System Impact Study for Interconnection of 580 MW Generation Facility near Tontitown, Arkansas

Southwest Transmission Planning

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Executive Summary

Customer has requested an Impact Study for the interconnection of a merchant plant near Tontitown, Arkansas, approximately seven miles west of Springdale. The plant will have a maximum output of 580 MW in the summer and 630 MW in the winter. The projected in service date is 2004.

The principal objectives of this study is to: 1) identify any system problems associated with the connection of the proposed plant, 2) determine potential system modifications that might be necessary to facilitate the installation of the plant while maintaining system reliability and stability, and 3) estimate the costs associated with those system modifications. The study includes a steady state contingency analysis, a transient stability analysis, and an analysis of whether the interrupting capabilities of the existing circuit breakers in the area are exceeded with the addition of this new generation.

For the purposes of this study, two seasons were studied, the 2004 summer peak and the 2004 winter peak. In each case, the plant's output was exported as follows: 230 MW to American Electric Power (AEP), 100 MW to Ameren, 100 MW to Associated Electric Cooperative (AECI), 50 MW to Entergy, 50 MW to Grand River Dam Authority (GRDA), and 50 MW to Oklahoma Gas and Electric (OG&E).

The estimated cost of interconnecting the proposed generation to the transmission system is $2,880,000. This cost includes interconnection costs on the American Electric Power (AEP) system including upgrades needed for short circuit problems. The study also identified several additional system improvements that will be paid for by AEP. See the table entitled Additional System Improvements by AEP.

The analysis in this document shows that to accommodate a transfer, upgrades may be required on neighboring transmission systems to relieve certain criteria violations. These violations are listed in Tables 1 and 2 of the Steady State Analysis section. Some of these violations are on systems not covered by the Southwest Power Pool (SPP) Tariff.

Transient stability analysis of the project showed that the project was stable under single and double contingencies and did not cause system instability.

Introduction

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

Stability analysis shows the effects of the new generation on the transient stability of Southwestern Electric Power Company (SWEPCO) and surrounding utility generators. Transient stability is concerned with recovery from faults on the transmission system that are in close proximity to generating facilities.

This study also includes a short circuit analysis that determines whether the interruption capabilities of existing circuit breakers are exceeded with the addition of the new generation.

Interconnection Facilities

The facilities listed below will be Customer's responsibility.

Tontitown 161 kV terminals
AEP will construct the Tontitown 161 kV station adjacent to the proposed Customer plant to provide the interface between the plant and the transmission system. The 161 kV yard will consist of twelve breakers in a breaker and a half configuration including five 161 kV line terminals and three generator terminals. The Customer plant will utilize three terminals in this new station. The facility will include all metering, protection and SCADA systems. Customer will construct and own the generating plant and maintain the equipment including the GSU high-side transformer disconnects at the ownership boundary. Customer will also provide the property and initial site preparation for the construction of the facility. AEP will retain ownership and operating authority of the 161 kV switchyard up to the high-side GSU transformer disconnects.

The design and construction of Customer's three terminals will meet all AEP specifications for stations. Support structures and line terminal equipment will be designed to terminate the respective conductors from the generator step-up transformers. Bus work and disconnect switches will be designed to accommodate the loading requirements, and circuit breakers will be rated to ensure adequate load and fault interrupting capability. Metering equipment will be installed to monitor the plant output and will meet the required accuracy specifications. The estimated cost of the three terminals is $1,560,000.

Tontitown-Elm Springs REC 161 kV line rebuild and reconductor
AEP will rebuild and reconductor the easternmost 1.6 mile portion of the existing Flint Creek-Elm Springs REC 161 kV line. This line section will become part of the 161 kV line from the proposed Tontitown station to Elm Springs REC. The line shall be supported on steel structures on an existing AEP easement. The phase conductors shall be 2156 ACSR with a 3/8" EHS steel shield wire. AEP will also replace the two sets of 1200 A switches at Elm Springs REC with 2000 A switches. The cost of this line construction and switches is estimated to be $720,000.

Dyess Breaker Replacements
AEP will replace 161 kV circuit breakers 8880 and 8890 at Dyess station due to short circuit ratings violations caused by the added generation of the Customer facility. AEP will also replace 161 kV circuit breaker 8870 at Dyess station due to both short circuit ratings violations as well as steady state loading violations caused by the added generation of the Customer facility. Details of the short circuit analysis are discussed in the Short Circuit Analysis section. AEP will also replace the 1200 A switches and 1033 AAC jumpers on the Dyess circuit to Elm Springs REC, as called for in the Steady State Analysis section. The estimated cost of this work is $600,000.

Interconnection Costs

Listed below are the costs associated with interconnecting the Cutomer 580 MW generation facility to the transmission system.

SYSTEM IMPROVEMENT	COST (2001 DOLLARS)
* Three Tontitown 161 kV terminals	$1,560,000
Tontitown-Elm Springs REC rebuild and reconductor 1.6 mile, 161 kV line to 2156 ACSR and replace switches at Elm Springs REC	$720,000
Replace (3) 161 kV breakers at Dyess (8870, 8880, and 8890) and the Dyess switches and jumpers on the circuit to Elm Springs REC	$600,000
TOTAL	$2,880,000

* This cost is assuming that Customer will provide the property and initial site preparation for the construction of the Tontitown station.

Additional System Improvements by AEP

Listed below are additional system improvements that will be paid for by AEP, which are associated with interconnecting the Customer 580 MW generation facility to the transmission system.

SYSTEM IMPROVEMENTS BY AEP
Build the Tontitown 161 kV station with twelve breakers forming eight terminals in a breaker-and-a-half scheme (Three of the 161 kV terminals are already included in the system improvements listed in the Interconnection Costs section above)
Route the Flint Creek-Elm Springs REC 161 kV line 0.34 miles into and out of the new Tontitown station.
Route the Chamber Springs-Dyess 161 kV line 0.57 miles into and out of the new Tontitown station.
Build the Tontitown-East Rogers 1590 ACSR, 161 kV line. This includes 10.7 miles of new line and the rebuild and reconductor of 8.8 miles of existing 69 kV line to 161 kV. This will require the conversion of Lowell and Rogers stations from 69 kV to 161 kV as listed below.
Convert the Lowell station from 69 kV to 161 kV. Replace the two 69-12.5 kV, 13/18/22.4 MVA LTC transformers with two 161-12.5 kV, 13/18/22.4 MVA LTC transformers and install two 161 kV breakers on the two outgoing lines.
Convert the Rogers station from 69 kV to 161 kV. Replace the 69-12.5 kV, 25/33 MVA LTC transformer and the 69-12.5 kV, 12/16/20 MVA LTC transformer with two 161-12.5 kV, 20/33/37 MVA LTC transformers and install two 161 kV breakers on the two outgoing lines.
Add a 161 kV terminal at East Rogers in ring bus configuration. This requires three 161 kV breakers.
Rebuild and reconductor the Tontitown-Dyess 6.8 mile, 161 kV, 666 ACSR line to 161 kV, 2156 ACSR.
On the Dyess 161 kV circuit to Tontitown that is being reconductored to 2156 ACSR, replace jumpers, wave trap, and two 1200 A switches. Also install a new line relay panel for the other Dyess 161 kV circuit to Tontitown that serves Elm Springs REC.

The line section lengths above are approximate based upon preferred routes and are subject to change.

A. Steady State Analysis

Study Methodology

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

1) More probable contingency testing .... must conclude that

    a) All facility loadings are within their emergency ratings and all voltages are within their emergency limits (0.90-1.05 per unit) and
    b) Facility loadings can be returned to their normal limits within four hours

2) Less probable contingency testing .... shall conclude that

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

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

The 2001 series Southwest Power Pool 2004 summer and winter peak base cases were used to model the transmission network and system loads. These cases were modified to reflect known firm point to point transmission requests that have been approved.

Per information received from Customer, the plant's output was exported as follows: 230 MW to AEP, 100 MW to Ameren, 100 MW to AECI, 50 MW to Entergy, 50 MW to GRDA, and 50 MW to OG&E.

Using the created 2004 summer peak model and PTI's PSS/E program, single and select double contingency outages on the SPP system were analyzed to determine the necessary facilities to interconnect the proposed plant to the transmission system. This load flow analysis is described on the following pages.

Next, using the two created models and the ACCC function of PTI's PSS/E program, single contingency outages were analyzed covering GRDA, Southwestern Power Administration (SWPA), Empire District Electric Company (EMDE), the northern zone of Entergy, and the Fayetteville zone of AEP, while monitoring these same areas. Select double contingency outages on the SPP system were also included. Facilities found to be overloaded in the transfer cases with the proposed plant addition and not in the base cases were flagged and listed in Tables 1 and 2.

<u>Load Flow Analysis</u>

The discussion below is not a summary of all outages or criteria violations. It lists certain key flow results most relevant to the discussion. These load flow analysis results do not include any additions or changes found in the stability analysis or the short circuit analysis. For approximate line lengths, see the first section of this study. The line lengths listed in this load flow analysis below are rough approximations.

Base Case

To develop the 2004 summer peak and winter peak base cases for this analysis, the following projects were removed from the cases B04SP_GEN-01-25.SAV and B04WP_GEN-01-25.SAV: (1) the Chamber Springs-Lake Elmdale 345 kV line and Lake Elmdale 345/161 kV station, (2) the Lake Elmdale-East Rogers 161 kV line, (3) the Siloam Springs-Chamber Springs 161 kV line, (4) the South Fayetteville-Dyess 161 kV conversion, and (5) the second East Centerton 161/69 kV autotransformer. The resulting summer and winter cases were saved as 04SP BASE1.SAV and 04WP BASE1.SAV respectively. These are the cases **without the Tontitown generation plant** to which the cases **with the Tontitown generation plant**, mentioned later, were compared using ACCC runs.

Tontitown 580 MW Generation Added

The 580 MW Tontitown generation plant was then added to the 2004 summer peak case 04SP BASE1.SAV **mentioned above. The plant was connected to Tontitown station (presently non-existent), modeled one mile to the east of the Tontitown generation plant, by (2) 2-1272 ACSR, 161 kV lines.** (It should be noted that after this analysis was completed, the parties decided to plan to build the Tontitown station next to the generation plant instead of one mile to the east of it.) **The Flint Creek-Elm Springs REC 161 kV line and the Chamber Springs-Dyess 161 kV line were each routed into and out of Tontitown Station, resulting in Tontitown Station having six 161 kV terminals. The length of the in and out line sections were modeled as 0.25 miles each, with 1590 ACSR conductor. The 580 MW was modeled to be exported as follows: 230 MW to AEP, 100 MW to Ameren, 100 MW to AECI, 50 MW to Entergy, 50 MW to GRDA, and 50 MW to OG&E. The generation was scaled down in each of these areas except in AEP. In AEP, generation was reduced by 70 MW at Knox Lee #4, 25 MW at Lieberman #1, 25 MW at Lieberman #2, 60 MW at Weleetka, and 50 MW at Tulsa Power Station #2-1.** This case was saved as 04SP TONT1.SAV. **The changes made in the 2004 winter peak case were the same, except for the AEP generation reduction. The AEP generation reduction in 2004 winter was 100 MW at Lieberman #3, 80 MW at Arsenal Hill, and 50 MW at Riverside Station #2.** This case was saved as 04WP TONT1.SAV.

In the summer case (04SP TONT1.SAV) with no contingencies, the Tontitown-Elm Springs REC 161 kV line overloads to 124% of the normal rating for the 2-397 ACSR conductor. This line section also overloads the emergency rating for almost any contingency. Also with no contingencies, the Tontitown-Dyess 161 kV line overloads to 110% of the normal rating for the 666 ACSR conductor.

The outage of either of the two 161 kV lines heading eastward out of Tontitown overloads the other. For the loss of the Tontitown-Dyess 161 kV line, the Tontitown-Elm Springs REC 161 kV line reaches 159% of the emergency rating of the 2-397 ACSR conductor, and the Elm Springs REC-Dyess 161 kV line reaches 132% of the emergency rating of the 2-397 ACSR conductor. Conversely, for the loss of the Tontitown-Elm Springs REC 161 kV line, the Tontitown-Dyess 161 kV line reaches 214% of the emergency rating of the 666 ACSR conductor.

Beyond Dyess there are still other overloads. For the loss of the Flint Creek-Gentry REC 161 kV line, the Dyess-East Rogers 161 kV line overloads to 119% of the emergency rating of the 666 ACSR conductor. Loss of the largest Dyess 161-69 kV autotransformer overloads each of the two smaller Dyess 161-69 kV autotransformers to 123% of their emergency ratings. Loss of the Dyess-Springdale 69 kV line overloads the Dyess Springdale ‘T’ 69 kV line to 130% of the emergency rating of the 666 ACSR conductor.

Tontitown-East Rogers 161 kV Line Added

The Tontitown-East Rogers 19.7 mile, 1590 ACSR, 161 kV line was then added. This includes about 10.9 miles of new line and the conversion of about 8.8 miles of 69 kV line to 161 kV and the conversion of the Lowell and Rogers stations from 69 kV to 161 kV. The resulting summer and winter cases were saved as 04SP TONT2.SAV and 04WP TONT2.SAV respectively.

In the summer case (04SP TONT2.SAV), the outage of either of the two 161 kV lines heading eastward out of Tontitown overloads the other. For the loss of the Tontitown-Dyess 161 kV line, the Tontitown-Elm Springs REC 161 kV line reaches 125% of the emergency rating of the 2-397 ACSR conductor. Conversely, for the loss of the Tontitown-Elm Springs REC 161 kV line, the Tontitown-Dyess 161 kV line reaches 164% of the emergency rating of the 666 ACSR conductor.

Rebuild/Reconductor Tontitown-Dyess & Tontitown-Elm Springs REC

The 6.25 mile Tontitown-Dyess 161 kV line and the 1.25 mile Tontitown-Elm Springs REC 161 kV line were then rebuilt and reconductored to 2156 ACSR. The resulting summer and winter cases were saved as 04SP TONT3.SAV and 04WP TONT3.SAV respectively.

In the summer case (04SP TONT3.SAV), loss of the Tontitown-Dyess 161 kV line loads the Elm Springs REC-Dyess 161 kV line to 98% of the emergency rating of the 2-397 ACSR conductor. This overloads the emergency rating of the 1200 A switches at Elm Springs REC on the circuit to Dyess, Dyess breaker 8870, and the Dyess 1200 A switches on the circuit to Elm Springs REC by 103%. Note that Dyess breaker 8870 is also identified in the Short Circuit Analysis as having its interrupting rating exceeded. This also overloads the emergency rating of the 1033 AAC jumpers at Dyess by 111%.

ACCC runs were then performed on this case (04SP TONT3.SAV) and also on the winter case (04WP TONT3.SAV) with these same improvements added. Facilities found to be overloaded in these two transfer cases but not in the corresponding base cases (04SP BASE1.SAV and 04WP BASE1.SAV) were flagged and listed in Tables 1 and 2.

Table 1 – Overloaded facilities for 2004 summer peak with 580 MW plant, which were not overloaded in the base case.

Branch Over 100% Rate B (Emergency Rating)	Rate B (MVA)	580 MW Transfer Case % Loading	Outaged Branch That Caused Overload
AURORA – MONETT 161 KV (EMDE)	157	101.4	BEAVER DAM (SWPA) – EUREKA SPRINGS 161 KV (AEP)
MAGNOLIA ST – MAGNOLIA E 115 KV (Entergy)	159	100.3	COUCH – MAGNOLIA DW 115 KV (Entergy)
CARTHAGE (SWPA) – REEDS 69 KV (AECI)	36	102.2	AURORA 124 – AURORA 355 69 KV (EMDE)
CARTHAGE (SWPA) - JASPER 69 KV (AECI)	47	101.7	CARTHAGE (SWPA) – REEDS 69 KV (AECI)
NEOSHO 161 KV (EMDE) – NEOSAC 69 KV (AECI)	56	101.4	MIAMI (GRDA) - SENECA 69 KV (AECI)

Table 2 – Overloaded facilities for 2004 winter peak with 580 MW plant, which were not overloaded in the base case.

Branch Over 100% Rate B (Emergency Rating)	Rate B (MVA)	580 MW Transfer Case % Loading	Outaged Branch That Caused Overload
CARTHAGE (SWPA) – REEDS 69 KV (AECI)	43	101.0	AURORA – MONETT 161 KV (EMDE)
COUCH – MAGNOLIA DW 115 KV (Entergy)	108	100.9	MAGNOLIA E – MCNEIL 115 KV (Entergy)
NORFORK DAM 161-69 KV (SWPA)	25	101.8	NORFORK DAM (SWPA) – 5WPLAIN 161 KV (AECI)

B. Stability Analysis

Stability Analysis showed that the addition of the Customer generation requires no new system facilities to be constructed. The system was shown to remain stable addition of the Customer generation.

C. Short Circuit Analysis

Scope

The subject of this study is the Customer proposed 630 MW (winter net) power plant near Tontitown, in Washington County, Arkansas. This plant will connect into the local 161 kV transmission system via five 161 kV lines. Tontitown will be connected by two lines to Dyess, one line to Flint Creek, one line to Chamber Springs and one line to East Rogers. The purpose of this study is to assess the impact of the addition of the proposed generation on the available fault current in the Southwestern Electric Power Company (SWEPCO) system, and to determine whether or not the interrupting rating of SWEPCO circuit breakers, circuit switchers, and power fuses would be exceeded as a result of the addition. The software used to study Customer's proposed plant at Tontitown has the ability to calculate ANSI X/R ratios for bus and close in faults and to perform breaker rating study in batch mode for determining the short-circuit duty imposed on circuit-interrupting devices. The base short-circuit case used was a Southwest Power Pool (SPP) 2005 case. This case includes prior IPP generation and related system improvements. This case was modified for the additional system change requirements for the injection of 630 MW generation by Customer , into the SWEPCO transmission system.

Customer 630 MW Case Model Data

The following facilities were modeled in the short-circuit case to determine the impact of 630 MW on available short-circuit levels:

- The Customer 161 kV generating facility comprised of a single 240 MW stream generator and two 195 MW Gas turbine generators.
- Two 161 kV lines from the Customer Tontitown station to the SWEPCO Dyess station.
- A 161 kV line from the Customer Tontitown station to the SWEPCO Chamber Springs station.
- A 161 kV line from the Customer Tontitown station to the SWEPCO Flint Creek station.

- A 161 kV line from the Customer Tontitown station to the SWEPCO East Rogers station.

Method

The batch short-circuit and breaker rating program was then used to place a three-phase-to-ground and a single-phase-to-ground close in fault on each transmission line connected to each breaker modeled in the short-circuit case. For each breaker, the worst case fault current level was compared to the breaker rating. This was performed with the above facilities excluded and then performed again with the above facilities included for comparative purposes.

Conclusion

It is standard practice for AEP to recommend replacing a circuit breaker when the current through the breaker for a fault exceeds 100% of its interrupting rating with recloser de-rating applied, as determined by the ANSI/IEEE C37.5-1979, C37.010-1979 & C37.04-1979 breaker rating methods.

In the SWEPCO system, the following breakers were found to exceed their interrupting capability after the addition of the Customer 630 MW generation and related facilities:
1) Dyess breakers 8870, 8880 and 8890.
Each of these breakers reached 115% of their interrupting capability.