INTERCONNECTION FACILITIES STUDY REPORT

GEN-2018-033

Published November 2023

By SPP Generator Interconnections Dept.

REVISION HISTORY

DATE OR VERSION NUMBER	AUTHOR	CHANGE DESCRIPTION
November 9, 2023	SPP	Initial draft report issued.
December 6, 2023	SPP	Final report issued.

CONTENTS

SUMMARY

INTRODUCTION

This Interconnection Facilities Study (IFS) for Interconnection Request GEN-2018-033 is for a 200 MW generating facility located in Cass, NE. The Interconnection Request was studied in the DISIS-2018-001 Impact Study for ER. The Interconnection Customer's requested in-service date is June 1, 2026.

The interconnecting Transmission Owner, Omaha Public Power District (OPPD), performed a detailed IFS at the request of SPP. The full report is included in Appendix A. SPP has determined that full Interconnection Service will be available after the assigned Transmission Owner Interconnection Facilities (TOIF), Non-Shared Network Upgrades, Shared Network Upgrades, Contingent Network Upgrades, and Affected System Upgrades that are required for full interconnection service are completed.

The primary objective of the IFS is to identify necessary Transmission Owner Interconnection Facilities, Network Upgrades, other direct assigned upgrades, cost estimates, and associated upgrade lead times needed to grant the requested Interconnection Service.

PHASE(S) OF INTERCONNECTION SERVICE

It is not expected that Interconnection Service will occur in phases. However, full Interconnection Service will not be available until all Interconnection Facilities and Network Upgrade(s) can be placed in service.

COMPENSATION FOR AMOUNTS ADVANCED FOR NETWORK UPGRADE(S)

FERC Order ER20-1687-000 eliminated the use of Attachment Z2 revenue crediting as an option for compensation. The Incremental Long Term Congestion Right (ILTCR) process will be the sole process to compensate upgrade sponsors as of July 1st, 2020.

INTERCONNECTION CUSTOMER INTERCONNECTION FACILITIES

The Generating Facility is proposed to consist of Sixty-eight (68) 2.9MW Inverters (PE FP3510M integrated skid) for a total generating nameplate capacity of 200 MW.

The Interconnection Customer's Interconnection Facilities to be designed, procured, constructed, installed, maintained, and owned by the Interconnection Customer at its sole expense include:

- 34.5 kV underground cable collection circuits;
- 34.5 kV to 345 kV transformation substation with associated 34.5 kV and 345 kV switchgear;
- One 345/34.5 kV 162/216/271 MVA (ONAN/ONAF/ONAF) step-up transformer to be owned and maintained by the Interconnection Customer at the Interconnection Customer's substation;
- An Approximately 0.4 mile overhead kV line to connect the Interconnection Customer's substation to the Point of Interconnection ("POI") at the 345 kV bus at existing Transmission Owner substation ("Cass County 345kV Substation") that is owned and maintained by Transmission Owner;
- All transmission facilities required to connect the Interconnection Customer's substation to the POI;
- Equipment at the Interconnection Customer's substation necessary to maintain a composite power delivery at continuous rated power output at the high-side of the generator substation at a power factor within the range of 95% lagging and 95% leading in accordance with Federal Energy Regulatory Commission (FERC) Order 827. The Interconnection Customer may use inverter manufacturing options for providing reactive power under no/reduced generation conditions. The Interconnection Customer will be required to provide documentation and design specifications demonstrating how the requirements are met; and,
- All necessary relay, protection, control and communication systems required to protect Interconnection Customer's Interconnection Facilities and Generating Facilities and coordinate with Transmission Owner's relay, protection, control and communication systems.

TRANSMISSION OWNER INTERCONNECTION FACILITIES AND NON-SHARED NETWORK UPGRADE(S)

To facilitate interconnection, the interconnecting Transmission Owner will perform work as shown below necessary for the acceptance of the Interconnection Customer's Interconnection Facilities.

Table 1 and **Table 2** list the Interconnection Customer's estimated cost responsibility for Transmission Owner Interconnection Facilities (TOIF) and Non-Shared Network Upgrade(s) and provides an estimated lead time for completion of construction. The estimated lead time begins when the Generator Interconnection Agreement has been fully executed.

Table 1: Transmission Owner Interconnection Facilities (TOIF)

Transmission Owner Interconnection Facilities (TOIF)	Total Cost Estimate ($)	Allocated Percent (%)	Allocated Cost Estimate ($)
Transmission Owner's Cass County 345kV Substation Interconnection Expansion GEN-2018-033 Interconnection (TOIF) (OPPD) (UID155898): Facilitate the interconnection of GEN-2018-033 Estimated Lead Time: 24 Months	$2,290,515	100.00%	$2,290,515
Total	**$2,290,515**		**$2,290,515**

Table 2: Non-Shared Network Upgrade(s)

Non-Shared Network Upgrades Description	ILTCR	Total Cost Estimate ($)	Allocated Percent (%)	Allocated Cost Estimate ($)
Transmission Owner's Cass County 345kV Substation Interconnection Expansion (DISIS-2018-001) (UID155897): Facilitate the interconnection of GEN-2018-033 Estimated Lead Time: 42 Months	Ineligible	$3,497,244	100.00%	$3,497,244
Total		**$3,497,244**		**$3,497,244**

SHARED NETWORK UPGRADE(S)

The Interconnection Customer's share of costs for Shared Network Upgrades is estimated in **Table 3** below.

Table 3: Interconnection Customer Shared Network Upgrade(s)

Shared Network Upgrades Description	ILTCR	Total Cost Estimate ($)	Allocated Percent (%)	Allocated Cost Estimate ($)
N/A				
Total		**$ 0**		**$ 0**

All studies have been conducted assuming that higher-queued Interconnection Request(s) and the associated Network Upgrade(s) will be placed into service. If higher-queued Interconnection Request(s) withdraw from the queue, suspend or terminate service, the Interconnection Customer's share of costs may be revised. Restudies, conducted at the customer's expense, will determine the Interconnection Customer's revised allocation of Shared Network Upgrades.

CONTINGENT NETWORK UPGRADE(S)

Certain Contingent Network Upgrades are **currently not the cost responsibility** of the Interconnection Customer but will be required for full Interconnection Service.

Table 4: Interconnection Customer Contingent Network Upgrade(s)

Contingent Network Upgrade(s) Description	Current Cost Assignment	Estimated In-Service Date
N/A		

Depending upon the status of higher- or equally-queued customers, the Interconnection Request's in-service date is at risk of being delayed or Interconnection Service is at risk of being reduced until the in-service date of these Contingent Network Upgrades.

AFFECTED SYSTEM UPGRADE(S)

To facilitate interconnection, the Affected System Transmission Owner will be required to perform the facilities study work as shown below necessary for the acceptance of the Interconnection Customer's Interconnection Facilities. **Table 5** displays the current impact study costs provided by either MISO or AECI as part of the Affected System Impact review. The Affected System facilities study could provide revised costs and will provide each Interconnection Customer's allocation responsibilities for the upgrades.

Table 5: Interconnection Customer Affected System Upgrade(s)

Affected System Upgrades Description	Total Cost Estimate ($)	Allocated Percent (%)	Allocated Cost Estimate ($)
AECI's NU01 OPEN BRANCH FROM BUS 300084 [5GRNFRT 161.00] TO BUS 505440 [DONIPHN5 161.00] CKT 1 OPEN BRANCH FROM BUS 300040 [7FLETCH 345.00] TO BUS 300054 [7GOBKNOB 345.00] CKT 1 OPEN BRANCH FROM BUS 300048 [7STFRAN 345.00] TO BUS 300054 [7GOBKNOB 345.00] CKT 1	$3,750,000	11.84%	$444,180
AECI's NU02 OPEN BRANCH FROM BUS 300084 [5GRNFRT 161.00] TO BUS 505440 [DONIPHN5 161.00] CKT 1 OPEN BRANCH FROM BUS 300040 [7FLETCH 345.00] TO BUS 300054 [7GOBKNOB 345.00] CKT 1 OPEN BRANCH FROM BUS 300048 [7STFRAN 345.00] TO BUS 300054 [7GOBKNOB 345.00] CKT 1	$8,850,000	11.84%	$1,048,266
AECI's NU03 OPEN BRANCH FROM BUS 300084 [5GRNFRT 161.00] TO BUS 505440 [DONIPHN5 161.00] CKT 1 OPEN BRANCH FROM BUS 300040 [7FLETCH 345.00] TO BUS 300054 [7GOBKNOB 345.00] CKT 1 OPEN BRANCH FROM BUS 300048 [7STFRAN 345.00] TO BUS 300054 [7GOBKNOB 345.00] CKT 1	$5,320,000	11.88%	$632,174
AECI's NU04 OPEN BRANCH FROM BUS 300084 [5GRNFRT 161.00] TO BUS 505440 [DONIPHN5 161.00] CKT 1 OPEN BRANCH FROM BUS 300040 [7FLETCH 345.00] TO BUS 300054 [7GOBKNOB 345.00] CKT 1 OPEN BRANCH FROM BUS 300048 [7STFRAN 345.00] TO BUS 300054 [7GOBKNOB 345.00] CKT 1	$1,820,000	11.88%	$216,270
AECI's NU05 OPEN LINE FROM BUS 300036 [5ELATHRP 161.00] TO BUS 301310 [5REX 161.00] CKT 1	$4,200,000	16.69%	$701,179

AECI's NU06 OPEN LINE FROM BUS 300036 [5ELATHRP 161.00] TO BUS 301310 [5REX 161.00] CKT 1	$3,264,800	16.90%	$551,891
AECI's NU07 OPEN BRANCH FROM BUS 300088 [5HUBEN 161.00] TO BUS 300102 [5MRSHFL 161.00] CKT 1	$4,418,000	11.84%	$522,980
Total	**$31,622,800**		**$4,116,940**

CONCLUSION

After all Interconnection Facilities and Network Upgrades have been placed into service, Interconnection Service for 200 MW can be granted. Full Interconnection Service will be delayed until the TOIF, Non-Shared NU, Shared NU, Contingent NU, Affected System Upgrades that are required for full interconnection service are completed. The Interconnection Customer's estimated cost responsibility for full interconnection service is summarized in the table below.

Table 6: Cost Summary

Description	Allocated Cost Estimate
Transmission Owner Interconnection Facilities Upgrade(s)	$2,290,515
Non-Shared Network Upgrade(s)	$3,497,244
Shared Network Upgrade(s)	$ 0
Affected System Upgrade(s)	$4,116,940
Total	**$9,904,699**

Use the following link for Quarterly Updates on upgrades from this report: https://spp.org/spp-documents-filings/?id=18641

A draft Generator Interconnection Agreement will be provided to the Interconnection Customer consistent with the final results of this IFS report. The Transmission Owner and Interconnection Customer will have 60 days to negotiate the terms of the GIA consistent with the SPP Open Access Transmission Tariff (OATT).

APPENDICES

A: TRANSMISSION OWNER'S INTERCONNECTION FACILITIES STUDY REPORT AND NETWORK UPGRADES REPORT(S)

See next page for the Transmission Owner's Interconnection Facilities Study Report and Network Upgrades Report(s).

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OPPD

Omaha Public Power District

DISIS-2018-001 Interconnection Facilities Study

Omaha Public Power District

Rev 0 – November 2, 2023

Executive Summary

This study evaluates the interconnection of new generation sites in the Omaha Public Power District (OPPD) service area. The interconnection was evaluated for the steady state, stability and fault current impacts to the OPPD and adjacent transmission system per North American Electric Reliability Corporation (NERC) Standard FAC-002 “Facility Interconnection Studies”.

The generation sites evaluated are:

- GEN-2018-025 is a 200MW battery located near the existing 345kV substation S3451. This request will interconnect directly to the substation.
- GEN-2018-033 is a 200MW battery located near the existing 345kV substation S3740. This request will interconnect directly to the substation.
- GEN-2018-037 is a 100MW battery located near the existing 161kV substation S1211. This request will interconnect to a new 161kV substation on the existing S1211-S1220 and S1211-S1299 161kV circuits.
- GEN-2018-043 is a 500WM solar facility located southeast of the city of Tekamah. This request will interconnect to a new 345kV substation on the existing Raun-S3451 345kV circuit.

The results of the study indicate that no issues are created by the addition of the new generation.

Note that this study did not evaluate the impact of battery charging load to the OPPD system. Additional studies will be required prior to battery charging load being placed on the OPPD system.

Contents

SECTION 1: POWER FLOW

Models

Southwest Power Pool (SPP) Integrated Transmission Planning (ITP) 2023 Base Reliability (BR) models. This will include the 1-, 5- and 10-year light, summer peak and winter peak models.

Base Model Changes

The OPPD North Omaha Station units 1, 2 and 3 are placed into service in the summer and light load models to reflect the OPPD Board of Directors decision to defer their retirement until the end of 2026. As part of this deferment, North Omaha Station units 4 and 5 will not be converted to gas operation. Therefore, their Pmax was modified to reflect coal output.

Prior queued generation and any OPPD transmission system upgrades assigned to those requests will also be included. Prior queued generation will be modeled using the same data used in their associated facility study.

Turtle Creek Station (S1363) will be added, but the generation will not be dispatched because they are lower queued requests.

Standing Bear Lake Station (S1347) will be added, but the generation will not be dispatched because they are lower queued requests.

The following approved system topology changes will also be added to reflect expected in-service dates.

- New 161kV circuit S1363-S1362
- Remove circuit S1361-S1362
- New 161kV circuit S1281-S1361
- Tap 161kV circuit S1345-S1236 into S1252
- Uprate 161kV circuits S1209-S1347-S1252
- Uprate 161kV circuit S1201-S1206
- Uprate 161kV circuit S1254-S1281
- New S1247 161kV delivery point
- New S1358 161kV delivery point
- New 161kV circuit S1252-S1358
- Uprate 161kV circuit S1209-S1358
- Uprate 161kV circuit S1358-S1250
- 10MVAR Capacitor at 69kV substation S971
- S1201 Load Addition

OPPD generation was then redispatched to cover the above load additions.

Generation Dispatch

The new generation under study (CQ) and any prior queued (PQ) generation will be dispatched per the table below. This generation will be sunk external to OPPD by simply allowing the excess generation to export to the entire interchange via swing machine reduction. This maximizes loading on the OPPD system to identify potential outlet issues and provided a sensitivity to the SPP DISIS; which reduces existing generation to sink the new generation uniformly.

	Summer		Winter		Light	
	PQ	**CQ**	**PQ**	**CQ**	**PQ**	**CQ**
Combined Cycle	100%	100%	100%	100%	0%	100%
Combustion Turbine	100%	100%	100%	100%	0%	100%
Diesel Engine	100%	100%	100%	100%	0%	100%
Hydro	50%	100%	50%	100%	50%	100%
Nuclear	100%	100%	100%	100%	100%	100%
Storage	100%	100%	100%	100%	0%	100%
Coal	100%	100%	100%	100%	0%	100%
Oil	100%	100%	100%	100%	0%	100%
Waste Heat	100%	100%	100%	100%	0%	100%
Wind	20%	100%	20%	100%	60%	100%
Solar	40%	100%	10%	100%	0%	100%

OPPD reserves the right, at its sole discretion, to utilize SPP's DISIS electrically equivalent dispatch methodology when appropriate.

Study Generation

The modeling data for the new generation will be extracted from the DISIS-2018-001 models.

Contingency Selection

NERC TPL-001-4 "Transmission System Planning Performance Requirements" Table 1 contingency events that do not allow for the interruption of firm transmission service will be evaluated. This is supported by the fact that any issue introduced by the new generation would also be mitigated by reducing that generation per the TPL-001-4 allowance.

This contingency set also includes contingencies from neighboring utilities.

Monitoring

The OPPD system and five buses beyond will be monitored for both voltage and thermal impacts.

Thermal monitoring will use Rate 1/A for system intact, and Rate 2/B for post-contingent loading. Any thermal loading greater than 100% will be identified.

Transfer Distribution Factor (TDF) will be calculated for each generation request. TDFs on facilities that exceed 20% will be considered significantly impacted facilities. TDFs on facilities that exceed 3% will be provided for informational only.

$$TDF = 100 \times \frac{MVA\ flow\ (with\ Project) - MVA\ flow\ (w/o\ Project)}{Project\ MW}$$

Voltage monitoring will be performed as follows: all voltages for greater than 1.05pu, >100kV for less than 0.95pu and <100kV for less than 0.90pu.

Voltage impacts that exceed 0.02pu will be considered significantly impacted facilities.

N-1 & Multiple Element Contingency Results

Steady State

No thermal or voltage issues were identified.

SECTION 2: Stability

Modeling

Southwest Power Pool (SPP) Model Development Advisory Group (MDAG) 2021 Dynamic models. This will include the 2-year summer peak and 3-year light and summer peak models.

Base Model Changes

Prior queued generation and any OPPD transmission system upgrades assigned to those requests will also be included. Prior queued generation will be modeled using the same data used in their associated facility study.

Turtle Creek Station (S1363) generation will not be dispatched because they are lower queued requests.

Standing Bear Lake Station (S1347) generation will not be dispatched because they are lower queued requests.

The following approved system topology changes will also be added to reflect expected in-service dates.

- Uprate 161kV circuit S1201-S1206
- Uprate 161kV circuit S1254-S1281
- New S1247 161kV delivery point
- New 1358 161kV delivery point
- New 161kV circuit S1252-S1358
- Uprate 161kV circuit S1209-S1358
- Uprate 161kV circuit S1358-S1250
- 10MVAR Capacitor at 69kV substation S971
- S1201 Load Addition

OPPD generation was then redispatched to cover the above load additions.

Generation Dispatch

The new generation (CQ) under study and any prior queued (PQ) generation will be dispatched per the table below. This generation will be sunk external to OPPD by simply allowing the excess generation to export to the entire interchange via swing machine reduction. This maximizes loading on the OPPD system to identify potential outlet issues and provided a sensitivity to the SPP DISIS; which reduces existing generation to sink the new generation uniformly.

	Summer		Winter		Light	
	PQ	**CQ**	**PQ**	**CQ**	**PQ**	**CQ**
Combined Cycle	100%	100%	100%	100%	0%	100%
Combustion Turbine	100%	100%	100%	100%	0%	100%
Diesel Engine	100%	100%	100%	100%	0%	100%
Hydro	50%	100%	50%	100%	50%	100%
Nuclear	100%	100%	100%	100%	100%	100%
Storage	100%	100%	100%	100%	0%	100%
Coal	100%	100%	100%	100%	0%	100%
Oil	100%	100%	100%	100%	0%	100%
Waste Heat	100%	100%	100%	100%	0%	100%
Wind	20%	100%	20%	100%	60%	100%
Solar	40%	100%	10%	100%	0%	100%

OPPD reserves the right, at its sole discretion, to utilize SPP's DISIS electrically equivalent dispatch methodology when appropriate.

Study Generation

The modeling data for the new generation will be extracted from the DISIS-2018-001 models.

Contingency Selection

The fault disturbances OPPD selected are based on engineering judgment for those disturbances involving facilities in OPPD's system that are expected to produce the most severe system impacts. Previous stability study results are used to aid in the selection of disturbances. Many of the selected disturbances are in close proximity to significant generation plants or generation outlets where such a disturbance could result in loss of synchronism, loss of generation and potentially lead to grid instability. Other reasons why disturbances were selected are the following:

- The disturbance involves the outage of one or more strong transmission sources to the location of a fault.
- The disturbance involves high-speed automatic reclosing or automatic reclosing after a relatively short time delay.
- It is believed that the voltage swings that will result from the disturbance will be larger than those resulting from other disturbances will.
- The disturbance involves a fault at a bus having a load to which a dynamic load model is applied in a manner specific to that load.
- Selection of the disturbance would increase the variety of locations at which disturbances are studied.

See Appendix 2 for a list of events.

Stability Monitoring

All simulations were performed using Siemens PSSE.

Rotor angle dynamic simulation plots were generated for all monitored generators. Because of the number of buses monitored for voltage violations, dynamic simulation plots were developed for those buses flagged for not meeting disturbance performance criteria as listed below. Simulation plots are available on request and are not included in this report. The following items are monitored and recorded and represent OPPD's criteria for identifying instability conditions as per TPL-001-4 R6:

Rotor angle stability and oscillation damping (conventional generation only) – Rotor angles were monitored for all OPPD area generators (Area 645) and all generators in the following areas:

- 635 MEC
- 640 NPPD
- 650 LES

Those units that exhibited signs of instability were marked for further analysis. Rotor angle deviations were calculated relative to the system swing machine, Brown's Ferry. The curves of rotor angle deviation versus time for machines with rotor angle deviation greater than or equal to 16 degrees (measured as absolute maximum peak to absolute minimum peak) were judged

against the SPPR1 and SPPR5 criteria as described in the SPP Disturbance Performance Requirements. Machines with rotor angle deviations less than 16 degrees that did not exhibit convergence were evaluated on an individual basis. Machines with rotor angle deviations greater than 180 degrees were also flagged. The SPPR1 and SPPR5 criteria is restated below:

- Well damped angular oscillations shall meet one of the following two requirements when calculated directly from the rotor angle:
    - Successive Positive Peak Ratio (SPPR1) must be less than or equal to 0.95 or have a Damping Factor % greater than or equal to 5%, where SPPR1 and its associated Damping Factor are calculated as follows:

$$SPPR1 = \frac{\text{Peak Rotor Angle of 2nd Positive Peak minus Minimum Value}}{\text{Peak Rotor Angle of 1st Positive Peak minus Minimum Value}} \leq 0.95$$

$$\text{Damping Factor \%} = (1 - SPPR1) \times 100\% \geq 5\%$$

    - Successive Positive Peak Ratio Five (SPPR5) must be less than or equal to 0.774 or have a Damping Factor % greater than or equal to 22.6%, where SPPR5 and its associated Damping Factor are calculated as follows:

$$SPPR5 = \frac{\text{Peak Rotor Angle of 6th Positive Peak minus Minimum Value}}{\text{Peak Rotor Angle of 1st Positive Peak minus Minimum Value}} \leq 0.774$$

$$\text{Damping Factor \%} = (1 - SPPR5) \times 100\% \geq 22.6\%$$

Transient voltage stability - Voltage was monitored at all OPPD generator buses, all OPPD buses 69 kV and above, generator buses in the areas monitored for rotor angle as listed above. The voltage responses were judged against the $0.70 < V_{transient} \leq 1.20$ p.u. criteria, as described in the SPP Disturbance Performance Requirements and restated below. Those units that violate the transient voltage criteria were marked for further analysis. (TPL-001-4 requirement R5)

- After a disturbance is cleared, bus voltages on the Bulk Electric System shall recover above 0.70 per unit, 2.5 seconds after the fault is cleared. Bus voltages shall not swing above 1.20 per unit after the fault is cleared, unless affected transmission system elements are designed to handle the rise above 1.2 per unit.

Protection System Operation – The analysis simulated the removal of all elements that the Protection System and other automatic controls are expected to disconnect for each contingency without operator intervention. This was accomplished by defining all appropriate actions in PSAS files that were run for each event. The analysis considered the impacts of high-speed reclosing, tripping of generators when bus voltages or high side of the GSU voltages are less than known or assumed generator low voltage ride through capability, and tripping of transmission lines or transformers where transient swings cause Protection System operation.

PSS/E system-wide monitoring models were used as a way to quickly scan for transmission lines or generators that may be impacted by the transient swings caused by a disturbance. PSS/E activity RELSCN was used to place a generic distance relay model at each end of every circuit. The model uses relay characteristics that are based on percentages of line impedance. PSS/E activity OSSCAN was also used and places a generic out-of-step relay at the end of every circuit to monitor for instances where apparent impedance is less than line impedance. Results were reviewed for instances where either RELSCN or OSSCAN flagged transient conditions. These were reviewed to determine whether subsequent tripping was required. If it was determined subsequent tripping was warranted, then this action was defined in the PSAS file for the event and the event was re-run.

Generator Low Voltage Ride Through – To simulate protection system responses to abnormal voltage conditions, OPPD reviewed generator voltage protective relay settings using PRC-024-2, Attachment 2 as a guideline and developed appropriate dynamic relay models for those units with generator voltage protective relaying. Additionally, OPPD post-processed disturbance results to look for any instances where generator bus voltages or GSU high side bus voltages lie in the allowable tripping region (either above or below the 'No Trip Zone' in Attachment 2 of PRC-024-2) per the high and low voltage ride through duration criteria listed in PRC-024-2, Attachment 2. These instances were flagged and examined further to determine if additional actions would occur based on in-service protection systems.

Cascading – Potential cascading due to a disturbance was evaluated for NERC Planning Events (category P1-P7) and Extreme Events to check for the uncontrolled successive loss of system elements. OPPD's evaluation of disturbances that have the potential to cause cascading is meant to identify those situations where unrestrained electric service interruption cannot be prevented from spreading. Simulation results were scanned for instances where units exhibit instability as evidenced by a loss of synchronism or violation of voltage criteria. Simulations are re-run with the unit(s) that exhibited a loss of stability being tripped at an appropriate simulation time. A steady state evaluation is also performed to simulate the outage of elements lost due to the original event and the subsequent tripping events to identify thermal issues that may arise as a result. The stability results are scanned again to look for instances of units that lose synchronism. If any are found, the previous steps are repeated to trip these additional elements. This entire process is repeated until either all units display rotor angle stability, or one of the following cascading criteria are met:

- The disturbance causes more than three iterations of successive instability, tripping, and reviewing following the initial event.
- The accumulated amount of generation lost due to the initial event and subsequent events is greater than 2000 MW. This criterion represents approximately 150% of OPPD's largest generation site, which is consistent with SPP cascading criteria.

The event is considered to have the potential of causing cascading if one of the above criteria is met. Per requirement R4.5, if an extreme event causes cascading an evaluation of possible actions designed to reduce the likelihood or mitigate the consequences of the event(s) will be conducted.

Scenarios

Requests will be studied simultaneous unless issues are identified. If issues are identified, then they will be run independently to determine the source of the issue.

Stability Results

The following instabilities were present:

- Loss of angular stability at Nebraska City Units 1 and 2 for an Extreme Event involving 345kV substation S3458.
    - This is an existing base case issue on the OPPD system that is mitigated by the automatic tripping of NC-1 and NC-2. No cascading occurs; therefore, no other mitigation is required.

SECTION 3: Short Circuit

The intent of the short circuit study is to determine if the interconnection of the new generation causes an increase in available fault current above the ratings of the currently installed circuit breakers on the OPPD Transmission System.

Modeling

Southwest Power Pool (SPP) Integrated Transmission Planning (ITP) 2023 Short Circuit (BR) models. This will include the 2- and 5-year summer peak max fault models.

Base Model Changes

The OPPD North Omaha Station units 1, 2 and 3 are placed into service in the summer and light load models to reflect the OPPD Board of Directors decision to defer their retirement until the end of 2026. As part of this deferment, North Omaha Station units 4 and 5 will not be converted to gas operation. Therefore, their Pmax was modified to reflect coal output.

Prior queued generation and any OPPD transmission system upgrades assigned to those requests will also be included. Prior queued generation will be modeled using the same data used in their associated facility study.

Turtle Creek Station (S1363) will be added, but the generation will not be dispatched because they are lower queued requests.

Standing Bear Lake Station (S1347) will be added, but the generation will not be dispatched because they are lower queued requests.

The following approved system topology changes will also be added to reflect expected in-service dates.

- New 161kV circuit S1363-S1362
- Remove circuit S1361-S1362
- New 161kV circuit S1281-S1361
- Tap 161kV circuit S1345-S1236 into S1252
- Uprate 161kV circuits S1209-S1347-S1252
- Uprate 161kV circuit S1201-S1206
- Uprate 161kV circuit S1254-S1281
- New S1247 161kV delivery point
- New 1358 161kV delivery point
- New 161kV circuit S1252-S1358
- Uprate 161kV circuit S1209-S1358
- Uprate 161kV circuit S1358-S1250
- 10MVAR Capacitor at 69kV substation S971
- S1201 Load Addition

Generation Dispatch

All generation will be placed in service to maximize fault current values.

Short Circuit Simulation

Analysis was performed using the Power System Simulation for Engineering (PSS/E) short circuit function ANSI. These results are then compared to breaker rating to determine whether the circuit breakers have interrupting capability for the faults that they will be expected to interrupt.

Contingency Selection

A contingency analysis will not be performed for the short circuit analysis. The intact system provides the most paths for fault current to flow, thereby resulting in the worst case. Any circuit breaker loaded greater than 100% will be identified for replacement.

Short Circuit Results

No circuit breaker fault duties are exceeded. Fault current results are listed in Appendix 1.

SECTION 4: MITIGATIONS

No issues were identified that require mitigation.

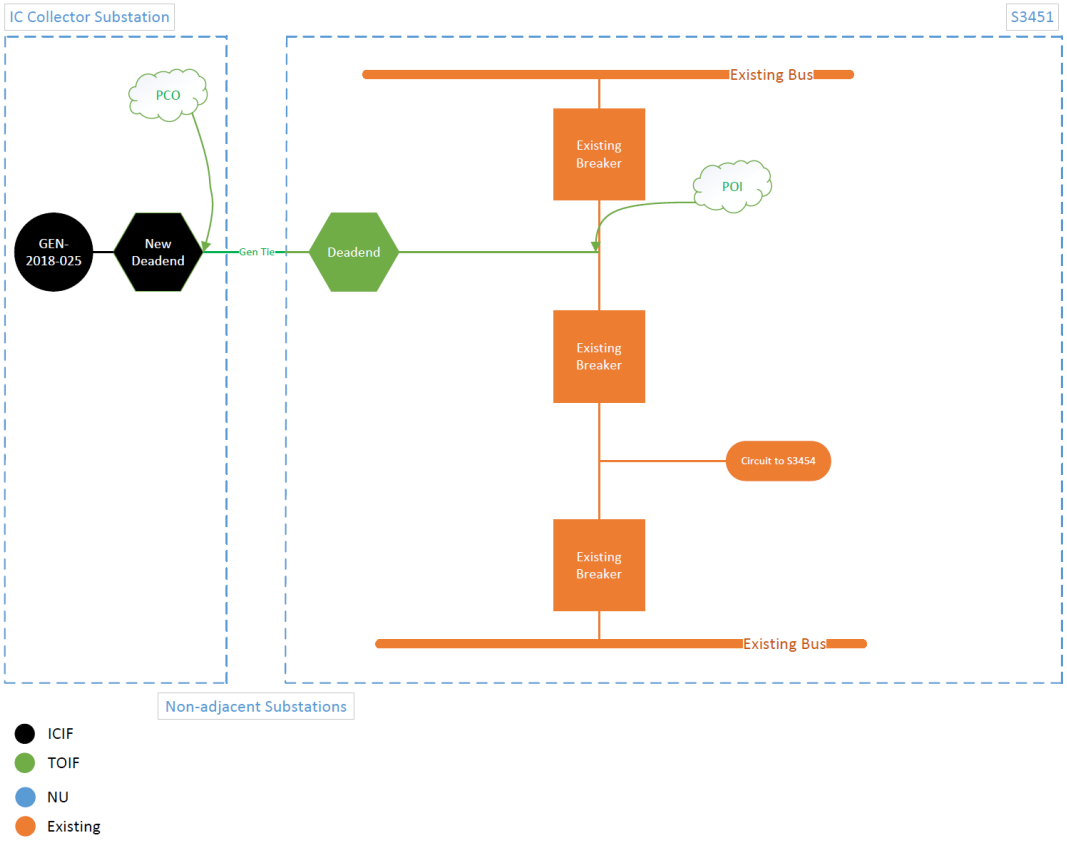
SECTION 5: Detailed Cost Estimates and Schedule

Detailed cost estimates have been prepared for the interconnection facilities and any identified network upgrades identified. The prepared cost estimates are Study level estimates (+20/-20%) and assume the implementation of standard OPPD construction and procurement practices. Figures are also provided below to clarify the interconnection scope and the cost allocation.

GEN-2018-025

SCERT	Category	Scope	Phase 2 Estimate	IFS Estimate	% Change	Lead Time (months)
155907	TOIF	S3451 Dead End Structure, Line Drops and ~1.0 mile 345kV gen tie line	$956,729	$4,691,922		36
156027	NU	No scope. This interconnection uses an existing spare bay.	$0	$0		36
		Total	$956,729	$4,691,922	390%	

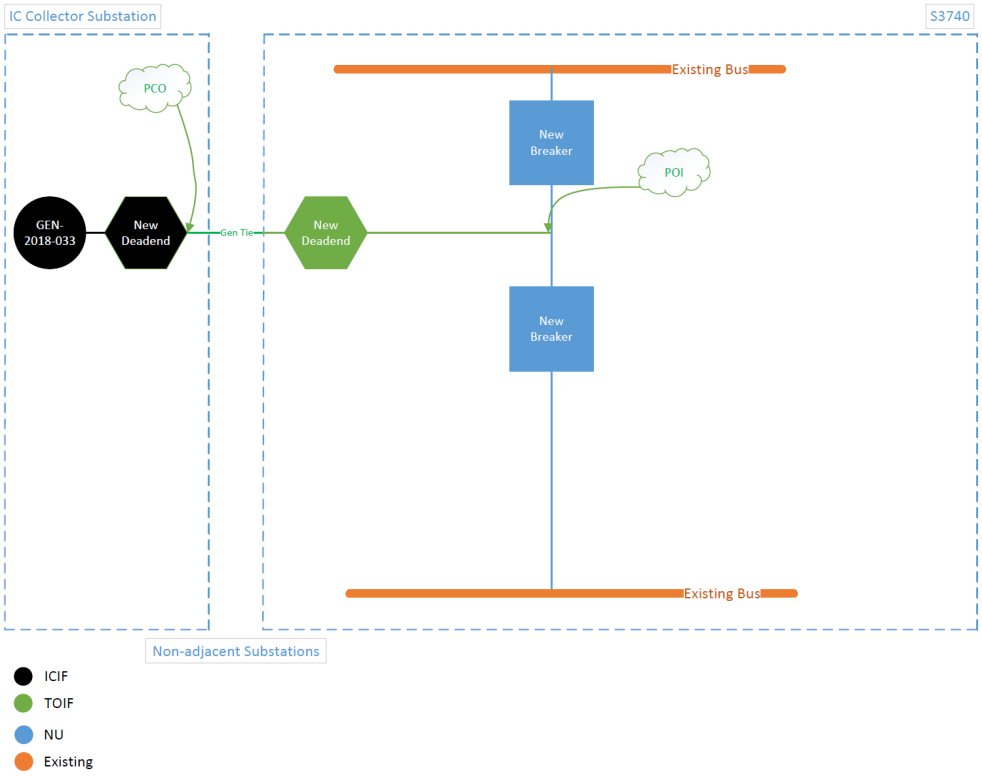
The previously estimated scope costs increased by 30% due to continued increases in material costs. However, the bulk of the overall project cost increase was due to the generator tie line now being included in the project scope and added to the TOIF estimate.



GEN-2018-033

SCERT	Category	Scope	Phase 2 Estimate	IFS Estimate	% Change	Lead Time (months)
155897	NU	S3740 Substation Expansion	$1,882,732	$3,497,244		42
155898	TOIF	S3740 Dead End Structure, Line Drops and ~0.25 mile 345kV gen tie line	$2,949,006	$2,290,515		24
		Total	$4,831,738	$5,787,759	20%	

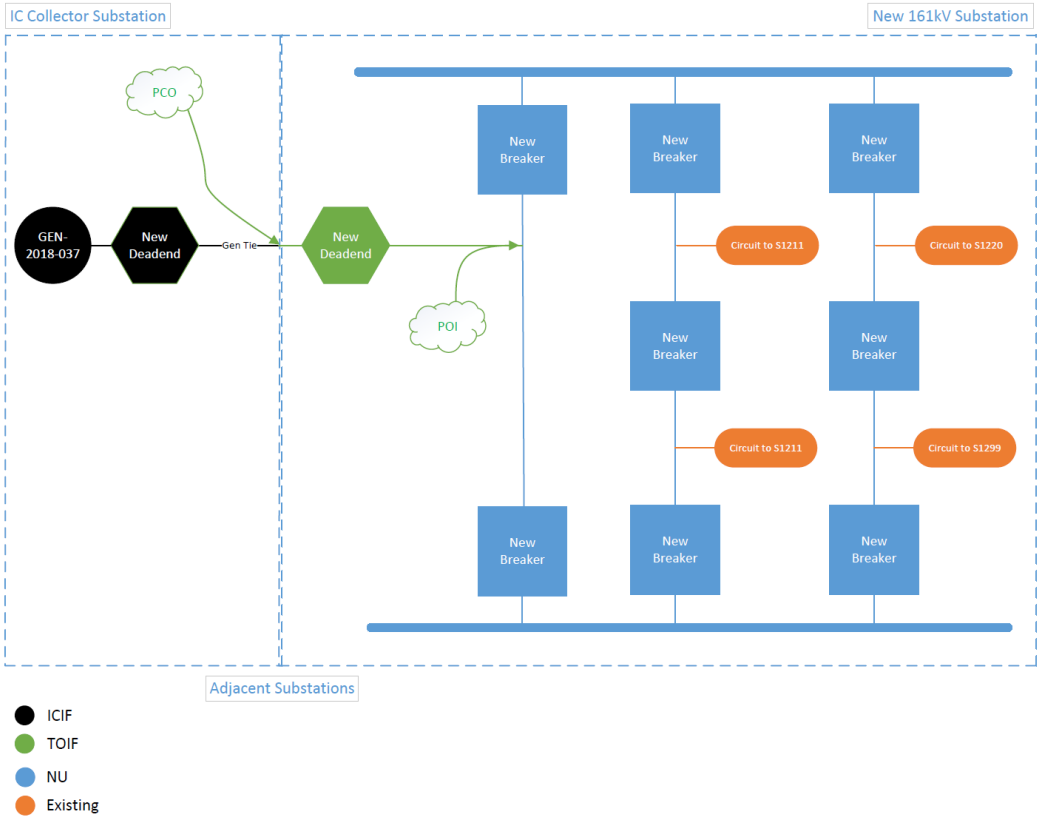
There was a total project cost increase due to continued increases in material costs. The generator tie line is now also included in the TOIF scope but was offset by reductions in other transmission line scope that is no longer required.



GEN-2018-037

SCERT	Category	Scope	Phase 2 Estimate	IFS Estimate	% Change	Lead Time (months)
156166	NU	New five terminal 161kV breaker and a half substation and supporting line work	$11,578,305	$18,110,759		36
156167	TOIF	Dead End Structure and Line Drops for gen tie line	$2,463,988	$150,000		24
		Total	$14,042,293	$18,260,759	30%	

Due to clarifications with how costs are categorized (TOIF vs NU), there was a significant shift in the costs assigned to the individual SCERTS. In addition, the overall cost of the previously estimated scope increased beyond the +/-20% allowance due to the steady increase of material costs between estimate phases.

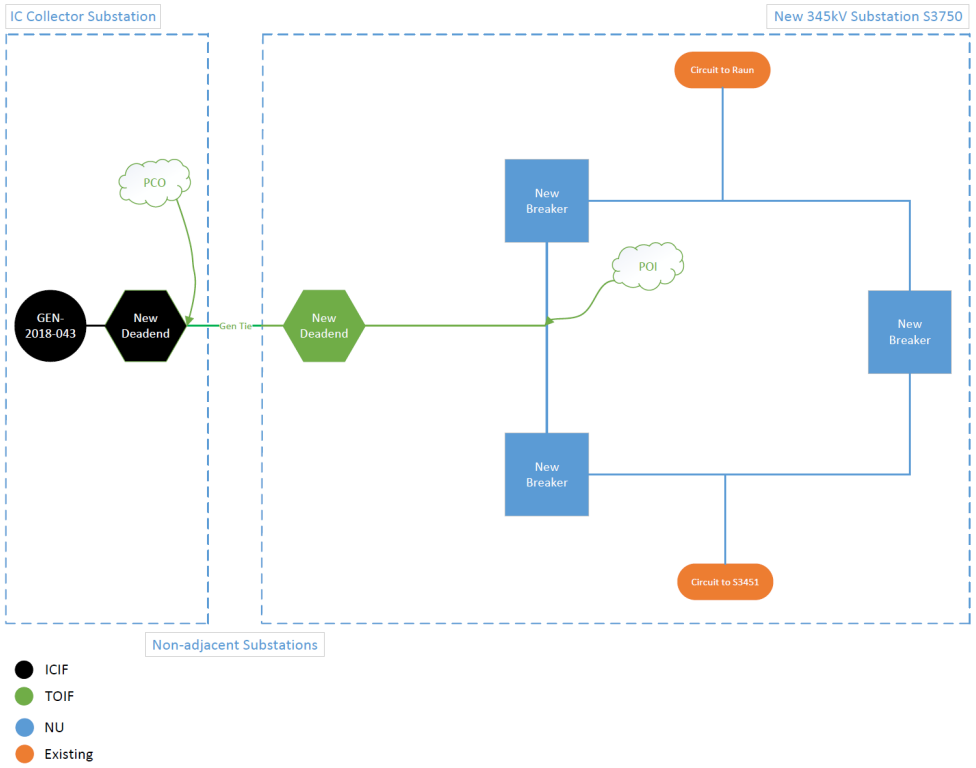


SCERT	Category	Scope	Phase 2 Estimate	IFS Estimate	% Change	Lead Time (months)
156030	TOIF	Dead End Structure, Line Drops and ~2.0 mile 345kV gen tie line	$3,905,348	$4,606,408		36
156031	NU	New three terminal 345kV ring bus substation and supporting line work	$7,810,696	$21,066,242		48
		Total*	$11,716,044	$25,672,650	119%	

*OPPD costs only. This POI is on an OPPD/MidAmerican Energy (MEC) tie line and MEC costs will be documented in a separate Facility Study.

Due to clarifications with how costs are categorized (TOIF vs NU), there was a significant shift in the costs assigned to the individual SCERTS. There was also an increase beyond the +/-20% allowance for the following reasons:

1. The existing transmission line does not have communication provisions. Therefore, a new communication path must be established to the new substation. This scope was not accounted for in the previous estimates.
2. The generator tie line is now being included in the scope and is included in the TOIF estimate.



Appendix 1 – Short Circuit Results

Sub	Breaker	Base kV	Final Interrupt Rating (kA)	Final Fault Current (kA)	Duty
1250	CB-11	161	40.00	39.02	98%
1211	CB 13	161	45.83	43.16	94%
1211	CB 14	161	45.83	43.16	94%
1211	CB 16	161	45.83	43.16	94%
1211	CB 17	161	45.83	43.16	94%
1211	CB 22	161	45.83	43.16	94%
1211	CB 23	161	45.83	43.16	94%
1231	CB 1	161	45.83	42.16	92%
1231	CB 2	161	45.83	42.16	92%
1231	CB 4	161	45.83	42.16	92%
1231	CB 6	161	45.83	42.16	92%
1206	CB-10	161	63.00	55.18	88%
1206	CB-11	161	63.00	55.18	88%
1206	CB-12	161	63.00	55.18	88%
1206	CB-13	161	63.00	55.18	88%
1206	CB-14	161	63.00	55.18	88%
1206	CB-15	161	63.00	55.18	88%
1206	CB-16	161	63.00	55.18	88%
1206	CB-17	161	63.00	55.18	88%
1206	CB-18	161	63.00	55.18	88%
1206	CB-19	161	63.00	55.18	88%
1206	CB-7	161	63.00	55.18	88%
1206	CB-8	161	63.00	55.18	88%
1206	CB-9	161	63.00	55.18	88%
1221	1541	161	40.00	34.59	86%
1211	CB-15	161	50.00	43.16	86%
1211	CB-18	161	50.00	43.16	86%
1211	CB-21	161	50.00	43.16	86%
1211	CB-24	161	50.00	43.16	86%
1211	CB-31	161	50.00	43.16	86%
1211	CB-32	161	50.00	43.16	86%
1211	CB-33	161	50.00	43.16	86%
1211	CB-7	161	50.00	43.16	86%
1211	CB-8	161	50.00	43.16	86%
1211	CB-9	161	50.00	43.16	86%
1260	CB-1	161	40.00	34.18	85%
923	CB-1	69	23.00	19.54	85%
923	CB-2	69	23.00	19.54	85%
1231	CB-7	161	50.00	42.16	84%
1231	CB-8	161	50.00	42.16	84%
1231	CB-9	161	50.00	42.16	84%

Sub	Breaker	Base kV	Final Interrupt Rating (kA)	Final Fault Current (kA)	Duty
1252	CB-1	161	40.00	33.49	84%
1250	CB 3	161	50.00	39.02	78%
1250	CB 4	161	50.00	39.02	78%
1250	CB 5	161	50.00	39.02	78%
3455	CB 1 A Phase	345	40.00	31.17	78%
3455	CB 1 B Phase	345	40.00	31.17	78%
3455	CB 1 C Phase	345	40.00	31.17	78%
3455	CB 10 A Phase	345	40.00	31.17	78%
3455	CB 10 B Phase	345	40.00	31.17	78%
3455	CB 10 C Phase	345	40.00	31.17	78%
3455	CB 11 A Phase	345	40.00	31.17	78%
3455	CB 11 B Phase	345	40.00	31.17	78%
3455	CB 11 C Phase	345	40.00	31.17	78%
3455	CB 12 A Phase	345	40.00	31.17	78%
3455	CB 12 B Phase	345	40.00	31.17	78%
3455	CB 12 C Phase	345	40.00	31.17	78%
1281	CB 1	161	40.00	30.94	77%
1281	CB 2	161	40.00	30.94	77%
910	647	69	35.59	27.34	77%
910	613 B	69	35.59	27.34	77%
910	646 B	69	35.59	27.34	77%
901	Circuit 613 (CB-1)	69	40.00	30.34	76%
901	Circuit 605 (CB-2)	69	40.00	30.34	76%
901	Circuit 601 GT 2 (CB-3)	69	40.00	30.34	76%
901	Circuit 603 (CB-5)	69	40.00	30.34	76%
901	Circuit 615 GT 1 (CB-4)	69	40.00	30.34	76%
1255	CB-21	161	63.00	47.48	75%
1255	CB-22	161	63.00	47.48	75%
1255	CB-23	161	63.00	47.48	75%
1255	CB-25	161	63.00	47.48	75%
1255	CB-26	161	63.00	47.48	75%
1255	CB-27	161	63.00	47.48	75%
1255	CB-28	161	63.00	47.48	75%
1255	CB-29	161	63.00	47.48	75%
1255	CB-30	161	63.00	47.48	75%
1255	CB-32	161	63.00	47.48	75%
1209	CB-21	161	63.00	47.27	75%
1209	CB-22	161	63.00	47.27	75%
1209	CB-23	161	63.00	47.27	75%
1209	CB-24	161	63.00	47.27	75%
1209	CB-25	161	63.00	47.27	75%
1209	CB-26	161	63.00	47.27	75%
1209	CB-27	161	63.00	47.27	75%

Sub	Breaker	Base kV	Final Interrupt Rating (kA)	Final Fault Current (kA)	Duty
1209	CB-28	161	63.00	47.27	75%
1209	CB-30	161	63.00	47.27	75%
1209	CB-31	161	63.00	47.27	75%
1209	CB-32	161	63.00	47.27	75%
911	CB-661	69	40.00	29.70	74%
911	CB-662	69	40.00	29.70	74%
911	CB-665	69	40.00	29.70	74%
911	CB-668	69	40.00	29.70	74%
1298	CB-1	161	40.00	29.58	74%
1210	CB-676	161	40.00	29.06	73%
1222	CB 1	161	40.00	28.75	72%
921	640	69	37.33	26.63	71%
921	653	69	37.33	26.63	71%
921	679	69	37.33	26.63	71%
921	680	69	37.33	26.63	71%
1286	CB-1	161	40.00	28.40	71%
3456	CB 1 A Phase	345	50.00	35.25	71%
3456	CB 1 B Phase	345	50.00	35.25	71%
3456	CB 1 C Phase	345	50.00	35.25	71%
3456	CB 2 A Phase	345	50.00	35.25	71%
3456	CB 2 B Phase	345	50.00	35.25	71%
3456	CB 2 C Phase	345	50.00	35.25	71%
3456	CB 3 A Phase	345	50.00	35.25	71%
3456	CB 3 B Phase	345	50.00	35.25	71%
3456	CB 3 C Phase	345	50.00	35.25	71%
3456	CB 4 A Phase	345	50.00	35.25	71%
3456	CB 4 B Phase	345	50.00	35.25	71%
3456	CB 4 C Phase	345	50.00	35.25	71%
3456	CB 5 A Phase	345	50.00	35.25	71%
3456	CB 5 B Phase	345	50.00	35.25	71%
3456	CB 5 C Phase	345	50.00	35.25	71%
3456	CB 6 A Phase	345	50.00	35.25	71%
3456	CB 6 B Phase	345	50.00	35.25	71%
3456	CB 6 C Phase	345	50.00	35.25	71%
909	CB-651	69	40.00	28.16	70%
938	CB 2	69	31.50	22.17	70%
906	BT-61	69	50.00	34.72	69%
906	BT-62	69	50.00	34.72	69%
906	BT-63	69	50.00	34.72	69%
906	CB-621	69	50.00	34.72	69%
906	CB-623	69	50.00	34.72	69%
906	CB-624	69	50.00	34.72	69%
906	CB-625	69	50.00	34.72	69%

Sub	Breaker	Base kV	Final Interrupt Rating (kA)	Final Fault Current (kA)	Duty
906	CB-626	69	50.00	34.72	69%
906	CB-628	69	50.00	34.72	69%
906	CB-629	69	50.00	34.72	69%
906	CB-631	69	50.00	34.72	69%
906	CB-632	69	50.00	34.72	69%
906	CB-634	69	50.00	34.72	69%
906	CB-635	69	50.00	34.72	69%
906	CB-636	69	50.00	34.72	69%
906	CB-637	69	50.00	34.72	69%
906	CB-658	69	50.00	34.72	69%
3454	CB 1 A PHASE	345	40.00	27.74	69%
3454	CB 1 B PHASE	345	40.00	27.74	69%
3454	CB 1 C PHASE	345	40.00	27.74	69%
3454	CB 2 A PHASE	345	40.00	27.74	69%
3454	CB 2 B PHASE	345	40.00	27.74	69%
3454	CB 2 C PHASE	345	40.00	27.74	69%
3454	CB 3 A Phase	345	40.00	27.74	69%
3454	CB 3 B Phase	345	40.00	27.74	69%
3454	CB 3 C Phase	345	40.00	27.74	69%
3454	CB 6 A PHASE	345	40.00	27.74	69%
3454	CB 6 B PHASE	345	40.00	27.74	69%
3454	CB 6 C PHASE	345	40.00	27.74	69%
1211	CB 19	161	63.00	43.16	69%
1211	CB 20	161	63.00	43.16	69%
1201	CB-4	161	50.00	34.17	68%
1201	CB-7	161	50.00	34.17	68%
1201	CB-8	161	50.00	34.17	68%
1217	CB-11	161	50.00	33.91	68%
1217	CB-1579	161	50.00	33.91	68%
1217	CB-1580	161	50.00	33.91	68%
1217	CB-1619	161	50.00	33.91	68%
1253	CB-22	161	40.00	26.84	67%
1231	CB-3	161	63.00	42.16	67%
917	CB 1	69	40.00	26.76	67%
917	CB 3	69	40.00	26.76	67%
917	CB-2	69	40.00	26.76	67%
1251	CB-104	161	50.00	33.35	67%
1251	CB-105	161	50.00	33.35	67%
1251	CB-106	161	50.00	33.35	67%
1251	CB-107	161	50.00	33.35	67%
1251	CB-108	161	50.00	33.35	67%
1251	CB-109	161	50.00	33.35	67%
1251	CB-110	161	50.00	33.35	67%

Sub	Breaker	Base kV	Final Interrupt Rating (kA)	Final Fault Current (kA)	Duty
1251	CB-111	161	50.00	33.35	67%
1251	CB-112	161	50.00	33.35	67%
1229	CB 1	161	45.83	30.39	66%
3458	CB 1 A Phase	345	50.00	32.97	66%
3458	CB 1 B Phase	345	50.00	32.97	66%
3458	CB 1 C Phase	345	50.00	32.97	66%
3458	CB 10 A Phase	345	50.00	32.97	66%
3458	CB 10 B Phase	345	50.00	32.97	66%
3458	CB 10 C Phase	345	50.00	32.97	66%
3458	CB 12 A Phase	345	50.00	32.97	66%
3458	CB 12 B Phase	345	50.00	32.97	66%
3458	CB 12 C Phase	345	50.00	32.97	66%
3458	CB 16 A Phase	345	50.00	32.97	66%
3458	CB 16 B Phase	345	50.00	32.97	66%
3458	CB 16 C Phase	345	50.00	32.97	66%
3458	CB 18 A Phase	345	50.00	32.97	66%
3458	CB 18 B Phase	345	50.00	32.97	66%
3458	CB 18 C Phase	345	50.00	32.97	66%
3458	CB 23 A Phase	345	50.00	32.97	66%
3458	CB 23 B Phase	345	50.00	32.97	66%
3458	CB 23 C Phase	345	50.00	32.97	66%
3458	CB 24 A Phase	345	50.00	32.97	66%
3458	CB 24 B Phase	345	50.00	32.97	66%
3458	CB 24 C Phase	345	50.00	32.97	66%
3458	CB 25 A Phase	345	50.00	32.97	66%
3458	CB 25 B Phase	345	50.00	32.97	66%
3458	CB 25 C Phase	345	50.00	32.97	66%
3458	CB-19 - A PHASE, POLE 1	345	50.00	32.97	66%
3458	CB-19 - B PHASE, POLE 2	345	50.00	32.97	66%
3458	CB-19 - C PHASE, POLE 3	345	50.00	32.97	66%
3458	CB-21 - A PHASE, POLE 1	345	50.00	32.97	66%
3458	CB-21 - B PHASE, POLE 2	345	50.00	32.97	66%
3458	CB-21 - C PHASE, POLE 3	345	50.00	32.97	66%
3458	CB-27 - A PHASE, POLE 1	345	50.00	32.97	66%
3458	CB-27 - B PHASE, POLE 2	345	50.00	32.97	66%
3458	CB-27 - C PHASE, POLE 3	345	50.00	32.97	66%
3458	CB-3 - A PHASE, POLE 1	345	50.00	32.97	66%
3458	CB-3 - B PHASE, POLE 2	345	50.00	32.97	66%
3458	CB-3 - C PHASE, POLE 3	345	50.00	32.97	66%
3458	CB-4 - A PHASE, POLE 1	345	50.00	32.97	66%
3458	CB-4 - B PHASE, POLE 2	345	50.00	32.97	66%
3458	CB-4 - C PHASE, POLE 3	345	50.00	32.97	66%
3458	CB-6 - A PHASE, POLE 1	345	50.00	32.97	66%

Sub	Breaker	Base kV	Final Interrupt Rating (kA)	Final Fault Current (kA)	Duty
3458	CB-6 - B PHASE, POLE 2	345	50.00	32.97	66%
3458	CB-6 - C PHASE, POLE 3	345	50.00	32.97	66%
1235	CB-1	161	50.00	32.94	66%
1235	CB-2	161	50.00	32.94	66%
1235	CB-3	161	50.00	32.94	66%
1235	CB-4	161	50.00	32.94	66%
1234	CB-1	161	40.00	26.19	65%
1227	CB-1	161	50.00	32.65	65%
1254	CB-11	161	50.00	32.04	64%
1254	CB-12	161	50.00	32.04	64%
1236	CB 1	161	40.00	25.07	63%
1216	CB-1	161	50.00	31.18	62%
3455	CB 2 A Phase	345	50.00	31.17	62%
3455	CB 2 B Phase	345	50.00	31.17	62%
3455	CB 2 C Phase	345	50.00	31.17	62%
3455	CB 3 A Phase	345	50.00	31.17	62%
3455	CB 3 B Phase	345	50.00	31.17	62%
3455	CB 3 C Phase	345	50.00	31.17	62%
3455	CB 5	345	50.00	31.17	62%
3455	CB 6 A Phase	345	50.00	31.17	62%
3455	CB 6 B Phase	345	50.00	31.17	62%
3455	CB 6 C Phase	345	50.00	31.17	62%
924	CB-1	69	40.00	24.89	62%
1250	CB-1	161	63.00	39.02	62%
1250	CB-6	161	63.00	39.02	62%
1220	CB-1	161	50.00	30.84	62%
1299	CB-1	161	50.00	30.66	61%
1249	CB 1	161	40.00	23.98	60%
916	CB 636	69	40.00	23.91	60%
916	CB 680	69	40.00	23.91	60%
911	CB-664	69	50.00	29.70	59%
1298	CB-2	161	50.00	29.58	59%
1298	CB-3	161	50.00	29.58	59%
1298	CB-4	161	50.00	29.58	59%
1361	CB-23	161	63.00	37.05	59%
1361	CB-24	161	63.00	37.05	59%
1361	CB-25	161	63.00	37.05	59%
1361	CB-27	161	63.00	37.05	59%
1361	CB-28	161	63.00	37.05	59%
1361	CB-30	161	63.00	37.05	59%
1361	CB-31	161	63.00	37.05	59%
1361	CB-32	161	63.00	37.05	59%
1361	CB-33	161	63.00	37.05	59%

Sub	Breaker	Base kV	Final Interrupt Rating (kA)	Final Fault Current (kA)	Duty
1361	CB-34	161	63.00	37.05	59%
1361	CB-35	161	63.00	37.05	59%
1361	CB-36	161	63.00	37.05	59%
1361	CB-37	161	63.00	37.05	59%
1361	CB-38	161	63.00	37.05	59%
1361	CB-39	161	63.00	37.05	59%
1361	CB-40	161	63.00	37.05	59%
1361	CB-41	161	63.00	37.05	59%
1361	CB-42	161	63.00	37.05	59%
918	CB-651	69	40.00	23.45	59%
918	CB-661D	69	40.00	23.45	59%
918	CB-675B	69	40.00	23.45	59%
1210	CB-1	161	50.00	29.06	58%
1210	CB-2	161	50.00	29.06	58%
912	CB-1	69	40.00	23.16	58%
912	CB-2	69	40.00	23.16	58%
912	CB-3	69	40.00	23.16	58%
919	CB-1	69	40.00	22.98	57%
919	CB-2	69	40.00	22.98	57%
919	CB-3	69	40.00	22.98	57%
1259	CB-1	161	63.00	35.79	57%
1259	CB-2	161	63.00	35.79	57%
1259	CB-3	161	63.00	35.79	57%
1259	CB-4	161	63.00	35.79	57%
1233	CB-1	161	50.00	28.40	57%
1244	CB-1	161	40.00	22.70	57%
909	CB-648	69	50.00	28.16	56%
909	CB-649	69	50.00	28.16	56%
909	CB-652	69	50.00	28.16	56%
909	CB-653	69	50.00	28.16	56%
1305	CB-1	161	50.00	28.05	56%
1305	CB-2	161	50.00	28.05	56%
930	CB 1	69	40.00	22.24	56%
930	CB 2	69	40.00	22.24	56%
938	CB-1	69	40.00	22.17	55%
908	CB-1	69	35.59	19.63	55%
908	CB-2	69	35.59	19.63	55%
1221	CB-1550	161	63.00	34.59	55%
3451	CB 1 A PHASE	345	40.00	21.90	55%
3451	CB 1 B PHASE	345	40.00	21.90	55%
3451	CB 1 C PHASE	345	40.00	21.90	55%
3451	CB 10 A PHASE	345	40.00	21.90	55%
3451	CB 10 B PHASE	345	40.00	21.90	55%

Sub	Breaker	Base kV	Final Interrupt Rating (kA)	Final Fault Current (kA)	Duty
3451	CB 10 C PHASE	345	40.00	21.90	55%
3451	CB 11 A PHASE	345	40.00	21.90	55%
3451	CB 11 B PHASE	345	40.00	21.90	55%
3451	CB 11 C PHASE	345	40.00	21.90	55%
3451	CB 12 A PHASE	345	40.00	21.90	55%
3451	CB 12 B PHASE	345	40.00	21.90	55%
3451	CB 12 C PHASE	345	40.00	21.90	55%
3451	CB 2 A PHASE	345	40.00	21.90	55%
3451	CB 2 B PHASE	345	40.00	21.90	55%
3451	CB 2 C PHASE	345	40.00	21.90	55%
3451	CB 3 A PHASE	345	40.00	21.90	55%
3451	CB 3 B PHASE	345	40.00	21.90	55%
3451	CB 3 C PHASE	345	40.00	21.90	55%
3451	CB 4 A PHASE	345	40.00	21.90	55%
3451	CB 4 B PHASE	345	40.00	21.90	55%
3451	CB 4 C PHASE	345	40.00	21.90	55%
3451	CB 5 A PHASE	345	40.00	21.90	55%
3451	CB 5 B PHASE	345	40.00	21.90	55%
3451	CB 5 C PHASE	345	40.00	21.90	55%
3451	CB 6 A PHASE	345	40.00	21.90	55%
3451	CB 6 B PHASE	345	40.00	21.90	55%
3451	CB 6 C PHASE	345	40.00	21.90	55%
1341	CB-1	161	50.00	27.28	55%
1260	CB-10	161	63.00	34.18	54%
1260	CB-11	161	63.00	34.18	54%
1260	CB-12	161	63.00	34.18	54%
1260	CB-13	161	63.00	34.18	54%
1260	CB-2	161	63.00	34.18	54%
1260	CB-3	161	63.00	34.18	54%
1260	CB-4	161	63.00	34.18	54%
1260	CB-5	161	63.00	34.18	54%
1260	CB-6	161	63.00	34.18	54%
1260	CB-7	161	63.00	34.18	54%
1260	CB-8	161	63.00	34.18	54%
1260	CB-9	161	63.00	34.18	54%
1201	CB-1	161	63.00	34.17	54%
1201	CB-2	161	63.00	34.17	54%
1201	CB-3	161	63.00	34.17	54%
1201	CB-5	161	63.00	34.17	54%
1201	CB-6	161	63.00	34.17	54%
1201	CB-9	161	63.00	34.17	54%
1367	CB-1	161	40.00	21.62	54%
1253	CB-21	161	50.00	26.84	54%

Sub	Breaker	Base kV	Final Interrupt Rating (kA)	Final Fault Current (kA)	Duty
1253	CB-23	161	50.00	26.84	54%
1232	CB-1	161	50.00	26.72	53%
1278	CB-1	161	50.00	26.66	53%
6866	CB-11	69	40.00	21.16	53%
6866	CB-12	69	40.00	21.16	53%
1234	CB-2	161	50.00	26.19	52%
940	680	69	40.00	20.85	52%
940	680-B	69	40.00	20.85	52%
907	CB-1	69	40.00	20.66	52%
939	CB-1	69	40.00	20.45	51%
939	CB-2	69	40.00	20.45	51%
1254	CB-13	161	63.00	32.04	51%
1254	CB-14	161	63.00	32.04	51%
1254	CB-15	161	63.00	32.04	51%
3459	CB 1 A Phase	345	50.00	25.39	51%
3459	CB 1 B Phase	345	50.00	25.39	51%
3459	CB 1 C Phase	345	50.00	25.39	51%
3459	CB 2 A Phase	345	50.00	25.39	51%
3459	CB 2 B Phase	345	50.00	25.39	51%
3459	CB 2 C Phase	345	50.00	25.39	51%
3459	CB 3 A Phase	345	50.00	25.39	51%
3459	CB 3 B Phase	345	50.00	25.39	51%
3459	CB 3 C Phase	345	50.00	25.39	51%
3459	CB 4 A Phase	345	50.00	25.39	51%
3459	CB 4 B Phase	345	50.00	25.39	51%
3459	CB 4 C Phase	345	50.00	25.39	51%
3459	CB 5 A Phase	345	50.00	25.39	51%
3459	CB 5 B Phase	345	50.00	25.39	51%
3459	CB 5 C Phase	345	50.00	25.39	51%
3459	CB 6 A Phase	345	50.00	25.39	51%
3459	CB 6 B Phase	345	50.00	25.39	51%
3459	CB 6 C Phase	345	50.00	25.39	51%
1226	CB 1	161	50.00	25.10	50%
1226	CB 3	161	50.00	25.10	50%
1226	CB 4	161	50.00	25.10	50%
1226	CB 5	161	50.00	25.10	50%
1226	CB 6	161	50.00	25.10	50%
1226	CB 7	161	50.00	25.10	50%
1226	CB 8	161	50.00	25.10	50%
1226	CB 9	161	50.00	25.10	50%
3455	CB-7 A Phase	345	63.00	31.17	49%
3455	CB-7 B Phase	345	63.00	31.17	49%
3455	CB-7 C Phase	345	63.00	31.17	49%

Sub	Breaker	Base kV	Final Interrupt Rating (kA)	Final Fault Current (kA)	Duty
3455	CB-9 A Phase	345	63.00	31.17	49%
3455	CB-9 B Phase	345	63.00	31.17	49%
3455	CB-9 C Phase	345	63.00	31.17	49%
1281	CB 3	161	63.00	30.94	49%
1281	CB 4	161	63.00	30.94	49%
923	CB 3	69	40.00	19.54	49%
3740	CB 2 A Phase	345	50.00	23.91	48%
3740	CB 2 B Phase	345	50.00	23.91	48%
3740	CB 2 C Phase	345	50.00	23.91	48%
3740	CB 3 A Phase	345	50.00	23.91	48%
3740	CB 3 B Phase	345	50.00	23.91	48%
3740	CB 3 C Phase	345	50.00	23.91	48%
3740	CB 4 A Phase	345	50.00	23.91	48%
3740	CB 4 B Phase	345	50.00	23.91	48%
3740	CB 4 C Phase	345	50.00	23.91	48%
3740	CB 5 A Phase	345	50.00	23.91	48%
3740	CB 5 B Phase	345	50.00	23.91	48%
3740	CB 5 C Phase	345	50.00	23.91	48%
3740	CB 6 A Phase	345	50.00	23.91	48%
3740	CB 6 B Phase	345	50.00	23.91	48%
3740	CB 6 C Phase	345	50.00	23.91	48%
3740	CB 7 A Phase	345	50.00	23.91	48%
3740	CB 7 B Phase	345	50.00	23.91	48%
3740	CB 7 C Phase	345	50.00	23.91	48%
3740	CB 8 A Phase	345	50.00	23.91	48%
3740	CB 8 B Phase	345	50.00	23.91	48%
3740	CB 8 C Phase	345	50.00	23.91	48%
1250	CB 2	69	50.00	23.89	48%
1345	CB-1	161	50.00	23.66	47%
1362	CB-21	161	63.00	29.71	47%
1362	CB-22	161	63.00	29.71	47%
1362	CB-23	161	63.00	29.71	47%
1362	CB-24	161	63.00	29.71	47%
1362	CB-25	161	63.00	29.71	47%
1362	CB-26	161	63.00	29.71	47%
1362	CB-27	161	63.00	29.71	47%
1362	CB-28	161	63.00	29.71	47%
1362	CB-29	161	63.00	29.71	47%
1362	CB-30	161	63.00	29.71	47%
1362	CB-31	161	63.00	29.71	47%
1362	CB-32	161	63.00	29.71	47%
1244	CB-2	161	50.00	22.70	45%
913	CB-1	69	40.00	17.83	45%

Sub	Breaker	Base kV	Final Interrupt Rating (kA)	Final Fault Current (kA)	Duty
913	CB-2	69	40.00	17.83	45%
1237	CB-1	161	50.00	22.24	44%
1237	CB-2	161	50.00	22.24	44%
1237	CB-3	161	50.00	22.24	44%
1256	CB-1	161	50.00	22.06	44%
928	CB-1	69	40.00	17.57	44%
1253	CB-25	161	63.00	26.84	43%
1366	CB-1	161	40.00	16.70	42%
1366	CB-2	161	40.00	16.70	42%
942	CB-1	69	40.00	16.45	41%
942	CB-2	69	40.00	16.45	41%
902	CB 1	69	23.00	9.24	40%
902	CB 2	69	23.00	9.24	40%
902	CB 3	69	23.00	9.24	40%
1226	CB-2	161	63.00	25.10	40%
975	CB-23	69	23.00	8.79	38%
985	CB 2	69	23.00	8.57	37%
985	CB1	69	23.00	8.57	37%
900	CB 1	69	23.00	8.37	36%
900	CB 2	69	23.00	8.37	36%
900	CB 3	69	23.00	8.37	36%
900	CB 5	69	23.00	8.37	36%
900	CB 6	69	23.00	8.37	36%
3761	CB-2 A Phase	345	63.00	22.33	35%
3761	CB-2 B Phase	345	63.00	22.33	35%
3761	CB-2 C Phase	345	63.00	22.33	35%
1287	CB-1	161	63.00	20.43	32%
991	CB-1	69	40.00	12.77	32%
991	CB-2	69	40.00	12.77	32%
6815	CB-1	T2 869.000	40.00	12.73	32%
6815	CB-2	T2 869.000	40.00	12.73	32%
1214	CB-14	161	40.00	12.33	31%
1214	CB-2	161	40.00	12.33	31%
1214	CB-3	161	40.00	12.33	31%
1214	CB-1	69	40.00	12.12	30%
1214	CB-11	69	40.00	12.12	30%
1214	CB-12	69	40.00	12.12	30%
1214	CB-13	69	40.00	12.12	30%
963	683	69	40.00	11.97	30%
963	684	69	40.00	11.97	30%
963	689	69	40.00	11.97	30%
963	690	69	40.00	11.97	30%
6874	CB-1	69	29.85	8.50	28%

Sub	Breaker	Base kV	Final Interrupt Rating (kA)	Final Fault Current (kA)	Duty
6874	CB-2	69	29.85	8.50	28%
976	CB-1	69	50.00	12.76	26%
904	CB-1	69	40.00	9.10	23%
975	CB-21	69	40.00	8.79	22%
975	CB-22	69	40.00	8.79	22%
975	CB-24	69	40.00	8.79	22%
1263	CB-1	161	40.00	8.66	22%
1263	CB-11	161	40.00	8.66	22%
1263	CB-12	161	40.00	8.66	22%
1263	CB-2	161	40.00	8.66	22%
1263	CB-3	161	40.00	8.66	22%
1280	CB-1	161	50.00	10.81	22%
1280	CB-2	161	50.00	10.81	22%
1280	CB-3	161	50.00	10.81	22%
960	CB-20	69	40.00	8.33	21%
984	CB-1	69	40.00	8.12	20%
914	CB-1	69	40.00	7.87	20%
962	682	69	31.50	5.88	19%
962	694	69	31.50	5.88	19%
962	697	69	31.50	5.88	19%
6846	CB-1	69	40.00	7.46	19%
983	CB-1	69	40.00	7.30	18%
1291	CB-21	161	40.00	7.18	18%
NCU 903	CB 683	69	40.00	6.40	16%
NCU 903	CB 697	69	40.00	6.40	16%
974	CB-602	69	40.00	5.74	14%
974	CB-604	69	40.00	5.74	14%
1399	CB-1	161	50.00	7.10	14%
1399	CB-2	161	50.00	7.10	14%
1399	CB-3	161	50.00	7.10	14%
961	CB-1	69	40.00	5.16	13%
1258	CB-41	161	50.00	6.13	12%
1258	CB-42	161	50.00	6.13	12%
1258	CB-44	161	50.00	6.13	12%
1258	CB-45	161	50.00	6.13	12%
1258	CB-46	161	50.00	6.13	12%
1258	CB-48	161	50.00	6.13	12%
1258	CB-49	161	50.00	6.13	12%
971	687	69	40.00	4.88	12%
971	693	69	40.00	4.88	12%
971	694	69	40.00	4.88	12%

Sub	Breaker	Base kV	Final Interrupt Rating (kA)	Final Fault Current (kA)	Duty
968	CB-1	69	40.00	4.57	11%
968	CB-2	69	40.00	4.57	11%
970	CB-1	69	40.00	4.41	11%
982	CB-1	69	40.00	4.05	10%
972	CB-1	69	50.00	4.49	9%

Appendix 2 – Stability Events

Category	Fault Type	Bus Name	Voltage (kV)	Bus Number	R	X	Units	Run For Cycles/ Set Scale (MW, Max, Min)	Action	Element	From Bus	To Bus	Tertiary Bus	Circuit ID	Clear Fault
P1_2	3PH	S3458 3	345.00	645458				5	Open	Transmission Circuit	645458	640139		1	Yes
P1_2	3PH	S3740 3	345.00	645740				5	Open	Transmission Circuit	645455	645740		1	Yes
								600							
	SLG	S3455 3	345.00	645455	932	-10192	MVA	7.5							Yes
P1_2	3PH	S1206 5	161.00	646206				9	Open	Transmission Circuit	646206	646232		1	Yes
								0	Open	Load	646232			O0	
								600							
	SLG	S1232 5	161.00	646232	1434	-9156	MVA	11.5							Yes
P1_2	3PH	S1211 5	161.00	646211				6	Open	Transmission Circuit	646211	762712		1	Yes
								600							
	SLG	G18-037-TAP	161.00	762712	2872	-18493	MVA	8.5							Yes
P1_2	3PH	S1211 5	161.00	646211				6	Open	Transmission Circuit	646211	762712		2	Yes
								600							
	SLG	G18-037-TAP	161.00	762712	2872	-18493	MVA	8.5							Yes
P1_2	3PH	S1211 5	161.00	646211				6	Open	Transmission Circuit	646211	646250		2	Yes
								0	Open	Load	646211			O0	
								600							
	SLG	S1250 5	161.00	646250	1454	-9334	MVA	8.5							Yes
P1_3	3PH	S3451 3	345.00	645451				7.5	Open	Three Winding	645451	646251	648251	1	Yes
P2_2	SCMU L-G	S1217 5	161.00	646217				8.5	Open	Trip Bus	646217				Yes
P3_2									Prior Outage	Generator	635024			4	
	3PH	S3458 3	345.00	645458				5	Open	Transmission Circuit	645458	645456		1	Yes
								600							
	SLG	S3456 3	345.00	645456	411	-4361	MVA	7.5							Yes
P3_2									Prior Outage	Generator	635024			4	
	3PH	S3456 3	345.00	645456				5	Open	Transmission Circuit	645458	645456		1	Yes
								600							
	3PH	S3456 3	345.00	645456				4.5							Yes
P3_2									Prior Outage	Generator	635024			4	
	3PH	S3451 3	345.00	645451				5	Open	Transmission Circuit	645451	645459		1	Yes
								20	Close	Transmission Circuit	645451	645459		1	
	3PH	S3451 3	345.00	645451				4.5	Open	Transmission Circuit	645451	645459		1	Yes
	SLG	S3459 3	345.00	645459	994	-11394	MVA	3							Yes
P3_2									Prior Outage	Generator	635024			4	
	3PH	S3451 3	345.00	645451				5	Open	Transmission Circuit	645451	645459		1	Yes

Category	Fault Type	Bus Name	Voltage (kV)	Bus Number	R	X	Units	Run For Cycles/ Set Scale (MW, Max, Min)	Action	Element	From Bus	To Bus	Tertiary Bus	Circuit ID	Clear Fault
								20	Close	Transmission Circuit	645451	645459		1	
P3_2									Prior Outage	Generator	635024			4	
	3PH	S3459 3	345.00	645459				5	Open	Transmission Circuit	645451	645459		1	Yes
								20	Close	Transmission Circuit	645451	645459		1	
	3PH	S3459 3	345.00	645459				4.5	Open	Transmission Circuit	645451	645459		1	Yes
	SLG	S3451 3	345.00	645451	994	-11394	MVA	3							Yes
P3_2									Prior Outage	Generator	635024			4	
	3PH	S3459 3	345.00	645459				5	Open	Transmission Circuit	645451	645459		1	Yes
								20	Close	Transmission Circuit	645451	645459		1	
P4_2	SCMU L-G	S3451 3	345.00	645451				5	Open	Transmission Circuit	645451	645551		Z1	
								0	Open	Transmission Circuit	645551	762779		1	Yes
	SCMU L-G	S3451 3	345.00	645451				9.5	Open	Three Winding	645451	646251	648351	1	Yes
P4_2	SCMU L-G	S3454 3	345.00	645454				5	Open	Transmission Circuit	645454	650185		1	Yes
	SCMU L-G	S3454 3	345.00	645454				9	Open	Transmission Circuit	645454	645455		1	Yes
P4_2	SCMU L-G	S3458 3	345.00	645458				5	Open	Transmission Circuit	645458	640139		1	Yes
	SCMU L-G	S3458 3	345.00	645458				8.5							Yes
P4_2	SCMU L-G	S3740 3	345.00	645740				5	Open	Transmission Circuit	645455	645740		1	Yes
	SCMU L-G	S3740 3	345.00	645740				8.5							Yes
P4_2	SCMU L-G	S1206 5	161.00	646206				9	Open	Transmission Circuit	646206	646232		1	Yes
								0	Open	Load	646232			O0	
	SCMU L-G	S1206 5	161.00	646206				10.5	Open	Transmission Circuit	646206	646201		1	Yes
								0	Open	Load	646206			O0	
P5_5	SCMU L-G	S1244 5	161.00	646244				25.5	Open	Transmission Circuit	646244	646206		1	Yes
								0	Open	Transmission Circuit	646244	646366		1	
P5_5	SCMU L-G	S1305 5	161.00	646305				25.5	Open	Transmission Circuit	646305	646298		1	Yes
								0	Open	Transmission Circuit	646305	646341		1	
P6_1_1									Prior Outage	Transmission Circuit	645455	645740		1	
	3PH	S3458 3	345.00	645458				5	Open	Transmission Circuit	645458	640139		1	Yes
P6_1_1									Prior Outage	Transmission Circuit	645458	650189		1	
	3PH	S3458 3	345.00	645458				5	Open	Transmission Circuit	645458	640139		1	Yes

Category	Fault Type	Bus Name	Voltage (kV)	Bus Number	R	X	Units	Run For Cycles/ Set Scale (MW, Max, Min)	Action	Element	From Bus	To Bus	Tertiary Bus	Circuit ID	Clear Fault
P6_1_1									Prior Outage	Transmission Circuit	645458	640139		1	
	3PH	S3740 3	345.00	645740				5	Open	Transmission Circuit	645455	645740		1	Yes
								600							
	SLG	S3455 3	345.00	645455	932	-10192	MVA	7.5							Yes
P6_1_1									Prior Outage	Transmission Circuit	646211	762712		1	
	3PH	S1211 5	161.00	646211				6	Open	Transmission Circuit	646211	762712		2	Yes
								600							
	SLG	G18-037-TAP	161.00	762712	2872	-18493	MVA	8.5							Yes
P6_1_1									Prior Outage	Transmission Circuit	645454	645451		1	
	3PH	S3454 3	345.00	645454				5	Open	Transmission Circuit	645454	645455		1	Yes
								20	Close	Transmission Circuit	645454	645455		1	
	3PH	S3454 3	345.00	645454				4.5	Open	Transmission Circuit	645454	645455		1	Yes
	SLG	S3455 3	345.00	645455	2782	-31399	MVA	3							Yes
P6_1_1									Prior Outage	Transmission Circuit	645454	645451		1	
	3PH	S3454 3	345.00	645454				5	Open	Transmission Circuit	645454	645455		1	Yes
								20	Close	Transmission Circuit	645454	645455		1	
P6_1_1									Prior Outage	Transmission Circuit	645454	645455		1	
	3PH	S3455 3	345.00	645455				5	Open	Transmission Circuit	645455	645456		1	Yes
								20	Close	Transmission Circuit	645455	645456		1	
	3PH	S3455 3	345.00	645455				4.5	Open	Transmission Circuit	645455	645456		1	Yes
	SLG	S3456 3	345.00	645456	2687	-32674	MVA	3							Yes
P6_1_1									Prior Outage	Transmission Circuit	645454	645455		1	
	3PH	S3455 3	345.00	645455				5	Open	Transmission Circuit	645455	645456		1	Yes
								20	Close	Transmission Circuit	645455	645456		1	
P6_1_1									Prior Outage	Transmission Circuit	640139	300039		1	
	3PH	COOPER 3	345.00	640139				4.5	Open	Transmission Circuit	640139	541199		1	Yes
P6_1_1									Prior Outage	Transmission Circuit	645458	650189		1	
	3PH	S3458 3	345.00	645458				5	Open	Transmission Circuit	645458	645456		1	Yes
								600							
	SLG	S3456 3	345.00	645456	411	-4361	MVA	7.5							Yes
P6_1_2									Prior Outage	Transmission Circuit	645451	645551		Z1	
									Prior Outage	Transmission Circuit	645551	762779		1	
	3PH	S3451 3	345.00	645451				7.5	Open	Three Winding	645451	646251	648251	1	Yes

Category	Fault Type	Bus Name	Voltage (kV)	Bus Number	R	X	Units	Run For Cycles/ Set Scale (MW, Max, Min)	Action	Element	From Bus	To Bus	Tertiary Bus	Circuit ID	Clear Fault
P6_2_1									Prior Outage	Three Winding	645456	646206	648256	1	
	3PH	S1206 5	161.00	646206				9	Open	Transmission Circuit	646206	646201		1	Yes
								0	Open	Load	646206			O0	
								600							
	SLG	S1201 5	161.00	646201	589	-4038	MVA	11.5							Yes
P7_1	SCMU L-L-G	S3451 3	345.00	645451				5	Open	Transmission Circuit	645451	645459		1	Yes
								0	Open	Transmission Circuit	645451	645454		1	
								20	Close	Transmission Circuit	645451	645459		1	
								0	Close	Transmission Circuit	645451	645454		1	
	SCMU L-L-G	S3451 3	345.00	645451				5	Open	Transmission Circuit	645451	645459		1	Yes
								0	Open	Transmission Circuit	645451	645454		1	
P7_1	SCMU L-L-G	S3451 3	345.00	645451				5	Open	Transmission Circuit	645451	645459		1	Yes
								0	Open	Transmission Circuit	645451	645454		1	
								20	Close	Transmission Circuit	645451	645459		1	
								0	Close	Transmission Circuit	645451	645454		1	
P7_1	SCMU L-L-G	S1211 5	161.00	646211				6	Open	Transmission Circuit	646211	762712		1	Yes
								0	Open	Transmission Circuit	646211	762712		2	
								600							
	SLG	G18-037-TAP	161.00	762712	2872	-18493	MVA	8.5							Yes
P7_1	SCMU L-L-G	S1211 5	161.00	646211				6	Open	Transmission Circuit	646211	646250		1	Yes
								0	Open	Transmission Circuit	646211	646250		2	
								0	Open	Load	646211			O0	
								0	Open	Load	646250			O0	
								600							
	SCMU L-L-G	S1250 5	161.00	646250				8.5							Yes
Extreme_2_b	3PH	S3458 3	345.00	645458				5	Open	Transmission Circuit	645458	640139		1	Yes
	3PH	S3458 3	345.00	645458				8.5							Yes
Extreme_2_c	3PH	S3451 3	345.00	645451				7.5	Open	Three Winding	645451	646251	648251	1	Yes
	3PH	S3451 3	345.00	645451				9.5	Open	Transmission Circuit	645451	645459		1	Yes
Extreme_2_f									Prior Outage	Transmission Circuit	645451	645551		Z1	
									Prior Outage	Transmission Circuit	645551	762779		1	
	SCMU L-G	S3451 3	345.00	645451				7.5	Open	Three Winding	645451	646251	648251	1	Yes
	SCMU L-G	S3451 3	345.00	645451				9.5	Open	Transmission Circuit	645451	645459		1	Yes
Extreme_2_f									Prior Outage	Transmission Circuit	645455	645740		1	

Category	Fault Type	Bus Name	Voltage (kV)	Bus Number	R	X	Units	Run For Cycles/ Set Scale (MW, Max, Min)	Action	Element	From Bus	To Bus	Tertiary Bus	Circuit ID	Clear Fault
	SCMU L-G	S3458 3	345.00	645458				5	Open	Transmission Circuit	645458	640139		1	Yes
	SCMU L-G	S3458 3	345.00	645458				8.5							Yes
Extreme_2_f									Prior Outage	Transmission Circuit	645458	640139		1	
	SCMU L-G	S3740 3	345.00	645740				5	Open	Transmission Circuit	645455	645740		1	Yes
	SCMU L-G	S3740 3	345.00	645740				8.5							Yes
Extreme_2_f									Prior Outage	Transmission Circuit	646201	646206		1	
	SCMU L-G	S1206 5	161.00	646206				9	Open	Transmission Circuit	646206	646232		1	Yes
								0	Open	Load	646232			O0	
	SCMU L-G	S1206 5	161.00	646206				8	Open	Three Winding	646206	647906	648206	1	Yes
Extreme_2_f									Prior Outage	Transmission Circuit	645454	645455		1	
	SCMU L-G	S3455 3	345.00	645455				5	Open	Transmission Circuit	645455	645456		1	Yes
	SCMU L-G	S3455 3	345.00	645455				9.5	Open	Three Winding	645455	646255	648255	1	Yes
Extreme_2_f									Prior Outage	Transmission Circuit	645458	640139		1	
	SCMU L-G	S3458 3	345.00	645458				5	Open	Transmission Circuit	645458	645456		1	Yes
	SCMU L-G	S3458 3	345.00	645458				8.5							Yes
Extreme_2_f									Prior Outage	Transmission Circuit	645458	640139		1	
	SCMU L-G	S3458 3	345.00	645458				4.5	Open	Transmission Circuit	645458	650189		1	Yes
	SCMU L-G	S3458 3	345.00	645458				9							Yes
Extreme_2_f									Prior Outage	Transmission Circuit	640139	300039		1	
	SCMU L-G	COOPER 3	345.00	640139				4.5	Open	Transmission Circuit	640139	541199		1	Yes
	SCMU L-G	COOPER 3	345.00	640139				9	Open	Transmission Circuit	640139	635017		1	Yes
P1_2	3PH	S3456 3	345.00	645456				5	Open	Transmission Circuit	645456	635000		1	Yes
								600							
	3PH	S3456 3	345.00	645456				4.5							Yes
P4_2	SCMU L-G	S3456 3	345.00	645456				5	Open	Transmission Circuit	645456	635000		1	Yes
	SCMU L-G	S3456 3	345.00	645456				9	Open	Transmission Circuit	645456	645455		1	Yes

Category	Fault Type	Bus Name	Voltage (kV)	Bus Number	R	X	Units	Run For Cycles/ Set Scale (MW, Max, Min)	Action	Element	From Bus	To Bus	Tertiary Bus	Circuit ID	Clear Fault
P4_2	SCMU L-G	S3456 3	345.00	645456				5	Open	Transmission Circuit	645456	645455		1	Yes
	SCMU L-G	S3456 3	345.00	645456				9	Open	Transmission Circuit	645456	635000		1	Yes
P6_1_1									Prior Outage	Transmission Circuit	645456	645455		1	
	3PH	S3456 3	345.00	645456				5	Open	Transmission Circuit	645456	635000		1	Yes
								600							
	3PH	S3456 3	345.00	645456				4.5							Yes
P1_3	3PH	S1206 5	161.00	646206				7.5	Open	Three Winding	645456	646206	648256	1	Yes
P4_2	SCMU L-G	S1206 5	161.00	646206				9	Open	Transmission Circuit	646206	646216		1	Yes
								0	Open	Load	646216			O0	
	SCMU L-G	S1206 5	161.00	646206				10	Open	Three Winding	645456	646206	648256	1	Yes
P4_3	SCMU L-G	S1206 5	161.00	646206				7.5	Open	Three Winding	645456	646206	648256	1	Yes
	SCMU L-G	S1206 5	161.00	646206				12	Open	Transmission Circuit	646206	646216		1	Yes
								0	Open	Load	646216			O0	
P6_1_2									Prior Outage	Transmission Circuit	646206	646216		1	
	3PH	S1206 5	161.00	646206				7.5	Open	Three Winding	645456	646206	648256	1	Yes
P6_1_1									Prior Outage	Transmission Circuit	646211	646250		1	
	3PH	S1211 5	161.00	646211				6	Open	Transmission Circuit	646211	646250		2	Yes
								0	Open	Load	646211			O0	
								600							
	SLG	S1250 5	161.00	646250	1454	-9334	MVA	8.5							Yes
P1_2	3PH	S3459 3	345.00	645459				5	Open	Transmission Circuit	645459	645456		1	Yes
								20	Close	Transmission Circuit	645459	645456		1	
	3PH	S3459 3	345.00	645459				4.5	Open	Transmission Circuit	645459	645456		1	Yes
	SLG	S3456 3	345.00	645456	1690	-19307	MVA	3							Yes
P1_2	3PH	S3459 3	345.00	645459				5	Open	Transmission Circuit	645459	645456		1	Yes
								20	Close	Transmission Circuit	645459	645456		1	
P1_2	3PH	S1258 5	161.00	646258				6	Open	Transmission Circuit	646258	646263		1	Yes
								20							
	SLG	S1263 5	161.00	646263	261	-1983	MVA	8.5							Yes
P1_2	3PH	S1258 5	161.00	646258				6	Open	Transmission Circuit	646258	646263		1	Yes
								200	Close	Transmission Circuit	646258	646263		1	
P6_2_1									Prior Outage	Three Winding	645456	646206	648256	1	
	3PH	S1258 5	161.00	646258				6	Open	Transmission Circuit	646258	646263		1	Yes
								20							
	SLG	S1263 5	161.00	646263	261	-1983	MVA	8.5							Yes

Category	Fault Type	Bus Name	Voltage (kV)	Bus Number	R	X	Units	Run For Cycles/ Set Scale (MW, Max, Min)	Action	Element	From Bus	To Bus	Tertiary Bus	Circuit ID	Clear Fault
P6_2_1									Prior Outage	Three Winding	645456	646206	648256	1	
	3PH	S1258 5	161.00	646258				6	Open	Transmission Circuit	646258	646263		1	Yes
								200	Close	Transmission Circuit	646258	646263		1	
P1_2	3PH	S1298 5	161.00	646298				6	Open	Transmission Circuit	646298	646251		1	Yes
								20							
	3PH	S1298 5	161.00	646298				6							Yes
P1_2	3PH	S1298 5	161.00	646298				6	Open	Transmission Circuit	646298	646251		1	Yes
								200	Close	Transmission Circuit	646298	646251		1	
P4_2	SCMU L-G	S1298 5	161.00	646298				6	Open	Transmission Circuit	646298	646251		1	Yes
	SCMU L-G	S1298 5	161.00	646298				13.5	Open	Transmission Circuit	646298	646305		1	Yes
P4_2	SCMU L-G	S1298 5	161.00	646298				9	Open	Transmission Circuit	646298	646305		1	Yes
	SCMU L-G	S1298 5	161.00	646298				10.5	Open	Transmission Circuit	646298	646251		1	Yes
P6_1_1									Prior Outage	Transmission Circuit	646298	646305		1	
	3PH	S1298 5	161.00	646298				6	Open	Transmission Circuit	646298	646251		1	Yes
								20							
	3PH	S1298 5	161.00	646298				6							Yes
P6_1_1									Prior Outage	Transmission Circuit	646298	646305		1	
	3PH	S1298 5	161.00	646298				6	Open	Transmission Circuit	646298	646251		1	Yes
								200	Close	Transmission Circuit	646298	646251		1	
	3PH	S1298 5	161.00	646298				6	Open	Transmission Circuit	646298	646251		1	Yes
								200	Close	Transmission Circuit	646298	646251		1	
P5_5	SCMU L-G	S1210 5	161.00	646210				25.5	Open	Transmission Circuit	646210	646222		1	Yes
	SCMU L-G	S1210 5	161.00	646210				4.0	Open	Transmission Circuit	646210	646217		1	Yes
	SCMU L-G	S1210 5	161.00	646210				103.0	Open	Three Winding	646210	647910	648210	1	Yes
P0		System Intact													
P4_2	SCMU L-G	S1260 5	161.00	646260				6	Open	Trip Bus	646281				Yes
	SCMU L-G	S1260 5	161.00	646260				10.5	Open	Transmission Circuit	646260	646361		1	Yes
								0	Open	Load	646260			O0	
P4_2	SCMU L-G	S3455 3	345.00	645455				4.5	Open	Transmission Circuit	645455	645761		1	Yes
	SCMU L-G	S3455 3	345.00	645455				9.5	Open	Three Winding	645455	646255	648355	1	Yes
P4_2	SCMU L-G	S1361 5	161.00	646361				6	Open	Transmission Circuit	646255	646361		1	Yes
	SCMU L-G	S1361 5	161.00	646361				9							Yes
P1_2	3PH	S1361 5	161.00	646361				6	Open	Transmission Circuit	646255	646361		1	Yes

Category	Fault Type	Bus Name	Voltage (kV)	Bus Number	R	X	Units	Run For Cycles/ Set Scale (MW, Max, Min)	Action	Element	From Bus	To Bus	Tertiary Bus	Circuit ID	Clear Fault
								20	Close	Transmission Circuit	646255	646361		1	
	3PH	S1361 5	161.00	646361				6	Open	Transmission Circuit	646255	646361		1	Yes
P1_2	3PH	S1361 5	161.00	646361				6	Open	Transmission Circuit	646255	646361		1	Yes
								20	Close	Transmission Circuit	646255	646361		1	
Extreme_2_f									Prior Outage	Three Winding	645456	646206	648256	1	
	SCMU L-G	S3455 3	345.00	645455				4.5	Open	Transmission Circuit	645455	645761		1	Yes
	SCMU L-G	S3455 3	345.00	645455				9.5	Open	Three Winding	645455	646255	648355	1	Yes
Extreme_2_f	3PH	S3761 3	345.00	645761											No
	3PH	S1361 5	161.00	646361				4.5	Open	Transmission Circuit	645455	645761		1	Yes
								1.5	Open	Transmission Circuit	646255	646361		1	Yes
								20	Close	Transmission Circuit	646255	646361		1	
	3PH	S1361 5	161.00	646361				6	Open	Transmission Circuit	646255	646361		1	Yes
								572.5							
	SLG	S3455 3	345.00	645455	2615	-47487	MVA	4.5							Yes
Extreme_2_f	3PH	S3761 3	345.00	645761											No
	3PH	S1361 5	161.00	646361				4.5	Open	Transmission Circuit	645455	645761		1	Yes
								1.5	Open	Transmission Circuit	646255	646361		1	Yes
								20	Close	Transmission Circuit	646255	646361		1	
								596.5	Close	Transmission Circuit	645455	645761		1	
Extreme_2_f	3PH	S3455 3	345.00	645455											No
	3PH	S1255 5	161.00	646255				4.5	Open	Transmission Circuit	645455	645761		1	Yes
								1.5	Open	Transmission Circuit	646255	646361		1	Yes
								20	Close	Transmission Circuit	646255	646361		1	
	3PH	S1255 5	161.00	646255				6	Open	Transmission Circuit	646255	646361		1	Yes
								572.5							
	3PH	S3455 3	345.00	645455				4.5							Yes
Extreme_2_f	3PH	S3455 3	345.00	645455											No
	3PH	S1255 5	161.00	646255				4.5	Open	Transmission Circuit	645455	645761		1	Yes
								1.5	Open	Transmission Circuit	646255	646361		1	Yes
								20	Close	Transmission Circuit	646255	646361		1	
								596.5	Close	Transmission Circuit	645455	645761		1	
P1_2	3PH	S1347 5	161.00	646347				6	Open	Transmission Circuit	646209	646347		1	Yes
								600							
	SLG	S1209 5	161.00	646209	1931	-13978	MVA	8.5							Yes
P1_2	3PH	S1347 5	161.00	646347				6	Open	Transmission Circuit	646209	646347		1	Yes
								620	Close	Transmission Circuit	646209	646347		1	
P6_1_1									Prior Outage	Transmission Circuit	646236	646252		1	
	3PH	S1347 5	161.00	646347				6	Open	Transmission Circuit	646209	646347		1	Yes
								600							

Category	Fault Type	Bus Name	Voltage (kV)	Bus Number	R	X	Units	Run For Cycles/ Set Scale (MW, Max, Min)	Action	Element	From Bus	To Bus	Tertiary Bus	Circuit ID	Clear Fault
	SLG	S1209 5	161.00	646209	1931	-13978	MVA	8.5							Yes
P6_1_1									Prior Outage	Transmission Circuit	646236	646252		1	
	3PH	S1347 5	161.00	646347				6	Open	Transmission Circuit	646209	646347		1	Yes
								620	Close	Transmission Circuit	646209	646347		1	
P1_2	3PH	S1347 5	161.00	646347				6	Open	Transmission Circuit	646252	646347		1	Yes
								0	Open	Load	646252			O0	
								600							
	SLG	S1252 5	161.00	646252	1931	-13978	MVA	8.5							Yes
P1_2	3PH	S1347 5	161.00	646347				6	Open	Transmission Circuit	646252	646347		1	Yes
								0	Open	Load	646252			O0	
								620	Close	Transmission Circuit	646252	646347		1	
P6_2_1									Prior Outage	Three Winding	645459	646209	648359	1	
	3PH	S1347 5	161.00	646347				6	Open	Transmission Circuit	646252	646347		1	Yes
								0	Open	Load	646252			O0	
								600							
	SLG	S1252 5	161.00	646252	1931	-13978	MVA	8.5							Yes
P6_2_1									Prior Outage	Three Winding	645459	646209	648359	1	
	3PH	S1347 5	161.00	646347				6	Open	Transmission Circuit	646252	646347		1	Yes
								0	Open	Load	646252			O0	
								620	Close	Transmission Circuit	646252	646347		1	
P1_2	3PH	S1363 5	161.00	646363				6	Open	Transmission Circuit	646362	646363		1	Yes
								600							
	SLG	S1362 5	161.00	646362	1133	-9911	MVA	8.5							Yes
P1_2	3PH	S1363 5	161.00	646363				6	Open	Transmission Circuit	646362	646363		1	Yes
								620	Close	Transmission Circuit	646362	646363		1	
P6_1_1									Prior Outage	Transmission Circuit	646362	646363		2	
	3PH	S1363 5	161.00	646363				6	Open	Transmission Circuit	646362	646363		1	Yes
								600							
	SLG	S1362 5	161.00	646362	1133	-9911	MVA	8.5							Yes
P6_1_1									Prior Outage	Transmission Circuit	646362	646363		2	
	3PH	S1363 5	161.00	646363				6	Open	Transmission Circuit	646362	646363		1	Yes
								620	Close	Transmission Circuit	646362	646363		1	
P1_2	3PH	S1363 5	161.00	646363				6	Open	Transmission Circuit	646281	646363		1	Yes
								600							
	SLG	S1281 5	161.00	646281	972	-8495	MVA	8.5							Yes
P1_2	3PH	S1363 5	161.00	646363				6	Open	Transmission Circuit	646281	646363		1	Yes
								620	Close	Transmission Circuit	646281	646363		1	

Category	Fault Type	Bus Name	Voltage (kV)	Bus Number	R	X	Units	Run For Cycles/ Set Scale (MW, Max, Min)	Action	Element	From Bus	To Bus	Tertiary Bus	Circuit ID	Clear Fault
P6_1_1									Prior Outage	Transmission Circuit	646362	646363		2	
	3PH	S1363 5	161.00	646363				6	Open	Transmission Circuit	646281	646363		1	Yes
								600							
	SLG	S1281 5	161.00	646281	972	-8495	MVA	8.5							Yes
P6_1_1									Prior Outage	Transmission Circuit	646362	646363		2	
	3PH	S1363 5	161.00	646363				6	Open	Transmission Circuit	646281	646363		1	Yes
								620	Close	Transmission Circuit	646281	646363		1	