# SPP DISIS 2017-001 AFS STUDY REPORT

## INTRODUCTION

Associated Electric Cooperative Inc. (AECI), through coordination with the Southwest Power Pool (SPP), has identified 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 full 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-2016-037 | AEPW | 300.0 | ER | Wind | Chisholm-Gracemont 345kV | 07 - Southwestern Oklahoma |
| GEN-2016-103 | WAPA | 240.0 | ER | Wind | Fort Thompson-Leland Olds 345kV | 15 - Eastern South Dakota |
| GEN-2016-159 | NPPD | 427.8 | ER | Wind | Turtle Creek 345kV | 09 - Nebraska |
| GEN-2016-172 | SWPS | 231.0 | ER | Wind | Newhart 115kV | 06 - South Texas Panhandle/New Mexico |
| GEN-2017-004 | SUNC | 201.6 | ER | Wind | Elm Creek - Summit 345 kV | 04 - Northwest Kansas |
| GEN-2017-005 | WERE | 190.0 | ER | Wind | Marmaton - Litchfield 161 kV | 08 - North Oklahoma/South Central Kansas |
| GEN-2017-007 | SWPS | 297.5 | ER | Wind | Pleasant Hill 230 kV sub | 06 - South Texas Panhandle/New Mexico |
| GEN-2017-008 | NPPD | 305.0 | ER | Solar | Pauline 345kV Substation | 09 - Nebraska |
| GEN-2017-009 | WERE | 302.5 | ER | Wind | Neosho - Caney River 345 kV | 08 - North Oklahoma/South Central Kansas |
| GEN-2017-010 | WAPA | 200.1 | ER | Wind | Rhame 230 kV Sub | 16 - Western North Dakota |
| GEN-2017-014 | WAPA | 300.0 | ER/NR | Wind | Underwood - Philip Tap 230 kV | 17 - Western South Dakota |
| GEN-2017-018 | SUNC | 190.0 | ER/NR | Solar | Thistle 345 kV sub | 03 - Spearville |
| GEN-2017-022 | WERE | 65.0 | ER/NR | Solar | Altoona- NE Parson 138kV | 08 - North Oklahoma/South Central Kansas |
| GEN-2017-026 | SWPS | 235.0 | ER/NR | Wind | Tolk 230kV | 06 - South Texas Panhandle/New Mexico |
| GEN-2017-027 | OKGE | 140.0 | ER | Wind | Pooleville-Ratliff (Carter County) 138kV | 14 - South Central Oklahoma |
| GEN-2017-030 | KCPL | 200.0 | ER | Wind | Eastown - Iatan 345kV | 13 - Northeast Kansas/Northwest Missouri |
| GEN-2017-033 | AEPW | 200.0 | ER/NR | Wind | Oklaunion 345 kV sub | 06 - South Texas Panhandle/New Mexico |
| GEN-2017-039 | SWPS | 200.1 | ER | Wind | Needmore 230 kV sub | 06 - South Texas Panhandle/New Mexico |
| GEN-2017-040 | OKGE | 200.0 | ER | Solar | Canadian River-Muskogee and Muskogee-Seminole 345kV | 08 - North Oklahoma/South Central Kansas |
| GEN-2017-048 | BEPC | 300.0 | ER | Wind | Neset 230 kV Substation | 16 - Western North Dakota |
| GEN-2017-055 | LES | 228.3 | ER/NR | Solar | Wagener 115 kV Sub | 09 - Nebraska |
| GEN-2017-060 | EDE | 149.4 | ER | Wind | LaRussell Energy Center 161kV | 12 - Northwest Arkansas |
| GEN-2017-061 | GRDA | 101.5 | ER/NR | Solar | GRDA1 to CLARMR 5 161kV line | 08 - North Oklahoma/South Central Kansas |
| GEN-2017-064 | WAPA | 110.0 | ER/NR | Solar | Underwood - Wayside 230 kV | 17 - Western South Dakota |
| GEN-2017-065 | AEPW | 200.3 | ER/NR | Solar | Oklaunion 345 kV sub | 06 - South Texas Panhandle/New Mexico |
| 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-2017-073 | GRDA | 72.5 | ER | Solar | Dry Gulch 161kV sub | 08 - North Oklahoma/South Central Kansas |
| GEN-2017-074 | AEPW | 72.5 | ER | Solar | Pryor Junction 138kV sub | 08 - North Oklahoma/South Central Kansas |

| Project # | CA | Capacity (MW) | Service Type | Fuel Type | POI | Cluster Group |
|---|---|---|---|---|---|---|
| GEN-2017-075 | OKGE | 200.0 | ER | Solar | Hugo-Sunnyside 345 kV | 14 - South Central Oklahoma |
| GEN-2017-076 | AEPW | 52.2 | ER | Solar | Chamber Springs 161kV sub | 12 - Northwest Arkansas |
| GEN-2017-077 | AEPW | 124.7 | ER | Solar | Explorer Claremore Tap EXCLART4 | 08 - North Oklahoma/South Central Kansas |
| GEN-2017-078 | SWPS | 220.0 | ER/NR | Wind | Eddy County-Tolk (Crossroads) 345kV | 06 - South Texas Panhandle/New Mexico |
| GEN-2017-080 | SWPS | 525.0 | ER | Solar | Tolk 230 kV substation | 06 - South Texas Panhandle/New Mexico |
| GEN-2017-082 | EDE | 149.4 | ER | Wind | Asbury Plant 161 kV | 12 - Northwest Arkansas |
| GEN-2017-086 | WERE | 150.0 | ER/NR | Wind | Viola 345kV | 08 - North Oklahoma/South Central Kansas |
| GEN-2017-090 | KCPL | 150.0 | ER | Solar | Adrian 161 kV sub | 13 - Northeast Kansas/Northwest Missouri |
| GEN-2017-092 | OKGE | 200.0 | ER | Solar | Canadian River-Muskogee and Muskogee-Seminole 345kV | 08 - North Oklahoma/South Central Kansas |
| GEN-2017-094 | WAPA | 200.0 | ER/NR | Wind | Fort Thompson-Huron 230 kV | 15 - Eastern South Dakota |
| GEN-2017-097 | WAPA | 128.0 | ER | Solar | Underwood 115 kV Sub | 17 - Western South Dakota |
| GEN-2017-104 | SWPS | 240.0 | ER/NR | Solar | Hobbs 230kV Substation | 06 - South Texas Panhandle/New Mexico |

The following key assumptions were included in the basis of the Study.

- AECI GI-083 network upgrades
    - Upgrade Kingdom City 161/69 kV transformers #2 and #3 to 84/96 MVA units
    - Rebuild Kingdom City – Williamsburg 161 kV, 11.89 miles, utilize 1590 ACSR conductor to be designed for 100ºC
    - Rebuild Williamsburg – Montgomery City 161 kV, 17.84 miles, utilize 1590 ACSR conductor to be designed for 100ºC
    - Upgrade Thomas Hill 345/161 kV transformer #4 to 625/712 MVA unit
    - Thomas Hill – Bevier area upgrades:
        - Move Thomas Hill – Meadville 161 kV line to Thomas Hill Bus #3
        - Move Thomas Hill – Salisbury 161 kV line to Thomas Hill Bus #4
        - Add Thomas Hill Bus #2 – Bevier 161 kV line
        - Add Bevier 161/69 kV transformer rated for 112/127 MVA
        - Remove Thomas Hill – Bevier 69 kV line
    - Rebuild Reform-Chamois 69kV, 4.00 miles, utilize 795 ACSR conductor to be designed for 100ºC
    - Rebuild Bevier - Macon Lake 69 kV, 4.14 miles, utilize 477 ACSR conductor to be designed for 100ºC (Contingent facility)

- Rebuild Axtell - Macon Lake 69 kV, 1.15 miles, utilize 477 ACSR conductor to be designed for 100ºC (Contingent facility)
- Rebuild Axtell - Macon Tap 69 kV, 1.05 miles, utilize 477 ACSR conductor to be designed for 100ºC (Contingent facility)

- MISO J1488 and J1490 preliminary network upgrade
  - New J1145 – Montgomery 345 kV double circuit (2 and 3, Ameren facilities)

The listed network upgrades assigned to GI-083, J1488, and J1490 were included in the Study models to resolve convergence issues for outage conditions near and at their interconnection point on the system in order to determine the impact of the Study Cycle on the AECI system. These network upgrade assumptions and their associated impacts to later queue requests will be revisited in the next iteration of analysis based on the status of GI-083, J1488, and/or J1490 within their respective queues.

The results of the analysis for the Study Cycle, as well as network upgrades assigned, are included below.

## 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. 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-001-4 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 projects to have a negative impact (i.e. criteria violation) on the system, the Study Cycle must cause a thermal violation and have a three percent (3%) or greater increase in flow on the 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 under P0, P1, P2.1, P2.2 (EHV only), and P2.3 (EHV only) system conditions. All improvements were developed and studied in coordination with AECI.

## STEADY STATE ANALYSIS RESULTS

Steady state analysis results showed eleven (11) new thermal violations 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 (%MVA) | Project Loading (%MVA) |
|---|---|---|---|---|---|---|---|
| NU01 | P1 | 300203 2KIDDER 69.000 300215 2MABELTP 69.000 1 | FROM BUS 300107 [5OSBORN 161.00] TO BUS 301564 [5FAIRPTB1 161.00] CKT 1 | 25H | 35 | 87.7 | 101.2 |
| NU02 | | 300206 2MABEL 69.000 300215 2MABELTP 69.000 1 | | 25H | 35 | 87.6 | 100.9 |
| NU03 | | 300260 2MIDWAY 69.000 300264 2SAVANH 69.000 1 | FROM BUS 300073 [5GENTRY 161.00] TO BUS 300076 [5FAIRPTB2 161.00] CKT 1 | 25L | 35 | 98.7 | 101.9 |
| NU08 | | 300251 2FLGGSP 69.000 300257 2KINGCT 69.000 1* | | 25L | 35 | 97.2 | 100.6 |
| NU09 | | 300251 2FLGGSP 69.000 300264 2SAVANH 69.000 1* | | 25L | 35 | 99.4 | 102.8 |
| NU07 | | 301251 2VANDSR 69.000 301255 2MORLEY 69.000 1 | FROM BUS 300075 [5ESSEX 161.00] TO BUS 345791 [5STODDARD 2 161.00] CKT 1 FROM BUS 345588 [5RCHLND 1 161.00] TO BUS 345791 [5STODDARD 2 161.00] CKT 1 FROM BUS 345790 [5STODDARD 1 161.00] TO BUS 345791 [5STODDARD 2 161.00] CKT Z | 25S | 35 | 99.3 | 103.0 |
| | | | FROM BUS 300075 [5ESSEX 161.00] TO BUS 300038 [7ESSEX 345.00] CKT 1 FROM BUS 300075 [5ESSEX 161.00] TO BUS 505434 [IDALIA 5 161.00] CKT 1 FROM BUS 300075 [5ESSEX 161.00] TO BUS 301533 [5ESSEXGSU1 161.00] CKT 1 FROM BUS 300075 [5ESSEX 161.00] TO BUS 345791 [5STODDARD 2 161.00] CKT 1 | 30S | 35 | 105.4 | 110.4 |
| NU04 | P2EHV | 300121 5MORLEY 161.00 301255 2MORLEY 69.000 1 | FROM BUS 300038 [7ESSEX 345.00] TO BUS 301407 [7WNWMADRID1A345.00] CKT 1 FROM BUS 300038 [7ESSEX 345.00] TO BUS 344974 [7LUTESVIL 345.00] CKT 1 FROM BUS 301407 [7WNWMADRID1A345.00] TO BUS 301416 [7WNWMADRID1B345.00] CKT Z1 FROM BUS 300075 [5ESSEX 161.00] TO BUS 300038 [7ESSEX 345.00] CKT 1 FROM BUS 300075 [5ESSEX 161.00] TO BUS 505434 [IDALIA 5 161.00] CKT 1 FROM BUS 300075 [5ESSEX 161.00] TO BUS 301533 [5ESSEXGSU1 161.00] CKT 1 | 25S | 56 | 110.3 | 115.4 |
| | | | | 30S | 56 | 101.2 | 106.4 |
| | | | | 30W | 63 | 96.0 | 101.2 |

| Constraint ID | Event | Monitored Facility | Contingency | Season | Rating (MVA) | Base Loading (%MVA) | Project Loading (%MVA) |
|---|---|---|---|---|---|---|---|
| | | | FROM BUS 300075 [5ESSEX 161.00] TO BUS 345791 [5STODDARD 2 161.00] CKT 1 | | | | |
| NU05 | | 300740 7SPORTSMAN 345.00<br>300741 5SPORTSMAN 161.00 1 | FROM BUS 300741 [5SPORTSMAN 161.00] TO BUS 300740 [7SPORTSMAN 345.00] CKT 2<br>FROM BUS 300739 [7BLACKBERRY 345.00] TO BUS 300740 [7SPORTSMAN 345.00] CKT 1 | 25H | 500 | 97.1 | 101.8 |
| | | | | 25L | 500 | 101.5 | 106.2 |
| NU06 | | 300740 7SPORTSMAN 345.00<br>300741 5SPORTSMAN 161.00 2 | FROM BUS 300739 [7BLACKBERRY 345.00] TO BUS 300740 [7SPORTSMAN 345.00] CKT 1<br>FROM BUS 300741 [5SPORTSMAN 161.00] TO BUS 300740 [7SPORTSMAN 345.00] CKT 1 | 25H | 500 | 97.1 | 101.8 |
| | | | | 25L | 500 | 101.5 | 106.2 |
| NU07 | | 301251 2VANDSR 69.000<br>301255 2MORLEY 69.000 1 | FROM BUS 300038 [7ESSEX 345.00] TO BUS 301407 [7WNWMADRID1A345.00] CKT 1<br>FROM BUS 300038 [7ESSEX 345.00] TO BUS 344974 [7LUTESVIL 345.00] CKT 1<br>FROM BUS 301407 [7WNWMADRID1A345.00] TO BUS 301416 [7WNWMADRID1B345.00] CKT Z1<br>FROM BUS 300075 [5ESSEX 161.00] TO BUS 300038 [7ESSEX 345.00] CKT 1<br>FROM BUS 300075 [5ESSEX 161.00] TO BUS 505434 [IDALIA 5 161.00] CKT 1<br>FROM BUS 300075 [5ESSEX 161.00] TO BUS 301533 [5ESSEXGSU1 161.00] CKT 1<br>FROM BUS 300075 [5ESSEX 161.00] TO BUS 345791 [5STODDARD 2 161.00] CKT 1 | 25S | 35 | 106.0 | 113.6 |
| | | | | 30S | 35 | 118.1 | 125.5 |
| NU10 | P1 | 300293 2CAMRNJ 69.000<br>300312 2TURNEY 69.000 1* | FROM BUS 300107 [5OSBORN 161.00] TO BUS 301310 [5REX 161.00] CKT 1 | 25H | 35 | 83.4 | 100.2 |
| NU11 | | 300101 5MORGAN 161.00<br>300782 2MORGAN 69.000 1 | FROM BUS 300774 [2EUDORA 69.000] TO BUS 300788 [2SLAGLE 69.000] CKT 1 | 25L | 56 | 105.2 | 108.3 |

**Adverse impact with the inclusion of the first round of network upgrades applied for the Project*

## 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.

Twelve (12) 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 (%MVA) | Project Loading (%MVA) | Contingent Generator(s) |
|---|---|---|---|---|---|---|---|
| CF01 | P2EHV | 300042 7HUBEN 345.00 300088 5HUBEN 161.00 1 | 25S | 392 | 100.8 | 105.8 | GI-085 |
| | | | 25W | 446 | 99.7 | 104.0 | GI-085 |
| | | | 30S | 392 | 104.6 | 108.9 | GI-085 |
| | | | 30W | 446 | 106.0 | 110.1 | GI-085 |
| CF02 | | 300045 7MORGAN 345.00 301622 5MORGANXF2 161.00 2 | 25H | 400 | 108.5 | 113.8 | GI-085 |
| | | | 25S | 400 | 104.2 | 107.4 | GI-085 |
| | | | 25W | 456 | 102.4 | 108.9 | GI-085 |
| | | | 30W | 456 | 107.7 | 113.1 | GI-085 |
| CF03 | P1 | 300126 5MOBTAP 161.00 345221 5MOBERLY 1 161.00 Z1 | 25S | 372 | 108.9 | 112.4 | GI-092 |
| CF04 | | 300173 2GOBKNOB 69.000 301218 2PBSOUTH 69.000 1 | 25L | 35 | 109.3 | 115.3 | MISO DPP 2019 |
| | P2EHV | | 25L | 35 | 110.6 | 116.4 | MISO DPP 2019 |
| CF05 | P1 | 300193 2AVLON 69.000 300199 2HALE 69.000 1 | 25S | 35 | 111.0 | 115.9 | MISO DPP 2019 |
| CF06 | | 300194 2CHILLI 69.000 300195 2CHILLR 69.000 1 | 25S | 35 | 100.3 | 104.8 | MISO DPP 2019 |
| | | | 30S | 35 | 102.4 | 106.0 | MISO DPP 2019 |
| CF07 | | 300199 2HALE 69.000 300201 2INGROV 69.000 1 | 25S | 35 | 123.5 | 127.4 | MISO DPP 2019 |
| | P2EHV | | 25S | 35 | 97.1 | 100.2 | MISO DPP 2019 |
| CF08 | P1 | 300327 2ELM 69.000 300336 2HOLDEN 69.000 1 | 25S | 51 | 105.5 | 110.2 | MISO DPP 2019 |
| | | | 30S | 51 | 109.0 | 113.2 | MISO DPP 2019 |
| CF09 | P0 | 300774 2EUDORA 69.000 300788 2SLAGLE 69.000 1 | 25H | 51 | 106.3 | 110.4 | GI-088 |
| | | | 25S | 51 | 102.3 | 107.3 | GI-088 |
| | | | 30S | 51 | 102.4 | 106.9 | GI-088 |
| | P2EHV | | 25H | 51 | 132.8 | 138.8 | GI-088 |
| | | | 25L | 51 | 119.0 | 127.3 | GI-088 |
| | | | 25S | 51 | 115.1 | 121.3 | GI-088 |
| | | | 25W | 72 | 96.4 | 102.5 | GI-088 |
| | | | 30S | 51 | 115.6 | 121.1 | GI-088 |

| Constraint ID | Event | Monitored Facility | Season | Rating (MVA) | Base Loading (%MVA) | Project Loading (%MVA) | Contingent Generator(s) |
|---|---|---|---|---|---|---|---|
| | | | 30W | 72 | 98.3 | 104.3 | GI-088 |
| CF10 | P1 | 301168 2MANSFL 69.000 301174 2SEYMOR 69.000 1 | 25L | 35 | 117.1 | 123.1 | GI-085 |
| | P2EHV | | 25L | 35 | 96.0 | 101.2 | GI-085 |
| CF11 | P1 | 301209 2HARVEL 69.000 301218 2PBSOUTH 69.000 1 | 25L | 35 | 105.4 | 111.3 | GI-084 |
| | P2EHV | | 25L | 35 | 106.6 | 112.5 | GI-084 |
| CF12 | P1 | 300115 5STFRANB2 161.00 338202 5JIM HILL% 161.00 1 | 25S | 247 | 126.3 | 129.9 | MISO DPP 2019 |
| | | | 30S | 247 | 124.2 | 128.1 | MISO DPP 2019 |
| | | | 30W | 302 | 111.8 | 115.6 | MISO DPP 2019 |
| | P2EHV | | 25S | 247 | 126.3 | 129.9 | MISO DPP 2019 |
| | | | 30S | 247 | 124.2 | 128.1 | MISO DPP 2019 |
| | | | 30W | 302 | 111.8 | 115.6 | MISO DPP 2019 |

## NETWORK UPGRADES

Transmission upgrades were evaluated to mitigate the impacts reported from the analyses as a result of the Study Cycle projects. The upgrades shown in Table 4 were evaluated in order to mitigate the reported steady state constraints for the Study Cycle as listed in Table 2.

**Table 4: Network Upgrades for the Study Cycle Constraints**

| Constraint ID | Monitored Facility | Network Upgrade |
|---|---|---|
| NU01 | 300203 2KIDDER 69.000<br>300215 2MABELTP 69.000 1 | Rebuild 4.4-mile-long Kidder to Mabel Tap 69 kV line to 336 ACSR at 100C |
| NU02 | 300206 2MABEL 69.000<br>300215 2MABELTP 69.000 1 | Rebuild 5.06-mile-long Mabel to Mabel Tap 69 kV line to 336 ACSR at 100C |
| NU03 | 300260 2MIDWAY 69.000<br>300264 2SAVANH 69.000 1 | Rebuild 9.6-mile-long Midway to Savannah 69 kV line to 336 ACSR at 100C |
| NU04 | 300121 5MORLEY 161.00<br>301255 2MORLEY 69.000 1 | Replace Morley 69/161 kV transformer with 84/95 MVA transformer |
| NU05 | 300740 7SPORTSMAN 345.00<br>300741 5SPORTSMAN 161.00 1 | Replace Sportsman 161/345 kV transformer #1 with 625/712 MVA transformer |
| NU06 | 300740 7SPORTSMAN 345.00<br>300741 5SPORTSMAN 161.00 2 | Replace Sportsman 161/345 kV transformer #2 with 625/712 MVA transformer |
| NU07 | 301251 2VANDSR 69.000<br>301255 2MORLEY 69.000 1 | Rebuild 2.9-mile-long Vanduser-Morley 69 kV line to 336 ACSR at 100C |
| NU08 | 300251 2FLGGSP 69.000<br>300257 2KINGCT 69.000 1 | Rebuild 9.76-mile-long Flag Springs-King City 69 kV line to 336 ACSR at 100C |
| NU09 | 300251 2FLGGSP 69.000<br>300264 2SAVANH 69.000 1 | Rebuild 6.69-mile-long Flag Springs-Savannah 69 kV line to 336 ACSR at 100C |
| NU10 | 300293 2CAMRNJ 69.000<br>300312 2TURNEY 69.000 1 | Rebuild 7.68-mile-long Cameron-Turney 69 kV line to 336 ACSR at 100C |
| NU11 | 300101 5MORGAN 161.00<br>300782 2MORGAN 69.000 1 | Adjustment of transformer taps able to mitigate overload, no upgrade evaluated |

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 5: Network Upgrades for the Study Cycle Contingent Constraints**

| Constraint ID | Monitored Facility | Network Upgrade |
|---|---|---|
| CF01 | 300042 7HUBEN 345.00<br>300088 5HUBEN 161.00 1 | Contingent on GI-085<br>Reconfigure Morgan 345 kV to breaker-and-a-half |
| CF02 | 300045 7MORGAN 345.00<br>301622 5MORGANXF2 161.00 2 | Contingent on GI-085<br>Reconfigure Morgan 345 kV to breaker-and-a-half |
| CF03 | 300126 5MOBTAP 161.00<br>345221 5MOBERLY 1 161.00 Z1 | Contingent on GI-092<br>Rebuild 0.02 mile-long line to double bundle 1192 ACSR at 100C |
| CF04 | 300173 2GOBKNOB 69.000<br>301218 2PBSOUTH 69.000 1 | Contingent on MISO DPP 2019<br>Rebuild 4.36 mile-long line to 336 ACSR at 100C |
| CF05 | 300193 2AVLON 69.000<br>300199 2HALE 69.000 1 | Contingent on MISO DPP 2019<br>Rebuild 10.23 mile-long line to 336 ACSR at 100C |
| CF06 | 300194 2CHILLI 69.000 300195<br>2CHILLR 69.000 1 | Contingent on MISO DPP 2019<br>Rebuild 2.05 mile-long line to 336 ACSR at 100C |
| CF07 | 300199 2HALE 69.000 300201<br>2INGROV 69.000 1 | Contingent on MISO DPP 2019<br>Rebuild 10.9 mile-long 4/0 segment of line to 336 ACSR at 100C |
| CF08 | 300327 2ELM 69.000 300336<br>2HOLDEN 69.000 1 | Contingent on MISO DPP 2019<br>Use of Holden Operating Guide unable to mitigate overload<br>Uprate 3.1 mile-long segment to 336 ACSR from 75C to 100C |
| CF09 | 300774 2EUDORA 69.000<br>300788 2SLAGLE 69.000 1 | Contingent on GI-088<br>Rebuild 9.9 mile-long line to 795 ACSR at 100C |

| Constraint ID | Monitored Facility | Network Upgrade |
|---|---|---|
| CF10 | 301168 2MANSFL 69.000<br>301174 2SEYMOR 69.000 1 | Contingent on GI-085<br>Reconductor 4.2 mile-long line to 336 ACSR at 75C |
| CF11 | 301209 2HARVEL 69.000<br>301218 2PBSOUTH 69.000 1 | Contingent on GI-084<br>Uprate 2.34 mile-long 4/0 segment of line to 100C |
| CF12 | 300115 5STFRANB2 161.00<br>338202 5JIM HILL% 161.00 1 | Contingent on MISO DPP 2019<br>Use of St. Francis Operating Guide unable to mitigate overload<br>Rebuild 9.93 mile-long line to 1192 ACSR at 100C<br>Replace jumpers at St. Francis with 1192 ACSR at 100C<br>Replace disconnect switches at St. Francis 161 kV bus |

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 6 below.

**Table 6: Steady State Results with Upgrades**

| Constraint ID | Event | Monitored Facility | Season | Rating (MVA) | Base Loading (%MVA) | Project Loading (%MVA) | Mitigation Loading (%MVA) |
|---|---|---|---|---|---|---|---|
| NU01 | P1 | 300203 2KIDDER 69.000<br>300215 2MABELTP 69.000 1 | 25H | 35 | 87.7 | 101.2 | 51.1 |
| NU02 | | 300206 2MABEL 69.000<br>300215 2MABELTP 69.000 1 | 25H | 35 | 87.6 | 100.9 | 51.1 |
| NU03 | | 300260 2MIDWAY 69.000<br>300264 2SAVANH 69.000 1 | 25L | 35 | 98.7 | 101.9 | 52.8 |
| NU08 | | 300251 2FLGGSP 69.000<br>300257 2KINGCT 69.000 1* | 25L | 35 | 97.2 | 100.6 | 53.6 |
| NU09 | | 300251 2FLGGSP 69.000<br>300264 2SAVANH 69.000 1* | 25L | 35 | 99.4 | 102.8 | 54.3 |
| NU07 | | 301251 2VANDSR 69.000<br>301255 2MORLEY 69.000 1 | 25S | 35 | 99.3 | 103.0 | 60.8 |
| | | | 30S | 35 | 105.4 | 110.4 | 64.7 |
| NU04 | P2EHV | 300121 5MORLEY 161.00<br>301255 2MORLEY 69.000 1 | 25S | 56 | 110.3 | 115.4 | 81.9 |
| | | | 30S | 56 | 101.2 | 106.4 | 88.8 |
| | | | 30W | 63 | 96.0 | 101.2 | 77.2 |
| NU05 | | 300740 7SPORTSMAN 345.00<br>300741 5SPORTSMAN 161.00 1 | 25H | 500 | 97.1 | 101.8 | 83.4 |
| | | | 25L | 500 | 101.5 | 106.2 | 86.9 |
| NU06 | | 300740 7SPORTSMAN 345.00<br>300741 5SPORTSMAN 161.00 2 | 25H | 500 | 97.1 | 101.8 | 83.4 |
| | | | 25L | 500 | 101.5 | 106.2 | 86.9 |
| NU07 | | 301251 2VANDSR 69.000<br>301255 2MORLEY 69.000 1 | 25S | 35 | 106.0 | 113.6 | 66.4 |
| | | | 30S | 35 | 118.1 | 125.5 | 73.2 |
| NU10 | P1 | 300293 2CAMRNJ 69.000<br>300312 2TURNEY 69.000 1* | 25H | 35 | 83.4 | 100.2 | 52.3 |
| NU11 | P1 | 300101 5MORGAN 161.00<br>300782 2MORGAN 69.000 1 | 25L | 56 | 105.2 | 108.3 | 91.5 |
| CF01 | P2EHV | 300042 7HUBEN 345.00<br>300088 5HUBEN 161.00 1 | 25S | 392 | 100.8 | 105.8 | 88.9 |
| | | | 25W | 446 | 99.7 | 104.0 | 91.0 |
| | | | 30S | 392 | 104.6 | 108.9 | 90.5 |
| | | | 30W | 446 | 106.0 | 110.1 | 96.0 |
| CF02 | | 300045 7MORGAN 345.00<br>301622 5MORGANXF2 161.00 2 | 25H | 400 | 108.5 | 113.8 | 67.5 |
| | | | 25S | 400 | 104.2 | 107.4 | 72.9 |

| Constraint ID | Event | Monitored Facility | Season | Rating (MVA) | Base Loading (%MVA) | Project Loading (%MVA) | Mitigation Loading (%MVA) |
|---|---|---|---|---|---|---|---|
| | | | 25W | 456 | 102.4 | 108.9 | 66.9 |
| | | | 30W | 456 | 107.7 | 113.1 | 73.4 |
| CF03 | P1 | 300126 5MOBTAP 161.00 345221 5MOBERLY 1 161.00 Z1 | 25S | 372 | 108.9 | 112.4 | 85.2 |
| CF04 | P1 | 300173 2GOBKNOB 69.000 301218 2PBSOUTH 69.000 1 | 25L | 35 | 109.3 | 115.3 | 60.1 |
| | P2EHV | | 25L | 35 | 110.6 | 116.4 | 60.7 |
| CF05 | P1 | 300193 2AVLON 69.000 300199 2HALE 69.000 1 | 25S | 35 | 111.0 | 115.9 | 70.3 |
| CF06 | P1 | 300194 2CHILLI 69.000 300195 2CHILLR 69.000 1 | 25S | 35 | 100.3 | 104.8 | 52.5 |
| | | | 30S | 35 | 102.4 | 106.0 | 53.1 |
| CF07 | P1 | 300199 2HALE 69.000 300201 2INGROV 69.000 1 | 25S | 35 | 123.5 | 127.4 | 74.8 |
| | P2EHV | | 25S | 35 | 97.1 | 100.2 | 59.1 |
| CF08 | P1 | 300327 2ELM 69.000 300336 2HOLDEN 69.000 1 | 25S | 51 | 105.5 | 110.2 | 81.4 |
| | | | 30S | 51 | 109.0 | 113.2 | 83.6 |
| CF09 | P0 | 300774 2EUDORA 69.000 300788 2SLAGLE 69.000 1 | 25H | 51 | 106.3 | 110.4 | 48.9 |
| | | | 25S | 51 | 102.3 | 107.3 | 47.4 |
| | | | 30S | 51 | 102.4 | 106.9 | 47.2 |
| | P2EHV | | 25H | 51 | 132.8 | 138.8 | 56.0 |
| | | | 25L | 51 | 119.0 | 127.3 | 48.9 |
| | | | 25S | 51 | 115.1 | 121.3 | 51.6 |
| | | | 25W | 72 | 96.4 | 102.5 | 50.0 |
| | | | 30S | 51 | 115.6 | 121.1 | 51.5 |
| | | | 30W | 72 | 98.3 | 104.3 | 51.0 |
| CF10 | P1 | 301168 2MANSFL 69.000 301174 2SEYMOR 69.000 1 | 25L | 35 | 117.1 | 123.1 | 92.8 |
| | P2EHV | | 25L | 35 | 96.0 | 101.2 | 76.6 |
| CF11 | P1 | 301209 2HARVEL 69.000 301218 2PBSOUTH 69.000 1 | 25L | 35 | 105.4 | 111.3 | 88.7 |
| | P2EHV | | 25L | 35 | 106.6 | 112.5 | 89.6 |
| CF12 | P1 | 300115 5STFRANB2 161.00 338202 5JIM HILL% 161.00 1 | 25S | 247 | 126.3 | 129.9 | 87.8 |
| | | | 30S | 247 | 124.2 | 128.1 | 86.5 |
| | | | 30W | 302 | 111.8 | 115.6 | 77.9 |
| | P2EHV | | 25S | 247 | 126.3 | 129.9 | 87.8 |
| | | | 30S | 247 | 124.2 | 128.1 | 86.5 |
| | | | 30W | 302 | 111.8 | 115.6 | 77.9 |

**Adverse impact with the inclusion of network upgrades from the new Project impacts*

AECI developed non-binding, good faith estimates of the timing and cost estimates for upgrades needed as a result of the addition of the Study Cycle projects as shown in Table 7.

**Table 7: Network Upgrade Costs**

| ID | Option / Description | Current Cost | Year In Service |
|---|---|---|---|
| NU01 | Rebuild 4.4-mile-long Kidder to Mabel Tap 69 kV line to 336 ACSR at 100C | $2,042,000 | 2025 |
| NU02 | Rebuild 5.06-mile-long Mabel to Mabel Tap 69 kV line to 336 ACSR at 100C | $2,348,000 | 2025 |
| NU03 | Rebuild 9.6-mile-long Midway to Savannah 69 kV line to 336 ACSR at 100C | $4,455,000 | 2025 |
| NU04 | Replace Morley 69/161 kV transformer with 84/95 MVA transformer | $2,929,000 | 2025 |
| NU05 | Replace Sportsman 161/345 kV transformer #1 with 625/712 MVA transformer | $6,500,000 | 2025 |
| NU06 | Replace Sportsman 161/345 kV transformer #2 with 625/712 MVA transformer | $6,500,000 | 2025 |
| NU07 | Rebuild 2.9-mile-long Vanduser-Morley 69 kV line to 336 ACSR at 100C | $1,022,000 | 2025 |
| NU08 | Rebuild 9.76-mile-long Flag Springs-King City 69 kV line to 336 ACSR at 100C | $4,530,000 | 2025 |
| NU09 | Rebuild 6.69-mile-long Flag Springs-Savannah 69 kV line to 336 ACSR at 100C | $3,105,000 | 2025 |
| NU10 | Rebuild 7.68-mile-long Cameron-Turney 69 kV line to 336 ACSR at 100C | $3,564,000 | 2025 |
| | Total Cost: | $36,995,000 | |

Cost allocations for each of the impacted facilities is discussed in the Cost Allocation section below.

## COST ALLOCATION

Network upgrade costs are allocated to each of the Study Cycle projects based on the worst MW impact[1] 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:

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

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

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

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

$$Project\ X\ Upgrade\ 1\ Cost\ Allocation\ (\$) = \frac{Network\ Upgrade\ 1\ Cost\ (\$) * X1}{X1 + Y1 + Z1}$$

[1] All negative impacts > 0 MW.

The associated cost allocation of the network upgrades to each of the Study Cycle projects is provided in Table 8[2].

[2] Associated is exploring business practice updates to include a process to remove certain "de minimis" contributions from cost allocation. A future update of this study may remove cost allocation from some projects.

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**Table 8: Network Upgrade Cost Allocation**

| Project | NU01 | NU02 | NU03 | NU04 | NU05 | NU06 | NU07 | NU08 | NU09 | NU10 | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| G16-037 | $0 | $0 | $0 | $0 | $68,800 | $68,800 | $0 | $0 | $0 | $0 | $137,600 |
| G16-103 | $186,343 | $214,267 | $457,768 | $276,172 | $0 | $0 | $95,302 | $465,474 | $319,050 | $318,109 | $2,332,484 |
| G16-159 | $380,001 | $436,945 | $930,068 | $467,663 | $0 | $0 | $161,702 | $945,726 | $648,229 | $661,533 | $4,631,867 |
| G16-172 | $0 | $0 | $0 | $0 | $29,544 | $29,544 | $0 | $0 | $0 | $0 | $59,089 |
| G17-004 | $0 | $0 | $0 | $58,914 | $0 | $0 | $22,654 | $0 | $0 | $0 | $81,568 |
| G17-005 | $0 | $0 | $0 | $0 | $98,040 | $98,040 | $0 | $0 | $0 | $0 | $196,081 |
| G17-007 | $0 | $0 | $0 | $0 | $39,362 | $39,362 | $0 | $0 | $0 | $0 | $78,723 |
| G17-008 | $232,218 | $267,017 | $367,289 | $256,253 | $0 | $0 | $89,967 | $373,472 | $255,989 | $417,934 | $2,260,139 |
| G17-009 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| G17-010 | $151,059 | $173,696 | $381,664 | $244,911 | $0 | $0 | $83,944 | $388,089 | $266,008 | $254,973 | $1,944,344 |
| G17-014 | $225,185 | $258,930 | $545,539 | $332,662 | $0 | $0 | $114,397 | $554,723 | $380,224 | $386,110 | $2,797,770 |
| G17-018 | $0 | $0 | $0 | $4,905 | $0 | $0 | $2,669 | $0 | $0 | $0 | $7,574 |
| G17-022 | $0 | $0 | $0 | $0 | $20,640 | $20,640 | $0 | $0 | $0 | $0 | $41,280 |
| G17-026 | $0 | $0 | $0 | $0 | $31,611 | $31,611 | $0 | $0 | $0 | $0 | $63,221 |
| G17-027 | $0 | $0 | $0 | $0 | $67,918 | $67,918 | $0 | $0 | $0 | $0 | $135,836 |
| G17-030 | $97,645 | $112,277 | $0 | $137,767 | $0 | $0 | $50,968 | $0 | $0 | $197,857 | $596,515 |
| G17-033 | $0 | $0 | $0 | $0 | $51,159 | $51,159 | $0 | $0 | $0 | $0 | $102,318 |
| G17-039 | $0 | $0 | $0 | $0 | $26,916 | $26,916 | $0 | $0 | $0 | $0 | $53,832 |
| G17-040 | $0 | $0 | $0 | $0 | $157,888 | $157,888 | $0 | $0 | $0 | $0 | $315,775 |
| G17-048 | $228,412 | $262,640 | $586,757 | $379,736 | $0 | $0 | $129,696 | $596,635 | $408,952 | $383,229 | $2,976,056 |
| G17-055 | $212,612 | $244,472 | $383,788 | $221,602 | $0 | $0 | $77,573 | $390,249 | $267,488 | $381,540 | $2,179,323 |
| G17-060 | $0 | $0 | $0 | $0 | $40,193 | $40,193 | $0 | $0 | $0 | $0 | $80,385 |
| G17-061 | $0 | $0 | $0 | $0 | $2,006,300 | $2,006,300 | $0 | $0 | $0 | $0 | $4,012,600 |
| G17-064 | $78,073 | $89,772 | $177,805 | $111,884 | $0 | $0 | $38,749 | $180,799 | $123,925 | $134,882 | $935,889 |
| G17-065 | $0 | $0 | $0 | $0 | $51,236 | $51,236 | $0 | $0 | $0 | $0 | $102,472 |
| G17-071 | $0 | $0 | $0 | $0 | $78,919 | $78,919 | $0 | $0 | $0 | $0 | $157,839 |
| G17-072 | $0 | $0 | $0 | $0 | $33,036 | $33,036 | $0 | $0 | $0 | $0 | $66,072 |
| G17-073 | $0 | $0 | $0 | $0 | $1,458,704 | $1,458,704 | $0 | $0 | $0 | $0 | $2,917,409 |

| Project | NU01 | NU02 | NU03 | NU04 | NU05 | NU06 | NU07 | NU08 | NU09 | NU10 | Total Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| G17-074 | $0 | $0 | $0 | $0 | $659,159 | $659,159 | $0 | $0 | $0 | $0 | $1,318,317 |
| G17-075 | $0 | $0 | $0 | $0 | $101,877 | $101,877 | $0 | $0 | $0 | $0 | $203,754 |
| G17-076 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| G17-077 | $0 | $0 | $0 | $0 | $1,036,524 | $1,036,524 | $0 | $0 | $0 | $0 | $2,073,048 |
| G17-078 | $0 | $0 | $0 | $0 | $29,593 | $29,593 | $0 | $0 | $0 | $0 | $59,186 |
| G17-080 | $0 | $0 | $0 | $0 | $70,619 | $70,619 | $0 | $0 | $0 | $0 | $141,239 |
| G17-082 | $0 | $0 | $0 | $0 | $150,887 | $150,887 | $0 | $0 | $0 | $0 | $301,774 |
| G17-086 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| G17-090 | $0 | $0 | $0 | $58,859 | $0 | $0 | $24,428 | $0 | $0 | $0 | $83,287 |
| G17-092 | $0 | $0 | $0 | $0 | $157,888 | $157,888 | $0 | $0 | $0 | $0 | $315,775 |
| G17-094 | $156,576 | $180,039 | $400,870 | $239,567 | $0 | $0 | $82,621 | $407,619 | $279,394 | $266,371 | $2,013,057 |
| G17-097 | $93,877 | $107,944 | $223,453 | $138,588 | $0 | $0 | $47,549 | $227,214 | $155,740 | $161,462 | $1,155,827 |
| G17-104 | $0 | $0 | $0 | $0 | $33,342 | $33,342 | $0 | $0 | $0 | $0 | $66,683 |
| **Total Cost** | $2,042,000 | $2,348,000 | $4,455,000 | $2,929,000 | $6,500,000 | $6,500,000 | $1,022,000 | $4,530,000 | $3,105,000 | $3,564,000 | $36,995,000 |

# VERSION HISTORY

| Version Number and Date | Author | Change Description |
|---|---|---|
| V0 – 04/16/2021 | AECI | Initial release |