INTERCONNECTION FACILITIES STUDY REPORT

GEN-2020-043

Published September 2022

By SPP Generator Interconnections Dept.

REVISION HISTORY

DATE OR VERSION NUMBER	AUTHOR	CHANGE DESCRIPTION
09/07/2022	SPP	Initial draft report issued.

CONTENTS

SUMMARY

INTRODUCTION

This Interconnection Facilities Study (IFS) for Interconnection Request GEN-2020-043 is for a 56.52 MW generating facility located in Douglas County Nebraska. The Interconnection Request was studied in the Group 9 2020 Interim Impact Study for ERIS/NRIS. The Interconnection Customer's requested in-service date is May 31, 2023.

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 one (1) 56.52 MW gas fired reciprocating engine for a total generating nameplate capacity of 56.52 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:

- 13.8 kV underground cable collection circuits;
- 13.8 kV to 161 kV transformation substation with associated 13.8 kV and 161 kV switchgear;
- One (1) 161/20 kV 60/80/100 MVA (ONAN/ONAF/ONAF) step-up transformer to be owned and maintained by the Interconnection Customer at the Interconnection Customer's substation;
- An overhead 161kV line to connect the Interconnection Customer's substation to the Point of Interconnection ("POI") at the 161 kV bus at existing Transmission Owner substation ("S1347") 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** lists 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 ($)	Allocated Percent (%)	Allocated Cost Estimate ($)	Estimated Lead Time
S1347 161kV GEN-2020-043 Interconnection (TOIF) (156388): Install a double breaker bay at substation S1347.	$2,292,537	100%	$2,292,537	10 Months
Total	**$2,292,537**		**$2,292,537**	

Table 2: Non-Shared Network Upgrade(s)

Non-Shared Network Upgrades Description	ILTCR	Total Cost Estimate ($)	Allocated Percent (%)	Allocated Cost Estimate ($)	Estimated Lead Time
None	N/A	$0	N/A	$0	N/A
Total		**$0**		**$0**	

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 ($)	Allocated Percent (%)	Allocated Cost Estimate ($)	Estimated Lead Time
S1347 161kV Interconnection Expansion (156393): • S1209-S1347 161kV line Reroute • S1252-S1347 161kV line Reroute • S1347 161kV Switchyard	TBD	$27,418,650	33.33%	$9,139,550	10 Months
Total		**$27,418,650**		**$9,139,550**	

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
None	$0	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 ($)	Allocated Percent (%)	Allocated Cost Estimate ($)
None	$0	N/A	$0
Total	$0		$0

CONCLUSION

After all Interconnection Facilities and Network Upgrades have been placed into service, Interim Interconnection Service for 56.52 MW can be granted. Interim Interconnection Service will be delayed until the TOIF, Non-Shared NU, Shared NU, Contingent NU, Affected System Upgrades that are required for interconnection service are completed. The Interconnection Customer's estimated cost responsibility for Interim interconnection service is summarized in the table below.

Table 6: Cost Summary

Description	Allocated Cost Estimate
Transmission Owner Interconnection Facilitie Upgrade(s)	$2,292,537
Non-Shared Network Upgrade(s)	$0
Shared Network Upgrade(s)	$9,139,550
Affected System Upgrade(s)	$0
Total	**$11,432,087**

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).

your energy partner®

OPPD

Omaha Public Power District

Interconnection Facilities Study

Omaha Public Power District

Rev 0 – August 26, 2022

Executive Summary

This study evaluates the interconnection of two 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".

Turtle Creek Station (TCS) consists of two 255MW combustion turbines (GEN-2020-025 and GEN-2020-028). This new station will interconnect to a new 161kV switchyard named S1363. This new switchyard will network to existing OPPD switchyards S1362 and S1280.

Standing Bear Lake Station (SBLS) consists of nine 18.84MW reciprocating engines grouped in blocks of three (GEN-2020-043, -044 and -045) (i.e. 56.52MW per request). This new station will interconnect to a new 161kV switchyard named S1347. This new switchyard will network to existing OPPD substation S1209 and switchyard S1252.

Both stations are expected to be in-service by 2024. However, this study will include evaluation of 2023 models due to the deferral of North Omaha Station retirements and natural gas conversions approved by the OPPD Board of Directors in August of 2022. These retirements and conversions are currently implemented in the 2024 and later models; by including 2023 models the combined impact from the deferral and new generation will be captured.

In addition, this study also evaluates the impact of several network upgrades that OPPD has planned to enhance the resiliency of the transmission system in regards to transferring power from these new units during certain system events. The network upgrades consist of:

a. A second new 161kv line S1362-S1363
b. A rebuild of 161kv line S1281-S1254
c. A rebuild of 161kV line S1201-S1206
d. New 161kV line S1281-S1361
e. Uprate S1209-S1347
f. Uprate S1252-S1347
g. Tap existing 161kV line S1236-S1345 into substation S1252 to create two "new" circuits.
    i. S1236-S1252
    ii. S1345-S1252

The results of the study indicate that in order to support full generation output of GEN-2020-025 and -028, that 161kV line S1254-S1281 line must be uprated. As mentioned above, this is already a planned upgrade for the project.

In addition, the study shows that the network upgrades identified above do not introduce any adverse impacts to the transmission system.

Contents

SECTION 1: POWER FLOW

Models

Southwest Power Pool (SPP) Integrated Transmission Planning (ITP) 2022 Base Reliability (BR) models. This will include the 1, 5 and 10 year light, summer peak and winter peak models.

Base Model Changes

The Platteview solar installation is an 81MW generation source located at OPPD's 69kV switchyard S6846. This installation has been granted interim service and therefore will be added to the base model.

Generation Dispatch

Two dispatch scenarios will be studied for steady state.

1. The new generation will be sunk to the OPPD service area by reducing the existing OPPD generation by an equivalent MW amount. Units will be reduced in an economic dispatch order .
2. The new generation will be sunk external to OPPD by simply allowing the excess generation to export to the entire interchange via swing machine reduction.

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.

Scenarios

The following interconnection scenarios will be evaluated for steady state using Siemens PSSE.

1. The new generation stations will be interconnected with minimal new infrastructure. This scenario closely replicates what is being studied in the SPP generation interconnection studies. This scenario will identify the minimum TPL/FAC required upgrades to support interconnection.
    a. Turtle Creek Station (S1363) will interconnect by tapping into the existing S1281-S1362 161kV line resulting in two "new" 161kV circuits.
        i. S1281-S1363 (558MVA)
        ii. S1362-S1363 (558MVA)
    b. Standing Bear Lake Station (S1347) will interconnect by tapping into the existing S1209-S1252 161kV line resulting in two "new" 161kV circuits.
        i. S1209-S1347
        ii. S1252-S1347
2. The generation stations will be interconnected the same as scenario 1; however, additional system upgrades will also be implemented to improve system reliability and resiliency. These upgrades were previously identified in OPPD sensitivity studies, but are being formally studied here. See Appendix 1 for a local area transmission interconnection map of GEN-2020-025/-028.
    a. A second new 161kv line S1362-S1363 (558MVA)
    b. A rebuild of 161kv line S1281-S1254 (558MVA)
    c. A rebuild of 161kV line S1201-S1206 (377MVA)
    d. New 161kV line S1281-S1361 (558MVA)
    e. Uprate S1209-S1347 (377MVA)
    f. Uprate S1252-S1347 (377MVA)
    g. Tap existing 161kV line S1236-S1345 in to substation S1252 to create two "new" circuits.
        i. S1236-S1252
        ii. S1345-S1252

N-1 & Multiple Element Contingency Results

Steady State without Upgrades (Scenario 1)

There is one thermal overload identified for the addition of the new generation. This overload is associated with the addition of GEN-2020-025 and/or -028.

- S1281-S1254 Ckt 1 (161kV) overloads for a loss of S1363-S1362 Ckt 1.
    - This results in a worst case loading of 149.5% in the 23L model.
    - This results in a worst case TDF of 82.9% in the 23L model.
    - The TDF is greater than 20% in all models.

There are no voltage issues for the addition of GEN-2020-025 or -028.

There are no thermal or voltage issues for the addition of GEN-2020-043, -044 or -045.

Steady State with Upgrades (Scenario 2)

There are no thermal or voltage violations with all previously planned upgrades implemented.

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

The Platteview solar installation is an 81MW generation source located at OPPD's 69kV switchyard S6846. This installation has been granted interim service and therefore will be added to the base model.

The base stability models already included these generation interconnection requests (GEN-2020-025, GEN-2020-028, GEN-2020-043, GEN-2020-044 and GEN-2020-045) along with some of the proposed transmission upgrades described in the Section 1: Power Flow, Scenario 2 model that are intended to support these generation interconnection requests. These upgrades were removed from the base model using the following changes:

- Remove S1363-S1362 161kV Ckt 2
- Remove S1345-S1252 161kV Ckt 1
- Remove S1236-S1252 161kV Ckt 1
- Add S1236-S1345 161kV Ckt 1
- Remove S1281-S1361 Ckt1
- Add S1281-S1362 Ckt 1

This results in the models matching the base steady state power flow models used for Scenario 1.

Generation Dispatch

For stability, the generation will be sunk to only the swing machine (i.e. Steady State Dispatch Scenario 2) in order to preserve the base case stability. This will still provide a case where all generation is interacting to events (i.e. summer peak), and another case where conventional and nearby generation is minimized (i.e. light load).

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 3 for a list of event.

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 – 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:

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

$$\text{SPPR1} = \frac{\text{Peak Rotor Angle of 1st Positive Peak minus Minimum Value}}{\text{Peak Rotor Angle of 1st Positive Peak minus Minimum Value}} \leq 0.774$$

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

- 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:

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

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

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.

Stability Modeling

Stability data was obtained from the SPP supplied PSSE dyr file for the new generation requests. For the Platteview solar addition, it was obtained from the previously performed IGIA IFS.

Scenarios

The following interconnection scenarios will be evaluated for stability.

1. The new generation stations will be interconnected with minimal new infrastructure. This scenario closely replicates what is being studied in the SPP generation interconnection studies. This scenario will identify the minimum TPL/FAC required upgrades to support interconnection.
    a. Turtle Creek Station (S1363) will interconnect by tapping into the existing S1281-S1362 161kV line resulting in two "new" 161kV circuits.
        i. S1281-S1363 (558MVA)
        ii. S1362-S1363 (558MVA)
    b. Standing Bear Lake Station (S1347) will interconnect by tapping into the existing S1209-S1252 161kV line resulting in two "new" 161kV circuits.
        i. S1209-S1347
        ii. S1252-S1347
2. The generation stations will be interconnected the same as scenario 1; however, additional system upgrades will also be implemented to improve system reliability and resiliency. These upgrades were previously identified in OPPD sensitivity studies, but are being formally studied here. See Appendix 1 for a local area transmission interconnection map of GEN-2020-025/-028.
    a. A second new 161kv line S1362-S1363 (558MVA)
    b. A rebuild of 161kv line S1281-S1254 (558MVA)
    c. A rebuild of 161kV line S1201-S1206 (377MVA)
    d. New 161kV line S1281-S1361 (558MVA)
    e. Uprate S1209-S1347 (377MVA)
    f. Uprate S1252-S1347 (377MVA)
    g. Tap existing 161kV line S1236-S1345 in to substation S1252 to create two "new" circuits.
        i. S1236-S1252
        ii. S1345-S1252

Stability Results

Stability without Upgrades (Scenario 1)

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.
- Low voltage ride thru issues on the North Omaha Units 2 and 3 auxiliary transformers may cause the units to trip during an Extreme Event at 345kV substation S3451. No cascading occurs because of this; therefore, no other mitigation is required.

Stability with Upgrades (Scenario 2)

The addition of the previously planned upgrades does not have a significant impact on the stability results.

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) 2022 Short Circuit (BR) models. This will include the 2, 5 and 10 year summer peak max fault models.

Base Model Changes

The Platteview solar installation is an 81MW generation source located at OPPD's 69kV switchyard S6846. This installation has been granted interim service and therefore will be added to the base model.

Generation Dispatch

All generation will be placed in service in order 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.

Scenarios

Steady State Scenario 1 will not be run for short circuit because Scenario 2 will produce the maximum fault values due to maximized flow paths for fault current.

2. The generation stations will be interconnected the same as scenario 1; however, additional system upgrades will also be implemented to improve system reliability and resiliency. These upgrades were previously identified in OPPD sensitivity studies, but are being formally studied here. See Appendix 1 for a local area transmission interconnection map of GEN-2020-025/-028.
    a. A second new 161kv line S1362-S1363 (558MVA)
    b. A rebuild of 161kv line S1281-S1254 (558MVA)
    c. A rebuild of 161kV line S1201-S1206 (377MVA)
    d. New 161kV line S1281-S1361 (558MVA)
    e. Uprate S1209-S1347 (377MVA)
    f. Uprate S1252-S1347 (377MVA)
    g. Tap existing 161kV line S1236-S1345 in to substation S1252 to create two "new" circuits.
        i. S1236-S1252
        ii. S1345-S1252

Short Circuit Results

No circuit breaker fault duty ratings are exceed with the interconnection of the generating facilities. Fault current results are listed in Appendix 2.

SECTION 4: MITIGATIONS

This section analyzes the impacts of different facility improvements needed to mitigate the issues on the Transmission System caused by adding the new generating facility.

Impact of Facility Improvements

The process of identifying improvements to the Transmission System began with a focus on upgrades to the existing facilities in lieu of constructing new facilities.

The following issues required mitigation:

OVERLOADED FACILITY		MITIGATION
FROM BUS	TO BUS	
S1281	S1254	Rebuild the circuit to 558MVA

As mentioned in the study scenario sections, OPPD is already planning this rebuild of S1281-S1254 161kV line to support the interconnection and delivery of these units, and this rebuild was included and evaluated as part of the Scenario 2 upgrade package in each of the aforementioned power flow, stability and short circuit assessments. Therefore, the operating limits determined by SPP in their Interim Interconnection study for GEN-2020-025 and -028 will be resolved and can be removed prior to the units being placed in service.

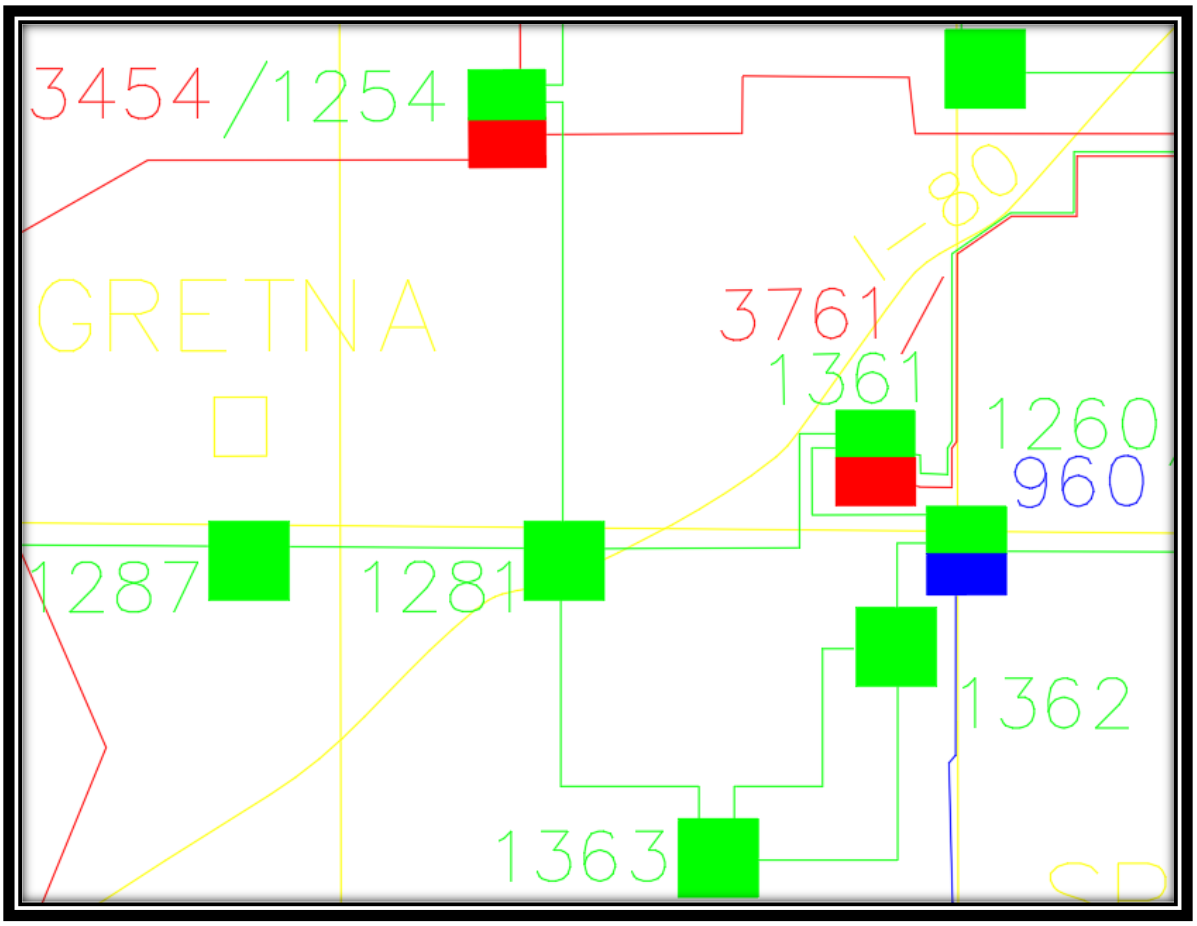
SECTION 5: Detailed Cost Estimates and Schedule

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. The cost estimates for the interconnection and network upgrades are below:

SCERT	Title	Scope	Estimate	In-Service Date
156388	S1363 161kV GEN-2020-025 Interconnection	Double Breaker Bay	$2,292,537	8/7/2023
156389	S1363 161kV GEN-2020-028 Interconnection	Double Breaker Bay	$2,292,537	8/7/2023
156390	S1209 - S1252 161kV GEN-2020-043 Interconnection	Double Breaker Bay	$2,292,537	8/7/2023
156391	S1209 - S1252 161kV GEN-2020-044 Interconnection	Double Breaker Bay	$2,292,537	8/7/2023
156392	S1209 - S1252 161kV GEN-2020-045 Interconnection	Double Breaker Bay	$2,292,537	8/7/2023
156393	S1363 161kV Interconnection Expansion	• S1281-S1363 161kV line Reroute • S1362-S1363 161kV line Reroute • S1363 161kV Switchyard	$41,063,166	8/7/2023
156394	S1209 - S1252 161kV Line Tap (S1347)	• S1209-S1347 161kV line Reroute • S1252-S1347 161kV line Reroute • S1347 161kV Switchyard	$27,418,650	8/7/2023
N/A	S1254-S1281 Rebuild	Circuit rebuild to 558MVA	N/A*	8/7/2023

*An estimate is not being provided due to this network upgrade not being assigned out of the SPP Interim Generation Interconnection process.

Appendix 1 – GEN-2020-025 and GEN-2020-028 Interconnection Map



Appendix 2 – Short Circuit Results

Sub	Breaker	Base kV	Final Interupt Rating (kA)	Final Fault Current (kA)	Duty
900	CB 1	69	23.00	8.44	37%
900	CB 2	69	23.00	8.44	37%
900	CB 3	69	23.00	8.44	37%
900	CB 5	69	23.00	8.44	37%
900	CB 6	69	23.00	8.44	37%
901	Cicuit 613 (CB-1)	69	40.00	30.29	76%
901	Circuit 605 (CB-2)	69	40.00	30.29	76%
901	Circuit 601 GT 2 (CB-3)	69	40.00	30.29	76%
901	Circuit 603 (CB-5)	69	40.00	30.29	76%
901	Circuit 615 GT 1 (CB-4)	69	40.00	30.29	76%
902	CB 1	69	23.00	9.56	42%
902	CB 2	69	23.00	9.56	42%
902	CB 3	69	23.00	9.56	42%
904	CB-1	69	40.00	9.14	23%
906	BT-61	69	50.00	35.08	70%
906	BT-62	69	50.00	35.08	70%
906	BT-63	69	50.00	35.08	70%
906	CB-621	69	50.00	35.08	70%
906	CB-623	69	50.00	35.08	70%
906	CB-624	69	50.00	35.08	70%
906	CB-625	69	50.00	35.08	70%
906	CB-626	69	50.00	35.08	70%
906	CB-628	69	50.00	35.08	70%
906	CB-629	69	50.00	35.08	70%
906	CB-631	69	50.00	35.08	70%
906	CB-632	69	50.00	35.08	70%
906	CB-633	69	50.00	35.08	70%
906	CB-634	69	50.00	35.08	70%
906	CB-635	69	50.00	35.08	70%
906	CB-636	69	50.00	35.08	70%
906	CB-637	69	50.00	35.08	70%
906	CB-658	69	50.00	35.08	70%
907	CB-1	69	40.00	20.38	51%
908	CB-1	69	35.59	19.55	55%
908	CB-2	69	35.59	19.55	55%
909	CB-648	69	50.00	28.70	57%
909	CB-649	69	50.00	28.70	57%
909	CB-651	69	40.00	28.70	72%
909	CB-652	69	50.00	28.70	57%
909	CB-653	69	50.00	28.70	57%
910	647	69	35.59	27.23	77%
910	613 B	69	35.59	27.23	77%

Sub	Breaker	Base kV	Final Interupt Rating (kA)	Final Fault Current (kA)	Duty
910	646 B	69	35.59	27.23	77%
911	CB-661	69	40.00	29.51	74%
911	CB-662	69	40.00	29.51	74%
911	CB-664	69	50.00	29.51	59%
911	CB-665	69	40.00	29.51	74%
911	CB-668	69	40.00	29.51	74%
912	CB-1	69	40.00	23.23	58%
912	CB-2	69	40.00	23.23	58%
912	CB-3	69	40.00	23.23	58%
913	CB-1	69	40.00	17.64	44%
913	CB-2	69	40.00	17.64	44%
914	CB-1	69	40.00	8.05	20%
916	CB 636	69	40.00	24.34	61%
916	CB 680	69	40.00	24.34	61%
917	CB 1	69	40.00	27.18	68%
917	CB 3	69	40.00	27.18	68%
917	CB-2	69	40.00	27.18	68%
918	CB-651	69	40.00	23.71	59%
918	CB-661D	69	40.00	23.71	59%
918	CB-675B	69	40.00	23.71	59%
919	CB-1	69	40.00	22.91	57%
919	CB-2	69	40.00	22.91	57%
919	CB-3	69	40.00	22.91	57%
921	640	69	35.59	27.16	76%
921	653	69	35.59	27.16	76%
921	679	69	37.20	27.16	73%
921	680	69	35.59	27.16	76%
923	CB 3	69	40.00	19.58	49%
923	CB-1	69	23.00	19.58	85%
923	CB-2	69	23.00	19.58	85%
924	CB-1	69	40.00	25.06	63%
928	CB-1	69	40.00	17.72	44%
930	CB 1	69	40.00	22.43	56%
930	CB 2	69	40.00	22.43	56%
938	CB 2	69	31.50	22.42	71%
938	CB-1	69	40.00	22.42	56%
939	CB-1	69	40.00	20.81	52%
939	CB-2	69	40.00	20.81	52%
940	680	69	40.00	21.37	53%
940	680-B	69	40.00	21.37	53%
942	CB-1	69	40.00	16.59	41%
942	CB-2	69	40.00	16.59	41%
960	CB-20	69	40.00	8.38	21%

Sub	Breaker	Base kV	Final Interupt Rating (kA)	Final Fault Current (kA)	Duty
961	CB-1	69	40.00	5.17	13%
962	682	69	31.50	5.88	19%
962	694	69	31.50	5.88	19%
962	697	69	31.50	5.88	19%
963	683	69	40.00	11.98	30%
963	684	69	40.00	11.98	30%
963	689	69	40.00	11.98	30%
963	690	69	40.00	11.98	30%
968	CB-1	69	40.00	4.57	11%
968	CB-2	69	40.00	4.57	11%
970	CB-1	69	40.00	4.40	11%
971	687	69	40.00	4.88	12%
971	693	69	40.00	4.88	12%
971	694	69	40.00	4.88	12%
972	CB-1	69	50.00	4.51	9%
974	CB-602	69	40.00	5.70	14%
974	CB-604	69	40.00	5.70	14%
975	CB-21	69	40.00	8.81	22%
975	CB-22	69	40.00	8.81	22%
975	CB-23	69	23.00	8.81	38%
975	CB-24	69	40.00	8.81	22%
976	CB-1	69	50.00	13.32	27%
982	CB-1	69	40.00	4.05	10%
983	CB-1	69	40.00	7.87	20%
984	CB-1	69	40.00	8.31	21%
985	CB 2	69	23.00	8.60	37%
985	CB1	69	23.00	8.60	37%
991	CB-1	69	40.00	12.98	32%
991	CB-2	69	40.00	12.98	32%
1201	CB-1	161	63.00	35.03	56%
1201	CB-2	161	63.00	35.03	56%
1201	CB-3	161	63.00	35.03	56%
1201	CB-4	161	50.00	35.03	70%
1201	CB-5	161	63.00	35.03	56%
1201	CB-6	161	63.00	35.03	56%
1201	CB-7	161	50.00	35.03	70%
1201	CB-8	161	50.00	35.03	70%
1201	CB-9	161	63.00	35.03	56%
1206	CB-10	161	63.00	57.54	91%
1206	CB-11	161	63.00	57.54	91%
1206	CB-12	161	63.00	57.54	91%
1206	CB-13	161	63.00	57.54	91%
1206	CB-14	161	63.00	57.54	91%

Sub	Breaker	Base kV	Final Interupt Rating (kA)	Final Fault Current (kA)	Duty
1206	CB-15	161	63.00	57.54	91%
1206	CB-16	161	63.00	57.54	91%
1206	CB-17	161	63.00	57.54	91%
1206	CB-18	161	63.00	57.54	91%
1206	CB-19	161	63.00	57.54	91%
1206	CB-7	161	63.00	57.54	91%
1206	CB-8	161	63.00	57.54	91%
1206	CB-9	161	63.00	57.54	91%
1209	CB-21	161	63.00	51.77	82%
1209	CB-22	161	63.00	51.77	82%
1209	CB-23	161	63.00	51.77	82%
1209	CB-24	161	63.00	51.77	82%
1209	CB-25	161	63.00	51.77	82%
1209	CB-26	161	63.00	51.77	82%
1209	CB-27	161	63.00	51.77	82%
1209	CB-28	161	63.00	51.77	82%
1209	CB-30	161	63.00	51.77	82%
1209	CB-31	161	63.00	51.77	82%
1209	CB-32	161	63.00	51.77	82%
1210	CB-1	161	50.00	29.96	60%
1210	CB-2	161	50.00	29.96	60%
1210	CB-676	161	40.00	29.96	75%
1211	CB 13	161	45.83	43.46	95%
1211	CB 14	161	45.83	43.46	95%
1211	CB 16	161	45.83	43.46	95%
1211	CB 17	161	45.83	43.46	95%
1211	CB 19	161	63.00	43.46	69%
1211	CB 20	161	63.00	43.46	69%
1211	CB 22	161	45.83	43.46	95%
1211	CB 23	161	45.83	43.46	95%
1211	CB-15	161	50.00	43.46	87%
1211	CB-18	161	50.00	43.46	87%
1211	CB-21	161	50.00	43.46	87%
1211	CB-24	161	50.00	43.46	87%
1211	CB-31	161	50.00	43.46	87%
1211	CB-32	161	50.00	43.46	87%
1211	CB-33	161	50.00	43.46	87%
1211	CB-7	161	50.00	43.46	87%
1211	CB-8	161	50.00	43.46	87%
1211	CB-9	161	50.00	43.46	87%
1214	CB-1	69	40.00	12.51	31%
1214	CB-11	69	40.00	12.51	31%
1214	CB-12	69	40.00	12.51	31%

Sub	Breaker	Base kV	Final Interupt Rating (kA)	Final Fault Current (kA)	Duty
1214	CB-13	69	40.00	12.51	31%
1214	CB-14	161	40.00	12.79	32%
1214	CB-2	161	40.00	12.79	32%
1214	CB-3	161	40.00	12.79	32%
1216	CB-1	161	50.00	32.38	65%
1217	CB-11	161	50.00	35.41	71%
1217	CB-1579	161	50.00	35.41	71%
1217	CB-1580	161	50.00	35.41	71%
1217	CB-1619	161	50.00	35.41	71%
1220	CB-1	161	50.00	31.21	62%
1221	1541	161	40.00	36.75	92%
1221	CB-1550	161	63.00	36.75	58%
1222	CB 1	161	40.00	29.55	74%
1226	CB 1	161	50.00	26.03	52%
1226	CB 3	161	50.00	26.03	52%
1226	CB 4	161	50.00	26.03	52%
1226	CB 5	161	50.00	26.03	52%
1226	CB 6	161	50.00	26.03	52%
1226	CB 7	161	50.00	26.03	52%
1226	CB 8	161	50.00	26.03	52%
1226	CB 9	161	50.00	26.03	52%
1226	CB-2	161	63.00	26.03	41%
1227	CB-1	161	50.00	34.29	69%
1229	CB 1	161	45.83	31.18	68%
1231	CB 1	161	45.83	45.35	99%
1231	CB 2	161	45.83	45.35	99%
1231	CB 4	161	45.83	45.35	99%
1231	CB 6	161	45.83	45.35	99%
1231	CB-3	161	63.00	45.35	72%
1231	CB-7	161	50.00	45.35	91%
1231	CB-8	161	50.00	45.35	91%
1231	CB-9	161	50.00	45.35	91%
1232	CB-1	161	50.00	27.75	56%
1233	CB-1	161	50.00	29.99	60%
1234	CB-1	161	40.00	27.56	69%
1234	CB-2	161	50.00	27.56	55%
1235	CB-1	161	50.00	35.22	70%
1235	CB-2	161	50.00	35.22	70%
1235	CB-3	161	50.00	35.22	70%
1235	CB-4	161	50.00	35.22	70%
1236	CB 1	161	40.00	25.30	63%
1237	CB-1	161	50.00	22.63	45%
1237	CB-2	161	50.00	22.63	45%

Sub	Breaker	Base kV	Final Interupt Rating (kA)	Final Fault Current (kA)	Duty
1237	CB-3	161	50.00	22.63	45%
1244	CB-1	161	40.00	23.23	58%
1244	CB-2	161	50.00	23.23	46%
1249	CB 1	161	40.00	25.41	64%
1250	CB 2	69	50.00	23.84	48%
1250	CB 3	161	50.00	39.09	78%
1250	CB 4	161	50.00	39.09	78%
1250	CB 5	161	50.00	39.09	78%
1250	CB-1	161	63.00	39.09	62%
1250	CB-11	161	40.00	39.09	98%
1250	CB-6	161	63.00	39.09	62%
1251	CB-104	161	50.00	35.66	71%
1251	CB-105	161	50.00	35.66	71%
1251	CB-106	161	50.00	35.66	71%
1251	CB-107	161	50.00	35.66	71%
1251	CB-108	161	50.00	35.66	71%
1251	CB-109	161	50.00	35.66	71%
1251	CB-110	161	50.00	35.66	71%
1251	CB-111	161	50.00	35.66	71%
1251	CB-112	161	50.00	35.66	71%
1252	CB-1	161	40.00	31.17	78%
1253	CB-21	161	50.00	28.36	57%
1253	CB-22	161	40.00	28.36	71%
1253	CB-23	161	50.00	28.36	57%
1253	CB-25	161	63.00	28.36	45%
1254	CB-11	161	50.00	34.18	68%
1254	CB-12	161	50.00	34.18	68%
1254	CB-13	161	63.00	34.18	54%
1254	CB-14	161	63.00	34.18	54%
1254	CB-15	161	63.00	34.18	54%
1255	CB-21	161	63.00	52.12	83%
1255	CB-22	161	63.00	52.12	83%
1255	CB-23	161	63.00	52.12	83%
1255	CB-25	161	63.00	52.12	83%
1255	CB-26	161	63.00	52.12	83%
1255	CB-27	161	63.00	52.12	83%
1255	CB-28	161	63.00	52.12	83%
1255	CB-29	161	63.00	52.12	83%
1255	CB-30	161	63.00	52.12	83%
1255	CB-32	161	63.00	52.12	83%
1256	CB-1	161	50.00	23.18	46%
1258	CB-41	161	50.00	6.14	12%
1258	CB-42	161	50.00	6.14	12%

Sub	Breaker	Base kV	Final Interupt Rating (kA)	Final Fault Current (kA)	Duty
1258	CB-44	161	50.00	6.14	12%
1258	CB-45	161	50.00	6.14	12%
1258	CB-46	161	50.00	6.14	12%
1258	CB-48	161	50.00	6.14	12%
1258	CB-49	161	50.00	6.14	12%
1259	CB-1	161	63.00	38.96	62%
1259	CB-2	161	63.00	38.96	62%
1259	CB-3	161	63.00	38.96	62%
1259	CB-4	161	63.00	38.96	62%
1260	CB-1	161	40.00	39.20	98%
1260	CB-10	161	63.00	39.20	62%
1260	CB-11	161	63.00	39.20	62%
1260	CB-12	161	63.00	39.20	62%
1260	CB-13	161	63.00	39.20	62%
1260	CB-2	161	63.00	39.20	62%
1260	CB-3	161	63.00	39.20	62%
1260	CB-4	161	63.00	39.20	62%
1260	CB-5	161	63.00	39.20	62%
1260	CB-6	161	63.00	39.20	62%
1260	CB-7	161	63.00	39.20	62%
1260	CB-8	161	63.00	39.20	62%
1260	CB-9	161	63.00	39.20	62%
1263	CB-1	161	40.00	8.67	22%
1263	CB-11	161	40.00	8.67	22%
1263	CB-12	161	40.00	8.67	22%
1263	CB-2	161	40.00	8.67	22%
1263	CB-3	161	40.00	8.67	22%
1278	CB-1	161	50.00	28.10	56%
1280	CB-1	161	50.00	10.83	22%
1280	CB-2	161	50.00	10.83	22%
1280	CB-3	161	50.00	10.83	22%
1281	CB 1	161	40.00	35.41	89%
1281	CB 2	161	40.00	35.41	89%
1286	CB-1	161	40.00	29.00	73%
1287	CB-1	161	63.00	22.00	35%
1291	CB-21	161	40.00	7.26	18%
1298	CB-1	161	40.00	31.33	78%
1298	CB-2	161	50.00	31.33	63%
1298	CB-3	161	50.00	31.33	63%
1298	CB-4	161	50.00	31.33	63%
1299	CB-1	161	50.00	30.74	61%
1305	CB-1	161	50.00	29.63	59%
1305	CB-2	161	50.00	29.63	59%

Sub	Breaker	Base kV	Final Interupt Rating (kA)	Final Fault Current (kA)	Duty
1341	CB-1	161	50.00	28.79	58%
1345	CB-1	161	50.00	23.46	47%
1361	CB-23	161	63.00	41.98	67%
1361	CB-24	161	63.00	41.98	67%
1361	CB-25	161	63.00	41.98	67%
1361	CB-27	161	63.00	41.98	67%
1361	CB-28	161	63.00	41.98	67%
1361	CB-30	161	63.00	41.98	67%
1361	CB-31	161	63.00	41.98	67%
1361	CB-32	161	63.00	41.98	67%
1361	CB-33	161	63.00	41.98	67%
1361	CB-34	161	63.00	41.98	67%
1361	CB-35	161	63.00	41.98	67%
1361	CB-36	161	63.00	41.98	67%
1361	CB-37	161	63.00	41.98	67%
1361	CB-38	161	63.00	41.98	67%
1361	CB-39	161	63.00	41.98	67%
1361	CB-40	161	63.00	41.98	67%
1361	CB-41	161	63.00	41.98	67%
1361	CB-42	161	63.00	41.98	67%
1362	All	161	63.00	34.42	55%
1366	CB-1	161	40.00	16.97	42%
1366	CB-2	161	40.00	16.97	42%
1367	CB-1	161	40.00	22.35	56%
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%
3451	CB 1 A PHASE	345	40.00	24.94	62%
3451	CB 1 B PHASE	345	40.00	24.94	62%
3451	CB 1 C PHASE	345	40.00	24.94	62%
3451	CB 10 A PHASE	345	40.00	24.94	62%
3451	CB 10 B PHASE	345	40.00	24.94	62%
3451	CB 10 C PHASE	345	40.00	24.94	62%
3451	CB 11 A PHASE	345	40.00	24.94	62%
3451	CB 11 B PHASE	345	40.00	24.94	62%
3451	CB 11 C PHASE	345	40.00	24.94	62%
3451	CB 12 A PHASE	345	40.00	24.94	62%
3451	CB 12 B PHASE	345	40.00	24.94	62%
3451	CB 12 C PHASE	345	40.00	24.94	62%
3451	CB 2 A PHASE	345	40.00	24.94	62%
3451	CB 2 B PHASE	345	40.00	24.94	62%
3451	CB 2 C PHASE	345	40.00	24.94	62%
3451	CB 3 A PHASE	345	40.00	24.94	62%

Sub	Breaker	Base kV	Final Interupt Rating (kA)	Final Fault Current (kA)	Duty
3451	CB 3 B PHASE	345	40.00	24.94	62%
3451	CB 3 C PHASE	345	40.00	24.94	62%
3451	CB 4 A PHASE	345	40.00	24.94	62%
3451	CB 4 B PHASE	345	40.00	24.94	62%
3451	CB 4 C PHASE	345	40.00	24.94	62%
3451	CB 5 A PHASE	345	40.00	24.94	62%
3451	CB 5 B PHASE	345	40.00	24.94	62%
3451	CB 5 C PHASE	345	40.00	24.94	62%
3451	CB 6 A PHASE	345	40.00	24.94	62%
3451	CB 6 B PHASE	345	40.00	24.94	62%
3451	CB 6 C PHASE	345	40.00	24.94	62%
3454	CB 1 A PHASE	345	40.00	28.47	71%
3454	CB 1 B PHASE	345	40.00	28.47	71%
3454	CB 1 C PHASE	345	40.00	28.47	71%
3454	CB 2 A PHASE	345	40.00	28.47	71%
3454	CB 2 B PHASE	345	40.00	28.47	71%
3454	CB 2 C PHASE	345	40.00	28.47	71%
3454	CB 3 A Phase	345	40.00	28.47	71%
3454	CB 3 B Phase	345	40.00	28.47	71%
3454	CB 3 C Phase	345	40.00	28.47	71%
3454	CB 6 A PHASE	345	40.00	28.47	71%
3454	CB 6 B PHASE	345	40.00	28.47	71%
3454	CB 6 C PHASE	345	40.00	28.47	71%
3455	CB 1 A Phase	345	40.00	33.85	85%
3455	CB 1 B Phase	345	40.00	33.85	85%
3455	CB 1 C Phase	345	40.00	33.85	85%
3455	CB 10 A Phase	345	40.00	33.85	85%
3455	CB 10 B Phase	345	40.00	33.85	85%
3455	CB 10 C Phase	345	40.00	33.85	85%
3455	CB 11 A Phase	345	40.00	33.85	85%
3455	CB 11 B Phase	345	40.00	33.85	85%
3455	CB 11 C Phase	345	40.00	33.85	85%
3455	CB 12 A Phase	345	40.00	33.85	85%
3455	CB 12 B Phase	345	40.00	33.85	85%
3455	CB 12 C Phase	345	40.00	33.85	85%
3455	CB 2 A Phase	345	50.00	33.85	68%
3455	CB 2 B Phase	345	50.00	33.85	68%
3455	CB 2 C Phase	345	50.00	33.85	68%
3455	CB 3 A Phase	345	50.00	33.85	68%
3455	CB 3 B Phase	345	50.00	33.85	68%
3455	CB 3 C Phase	345	50.00	33.85	68%
3455	CB 5	345	50.00	33.85	68%
3455	CB 6 A Phase	345	50.00	33.85	68%

Sub	Breaker	Base kV	Final Interupt Rating (kA)	Final Fault Current (kA)	Duty
3455	CB 6 B Phase	345	50.00	33.85	68%
3455	CB 6 C Phase	345	50.00	33.85	68%
3455	CB-7 A Phase	345	63.00	33.85	54%
3455	CB-7 B Phase	345	63.00	33.85	54%
3455	CB-7 C Phase	345	63.00	33.85	54%
3455	CB-9 A Phase	345	63.00	33.85	54%
3455	CB-9 B Phase	345	63.00	33.85	54%
3455	CB-9 C Phase	345	63.00	33.85	54%
3456	CB 1 A Phase	345	50.00	38.09	76%
3456	CB 1 B Phase	345	50.00	38.09	76%
3456	CB 1 C Phase	345	50.00	38.09	76%
3456	CB 2 A Phase	345	50.00	38.09	76%
3456	CB 2 B Phase	345	50.00	38.09	76%
3456	CB 2 C Phase	345	50.00	38.09	76%
3456	CB 3 A Phase	345	50.00	38.09	76%
3456	CB 3 B Phase	345	50.00	38.09	76%
3456	CB 3 C Phase	345	50.00	38.09	76%
3456	CB 4 A Phase	345	50.00	38.09	76%
3456	CB 4 B Phase	345	50.00	38.09	76%
3456	CB 4 C Phase	345	50.00	38.09	76%
3456	CB 5 A Phase	345	50.00	38.09	76%
3456	CB 5 B Phase	345	50.00	38.09	76%
3456	CB 5 C Phase	345	50.00	38.09	76%
3456	CB 6 A Phase	345	50.00	38.09	76%
3456	CB 6 B Phase	345	50.00	38.09	76%
3456	CB 6 C Phase	345	50.00	38.09	76%
3458	CB 1 A Phase	345	50.00	33.24	66%
3458	CB 1 B Phase	345	50.00	33.24	66%
3458	CB 1 C Phase	345	50.00	33.24	66%
3458	CB 10 A Phase	345	50.00	33.24	66%
3458	CB 10 B Phase	345	50.00	33.24	66%
3458	CB 10 C Phase	345	50.00	33.24	66%
3458	CB 12 A Phase	345	50.00	33.24	66%
3458	CB 12 B Phase	345	50.00	33.24	66%
3458	CB 12 C Phase	345	50.00	33.24	66%
3458	CB 16 A Phase	345	50.00	33.24	66%
3458	CB 16 B Phase	345	50.00	33.24	66%
3458	CB 16 C Phase	345	50.00	33.24	66%
3458	CB 18 A Phase	345	50.00	33.24	66%
3458	CB 18 B Phase	345	50.00	33.24	66%
3458	CB 18 C Phase	345	50.00	33.24	66%
3458	CB 23 A Phase	345	50.00	33.24	66%
3458	CB 23 B Phase	345	50.00	33.24	66%

Sub	Breaker	Base kV	Final Interupt Rating (kA)	Final Fault Current (kA)	Duty
3458	CB 23 C Phase	345	50.00	33.24	66%
3458	CB 24 A Phase	345	50.00	33.24	66%
3458	CB 24 B Phase	345	50.00	33.24	66%
3458	CB 24 C Phase	345	50.00	33.24	66%
3458	CB 25 A Phase	345	50.00	33.24	66%
3458	CB 25 B Phase	345	50.00	33.24	66%
3458	CB 25 C Phase	345	50.00	33.24	66%
3458	CB-19 - A PHASE, POLE 1	345	50.00	33.24	66%
3458	CB-19 - B PHASE, POLE 2	345	50.00	33.24	66%
3458	CB-19 - C PHASE, POLE 3	345	50.00	33.24	66%
3458	CB-21 - A PHASE, POLE 1	345	50.00	33.24	66%
3458	CB-21 - B PHASE, POLE 2	345	50.00	33.24	66%
3458	CB-21 - C PHASE, POLE 3	345	50.00	33.24	66%
3458	CB-27 - A PHASE, POLE 1	345	50.00	33.24	66%
3458	CB-27 - B PHASE, POLE 2	345	50.00	33.24	66%
3458	CB-27 - C PHASE, POLE 3	345	50.00	33.24	66%
3458	CB-3 - A PHASE, POLE 1	345	50.00	33.24	66%
3458	CB-3 - B PHASE, POLE 2	345	50.00	33.24	66%
3458	CB-3 - C PHASE, POLE 3	345	50.00	33.24	66%
3458	CB-4 - A PHASE, POLE 1	345	50.00	33.24	66%
3458	CB-4 - B PHASE, POLE 2	345	50.00	33.24	66%
3458	CB-4 - C PHASE, POLE 3	345	50.00	33.24	66%
3458	CB-6 - A PHASE, POLE 1	345	50.00	33.24	66%
3458	CB-6 - B PHASE, POLE 2	345	50.00	33.24	66%
3458	CB-6 - C PHASE, POLE 3	345	50.00	33.24	66%
3459	CB 1 A Phase	345	50.00	27.51	55%
3459	CB 1 B Phase	345	50.00	27.51	55%
3459	CB 1 C Phase	345	50.00	27.51	55%
3459	CB 2 A Phase	345	50.00	27.51	55%
3459	CB 2 B Phase	345	50.00	27.51	55%
3459	CB 2 C Phase	345	50.00	27.51	55%
3459	CB 3 A Phase	345	50.00	27.51	55%
3459	CB 3 B Phase	345	50.00	27.51	55%
3459	CB 3 C Phase	345	50.00	27.51	55%
3459	CB 4 A Phase	345	50.00	27.51	55%
3459	CB 4 B Phase	345	50.00	27.51	55%
3459	CB 4 C Phase	345	50.00	27.51	55%
3459	CB 5 A Phase	345	50.00	27.51	55%
3459	CB 5 B Phase	345	50.00	27.51	55%
3459	CB 5 C Phase	345	50.00	27.51	55%
3459	CB 6 A Phase	345	50.00	27.51	55%
3459	CB 6 B Phase	345	50.00	27.51	55%
3459	CB 6 C Phase	345	50.00	27.51	55%

Sub	Breaker	Base kV	Final Interupt Rating (kA)	Final Fault Current (kA)	Duty
3740	CB 2 A Phase	345	50.00	20.09	40%
3740	CB 2 B Phase	345	50.00	20.09	40%
3740	CB 2 C Phase	345	50.00	20.09	40%
3740	CB 3 A Phase	345	50.00	20.09	40%
3740	CB 3 B Phase	345	50.00	20.09	40%
3740	CB 3 C Phase	345	50.00	20.09	40%
3740	CB 4 A Phase	345	50.00	20.09	40%
3740	CB 4 B Phase	345	50.00	20.09	40%
3740	CB 4 C Phase	345	50.00	20.09	40%
3740	CB 5 A Phase	345	50.00	20.09	40%
3740	CB 5 B Phase	345	50.00	20.09	40%
3740	CB 5 C Phase	345	50.00	20.09	40%
3740	CB 6 A Phase	345	50.00	20.09	40%
3740	CB 6 B Phase	345	50.00	20.09	40%
3740	CB 6 C Phase	345	50.00	20.09	40%
3740	CB 7 A Phase	345	50.00	20.09	40%
3740	CB 7 B Phase	345	50.00	20.09	40%
3740	CB 7 C Phase	345	50.00	20.09	40%
3740	CB 8 A Phase	345	50.00	20.09	40%
3740	CB 8 B Phase	345	50.00	20.09	40%
3740	CB 8 C Phase	345	50.00	20.09	40%
3761	CB-2 A Phase	345	63.00	23.88	38%
3761	CB-2 B Phase	345	63.00	23.88	38%
3761	CB-2 C Phase	345	63.00	23.88	38%
6815	CB-1	69	40.00	12.80	32%
6815	CB-2	69	40.00	12.80	32%
6846	CB-1	69	40.00	8.31	21%
6866	CB-11	69	40.00	21.34	53%
6866	CB-12	69	40.00	21.34	53%
6874	CB-1	69	29.85	8.54	29%
6874	CB-2	69	29.85	8.54	29%
NCU 903	CB 683	69	40.00	6.40	16%
NCU 903	CB 697	69	40.00	6.40	16%

Appendix 3 – Stability Events

Previous Event ID	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	Description
1	P1_2	3PH	S3458 3	345.00	645458				5	Open	Transmission Circuit	645458	640139		1	Yes	3-PH fault at S3458 on S3458-Cooper. Normal clearing.
2	P1_2	3PH	S3740 3	345.00	645740				5	Open	Transmission Circuit	645455	645740		1	Yes	3-PH fault at S3740 on S3455-S3740. Normal clearing with unsuccessful reclosing.
									600								
		SLG	S3455 3	345.00	645455	932	-10192	MVA	7.5							Yes	
3	P1_2	3PH	S1206 5	161.00	646206				9	Open	Transmission Circuit	646206	646232		1	Yes	3-PH fault at S1206 on S1206-S1232. Normal clearing with unsuccessful reclosing.
									0	Open	Load	646232			O0		
									600								
		SLG	S1232 5	161.00	646232	1434	-9156	MVA	11.5							Yes	
4	P1_2	3PH	S1211 5	161.00	646211				6	Open	Transmission Circuit	646211	646220		1	Yes	3-PH fault at S1211 on S1211-S1220. Normal clearing with unsuccessful reclosing.
									0	Open	Load	646220			O0		
									600								
		SLG	S1220 5	161.00	646220	1162	-7458	MVA	8.5							Yes	
5	P1_2	3PH	S1211 5	161.00	646211				6	Open	Transmission Circuit	646211	646299		1	Yes	3-PH fault at S1211 on S1211-S1299. Normal clearing with

																	unsuccessful reclosing.
									0	Open	Load	646299			O0		
									600								
		SLG	S1299 5	161.00	646299	2872	-18493	MVA	8.5							Yes	
6	P1_2	3PH	S1211 5	161.00	646211				6	Open	Transmission Circuit	646211	646250		2	Yes	3-PH fault at S1211 on S1211-S1250 Cir 1520. Normal clearing with unsuccessful reclosing.
									0	Open	Load	646211			O0		
									600								
		SLG	S1250 5	161.00	646250	1454	-9334	MVA	8.5							Yes	
7	P1_3	3PH	S3451 3	345.00	645451				7.5	Open	Three Winding	645451	646251	648251	1	Yes	3-PH fault at S3451 on S3451 T3 transformer. Normal clearing.
8	P2_2	SCMU L-G	S1217 5	161.00	646217				8.5	Open	Trip Bus	646217				Yes	SLG Fault at S1217 on 161-kV bus. Normal clearing.
9	P3_2									Prior Outage	Generator	635024			4		Prior outage of Council Bluffs Unit 4. 3-PH fault at S3458 on S3458-S3456. Normal clearing with unsuccessful reclosing.
		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	
10	P3_2									Prior Outage	Generator	635024			4		Prior outage of Council Bluffs Unit 4. 3-PH fault at S3456 on S3458-S3456. Normal clearing with

																	unsuccessful reclosing.
		3PH	S3456 3	345.00	645456				5	Open	Transmission Circuit	645458	645456		1	Yes	
									600								
		3PH	S3456 3	345.00	645456				4.5							Yes	
11	P3_2									Prior Outage	Generator	635024			4		Prior outage of Council Bluffs Unit 4. 3-PH fault at S3451 on S3451-S3459. Normal clearing with unsuccessful reclosing.
		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	
12	P3_2									Prior Outage	Generator	635024			4		Prior outage of Council Bluffs Unit 4. 3-PH fault at S3451 on S3451-S3459. Normal clearing with successful reclosing.
		3PH	S3451 3	345.00	645451				5	Open	Transmission Circuit	645451	645459		1	Yes	
									20	Close	Transmission Circuit	645451	645459		1		
13	P3_2									Prior Outage	Generator	635024			4		Prior outage of Council Bluffs Unit 4. 3-PH fault at S3459 on S3451-S3459. Normal clearing with unsuccessful reclosing.
		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	
14	P3_2									Prior Outage	Generator	635024			4		Prior outage of Council Bluffs Unit 4. 3-PH fault at S3459 on S3451-S3459. Normal clearing with successful reclosing.
		3PH	S3459 3	345.00	645459				5	Open	Transmission Circuit	645451	645459		1	Yes	
									20	Close	Transmission Circuit	645451	645459		1		
15	P4_2	SCMU L-G	S3451 3	345.00	645451				5	Open	Transmission Circuit	645451	645551		Z1		SLG Fault at S3451 on S3451-Raun followed by a stuck breaker opening S3451 T4. Delayed clearing.
									0	Open	Transmission Circuit	645551	635200		1	Yes	
		SCMU L-G	S3451 3	345.00	645451				9.5	Open	Three Winding	645451	646251	648351	1	Yes	
16	P4_2	SCMU L-G	S3454 3	345.00	645454				5	Open	Transmission Circuit	645454	650185		1	Yes	SLG Fault at S3454 on S3454-Wagener followed by a stuck breaker opening S3454-S3455. Delayed clearing.
		SCMU L-G	S3454 3	345.00	645454				9	Open	Transmission Circuit	645454	645455		1	Yes	
17	P4_2	SCMU L-G	S3458 3	345.00	645458				5	Open	Transmission Circuit	645458	640139		1	Yes	SLG Fault at S3458 on S3458-Cooper followed by a stuck breaker opening the west bus.

																	Delayed clearing.
		SCMU L-G	S3458 3	345.00	645458				8.5							Yes	
18	P4_2	SCMU L-G	S3740 3	345.00	645740				5	Open	Transmission Circuit	645455	645740		1	Yes	SLG Fault at S3740 on S3455-S3740 followed by a stuck breaker opening the west bus. Delayed clearing.
		SCMU L-G	S3740 3	345.00	645740				8.5							Yes	
19	P4_2	SCMU L-G	S1206 5	161.00	646206				9	Open	Transmission Circuit	646206	646232		1	Yes	SLG Fault at S1206 on S1206-S1232 followed by a stuck breaker opening S1201-S1206. Delayed clearing.
									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		
22	P6_1_1									Prior Outage	Transmission Circuit	645455	645740		1		Prior outage of S3455-S3740. 3-PH fault at S3458 on S3458-Cooper. Normal clearing.
		3PH	S3458 3	345.00	645458				5	Open	Transmission Circuit	645458	640139		1	Yes	
23	P6_1_1									Prior Outage	Transmission Circuit	645458	650189		1		Prior outage of S3458-103rd&RFirst OKeby. 3-PH fault at S3458 on S3458-Cooper. Normal clearing.
		3PH	S3458 3	345.00	645458				5	Open	Transmission Circuit	645458	640139		1	Yes	
24	P6_1_1									Prior Outage	Transmission Circuit	645458	640139		1		Prior outage of S3458-

																	Cooper. 3-PH fault at S3740 on S3455-S3740. Normal clearing with unsuccessful reclosing.
		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	
25	P6_1_1									Prior Outage	Transmission Circuit	646211	646220		1		Prior outage of S1211-S1220. 3-PH fault at S1211 on S1211-S1299. Normal clearing with unsuccessful reclosing.
		3PH	S1211 5	161.00	646211				6	Open	Transmission Circuit	646211	646299		1	Yes	
									0	Open	Load	646299			O0		
									600								
		SLG	S1299 5	161.00	646299	2872	-18493	MVA	8.5							Yes	
26	P6_1_1									Prior Outage	Transmission Circuit	645454	645451		1		Prior outage of S3454-S3451. 3-PH fault at S3454 on S3454-S3455. Normal clearing with unsuccessful reclosing.
		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	
27	P6_1_1									Prior Outage	Transmission Circuit	645454	645451		1		Prior outage of S3454-S3451. 3-PH fault at S3454 on S3454-S3455. Normal

																	clearing with successful reclosing.
		3PH	S3454 3	345.00	645454				5	Open	Transmission Circuit	645454	645455		1	Yes	
									20	Close	Transmission Circuit	645454	645455		1		
28	P6_1_1									Prior Outage	Transmission Circuit	645454	645455		1		Prior outage of S3454-S3455. 3-PH fault at S3455 on S3455-S3456. Normal clearing with unsuccessful reclosing.
		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	
29	P6_1_1									Prior Outage	Transmission Circuit	645454	645455		1		Prior outage of S3454-S3455. 3-PH fault at S3455 on S3455-S3456. Normal clearing with successful reclosing.
		3PH	S3455 3	345.00	645455				5	Open	Transmission Circuit	645455	645456		1	Yes	
									20	Close	Transmission Circuit	645455	645456		1		
30	P6_1_1									Prior Outage	Transmission Circuit	640139	300039		1		Prior outage of Cooper-Fairport. 3-PH fault at Cooper on Cooper-St. Joe. Normal clearing.
		3PH	COOPER 3	345.00	640139				4.5	Open	Transmission Circuit	640139	541199		1	Yes	
31	P6_1_1									Prior Outage	Transmission Circuit	645458	650189		1		Prior outage of S3458-103rd&Rokeb

																	y. 3-PH fault at S3458 on S3458-S3456. Normal clearing with unsuccessful reclosing.
		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	
32	P6_1_2									Prior Outage	Transmission Circuit	645451	645551		Z1		Prior outage of S3451-Raun. 3-PH fault at S3451 on T3 transformer. Normal clearing.
										Prior Outage	Transmission Circuit	645551	635200		1		
		3PH	S3451 3	345.00	645451				7.5	Open	Three Winding	645451	646251	648251	1	Yes	
33	P6_2_1									Prior Outage	Three Winding	645456	646206	648256	1		Prior outage of S3456 T4. 3-PH fault at S1206 on S1201-S1206. Normal clearing with unsuccessful reclosing.
		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	
34	P7_1	SCMU L-L-G	S3451 3	345.00	645451				5	Open	Transmission Circuit	645451	645459		1	Yes	DLG Fault at S3451 on S3451-S3459 and S3451-S3454. Normal clearing with unsuccessful reclosing.
									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		
35	P7_1	SCMU L-L-G	S3451 3	345.00	645451				5	Open	Transmission Circuit	645451	645459		1	Yes	DLG Fault at S3451 on S3451-S3459 and S3451-S3454. Normal clearing with successful reclosing.
									0	Open	Transmission Circuit	645451	645454		1		
									20	Close	Transmission Circuit	645451	645459		1		
									0	Close	Transmission Circuit	645451	645454		1		
36	P7_1	SCMU L-L-G	S1211 5	161.00	646211				6	Open	Transmission Circuit	646211	646220		1	Yes	DLG Fault at S1211 on S1211-S1220 and S1211-S1299. Normal clearing with unsuccessful reclosing.
									0	Open	Transmission Circuit	646211	646299		1		
									0	Open	Load	646220			O0		
									0	Open	Load	646299			O0		
									600								
		SLG	S1220 5	161.00	646220	1162	-7458	MVA	0							No	
		SLG	S1299 5	161.00	646299	2872	-18493	MVA	8.5							Yes	
									0							Yes	
37	P7_1	SCMU L-L-G	S1211 5	161.00	646211				6	Open	Transmission Circuit	646211	646250		1	Yes	DLG Fault at S1211 on S1211-S1250 Cir 1511 and S1211-S1250 Cir 1520. Normal clearing with unsuccessful reclosing.
									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	
38	Extreme_2_b	3PH	S3458 3	345.00	645458				5	Open	Transmission Circuit	645458	640139		1	Yes	3-PH fault at S3458 on S3458-Cooper followed by a stuck breaker opening the west bus. Delayed clearing.
		3PH	S3458 3	345.00	645458				8.5							Yes	
39	Extreme_2_c	3PH	S3451 3	345.00	645451				7.5	Open	Three Winding	645451	646251	648251	1	Yes	3-PH fault at S3451 on S3451 T3 transformer followed by a stuck breaker opening S3451-S3459. Delayed clearing.
		3PH	S3451 3	345.00	645451				9.5	Open	Transmission Circuit	645451	645459		1	Yes	
40	Extreme_2_f									Prior Outage	Transmission Circuit	645451	645551		Z1		Prior outage of S3451-Raun. SLG fault at S3451 on 3451 T3 transformer followed by a stuck breaker opening S3451-S3459. Delayed clearing.
										Prior Outage	Transmission Circuit	645551	635200		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	
41	Extreme_2_f									Prior Outage	Transmission Circuit	645455	645740		1		Prior outage of S3455-S3740. SLG Fault at S3458 on S3458-Cooper followed by a stuck breaker opening the west bus.

																	Delayed clearing.
		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	
42	Extreme_2_f									Prior Outage	Transmission Circuit	645458	640139		1		Prior outage of S3458-Cooper. SLG Fault at S3740 on S3455-S3740 followed by a stuck breaker opening the west bus. Delayed clearing.
		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	
43	Extreme_2_f									Prior Outage	Transmission Circuit	646201	646206		1		Prior outage of S1201-S1206. SLG Fault at S1206 on S1206-S1232 followed by a stuck breaker opening S1206T1. Delayed clearing.
		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	
44	Extreme_2_f									Prior Outage	Transmission Circuit	645454	645455		1		Prior outage of S3454-S3455. SLG Fault at S3455 on S3455-S3456 followed by a stuck breaker opening S3455 T1. Delayed clearing.
		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	
45	Extreme_2_f									Prior Outage	Transmission Circuit	645458	640139		1		Prior outage of S3458-Cooper. SLG Fault at S3458 on S3458-S3456 followed by a stuck breaker opening the west bus. Delayed clearing.
		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	
46	Extreme_2_f									Prior Outage	Transmission Circuit	645458	640139		1		Prior outage of S3458-Cooper. SLG Fault at S3458 on S3458-103rd&Rokeby followed by a stuck breaker opening the west bus. Delayed clearing.
		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	
47	Extreme_2_f									Prior Outage	Transmission Circuit	640139	300039		1		Prior outage of Cooper-Fairport. SLG Fault at Cooper on Cooper-St. Joe followed by a stuck breaker opening Cooper-Atchison. Delayed clearing.

		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	
48	P1_2	3PH	S3456 3	345.00	645456				5	Open	Transmission Circuit	645456	635000		1	Yes	3-PH fault at S3456 on S3456-C. Bluffs. Normal clearing with unsuccessful reclosing.
									600								
		3PH	S3456 3	345.00	645456				4.5							Yes	
49	P4_2	SCMU L-G	S3456 3	345.00	645456				5	Open	Transmission Circuit	645456	635000		1	Yes	SLG Fault at S3456 on S3456-C. Bluffs followed by a stuck breaker opening S3456-S3455. Delayed clearing.
		SCMU L-G	S3456 3	345.00	645456				9	Open	Transmission Circuit	645456	645455		1	Yes	
50	P4_2	SCMU L-G	S3456 3	345.00	645456				5	Open	Transmission Circuit	645456	645455		1	Yes	SLG Fault at S3456 on S3456-S3455 followed by a stuck breaker opening S3456-C. Bluffs. Delayed clearing.
		SCMU L-G	S3456 3	345.00	645456				9	Open	Transmission Circuit	645456	635000		1	Yes	
51	P6_1_1									Prior Outage	Transmission Circuit	645456	645455		1		Prior outage of S3456-S3455. 3-PH fault at S3456 on S3456-C. Bluffs. Normal clearing with unsuccessful reclosing.
		3PH	S3456 3	345.00	645456				5	Open	Transmission Circuit	645456	635000		1	Yes	
									600								
		3PH	S3456 3	345.00	645456				4.5							Yes	

52	P1_3	3PH	S1206 5	161.00	646206				7.5	Open	Three Winding	645456	646206	648256	1	Yes	3-PH fault at S1206 on S3456 T4. Normal clearing.
53	P4_2	SCMU L-G	S1206 5	161.00	646206				9	Open	Transmission Circuit	646206	646216		1	Yes	SLG Fault at S1206 on S1206-S1216 followed by a stuck breaker opening S3456 T4. Delayed clearing.
									0	Open	Load	646216			O0		
		SCMU L-G	S1206 5	161.00	646206				10	Open	Three Winding	645456	646206	648256	1	Yes	
54	P4_3	SCMU L-G	S1206 5	161.00	646206				7.5	Open	Three Winding	645456	646206	648256	1	Yes	SLG Fault at S1206 on S3456 T4 followed by a stuck breaker opening S1206-S1216. Delayed clearing.
		SCMU L-G	S1206 5	161.00	646206				12	Open	Transmission Circuit	646206	646216		1	Yes	
									0	Open	Load	646216			O0		
55	P6_1_2									Prior Outage	Transmission Circuit	646206	646216		1		Prior outage of S1206-S1216. 3-PH fault at S1206 on S3456 T4. Normal clearing.
		3PH	S1206 5	161.00	646206				7.5	Open	Three Winding	645456	646206	648256	1	Yes	
56	P6_1_1									Prior Outage	Transmission Circuit	646211	646250		1		Prior outage of S1211-S1250 Cir 1511. 3-PH fault at S1211 on S1211-S1250 Cir 1520. Normal clearing with unsuccessful reclosing.
		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	
57	P1_2	3PH	S3459 3	345.00	645459				5	Open	Transmission Circuit	645459	645456		1	Yes	3-PH fault at S3459 on S3459-S3456. Normal clearing with unsuccessful reclosing.
									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	
58	P1_2	3PH	S3459 3	345.00	645459				5	Open	Transmission Circuit	645459	645456		1	Yes	3-PH fault at S3459 on S3459-S3456. Normal clearing with successful reclosing.
									20	Close	Transmission Circuit	645459	645456		1		
59	P1_2	3PH	S1258 5	161.00	646258				6	Open	Transmission Circuit	646258	646263		1	Yes	3-PH fault at S1258 on S1258-S1263. Normal clearing with unsuccessful reclosing.
									20								
		SLG	S1263 5	161.00	646263	261	-1983	MVA	8.5							Yes	
60	P1_2	3PH	S1258 5	161.00	646258				6	Open	Transmission Circuit	646258	646263		1	Yes	3-PH fault at S1258 on S1258-S1263. Normal clearing with successful reclosing.
									200	Close	Transmission Circuit	646258	646263		1		
61	P6_2_1									Prior Outage	Three Winding	645456	646206	648256	1		Prior outage of S3456 T4. 3-PH fault at S1258 on S1258-S1263. Normal clearing with unsuccessful reclosing.

		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	
62	P6_2_1									Prior Outage	Three Winding	645456	646206	648256	1		Prior outage of S3456 T4. 3-PH fault at S1258 on S1258-S1263. Normal clearing with successful reclosing.
		3PH	S1258 5	161.00	646258				6	Open	Transmission Circuit	646258	646263		1	Yes	
									200	Close	Transmission Circuit	646258	646263		1		
63	P1_2	3PH	S1298 5	161.00	646298				6	Open	Transmission Circuit	646298	646251		1	Yes	3-PH fault at S1298 on S1298-S1251. Normal clearing with unsuccessful reclosing.
									20								
		3PH	S1298 5	161.00	646298				6							Yes	
64	P1_2	3PH	S1298 5	161.00	646298				6	Open	Transmission Circuit	646298	646251		1	Yes	3-PH fault at S1298 on S1298-S1251. Normal clearing with successful reclosing.
									200	Close	Transmission Circuit	646298	646251		1		
65	P4_2	SCMU L-G	S1298 5	161.00	646298				6	Open	Transmission Circuit	646298	646251		1	Yes	SLG Fault at S1298 on S1298-S1251 followed by a stuck breaker opening S1298-S1305. Delayed clearing.
		SCMU L-G	S1298 5	161.00	646298				13.5	Open	Transmission Circuit	646298	646305		1	Yes	
66	P4_2	SCMU L-G	S1298 5	161.00	646298				9	Open	Transmission Circuit	646298	646305		1	Yes	SLG Fault at S1298 on S1298-S1305 followed by a stuck breaker opening

																	S1298-S1251. Delayed clearing.
		SCMU L-G	S1298 5	161.00	646298				10.5	Open	Transmission Circuit	646298	646251		1	Yes	
67	P6_1_1									Prior Outage	Transmission Circuit	646298	646305		1		Prior outage of S1298-S1305. 3-PH fault at S1298 on S1298-S1251. Normal clearing with unsuccessful reclosing.
		3PH	S1298 5	161.00	646298				6	Open	Transmission Circuit	646298	646251		1	Yes	
									20								
		3PH	S1298 5	161.00	646298				6							Yes	
68	P6_1_1									Prior Outage	Transmission Circuit	646298	646305		1		Prior outage of S1298-S1305. 3-PH fault at S1298 on S1298-S1251. Normal clearing with successful reclosing.
		3PH	S1298 5	161.00	646298				6	Open	Transmission Circuit	646298	646251		1	Yes	
									200	Close	Transmission Circuit	646298	646251		1		
70	P0		System Intact														System Intact.
71	P4_2	SCMU L-G	S1260 5	161.00	646260				6	Open	Trip Bus	646281				Yes	SLG Fault at S1260 on S1260-S1281 followed by a stuck breaker opening S1260-S1361. Delayed clearing.
		SCMU L-G	S1260 5	161.00	646260				10.5	Open	Transmission Circuit	646260	646361		1	Yes	
									0	Open	Load	646260			O0		
72	P4_2	SCMU L-G	S3455 3	345.00	645455				4.5	Open	Transmission Circuit	645455	645761		1	Yes	SLG Fault at S3455 on S3455-S3761 followed by a stuck breaker opening S3455 T3.

																	Delayed clearing.
		SCMU L-G	S3455 3	345.00	645455				9.5	Open	Three Winding	645455	646255	648355	1	Yes	
73	P4_2	SCMU L-G	S1361 5	161.00	646361				6	Open	Transmission Circuit	646255	646361		1	Yes	SLG Fault at S1361 on S1361-S1255 followed by a stuck breaker opening the east bus. Delayed clearing.
		SCMU L-G	S1361 5	161.00	646361				9							Yes	
74	P1_2	3PH	S1361 5	161.00	646361				6	Open	Transmission Circuit	646255	646361		1	Yes	3-PH fault at S1361 on S1361-S1255. Normal clearing with unsuccessful reclosing.
									20	Close	Transmission Circuit	646255	646361		1		
		3PH	S1361 5	161.00	646361				6	Open	Transmission Circuit	646255	646361		1	Yes	
75	P1_2	3PH	S1361 5	161.00	646361				6	Open	Transmission Circuit	646255	646361		1	Yes	3-PH fault at S1361 on S1361-S1255. Normal clearing with successful reclosing.
									20	Close	Transmission Circuit	646255	646361		1		
76	Extreme_2_f									Prior Outage	Three Winding	645456	646206	648256	1		Prior outage of S3456 T4. SLG Fault at S3455 on S3455-S3761 followed by a stuck breaker opening S3455 T3. Delayed clearing.
		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	
77	Extreme_2_f	3PH	S3761 3	345.00	645761											No	3-PH fault at S3761 on S3455-S3761

																	and 3-PH fault at S1361 on S1255-S1361. Normal clearing with unsuccessful reclosing.
		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	
78	Extreme_2_f	3PH	S3761 3	345.00	645761											No	3-PH fault at S3761 on S3455-S3761 and 3-PH fault at S1361 on S1255-S1361. Normal clearing with successful reclosing.
		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		
79	Extreme_2_f	3PH	S3455 3	345.00	645455											No	3-PH fault at S3455 on S3455-S3761 and 3-PH fault at S1255 on S1255-S1361. Normal clearing with unsuccessful reclosing.
		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	
80	Extreme_2_f	3PH	S3455 3	345.00	645455											No	3-PH fault at S3455 on S3455-S3761 and 3-PH fault at S1255 on S1255-S1361. Normal clearing with successful reclosing.
		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		
81	P1_2	3PH	S1347 5	161.00	646347				6	Open	Transmission Circuit	646209	646347		1	Yes	3-PH fault at S1347 on S1347-S1209. Normal clearing with unsuccessful reclosing.
									600								
		SLG	S1209 5	161.00	646209	1931	-13978	MVA	8.5							Yes	
82	P1_2	3PH	S1347 5	161.00	646347				6	Open	Transmission Circuit	646209	646347		1	Yes	3-PH fault at S1347 on S1347-S1209. Normal clearing with successful reclosing.
									620	Close	Transmission Circuit	646209	646347		1		
83	P6_1_1									Prior Outage	Transmission Circuit	646236	646252		1		Prior outage of S1236-S1252. 3-PH fault at S1347 on S1347-S1209. Normal clearing with unsuccessful reclosing.

		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	
84	P6_1_1									Prior Outage	Transmission Circuit	646236	646252		1		Prior outage of S1236-S1252. 3-PH fault at S1347 on S1347-S1209. Normal clearing with successful reclosing.
		3PH	S1347 5	161.00	646347				6	Open	Transmission Circuit	646209	646347		1	Yes	
									620	Close	Transmission Circuit	646209	646347		1		
85	P1_2	3PH	S1347 5	161.00	646347				6	Open	Transmission Circuit	646252	646347		1	Yes	3-PH fault at S1347 on S1347-S1252. Normal clearing with unsuccessful reclosing.
									0	Open	Load	646252			O0		
									600								
		SLG	S1252 5	161.00	646252	1931	-13978	MVA	8.5							Yes	
86	P1_2	3PH	S1347 5	161.00	646347				6	Open	Transmission Circuit	646252	646347		1	Yes	3-PH fault at S1347 on S1347-S1252. Normal clearing with successful reclosing.
									0	Open	Load	646252			O0		
									620	Close	Transmission Circuit	646252	646347		1		
87	P6_2_1									Prior Outage	Three Winding	645459	646209	648359	1		Prior outage of S3459 T6. 3-PH fault at S1347 on S1347-S1252. Normal clearing with unsuccessful reclosing.
		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	
88	P6_2_1									Prior Outage	Three Winding	645459	646209	648359	1		Prior outage of S3459 T6. 3-PH fault at S1347 on S1347-S1252. Normal clearing with successful reclosing.
		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		
89	P1_2	3PH	S1363 5	161.00	646363				6	Open	Transmission Circuit	646362	646363		1	Yes	3-PH fault at S1363 on S1363-S1362 Ckt 1. Normal clearing with unsuccessful reclosing.
									600								
		SLG	S1362 5	161.00	646362	1133	-9911	MVA	8.5							Yes	
90	P1_2	3PH	S1363 5	161.00	646363				6	Open	Transmission Circuit	646362	646363		1	Yes	3-PH fault at S1363 on S1363-S1362 Ckt 1. Normal clearing with successful reclosing.
									620	Close	Transmission Circuit	646362	646363		1		
91	P6_1_1									Prior Outage	Transmission Circuit	646362	646363		2		Prior outage of S1362-S1363 Ckt 2. 3-PH fault at S1363 on S1363-S1362 Ckt 1. Normal clearing with unsuccessful reclosing.
		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	
92	P6_1_1									Prior Outage	Transmission Circuit	646362	646363		2		Prior outage of

																	S1362-S1363 Ckt 2. 3-PH fault at S1363 on S1363-S1362 Ckt 1. Normal clearing with successful reclosing.
		3PH	S1363 5	161.00	646363				6	Open	Transmission Circuit	646362	646363		1	Yes	
									620	Close	Transmission Circuit	646362	646363		1		
93	P1_2	3PH	S1363 5	161.00	646363				6	Open	Transmission Circuit	646281	646363		1	Yes	3-PH fault at S1363 on S1363-S1281. Normal clearing with unsuccessful reclosing.
									600								
		SLG	S1281 5	161.00	646281	972	-8495	MVA	8.5							Yes	
94	P1_2	3PH	S1363 5	161.00	646363				6	Open	Transmission Circuit	646281	646363		1	Yes	3-PH fault at S1363 on S1363-S1281. Normal clearing with successful reclosing.
									620	Close	Transmission Circuit	646281	646363		1		
95	P6_1_1									Prior Outage	Transmission Circuit	646362	646363		2		Prior outage of S1362-S1363 Ckt 2. 3-PH fault at S1363 on S1363-S1281. Normal clearing with unsuccessful reclosing.
		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	
96	P6_1_1									Prior Outage	Transmission Circuit	646362	646363		2		Prior outage of S1362-S1363 Ckt 2. 3-PH fault at S1363 on

																	S1363-S1281. Normal clearing with successful reclosing.
		3PH	S1363 5	161.00	646363				6	Open	Transmission Circuit	646281	646363		1	Yes	
									620	Close	Transmission Circuit	646281	646363		1		