GEN-2015-089

Limited Operation Impact Restudy

Published September 2019
By SPP Generator Interconnections Dept.

REVISION HISTORY

DATE OR VERSION NUMBER	AUTHOR	CHANGE DESCRIPTION
09/25/2019	SPP	Initial report issued.

CONTENTS

SUMMARY

Interconnection Customer GEN-2015-089 has requested a Limited Operation System Impact Study (LOIS) consistent with Southwest Power Pool Open Access Transmission Tariff (OATT) for 200.0 MW of wind generation to be interconnected with 200.0 MW of Energy Resource interconnection Service (ERIS)   The generator is planned to interconnect to the transmission system of Western Area Power Administration (WAPA) in Bon Homme County, South Dakota.

As the DISIS identified previously assigned upgrade, R-Plan, has currently been delayed until 5/1/2021, GEN-2015-089 has requested SPP to conduct a LOIS to determine the limited operation amount available to GEN-2015-089 under the following assumptions:

1. All planned transmission system improvements with ISD at the beginning of 2019 or earlier are included in the model
2. Gentleman – Thedford – Holt 345 kV ("R-Plan") Project **NOT** in-service after year end 2019.
3. SPP GEN-2015-089 Generation Interconnection Request in-service at year end 2019.

For this LOIS, powerflow and stability analysis were conducted by Electric Power Engineers, Inc. (EPE). The LOIS assumes that only the higher-queued projects listed within the EPE reports of this study will be in-service. If additional generation projects with queue priority equal-to or higher-than the study project, request to go into commercial operation, this LOIS may need to be restudied to ensure that interconnection service remains available for the customer's request.

Under the study assumptions outlined above, powerflow and stability analysis from this LOIS has determined GEN-2015-089 can have full interconnection capacity at **200.0 MW ERIS**. However, should any other projects, other than those listed within the EPE reports come into service, an additional study may be required to determine if any new limit exists.

It should be noted that although this LOIS analyzed many of the most probable contingencies, it is not an all-inclusive list that can account for every operational situation. Additionally, the generator may not be able to inject any power onto the Transmission System due to constraints that fall below the threshold of mitigation for a Generator Interconnection request. Because of this, the Customer may be required by the Transmission Provider to reduce their generation output to 0 MW under certain system conditions to allow system operators to maintain the reliability of the transmission network.

Short circuit analysis was not performed for this LOIS study.

Nothing in this study should be construed as a guarantee of delivery or transmission service within Southwest Power Pool's (SPP) transmission system. If the customer wishes to sell power from the facility, a separate request for transmission service must be requested on Southwest Power Pool's OASIS by the Customer.

A: CONSULTANT'S POWERFLOW STUDY REPORT

See next page for the EPE powerflow analysis Study report.

GEN-2015-089

LIMITED OPERATION IMPACT STUDY (LOIS)

The seal on this document
Authorized by
Hugo E. Mena, P.E.
On September 23, 2019

Registration # 3386

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Executive Summary

Introduction

The Interconnection Customer (IC) for GEN-2015-089 requested Electric Power Engineers, Inc. (EPE) to perform a Limited Operation Impact Study (LOIS) for their wind project falling in Cluster Group 9 within the Southwest Power Pool (SPP) service territory.

As part of this LOIS, EPE completed a Powerflow analysis to address the steady state voltage and thermal effects of interconnecting GEN-2015-089 to the transmission system assuming the generation requests of Table 1 do not achieve commercial operation while the transmission upgrades shown in Table 2 are not completed yet.

Table 1 - Generation Requests not Included in the LOIS

Project	MW	Service	Fuel Type	Status
GEN-2016-021	300	ER	Wind	IA FULLY EXECUTED/ON SCHEDULE
GEN-2016-023	150.5	ER	Wind	FACILITY STUDY STAGE
GEN-2016-029	150	ER	Wind	FACILITY STUDY STAGE
GEN-2016-050	250.7	ER	Wind	FACILITY STUDY STAGE
GEN-2016-075	50	ER	Wind	FACILITY STUDY STAGE
GEN-2015-087	66	ER/NR	Wind	TERMINATED

Table 2 – Upgrade Projects not Included in the LOIS

Upgrade Project	Type	Description	Status	Study Assignment
Gentleman – Thedford – Holt County 345kV	New Line, Transformer, and Substation	Build approximately 227 miles of new 345kV transmission from Gentleman to Thedford to Holt County. Install Thedford 345/115/13kV transformer and build Holt County substation	Delayed ISD 5/1/2021	2012 SPP Integrated Transmission Plan (ITP10)
Keystone – Gentleman 345kV CKT 2	New Line	Build approximately 30 miles of new 345kV transmission from Keystone to Gentleman	Facility Study Stage	DISIS-2016-001-4
Sidney – Keystone 345kV CKT 2	New Line	Build approximately 95 miles of new 345kV transmission from Sidney to Keystone		DISIS-2016-001-4

GEN-2015-089 was evaluated in DISIS-2016-001 study as a 200 MW interconnecting to the 230 kV Utica substation as an Energy Resource (ER) interconnection service request.

Conclusion

The Powerflow analysis conducted as part of this LOIS has determined that Gen-2015-089 request can interconnect 200 MW of generation with ER interconnection service request on an interim basis prior to the completion of the network upgrades listed in Table 2, and assuming the generation projects of Table 1 have not reached Commercial Operation Date.

Results of this study are a snapshot in time and largely depend on the generation dispatch and transmission system configuration. Any change in the assumptions underlying this study, such as the generation projects listed in Table 1 or other projects coming into service, may greatly impact the findings in this report.

Powerflow Analysis Methodology

A Powerflow analysis was conducted to determine whether the transmission system can accommodate the GEN-2015-089 interconnection request at 200 MW without violating SPP's thermal or voltage transmission planning criteria per the methodology detailed in the following sections.

Models Preparation

The LOIS Powerflow study was completed using the following modified versions of the 2016 series of 2017 ITP Near-term study models that were obtained from SPP; these study models included all generation requests as modeled by SPP.

- Year 1 (2017) Winter Peak (17WP)
- Year 2 (2018) Spring (18G)
- Year 2 (2018) Summer Peak (18SP)
- Year 5 (2021) Light (21L)
- Year 5 (2021) Summer (21SP)
- Year 5 (2021) Winter (21WP) peak
- Year 10 (2026) Summer (26SP) peak

These models were modified as follows:

- Generation projects, listed in Table 1, were disconnected, and Gen-2015-089 size is increased to 200 MW. To offset the total generation reduction driven by these generation projects disconnection, generation units modeled at busses of the "footprint_im" subsystem, that SPP defines in the "sub2017.sub" file, are scaled up as advised by SPP.
- The network upgrades listed in Table 2, if modeled, are disconnected from the cases.

EPE also created a modified version of these models were Gen-2015-089 is disconnected.

Projects in cluster 9 and that were kept modeled in the study cases are listed in the section titled "Generation Requests".

Base case upgrades that were modeled in the study cases are listed in the section titled “Base Case Upgrades”.

Thermal Overloads

Network constraints are found by using PSS/E AC Contingency Calculation (ACCC) analysis and PSS/E transmission interchange limits calculation (TLTG) analysis under basecase, as well as the contingencies defined by SPP. All transmission elements within the SPP footprint are monitored; after discussion with SPP, transmission elements outside the SPP footprint were not monitored.

For Energy Resource Interconnection Service (ERIS), thermal overloads are determined for system intact (N-0) (greater than or equal to 100% of Rate A - normal) and for contingency (N-1) (greater than or equal to 100% of Rate B – emergency) conditions.

For the purpose of this analysis, PTDF calculations were run using the modified base case models without Gen-2015-089. The simulation tool calculated the incremental capability of injecting power at Gen-2015-089 and transferring this power to the “footprint_im” subsystem, while reporting non-converging limitations and thermal overloads.

The overloads are then screened to determine which of generator interconnection requests have at least

- 3% Distribution Factor (DF) for system intact conditions (n-0),
- 20% DF upon outage based conditions (n-1),
- or 3% DF on contingent elements that resulted in a non-converged solution.

Voltage Violations

High voltage, low voltage, and voltage deviation are determined by using PSS/E AC Contingency Calculation (ACCC) analysis. For this purpose, ACCC was performed with and without Gen-2015-089 in all the study models to identify whether SPP voltage criteria would be violated.

Generation Requests

Table 3 - Generation Requests Included in the LOIS

Project	MW	Service	Fuel Type	Group Number	Status
NPPD Distributed (Broken Bow)	7.3	ER	Heat	09 NEB	
NPPD Distributed (Burwell)	3	ER	Heat	09 NEB	
NPPD Distributed (Ord)	10.8	ER	Heat	09 NEB	
NPPD Distributed (Stuart)	1.8	ER	Heat	09 NEB	
NPPD Distributed (Columbus Hydro)	45	ER	Hydro	09 NEB	
WAPA SEAMS (Gavins Pt Hydro)	102	ER	Hydro	09 NEB	
WAPA SEAMS (Ft Randle Hydro)	352	ER	Hydro	09 NEB	
WAPA SEAMS (Spirit Mound Heat)	120	ER	Heat	09 NEB	
NPPD Distributed (Burt County Wind)	12	ER	Wind	09 NEB	
NPPD Distributed (Buffalo County Solar)	10	ER	Solar	09 NEB	
NPPD Distributed (North Platte - Lexington)	54	ER	Hydro	09 NEB	
GEN-2003-021N	75	ER	Wind	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2004-023N	75	ER	Coal	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2006-020N	42	ER	Wind	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2006-038N005	80	ER	Wind	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2006-038N019	80	ER	Wind	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2007-011N08	81	ER	Wind	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2008-119O	60	ER	Wind	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2006-037N1	74.8	ER	Wind	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2006-044N	40.5	ER	Wind	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2008-086N02	201	ER	Wind	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2008-123N	89.7	ER	Wind	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2009-040	73.8	ER	Wind	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2010-041	10.5	ER	Wind	09 NEB	IA FULLY EXECUTED/ON SCHEDULE
GEN-2010-051	200	ER	Wind	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2011-018	73.6	ER/NR	Wind	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2011-027	120	ER/NR	Wind	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2011-056	3.6	ER	Hydro	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2011-056A	3.6	ER	Hydro	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2011-056B	4.5	ER	Hydro	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2012-021	4.8	ER	Gas	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2013-002	50.6	ER/NR	Wind	09 NEB	IA FULLY EXECUTED/ON SUSPENSION
GEN-2013-008	1.2	ER	Wind	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2013-019	73.6	ER/NR	Wind	09 NEB	IA FULLY EXECUTED/ON SUSPENSION
GEN-2013-032	204	ER	Wind	09 NEB	IA FULLY EXECUTED/ON SCHEDULE
GEN-2014-004	3.96	ER	Wind	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2014-013	73.5	ER/NR	Wind	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2014-031	35.8	ER/NR	Wind	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2014-032	10.22	ER/NR	Wind	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2014-039	73.39	ER/NR	Wind	09 NEB	IA FULLY EXECUTED/COMMERCIAL OPERATION
GEN-2007-017IS	200	ER/NR	Wind	09 NEB	ON SCHEDULE
GEN-2007-018IS	200	ER/NR	Wind	09 NEB	ON SCHEDULE
GEN-2015-007	160	ER	Wind	09 NEB	IA FULLY EXECUTED/ON SCHEDULE
GEN-2015-023	300.72	ER/NR	Wind	09 NEB	IA FULLY EXECUTED/ON SCHEDULE
GEN-2015-076	158.4	ER	Wind	09 NEB	IA FULLY EXECUTED/ON SUSPENSION
GEN-2015-088	300	ER/NR	Wind	09 NEB	IA FULLY EXECUTED/ON SCHEDULE
GEN-2016-043	230	ER	Wind	09 NEB	IA FULLY EXECUTED/ON SCHEDULE
GEN-2015-089	*200*	*ER*	*Wind*	*09 NEB*	*IA FULLY EXECUTED/ON SCHEDULE*

Base Case Upgrades

The facilities listed in Table 4 below are part of the SPP Transmission Expansion Plan, the Balanced Portfolio, or recently approved Priority Projects. These facilities have an approved Notification to Construct (NTC) or are in construction stages and were assumed to be in-service at the time of dispatch and added to the base case models. GEN-2015-089 has not been assigned advancement costs for the projects listed below.

Table 4 - Base Case Upgrades Included in the Study Cases

SPP Notification to Construct (NTC) ID	Project Owner	Upgrade Name	Estimated Date of Upgrade Completion (EOC)
200223	OGE	Tatonga - Woodward District EHV 345 kV Ckt 2	7/1/2018
200223	OGE	Matthewson - Tatonga 345 kV Ckt 2	7/1/2018
200240	OGE	Chisholm - Gracemont 345 kV Ckt 1 (OGE)	3/1/2018
200255	AEP	Chisholm - Gracemont 345kV Ckt 1 (AEP)	3/1/2018
200255	AEP	Chisholm 345/230 kV Substation	3/1/2018
200255	AEP	Chisholm 230 kV	3/1/2018
200360	SPS	IMC #1 Tap - Livingston Ridge 115 kV Ckt 1 Rebuild	11/16/2018
200360	SPS	Intrepid West - Potash Junction 115 kV Ckt 1 Rebuild	11/16/2018
200360	SPS	IMC #1 Tap - Intrepid West 115 kV Ckt 1 Rebuild	11/16/2018
200360	SPS	Cardinal - Targa 115 kV Ckt 1 Rebuild	5/31/2018
200360	SPS	National Enrichment Plant - Targa 115 kV Ckt 1	8/15/2017
200391	OGE	DeGrasse 345 kV Substation	6/1/2017 (RTO Determined Need Date)
200391	OGE	DeGrasse 345/138 kV Transformer	6/1/2017 (RTO Determined Need Date)
200391	OGE	DeGrasse - Knob Hill 138 kV New Line	6/1/2017 (RTO Determined Need Date)
200391	OGE	DeGrasse 138 kV Substation (OGE)	6/1/2017 (RTO Determined Need Date)
200253	NPPD	Neligh 345/115 kV Substation	6/1/2017
200309	SPS	Hobbs 345/230 kV Ckt 1 Transformer	6/1/2018
200309	SPS	Hobbs - Yoakum 345 kV Ckt 1	6/1/2020
200395	SPS	Tuco - Yoakum 345 kV Ckt 1	6/1/2020
200395	SPS	Yoakum 345/230 kV Ckt 1 Transformer	6/1/2020
200256	SPS	Chaves - Price 115 kV Ckt 1 Rebuild	12/30/2017
200256	SPS	CV Pines - Price 115 kV Ckt 1 Rebuild	12/30/2017
200256	SPS	Capitan - CV Pines 115 kV Ckt 1 Rebuild	12/30/2017
200282	SPS	China Draw - Yeso Hills 115 kV Ckt 1	6/1/2018
200282	SPS	Dollarhide - Toboso Flats 115 kV Ckt 1	6/1/2018
200309	SPS	Hobbs - Kiowa 345 kV Ckt 1	6/1/2018
200309	SPS	Kiowa 345 kV Substation	6/1/2018
200309	SPS	Kiowa - North Loving 345 kV Ckt 1	6/1/2018
200309	SPS	North Loving 345 kV Terminal Upgrades	6/1/2018
200309	SPS	China Draw - North Loving 345 kV Ckt 1	6/1/2018
200309	SPS	China Draw 345 kV Ckt 1 Terminal Upgrades	6/1/2018
200309	SPS	China Draw 345/115 kV Ckt 1 Transformer	6/1/2018
200309	SPS	North Loving 345/115 kV Ckt 1 Transformer	6/1/2018
200309	SPS	Kiowa 345/115 kV Ckt 1 Transformer	6/1/2018
200395	SPS	Livingston Ridge 115 kV Substation Conversion	8/31/2017
200411	SPS	Livingston Ridge - Sage Brush 115 kV Ckt 1	6/1/2018
200309	SPS	Sage Brush 115 kV Substation	12/16/2016
200309	SPS	Largarto - Sage Brush 115 kV Ckt 1	12/15/2016
200309	SPS	Lagarto 115 kV Substation	6/1/2018
200309	SPS	Cardinal - Lagarto 115 kV Ckt 1	12/15/2016
200309	SPS	Cardinal 115 kV Substation	12/15/2016
200411	SPS	Ponderosa - Ponderosa Tap 115 kV Ckt 1	6/1/2017

SPP Notification to Construct (NTC) ID	Project Owner	Upgrade Name	Estimated Date of Upgrade Completion (EOC)
20097	TSMO	Sibley - Mullin Creek 345 kV	12/31/2016
20097	TSMO	Nebraska City - Mullin Creek 345 kV (GMO)	12/31/2016
20098	OPPD	Nebraska City - Mullin Creek 345 kV (OPPD)	12/31/2016
200395	SPS	Canyon West – Dawn – Panda – Deaf Smith 115kV Ckt 1	12/15/2018
200369	SPS	Canyon East Sub – Randall County Interchange 115kV Ckt 1	12/31/2020
200359	SPS	Carlisle 230/115kV transformer replacement	12/31/2017
200309	SPS	Hobbs – Yoakum – TUCO 345kV project	6/1/2018
200395	SPS	Terry County – Wolfforth 115kV Ckt 1 terminal equipment replacement	6/1/2018
200391	OGE	DeGrasse 345/138kV project	6/1/2017
200396	WFEC	DeGrasse 345/138kV project	6/1/2017
200395	SPS	Harrington East – Potter 230kV Ckt 1 terminal equipment replacement	6/1/2019
200228	WERE	Viola 345/138kV project	6/1/2018
200228	MKEC	Viola 345/138kV project	6/1/2018
200395	SPS	Seminole 230/115kV transformer Ckt 1 & 2 replacement	5/15/2018
200262	SPS	Yoakum County Interchange 230/115kV transformer Ckt 1 & 2 replacement	6/1/2019

Powerflow Study Results

The ACCC analysis indicated that no voltage violations per the SPP criteria are triggered under basecase and contingency conditions.

Additionally, the TLTG analysis indicated that no thermal violations under basecase and contingency conditions are triggered.

The simulation tool, however, reported the following non-converging contingencies, to which Gen-2015-089 has a distribution factor higher than the 3% cutoff, before interconnecting the project. Nevertheless, sensitivity analysis showed that when adding Gen-2015-089 to the transmission network, it provided P/Q support for these contingencies to converge; and therefore, these non-converging contingencies are not reported as violations for Gen-2015-089.

- Remove switch shunt from bus 653571 [GR ISLD3 345.00]
- Open line from bus 653571 [GR ISLD3 345.00] to bus 653871 [GR ISLD-LNX3345.00] CKT Z
- Open line from bus 640510 [HOLT.CO3 345.00] to bus 653871 [GR ISLD-LNX3345.00] CKT 1

Furthermore, EPE investigated non-converging contingencies identified in the ACCC analysis when Gen-2015-089 is modeled. None of these contingencies had a distribution factor higher than the 3% cutoff.

It is to be noted, however, that the Iteration Limit Exceeded for a significant number of contingencies. Generally, this is a limitation of the PSS/E solution engine and a common source is the switching of switched shunt equipment in-service amounts. These contingencies require a fine-tuned solution to determine whether they would cause any non-convergence issues. EPE attempted to solve these contingencies by locking switch shunts or MVAr of generators that were oscillating; then a solution is achieved by allowing the adjustments of switch shunts or the MVAr of generators. No non-converging contingencies with a DF higher than 3% were identified.

B: CONSULTANT'S STABILITY STUDY REPORT

See next page for the EPE stability analysis study report.

GEN-2015-089

LIMITED OPERATION IMPACT STUDY (LOIS)

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Document Revisions

NO.	Revision	Date	PRD	CHK	APV
1	Final Submittal	09/13/2019	CL	AS	BFY

Executive Summary

The Interconnection Customer for GEN-2015-089 requested Electric Power Engineers, Inc. (EPE) to complete a Limited Operation Impact Study (LOIS) for the Prevailing wind project, GEN-2015-089, falling in Cluster Group 9 within the Southwest Power Pool (SPP) service territory. Prevailing wind is a proposed 200 MW generating facility interconnecting to the 230 kV Utica substation as an Energy Resource (ER) interconnection service request. EPE performed a dynamic stability analysis to evaluate the dynamic performance of the SPP network with focus on GEN-2015-089 during transmission disturbances in accordance with SPP LOIS Report Scope **[1]**. This dynamic stability study was performed utilizing the SPP steady state and dynamic models as provided by SPP following the requirements listed within the LOIS Report Scope **[1]**.

EPE studied all contingencies listed within the GEN-2015-089 Impact Restudy for Generator Modification **[2]** as well as additional contingencies requested by SPP **[3]** and as defined in **Appendix A** for the 2016 SPP Model Development Working Group (MDWG) models as shown below.

- Year 1 2017 winter peak (17WP)
- Year 2 2018 summer peak (18SP)
- Year 10 2026 summer peak (26SP)

For each case above, two dispatch scenarios were evaluated as provided by SPP.

- Standard dispatch for dynamic study
- Dispatch to evaluate the Gerald Gentleman Station registered NERC flowgate #6006

Prior to performing the dynamic analysis, the generators listed in **Table 1** were removed from each of the cases as they are assumed to not be in-service until the transmission upgrades listed in **Table 2** been completed. For each contingency studied, the simulation was run for the contingency event with any prior outages or faults added for the time specified as stated within the contingency description.

The results of the dynamic simulations performed without the generators and transmission upgrades listed in, **Table 1** and **Table 2** respectively, show no machinetripping, rotor angle damping or transient voltage recovery violations for the simulated contingency events shown in **Appendix A**. Plots of the acceptable voltage recovery for each contingency event is shown in **Appendix B** with a summary in **Table 3**.

This study was completed with the steady state and dynamic models and contingencies as provided by SPP. Any modifications or updates to these models or contingencies outside of what is described within this report will require a restudy to evaluate the performance of GEN-2015-089.

Table 1. Generation requests not included in the LOIS

Project	MW	Service	Fuel Type	Status
GEN-2016-021	300	ER	Wind	Facility Study Stage
GEN-2016-023	150.5	ER	Wind	Facility Study Stage
GEN-2016-029	150	ER	Wind	Facility Study Stage
GEN-2016-075	50	ER	Wind	Facility Study Stage

Table 2. Transmission upgrade projects not included in the LOIS

Upgrade Project	Type	Description	Status	Study Assignment	PTI Buses
Gentleman – Thedford – Holt County 345kV	New Line, Transformer, and Substation	Build approximately 227 miles of new 345kV transmission from Gentleman to Thedford to Holt County. Install Thedford 345/115/13kV transformer and build Holt County substation	Delayed ISD 1/1/2021	2012 SPP Integrated Transmission Plan (ITP10)	BRANCHES: 640183-640500 ID: 1 640500-640510 ID: 1 TRANSFORMER: 640381-640500-640570 ID:1
Keystone – Gentleman 345kV CKT 2	New Line	Build approximately 30 miles of new 345kV transmission from Keystone to Gentleman	Facility Study Stage	DISIS-2016-001-4	BRANCH: 640183-640252 (2)
Sidney – Keystone 345kV CKT 2	New Line	Build approximately 95 miles of new 345kV transmission from Sidney to Keystone		DISIS-2016-001-4	

Introduction

EPE performed a dynamic stability analysis in PSS®E v33.11 to evaluate the dynamic performance of the proposed 200 MW Prevailing wind, GEN-2015-089, as well as the SPP network during transmission disturbances in accordance with SPP's GEN-2015-089 Modification Study **[2]** and LOIS Report Scope **[1]**. GEN-2015-089 is to interconnect at the 230 kV Utica substation.

Study Assumptions and Modifications to Base Cases

GEN-2015-089 is to be a 200 MW project connecting at the 230 kV Utica substation. EPE was provided with the DISIS-2016-001-4 Group 9 SPP MDWG dynamic case files for 2017 Winter, 2018 Summer and 2026 Summer to be used for this study and are listed below for reference.

- MDWG16-17W_DIS16014_G09
- MDWG16-18S_DIS16014_G09
- MDWG16-26S_DIS16014_G09

Each case above has two steady state dispatch cases to be evaluated for a total of six (6) cases to be evaluated.

- MDWG16-xxx_DIS16014_G09
- MDWG16-xxx_DIS16014_G09GGS

Prior to performing the dynamic analysis, the generators listed in **Table 1** were removed from each of the cases as they are not expected to be in service prior to the completion of the transmission upgrades listed in **Table 2**. The projects and generators are removed by using the following IDEVs for each case.

- removeGens.idv
- removeProjects.idv

Upon removal of the generators and projects, the SPP system model dispatch was updated using the SPP tool as follows to maintain the system swing:

- MDWG16_SPP_Scale_Subsystem.idv

Once the system dispatch was updated, the steady state solution for each of the cases was performed with FDNS with the following solution parameters:

- BAT_FDNS,1,0,1,1,1,0,0,0

Additionally, it was determined that some of the cases would not solve properly without additional modifications. These modifications are mentioned below:

MDWG16-17W_DIS16014_G09

- No additional changes necessary

MDWG16-17W_DIS16014_G09GGS

- Switched shunt at bus AINSWND.PLTD PTI #640025 set to locked

MDWG16-18S_DIS16014_G09

- No additional changes necessary

MDWG16-18S_DIS16014_G09GGS

- Switched shunt at bus AINSWND.PLTD PTI #640025 set to locked

MDWG16-26S_DIS16014_G09

- Switched shunt at bus AINSWND.PLTD PTI #640025 set to locked
- Switched shunt at bus INTERSTE 8PTI # 659828 set to locked

MDWG16-26S_DIS16014_G09GGS

- Switched shunt at bus AINSWND.PLTD PTI #640025 set to locked
- Switched shunt at bus INTERSTE 8PTI # 659828 set to locked

Upon completion of solving the steady state case, EPE prepared the contingency list shown in **Appendix A** for the use in the PSS®E dynamic simulation. For each contingency studied, the simulation was run for the contingency event with any prior outages or faults added for the time specified as stated within the contingency description. During the fault simulations, the active power, reactive power and terminal voltage for GEN-2015-089 as well as other renewable and conventional generators within a five (5) radius of GEN-2015-089 were monitored. Additionally, the angle of conventional generators and bus voltages above 100 kV were monitored to evaluate stability.

Dynamic Contingency Analysis and Results

EPE performed dynamic contingency analysis by simulating the dynamic contingencies in PSS®E as shown in **Appendix A**. The dynamic stability analysis without the generators and transmission upgrades, **Table 1** and **Table 2** respectively, show no machine rotor angle damping or transient voltage recovery violations for the simulated contingency events shown in **Appendix A**. Plots of the acceptable voltage recovery for each contingency event is shown in **Appendix B** with a summary in **Table 3**.

While evaluating the results from the contingencies, it was noticed that there were high frequency oscillations within the Flat Start case. These high frequency oscillations were determined to be attributed to the Static Var Compensator (SVC) located at the Watertown SVC bus (PTI #652539) per SPP. Additionally, while evaluating the results for different scenarios, it was observed that some simulations were not solving due to the complex loads showing results of NAN. Thus, in order to alleviate the high frequency oscillations from the Flat Start and the NAN results for the complex loads, the frequency filter was increased from 0.01667 to 0.04 by EPE. This resulted in all cases solving and no high frequency oscillations in the Flat Start.

Conclusion

The findings of this stability study show that the interconnection of GEN-2015-089 to the 230 kV Utica substation, without the generators and transmission upgrade projects listed in **Table 1** and ***Table 2*** result in no transient voltage recovery violations.

This study was completed with the steady state and dynamic models and contingencies as provided by SPP. Any modifications or updates to these models or contingencies outside of what is described within this report will require a restudy to evaluate the performance of GEN-2015-089.

Table 3. Dynamic stability analysis results

Fault ID	Main			GGS		
	17W	18S	26S	17W	18S	26S
FLT107-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT108-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT109-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT110-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT111-SB	Stable	Stable	Stable	Stable	Stable	Stable
FLT112-SB	Stable	Stable	Stable	Stable	Stable	Stable
FLT113-SB	Stable	Stable	Stable	Stable	Stable	Stable
FLT114-PO	Stable	Stable	Stable	Stable	Stable	Stable
FLT115-PO	Stable	Stable	Stable	Stable	Stable	Stable
FLT116-PO	Stable	Stable	Stable	Stable	Stable	Stable
FLT9001-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9002-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9003-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9004-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9005-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9006-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9007-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9008-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9009-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9010-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9011-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9012-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9013-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9014-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9015-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9016-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9017-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9018-3PH	Stable	Stable	Stable	Stable	Stable	Stable

Fault ID	Main			GGS		
	17W	18S	26S	17W	18S	26S
FLT9019-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9020-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9021-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9022-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9023-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9024-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9025B-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9026-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9027-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9028-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9029-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9030-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9031-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9032-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9033-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9034-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9035-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9036-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9037-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9038-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9039-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9040-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9041-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9001-PO1	Stable	Stable	Stable	Stable	Stable	Stable
FLT9002-PO1	Stable	Stable	Stable	Stable	Stable	Stable
FLT9003-PO1	Stable	Stable	Stable	Stable	Stable	Stable
FLT9010-PO1	Stable	Stable	Stable	Stable	Stable	Stable
FLT9011-PO1	Stable	Stable	Stable	Stable	Stable	Stable
FLT9012-PO1	Stable	Stable	Stable	Stable	Stable	Stable
FLT9013-PO1	Stable	Stable	Stable	Stable	Stable	Stable
FLT9037-PO1	Stable	Stable	Stable	Stable	Stable	Stable
FLT9038-PO1	Stable	Stable	Stable	Stable	Stable	Stable
FLT9039-PO3	Stable	Stable	Stable	Stable	Stable	Stable
FLT9010-PO4	Stable	Stable	Stable	Stable	Stable	Stable
FLT9011-PO4	Stable	Stable	Stable	Stable	Stable	Stable
FLT9012-PO4	Stable	Stable	Stable	Stable	Stable	Stable
FLT9013-PO4	Stable	Stable	Stable	Stable	Stable	Stable
FLT9027-PO4	Stable	Stable	Stable	Stable	Stable	Stable
FLT9028-PO4	Stable	Stable	Stable	Stable	Stable	Stable

Fault ID	Main			GGS		
	17W	18S	26S	17W	18S	26S
FLT9037-PO4	Stable	Stable	Stable	Stable	Stable	Stable
FLT9038-PO4	Stable	Stable	Stable	Stable	Stable	Stable
FLT9039-PO4	Stable	Stable	Stable	Stable	Stable	Stable
FLT1001-SB	Stable	Stable	Stable	Stable	Stable	Stable
FLT1002-SB	Stable	Stable	Stable	Stable	Stable	Stable
FLT1003-SB	Stable	Stable	Stable	Stable	Stable	Stable
FLT1004-SB	Stable	Stable	Stable	Stable	Stable	Stable
FLT1005-SB	Stable	Stable	Stable	Stable	Stable	Stable
FLT1006-SB	Stable	Stable	Stable	Stable	Stable	Stable
FLT1007-SB	Stable	Stable	Stable	Stable	Stable	Stable
FLT1008-SB	Stable	Stable	Stable	Stable	Stable	Stable
FLT1009-SB	Stable	Stable	Stable	Stable	Stable	Stable
FLT1010-SB	Stable	Stable	Stable	Stable	Stable	Stable
FLT1011-SB	Stable	Stable	Stable	Stable	Stable	Stable
FLT9042-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9042.1-3PH	Stable	Stable	Stable	Stable	Stable	Stable
FLT9043-PO5	Stable	Stable	Stable	Stable	Stable	Stable
FLT9044-PO5	Stable	Stable	Stable	Stable	Stable	Stable

References

[1] Limited Operation Impact Study Scope – GEN-2015-089, LOIS_Report-Scope.docx

[2] GEN-2015-089 Impact Restudy for Generator Modification, GEN-2015-089 Modification Study.pdf

[3] Additional contingencies and updated contingencies, RE_ GEN-2015-089 powerflow models.pdf

Appendix A – Dynamic Contingency Definitions

Fault ID	Fault Descriptions
FLT107-3PH	3 phase fault on the UticaJ4 (652526) 230 kV to Rasmusn4 (652536) 230kV circuit 1 line a. Apply fault at the UticaJ4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT108-3PH	3 phase fault on the UticaJ4 (652526) 230kV to VFODNES4 (652398) 230kV circuit 1 line a. Apply fault at the UticaJ4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT109-3PH	3 phase fault on the UticaJ4 (652526) 230 kV to FTRANDL4 (652509) 230 kV circuit 1 line a. Apply fault at the UticaJ4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT110-3PH	3 phase fault on the Uticajc4 230/115/13.2kV (652526/652626/652627) Transformer. a. Apply fault at the UticaJ4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line Uticajc4 230/115/13.2kV (652526/652626/652627) Transformer
FLT111-SB	RASMUSN4 230 kV Stuck Breaker Scenario 1 a. Apply fault at the Rasmusn4 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. RASMUSN4 (652536) to UticaJ4 (652526) 230 kV d. RASMUSN4 (652536) to Siouxcy4 (652565) 230 kV
FLT112-SB	VFODNES4 230 kV Stuck Breaker Scenario 1 a. Apply fault at the VFODNES4 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. VFODNES4 (652398) - Uticajc4 (652526) 230 kV d. VFODNES4 (652398) - Siouxcy4 (652523) 230 kV
FLT113-SB	FTRANDL4 230 kV Stuck Breaker Scenario 1 a. Apply fault at the VFODNES4 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. FTRANDL4 (652509) to UticaJ4 (652526) 230 kV d. FTRANDL4 (652509) to Meadowgrove4 (640540) 230 kV
FLT114-PO	Prior Outage of Uticajc4 230 kV (652526) to Rasmusn4 230 kV (652536) CKT 1; 3 phase fault on UTICAJC4 (652526) to FTRANDL4 230 kV (652509) circuit 1 line a. Apply fault at the FTRANDL4 (652509) 230 kV b. Clear fault after 6 cycles by tripping the faulted line
FLT115-PO	Prior Outage of Uticajc4 230 kV (652526) to VFODNES4 230 kV (652398) CKT 1; 3 phase fault on UTICAJC4 (652526) to FTRANDL4 230 kV (652509) circuit 1 line a. Apply fault at the RASMUSN4 (652536) 230 kV b. Clear fault after 6 cycles by tripping the faulted line

Fault ID	Fault Descriptions
FLT116-PO	Prior Outage of Uticajc4 230 kV (652526) to FTRANDL4 (652509) CKT 1; 3 phase fault on UTICAJC4 (652526) to RASMUSN4 230 kV (652536) circuit 1 line a. Apply fault at the RASMUSN4 (652536) 230 kV b. Clear fault after 6 cycles by tripping the faulted line
FLT9001-3PH	3 phase fault on the VFODNES 230/69 kV (652398/652399) Transformer. a. Apply fault at the VFODNES (652398) 230 kV bus b. Clear fault after 6 cycles by tripping the faulted VFODNES 230/69 kV (652398/652399) Transformer.
FLT9002-3PH	3 phase fault on the VFODNES 230/115/12.5 kV (652398/652397/652396) Transformer. a. Apply fault at the VFODNES (652398) 230 kV bus b. Clear fault after 6 cycles by tripping the faulted VFODNES 230/115/12.5 kV (652398/652397/652396) Transformer.
FLT9003-3PH	3 phase fault on the VFODNES (652398) 230 kV to SIOUXFL4 (652523) 230 kV circuit 1 line a. Apply fault at the VFODNES 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9004-3PH	3 phase fault on the SIOUXFL4 (652523) 230 kV to LETCHER4 (652606) 230 kV circuit 1 line a. Apply fault at the SIOUXFL4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9005-3PH	3 phase fault on the SIOUXFL4 (652523) 230 kV to PAHOJA4 (652578) 230 kV circuit 1 line a. Apply fault at the SIOUXFL4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9006-3PH	3 phase fault on the SIOUXFL4 (652523) 230 kV to SPLT RK4 (602004) 230 kV circuit 1 line a. Apply fault at the SIOUXFL4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9007-3PH	3 phase fault on the SIOUXFL4 (652523) 230 kV to HANLON (652513) 230 kV circuit 1 line a. Apply fault at the SIOUXFL4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9008-3PH	3 phase fault on the SIOUXFL4 230/115/13.2 kV (652523/652524/652233) Transformer a. Apply fault at the SIOUXFL4 (652523) 230 kV bus b. Clear fault after 6 cycles by tripping the faulted SIOUXFL4 230/115/13.2 kV (652523/652524/652233) Transformer.
FLT9009-3PH	3 phase fault on the VFODNES7 (652397) 115 kV to HANLON (652591) 115 kV circuit 1 line a. Apply fault at the VFODNES7 115 kV bus b. Clear fault after 7 cycles by tripping the faulted line.
FLT9010-3PH	3 phase fault on the FTRANDL4 (652509) 230 kV to MEADOWGROVE (640540) 230 kV circuit 1 line

Fault ID	Fault Descriptions
	a. Apply fault at the FTRANDL4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9011-3PH	3 phase fault on the FTRANDL4 (652509) 230 kV to SIOUXCY4 (652565) 230 kV circuit 1 line a. Apply fault at the FTRANDL4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9012-3PH	3 phase fault on the FTRANDL4 (652509) 230 kV to FTTHOMP4 (652507) 230 kV circuit 1 line a. Apply fault at the FTRANDL4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9013-3PH	3 phase fault on the FTRANDL4 (652509) 230 kV to LAKPLAT4 (652516) 230 kV circuit 1 line a. Apply fault at the FTRANDL4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9014-3PH	3 phase fault on the LAKPLAT 230/69 kV (652516/652277) Transformer. a. Apply fault at the LAKPLAT (652516) 230 kV bus b. Clear fault after 6 cycles by tripping the faulted LAKPLAT 230/69 kV (652516/652277) Transformer.
FLT9015-3PH	3 phase fault on the LAKPLAT4 (652516) 230 kV to FTTHOMP4 (652507) 230 kV circuit 1 line a. Apply fault at the LAKPLAT4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9016-3PH	3 phase fault on the FTTHOMP4 (652507) 230 kV to BIGBND14 (652540) 230 kV circuit 1 line a. Apply fault at the FTTHOMP4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9017-3PH	3 phase fault on the FTTHOMP4 (652507) 230 kV to WESSINGTON4 (652607) 230 kV circuit 1 line a. Apply fault at the FTTHOMP4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9018-3PH	3 phase fault on the FTTHOMP4 (652507) 230 kV to BIGBND24 (652541) 230 kV circuit 1 line a. Apply fault at the FTTHOMP4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9019-3PH	3 phase fault on the FTTHOMP4 (652507) 230 kV to HURON (652514) 230 kV circuit 1 line a. Apply fault at the FTTHOMP4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9020-3PH	3 phase fault on the FTTHOMP4 (652507) 230 kV to G16-094-TAP (587764) 230 kV circuit 1 line a. Apply fault at the FTTHOMP4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9021-3PH	3 phase fault on the FTTHOMP4 (652507) 230 kV to OAHE (652519) 230 kV circuit 1 line a. Apply fault at the FTTHOMP4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.

Fault ID	Fault Descriptions
FLT9022-3PH	3 phase fault on the FTTHOMP 345/230/13.8 kV (652506/652507/652273) Transformer. a. Apply fault at the FTTHOMP (652507) 230 kV bus b. Clear fault after 6 cycles by tripping the faulted FTTHOMP 345/230/13.8 kV (652506/652507/652273) Transformer.
FLT9023-3PH	3 phase fault on the FTTHOMP 230/69 kV (652507/652276) Transformer. a. Apply fault at the FTTHOMP 230 kV bus b. Clear fault after 6 cycles by tripping the faulted FTTHOMP 230/69 kV (652507/652276) Transformer.
FLT9024-3PH	3 phase fault on the 345 kV FTTHOMP3 (652506) to FTTHOM1-LNX3 (652806) circuit Z to GEN-2016-017 Tap (560074) circuit 1 line a. Apply fault at the FTTHOMP3 345 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9025B-3PH	3 phase fault on the 345 kV FTTHOMP3 (652506) to FTTHOM2-LNX3 (652807) circuit Z to GRPRAR2-LNX3 (652833) circuit 1 to Grand Prairie (652532) circuit Z line a. Apply fault at the FTTHOMP3 345 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9026-3PH	3 phase fault on the G16-094-TAP (587764) 230 kV to OAHE (652519) 230 kV circuit 1 line a. Apply fault at the G16-094-TAP 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9027-3PH	3 phase fault on the RASMUSN4 (652536) 230 kV to SIOUXCY4 (652565) 230 kV circuit 1 line a. Apply fault at the RASMUSN4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9028-3PH	3 phase fault on the RASMUSN 230/69 kV (652536/652287) Transformer. a. Apply fault at the RASMUSN (652536) 230 kV bus b. Clear fault after 6 cycles by tripping the faulted RASMUSN 230/69 kV (652536/652287) Transformer.
FLT9029-3PH	3 phase fault on the SIOUXCY 345/230/13.8 kV (652564/652565/652305) Transformer. a. Apply fault at the SIOUXCY (652565) 230 kV bus b. Clear fault after 6 cycles by tripping the faulted SIOUXCY 345/230/13.8 kV (652564/652565/652305) Transformer.
FLT9030-3PH	3 phase fault on the SIOUXCY 230/161/13.8 kV (652565/652566/652308) Transformer. a. Apply fault at the SIOUXCY (652565) 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line SIOUXCY 230/161/13.8 kV (652565/652566/652308) Transformer.
FLT9031-3PH	3 phase fault on the SIOUXCY (652565) 230 kV to TWIN CH4 (640386) 230 kV circuit 1 line a. Apply fault at the SIOUXCY 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.

Fault ID	Fault Descriptions
FLT9032-3PH	3 phase fault on the SIOUXCY (652565) 230 kV to DENISON4 (652567) 230 kV circuit 1 line a. Apply fault at the SIOUXCY 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9033-3PH	3 phase fault on the SIOUXCY (652565) 230 kV to EAGLE (659900) 230 kV circuit 1 line a. Apply fault at the SIOUXCY 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9034-3PH	3 phase fault on the SIOUXCY3 (652564) 345 kV to SIOUXCY-LNX3 (652864) 345 kV circuit Z line a. Apply fault at the SIOUXCY3 345 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9035-3PH	3 phase fault on the SIOUXCY3 (652564) 345 kV to RAUN (635200) 345 kV circuit Z line a. Apply fault at the SIOUXCY3 345 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9036-3PH	3 phase fault on the FTTHOMP4 (652507) 230 kV to LETCHER4 (652606) 230 kV circuit 1 line a. Apply fault at the FTTHOMP4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9037-3PH	3 phase fault on the UTICAJC7 (652626) 115 kV to FREEMAN-ER7 (655418) 115 kV circuit 1 line a. Apply fault at the UTICAJC7 115 kV bus b. Clear fault after 7 cycles by tripping the faulted line.
FLT9038-3PH	3 phase fault on the UTICAJC7 (652626) 115 kV to MENNOJT7 (660007) 115 kV circuit 1 line a. Apply fault at the UTICAJC7 115 kV bus b. Clear fault after 7 cycles by tripping the faulted line.
FLT9039-3PH	3 phase fault on the UTICAJC7 (652626) 115 kV to NAPA JCT7 (660026) 115 kV circuit 1 line a. Apply fault at the UTICAJC7 115 kV bus b. Clear fault after 7 cycles by tripping the faulted line.
FLT9040-3PH	3 phase fault on the MEADOWGROVE (640540) 230 kV to COLMBUS4 (640133) 230 kV circuit 1 line a. Apply fault at the MEADOWGROVE 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9041-3PH	3 phase fault on the MEADOWGROVE (640540) 230 kV to PR BRZ4 (648506) 230 kV circuit 1 line a. Apply fault at the MEADOWGROVE 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line, trip generators at PR BRZ
FLT9001-PO1	Prior Outage of UTICALJC4 230 kV (652526) to RASMUSN 230 kV (652536) circuit 1 line 3 phase fault on the VFODNES 230/69 kV (652398/652399) Transformer. a. Apply fault at the VFODNES 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line VFODNES 230/69 kV (652398/652399) Transformer.

Fault ID	Fault Descriptions
FLT9002-PO1	Prior Outage of UTICALJC4 230 kV (652526) to RASMUSN 230 kV (652536) circuit 1 line 3 phase fault on the VFODNES 230/115/12.5 kV (652398/652397/652396) Transformer. a. Apply fault at the VFODNES 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line VFODNES 230/115/12.5 kV (652398/652397/652396) Transformer.
FLT9003-PO1	Prior Outage of UTICALJC4 230 kV (652526) to RASMUSN 230 kV (652536) circuit 1 line 3 phase fault on the VFODNES (652398) 230 kV to SIOUXFL4 (652523) 230 kV circuit 1 line a. Apply fault at the VFODNES 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9010-PO1	3 phase fault on the FTRANDL4 (652509) 230 kV to MEADOWGROVE (640540) 230 kV circuit 1 line a. Apply fault at the FTRANDL4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9011-PO1	Prior Outage of UTICALJC4 230 kV (652526) to RASMUSN 230 kV (652536) circuit 1 line 3 phase fault on the FTRANDL4 (652509) 230 kV to SIOUXCY4 (652565) 230 kV circuit 1 line a. Apply fault at the FTRANDL4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9012-PO1	Prior Outage of UTICALJC4 230 kV (652526) to RASMUSN 230 kV (652536) circuit 1 line 3 phase fault on the FTRANDL4 (652509) 230 kV to FTTHOMP4 (652507) 230 kV circuit 1 line a. Apply fault at the FTRANDL4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9013-PO1	Prior Outage of UTICALJC4 230 kV (652526) to RASMUSN 230 kV (652536) circuit 1 line 3 phase fault on the FTRANDL4 (652509) 230 kV to LAKPLAT4 (652516) 230 kV circuit 1 line a. Apply fault at the FTRANDL4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9037-PO1	Prior Outage of UTICALJC4 230 kV (652526) to RASMUSN 230 kV (652536) circuit 1 line 3 phase fault on the UTICAJC7 (652626) 115 kV to FREEMAN-ER7 (655418) 115 kV circuit 1 line a. Apply fault at the UTICAJC7 115 kV bus b. Clear fault after 7 cycles by tripping the faulted line.
FLT9038-PO1	Prior Outage of UTICALJC4 230 kV (652526) to RASMUSN 230 kV (652536) circuit 1 line 3 phase fault on the UTICAJC7 (652626) 115 kV to MENNOJT7 (660007) 115 kV circuit 1 line a. Apply fault at the UTICAJC7 115 kV bus b. Clear fault after 7 cycles by tripping the faulted line.
FLT9039-PO3	Prior Outage of UTICALJC4 230 kV (652526) to FTRANDL4 (652509) circuit 1 line 3 phase fault on the UTICAJC7 (652626) 115 kV to NAPA JCT7 (660026) 115 kV circuit 1 line a. Apply fault at the UTICAJC7 115 kV bus b. Clear fault after 7 cycles by tripping the faulted line.

Fault ID	Fault Descriptions
FLT9010-PO4	Prior Outage of UTICALJC4 230 kV (652526) to VFODNES4 230 kV (652398) circuit 1 line 3 phase fault on the FTRANDL4 (652509) 230 kV to MEADOWGROVE (640540) 230 kV circuit 1 line a. Apply fault at the FTRANDL4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9011-PO4	Prior Outage of UTICALJC4 230 kV (652526) to VFODNES4 230 kV (652398) circuit 1 line 3 phase fault on the FTRANDL4 (652509) 230 kV to SIOUXCY4 (652565) 230 kV circuit 1 line a. Apply fault at the FTRANDL4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9012-PO4	Prior Outage of UTICALJC4 230 kV (652526) to VFODNES4 230 kV (652398) circuit 1 line 3 phase fault on the FTRANDL4 (652509) 230 kV to FTTHOMP4 (652507) 230 kV circuit 1 line a. Apply fault at the FTRANDL4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9013-PO4	Prior Outage of UTICALJC4 230 kV (652526) to VFODNES4 230 kV (652398) circuit 1 line 3 phase fault on the FTRANDL4 (652509) 230 kV to LAKPLAT4 (652516) 230 kV circuit 1 line a. Apply fault at the FTRANDL4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9027-PO4	Prior Outage of UTICALJC4 230 kV (652526) to VFODNES4 230 kV (652398) circuit 1 line 3 phase fault on the RASMUSN4 (652536) 230 kV to SIOUXCY4 (652565) 230 kV circuit 1 line a. Apply fault at the RASMUSN4 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9028-PO4	Prior Outage of UTICALJC4 230 kV (652526) to VFODNES4 230 kV (652398) circuit 1 line 3 phase fault on the RASMUSN 230/69 kV (652536/652287) Transformer. a. Apply fault at the RASMUSN 230 kV bus b. Clear fault after 6 cycles by tripping the faulted line RASMUSN 230/69 kV (652536/652287) Transformer.
FLT9037-PO4	Prior Outage of UTICALJC4 230 kV (652526) to VFODNES4 230 kV (652398) circuit 1 line 3 phase fault on the UTICAJC7 (652626) 115 kV to FREEMAN-ER7 (655418) 115 kV circuit 1 line a. Apply fault at the UTICAJC7 115 kV bus b. Clear fault after 6 cycles by tripping the faulted line.
FLT9038-PO4	Prior Outage of UTICALJC4 230 kV (652526) to VFODNES4 230 kV (652398) circuit 1 line 3 phase fault on the UTICAJC7 (652626) 115 kV to MENNOJT7 (660007) 115 kV circuit 1 line a. Apply fault at the UTICAJC7 115 kV bus b. Clear fault after 7 cycles by tripping the faulted line.
FLT9039-PO4	Prior Outage of UTICALJC4 230 kV (652526) to VFODNES4 230 kV (652398) circuit 1 line 3 phase fault on the UTICAJC7 (652626) 115 kV to NAPA JCT7 (660026) 115 kV circuit 1 line a. Apply fault at the UTICAJC7 115 kV bus b. Clear fault after 7 cycles by tripping the faulted line.

Fault ID	Fault Descriptions
FLT1001-SB	Stuck Breaker at UTICAJC7 (652626) a. Apply single phase fault at UTICAJC7 (652626) 115 kV bus. b. Clear fault after 16 cycles and trip the following elements c. UTICAJC7 (652526) 230 kV/ (652626)115 kV/ (652627) 13.2 kV transformer d. UTICAJC7 (652626) 115 kV to FREEMAN-ER7 (655418) 115 kV circuit 1 line
FLT1002-SB	VFODNES4 230 kV Stuck Breaker Scenario 1 a. Apply fault at the VFODNES4 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. VFODNES4 (652398) to UticaJ4 (652526) 230 kV d. VFODNES4 230kV (652398) to 69kV (652399) Transformer
FLT1003-SB	VFODNES4 230 kV Stuck Breaker Scenario 2 a. Apply fault at the VFODNES4 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. VFODNES4 (652398) to UticaJ4 (652526) 230 kV d. VFODNES4 230kV (652398) to 115kV (652397) to 12.5kV (652396) Transformer
FLT1004-SB	VFODNES4 230 kV Stuck Breaker Scenario 3 a. Apply fault at the VFODNES4 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. VFODNES4 (652398) to Siouxcy4 (652523) 230 kV d. VFODNES4 230kV (652398) to 69kV (652399) Transformer
FLT1005-SB	VFODNES4 230 kV Stuck Breaker Scenario 4 a. Apply fault at the VFODNES4 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. VFODNES4 (652398) to Siouxcy4 (652523) 230 kV d. VFODNES4 230kV (652398) to 115kV (652397) to 12.5kV (652396) Transformer
FLT1006-SB	UTICAJC4 230 kV Stuck Breaker Scenario 1 a. Apply fault at the UTICAJC4 (652526) 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. RASMUSN4 (652536) to UticaJ4 (652526) 230 kV d. VFODNES4 (652398) to UticaJ4 (652526) 230 kV
FLT1007-SB	UTICAJC4 230 kV Stuck Breaker Scenario 2 a. Apply fault at the UTICAJC4 (652526) 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. RASMUSN4 (652536) to UticaJ4 (652526) 230 kV d. FTRANDL4 (652509) to UticaJ4 (652526) 230 kV
FLT1008-SB	UTICAJC4 230 kV Stuck Breaker Scenario 3 a. Apply fault at the UTICAJC4 (652526) 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. UTICAJC4 (652526) 230 kV to (652626) 115kV to (652627) 13.2kV Transformer d. VFODNES4 (652398) to UticaJ4 (652526) 230 kV

Fault ID	Fault Descriptions
FLT1009-SB	UTICAJC4 230 kV Stuck Breaker Scenario 4 a. Apply fault at the UTICAJC4 (652526) 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. UTICAJC4 (652526) 230 kV to (652626) 115kV to (652627) 13.2kV Transformer d. FTRANDL4 (652509) to UticaJ4 (652526) 230 kV
FLT1010-SB	UTICAJC4 (652526) 230kV Stuck Breaker Scenario 5 a. Apply fault at the UTICAJC4 (652526) 230kV bus b. Clear fault after 16 cycles and trip the following elements c. UTICAJC4 (652526) to VFODNES4 (652398) 230 kV line d. UTICAJC4 (652526) to FTRANDL4 (652509) 230 kV line
FLT1011-SB:	UTICAJC4 (652526) 230kV Stuck Breaker Scenario 6 a. Apply fault at the UTICAJC4 (652526) 230kV bus b. Clear fault after 16 cycles and trip the following elements c. UTICAJC4 (652526) 230 kV to (652626) 115kV to (652627) 13.2kV Transformer d. UTICAJC4 (652526) to RASMUSN4 (652536) 230 kV line
FLT9042-3PH:	3 phase fault on the GR ISLD-LNX3 (653871) to HOLT.CO3 (640510) 345 kV circuit 1 line a. Apply fault at the GR ISLD-LNX3 (653871) 345 kV bus b. Clear fault after 6 cycles by tripping the faulted line
FLT9042.1-3PH:	3 phase fault on the GR ISLD-LNX3 (653871) to HOLT.CO3 (640510) 345 kV circuit 1 line a. Apply fault at the HOLT.CO3 (640510) 345 kV bus b. Clear fault after 6 cycles by tripping the faulted line
FLT9043-PO5:	Prior Outage of GR ISLD-LNX3 (653871) to HOLT.CO3 (640510) 345 kV circuit 1 line; 3 phase fault on the UTICAJC4 (652526) to RASMUSN4 (652536) 230 kV circuit 1 line a. Apply fault at the UTICAJC4 (652526) 230kV bus b. Clear fault after 6 cycles by tripping the faulted UTICAJC4 (652526) to RASMUSN4 (652536) 230 kV line
FLT9044-PO5:	Prior Outage of GR ISLD-LNX3 (653871) to HOLT.CO3 (640510) 345 kV circuit 1 line; 3 phase fault on the FTRANDL4 (652509) to SIOUXCY4 (652565) 230 kV circuit 1 line a. Apply fault at the FTRANDL4 (652509) 230kV bus b. Clear fault after 6 cycles by tripping the faulted FTRANDL4 (652509) to SIOUXCY4 (652565) 230 kV line

Appendix B – Dynamic Analysis Plots