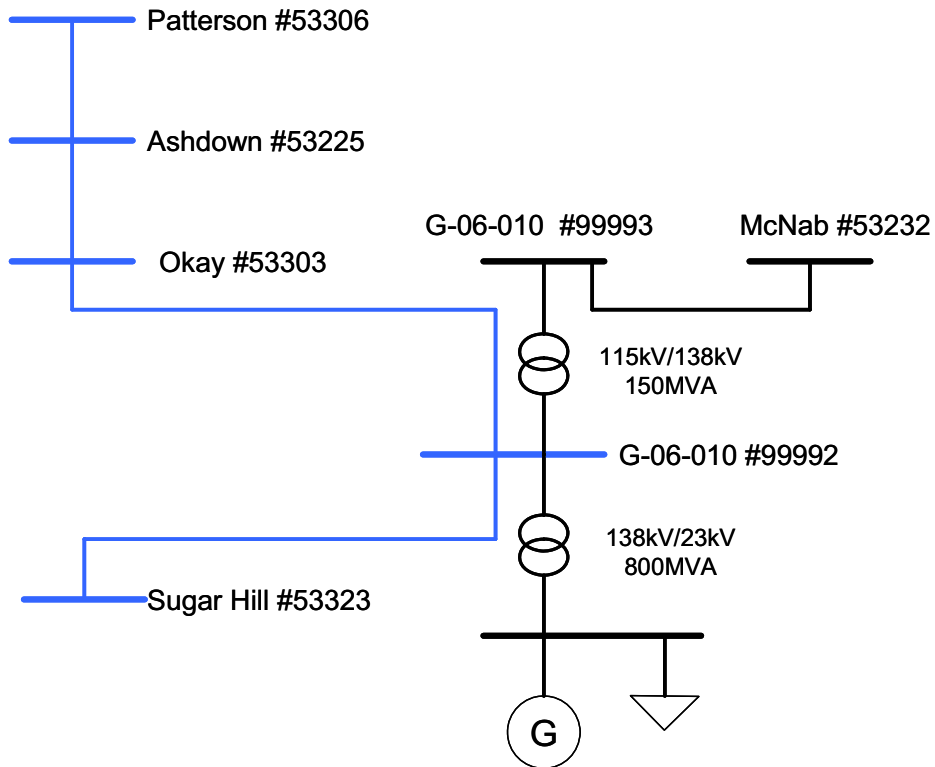


Figure 1-6 Interconnection Configuration 6 for the Proposed Project

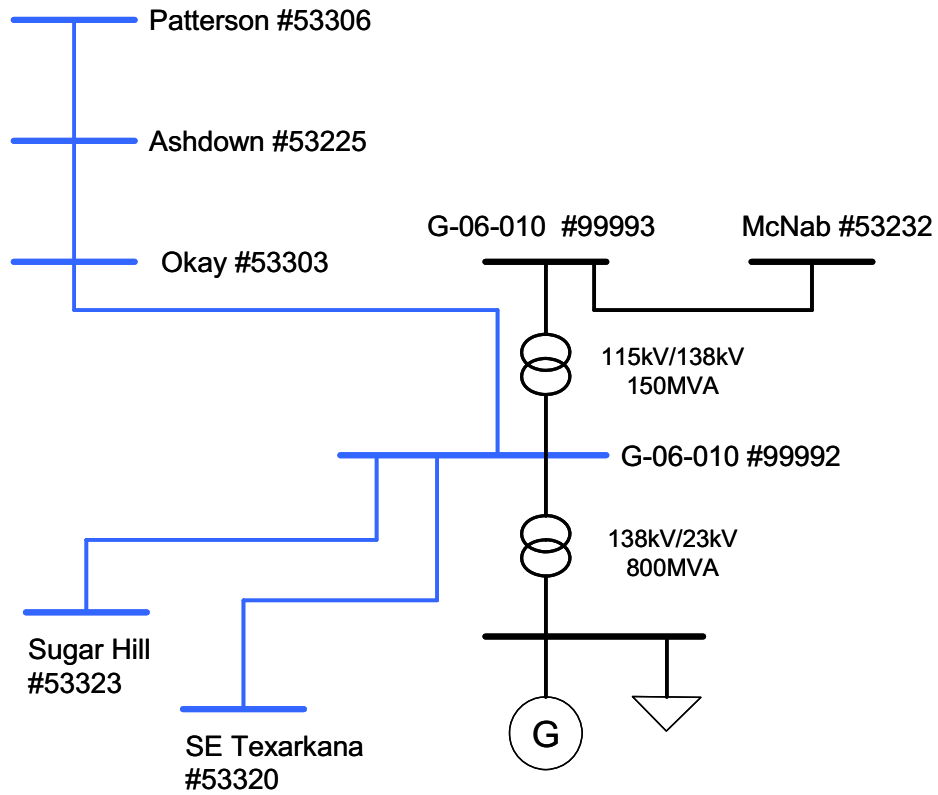


Figure 1-7 Interconnection Configuration 7 for the Proposed Project

2 STABILITY ANALYSIS

In this study, ABB investigated the stability of the system for the faults in the vicinity of the proposed plant as defined by SPP. The faults involve three-phase and single-phase faults cleared by primary protection, re-closing with the fault still on, and then permanently clearing the fault with primary protection.

2.1 STABILITY ANALYSIS METHODOLOGY

Using Planning Standards approved by NERC, the following stability definition was applied in the Transient Stability Analysis:

“Power system stability is defined as that condition in which the differences of the angular positions of synchronous machine rotors become constant following an aperiodic system disturbance.”

Stability analysis was performed using Siemens-PTI's PSS/E dynamics program V29. Disturbances such as three-phase and single-phase line faults were simulated for the specified durations, including re-closing, and the synchronous machine rotor angles were monitored to make sure they maintained synchronism following the fault removal.

Single-phase line faults were simulated with the standard method of applying fault impedance to the positive sequence network 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 fault location of approximately 60% of pre-fault voltage, which is a typical value.

2.2 STUDY MODEL DEVELOPMENT

The study model consists of power flow cases and dynamics databases, developed as follows.

Power Flow Case

SPP provided two (2) Pre-project PSS/E power flow cases called “*gen06-10_11SP_base.sav*” representing the Summer Peak conditions of the SPP system for the year 2011 and the “*gen06-10_07wp_base.sav*” representing the Winter Peak conditions of the SPP system for the year 2007.

The proposed GEN-2006-010 project is comprised of a single steam turbine generator rated 840 MVA and a step-up transformer (23 / 138 kV) rated 800 MVA. The unit will be connected to the existing Okay-McNab 115 kV transmission line by a 138 / 115 kV autotransformer rated 650 MVA or 150 MVA for different interconnection configurations.

The proposed project was added to the Pre-project cases with gross power output rated 645 MW (summer) or 655 MW (winter), so that the net injection from GEN-2006-010 will be 610 MW (summer) or 620 MW (winter) after deducting the assumed plant auxiliary load (35 MW and 25 MVAR). To balance the power output from GEN-2006-010, the generation was dispatched by scaling down generation in five control areas 524, 526, 536, 540, and 541.

Initially, four interconnection configurations were studied (Configurations 1-4). Two additional configurations were added (Configurations 6 and 7) after it was determined that these were more realistic. Ultimately, twelve power flow cases with GEN-2006-010 were established, two cases (07wp and 11sp) for each interconnection configuration:

- *Configuration 1: gen06-10_11sp_c1.sav and gen06-10_07wp_c1.sav*
- *Configuration 2: gen06-10_11sp_c2.sav and gen06-10_07wp_c2.sav*
- *Configuration 3: gen06-10_11sp_c3.sav and gen06-10_07wp_c3.sav*
- *Configuration 4: gen06-10_11sp_c4.sav and gen06-10_07wp_c4.sav*
- *Configuration 6: gen06-10_11sp_c6.sav and gen06-10_07wp_c6.sav*
- *Configuration 7: gen06-10_11sp_c7.sav and gen06-10_07wp_c7.sav*

Note: Configuration 5 was not investigated in this study

Figure 2-1 and Figure 2-2 show the power flow diagrams corresponding to Configuration 7 for the local area of GEN-2006-010 for Summer Peak 2011 and Winter Peak 2007 system conditions, respectively.

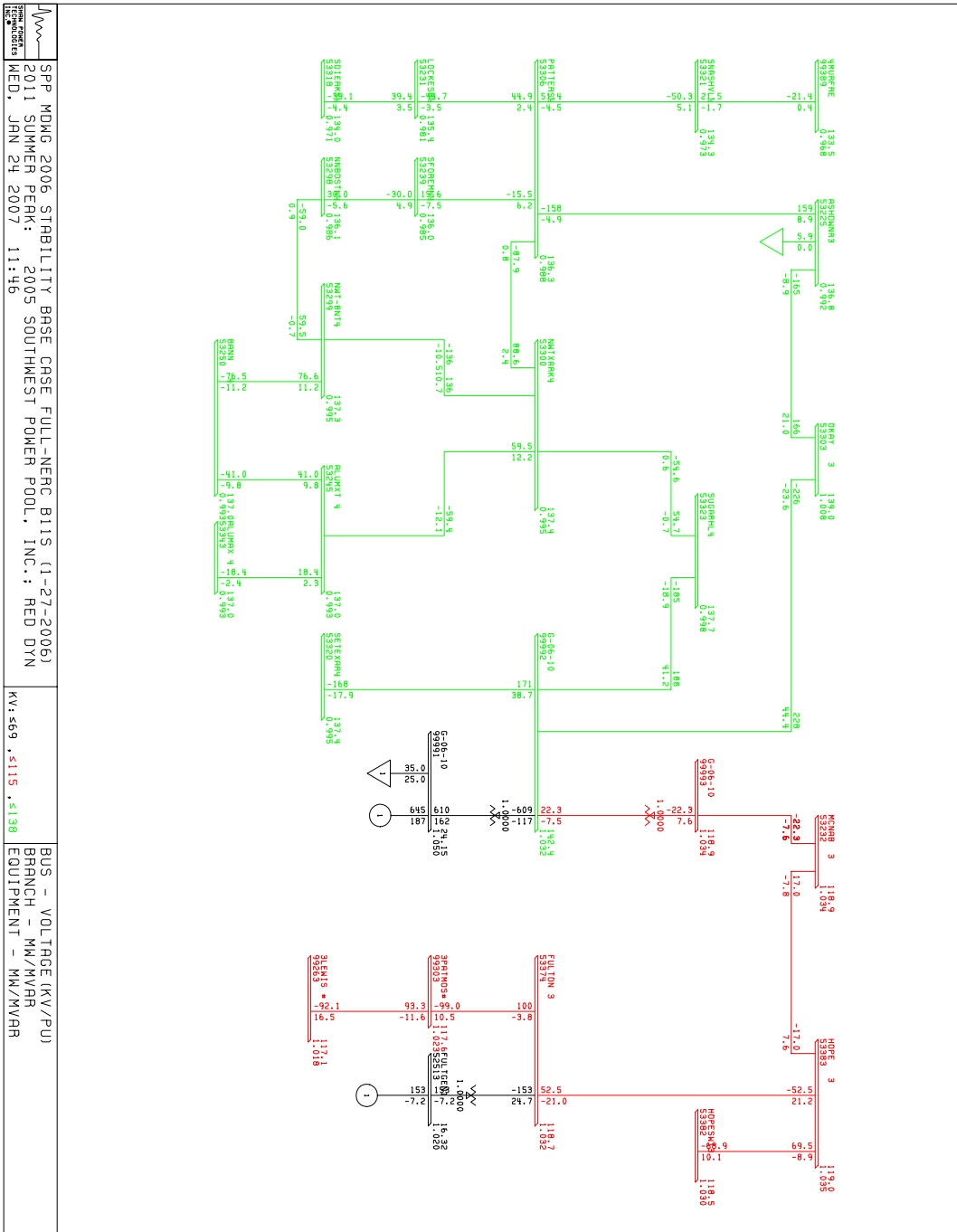


Figure 2-1: Power flow diagram for GEN-2006-010 (Summer Peak 2011, Config. 7)

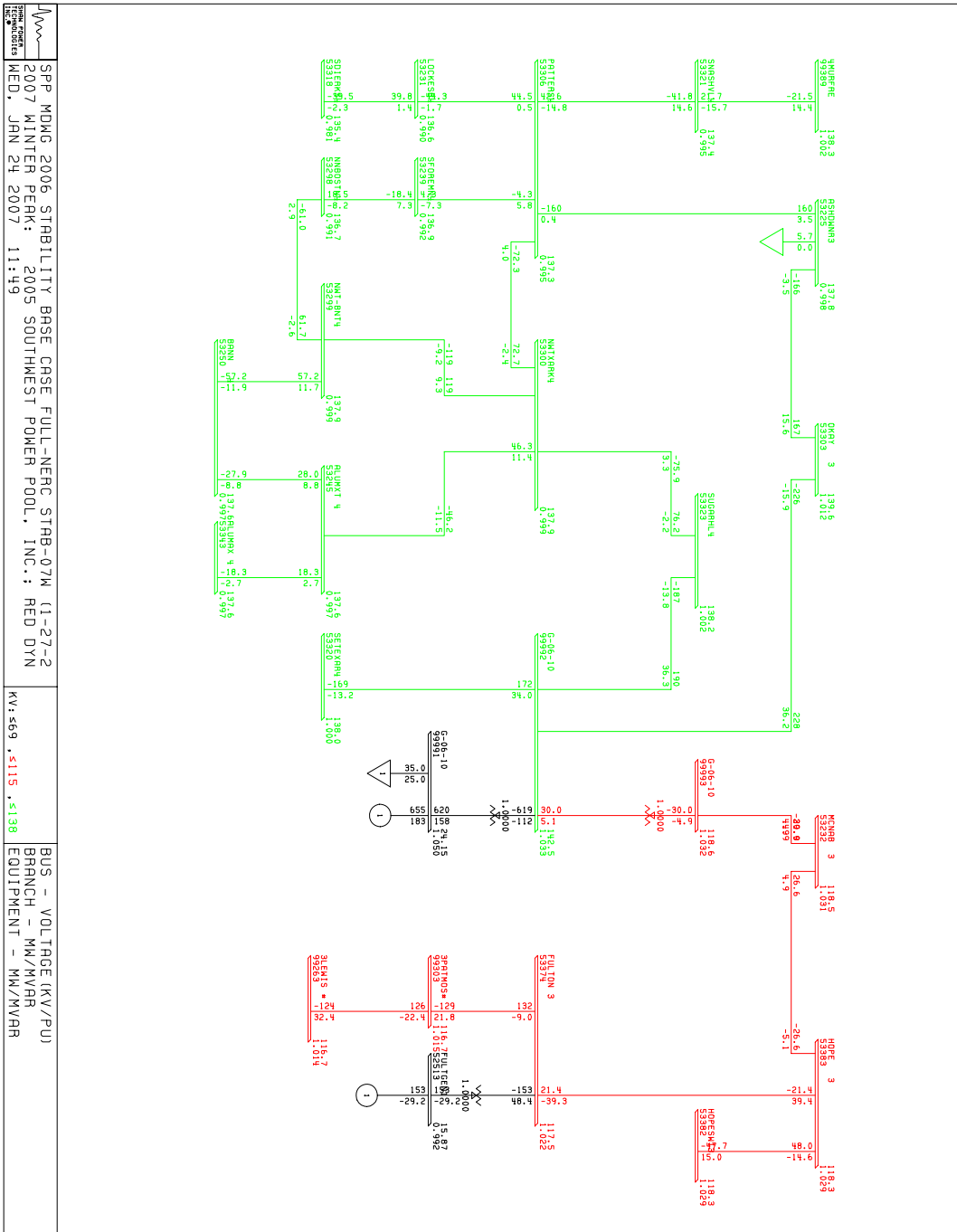


Figure 2-2: Power flow diagram for GEN-2006-010 (Winter Peak 2007, Config. 7)

Stability Database

SPP provided the stability database in the form of a PSS/E dynamic dyr data file “gen06-10_11sp_base.dyr” to model the Summer Peak stability dynamics database for 2011 and “gen06-10_07wp_base.dyr” to model the Winter Peak stability dynamics database for the year 2007. Along with the above-mentioned files, idev and batch files were also provided to compile and link user-written models. The provided files required the use of PSS/E version 29.

The stability data for GEN-2006-010 was appended to the Pre-GEN-2006-010 snapshot. The stability model parameters were based on data provided by the developer, including synchronous machine model, excitation model, turbine-governor model, and power stability stabilizer model. The power stability stabilizer model was not enabled in this impact study.

Fault Simulations

Table 2-1 lists the disturbances simulated for stability analysis. All transmission lines were assumed to have re-closing enabled. All faults were simulated for 15 seconds.

Initially, only the worst faults, normally those on network branches at the point of interconnection (POI), were simulated for each Configuration. Once the preferred Configuration was selected, all faults were simulated on that Configuration.

Table 2-1: List of Faults for Stability Analysis

FAULT	FAULT DESCRIPTION
FLT_1_3PH	Fault on the GEN-2006-010 – Okay (#53303) 138 kV line near GEN-2006-010. a. Apply Fault at GEN-2006-010 138 kV (#99992). b. Clear Fault after 5 cycles by removing the line from service. c. Wait 30 cycles; and reclose into the fault d. Clear fault after 5 cycles by removing the line from service.
FLT_2_1PH	SLG fault same as FLT_1_3PH
FLT_3_3PH	Fault on the GEN-2006-010 – McNab (#53232) 115 kV line near GEN-2006-010. a. Apply Fault at GEN-2006-010 115 kV (#99993). b. Clear Fault after 5 cycles by removing the line from service. c. Wait 30 cycles; and reclose into the fault d. Clear fault after 5 cycles by removing the line from service.
FLT_4_1PH	SLG fault same as FLT_3_3PH
FLT_5_3PH	Fault on the GEN-2006-010 – NW Texarkana (#53300) 138 kV line near GEN-2006-010. a. Apply Fault at GEN-2006-010 138 kV (#99992). b. Clear Fault after 5 cycles by removing the line from service. c. Wait 30 cycles; and reclose into the fault d. Clear fault after 5 cycles by removing the line from service.
FLT_6_1PH	SLG same as FLT_5_3PH
FLT_7_3PH	Fault on the Fulton (#53374) – Patmos (#99303) – Lewisville (#99263) 115 kV line near Fulton. a. Apply Fault at Fulton 115 kV (#53374). b. Clear Fault after 5 cycles by removing the line from service. c. Wait 30 cycles; and reclose into the fault d. Clear fault after 5 cycles by removing the line from service.
FLT_8_1PH	SLG same as FLT_7_3PH

FAULT	FAULT DESCRIPTION
FLT_9_3PH	Fault on the GEN-2006-010 – Sugar Hill (#53323) 138 kV line near GEN-2006-010. a. Apply Fault at GEN-2006-010 138 kV (#99992). b. Clear Fault after 5 cycles by removing the line from service. c. Wait 30 cycles; and reclose into the fault d. Clear fault after 5 cycles by removing the line from service.
FLT_10_1PH	SLG same as FLT_9_3PH
FLT_11_3PH	Fault on the Patterson (#53306) – South Foreman (#53239) 138 kV line near Patterson. a. Apply Fault at Patterson (53306). b. Clear Fault after 5 cycles by removing the line from service. c. Wait 30 cycles; and reclose into the fault d. Clear fault after 5 cycles by removing the line from service.
FLT_12_1PH	SLG same as FLT_11_3PH
FLT_13_3PH	Fault on the Northwest Texarkana (#53301) – Welsh (#53615) 345V line near NW Texarkana. a. Apply Fault at NW Texarkana (#53301). b. Clear Fault after 5 cycles by removing the line from service. c. Wait 30 cycles; and reclose into the fault d. Clear fault after 5 cycles by removing the line from service.
FLT_14_1PH	SLG same as FLT_13PH
FLT_15_3PH	Fault on the GEN-2006-010 autotransformer. a. Apply Fault at GEN-2006-010 138 kV (#99992). b. Clear Fault after 5 cycles by removing the autotransformer from service.
FLT_16_1PH	SLG same as FLT_15_3PH
FLT_17_3PH	Fault on the GEN-2006-010 – SE Texarkana (#53320) 138 kV line near GEN-2006-010. a. Apply Fault at GEN-2006-010 138 kV (#99992). b. Clear Fault after 5 cycles by removing the line from service. c. Wait 30 cycles; and reclose into the fault d. Clear fault after 5 cycles by removing the line from service.
FLT_18_1PH	SLG same as FLT_17_3PH

2.3 STUDY RESULTS

As mentioned, only the worst faults were initially run on each configuration.

Configuration 1

The plant was found unstable for Configuration 1 as shown in Table 2-2. The plots for these simulated faults are included in Appendix A.

Table 2-2: Results for Stability Analysis of Configuration 1

FAULT	Summer Peak 2011	Winter Peak 2007
FLT_1_3PH	UNSTABLE	UNSTABLE
FLT_3_3PH	UNSTABLE	UNSTABLE

Configuration 2

The plant was found unstable for Configuration 2 as shown in Table 2-3. The plots for these simulated faults are included in Appendix B.

Table 2-3: Results for Stability Analysis of Configuration 2

FAULT	Summer Peak 2011	Winter Peak 2007
FLT_5_3PH	UNSTABLE	UNSTABLE
FLT_15_3PH	POORLY DAMPED	POORLY DAMPED

Configuration 3

The plant was found marginally stable for Configuration 3, due to poor damping following fault 5, as shown in Table 2-4. The plots for these simulated faults are included in Appendix C.

Table 2-4: Results for Stability Analysis of Configuration 3

FAULT	Summer Peak 2011	Winter Peak 2007
FLT_1_3PH	STABLE	STABLE
FLT_5_3PH	POORLY DAMPED	POORLY DAMPED
FLT_15_3PH	STABLE	STABLE

Configuration 4

The results for all the disturbances simulated for Configuration 4 are summarized in Table 2-5. The results of the simulation indicate that the SPP system will be clearly stable following all the critical faults in both Summer Peak and Winter Peak system conditions. The plots for Configuration 4 are included in Appendix D and Appendix E.

Table 2-5 Results for Stability Analysis of Configuration 4

FAULT	Summer Peak 2011	Winter Peak 2007
FLT_1_3PH	STABLE	STABLE
FLT_5_3PH	STABLE	STABLE
FLT_9_3PH	STABLE	STABLE
FLT_15_3PH	STABLE	STABLE

Configuration 5

The configuration involving 345 kV was not investigated in this study.

Configuration 6

The plant was found marginally stable for Configuration 6, due to poor damping following fault 9, as shown in Table 2-6. The plots for these simulated faults are included in Appendix F.

Table 2-6: Results for Stability Analysis of Configuration 6

FAULT	Summer Peak 2011	Winter Peak 2007
FLT_1_3PH	STABLE	STABLE
FLT_9_3PH	POORLY DAMPED	POORLY DAMPED
FLT_15_3PH	STABLE	STABLE

Configuration 7

The results for all the disturbances simulated for Configuration 7 are summarized in Table 2-7. The results of the simulation indicate that the SPP system will be clearly stable following all the simulated faults in both Summer Peak and Winter Peak system conditions. The plots for Configuration 7 are included in Appendix G and Appendix H.

Table 2-7: Results for Stability Analysis of Configuration 7

FAULT	Summer Peak 2011	Winter Peak 2007
FLT_1_3PH	STABLE	STABLE
FLT_2_1PH	STABLE	STABLE
FLT_3_3PH	STABLE	STABLE
FLT_4_1PH	STABLE	STABLE
FLT_5_3PH	STABLE	STABLE
FLT_6_1PH	STABLE	STABLE
FLT_7_3PH	STABLE	STABLE
FLT_8_1PH	STABLE	STABLE
FLT_9_3PH	STABLE	STABLE
FLT_10_1PH	STABLE	STABLE
FLT_11_3PH	STABLE	STABLE
FLT_12_1PH	STABLE	STABLE
FLT_13_3PH	STABLE	STABLE
FLT_14_1PH	STABLE	STABLE
FLT_15_3PH	STABLE	STABLE
FLT_16_1PH	STABLE	STABLE
FLT_17_3PH	STABLE	STABLE
FLT_18_1PH	STABLE	STABLE

2.4 SENSITIVITIES

As shown above, results for Configuration 6 are similar to those for Configuration 3, and results for Configuration 7 are similar to those for Configuration 4. Since Configurations 6 and 7 are considered more likely, these were the focus of additional analyses.

Configuration 7 is definitely stable. Configuration 6, however, is on the margin, particularly following Fault 9, which involves the loss of the proposed line from GEN-2006-010 to Sugar Hill. The following sensitivity analyses were performed on Configuration 6 and Fault 9 in the 2007 winter peak case.

Sensitivity to Impedance of GEN-2006-010 to Okay 138 kV line

As construction of the GEN-2006-010 to Okay 138 kV line has not yet begun, the impedance of this converted line is not yet known with certainty. Starting with the initial impedance of this line given by SPP, Fault 9 was simulated with larger impedances (series reactance only). See Figure 2-3. With an increase of 1.3% impedance, on 100 MVA base, Fault 9 becomes transiently unstable. The square symbol is the original plot. The triangle symbol is the plot with the impedance to Okay increased by 1.2%. The diamond symbol is for an increase of 1.3%.

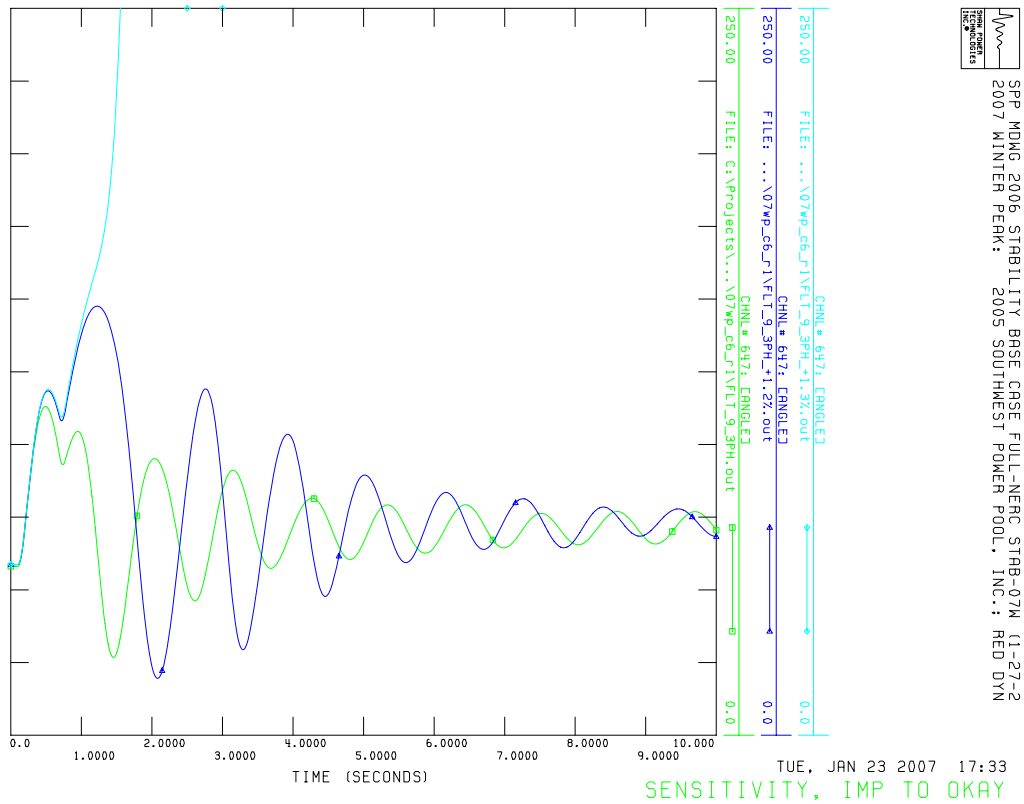


Figure 2-3: Angle of New Generator, Sensitivity to Impedance of 138 kV line to Okay

Generation Dispatch

Two alternative generation dispatches were tested. See Figure 2-4. The updated impedance was used for the GEN-2006-010 to McNab 115 kV line, and the original impedance was used for the GEN-2006-010 to Okay 138 kV line.

The first alternative dispatch involved turning on all generators in the GEN-2006-010 area to their maximum. This included Couch, Welsh, Wilkes, and Hugo 1. This dispatch

(plot with triangle symbol) did not change the results much, besides shifting the curve up a few degrees compared to the original (curve with square symbol).

The second alternative dispatch was like the first, except that Fulton and Couch plants were shut down. This dispatch resulted in a worse oscillation (curve with diamond symbol) than the other dispatches.

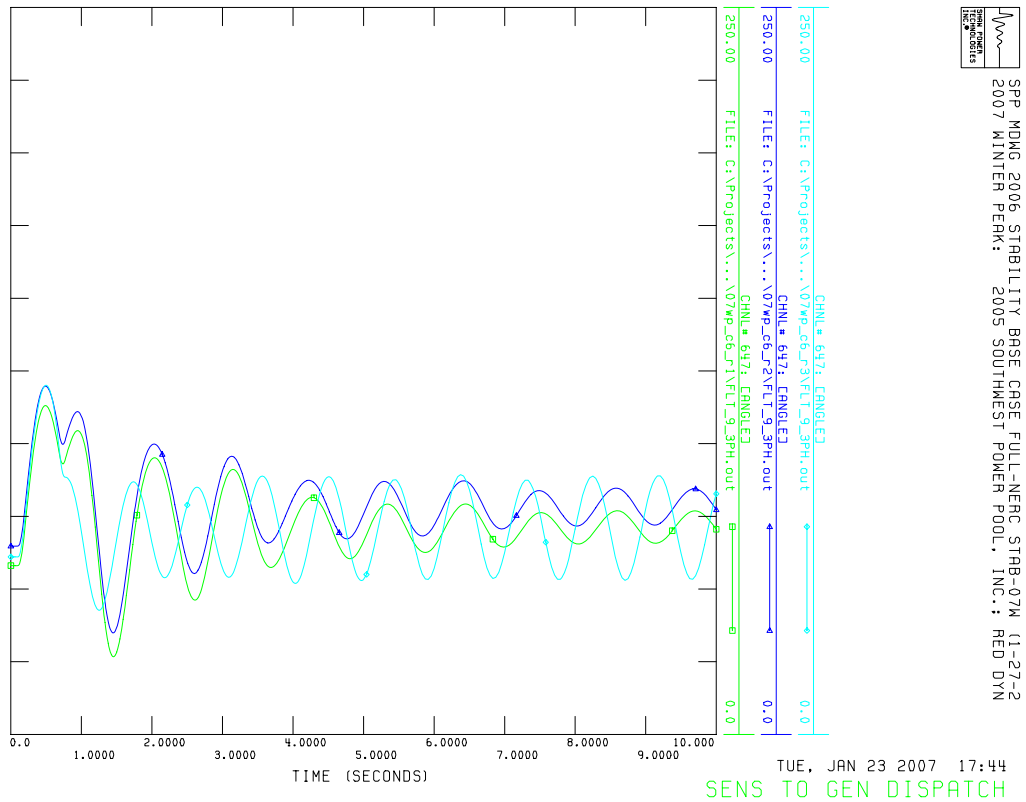


Figure 2-4: Angle of New Generator, Sensitivity to Generation Dispatch

3 CONCLUSIONS

The objective of this study was to evaluate the impact on system stability after connecting the GEN-2006-010 power plant and its effect on the nearby transmission system and generating stations. The study is performed on two seasonal models, 2007 Winter Peak and the 2011 Summer Peak, along with numerous interconnection configurations.

The recommended Configuration for clearly maintaining stability is Configuration 7. This Configuration includes two new 138 kV lines from GEN-2006-010 (one to Sugar Hill and one to SE Texarkana) and the uprating of the GEN-2006-010 – Okay – Ashdown – Patterson 115 kV line to 138 kV.

Configuration 6 is not recommended because of large, poorly damped oscillations following Fault 9, and the sensitivity of this configuration to changes in generation dispatch and future line impedances.

The results of this analysis are based on available data and assumptions made at the time of conducting this study. If any of the data and/or assumptions made in developing the study model change, the results provided in this report may not apply.

- APPENDIX A - SIMULATION PLOTS FOR CONFIGURATION 1**
- APPENDIX B - SIMULATION PLOTS FOR CONFIGURATION 2**
- APPENDIX C - SIMULATION PLOTS FOR CONFIGURATION 3**
- APPENDIX D - SIMULATION PLOTS FOR CONFIGURATION 4**
- APPENDIX E - SIMULATION PLOTS FOR CONFIGURATION 6**
- APPENDIX F - SIMULATION PLOTS FOR CONFIGURATION 7 (11SP)**
- APPENDIX G - SIMULATION PLOTS FOR CONFIGURATION 7 (07WP)**