

Steady State Analysis of Clay Center Junction to Clifton Transmission Line

SPP Engineering, SPP Transmission Service Studies
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Revision History

Revisions to this study will be tracked in the following table

Revision Date	Revised By	Summary of Changes
2/18/2011	Patrick deLassus	Initial posting
2/24/2011	Patrick deLassus	Added Table E and F, added MVA loading to tables

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Executive Summary

The objective of this study is to determine the ability of the proposed Clifton to Clay Center project to replace currently-approved transmission upgrade projects.

Oklahoma Municipal Power Authority (OMPA) proposed the new Clifton to Clay Center project that consists of:

- New 115 kV line from Clay Center Junction to Clifton
- New Riley substation with a radial line tapping the Clay Center Junction to Clifton line
- Relocation of Riley load from the Clay Center Junction bus to the new Riley bus.

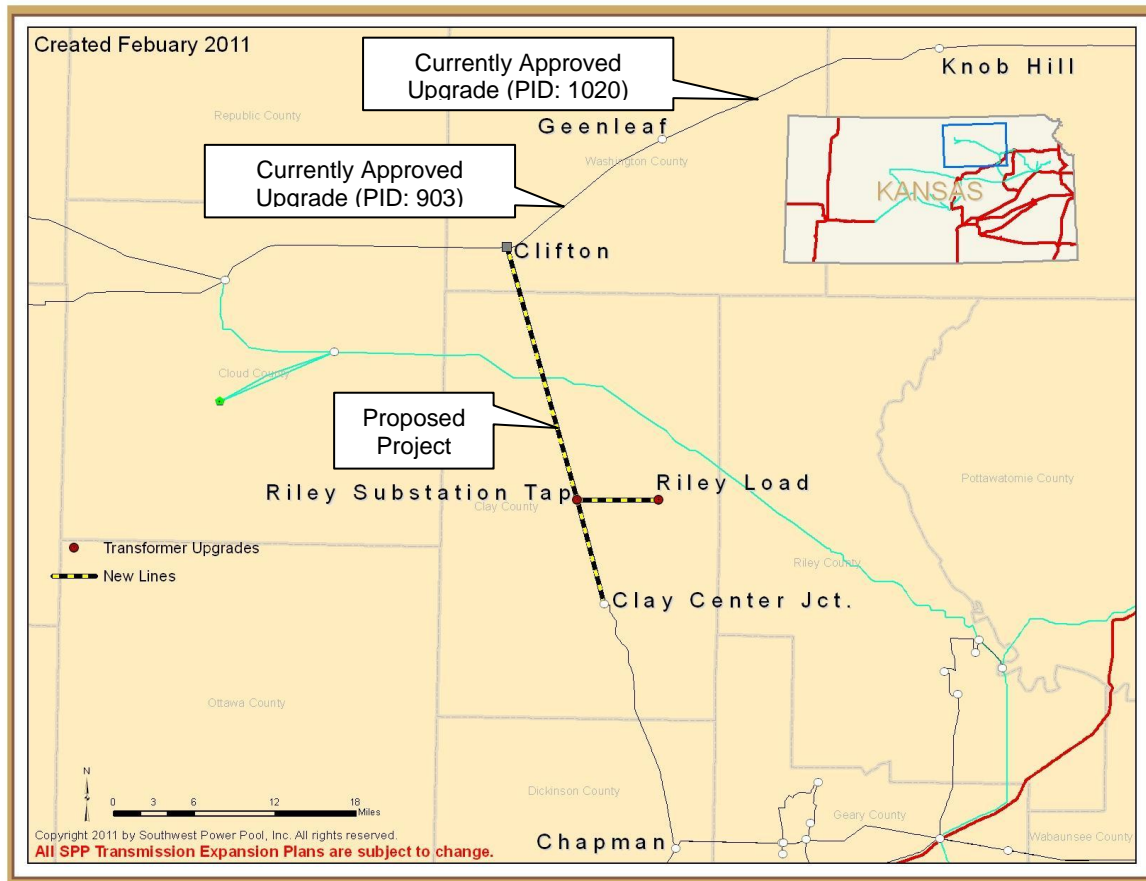
The currently-approved projects which were studied for replacement are as follows:

- Clifton to Greenleaf 115 kV rebuild identified in 2007-AG3,
- Greenleaf to Knob Hill 115 kV rebuild (MKEC portion) identified in 2008-AGP1
- 10.8 MVAR Capacitor at Clay Center Junction identified in 2009-AGP2.

SPP's analysis shows that the proposed project does not relieve the overloads of Clifton to Greenleaf 115kV and Greenleaf to Knob Hill 115kV, and would not eliminate the need for the currently-approved upgrades.

Introduction

SPP Transmission Service Studies performed a steady-state analysis of the proposed Westar Clay Center Junction to MKEC Clifton 115 kV Interconnection as an alternative to the MKEC Clifton to Greenleaf to Knob Hill 115 kV rebuilds (NTC Project ID 903 and 1020, and Upgrade ID 11200 and 11342, respectively) and the Clay Center Junction 115 kV 10.8 MVAR capacitor addition assigned in 2009-AGP2-AFS-6.



Note: Location of proposed lines and substations are approximate.

The study work includes AC contingency analysis comparisons using results from the 2009-AGP2-AFS-6 and 2010-AGP1-AFS-3 studies. The electrical characteristics for the proposed project were taken from the “OMPA TWG Interconnection Analysis for Clay Center – Clifton” report presented at the May 12-13, 2009 TWG meeting and included in the meeting materials. This includes approximately 9 miles from Westar’s Clay Center Junction 115 kV to the new Riley Tap Substation 115 kV and approximately 24 miles from the new Riley Tap Substation to MKEC Clifton 115 kV. In addition, a radial 115 kV

line from the new Riley Tap Substation to the new Riley Load was modeled using data calculated from the mileage received from OMPA and per-mile modeling data from the previous two lines. Electrical characteristics are listed in the tables below.

The models used in 2010-AGP1-AFS-3 were used to complete this study. Modeling information from the above-listed TWG document was applied to all models, and the currently approved upgrades were removed. The analysis process was similar to the process used in the aggregate study.

Mileage and impedance values used for proposed project

Transmission Line	Rate A/B (MVA)	Length (miles)	R (p.u.)	X (p.u.)	B (p.u.)
Clay Center Jct. to Riley Substation Tap 115 kV	215/225	9	0.00798	0.04666	0.00743
Riley Substation Tap to Clifton 115 kV	215/225	24	0.02128	0.12444	0.01980
Riley Substation Tap to Riley Load 115 kV	215/225	6	0.00532	0.03111	0.00495

Mileage and impedance values used for currently approved project:

Transmission Line	Rate A/B (MVA)	R (p.u.)	X (p.u.)	B (p.u.)
Clifton to Greenleaf 115 kV	83.9/89.6	0.04019	0.08780	0.0099
Greenleaf to Knob Hill 115 kV	92/92	0.05560	0.12800	0.01440

Above rating Clifton to Greenleaf 115 kV is for summer peak.

The winter ratings are 113.7/117.7 MVA

Study Methodology

Description

The steady-state analysis was performed to ensure current SPP Criteria and NERC Reliability Standards requirements are fulfilled. SPP conforms to NERC Reliability Standards, which provide strict requirements related to voltage violations and thermal overloads during normal conditions and during a contingency. NERC Standards require all facilities to be within normal operating ratings for normal system conditions and within emergency ratings after a contingency.

Normal operating ratings and emergency operating ratings monitored are Rate A and B in the SPP Model Development Working Group (MDWG) models, respectively. The upper bound and lower bound of the normal voltage range monitored is 105% and 95%. The upper bound and lower bound of the emergency voltage range monitored is 105% and 90%. Transmission Owner voltage monitoring criteria is used if more restrictive. The SPS Tuco 230 kV bus voltage is monitored at 92.5% due to pre-determined system stability limitations. The WERE Wolf Creek 345 kV bus voltage is monitored at 103.5% and 98.5% due to transmission operating procedure.

The contingency set includes all SPP control area branches and ties 69 kV and above; first tier non-SPP control area branches and ties 115 kV and above; any defined contingencies for these control areas; and generation unit outages for the control areas with SPP reserve share program redispatch. The monitored elements include all SPP control area branches, ties, and buses 69 kV. and above,. Voltage monitoring was performed for SPP control area buses 69 kV and above.

Model Updates

The following SPP Transmission Expansion Plan 2010 Build 2 Cases were used to study the effectiveness of the proposed project:

2010/11 Winter Peak (10WP)

2011 Summer Peak (11SP)

2011/12 Winter Peak (11WP)

2012 Summer Peak (12SP)

2012/13 Winter Peak (12WP)

- 2016 Summer Peak (16SP)
- 2016/17 Winter Peak (16WP)
- 2021 Summer Peak (21SP)

The study case models were updated to reflect the most-current modeling information.

Two scenarios were studied to capture the system limitations caused or impacted by the requested service currently in study mode. Scenario 0 includes projected usage of transmission service included in the SPP 2010 Series Cases. Scenario 5 includes transmission service not already included in the SPP 2010 Series Cases.

The “base cases” represent the model with all confirmed service through 2009-AGP2. The “transfer cases” are the base cases with the addition of all service requests still in study 2010-AGP1.

Transfer Analysis

Using the study case models, the PSS/E Activity ACCC was run on the cases and compared to determine the facility overloads. Transfer distribution factor cutoffs and voltage threshold (0.02 change) were applied to determine the impacted facilities. The PSS/E options chosen to conduct the analysis can be found in Appendix A.

Study Results

Study Analysis Results

The study showed that with the proposed project in service, overloads of Clifton-Greenleaf and Greenleaf-Knob Hill still exist that would not exist with the currently-approved projects in service.

Table A shows all instances of Clifton – Greenleaf 115kV and Greenleaf – Knob Hill 115kV being overloaded.

The highest loading for the Clifton to Greenleaf 115kV line occurred with the Kelly to South Seneca contingency (122.5%). The highest loading for the Greenleaf to Knob Hill 115 kV line also occurred for the Kelly to South Seneca contingency (107%).

For comparison, Table B shows the loadings with the currently-approved upgrades in service without the proposed upgrade. The maximum loadings are 51.3% and 44.7%, respectively.

Tables C and D show the effect of Transmission Operating Directive (TOD) 400 on the loading both with only the proposed upgrade and with only the approved upgrades, respectively.

These results show that overloads would still exist with the proposed project that would be fully mitigated with the currently approved projects.

Table A

Element loading with proposed project as a replacement for currently approved projects:

SEASON	MONTCOMMONNAME	BC Loading		TC Loading		CONTNAME
16SP	CLIFTON - GREENLEAF 115KV CKT 1	77.5 MVA	86.5%	90.4 MVA	100.9%	ELMCREK6 230.00 - NWMANHT6 230.00 230KV CKT 1
21SP	CLIFTON - GREENLEAF 115KV CKT 1	74.7 MVA	83.4%	91.2 MVA	101.8%	ELMCREK6 230.00 - NWMANHT6 230.00 230KV CKT 1
12SP	CLIFTON - GREENLEAF 115KV CKT 1	88.1 MVA	98.3%	99.0 MVA	110.5%	HOYT - JEFFERY ENERGY CENTER 345KV CKT 1
16SP	CLIFTON - GREENLEAF 115KV CKT 1	87.4 MVA	97.5%	102.5 MVA	114.4%	HOYT - JEFFERY ENERGY CENTER 345KV CKT 1
21SP	CLIFTON - GREENLEAF 115KV CKT 1	83.6 MVA	93.3%	102.3 MVA	114.2%	HOYT - JEFFERY ENERGY CENTER 345KV CKT 1
12SP	CLIFTON - GREENLEAF 115KV CKT 1	90.9 MVA	101.4%	99.0 MVA	110.5%	KELLY - SOUTH SENECA 115KV CKT 1
16SP	CLIFTON - GREENLEAF 115KV CKT 1	96.2 MVA	107.3%	106.9 MVA	119.3%	KELLY - SOUTH SENECA 115KV CKT 1
21SP	CLIFTON - GREENLEAF 115KV CKT 1	97.2 MVA	108.5%	109.8 MVA	122.5%	KELLY - SOUTH SENECA 115KV CKT 1
16SP	GREENLEAF - KNOB HILL 115KV CKT 1	85.7 MVA	93.1%	96.3 MVA	104.6%	KELLY - SOUTH SENECA 115KV CKT 1
21SP	GREENLEAF - KNOB HILL 115KV CKT 1	86.1 MVA	93.6%	98.6 MVA	107.2%	KELLY - SOUTH SENECA 115KV CKT 1

Table B

Same elements with currently approved topology:

SEASON	MONTCOMMONNAME	BC Loading		TC Loading		CONTNAME
16SP	CLIFTON - GREENLEAF 115KV CKT 1	106.3 MVA	44.3%	121.4 MVA	50.6%	ELMCREK6 230.00 - NWMANHT6 230.00 230KV CKT 1
21SP	CLIFTON - GREENLEAF 115KV CKT 1	104.9 MVA	43.7%	123.1 MVA	51.3%	ELMCREK6 230.00 - NWMANHT6 230.00 230KV CKT 1
12SP	CLIFTON - GREENLEAF 115KV CKT 1	100.8 MVA	42.0%	111.4 MVA	46.4%	HOYT - JEFFERY ENERGY CENTER 345KV CKT 1
16SP	CLIFTON - GREENLEAF 115KV CKT 1	100.8 MVA	42.0%	116.2 MVA	48.4%	HOYT - JEFFERY ENERGY CENTER 345KV CKT 1
21SP	CLIFTON - GREENLEAF 115KV CKT 1	98.2 MVA	40.9%	116.6 MVA	48.6%	HOYT - JEFFERY ENERGY CENTER 345KV CKT 1
12SP	CLIFTON - GREENLEAF 115KV CKT 1	98.6 MVA	41.1%	106.3 MVA	44.3%	KELLY - SOUTH SENECA 115KV CKT 1
16SP	CLIFTON - GREENLEAF 115KV CKT 1	103.7 MVA	43.2%	115.0 MVA	47.9%	KELLY - SOUTH SENECA 115KV CKT 1
21SP	CLIFTON - GREENLEAF 115KV CKT 1	104.6 MVA	43.6%	117.8 MVA	49.1%	KELLY - SOUTH SENECA 115KV CKT 1
16SP	GREENLEAF - KNOB HILL 115KV CKT 1	94.1 MVA	39.2%	105.1 MVA	43.8%	KELLY - SOUTH SENECA 115KV CKT 1
21SP	GREENLEAF - KNOB HILL 115KV CKT 1	94.6 MVA	39.4%	107.3 MVA	44.7%	KELLY - SOUTH SENECA 115KV CKT 1

Note: Both tables reflect results from Group 5 and Scenario 5. Direction of flow is west to east (Clifton to Greenleaf to Knob Hill).

Transmission Operating Directive 400 (TOD400) was applied to overloads from previous page with Hoyt – Jeffrey Energy Center 345kV CKT 1 in contingency.

Table C

Element loading with proposed project as a replacement for currently approved projects:

SEASON	MONTCOMMONNAME	TOD 400
12SP	CLIFTON - GREENLEAF 115KV CKT 1	TOD 400 causes Clifton to Greenleaf to be at 96.5 MVA (107.6%)
16SP	CLIFTON - GREENLEAF 115KV CKT 1	TOD 400 causes Clifton to Greenleaf to be at 101.3 MVA (113.1%)
21SP	CLIFTON - GREENLEAF 115KV CKT 1	TOD 400 causes Clifton to Greenleaf to be at 101.7 MVA (113.5%)

Table D

Same elements with currently approved topology:

SEASON	MONTCOMMONNAME	TOD 400
12SP	CLIFTON - GREENLEAF 115KV CKT 1	TOD 400 causes Clifton to Greenleaf to be at 108.5 MVA (45.2%)
16SP	CLIFTON - GREENLEAF 115KV CKT 1	TOD 400 causes Clifton to Greenleaf to be at 114.7 MVA (47.8%)
21SP	CLIFTON - GREENLEAF 115KV CKT 1	TOD 400 causes Clifton to Greenleaf to be at 114.7 MVA (47.8%)

Note: Direction of flow is west to east (Clifton to Greenleaf to Knob Hill).

Table E

Pre-contingency loading with proposed project as a replacement for currently approved projects:

SEASON	MONTCOMMONNAME	BC Loading		TC Loading	
12SP	CLIFTON - GREENLEAF 115KV CKT 1	65.5 MVA	73.1%	74.4 MVA	83.0%
16SP	CLIFTON - GREENLEAF 115KV CKT 1	66.8 MVA	74.6%	78.3 MVA	87.4%
21SP	CLIFTON - GREENLEAF 115KV CKT 1	63.8 MVA	71.2%	77.8 MVA	86.8%
12SP	GREENLEAF - KNOB HILL 115KV CKT 1	57.1 MVA	62.1%	65.8 MVA	71.5%
16SP	GREENLEAF - KNOB HILL 115KV CKT 1	57.8 MVA	62.8%	69.2 MVA	75.2%
21SP	GREENLEAF - KNOB HILL 115KV CKT 1	54.5 MVA	59.2%	68.3 MVA	74.2%

Table F

Pre-contingency loading with currently approved topology:

SEASON	MONTCOMMONNAME	BC Loading		TC Loading	
12SP	CLIFTON - GREENLEAF 115KV CKT 1	80.3 MVA	33.5%	88.9 MVA	37.0%
16SP	CLIFTON - GREENLEAF 115KV CKT 1	82.2 MVA	34.3%	94.6 MVA	39.4%
21SP	CLIFTON - GREENLEAF 115KV CKT 1	80.2 MVA	33.4%	95.1 MVA	39.6%
12SP	GREENLEAF - KNOB HILL 115KV CKT 1	71.4 MVA	29.8%	79.9 MVA	33.3%
16SP	GREENLEAF - KNOB HILL 115KV CKT 1	72.9 MVA	30.4%	85.1 MVA	35.5%
21SP	GREENLEAF - KNOB HILL 115KV CKT 1	70.3 MVA	29.3%	85.1 MVA	35.5%

Note: Direction of flow is west to east (Clifton to Greenleaf to Knob Hill).

Appendix A

PSS/E CHOICES IN RUNNING LOAD FLOW PROGRAM AND ACCC

BASE CASES:

- Solutions: Fixed slope decoupled Newton-Raphson solution (FDNS)
- Tap adjustment: Stepping
- Area interchange control: Tie lines and loads
- VAR limits: Apply immediately
- Solution options:
 - Phase shift adjustment
 - Flat start
 - Lock DC taps
 - Lock switched shunts

ACCC CASES for system intact:

- Solutions: AC contingency checking (ACCC)
- MW mismatch tolerance: 0.5
- Contingency case rating: Rate A
- Percent of rating: 100
- Output code: Summary
- Min flow change in overload report: 3 MW
- Excl'd cases w/ no overloads form report: YES
- Exclude interfaces from report: NO
- Perform voltage limit check: YES
- Elements in available capacity table: 60000
- Cutoff threshold for available capacity table: 99999.0
- Min. contng. case Vltg chng for report: 0.02
- Sorted output: None
- Newton Solution:
- Tap adjustment: Stepping
- Area interchange control: Tie lines and loads
- VAR limits: Apply automatically
- Solution options:
 - Phase shift adjustment
 - Flat start
 - Lock DC taps
 - Lock switched shunts

ACCC CASES for branch and transformer contingencies:

- Solutions: AC contingency checking (ACCC)
- MW mismatch tolerance: 0.5
- Contingency case rating: Rate B
- Percent of rating: 100
- Output code: Summary
- Min flow change in overload report: 3mw

- Excl'd cases w/ no overloads form report: YES
- Exclude interfaces from report: NO
- Perform voltage limit check: YES
- Elements in available capacity table: 60000
- Cutoff threshold for available capacity table: 99999.0
- Min. contng. case Vltg chng for report: 0.02
- Sorted output: None
- Newton Solution:
- Tap adjustment: Stepping
- Area interchange control: Tie lines and loads
- VAR limits: Apply automatically
- Solution options:
 - X Phase shift adjustment
 - _ Flat start
 - _ Lock DC taps
 - _ Lock switched shunts

ACCC CASES for generator contingencies (largest machine at a bus):

- Solutions: AC contingency checking (ACCC)
- MW mismatch tolerance: 0.5
- Contingency case rating: Rate B
- Percent of rating: 100
- Output code: Summary
- Min flow change in overload report: 3mw
- Excl'd cases w/ no overloads form report: YES
- Exclude interfaces from report: NO
- Perform voltage limit check: YES
- Elements in available capacity table: 60000
- Cutoff threshold for available capacity table: 99999.0
- Min. contng. case Vltg chng for report: 0.02
- Sorted output: None
- Newton Solution:
- Tap adjustment: Stepping
- Area interchange control: Disabled
- Var limits: Apply automatically
- Solution options:
 - X Phase shift adjustment
 - _ Flat start
 - _ Lock DC taps
 - _ Lock switched shunts