SPP DISIS 2017-001 AFS STUDY REPORT

INTRODUCTION

Associated Electric Cooperative Inc. (AECI), through coordination with the Southwest Power Pool (SPP), has updated the analysis for generator interconnection requests (GIRs) within the DISIS 2017-001 Study Cycle (the "Study Cycle") for an Affected System Study (AFS) evaluation on the AECI transmission system (the "Study"). The restudy has been conducted to re-evaluate the dispatch of existing GRDA generation local to AECI and the impacts on the AECI system. The list of Study Cycle requests included in the Study is listed in Table 1.

Table 1: Study Cycle Requests Evaluated

Project #	CA	Capacity (MW)	Service Type	Fuel Type	POI	Cluster Group
GEN-2017-009	WERE	302.0	ER	Wind	Neosho - Caney River 345 kV	08 - North Oklahoma/South Central Kansas
GEN-2017-061	GRDA	101.5	ER/NR	Solar	GRDA1 to CLARMR 5 161kV line	08 - North Oklahoma/South Central Kansas
GEN-2017-005	WERE	190.0	ER	Wind	Marmaton - Litchfield 161 kV	08 - North Oklahoma/South Central Kansas
GEN-2017-060	EDE	149.4	ER	Wind	LaRussell Energy Center 161kV	12 - Northwest Arkansas
GEN-2017-073	GRDA	72.5	ER	Solar	Dry Gulch 161kV sub	08 - North Oklahoma/South Central Kansas
GEN-2017-022	WERE	65.0	ER/NR	Solar	Altoona- NE Parson 138kV	08 - North Oklahoma/South Central Kansas
GEN-2017-076	AEPW	52.2	ER	Solar	Chamber Springs 161kV sub	12 - Northwest Arkansas
GEN-2017-074	AEPW	72.5	ER	Solar	Pryor Junction 138kV sub	08 - North Oklahoma/South Central Kansas
GEN-2017-082	EDE	149.4	ER	Wind	Asbury Plant 161 kV	12 - Northwest Arkansas
GEN-2017-092	OKGE	200.0	ER	Solar	Canadian River-Muskogee and Muskogee-Seminole 345kV	08 - North Oklahoma/South Central Kansas
GEN-2017-077	AEPW	124.7	ER	Solar	Explorer Claremore Tap EXCLART4	08 - North Oklahoma/South Central Kansas
GEN-2017-086	WERE	150.0	ER	Wind	Viola 345kV	08 - North Oklahoma/South Central Kansas
GEN-2017-018	SUNC	189.0	ER/NR	Solar	Thistle 345 kV sub	03 - Spearville
GEN-2017-040	OKGE	200.1	ER	Solar	Canadian River-Muskogee and Muskogee-Seminole 345kV	08 - North Oklahoma/South Central Kansas
GEN-2017-071	OKGE	124.7	ER	Solar	Greenwood 138kV sub	08 - North Oklahoma/South Central Kansas
GEN-2017-072	OKGE	52.2	ER	Solar	Greenwood 138kV sub	08 - North Oklahoma/South Central Kansas
GEN-2017-075	OKGE	200.0	ER	Solar	Hugo-Sunnyside 345 kV	14 - South Central Oklahoma
GEN-2016-037	AEPW	300.0	ER	Wind	Chisholm-Gracemont 345kV	07 - Southwestern Oklahoma
GEN-2017-004	SUNC	201.6	ER	Wind	Elm Creek - Summit 345 kV	04 - Northwest Kansas

Project #	CA	Capacity (MW)	Service Type	Fuel Type	POI	Cluster Group
GEN-2017-094	WAPA	200.0	ER	Wind	Fort Thompson-Huron 230 kV	15 - Eastern South Dakota
GEN-2017-027	OKGE	140.0	ER	Wind	Pooleville-Ratliff (Carter County) 138kV	14 - South Central Oklahoma
GEN-2017-014	WAPA	300.0	ER	Wind	Philip Tap 230 kV	17 - Western South Dakota
GEN-2017-033	AEPW	200.0	ER/NR	Wind	Oklaunion 345 kV sub	06 - South Texas Panhandle/New Mexico
GEN-2017-097	WAPA	128.0	ER	Solar	Underwood 115 kV Sub	17 - Western South Dakota
GEN-2017-048	BEPC	300.0	ER	Wind	Neset 230 kV Substation	16 - Western North Dakota
GEN-2017-010	BEPC	200.1	ER	Wind	Rhame 230 kV Sub	16 - Western North Dakota

The results of the analysis for the Study Cycle requests are included below. Network upgrades and cost allocations are subject to change in accounting for any withdrawals of equally queued or higher queued requests included in this Study.

INPUTS AND ASSUMPTIONS

Each of the SERC member transmission planners is responsible for submitting system modeling data to SERC for development of the power flow models. Power flow analysis utilized the latest Long-Term Working Group (LTWG) models as developed by SERC Reliability Corporation (SERC). Each of the power flow models for the steady state analysis was modified to include appropriate higher-queued generation interconnection requests at the level of dispatch consistent with requirements of the service type requested as defined in AECI's GI Study Guidelines document. The direct connection network upgrades for MISO higher queued requests J1488 and J1490, as identified through their merchant HVDC requests H104 and H105, were included in the models:

- New J1145 – Montgomery 345 kV double circuit (2 and 3, Ameren facilities)

Modeling parameters in the SPP DISIS 2017-001 steady state models were referenced for each of the Study Cycle requests.

Full details of the inputs and assumptions are provided in Appendix A.

METHODOLOGY

Steady state analysis was performed to confirm the reliability impacts on the AECI system under a variety of system conditions and outages. AECI's transmission system must be capable of operating within the applicable normal ratings, emergency ratings, and voltage limits of AECI planning criteria. AECI is a member of SERC, one of eight Electric Reliability Organizations under the North American Electric Reliability Corporation (NERC). As a member of SERC, AECI develops its planning criteria consistent with NERC Reliability Planning Standards and the SERC planning criteria. The NERC TPL-001-5 Planning Standard Table I requires that, for normal and contingency conditions, line and equipment loading shall be within applicable thermal limits, voltage levels shall be maintained within applicable limits, all customer demands shall be supplied (except as noted), and stability of the network shall be maintained.

In evaluating the impacts of the Study Cycle projects, the following thermal and voltage limits were applied to the analysis for P0 or normal system conditions:

- Thermal Limits within Applicable Rating – Applicable Rating shall be defined as the Normal Rating. The thermal limit shall be 100% of Rating A.
- Voltage Limits within Applicable Rating – Applicable Rating shall have the meaning of Nominal Voltage. Voltage limits shall be set at plus or minus five percent (+/- 5%), 0.95 p.u. - 1.05 p.u. for systems operating at 60 kV or above on load serving buses.

The following thermal and voltage limits were applied to the analysis for contingency conditions under P1 and P2EHV planning events:

- Thermal Limits within Applicable Rating – Applicable Rating shall be defined as the Emergency Rating. The thermal limit shall be 100% of Rating B.
- Voltage Limits within Applicable Rating – Applicable Rating shall have the meaning of Nominal Voltage. Voltage limits shall be set at plus five percent to minus ten percent (+5%/-10%), 0.90 p.u. – 1.05 p.u. for systems operating at 60 kV or above on load serving buses.

In order for the Study Cycle requests to have a negative impact (i.e. criteria violation) on the system, the Study Cycle must cause a three percent (3%) or greater increase in flow on an overloaded facility based upon the rating of the facility. In order for the Project to have a negative voltage impact on the system, the Project must cause a voltage violation and have a two percent (2%) or greater change in the voltage.

System upgrades are required for constraints resulting from the addition of the Study Cycle requests under P0, P1, P2.1, P2.2 (EHV only), and P2.3 (EHV only) system conditions. For the purpose of this study, P2.1 events are included as part of the P1 contingency file. As such, these events will be denoted as a P1 event in the results. All improvements were developed and studied in coordination with AECI.

STEADY STATE ANALYSIS RESULTS

Steady state analysis results showed one (1) new thermal violation on the AECI system due to the addition of the Study Cycle projects as shown in Table 2.

Table 2: Steady State Constraints for the Study Cycle

Constraint ID	Event	Monitored Facility	Contingency	Season	Rating (MVA)	Base Loading	Project Loading
NU01	P1	301201 2DONIPH 69.000 505440 DONIPHN5 161.00 1	OPEN BRANCH FROM BUS 301201 [2DONIPH 69.000] TO BUS 505440 [DONIPHN5 161.00] CKT 2	25S	18	115.5	119.3

The facility was reported as overloaded prior to the addition of the Project, this is due to the stressed condition modeled. However, with the loading increase of three percent (3%) or more this facility, the facility is included as a Project impact.

CONTINGENT FACILITY RESULTS

Contingent Facilities are those facilities identified that are the responsibility of higher-queued generators or are included in the Transmission Provider's transmission expansion plan and that if not included in the Study would otherwise be the responsibility of the Study Cycle requests as necessary to interconnect to the transmission system.

Eight (8) facilities were reported as Contingent Facilities with the addition of the Study Cycle requests. The most severe constraints are shown in Table 3.

Table 3: Steady State Contingent Constraints for the Study Cycle

Constraint ID	Event	Monitored Facility	Season	Rating (MVA)	Base Loading	Project Loading	Contingent Generator(s)
CF01	P1	300124 5HOLDENB2 161.00 300336 2HOLDEN 69.000 1	25S	56	150.7	157.6	MISO DPP 2019
			25W	63	135.7	140.6	
			30S	56	155.8	162.0	
			30W	63	138.6	142.9	
CF02	P1	300193 2AVLON 69.000 300199 2HALE 69.000 1	25S	35	98.3	103.9	MISO DPP 2019

Constraint ID	Event	Monitored Facility	Season	Rating (MVA)	Base Loading	Project Loading	Contingent Generator(s)
			30S		108.4	112.3	
CF03	P1	300194 2CHILLI 69.000 300218 5CHILLIS 161.00 1	25S	56	117.9	122.8	MISO DPP 2019
			30S		124.4	128.9	
CF04	P1	300199 2HALE 69.000 300201 2INGROV 69.000 1	25S	35	108.1	114.2	MISO DPP 2019
			30S		118.4	122.9	
CF05	P1	300327 2ELM 69.000 300336 2HOLDEN 69.000 1	25S	51	94.2	100.4	MISO DPP 2019
			30S		98.0	103.8	
CF06	P1	300061 5BOONE 161.00 300519 5MLRSBGB1 161.00 1	25S	285	97.0	101.4	MISO DPP 2019
			30S		104.3	108.1	
	P2EHV		25S		101.3	107.2	
			30S		111.5	116.7	
CF07	P1	300090 5KINGDMB1 161.00 301498 5MLRSBGB2 161.00 1	25S	285	100.3	104.8	GI-083
			30S		107.9	111.8	
	P2EHV		25S		104.7	110.5	
			30S		115.2	120.3	
CF08	P1	300519 5MLRSBGB1 161.00 301498 5MLRSBGB2 161.00 Z1	25S	285	100.3	104.8	GI-083
			30S		107.9	111.8	
	P2EHV		25S		104.7	110.5	
			30S		115.2	120.3	

NEIGHBORING SYSTEM RESULTS

The Study has identified impacts from the Study Cycle requests on the AECI ties with neighboring systems. The most limiting component of the AECI owned portion of the facility was evaluated and if found inadequate, a network upgrade for the AECI equipment was determined. Network upgrades for transmission facilities limited by non-AECI equipment are not captured and will need to be coordinated with the appropriate transmission owner.

Two (2) facilities were reported on the AECI ties with the addition of the Study Cycle requests. The most severe constraints are shown in Table 4.

Table 4: Steady State Neighboring System Constraints for the Study Cycle Requests

Constraint ID	Event	Monitored Facility					Season	Rating (MVA)	Base Loading	Project Loading	Area
AFS01	P1	300044	7MCCRED	345.00 345408	7OVERTON	345.00 1	30S	956	97.0	101.2	AMMO
	P2EHV						30S		97.6	101.8	
AFS02	P1	300133	5THMHLB3	161.00 543062	SALSBRY5	161.00 1	25S	334	104.8	107.9	KCPL

NETWORK UPGRADES

Transmission upgrades were evaluated to mitigate the impacts reported from the analyses as a result of the Study Cycle projects. The upgrade shown in Table 5 was evaluated in order to mitigate the reported steady state constraint for the Study Cycle as listed in Table 2.

Table 5: Network Upgrades for the Study Cycle Constraints

Constraint ID	Monitored Facility	Network Upgrade
NU01	301201 2DONIPH 69.000 505440 DONIPHN5 161.00 1	Adjustment of transformer taps required to mitigate overload.

The upgrades shown in Table 6 were evaluated in order to mitigate the reported steady state contingent constraints for the Study Cycle as listed in Table 3.

Table 6: Network Upgrades for the Study Cycle Contingent Constraints

Constraint ID	Monitored Facility	Network Upgrade
CF01	300124 5HOLDENB2 161.00 300336 2HOLDEN 69.000 1	**Contingent on MISO DPP 2019:** Add a second 161/69 kV transformer at Holden rated for 84/96 MVA.
CF02	300193 2AVLON 69.000 300199 2HALE 69.000 1	**Contingent on MISO DPP 2019:** Rebuild 10.30 mile long Avalon-Hale line for 161/69 kV operation. Install (1) circuit of 1192 ACSR at 100C to be operated at 69 kV.
CF03	300194 2CHILLI 69.000 300218 5CHILLIS 161.00 1	**Contingent on MISO DPP 2019:** Reconfigure Chillicothe 161 kV bus to main/transfer bus configuration.
CF04	300199 2HALE 69.000 300201 2INGROV 69.000 1	**Contingent on MISO DPP 2019:** Rebuild 17.20 mile long Indian Grove-Hale line for 161/69 kV operation. Install (1) circuit of 1192 ACSR at 100C to be operated at 69 kV.
CF05	300327 2ELM 69.000 300336 2HOLDEN 69.000 1	**Contingent on MISO DPP 2019:** Rebuild 3.1 mile 336 ACSR segment of Elm-Holden existing double circuit to 556 ACSR at 100C.
CF06	300061 5BOONE 161.00 300519 5MLRSBGB1 161.00 1	**Contingent on MISO DPP 2019:** Reconductor 9.4 mile long Boone-Millersburg 161 kV line with 795 ACSS at 250C. Replace jumpers on both side of line with 795 ACSS High Temp.

Constraint ID	Monitored Facility	Network Upgrade
CF07	300090 5KINGDMB1 161.00 301498 5MLRSBGB2 161.00 1	**Contingent on GI-083:** Upgrade Kingdom City 161/69 kV transformer #3 to 84/96 MVA unit. Remove Kingdom City 161/69 kV transformer #2 from service. Salt River area upgrades: - Add two new terminal positions to the Salt River 161 kV substation. - Add Salt River 161/69 kV transformer rated for 84/96 MVA. - Convert Auxvasse 69 kV substation to 161 kV operation. - Rebuild Kingdom City - Auxvasse 69 kV line, 8.00 miles, to 161 kV service, utilize 795 ACSR conductor to be designed for 100ºC and re-terminate line at the Kingdom City 161 kV bus 1. - Rebuild Auxvasse - Salt River 69 kV line, 10.00 miles, to 161 kV service, utilize 795 ACSR conductor to be designed for 100ºC and re-terminate line at the Salt River 161 kV bus. - Add one new terminal position to the Montgomery City 161 kV substation. - Build a new 161/69 kV double circuit from Salt River - Vandiver - Scotts Corner, 17.00 miles. --161 kV line will be 795 ACSR at 100C. Terminated at Salt River and will continue to Montgomery City. --69 kV line will be 336 ACSR at 100C. Terminated at Salt River, Vandiver, Lindell, and Scotts Corner. - Upgrade Lindell, Vandiver, and Scotts Corner 69 kV bus tie jumpers, utilize 336 ACSR conductor to be designed for 100ºC. - Build a new 161 kV line from Scotts Corner - Montgomery City, 16.30 miles, utilize 795 ACSR conductor to be designed for 100ºC. - Add two new breakers to Vandalia 69 kV substation. - Build a new 69 kV line from Scotts Corner - Vandalia, 12.00 miles, utilize 336 ACSR conductor to be designed for 100ºC.
CF08	300519 5MLRSBGB1 161.00 301498 5MLRSBGB2 161.00 Z1	**Contingent on GI-083:** Upgrade Millersburg 161 kV bus tie jumpers, utilize 1590 ACSR conductor to be designed for 100ºC.

No upgrades were evaluated for the neighboring system constraints listed in Table 4. The upgrades for these impacts will need to be resolved through coordination with the transmission owner as listed in Table 7 below.

Table 7: Neighboring System Constraints

Constraint ID	Monitored Facility	Network Upgrade
AFS01	300044 7MCCRED 345.00 345408 7OVERTON 345.00 1	Ameren owned line. No upgrade evaluated.
AFS02	300133 5THMHLB3 161.00 543062 SALSBRY5 161.00 1	Evergy owned line. No upgrade evaluated.

Simulations were performed on each of the scenarios with the identified network upgrade and contingent network upgrades included. Results from the simulations found that the network upgrades were able to mitigate the reported overload conditions as shown in Table 8 below.

Table 8: Steady State Results with Upgrades

Constraint ID	Event	Monitored Facility	Season	Base Loading	Project Loading	Mitigation Loading
NU01	P1	301201 2DONIPH 69.000 505440 DONIPHN5 161.00 1	25S	115.5	119.3	78.2[1]
CF01	P1	300124 5HOLDENB2 161.00 300336 2HOLDEN 69.000 1	25S	150.7	157.6	59.2
			25W	135.7	140.6	55.2

[1] Loading reflects transformer tap adjustment.

Constraint ID	Event	Monitored Facility	Season	Base Loading	Project Loading	Mitigation Loading
			30S	155.8	162.0	60.9
			30W	138.6	142.9	55.9
CF02	P1	300193 2AVLON 69.000 300199 2HALE 69.000 1	25S	98.3	103.9	26.4
			30S	108.4	112.3	28.4
CF03	P1	300194 2CHILLI 69.000 300218 5CHILLIS 161.00 1	25S	117.9	122.8	76.3
			30S	124.4	128.9	78.9
CF04	P1	300199 2HALE 69.000 300201 2INGROV 69.000 1	25S	108.1	114.2	28.8
			30S	118.4	122.9	30.9
CF05	P1	300327 2ELM 69.000 300336 2HOLDEN 69.000 1	25S	94.2	100.4	83.5
			30S	98.0	103.8	86.2
CF06	P1	300061 5BOONE 161.00 300519 5MLRSBGB1 161.00 1	25S	97.0	101.4	81.3
			30S	104.3	108.1	87.0
	P2EHV		25S	101.3	107.2	85.8
			30S	111.5	116.7	93.8
CF07	P1	300090 5KINGDMB1 161.00 301498 5MLRSBGB2 161.00 1	25S	100.3	104.8	84.2
			30S	107.9	111.8	90.1
	P2EHV		25S	104.7	110.5	88.7
			30S	115.2	120.3	96.9
CF08	P1	300519 5MLRSBGB1 161.00 301498 5MLRSBGB2 161.00 Z1	25S	100.3	104.8	64.5
			30S	107.9	111.8	69.0
	P2EHV		25S	104.7	110.5	67.9
			30S	115.2	120.3	74.2

At the time of this study (v5), there are no network upgrades assigned to the DISIS-2017-001 Cluster. As such, these requests do not have any costs allocated to them.

COST ALLOCATION

The below section outlines the procedure used for cost allocations for impacts identified in an Affected System Study. No network upgrades were assigned to the Study Cycle. Thus, no associated cost allocation of the network upgrades to each of the Study Cycle projects is required at this time.

Network upgrade costs are allocated to each of the Study Cycle projects based on the worst MW impact[2] each project had on the constraint and as described in the steps below:

1. Determine the MW impact each Study Cycle project had on each constraint using the size of each request:

[2] All negative MW impacts (helpers) were set to 0 MW impact.

$$Project\ X\ MW\ Impact\ on\ Constraint\ 1 = DFAX\ (X) * MW\ (X) = X1$$

$$Project\ Y\ MW\ Impact\ on\ Constraint\ 1 = DFAX\ (Y) * MW\ (Y) = Y1$$

$$Project\ Z\ MW\ Impact\ on\ Constraint\ 1 = DFAX\ (Z) * MW\ (Z) = Z1$$

2. Determine the maximum MW% impact each generator has as a percentage of the total Study Cycle impact on a given constraint.

$$X2\ =\ Project\ X\ MW\ impact\ \%\ = \frac{X1}{Total\ MW\ Impact\ of\ Study\ Cycle\ on\ Constraint}$$

$$Y2\ =\ Project\ Y\ MW\ impact\ \%\ = \frac{Y1}{Total\ MW\ Impact\ of\ Study\ Cycle\ on\ Constraint}$$

$$Z2\ =\ Project\ Z\ MW\ impact\ \%\ = \frac{Z1}{Total\ MW\ Impact\ of\ Study\ Cycle\ on\ Constraint}$$

3. Apply three percent (3%) MW impact De Minimis Threshold: If a Study Cycle project MW% impact is less than 3% for a particular constraint then the project MW% impact is adjusted to 0 for that constraint and the Study Cycle project will not be allocated cost for that particular constraint.

4. Determine the cost allocated to each remaining Study Cycle project for each upgrade using the total cost of a given upgrade:

$$Project\ X\ Upgrade\ 1\ Cost\ Allocation\ (\$) = \frac{Network\ Upgrade\ 1\ Cost\ (\$) * X2}{X2 + Y2 + Z2}$$

VERSION HISTORY

Version Number and Date	Author	Change Description
V0 – 04/07/2020	AECI	Initial release
V1 – 10/28/2021	AECI	Withdrawal of the thirteen (13) SPP Study Cycle requests
V2 – 05/16/2022	AECI	Withdrawal of the two (2) SPP Study Cycle requests
V3 – 04/06/2023	AECI	Withdrawal of MISO higher queued requests from the DPP 2019 Cycle and AECI higher queued requests GI-088 and GI-092
V4 – 06/21/2023	AECI	Withdrawal of AECI higher queued request GI-085
V5 – 02/28/2024	AECI	Review existing GRDA generator dispatch levels. Add missing Pmin values to GRDA gens and adhere to those values.