GEN-2016-123
GEN-2016-124
GEN-2016-125

Limited Operation Interconnection System Impact Study

GEN-2017-069

Interim Availability Interconnection System Impact Study

Published March 2021
By SPP Generator Interconnections Dept.

REVISION HISTORY

DATE OR VERSION NUMBER	AUTHOR	CHANGE DESCRIPTION
10/7/2020	SPP	Final report issued for Scenario 1, system conditions prior to commercial operation of GEN-2016-123, GEN-2016-124, & GEN-2016-125.
11/17/2020	SPP	Final report issued for Scenario 2, system conditions on 12/1/2020.
1/8/2021	SPP	Final report updated for Scenario 2: stability analysis and operating limits.
3/5/2021	SPP	Final report updated for Scenario 2: stability analysis and operating limits.

CONTENTS

CONSULTANT'S STUDY REPORT – SCENARIO 1

See next page for the Consultant's Interim Availability Interconnection System Impact Study report for GEN-2017-069 with system conditions prior to commercial operation of GEN-2016-123, GEN-2016-124, & GEN-2016-125.

The GEN-2017-069 requested Interim Interconnection Service is feasible at the requested 3.6 MW under the studied conditions.

MITSUBISHI ELECTRIC POWER PRODUCTS, INC.
POWER SYSTEMS ENGINEERING DIVISION
530 KEYSTONE DRIVE
WARRENDALE, PA 15086, U.S.A.

Phone: (724) 778-5111 Fax: (724) 778-5149
Home Page: www.meppi.com

Southwest Power Pool, Inc. (SPP)

GEN-2017-069 Interim Availability Interconnection System Impact Study

Final Report

REP-0944
Revision #02

October 2020

Submitted By:
Mitsubishi Electric Power Products, Inc. (MEPPI)
Power Systems Engineering Division
Warrendale, PA

MITSUBISHI ELECTRIC POWER PRODUCTS, INC.
POWER SYSTEMS ENGINEERING DIVISION
530 KEYSTONE DRIVE
WARRENDALE, PA 15086, U.S.A.

Phone: (724) 778-5111 Fax: (724) 778-5149
Home Page: www.meppi.com

Report Revision Table

Revision	Report Revision Table	Date
0	Issue Draft Report for Review	09/21/2020
1	Issued Draft Report with Power Flow Results	09/30/2020
2	Issued Final Report	10/07/2020

MITSUBISHI ELECTRIC POWER PRODUCTS, INC.
POWER SYSTEMS ENGINEERING DIVISION
530 KEYSTONE DRIVE
WARRENDALE, PA 15086, U.S.A.

Phone: (724) 778-5111 Fax: (724) 778-5149
Home Page: www.meppi.com

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Title:	**GEN-2017-069 Interim Availability Interconnection System Impact Study: Final Report REP-0944**
Date:	October 2020
Author:	Nicholas Tenza; M. Principle Consultant, Power Systems Engineering Division *Nicholas Tenza*
Approved:	Taylor Cramer; Senior Engineer, Power Systems Engineering Division *Taylor Cramer*

EXECUTIVE SUMMARY

SPP requested an Interim Availability Interconnection System Impact Study for Group 06 study request GEN-2017-069 for system conditions through November 30, 2020. This study required a power flow analysis and stability analysis detailing the impacts of the interconnecting project as shown in Table ES-1. GEN-2017-069 has requested 3.6 MW of solar generation to be interconnected with Energy Resource Interconnection Service (ERIS) and Network Resource Interconnection Service (NRIS) into the transmission system of Xcel Energy – Southwestern Public Service Company (SPS) in Quay County, New Mexico. This study did not require short circuit analysis as there was no change to the equipment contributing to fault currents.

Table ES-1
Interconnection Project Evaluated

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2017-069	3.6 increase to GEN-2013-022	SMASC Solar PV Inverter (524491)	Norton 115kV Switching Station (524502)

SUMMARY OF POWER FLOW ANALYSIS

The power flow Analysis determined there were no steady-state thermal or voltage constraints meeting the distribution factor criteria requiring mitigation with ERIS or NRIS service through November 30, 2020.

SUMMARY OF STABILITY ANALYSIS

The stability analysis determined that there was a P1 contingency that resulted in high post-fault steady-state voltage across all seasons and P6 contingencies in the 2018 Summer Peak study scenario that resulted in non-damped voltage oscillations and poor post-fault voltage recovery when all generation interconnection requests were at 100% output. To mitigate the damping voltage violations and high post-fault steady-state voltages, the following actions were implemented:

- High post-fault steady-state voltage at Oklaunion 345kV

  - Mitigation: Trip the Oklaunion HVDC reactive equipment at Oklaunion 345kV simultaneously with blocking of the Oklaunion HVDC tie
- Non-damped voltage oscillations
  - Following the loss of a segment on the TUCO to Border to Woodward 345kV transmission line or TUCO to Oklaunion to Lawton Eastside 345kV transmission line, curtail generation in SPS area CNPL zone by up to 600 MW.

After implementing the above changes, the contingency analysis was re-simulated for all contingencies. With the identified upgrades and curtailment above, the stability analysis determined that GEN-2017-069 has the ability to connect, from the transmission grid point of view, with full interim service. Additionally, a sensitivity of dispatching local generation to Norton 115kV did not result in any adverse impacts to system response.

Power flow and stability analysis from this Interim Availability study determined that GEN-2017-069 could interconnect with full interim service (3.6 MW) of solar generation with ERIS and NRIS service through November 30, 2020.

It should be noted that while this Interim Availability study analyzed many of the most probable contingencies, it is not an all-inclusive list that can account for every operation 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, it is likely that the Customers may be required to reduce their generation output to 0 MW under certain system conditions to allow system operators to maintain the reliability of the transmission network.

SECTION 1: OBJECTIVES

The objective of this report is to provide Southwest Power Pool, Inc. (SPP) with the deliverables for the "GEN-2017-069 Interim Availability Interconnection System Impact Study." SPP requested an Interconnection System Impact Study for one (1) generation interconnection request which requires a power flow analysis and stability analysis with results in an Impact Study Report.

SECTION 2: BACKGROUND

The Siemens Power Technologies International PSS/E power system simulation program Version 33.12 was used for this study. The DISIS-2016-002-2 stability cases for 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak cases under normal dispatch conditions were provided by SPP. The study request listed in Table 2-1 was added to the models and the models include the previously queued projects listed in Table 2-2. The study cases were updated to reflect known system conditions at the time of the in-service date for the GEN-2017-069 interim request. The projects with later ISD or withdrawn study projects shown in Table 2-3 were removed from the study models to reflect current system configurations. Refer to Section 3.1 for the changes made to the base cases to reflect the removal of previously assigned Network Upgrades and study projects associated with Q3 2020 conditions. Additionally, a sensitivity study was performed on all seasons to determine the impact of nearby generation.

A power flow one-line diagram for GEN-2017-069 is shown in Figure 2-1. Note that the one-line diagrams represent 2017 Winter Peak conditions.

The stability analysis determined the impacts of the new interconnecting project on the stability and voltage recovery of the nearby system and the ability of the interconnecting projects to meet FERC Order 661A. If problems with stability or voltage recovery are identified, the need for reactive compensation or system upgrades were investigated. Three-phase faults and single line-to-ground faults were examined prior to any mitigation or curtailment implemented. With exception of transformers and prior outage faults, the typical sequence of events for a three-phase fault is as follows:

- Apply fault at particular station
- Continue fault for five (5) cycles, clear the fault by tripping the faulted facility
- After an additional twenty (20) cycles, re-close the previous facility back into the fault
- Continue fault for five (5) additional cycles
- Trip the faulted facility and remove the fault

Refer to Section 4 for a list and description of fault events analyzed.

Table 2-1: Interconnection Projects Evaluated

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2017-069	3.6 increase to GEN-2013-022	SMASC Solar PV Inverter (524491)	Norton 115kV Switching Station (524502)

Table 2-2: Previously Queued Nearby Interconnection Projects Included

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2001-033 (Commercial Operation)	120	WT1G1 (524890)	San Juan Tap 230kV
GEN-2001-036	80	WT1G1 (599138)	Norton 115kV Switching Station
GEN-2006-018	168.1	GENSAL	TUCO 230kV
GEN-2006-026	604	GENROU (527901, 527902, 527903)	Hobbs 230kV & Hobbs 115kV
GEN-2008-022	299.65	Vestas	Eddy County-Tolk (Crossroads) 345kV
GEN-2010-006	180/205	GENROU	Jones 230kV
GEN-2011-025	79.96	GE 1.79MW	Tap Floyd County - Crosby County 115kV
GEN-2011-045	180/205	GENROU	Jones 230kV
GEN-2011-046	23	GENROU	Tucumcari 115kV
GEN-2011-048/ GEN-2012-036	172/182	GENROU	Mustang 230kV
GEN-2012-001	61.2	CCWE 3.6MW (WT4)	Tap Grassland Â□- Borden County 230 kv
GEN-2012-020	478	GE 1.68MW	TUCO 230kV
GEN-2004-015/ GEN-2012-034	157	GENROU (unit 4; 527164)	Mustang 230kV
GEN-2006-015/ GEN-2012-035	157	GENROU (unit 5; 527165)	Mustang 230kV (527151)
GEN-2012-037	196/203	GENROU (525844)	Tuco 345kV (525832)
GEN-2013-016 / GEN-2015-041	196/203	GE 7FA Gas CT 208 MW	Tuco 345 kV (525832)

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2013-022	25	SMASC (524491)	Norton 115kV (524502)
GEN-2013-027	148.4	Siemens 2.3/2.415	Tap on Yoakum to Tolk 230kV (562480)
GEN-2014-033	70	17 X GE Prolec 4MVA, 2 X GE Prolec 1 MVA, & 5 X Schneider XC680 0.680 MVA PV inverter	Chaves County 115kV
GEN-2014-034	70	17 X GE Prolec 4MVA PVinverter	Chaves County 115kV
GEN-2014-035	30	8 X GE Prolec 4MVA PV inverter	Chaves County 115kV
GEN-2014-040	319.7	GE 2.3 MW	Castro 115 kV (524746)
GEN-2015-014	150.0	Vestas V110 2.0MW (584563)	Tap on Cochran – LG Plains 115kV (560030)
GEN-2016-177	17	Gas Turbine	XTO-Cornell 115 kV station

Table 2-3: SPP Interconnection Projects Removed from the Model

Request	Size (MW)	Generator Model (Gen Bus Number)	Point of Interconnection
GEN-2001-033 (12/31/2022 COD)	60	WT1G1 (524896)	San Juan Tap 230kV
GEN-2011-049 (Withdrawn)	250.7	Siemens 2.3 MW (583093)	Border 345kV (515458)
GEN-2015-004 (Withdrawn)	151.8	Siemens 2.3 MW (583096)	Border 345kV (515458)
GEN-2015-099 (Withdrawn)	73.3	Power Electronics FS2000CU (587673)	Maddox 115kV (528355)
GEN-2016-023 (Withdrawn)	150.5	GE Wind (587093/587095)	Laramie to Sidney 345kV Tap (560075)

GEN-2016-029 (Withdrawn)	150.5	GE Wind (587193/587195)	Laramie to Sidney 345kV Tap (560075)
GEN-2016-037 (queued to DISIS-2017-001)	300	Vestas V110 2.0 MW (587233)	Chisholm to Gracemont 345kV Tap (560078)
GEN-2016-096 (Withdrawn)	227.7	Siemens 2.3 MW (587783/587787)	Pauline to Moore 345kV Tap (560062)
GEN-2016-121	110	SMA Sunny Central 2.5 MW (587993)	Road Runner 345kV (528025)
GEN-2016-123	298	Vestas V110 2.0 MW (588003/588006)	Cross Roads 345kV (527656)
GEN-2016-124	150	Vestas V110 2.0 MW (588013)	Cross Roads 345kV (527656)
GEN-2016-125	74	Vestas V110 2.0 MW (588023)	Cross Roads 345kV (527656)
GEN-2016-129 (Withdrawn)	132	Wind	Valliant 345 kV substation

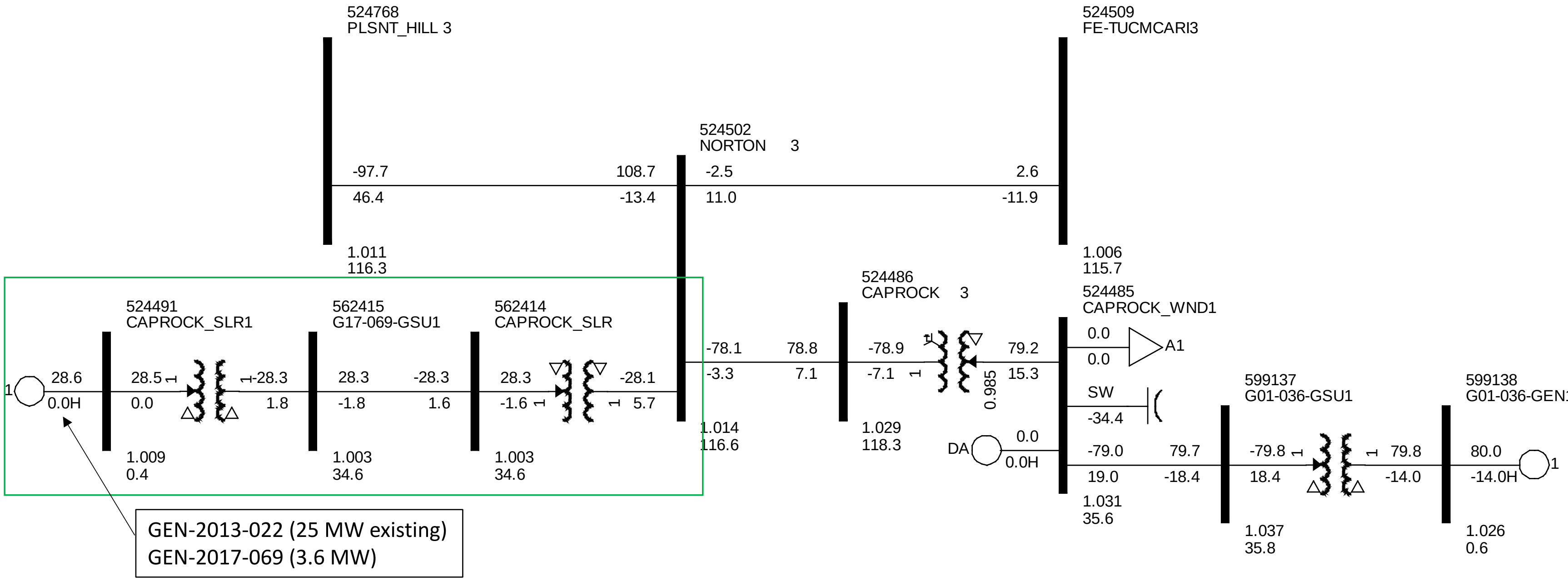

Figure 2-1. Power flow one-line diagram for interconnection project at Norton 115kV Switching Station (GEN-2017-069) for 2017 Winter Peak conditions.

SECTION 3: POWER FLOW ANALYSIS

The objective of the power flow analysis was to determine the impacts of the generator interconnection on the steady-state thermal and voltage constraints on the SPP transmission system. The analysis evaluated if GEN-2017-069 can interconnect 3.6 MW of solar generation with Energy Resource Interconnection Service (ERIS) and Network Resource Interconnection Service (NRIS) through November 30, 2020.

3.1 Approach

MEPPI utilized the seven (7) following DISIS-2016-002-2 power flow cases for this analysis:

- Steady-State Analysis
  - 2017 Winter Peak
  - 2018 Spring
  - 2018 Summer Peak
  - 2021 Light Load
  - 2021 Summer Peak
  - 2021 Winter Peak
  - 2026 Summer Peak

The power flow cases were dispatched in accordance with DISIS Manual, Table 1: Generation Dispatch in the Power Flow Models, and Business Practices 7250 to develop the ERIS and NRIS cases. Fourteen (14) Before Transfer (BC) cases were created by including GEN-2017-069 but dispatched at 0 MW for ER (7 cases) and NR (7 cases) dispatch scenarios. Fourteen (14) Transfer cases (TC) were created by including GEN-2017-069 online and dispatched at 3.6 MW for ER (7 cases) and NR (7 cases) dispatch scenarios. Refer to the attachment for the status of previously assigned upgrades and higher queued requests.

Note at the time of study commencement, the TUCO to Yoakum 345kV circuit #1 was not expected to be in-service by study completion. This circuit was excluded from the ERIS analysis. However, during the NRIS analysis, it was confirmed that the circuit is in-service per SPP Operations Engineering. The following is the status of the TUCO to Yoakum 345kV circuit #1 for this analysis:

- TUCO to Yoakum 345kV out-of-service
  - All ERIS models
  - NRIS 2017 Winter Peak
  - NRIS 2018 Spring
  - NRIS 2018 Summer Peak
- TUCO to Yoakum 345kV in-service

- NRIS 2021 Winter Peak
- NRIS 2021 Light Load
- NRIS 2021 Summer Peak
- NRIS 2026 Summer Peak

3.2 Steady-State Thermal and Voltage Analysis Results

The power flow analysis observed no limitations for full interim service for GEN-2017-069 for ERIS or NRIS service. Power flow analysis has determined that GEN-2017-069 can interconnect 3.6 MW of solar generation with Energy Resource Interconnection service or Network Resource Interconnection Service through November 30, 2020. The full power report can be found as an attachment to this document.

SECTION 4: STABILITY ANALYSIS

The objective of the stability analysis was to determine the impacts of the generator interconnection on the stability and voltage recovery on the SPP transmission system. If problems with stability or voltage recovery were identified, the need for reactive compensation or Network Upgrades was investigated.

4.1 Approach

MEPPI utilized the three (3) following DISIS-2016-002-2 Normal Dispatch Scenario power flow cases and dynamic databases:

- MDWG16-17W_DIS16022_G06
- MDWG16-18S_DIS16022_G06
- MDWG16-26S_DIS16022_G06

Each case was examined prior to the stability analysis to ensure the case contained the proposed study projects and any previously queued projects listed in Tables 2-1 and 2-2 respectively. The Normal Dispatch Scenario included previously assigned upgrades that were to be in service by the Commercial Operation Date of GEN-2017-069. The following previously assigned upgrades understood to be in-service, were included in the analysis:

- Upgrade Carlisle 230/115kV transformer
- TUCO to Yoakum to Hobbs 345kV circuit #1
- Yoakum 345/230kV transformer
- Hobbs 345/230kV transformer
- Rebuild Plant X to Tolk 230kV circuits #1 and #2
- Upgrade existing Tuco 345/230kV transformer circuit #1

The following previously assigned upgrades with a future in-service date were removed from the DISIS-2016-002-2 Group 06 cases prior to running the analysis:

- Eddy to Kiowa 345kV circuit #1

Additionally, sensitivity cases were created for all three seasons. The sensitivity cases included dispatching local generation to 100% output. Examples of electrically similar and adjacent substations include but are not limited to any kV of:

- the same substation
    - e.g. lower kV, zero-impedance branch connected bus, or alternate owner facilities
- radially connected substations

  - islanded topology resultant from a connected circuit outage
    - i.e. Generating Facility
  - substantially weakened interconnection from a connected circuit outage
    - i.e. loss of 100+ kV circuit maintains interconnection through 69kV system
- substations connected by a network circuit
  - sectionalized single (or double) circuits from substations or buses to accommodate generation and radial load are considered a single network circuit
    - i.e. a network circuit may include several buses each with two non-radial circuits
- substations within close electrical proximity
  - i.e. approximately 30 circuit miles at 345kV or a circuit impedance path less than 0.02 pu
- substations adjacent to another adjacent substation with a generating facility
  - i.e. generation both 1 & 2 levels away are electrically similar but generation that is only 2 levels way may not be electrically similar

The Quay County generation (GEN-2011-046) was the only generation unit that met the above criteria and was scaled to 100% and offset by the SPP footprint. Refer to Tables 2-1, 2-2, and 2-3 for the status of higher queued requests, DISIS-2016-001 requests, DISIS-2016-002, and select DISIS-2017-001 requests.

After updating the power flow cases with the above changes and dispatching units local to the study area according to SPP criteria, there was no suspect power flow data in the study area for the normal dispatch cases or sensitivity cases. The dynamic datasets were also verified and stable initial system conditions (i.e., “flat lines”) were achieved. Three-phase and single line-to-ground (single-phase) faults listed in Table 4-1 were examined for the normal dispatch scenario. A subset of the contingency list in Table 4-1 was examined for the sensitivity dispatch (Contingency FLT21 through FLT42). Single-phase fault impedances were calculated for each season to result in a voltage of approximately 60% of the pre-fault voltage. Refer to Table 4-2 for a list of the calculated single-phase fault impedances.

Table 4-1: Contingency Fault Definitions

Cont. No.	Cont. Name	Description
Tuco/OKU Fault Events		
1	FLT01-3PH	3 phase fault on the Tuco (525832) to Border (515458) 345 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
2	FLT02-3PH	3 phase fault on the Tuco (525832) to OKU (511456) 345 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
3	FLT03-3PH	3 phase fault on the Tuco 345/230/13.8 kV (525832/525830/525824) transformer circuit 1, near Tuco 345 kV. a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
4	FLT04-3PH	3 phase fault on the Tuco (525830) to Tolk East (525524) 230 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
5	FLT05-3PH	3 phase fault on the OKU (511456) to LES (511468) 345 kV line circuit 1, near OKU. a. Apply fault at the OKU 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line and remove the fault. c. Block the DC tie at OKU.
6	FLT06-3PH	3 phase fault on the OKU (511456) to LES (511468) 345 kV line circuit 1, near OKU. a. Apply fault at the OKU 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line and remove the fault.
7	FLT07-3PH	3 phase fault on the OKU (511456) to Oklaun (599891) 345 kV line circuit 1 (OKU DC tie), near OKU. a. Apply fault at the OKU 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line and remove the fault. c. Block the DC tie at OKU.
8	FLT08-SB	**Single phase fault with stuck breaker at Tuco 345 kV (525832)** a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Tuco 345/230/13.2 kV (525832/525830/525824) transformer d. Tuco (525832) – Border (515458) 345 kV
9	FLT09-SB	**Single phase fault with stuck breaker at Tuco 345 kV (525832)** a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Tuco 345/230/13.2 kV (525832/525830/525824) transformer d. Tuco (525832) – OKU (511456) 345 kV

10	FLT10-PO	**Prior Outage of the Tuco 345/230/13.2 kV (525832/525830/525824) transformer circuit 1;** 3 phase fault on the Tuco (525832) to Border (515458) 345 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
11	FLT11-PO	**Prior Outage of the Tuco (525832) to Border (515458) 345kV circuit 1;** 3 phase fault on the Tuco (525832) to OKU (511456) 345 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
12	FLT12-PO	**Prior Outage of the Tuco (525832) to Border (515458) 345kV circuit 1;** 3 phase fault on the OKU (511456) to LES (511468) 345 kV line circuit 1, near OKU. a. Apply fault at the OKU 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
13	FLT13-PO	**Prior Outage of the Tuco (525832) to Border (515458) 345kV circuit 1;** 3 phase fault on the OKU (511456) to LES (511468) 345 kV line circuit 1, near OKU. a. Apply fault at the OKU 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Block the DC tie at OKU.
14	FLT14-PO	**Prior Outage of the OKU (511456) to LES (511468) 345kV circuit 1;** 3 phase fault on the Tuco (525832) to Border (515458) 345 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
15	FLT15-PO	**Prior Outage of the OKU (511456) to LES (511468) 345kV circuit 1 (block OKU DC tie);** 3 phase fault on the Tuco (525832) to Border (515458) 345 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
16	FLT16-PO	**Prior Outage of the Potter County (523961) to Hitchland (523097) 345kV circuit 1;** 3 phase fault on the OKU (511456) to LES (511468) 345 kV line circuit 1, near OKU. a. Apply fault at the OKU 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
17	FLT17-PO	**Prior Outage of the Potter County (523961) to Hitchland (523097) 345kV circuit 1;** 3 phase fault on the OKU (511456) to LES (511468) 345 kV line circuit 1, near OKU. a. Apply fault at the OKU 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Block the DC tie at OKU.
18	FLT18-PO	**Prior Outage of the Potter County (523961) to Hitchland (523097) 345kV circuit 1;** 3 phase fault on the Tuco (525832) to Border (515458) 345 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Potter County Fault Events		
19	FLT19-3PH	3 phase fault on the Potter County (523961) to Hitchland (523097) 345 kV line circuit 1, near Potter County. a. Apply fault at the Potter County 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
20	FLT20-3PH	3 phase fault on the Potter County 345/230/13 kV (523961/523959/523957) transformer circuit 1, near Potter County. a. Apply fault at the Potter County 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
21	FLT20_2-SB	**Single phase fault with stuck breaker at Potter County 345 kV (523961)** a. Apply fault at the Potter County 345 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Potter County 345/230/13 kV (523961/523959/523957) transformer
Norton Fault Events		
22	FLT21-3PH	3 phase fault on the Norton (524502) to FE-Tucumcari (524509) 115 kV line circuit 1, near Norton. a. Apply fault at the Norton 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
23	FLT22-3PH	3 phase fault on the Pleasant Hills (524768) to East Clovis (524773) 115 kV line circuit 1, near Pleasant Hills. a. Apply fault at the Pleasant Hills 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
24	FLT23-3PH	3 phase fault on the Pleasant Hills (524768) to North Clovis (524776) 115 kV line circuit 1, near Pleasant Hills. a. Apply fault at the Pleasant Hills 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
25	FLT24-3PH	3 phase fault on the Pleasant Hills (524768) to Holland (524831) 115 kV line circuit 1, near Pleasant Hills. a. Apply fault at the Pleasant Hills 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
26	FLT25-3PH	3 phase fault on the Pleasant Hills 230/115/13.8 kV (524770/524768/524767) transformer circuit 1, near Pleasant Hills 115 kV. a. Apply fault at the Pleasant Hills 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
27	FLT26-3PH	3 phase fault on the Pleasant Hills (524770) to Oasis (524875) 230 kV line circuit 1, near Pleasant Hills. a. Apply fault at the Pleasant Hills 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.

28	FLT27-3PH	3 phase fault on the Pleasant Hills (524770) to Roosevelt (524911) 230 kV line circuit 1, near Pleasant Hills. a. Apply fault at the Pleasant Hills 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
29	FLT28-3PH	3 phase fault on the Roosevelt (524911) to Tolk East (525524) 230 kV line circuit 1, near Roosevelt. a. Apply fault at the Roosevelt 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
30	FLT29-3PH	3 phase fault on the Roosevelt (524909) to Tolk West (525531) 230 kV line circuit 2, near Roosevelt. a. Apply fault at the Roosevelt 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
31	FLT30-3PH	3 phase fault on the Roosevelt 230/115/13.8 kV (525909/524908/524907) transformer circuit 1, near Roosevelt 230 kV. a. Apply fault at the Roosevelt 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
32	FLT31-3PH	3 phase fault on the Oasis 230/115/13.8 kV (524875/524874/524872) transformer circuit 1, near Oasis 230 kV. a. Apply fault at the Oasis 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
33	FLT32-3PH	3 phase fault on the Oasis (524875) to Roosevelt (524915) 230 kV line circuit 1, near Oasis. a. Apply fault at the Oasis 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
34	FLT33-3PH	3 phase fault on the Oasis (524875) to San Juan Tap (524885) 230 kV line circuit 1, near Oasis. a. Apply fault at the Oasis 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
35	FLT34-SB	**Single phase fault with stuck breaker at Pleasant Hills 115 kV (524768)** a. Apply fault at the Pleasant Hills kV bus. b. Clear fault after 16 cycles and trip the following elements c. Pleasant Hills (524768) – East Clovis (524773) 115 kV d. Pleasant Hills (524768) – Holland (524831) 115 kV
36	FLT35-SB	**Single phase fault with stuck breaker at Pleasant Hills 115 kV (524768)** a. Apply fault at the Pleasant Hills kV bus. b. Clear fault after 16 cycles and trip the following elements c. Pleasant Hills (524768) – North Clovis (524776) 115 kV d. Pleasant Hills (524768) – Holland (524831) 115 kV

37	FLT36-PO	**Prior Outage of the Pleasant Hills (524768) to East Clovis (524773) 115 kV line circuit 1;** 3 phase fault on the Pleasant Hills (524768) to North Clovis (524776) 115 kV line circuit 1, near Pleasant Hills. a. Apply fault at the Pleasant Hills kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
38	FLT37-PO	**Prior Outage of the Pleasant Hills (524768) to East Clovis (524773) 115 kV line circuit 1;** 3 phase fault on the Pleasant Hills (524768) to Holland (524831) 115 kV line circuit 1, near Pleasant Hills. a. Apply fault at the Pleasant Hills kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
39	FLT38-PO	**Prior Outage of the Pleasant Hills Transformer (524770/524768/524767) circuit 1;** 3 phase fault on the Pleasant Hills (524768) to East Clovis (524773) 115 kV line circuit 1, near Pleasant Hills. a. Apply fault at the Pleasant Hills kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
40	FLT39-PO	**Prior Outage of the Pleasant Hills Transformer (524770/524768/524767) circuit 1;** 3 phase fault on the Pleasant Hills (524768) to North Clovis (524776) 115 kV line circuit 1, near Pleasant Hills. a. Apply fault at the Pleasant Hills kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
41	FLT40-PO	**Prior Outage of the Pleasant Hills Transformer (524770/524768/524767) circuit 1;** 3 phase fault on the Pleasant Hills (524768) to Holland (524831) 115 kV line circuit 1, near Pleasant Hills. a. Apply fault at the Pleasant Hills kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
42	FLT41-3PH	3 phase fault on the FE-Tucumcari (524509) to Ceilo-Tap (583610) 115 kV line circuit 1, near FE-Tucumcari. a. Apply fault at the FE-Tucumcari 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
43	FLT42-3PH	3 phase fault on the Lopez (524472) to Campbell St (524477) 115 kV line circuit 1, near Campbell St. a. Apply fault at the Campbell St 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.

Table 4-2: Calculated Single-Phase Fault Impedances

[1]Ref. No.	Cont. Name	Faulted Bus	Single-Phase Fault Impedance (MVA)		
			2017 Winter	2018 Summer	2026 Summer
8	FLT08-SB	Tuco 345kV (525832)	-3421.9	-4437.5	-4437.5
9	FLT09-SB	Tuco 345kV (525832)	-3421.9	-4437.5	-4437.5
21	FLT20_2-SB	Potter County 345kV (523961)	-2850.0	-2690.0	-2718.0
34	FLT34-SB	Pleasant Hills 115kV (524768)	-1250.0	-1250.0	-1250.0
35	FLT35-SB	Pleasant Hills 115kV (524768)	-1250.0	-1250.0	-1250.0

(1) Refer to Table 4-1 for a description of the contingency scenario.

Bus voltages, machine rotor angles, and previously queued generation in the study area were monitored in addition to bus voltages and machine rotor angles in the following areas:

- 520 AEPW
- 524 OKGE
- 525 WFEC
- 526 SPS
- 531 MIDW
- 534 SUNC
- 536 WERE

Requested and previously queued generation outside the above study area was also monitored.

The results of the analysis determined if reduce Interim Service was required to obtain acceptable system performance. Note all wind or solar farms are required to meet FERC Order 661A low voltage requirements and should return to its pre-disturbance operating voltage.

4.2 Normal Dispatch Stability Analysis Results

The normal dispatch stability analysis determined that was a P1 contingency across all three seasons that resulted in high post-fault steady-state voltages at Oklaunion 345kV and P6 contingencies in the 2018 Summer Peak season that resulted in a non-damped voltage response and high post-fault steady-state voltages following the fault event.

Refer to Table 4-3 for a summary of the stability analysis results for the normal dispatch scenario. Table 4-3 is a summary of the stability results for the 17WP, 18SP, and 26SP conditions and states whether the system remained stable or generation tripped offline, if acceptable voltage recovery was observed after the fault was cleared, and if the voltage recovered to above 0.9 p.u. and below 1.1 p.u. post fault steady-state conditions. Voltage recovery criteria includes ensuring that the transient voltage recovery is between 0.7 p.u. and 1.2 p.u. and ending in a steady-state voltage (for N-1 contingencies) at the pre-contingent level or at least above 0.9 p.u. and below 1.1. p.u.

Table 4-3: Summary of Results for 17WP, 18SP, and 26SP Conditions for Normal Dispatch Scenario

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
1	FLT01-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
2	FLT02-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
3	FLT03-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
4	FLT04-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
5	FLT05-3PH	-	-	OKU V > 1.1	Stable	-	-	OKU V > 1.1	Stable	-	-	OKU V > 1.1	Stable
6	FLT06-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
7	FLT07-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
8	FLT08-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
9	FLT09-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
10	FLT10-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
11	FLT11-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
12	FLT12-PO	-	-	Compliant	Stable	-	-	Compliant	Undamped V Oscillations	-	-	Compliant	Stable
13	FLT13-PO	-	-	OKU V > 1.1	Stable	-	-	OKU V > 1.1	Undamped V Oscillations	-	-	OKU V > 1.1	Stable
14	FLT14-PO	-	-	Compliant	Stable	-	-	Compliant	Undamped V Oscillations	-	-	Compliant	Stable
15	FLT15-PO	-	-	Compliant	Stable	-	-	Compliant	Undamped V Oscillations	-	-	Compliant	Stable
16	FLT16-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
17	FLT17-PO	-	-	OKU V > 1.1	Stable	-	-	OKU V > 1.1	Stable	-	-	OKU V > 1.1	Stable
18	FLT18-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
19	FLT19-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
20	FLT20-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
21	FLT20_2-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
22	FLT21-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
23	FLT22-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable

Table 4-3: Summary of Results for 17WP, 18SP, and 26SP Conditions for Normal Dispatch Scenario (cont.)

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
24	FLT23-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
25	FLT24-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
26	FLT25-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
27	FLT26-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
28	FLT27-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
29	FLT28-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
30	FLT29-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
31	FLT30-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
32	FLT31-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
33	FLT32-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
34	FLT33-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
35	FLT34--SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
36	FLT35--SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
37	FLT36-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
38	FLT37-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
39	FLT38-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
40	FLT39-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
41	FLT40-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
42	FLT41-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
43	FLT42-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable

It was observed that the limiting faults for the normal dispatch scenarios were NERC Category P1 and P6 events near Oklaunion 345kV and Tuco 345kV. The limiting NERC Category P1 contingency was FLT05-3PH, a three-phase fault at Oklaunion 345kV resulting in the loss of the Oklaunion to Lawton Eastside 345kV line and simultaneous blocking of the Oklaunion HVDC line. Following the clearing of the fault, the Oklaunion 345kV voltage has a post-fault steady-state voltage above 1.10 p.u. due to the Oklaunion HVDC capacitive support at Oklaunion. It is recommended the capacitive support be included in the simultaneous blocking of the HVDC line. Refer to Figure 4-1 for a representative voltage plot at Oklaunion and Tuco 345kV substations comparing the original fault event to the fault event including the tripping of the capacitive support.

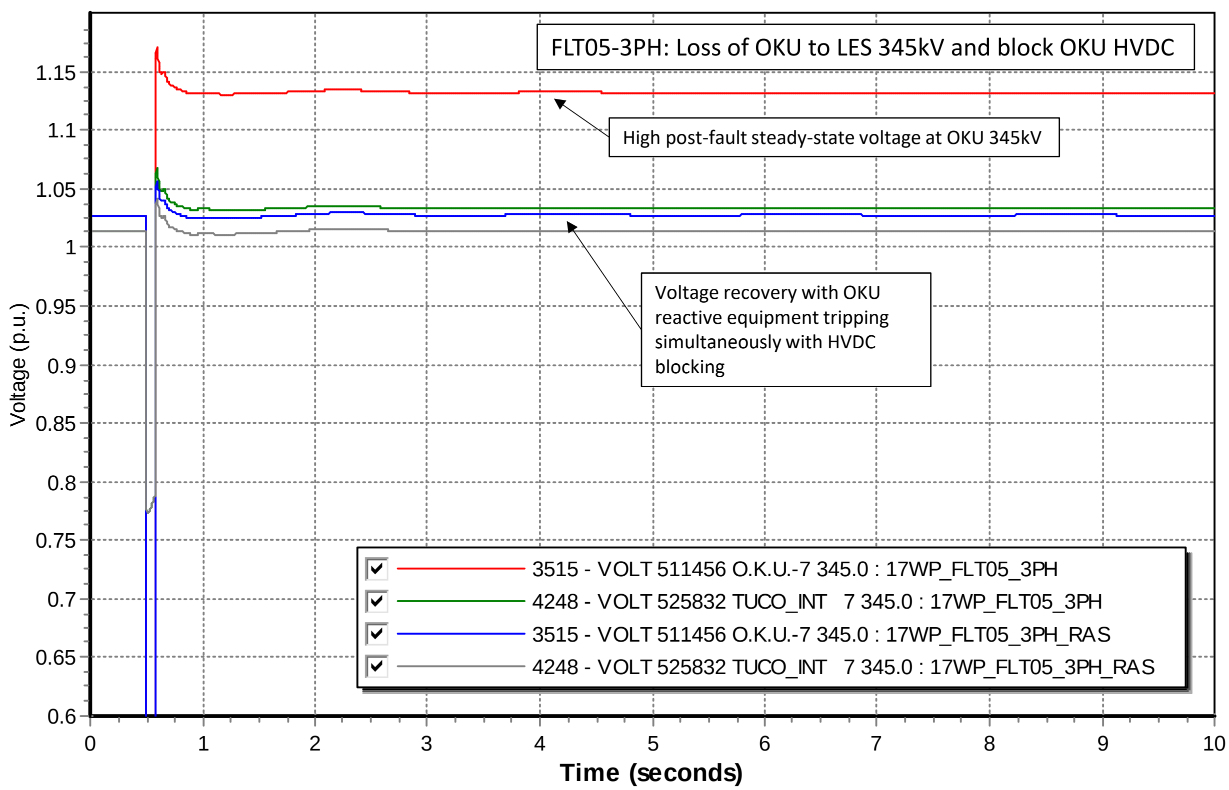

Figure 4-1: Representative voltage plot for FLT05-3PH for 2017 Winter Peak Conditions.

4.2.1 Curtailment for P6 Events for the Normal Dispatch Scenario

The limiting NERC Category P6 contingencies involved the outage of the area tie-lines out of the Tuco 345kV substation and Oklaunion 345kV substation in the 2018 Summer Peak season. The loss of the Tuco to Border 345kV line and loss of the Oklaunion to Lawton Eastside 345kV line (with and without Oklaunion 345kV HVDC blocking) results in non-damped voltage oscillations on the 230kV system in the Tolk, Deaf Smith, and Bushland areas. Following the prior outage of the Tuco to Border 345kV line or Oklaunion to Lawton Eastside 345kV line, generation curtailment of up to approximately 600 MW in the central SPS area (Zone 1505 – CNPL) was found to mitigate the non-damped voltage oscillations.

Refer to Figure 4-2 for a representative voltage plot of area bus voltages with and without generation curtailment for FLT12-PO. FLT12-PO is a prior outage of the Tuco to Border 345kV line followed by a three-phase fault on the Oklaunion to Lawton Eastside 345kV line. It can be observed in the 2018 Summer Peak, with the generation curtailment of approximately 600 MW, the system exhibits sufficient damping and recovers within SPP Performance Criteria.

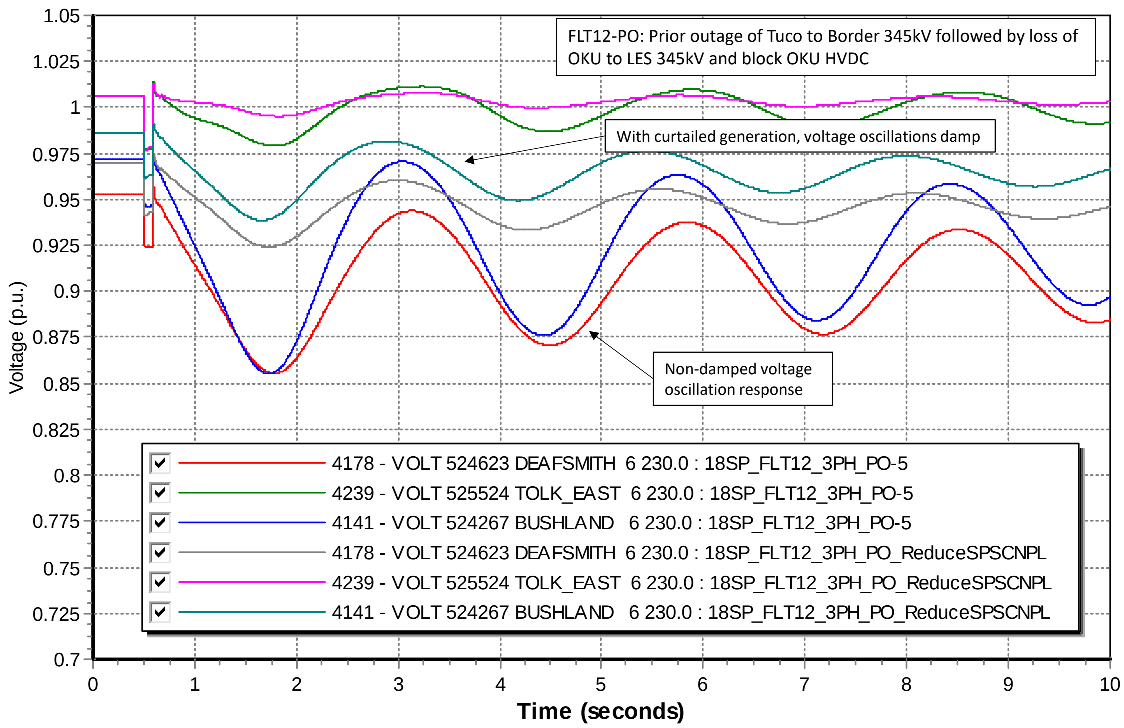

Figure 4-2: Representative voltage plot for FLT12-PO for 2018 Summer Peak Conditions.

4.2.2 Summary of the Normal Dispatch Scenario Results

The analysis of the Normal Dispatch Scenario determined mitigation is required to alleviate high post-fault steady-state voltages and non-damped voltage oscillation issues in the Tuco/Oklaunion 345kV vicinity for select P1 and P6 events. It was determined that tripping the Oklaunion reactive support at the Oklaunion substation under system conditions with the HVDC tie being blocked and curtailing area generation by up to approximately 600 MW would alleviate the voltage violation concerns.

It was determined from the fault events evaluated that GEN-2017-069 does not have an adverse impact on system stability. All system voltages, rotor angles, and real and reactive power of area generation recover within SPP Performance Criteria.

4.3 Sensitivity Stability Analysis Results

The sensitivity dispatch stability analysis determined that for each evaluated P1, P4, and P6 contingency events (contingency FLT21 through FLT42 from Table 4-1) across all three seasons, the system remained stable with damping and voltage recovery within SPP Performance Criteria.

Refer to Table 4-4 for a summary of the stability analysis results for the sensitivity dispatch scenario. Table 4-4 is a summary of the stability results for the 17WP, 18SP, and 26SP conditions and states whether the system remained stable or generation tripped offline, if acceptable voltage recovery was observed after the fault was cleared, and if the voltage recovered to above 0.9 p.u. and below 1.1 p.u. post fault steady-state conditions. Voltage recovery criteria includes ensuring that the transient voltage recovery is between 0.7 p.u. and 1.2 p.u. and ending in a steady-state voltage (for N-1 contingencies) at the pre-contingent level or at least above 0.9 p.u. and below 1.1. p.u.

Table 4-4: Sensitivity Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
1	FLT21-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
2	FLT22-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
3	FLT23-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
4	FLT24-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
5	FLT25-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
6	FLT26-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
7	FLT27-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
8	FLT28-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
9	FLT29-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
10	FLT30-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
11	FLT31-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
12	FLT32-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
13	FLT33-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
14	FLT34--SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
15	FLT35--SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
16	FLT36-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
17	FLT37-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
18	FLT38-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
19	FLT39-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
20	FLT40-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
21	FLT41-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
22	FLT42-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable

4.3.1 Summary of the Sensitivity Dispatch Scenario Results

The analysis of the sensitivity dispatch scenario determined there are no violation concerns for the fault events evaluated. All fault events resulted in acceptable voltage, rotor angle, and power oscillation recovery applicable to SPP Performance Criteria. It was determined from the sensitivity faults evaluated that GEN-2017-069 does not have an adverse impact on the generation interconnected within the same vicinity of SPS and neighboring transmission systems.

SECTION 5: CONCLUSION

Summary of Power Flow Analysis

The power flow Analysis determined there were no steady-state thermal or voltage constraints meeting the distribution factor criteria requiring mitigation with ERIS or NRIS service through November 30, 2020.

Summary of Stability Analysis

The stability analysis determined that there were multiple contingencies across all seasons and dispatch scenarios that resulted in high post-fault steady-state voltage and multiple P6 contingencies that resulted in non-damped voltage response in the 2018 Summer Peak season.

It was determined that fault events with high steady-state voltages observed at Oklaunion 345kV may be resolved by tripping the Oklaunion HVDC reactive equipment at Oklaunion 345kV simultaneously with blocking of the Oklaunion HVDC tie. Following the prior outage of any segment of the TUCO to Border to Woodward 345kV or TUCO to Oklaunion to Lawton Eastside 345kV, the analysis determined that curtailing generation by up to 600 MW in central SPS area resulted in a stable response with no generation tripping or system instability observed.

With the identified upgrades and curtailment above, the stability analysis determined that GEN-2017-069 has the ability to connect, from the transmission grid point of view, with full interim service.

Power flow and stability analysis from this Interim Availability study determined that GEN-2017-069 could interconnect with full interim service (3.6 MW) of solar generation with ERIS and NRIS service through November 30, 2020.

APPENDIX A: STABILITY ANALYSIS STEADY STATE AND DYNAMIC MODEL DATA

Base Case Power Flows

Three base case power flows were provided to MEPPI by SPP:

- MDWG16-17W_DIS16022_G06.sav
- MDWG16-18S_DIS16022_G06.sav
- MDWG16-26S_DIS16022_G06.sav

Three dynamic files were provided to MEPPI by SPP:

- MDWG16-17W_DIS16022_G06.dyr
- MDWG16-18S_DIS16022_G06.dyr
- MDWG16-26S_DIS16022_G06.dyr

Updates Applied to Base Case

Addition of:

- Upgrade Carlisle 230/115kV transformer
- Yoakum to Hobbs 345kV
- Yoakum 345/230kV transformer
- Hobbs 345/230kV transformer
- Rebuild Plant X to Tolk 230kV circuits #1 and #2
- Upgrade existing Tuco 345/230kV transformer

Removal of:

- Tuco to Yoakum 345kV circuit #1
- Eddy to Kiowa 345kV circuit #1
- SPP Withdrawn requests:
    - GEN-2011-049
    - GEN-2015-004
    - GEN-2015-099
    - GEN-2016-023
    - GEN-2016-029
    - GEN-2016-037
    - GEN-2016-096
    - GEN-2016-121
    - GEN-2016-123
    - GEN-2016-124
    - GEN-2016-125

Request Data:

GEN-2017-069

- Solar Farm Size: 3.6 MW (addition to Cap Rock Solar GEN-2013-022)
- Interconnection:
  - Voltage: 115kV
  - POI: Norton 115kV
  - Transformer: 115/34.5 kV step-up transformer
    - Z: 8.5%
- Collector System Equivalent Model:
  - Transmission Line:
    - R = 0.001415 p.u.
    - X = 0.0137 p.u.
    - B = 0.0027 p.u.
- Solar Farm Parameters
  - SMA Sunny Central
  - Machine Terminal Voltage: 0.7 kV
  - Rated Power: 3.6 MW
  - Generator Step-Up Transformer:
    - MVA: 26 Winding MVA
    - Z: 5.8%

The following is the dynamic data for GEN-2013-022 and GEN-2017-069:

```
524491 'USRMDL' 1 'SMASC139' 1 1 0 120 25 200
 1.0   1.000  0.123 0.8 1.0 0.0 1.0 0.0 0.35
 1.0 0.0 5.0 0.5 2.0
 0.0 0.9 0.5 1.0 0.9 0.9
 0.0 0.2 0.05 0.4
 1.0 1.0
 2.0 2.0 2.0 2.0 0.1 0.1 0.1 0.1 0.1 0.1
 0.01 0.0 20.0 0.01 0.2 0.0 0.0
 0.0 0.125 0.1
 1.22 5.0 1.21 1.0 1.2 10.0 1.18 9.5 1.15 9.0 0.88 12.0 0.8 10.0 0.7 9.0 0.6 2.0 0.5 0.2
 67.0 0.05 66.8 0.08 66.0 0.09 65.0 0.1 64.0 1.0 62.5 3.0 58.3 5.0 57.0 3.0 50.0 0.1 49.0 0.09 48.5 0.08 48.0 0.05
 30.0 1.0 100.0 30.0 0.0 0.0 5.0 0.3
 0.0 20.0 1.0 1.0
 0.0 360.0 0.5 0.01 0.05 0.0 0.5 1.0
 1.0 1.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0/
52449101 'VTGTPAT' 90104 90104 1  0.00  1.15  3.0   0.01 /
52449102 'VTGTPAT' 90104 90104 1  0.00  1.30  1.0   0.01 /
52449103 'VTGTPAT' 90104 90104 1  0.00  1.40  0.001 0.01 /
52449104 'VTGTPAT' 90104 90104 1  0.80  2.00  5.0   0.01 /
52449105 'VTGTPAT' 90104 90104 1  0.40  2.00  2.0   0.01 /
52449106 'FRQTPAT' 90104 90104 1 40.00 63.00 60.0   0.01 /
52449107 'FRQTPAT' 90104 90104 1 57.00 80.00 60.0   0.01 /
```

APPENDIX B: PLOTS FOR 2017 WINTER PEAK CONDITIONS WITH NORMAL DISPATCH

Plots available upon request

APPENDIX C: PLOTS FOR 2018 SUMMER PEAK CONDITIONS WITH NORMAL DISPATCH

Plots available upon request

APPENDIX D: PLOTS FOR 2026 SUMMER PEAK CONDITIONS WITH NORMAL DISPATCH

Plots available upon request

APPENDIX E: PLOTS FOR 2017 WINTER PEAK CONDITIONS WITH SENSITIVITY DISPATCH

Plots available upon request

APPENDIX F: PLOTS FOR 2018 SUMMER PEAK CONDITIONS WITH SENSITIVITY DISPATCH

Plots available upon request

APPENDIX G: PLOTS FOR 2026 SUMMER PEAK CONDITIONS WITH SENSITIVITY DISPATCH

Plots available upon request

CONSULTANT'S STUDY REPORT – SCENARIO 2

See subsequent pages for the Consultant's Limited Operation Interconnection System Impact Study for GEN-2016-123, GEN-2016-124, & GEN-2016-125 and Interim Availability Interconnection System Impact Study report for GEN-2017-069 with system conditions on 12/1/2020.

The analysis performed indicates that the GEN-2016-123, GEN-2016-124, & GEN-2016-125 generating facility may reliably operate the requested 522 MW under Limited Operation up to the following Crossroads 345 kV MW injection limits from all generating facilities:

Table 1: Crossroads 345 kV Cumulative Injection Limits

Crossroads 345 kV Cumulative Injection Limit	SPCWG Crossroads Sagamore RAS	Crossroads 345 kV breaker configuration to trip and lockout Sagamore Wind facility	Crossroads to Tolk 345 kV circuit	Tolk 345 kV to 230 kV transformer #1 (and #2)	Crossroads to Eddy County 345 kV circuit	Eddy County 345 kV to 230 kV transformer	Eddy County to Kiowa 345 kV circuit
N/A	In-service	In-service	In-service	In-service	In-service	In-service	In-service
*564 MW thermal 650 MW stability	Out-of-service	In-service	In-service	In-service	In-service	In-service	In-service
604 MW	In-service	Out-of-service	In-service	In-service	In-service	In-service	In-service
490 MW	In-service	N/A	Out-of-service	N/A	In-service	In-service	In-service
490 MW	In-service	N/A	N/A	Out-of-service	In-service	In-service	In-service
537 MW	In-service	N/A	In-service	In-service	Out-of-service	In-service	In-service
537 MW	In-service	N/A	In-service	In-service	In-service	Out-of-service	In-service
537 MW	In-service	N/A	In-service	In-service	In-service	In-service	Out-of-service

*Voltage schedules, applicable ratings, and actual system conditions may require a reduced value

The values in Table 1 represent a reduction from the consultant evaluation in accordance with SPP Operating Criteria Appendix OP-1 section 2.c.

The analysis identified potential voltage constraints that may require system adjustments to maintain acceptable voltages at Border 345 kV that should be monitored by the Transmission Operator and coordinated with SPP as appropriate.

Pursuant to GIA Article 5.9; GEN-2016-123, GEN-2016-124, & GEN-2016-125 may operate under Limited Operation in accordance with the injection limitations outlined in Table 1 for the portion of the injection limits not utilized by generating facilities with full interconnection service.

The GEN-2017-069 requested Interim Interconnection Service is feasible at the requested 3.6 MW under the studied conditions.

MITSUBISHI ELECTRIC POWER PRODUCTS, INC.
POWER SYSTEMS ENGINEERING DIVISION
530 KEYSTONE DRIVE
WARRENDALE, PA 15086, U.S.A.

Phone: (724) 778-5111 Fax: (724) 778-5149
Home Page: www.meppi.com

Southwest Power Pool, Inc. (SPP)

Group 06 Limited Operation and Interim Availability Interconnection System Impact Study

Final Report

REP-0981
Revision #04

March 2021

Submitted By:
Mitsubishi Electric Power Products, Inc. (MEPPI)
Power Systems Engineering Division
Warrendale, PA

MITSUBISHI ELECTRIC POWER PRODUCTS, INC.
POWER SYSTEMS ENGINEERING DIVISION
530 KEYSTONE DRIVE
WARRENDALE, PA 15086, U.S.A.

Phone: (724) 778-5111 Fax: (724) 778-5149
Home Page: www.meppi.com

Report Revision Table

Revision	Report Revision Table	Date
0	Issue Draft Report for Review	11/10/2020
1	Address comments and issue Final Report	11/17/2020
2	Report reflects SOL of 650MW at Crossroads	12/31/2020
3	Address SPP comments	1/8/2021
4	Update Crossroads 345kV breaker configuration and Sagamore Wind model parameters	3/5/2021

MITSUBISHI ELECTRIC POWER PRODUCTS, INC.
POWER SYSTEMS ENGINEERING DIVISION
530 KEYSTONE DRIVE
WARRENDALE, PA 15086, U.S.A.

Phone: (724) 778-5111 Fax: (724) 778-5149
Home Page: www.meppi.com

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Date:	Mar 2021	
Author:	Nicholas Tenza; M. Principle Consultant, Power Systems Engineering Division	*Nicholas Tenza*
Reviewed:	Taylor Cramer; Senior Engineer, Power Systems Engineering Division	*Taylor Cramer*

EXECUTIVE SUMMARY

SPP requested a Limited Operation Impact Study for Group 06 requests GEN-2016-123, GEN-2016-124, and GEN-2016-125 and an Interim Availability Interconnection System Impact Study for Group 06 study request GEN-2017-069 for system conditions as of December 1, 2020. This study required a power flow analysis and stability analysis detailing the impacts of the interconnecting projects as shown in Table ES-1. GEN-2016-123, GEN-2016-124, and GEN-2016-125 have requested 522 MW (total) of wind generation to be interconnected with Energy Resource Interconnection Service (ERIS) at Xcel Energy – Southwestern Public Service Company's (SPS) Crossroads 345kV substation and GEN-2017-069 has requested 3.6 MW of solar generation to be interconnected with ERIS and Network Resource Interconnection Service (NRIS) into the transmission system of SPS's Norton 115kV substation in Quay County, New Mexico.

Table ES-1
Interconnection Project Evaluated

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2016-123	298	Vestas Wind	Crossroads 345kV (527656)
GEN-2016-124	150	Vestas Wind	Crossroads 345kV (527656)
GEN-2016-125	74	Vestas Wind	Crossroads 345kV (527656)
GEN-2017-069	3.6 increase to GEN-2013-022	SMASC Solar PV Inverter (524491)	Norton 115kV Switching Station (524502)

This study determined the Limited Operation for GEN-2016-123, GEN-2016-124, and GEN-2016-125 was identified in the power flow analysis as 522 MW (full output) at generator terminals for Scenario 3 (274 MW for Scenario 2 at the generator terminals, 272 MW at Crossroads 345kV).

SUMMARY OF POWER FLOW ANALYSIS

The power flow analysis determined a limited operation amount for GEN-2016-123, GEN-2016-124, and GEN-2016-125 and the available interim service for GEN-2017-069. Refer to Table ES-2 for a summary of the scenarios performed and identified service available.

Table ES-2
Summary of Power Flow Analysis

Scenario	Scenario Description	LOIS (MW)	Interim Service (MW)
		GEN-2016-123/124/125	GEN-2017-069
1	No Adjustments AEP OKU RAS Retired SPS Sagamore RAS Disabled	270 gross 268 at Crossroads 345 kV	3.6 gross
2	No Adjustments AEP OKU RAS Retired SPS Sagamore RAS Enabled	274 gross 272 at Crossroads 345 kV	0.0
3	AEP OKU RAS Retired SPS Sagamore RAS Enabled Voltage and reactor adjustments	522 gross	3.6 gross
4	AEP OKU RAS Retired SPS Sagamore RAS Enabled Reactive support at Border 345kV	522 gross	3.6 gross

These values reflect the gross generating facility capacity prior to losses associated with the interconnection facilities. Scenario 3 in the power flow analysis examined system adjustments such as altering voltage schedules, switching reactors, and adjusting LTC transformer taps. With these system adjustments, it was determined GEN-2016-123, GEN-2016-124, and GEN-2016-125 and Interim Request GEN-2017-069 may connect at full output. However, SPP Management Staff has communicated limitation concerns to the system adjustments and may invalidate Scenario 3. Additional direction will be provided by SPP Management Staff.

SUMMARY OF STABILITY ANALYSIS

The stability analysis determined that there were multiple P1, P4, and P6 contingencies that resulted either high post-fault steady-state voltages, voltage instability, and/or generation tripping across all seasons when all generation interconnection requests were at 100% output. It was determined, with system adjustments, GEN-2016-123, GEN-2016-124, and GEN-2016-125 may interconnect with full output and interim request GEN-2017-069 can connect at full output. The following is a summary of results for all faults.

- High post-fault steady-state voltage at Oklaunion 345kV
    - Mitigation: Trip the Oklaunion HVDC reactive equipment at Oklaunion 345kV simultaneously with blocking of the Oklaunion HVDC tie
- Event resulting in outage of Crossroads to Eddy County 345kV circuit
    - Voltage instability is observed with a combined Roosevelt, Milo, and Sagamore output at 822 MW.
    - Stability is maintained when Sagamore Wind output does not exceed 392 MW at Crossroads 345kV or combined Roosevelt, Milo, and Sagamore output does not exceed 685 MW at Crossroads 345kV; without RAS that trips the Sagamore facility for this event enabled or
    - Stability is maintained when a RAS that trips the Sagamore facility for this event is enabled (**full interconnection capacity of Roosevelt, Milo and Sagamore facilities when RAS is enabled**)
- Event resulting in outage of Crossroads 345 kV to Tolk 345kV circuit or Tolk 345/230 kV transformer #1 (and #2 once in-service)
    - Voltage instability is observed with a combined Roosevelt, Milo, and Sagamore output at 822 MW.
    - Stability is maintained when Sagamore Wind output does not exceed 336 MW (stability margin calculation will include 300 MW from Roosevelt and Milo wind facilities) at Crossroads 345kV or when the combined Roosevelt, Milo, and Sagamore output does not exceed 636 MW at Crossroads 345kV with normal system configuration, all breakers in-service or
    - Stability is maintained when Crossroads 345 kV substation breaker configuration results in a trip of the Sagamore facility for these events (**full interconnection capacity of Roosevelt, Milo and Sagamore facilities with the new breaker configuration in-place**)
- Prior outage events resulting in voltage instability with a combined Roosevelt, Milo, and Sagamore output at 822 MW.
    - Loss of Crossroads to Tolk 345kV transmission line
        - Stability is maintained when Sagamore Wind output does not exceed 216 MW (stability margin calculation will include 300 MW from Roosevelt and Milo wind facilities) at Crossroads 345kV or when the combined Roosevelt, Milo, and Sagamore output does not exceed 516 MW at Crossroads 345kV
    - Loss of Crossroads to Eddy County 345kV transmission line
        - Stability is maintained when Sagamore Wind output does not exceed 266 MW (stability margin calculation will include 300 MW from Roosevelt and Milo wind facilities) at Crossroads 345kV or when the combined Roosevelt, Milo, and Sagamore output does not exceed 566 MW at Crossroads 345kV

Additionally, a sensitivity of dispatching local generation to Crossroads 345kV and Norton 115kV did not result in any adverse impacts to system response from the results above.

The stability analysis from this Limited Operation and Interim Availability study determined the following with identified system adjustments:

- GEN-2016-123, GEN-2016-124, GEN-2016-125 can interconnect at full output for system intact conditions.
- GEN-2017-069 can connect at full output.

The stability analysis was evaluated with two separate model parameter sets for Sagamore Wind facility which include preliminary model parameters and as-built model parameters. Additionally, the Roosevelt-Milo Wind facilities were represented with Vestas user-written generator models without a Power Plant Controller (PPC). Results presented in this report are based on the exclusion of the power plant controller and represent a conservative scenario. Inclusion of a PPC is anticipated to provide improved voltage control and inclusion in a subsequent analysis has potential to resolve the stability issues observed in this study.

It should be noted that while this Limited Operation and Interim Availability study analyzed many of the most probable contingencies, it is not an all-inclusive list that can account for every operation situation. Additionally, the study requests 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, it is likely that the Customers may be required to reduce their generation output to 0 MW under certain system conditions to allow system operators to maintain the reliability of the transmission network.

SECTION 1: OBJECTIVES

The objective of this report is to provide Southwest Power Pool, Inc. (SPP) with the deliverables for the "Group 06 Limited Operation and Interim Availability Interconnection System Impact Study." SPP requested an Interconnection System Impact Study for four (4) generation interconnection requests which requires a power flow analysis and stability analysis with results in an Impact Study Report.

SECTION 2: BACKGROUND

The Siemens Power Technologies International PSS/E power system simulation program Version 33.10 was used for this study. The DISIS-2016-002-2 power flow and stability cases under normal dispatch conditions were provided by SPP. The power flow cases include the Group 06 ERIS study models, Group 00 NRIS study models, and Group 06 NRIS models. Refer to the DISIS power flow report accompanying this report for details of changes made to the cases provided. The stability cases provided included the 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak cases. The study requests listed in Table 2-1 were added to the models and the models include the previously queued projects listed in Table 2-2. The study cases were updated to reflect known system conditions at the time of the in-service date for GEN-2016-123, GEN-2016-124, GEN-2016-125 and the GEN-2017-069 interim request. The projects with later ISD or withdrawn study projects shown in Table 2-3 were removed from the study models to reflect current system configurations. Refer to Section 3.1 for the changes made to the base cases to reflect the removal of previously assigned Network Upgrades and study projects associated with Q4 2020 conditions. Additionally, a sensitivity study was performed on all seasons to determine the impact of nearby generation.

Power flow one-line diagrams for GEN-2016-123, GEN-2016-124, GEN-2016-125, and GEN-2017-069 are shown in Figure 2-1 and Figure 2-2. Note that the one-line diagrams represent 2017 Winter Peak conditions.

The stability analysis determined the impacts of the new interconnecting project on the stability and voltage recovery of the nearby system and the ability of the interconnecting projects to meet FERC Order 661A. If problems with stability or voltage recovery are identified, the need for reactive compensation or system upgrades were investigated. Three-phase faults and single line-to-ground faults were examined prior to any mitigation or curtailment implemented. With exception of transformers and prior outage faults, the typical sequence of events for a three-phase fault is as follows (refer to Section 4 for a list and description of fault events analyzed):

- Apply fault at particular station
- Continue fault for five (5) cycles, clear the fault by tripping the faulted facility

- After an additional twenty (20) cycles, re-close the previous facility back into the fault
- Continue fault for five (5) additional cycles
- Trip the faulted facility and remove the fault

Table 2-1: Interconnection Projects Evaluated

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2016-123	298	Vestas Wind	Crossroads 345kV (527656)
GEN-2016-124	150	Vestas Wind	Crossroads 345kV (527656)
GEN-2016-125	74	Vestas Wind	Crossroads 345kV (527656)
GEN-2017-069	3.6 increase to GEN-2013-022 (28.6 MW total)	SMASC Solar PV Inverter (524491)	Norton 115kV Switching Station (524502)

Table 2-2: Previously Queued Nearby Interconnection Projects Included

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2001-033 (Commercial Operation)	120	WT1G1 (524890)	San Juan Tap 230kV
GEN-2001-036	80	WT1G1 (599138)	Norton 115kV Switching Station
GEN-2006-018	168.1	GENSAL	TUCO 230kV
GEN-2006-026	604	GENROU (527901, 527902, 527903)	Hobbs 230kV & Hobbs 115kV
GEN-2008-022	299.65	Vestas VWCOR6	Eddy County-Tolk (Crossroads) 345kV
GEN-2010-006	180/205	GENROU	Jones 230kV
GEN-2011-025	79.96	GE 1.79MW	Tap Floyd County - Crosby County 115kV
GEN-2011-045	180/205	GENROU	Jones 230kV
GEN-2011-046	23	GENROU	Tucumcari 115kV

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2011-048/ GEN-2012-036	172/182	GENROU	Mustang 230kV
GEN-2012-001	61.2	CCWE 3.6MW (WT4)	Tap Grassland Â□- Borden County 230 kv
GEN-2012-020	478	GE 1.68MW	TUCO 230kV
GEN-2004-015/ GEN-2012-034	157	GENROU (unit 4; 527164)	Mustang 230kV
GEN-2006-015/ GEN-2012-035	157	GENROU (unit 5; 527165)	Mustang 230kV (527151)
GEN-2012-037	196/203	GENROU (525844)	Tuco 345kV (525832)
GEN-2013-016 / GEN-2015-041	196/203	GE 7FA Gas CT 208 MW	Tuco 345 kV (525832)
GEN-2013-022	25	SMASC (524491)	Norton 115kV (524502)
GEN-2013-027	148.4	Siemens 2.3/2.415	Tap on Yoakum to Tolk 230kV (562480)
GEN-2014-033	70	17 X GE Prolec 4MVA, 2 X GE Prolec 1 MVA, & 5 X Schneider XC680 0.680 MVA PV inverter	Chaves County 115kV
GEN-2014-034	70	17 X GE Prolec 4MVA PVinverter	Chaves County 115kV
GEN-2014-035	30	8 X GE Prolec 4MVA PV inverter	Chaves County 115kV
GEN-2014-040	319.7	GE 2.3 MW	Castro 115 kV (524746)
GEN-2015-014	150.0	Vestas V110 2.0MW (584563)	Tap on Cochran – LG Plains 115kV (560030)
GEN-2016-177	17	Gas Turbine	XTO-Cornell 115 kV station

Table 2-3: SPP Interconnection Projects Removed from the Model

Request	Size (MW)	Generator Model (Gen Bus Number)	Point of Interconnection
GEN-2001-033 (12/31/2022 COD)	60	WT1G1 (524896)	San Juan Tap 230kV
GEN-2011-049 (Withdrawn)	250.7	Siemens 2.3 MW (583093)	Border 345kV (515458)
GEN-2015-004 (Withdrawn)	151.8	Siemens 2.3 MW (583096)	Border 345kV (515458)
GEN-2015-099 (Withdrawn)	73.3	Power Electronics FS2000CU (587673)	Maddox 115kV (528355)
GEN-2016-023 (Withdrawn)	150.5	GE Wind (587093/587095)	Laramie to Sidney 345kV Tap (560075)
GEN-2016-029 (Withdrawn)	150.5	GE Wind (587193/587195)	Laramie to Sidney 345kV Tap (560075)
GEN-2016-037 (queued to DISIS-2017-001)	300	Vestas V110 2.0 MW (587233)	Chisholm to Gracemont 345kV Tap (560078)
GEN-2016-096 (Withdrawn)	227.7	Siemens 2.3 MW (587783/587787)	Pauline to Moore 345kV Tap (560062)
GEN-2016-121 (12/1/2022 COD)	110	SMA Sunny Central 2.5 MW (587993)	Road Runner 345kV (528025)
GEN-2016-129 (Withdrawn)	132	Wind	Valliant 345 kV substation

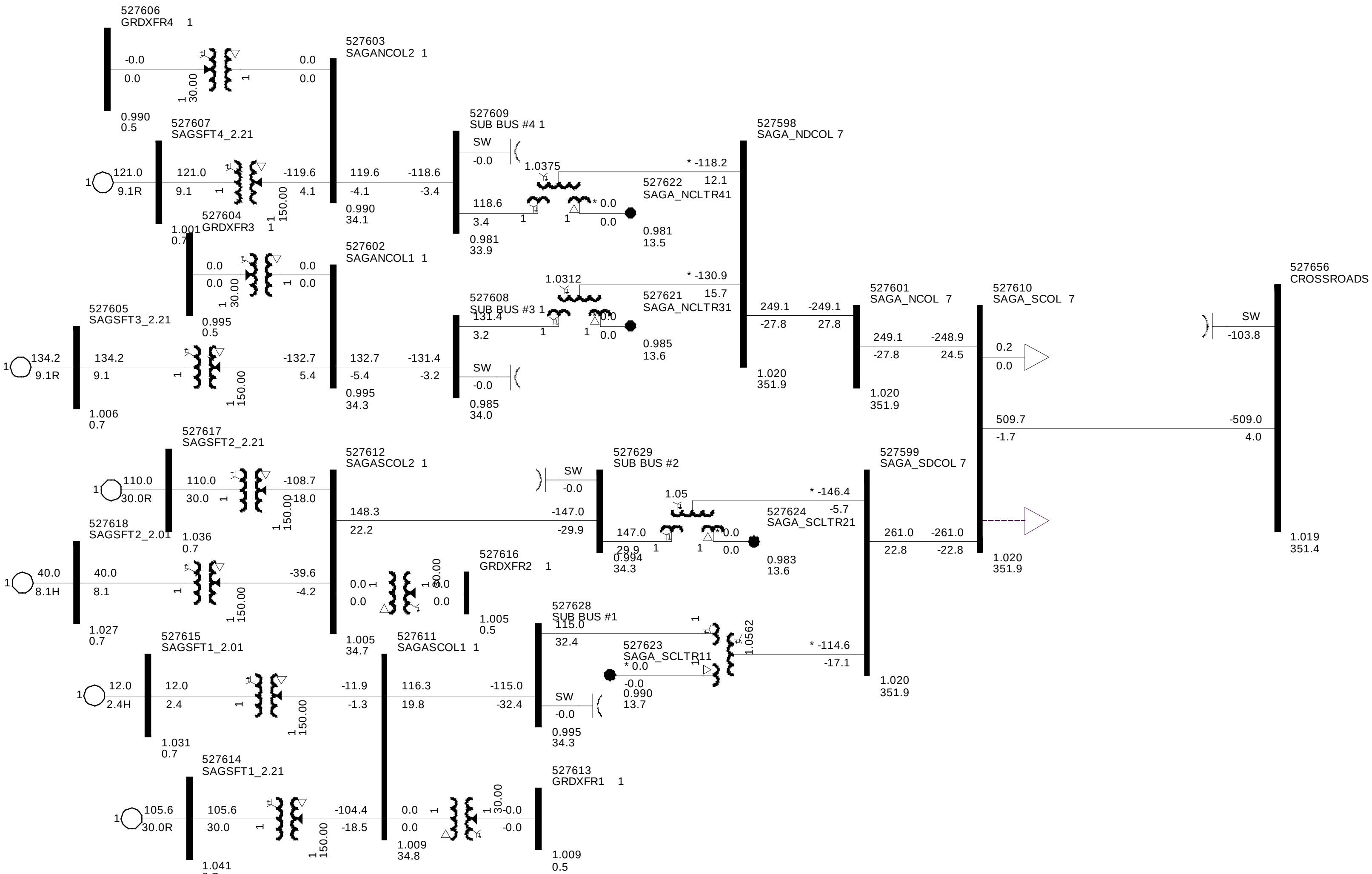

Figure 2-1. Power flow one-line diagram for interconnection projects at Crossroads 345kV Switching Station (GEN-2016-123/GEN-2016-124/GEN-2016-125) for 2017 Winter Peak conditions.

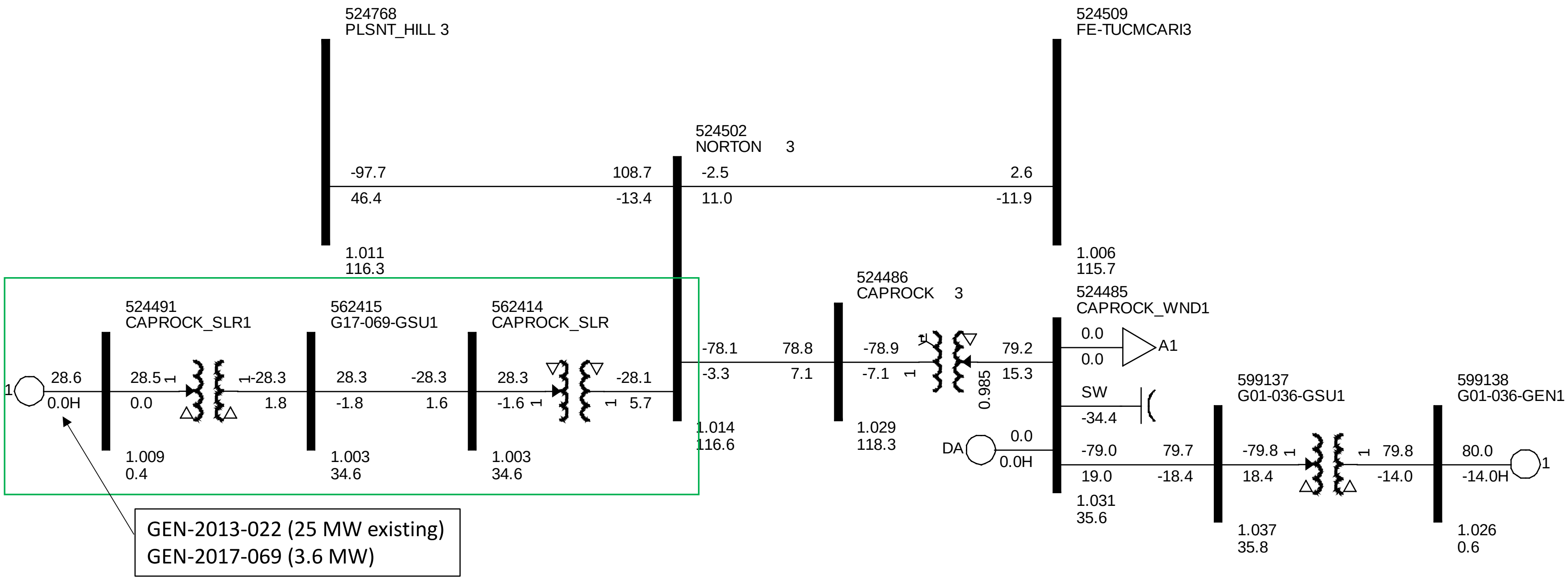

Figure 2-2. Power flow one-line diagram for interconnection project at Norton 115kV Switching Station (GEN-2017-069) for 2017 Winter Peak conditions.

SECTION 3: POWER FLOW ANALYSIS

The objective of the power flow analysis was to determine the impacts of the generator interconnection on the steady-state thermal and voltage constraints on the SPP transmission system. The analysis evaluated if GEN-2016-123, GEN-2016-124, and GEN-2016-125 can interconnect 522 MW of wind generation with Energy Resource Interconnection Service (ERIS) and if GEN-2017-069 can interconnect 3.6 MW of solar generation with ERIS and Network Resource Interconnection Service (NRIS) after December 1, 2020.

3.1 Approach

MEPPI utilized the seven (7) following DISIS-2016-002-2 power flow cases for this analysis:

- Steady-State Analysis
    - 2017 Winter Peak
    - 2018 Spring
    - 2018 Summer Peak
    - 2021 Light Load
    - 2021 Summer Peak
    - 2021 Winter Peak
    - 2026 Summer Peak

The power flow cases were dispatched in accordance with DISIS Manual, Table 1: Generation Dispatch in the Power Flow Models, and Business Practices 7250 to develop the ERIS and NRIS cases. Fourteen (14) Before Transfer (BC) cases were created by including the study requests but dispatched at 0 MW for ER (7 cases) and NR (7 cases) dispatch scenarios. Fourteen (14) Transfer cases (TC) were created by including the study requests and dispatched at full output for ER (7 cases) and NR (7 cases) dispatch scenarios (note GEN-2016-123, GEN-2016-124, and GEN-2016-125 are ER only requests and were dispatched in the NR cases in accordance with the DISIS Manual). Refer to the attachment for the status of previously assigned upgrades and higher queued requests.

3.2 Steady-State Thermal and Voltage Analysis Results

The power flow analysis observed system constraints with identified Limited Operation capacity for GEN-2016-123, GEN-2016-124, and GEN-2016-125 Interim service capacity for GEN-2017-069 as shown in Table 3-1.

- Scenario 1: Reflects the available capacity without mitigation.
- Scenario 2: Includes incremental mitigation of the SPS Sagamore RAS that trips the Sagamore Wind generating facility when loading of the Crossroads to Tolk 345kV circuit

exceeds a specified value (478 MVA for 21 seconds or 556 MVA for 30 cycles) to prevent overload of the existing Tolk 345/230kV transformer.

- Scenario 3: Includes Scenario 2 mitigation plus adjustments to voltage schedules at Castro County, Tolk, Antelope, and TUCO stations; and switching out shunt reactors at Border, TUCO, and Woodward stations to alleviate voltage violations.
- Scenario 4: Includes Scenario 2 mitigation and the DISIS-2016-002 assigned reactive equipment at Border 345kV.

The full power report can be found as an attachment to this document.

Table 3-1
Summary of Power Flow Analysis

Scenario	Scenario Description	LOIS (MW)	Interim Service (MW)
		GEN-2016-123/124/125	GEN-2017-069
1	No Adjustments AEP OKU RAS Retired SPS Sagamore RAS Disabled	270 gross 268 at Crossroads 345 kV	3.6 gross
2	No Adjustments AEP OKU RAS Retired SPS Sagamore RAS Enabled	274 gross 272 at Crossroads 345 kV	0.0
3	AEP OKU RAS Retired SPS Sagamore RAS Enabled Voltage and reactor adjustments	522 gross	3.6 gross
4	AEP OKU RAS Retired SPS Sagamore RAS Enabled Reactive support at Border 345kV	522 gross	3.6 gross

The generation dispatch values in Table 3-1 reflect the gross generating facility capacity prior to losses associated with the interconnection facilities. Scenario 3 in the power flow analysis examined system adjustments such as altering voltage schedules, switching reactors, and adjusting LTC transformer taps. With these system adjustments, it was determined GEN-2016-123, GEN-2016-124, and GEN-2016-125 and Interim Request GEN-2017-069 may connect at full output. However, SPP Staff has communicated limitation concerns to the system adjustments and may invalidate Scenario 3. Additional direction will be provided by SPP Management Staff.

SECTION 4: STABILITY ANALYSIS

The objective of the stability analysis was to determine the impacts of the generator interconnection on the stability and voltage recovery on the SPP transmission system. If problems with stability or voltage recovery were identified, limited operation amounts were investigated for GEN-2016-123, GEN-2016-124, and GEN-2016-125 and network upgrades were investigated for GEN-2017-069.

4.1 Approach

MEPPI utilized the three (3) following DISIS-2016-002-2 Normal Dispatch Scenario power flow cases and dynamic databases:

- MDWG16-17W_DIS16022_G06
- MDWG16-18S_DIS16022_G06
- MDWG16-26S_DIS16022_G06

Each case was examined prior to the stability analysis to ensure the case contained the proposed study projects and any previously queued projects listed in Tables 2-1 and 2-2 respectively. The DISIS-2016-002-2 stability cases included several existing generators in the SPS area scaled to 100% to incorporate a sensitivity dispatch into a single cluster group dispatch. In order to align with current dispatch methodology, these units were reverted back to their MDWG dispatch proportionally with the rest of the SPP footprint. Refer to Table 4-1 for a list of generation that was reverted to its MDWG dispatch. To accurately represent current system conditions, Tolk Unit #1 was modeled as a synchronous condenser in the 2017 Winter Peak case to evaluate 12/1/2020 system conditions.

Table 4-1: List of SPS Generation Reverted to MWDG Dispatch

Generation	Bus	Normal Scenario Dispatch		
		17W	18S	26S
Mustang Unit 1	527161	121.7	127.7	131.9
Mustang Unit 2	527162	121.7	127.7	131.9
Mustang Unit 3	527163	129.3	135.7	140.2
Mustang Unit 4	527164	93.4	124.6	130.2
Mustang Unit 5	527165	Offline	125.5	130.3
Mustang Unit 6	527166	Offline	132.7	142.7
Tuco (Elk 1)	525844	Offline	156.8	162.6
Tuco (Elk 2)	525845	Offline	153.8	158.5

Tolk Unit 1	525561	Synch Cond	416.8	467.1
Tolk Unit 2	525562	Offline	424.6	462.9
Plant X1	525491	Offline	Offline	37.4
Plant X2	525492	Offline	60.3	75.5
Plant X3	525493	76.5	60.3	84.8
Plant X4	525494	Offline	96.5	164.8
Hobbs Unit 1	527901	107.2	96.5	120.4
Hobbs Unit 2	527902	107.2	96.5	119.5
Hobbs Unit 3	527903	153.1	160.8	176.7
Maddox Unit 1	528361	53.6	80.4	95.4
Maddox Unit 2	528362	Offline	Offline	47.9
Maddox Unit 3	528363	Offline	Offline	8.3
Cunningham Unit 1	527881	Offline	56.3	63.9
Cunningham Unit 2	527882	130.1	160.8	169.3
Cunningham Unit 3	527883	Offline	81.2	89.6
Cunningham Unit 4	527884	76.6	78.0	88.8
Tuco (Antelope A1)	525841	Offline	43.1	46.5
Tuco (Antelope B1)	525842	Offline	43.1	46.5
Tuco (Antelope C1)	525843	Offline	Offline	46.5

The Normal Dispatch Scenario included previously assigned upgrades that were to be in-service by the Commercial Operation Date of GEN-2016-123, GEN-2016-124, and GEN-2016-125 (Sagamore Wind). The following previously assigned upgrades were included in the analysis:

- Upgrade Carlisle 230/115kV transformer
- TUCO to Yoakum to Hobbs 345kV circuit #1
- Yoakum 345/230kV transformer
- Hobbs 345/230kV transformer
- Rebuild Plant X to Tolk 230kV circuits #1 and #2
- Upgrade existing Tuco 345/230kV transformer circuit #1
- Eddy County to Kiowa 345kV circuit #1
- Crossroads capacitive support (+100 MVAR)
- Crossroads to Tolk 345kV circuit #1 rebuild
- Crossroads to Eddy County 345kV circuit #1 rebuild

- Deaf Smith to Plant X 230kV circuit #1 rebuild
- Newhart to Plant X 230kV circuit #1 rebuild
- Curry to Deaf Smith 115kV circuit #1 rebuild
- Tolk East to TUCO 230kV circuit #1 rebuild

Sagamore Wind was modeled with version 7.5.8 of the Vestas V110 VCS 2.0 MW and V120 VCS 2.2 MW dynamic model. The analysis was performed with two sets of model parameters for the Vestas V7.5.8 model, the as-built representation of the plant is denoted with an asterisk (*) next to the contingency name in Table 4-2. Refer to Appendix A for the dynamic data files for the two versions of the Vestas 7.5.8 model that were used for this analysis. At the time of this study, the Roosevelt-Milo Wind facility was modeled with version 7.6 of the Vestas OptiSpeed™ Wind Turbines (VWCOR6) to represent Vestas 2.0 MW V100 & V110 VCSS generators with the Power Plant Controller (PPC) excluded from the analysis. Results presented in this report are based on the exclusion of the Roosevelt-Milo PPC and represent a conservative scenario. To emulate power flow Scenario 3 conditions, the following system adjustments were made to the stability datasets:

- Switch off TUCO in-line reactors on the TUCO to Yoakum 345kV line
- Switch off the Border in-line reactors on the Border to Woodward 345kV line
- Adjust the low voltage setting for the Woodward transformer tertiary shunt reactors.
- Adjust Hale County Wind, Antelope, and TUCO SVC to control TUCO 230 kV at 1.02 p.u.
- Adjust Hale County Wind main power transformers to maintain normal voltages at 34.5 kV.
- Adjust Elk 1 & 2 to control TUCO 345 kV at 1.00725 p.u.
- Adjust Bethel Wind generation to control Castro County 115 kV at 1.02 p.u.

Additionally, sensitivity cases were created for all three seasons. The sensitivity cases included dispatching local generation to 100% output. Examples of electrically similar and adjacent substations include but are not limited to any kV of:

- the same substation
  - e.g. lower kV, zero-impedance branch connected bus, or alternate owner facilities
- radially connected substations
  - islanded topology resultant from a connected circuit outage
    - i.e. Generating Facility
  - substantially weakened interconnection from a connected circuit outage
    - i.e. loss of 100+ kV circuit maintains interconnection through 69kV system
- substations connected by a network circuit
  - sectionalized single (or double) circuits from substations or buses to accommodate generation and radial load are considered a single network circuit

        - i.e. a network circuit may include several buses each with two non-radial circuits
- substations within close electrical proximity
    - i.e. approximately 30 circuit miles at 345kV or a circuit impedance path less than 0.02 pu
- substations adjacent to another adjacent substation with a generating facility
    - i.e. generation both 1 & 2 levels away are electrically similar but generation that is only 2 levels way may not be electrically similar

The TUCO, Plant X, Tolk, and Quay County generation (GEN-2011-046) met the above criteria and was scaled to 100% and offset by other synchronous units within the same control area (SPS). Refer to Tables 2-1, 2-2, and 2-3 for the status of higher queued requests, DISIS-2016-001 requests, DISIS-2016-002, and select DISIS-2017-001 requests.

After updating the power flow cases with the above changes and dispatching units local to the study area according to SPP criteria, there was no suspect power flow data in the study area for the normal dispatch cases or sensitivity cases. The dynamic datasets were also verified and stable initial system conditions (i.e., "flat lines") were achieved. Three-phase and single line-to-ground (single-phase) faults listed in Table 4-2 were examined for the normal dispatch scenario. A subset of the contingency list in Table 4-2 was examined for the sensitivity dispatch. Single-phase fault impedances were calculated for each season to result in a voltage of approximately 60% of the pre-fault voltage. Refer to Table 4-3 for a list of the calculated single-phase fault impedances.

Table 4-2: Contingency List for Normal Dispatch and Sensitivity Dispatch

Cont. No.	Cont. Name	Description	Sens. Cont.
Tuco/OKU Fault Events			
1	FLT01-3PH	3 phase fault on the Tuco (525832) to Border (515458) 345 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
2	FLT02-3PH	3 phase fault on the Tuco (525832) to OKU (511456) 345 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X

Cont. No.	Cont. Name	Description	Sens. Cont.
3	FLT03-3PH	3 phase fault on the Tuco 345/230/13.8 kV (525832/525830/525824) transformer circuit 1, near Tuco 345 kV. a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.	X
4	FLT04-3PH	3 phase fault on the Tuco (525830) to Tolk East (525524) 230 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
5	FLT05-3PH	3 phase fault on the OKU (511456) to LES (511468) 345 kV line circuit 1, near OKU. a. Apply fault at the OKU 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line and remove the fault. c. Block the DC tie at OKU.	
6	FLT06-3PH	3 phase fault on the OKU (511456) to LES (511468) 345 kV line circuit 1, near OKU. a. Apply fault at the OKU 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line and remove the fault.	
7	FLT07-3PH	3 phase fault on the OKU (511456) to Oklaun (599891) 345 kV line circuit 1 (OKU DC tie), near OKU. a. Apply fault at the OKU 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line and remove the fault. c. Block the DC tie at OKU.	
8	FLT08-SB	**Single phase fault with stuck breaker at Tuco 345 kV (525832)** a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Tuco 345/230/13.2 kV (525832/525830/525824) transformer d. Tuco (525832) – Border (515458) 345 kV	X
9	FLT09-SB	**Single phase fault with stuck breaker at Tuco 345 kV (525832)** a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Tuco 345/230/13.2 kV (525832/525830/525824) transformer d. Tuco (525832) – OKU (511456) 345 kV	X
10	FLT10-PO	**Prior Outage of the Tuco 345/230/13.2 kV (525832/525830/525824) transformer circuit 1;** 3 phase fault on the Tuco (525832) to Border (515458) 345 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.	X
11	FLT11-PO	**Prior Outage of the Tuco (525832) to Border (515458) 345kV circuit 1;** 3 phase fault on the Tuco (525832) to OKU (511456) 345 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.	X

Cont. No.	Cont. Name	Description	Sens. Cont.
12	FLT12-PO	**Prior Outage of the Tuco (525832) to Border (515458) 345kV circuit 1;** 3 phase fault on the OKU (511456) to LES (511468) 345 kV line circuit 1, near OKU. a. Apply fault at the OKU 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.	
13	FLT13-PO	**Prior Outage of the Tuco (525832) to Border (515458) 345kV circuit 1;** 3 phase fault on the OKU (511456) to LES (511468) 345 kV line circuit 1, near OKU. a. Apply fault at the OKU 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Block the DC tie at OKU.	
14	FLT14-PO	**Prior Outage of the OKU (511456) to LES (511468) 345kV circuit 1;** 3 phase fault on the Tuco (525832) to Border (515458) 345 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.	X
15	FLT15-PO	**Prior Outage of the OKU (511456) to LES (511468) 345kV circuit 1 (block OKU DC tie);** 3 phase fault on the Tuco (525832) to Border (515458) 345 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.	X
16	FLT16-PO	**Prior Outage of the Potter County (523961) to Hitchland (523097) 345kV circuit 1;** 3 phase fault on the OKU (511456) to LES (511468) 345 kV line circuit 1, near OKU. a. Apply fault at the OKU 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.	
17	FLT17-PO	**Prior Outage of the Potter County (523961) to Hitchland (523097) 345kV circuit 1;** 3 phase fault on the OKU (511456) to LES (511468) 345 kV line circuit 1, near OKU. a. Apply fault at the OKU 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Block the DC tie at OKU.	
18	FLT18-PO	**Prior Outage of the Potter County (523961) to Hitchland (523097) 345kV circuit 1;** 3 phase fault on the Tuco (525832) to Border (515458) 345 kV line circuit 1, near Tuco. a. Apply fault at the Tuco 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.	X
Potter County Fault Events			
19	FLT19-3PH	3 phase fault on the Potter County (523961) to Hitchland (523097) 345 kV line circuit 1, near Potter County. a. Apply fault at the Potter County 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	

Cont. No.	Cont. Name	Description	Sens. Cont.
20	FLT19_1-PO	**Prior Outage of the Tuco (525832) to Border (515458) 345kV circuit 1;** 3 phase fault on the Potter County (523961) to Hitchland (523097) 345 kV line circuit 1, near Potter County. a. Apply fault at the Potter County 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.	
21	FLT19_2-PO	**Prior Outage of the OKU (511456) to LES (511468) 345kV circuit 1;** 3 phase fault on the Potter County (523961) to Hitchland (523097) 345 kV line circuit 1, near Potter County. a. Apply fault at the Potter County 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line.	
22	FLT20-3PH	3 phase fault on the Potter County 345/230/13 kV (523961/523959/523957) transformer circuit 1, near Potter County. a. Apply fault at the Potter County 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.	
23	FLT20_2-SB	**Single phase fault with stuck breaker at Potter County 345 kV (523961)** a. Apply fault at the Potter County 345 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Potter County 345/230/13 kV (523961/523959/523957) transformer	
Norton Fault Events			
24	FLT21-3PH	3 phase fault on the Norton (524502) to FE-Tucumcari (524509) 115 kV line circuit 1, near Norton. a. Apply fault at the Norton 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
25	FLT22-3PH	3 phase fault on the Pleasant Hills (524768) to East Clovis (524773) 115 kV line circuit 1, near Pleasant Hills. a. Apply fault at the Pleasant Hills 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
26	FLT23-3PH	3 phase fault on the Pleasant Hills (524768) to North Clovis (524776) 115 kV line circuit 1, near Pleasant Hills. a. Apply fault at the Pleasant Hills 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
27	FLT24-3PH	3 phase fault on the Pleasant Hills (524768) to Holland (524831) 115 kV line circuit 1, near Pleasant Hills. a. Apply fault at the Pleasant Hills 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X

Cont. No.	Cont. Name	Description	Sens. Cont.
28	FLT25-3PH	3 phase fault on the Pleasant Hills 230/115/13.8 kV (524770/524768/524767) transformer circuit 1, near Pleasant Hills 115 kV. a. Apply fault at the Pleasant Hills 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.	X
29	FLT26-3PH	3 phase fault on the Pleasant Hills (524770) to Oasis (524875) 230 kV line circuit 1, near Pleasant Hills. a. Apply fault at the Pleasant Hills 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
30	FLT27-3PH	3 phase fault on the Pleasant Hills (524770) to Roosevelt (524911) 230 kV line circuit 1, near Pleasant Hills. a. Apply fault at the Pleasant Hills 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
31	FLT28-3PH	3 phase fault on the Roosevelt (524911) to Tolk East (525524) 230 kV line circuit 1, near Roosevelt. a. Apply fault at the Roosevelt 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
32	FLT29-3PH	3 phase fault on the Roosevelt (524909) to Tolk West (525531) 230 kV line circuit 2, near Roosevelt. a. Apply fault at the Roosevelt 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
33	FLT30-3PH	3 phase fault on the Roosevelt 230/115/13.8 kV (525909/524908/524907) transformer circuit 1, near Roosevelt 230 kV. a. Apply fault at the Roosevelt 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.	X
34	FLT31-3PH	3 phase fault on the Oasis 230/115/13.8 kV (524875/524874/524872) transformer circuit 1, near Oasis 230 kV. a. Apply fault at the Oasis 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.	X
35	FLT32-3PH	3 phase fault on the Oasis (524875) to Roosevelt (524915) 230 kV line circuit 1, near Oasis. a. Apply fault at the Oasis 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X

Cont. No.	Cont. Name	Description	Sens. Cont.
36	FLT33-3PH	3 phase fault on the Oasis (524875) to San Juan Tap (524885) 230 kV line circuit 1, near Oasis. a. Apply fault at the Oasis 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
37	FLT34-SB	**Single phase fault with stuck breaker at Pleasant Hills 115 kV (524768)** a. Apply fault at the Pleasant Hills kV bus. b. Clear fault after 16 cycles and trip the following elements c. Pleasant Hills (524768) – East Clovis (524773) 115 kV d. Pleasant Hills (524768) – Holland (524831) 115 kV	X
38	FLT35-SB	**Single phase fault with stuck breaker at Pleasant Hills 115 kV (524768)** a. Apply fault at the Pleasant Hills kV bus. b. Clear fault after 16 cycles and trip the following elements c. Pleasant Hills (524768) – North Clovis (524776) 115 kV d. Pleasant Hills (524768) – Holland (524831) 115 kV	X
39	FLT36-PO	**Prior Outage of the Pleasant Hills (524768) to East Clovis (524773) 115 kV line circuit 1;** 3 phase fault on the Pleasant Hills (524768) to North Clovis (524776) 115 kV line circuit 1, near Pleasant Hills. a. Apply fault at the Pleasant Hills kV bus. b. Clear fault after 5 cycles by tripping the faulted line.	X
40	FLT37-PO	**Prior Outage of the Pleasant Hills (524768) to East Clovis (524773) 115 kV line circuit 1;** 3 phase fault on the Pleasant Hills (524768) to Holland (524831) 115 kV line circuit 1, near Pleasant Hills. a. Apply fault at the Pleasant Hills kV bus. b. Clear fault after 5 cycles by tripping the faulted line.	X
41	FLT38-PO	**Prior Outage of the Pleasant Hills Transformer (524770/524768/524767) circuit 1;** 3 phase fault on the Pleasant Hills (524768) to East Clovis (524773) 115 kV line circuit 1, near Pleasant Hills. a. Apply fault at the Pleasant Hills kV bus. b. Clear fault after 5 cycles by tripping the faulted line.	X
42	FLT39-PO	**Prior Outage of the Pleasant Hills Transformer (524770/524768/524767) circuit 1;** 3 phase fault on the Pleasant Hills (524768) to North Clovis (524776) 115 kV line circuit 1, near Pleasant Hills. a. Apply fault at the Pleasant Hills kV bus. b. Clear fault after 5 cycles by tripping the faulted line.	X
43	FLT40-PO	**Prior Outage of the Pleasant Hills Transformer (524770/524768/524767) circuit 1;** 3 phase fault on the Pleasant Hills (524768) to Holland (524831) 115 kV line circuit 1, near Pleasant Hills. a. Apply fault at the Pleasant Hills kV bus. b. Clear fault after 5 cycles by tripping the faulted line.	X
44	FLT41-3PH	3 phase fault on the FE-Tucumcari (524509) to Ceilo-Tap (583610) 115 kV line circuit 1, near FE-Tucumcari. a. Apply fault at the FE-Tucumcari 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X

Cont. No.	Cont. Name	Description	Sens. Cont.
45	FLT42-3PH	3 phase fault on the Lopez (524472) to Campbell St (524477) 115 kV line circuit 1, near Campbell St. a. Apply fault at the Campbell St 115 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
Tolk 345kV Fault Events			
46	FLT43-3PH	3 phase fault on the Crossroads (527656) to Tolk (525549) 345 kV line circuit 1, near Crossroads. a. Apply fault at the Crossroads 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
47	FLT43a-3PH*	3 phase fault on the Crossroads (527656) to Tolk (525549) 345 kV line circuit 1, near Crossroads with tripping of Sagamore Wind Plant. a. Apply fault at the Crossroads 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line with simultaneous trip of Sagamore Facility with tripping and lockout of Crossroads to Sagamore 345 kV circuit. d. Wait 20 cycles, and then re-close the Tolk line in (b) back into the fault. e. Leave fault on for 5 cycles, then trip the Tolk line in (b) and remove fault.	X
48	FLT44-3PH	3 phase fault on the Tolk (525549) to Crossroads (527656) 345 kV line circuit 1, near Tolk. a. Apply fault at the Tolk 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
49	FLT44a-3PH*	3 phase fault on the Tolk (525549) to Crossroads (527656) 345 kV line circuit 1, near Tolk with tripping of Sagamore Wind Plant. a. Apply fault at the Tolk 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line with simultaneous trip of Sagamore Facility with tripping and lockout of Crossroads to Sagamore Wind Plant 345 kV circuit. d. Wait 20 cycles, and then re-close the line in (b) back into the fault. e. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
50	FLT45-3PH	3 phase fault on the Crossroads (527656) to Eddy County (527802) 345 kV line circuit 1, near Crossroads. a. Apply fault at the Crossroads 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
51	FLT46-3PH*	3 phase fault on the Tolk East (525524) to Roosevelt (524911) 230 kV line circuit 1, near Tolk East. a. Apply fault at the Tolk East 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X

Cont. No.	Cont. Name	Description	Sens. Cont.
52	FLT47-3PH*	3 phase fault on the Tolk East (525524) to Plant X (525481) 230 kV line circuit 2, near Tolk East. a. Apply fault at the Tolk East 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
53	FLT48-3PH*	3 phase fault on the Tolk East (525524) to Tuco (525830) 230 kV line circuit 1, near Tolk East. a. Apply fault at the Tolk East 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
54	FLT49-3PH*	3 phase fault on the Tolk West (525531) to Plant X (525481) 230 kV line circuit 1, near Tolk West. a. Apply fault at the Tolk West 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
55	FLT50-3PH*	3 phase fault on the Tolk West (525531) to Roosevelt (525909) 230 kV line circuit 2, near Tolk West. a. Apply fault at the Tolk West 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
56	FLT51-3PH*	3 phase fault on the Tolk West (525531) to G13-027-Tap (562480) 230 kV line circuit 1, near Tolk West. a. Apply fault at the Tolk West 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
57	FLT52-3PH*	3 phase fault on the Tolk West (525531) to Lamb County (525637) 230 kV line circuit 1, near Tolk West. a. Apply fault at the Tolk West 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
58	FLT53-SB	**Single phase fault with stuck breaker at Tolk East 230 kV (525524)** a. Apply fault at the Tolk East 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Tolk East (525524) – Roosevelt (524911) 230 kV d. Tolk East (525524) – Plant X (525481) 230 kV	X
59	FLT54-SB	**Single phase fault with stuck breaker at Tolk East 230 kV (525524)** a. Apply fault at the Tolk East 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Tolk East (525524) – Tuco (525830) 230 kV d. Tolk East (525524) – Tolk Tap (525543) 230 kV	X

Cont. No.	Cont. Name	Description	Sens. Cont.
60	FLT55-SB	**Single phase fault with stuck breaker at Tolk West 230 kV (525531)** a. Apply fault at the Tolk West 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Tolk West (525531) – Roosevelt (524909) 230 kV d. Tolk West (525531) – Plant X (525481) 230 kV	X
61	FLT56-SB	**Single phase fault with stuck breaker at Tolk West 230 kV (525531)** a. Apply fault at the Tolk West 230 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Tolk West (525531) – G13-027-Tap (562480) 230 kV d. Tolk West (525531) – Lamb County (525637) 230 kV	X
62	FLT57-SB	**Single phase fault with stuck breaker at Tolk 345 kV (525549)** a. Apply fault at the Tolk 345 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Tolk (525549) – Crossroads (527656) 345 kV d. Tolk 345/230kV Transformer (525549/525543/525537)	X
63	FLT57a-SB*	**Single phase fault with stuck breaker at Tolk 345 kV (525549)** a. Apply fault at the Tolk 345 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Tolk (525549) – Crossroads (527656) 345 kV d. Trip Sagamore Facility with tripping and lockout of Crossroads to Sagamore 345 kV circuit. e. Tolk 345/230kV Transformer (525549/525543/525537)	X
64	FLT58-SB	**Single phase fault with stuck breaker at Eddy County 345 kV (527802)** a. Apply fault at the Eddy County 345 kV bus. b. Clear fault after 16 cycles and trip the following elements c. Eddy County (527802) – Crossroads (527656) 345 kV d. Eddy County 345/230kV Transformer (527656/527799/527796)	X
65	FLT59-PO	**Prior Outage of the Eddy County (527802) to Crossroads (527656) 345 kV line circuit 1;** 3 phase fault on the Tolk East (525524) to Roosevelt (524911) 230 kV line circuit 1, near Tolk East. a. Apply fault at the Tolk East 230 kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	X
66	FLT60-PO	**Prior Outage of the Eddy County (527802) to Crossroads (527656) 345 kV line circuit 1;** 3 phase fault on the Tolk East (525524) to Plant X (525481) 230 kV line circuit 2, near Tolk East. a. Apply fault at the Tolk East 230 kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	X
67	FLT61-PO	**Prior Outage of the Eddy County (527802) to Crossroads (527656) 345 kV line circuit 1;** 3 phase fault on the Tolk East (525524) to Tuco (525830) 230 kV line circuit 1, near Tolk East. a. Apply fault at the Tolk East 230 kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	X
68	FLT62-PO	**Prior Outage of the Eddy County (527802) to Crossroads (527656) 345 kV line circuit 1;** 3 phase fault on the Tolk West (525531) to Roosevelt (524909) 230 kV line circuit 2, near Tolk West. a. Apply fault at the Tolk West 230 kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	X

Cont. No.	Cont. Name	Description	Sens. Cont.
69	FLT63-PO	**Prior Outage of the Eddy County (527802) to Crossroads (527656) 345 kV line circuit 1;** 3 phase fault on the Tolk West (525531) to Plant X (525481) 230 kV line circuit 1, near Tolk West. a. Apply fault at the Tolk West 230 kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	X
70	FLT64-PO	**Prior Outage of the Eddy County (527802) to Crossroads (527656) 345 kV line circuit 1;** 3 phase fault on the Tolk West (525531) to G13-027-Tap (562480) 230 kV line circuit 1, near Tolk West. a. Apply fault at the Tolk West 230 kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	X
71	FLT65-PO	**Prior Outage of the Eddy County (527802) to Crossroads (527656) 345 kV line circuit 1;** 3 phase fault on the Tolk West (525531) to Lamb County (525637) 230 kV line circuit 1, near Tolk West. a. Apply fault at the Tolk West 230 kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	X
72	FLT66-PO	**Prior Outage of the Tolk (525549) to Crossroads (527656) 345 kV line circuit 1;** 3 phase fault on the Eddy County (527802) to Kiowa (527965) 345 kV line circuit 1, near Eddy County. a. Apply fault at the Eddy County 345 kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	X
73	FLT67-PO	**Prior Outage of the Tolk (525549) to Crossroads (527656) 345 kV line circuit 1;** 3 phase fault on the Eddy County 345/230kV transformer (527802/527799/527796), near Eddy County. a. Apply fault at the Eddy County 345 kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	X
74	FLT68-3PH	3 phase fault on the Plant X (525481) to Tolk East (525524) 230 kV line circuit 2, near Plant X. a. Apply fault at the Plant X 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
75	FLT69-3PH	3 phase fault on the Plant X (525481) to Newhart (525461) 230 kV line circuit 1, near Plant X. a. Apply fault at the Plant X 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
76	FLT70-3PH	3 phase fault on the Plant X (525481) to Tolk West (525531) 230 kV line circuit 1, near Plant X. a. Apply fault at the Plant X 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X

Cont. No.	Cont. Name	Description	Sens. Cont.
77	FLT71-3PH	3 phase fault on the Plant X (525481) to Sundown (526435) 230 kV line circuit 1, near Plant X. a. Apply fault at the Plant X 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
78	FLT72-3PH	3 phase fault on the Plant X 230/115/13.2 kV (525481/525480/525479) transformer circuit 1, near Plant X 230 kV. a. Apply fault at the Plant X 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.	X
79	FLT73-3PH	3 phase fault on the Plant X (525481) to Deaf Smith (524623) 230 kV line circuit 1, near Plant X. a. Apply fault at the Plant X 230 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
Kiowa 345kV Fault Events			
80	FLT74-3PH	3 phase fault on the Kiowa (527965) to Eddy County (527802) 345 kV line circuit 1, near Kiowa. a. Apply fault at the Kiowa 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
81	FLT75-3PH	3 phase fault on the Kiowa (527965) to Hobbs (527896) 345 kV line circuit 1, near Kiowa. a. Apply fault at the Kiowa 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
82	FLT76-3PH	3 phase fault on the Kiowa (527965) to Road Runner (528027) 345 kV line circuit 1, near Kiowa. a. Apply fault at the Kiowa 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
83	FLT77-3PH	3 phase fault on the Kiowa (527965) to North Loving (528185) 345 kV line circuit 1, near Kiowa. a. Apply fault at the Kiowa 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	X
84	FLT78-3PH	3 phase fault on the Kiowa 345/115/13.2 kV (527965/527966/527964) transformer circuit 1, near Kiowa 345 kV. a. Apply fault at the Kiowa 345 kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.	X

Cont. No.	Cont. Name	Description	Sens. Cont.
85	FLT79-PO	**Prior Outage of the Tolk (525549) to Crossroads (527656) 345 kV line circuit 1;** 3 phase fault on the Eddy County (527802) to Kiowa (527965) 345 kV line circuit 1, near Kiowa. a. Apply fault at the Kiowa 345 kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	X
86	FLT80-PO	**Prior Outage of the Tolk (525549) to Crossroads (527656) 345 kV line circuit 1;** 3 phase fault on the Kiowa (527965) to Hobbs (527896) 345 kV line circuit 1, near Kiowa. a. Apply fault at the Kiowa 345 kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	X
87	FLT81-PO	**Prior Outage of the Tolk (525549) to Crossroads (527656) 345 kV line circuit 1;** 3 phase fault on the Kiowa (527965) to Road Runner (528027) 345 kV line circuit 1, near Kiowa. a. Apply fault at the Kiowa 345 kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	X
88	FLT82-PO	**Prior Outage of the Tolk (525549) to Crossroads (527656) 345 kV line circuit 1;** 3 phase fault on the Kiowa (527965) to North Loving (528185) 345 kV line circuit 1, near Kiowa. a. Apply fault at the Kiowa 345 kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	X
89	FLT83-PO	**Prior Outage of the Tolk (525549) to Crossroads (527656) 345 kV line circuit 1;** 3 phase fault on the Kiowa 345/115 kV transformer (527965/527962/527964) circuit 1, near Kiowa. a. Apply fault at the Kiowa 345 kV bus. b. Clear fault after 6 cycles by tripping the faulted line.	X

Table 4-3: Calculated Single-Phase Fault Impedances

[1]Ref. No.	Cont. Name	Faulted Bus	Single-Phase Fault Impedance (MVA)		
			2017 Winter	2018 Summer	2026 Summer
8	FLT08-SB	Tuco 345kV (525832)	-3421.9	-4437.5	-4437.5
9	FLT09-SB	Tuco 345kV (525832)	-3421.9	-4437.5	-4437.5
21	FLT20_2-SB	Potter County 345kV (523961)	-2850.0	-2690.0	-2718.0
34	FLT34-SB	Pleasant Hills 115kV (524768)	-1250.0	-1250.0	-1250.0
35	FLT35-SB	Pleasant Hills 115kV (524768)	-1250.0	-1250.0	-1250.0
56	FLT56-SB	Tolk East 230kV (525524)	-6062.5	-6062.5	-6062.5
57	FLT57-SB	Tolk East 230kV (525524)	-6062.5	-6062.5	-6062.5
58	FLT58-SB	Tolk West 230kV (525531)	-6062.5	-6062.5	-6062.5
59	FLT59-SB	Tolk West 230kV (525531)	-6062.5	-6062.5	-6062.5
60	FLT60-SB	Tolk 345kV (525549)	-3421.9	-3421.9	-3421.9
61	FLT61-SB	Eddy County (527802)	-3421.9	-3421.9	-3421.9

(1) Refer to Table 4-2 for a description of the contingency scenario.

Bus voltages, machine rotor angles, and previously queued generation in the study area were monitored in addition to bus voltages and machine rotor angles in the following areas:

- 520 AEPW
- 524 OKGE
- 525 WFEC
- 526 SPS
- 531 MIDW
- 534 SUNC
- 536 WERE

Requested and previously queued generation outside the above study area was also monitored.

The results of the analysis determined if Limited Operation or reduced Interim Service was required to obtain acceptable system performance. Note all wind or solar farms are required to meet FERC Order 661A low voltage requirements and should return to its pre-disturbance operating voltage.

4.2 Normal Dispatch Stability Analysis Results

The normal dispatch stability analysis determined that there were multiple P1, P4, and P6 contingencies that resulted either high post-fault steady-state voltages, voltage instability, and/or generation tripping across all seasons when all generation interconnection requests were at 100% output.

Refer to Table 4-4 for a summary of the stability analysis results for the normal dispatch scenario and Table 4-5 for a summary of the required mitigation/generation curtailment. Note the generation dispatch values in Table 4-5 represent the gross generation capacity observed at the generator terminals. Table 4-4 is a summary of the stability results for the 17WP, 18SP, and 26SP conditions and states whether the system remained stable or generation tripped offline, if acceptable voltage recovery was observed after the fault was cleared, and if the voltage recovered to above 0.9 p.u. and below 1.1 p.u. post fault steady-state conditions. Voltage recovery criteria includes ensuring that the transient voltage recovery is between 0.7 p.u. and 1.2 p.u. and ending in a steady-state voltage (for N-1 contingencies) at the pre-contingent level or at least above 0.9 p.u. and below 1.1. p.u.

Table 4-4: Summary of Results for 17WP, 18SP, and 26SP Conditions for the Normal Dispatch Scenario

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
1	FLT01-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
2	FLT02-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
3	FLT03-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
4	FLT04-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
5	FLT05-3PH	-	-	Compliant	Stable	-	-	OKU V > 1.1	Stable	-	-	OKU V > 1.1	Stable
6	FLT06-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
7	FLT07-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
8	FLT08-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
9	FLT09-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
10	FLT10-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
11	FLT11-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
12	FLT12-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
13	FLT13-PO	-	-	OKU V > 1.1	Stable	-	-	OKU V > 1.1	Stable	-	-	OKU V > 1.1	Stable
14	FLT14-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
15	FLT15-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
16	FLT16-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
17	FLT17-PO	-	-	OKU V > 1.1	Stable	-	-	OKU V > 1.1	Stable	-	-	OKU V > 1.1	Stable
18	FLT18-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
19	FLT19-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
20	FLT19_1-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
21	FLT19_2-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
22	FLT20-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
23	FLT20_2-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
24	FLT21-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
25	FLT22-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable

Table 4-4: Summary of Results for 17WP, 18SP, and 26SP Conditions for the Normal Dispatch Scenario (cont.)

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
26	FLT23-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
27	FLT24-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
28	FLT25-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
29	FLT26-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
30	FLT27-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
31	FLT28-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
32	FLT29-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
33	FLT30-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
34	FLT31-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
35	FLT32-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
36	FLT33-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
37	FLT34--SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
38	FLT35--SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
39	FLT36-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
40	FLT37-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
41	FLT38-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
42	FLT39-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
43	FLT40-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
44	FLT41-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
45	FLT42-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
46	FLT43-3PH	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
47	FLT43a-3PH*	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable

*As-built Vestas V7.5.8 Model Parameters Utilized

Table 4-4: Summary of Results for 17WP, 18SP, and 26SP Conditions for the Normal Dispatch Scenario (cont.)

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
48	FLT44-3PH	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
49	FLT44a-3PH*	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
50	FLT45-3PH	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
51	FLT46-3PH*	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
52	FLT47-3PH*	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
53	FLT48-3PH*	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
54	FLT49-3PH*	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
55	FLT50-3PH*	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
56	FLT51-3PH*	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
57	FLT52-3PH*	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
58	FLT53-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
59	FLT54-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
60	FLT55-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
61	FLT56-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
62	FLT57-SB	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
63	FLT57a-SB*	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
64	FLT58-SB	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
65	FLT59-PO	-	-	Compliant	Stable	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
66	FLT60-PO	-	-	Compliant	Stable	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
67	FLT61-PO	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
68	FLT62-PO	-	-	Compliant	Stable	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
69	FLT63-PO	-	-	Compliant	Stable	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
70	FLT64-PO	-	-	Compliant	Stable	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability

*As-built Vestas V7.5.8 Model Parameters Utilized

Table 4-4: Summary of Results for 17WP, 18SP, and 26SP Conditions for the Normal Dispatch Scenario (cont.)

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
71	FLT65-PO	-	-	Compliant	Stable	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
72	FLT66-PO	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads	-	-	Compliant	Gen Trip Crossroads	-	-	Oscillatory voltages	Gen Trip Crossroads
73	FLT67-PO	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads	-	-	Compliant	Gen Trip Crossroads	-	-	Oscillatory voltages	Gen Trip Crossroads
74	FLT68-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
75	FLT69-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
76	FLT70-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
77	FLT71-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
78	FLT72-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
79	FLT73-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
80	FLT74-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
81	FLT75-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
82	FLT76-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
83	FLT77-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
84	FLT78-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
85	FLT79-PO	-	-	Compliant	Gen Trip Crossroads	-	-	Compliant	Gen Trip Crossroads	-	-	Voltage instabilty	Gen Trip Crossroads
86	FLT80-PO	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads	-	-	Voltage instabilty	Gen Trip Crossroads
87	FLT81-PO	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads	-	-	Voltage instabilty	Gen Trip Crossroads
88	FLT82-PO	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads	-	-	Voltage instabilty	Gen Trip Crossroads
89	FLT83-PO	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads	-	-	Voltage instabilty	Gen Trip Crossroads

Table 4-5: Required Mitigation/Generation Curtailment for the Normal Dispatch Scenario

Cont. No.	Cont. Name	2017 Winter Peak Mitigation	2018 Summer Peak Mitigation	2026 Summer Peak Mitigation
5	FLT05-3PH	Compliant	Trip OKU reactive support (capacitor bank)	Trip OKU reactive support (capacitor bank)
13	FLT13-PO	Trip OKU reactive support (capacitor bank)	Trip OKU reactive support (capacitor bank)	Trip OKU reactive support (capacitor bank)
17	FLT17-PO	Trip OKU reactive support (capacitor bank)	Trip OKU reactive support (capacitor bank)	Trip OKU reactive support (capacitor bank)
45	FLT43-3PH	Sagamore Output @ Gen Terminals = 350 MW Crossroads Cumulative Output = 650 MW GEN-2017-069 Interim Service = 3.6 MW	Sagamore Output @ Gen Terminals = 350 MW Crossroads Cumulative Output = 650 MW GEN-2017-069 Interim Service = 3.6 MW	Sagamore Output @ Gen Terminals = 350 MW Crossroads Cumulative Output = 650 MW GEN-2017-069 Interim Service = 3.6 MW
46	FLT44-3PH	Sagamore Output @ Gen Terminals = 350 MW Crossroads Cumulative Output = 650 MW GEN-2017-069 Interim Service = 3.6 MW	Sagamore Output @ Gen Terminals = 350 MW Crossroads Cumulative Output = 650 MW GEN-2017-069 Interim Service = 3.6 MW	Sagamore Output @ Gen Terminals = 350 MW Crossroads Cumulative Output = 650 MW GEN-2017-069 Interim Service = 3.6 MW
48	FLT45-3PH	Sagamore Output @ Gen Terminals = 400 MW Crossroads Cumulative Output = 700 MW GEN-2017-069 Interim Service = 3.6 MW or Enable Sagamore Wind RAS	Sagamore Output @ Gen Terminals = 400 MW Crossroads Cumulative Output = 700 MW GEN-2017-069 Interim Service = 3.6 MW or Enable Sagamore Wind RAS	Sagamore Output @ Gen Terminals = 400 MW Crossroads Cumulative Output = 700 MW GEN-2017-069 Interim Service = 3.6 MW or Enable Sagamore Wind RAS
62	FLT57-SB	Sagamore Output @ Gen Terminals = 350 MW Crossroads Cumulative Output = 650 MW GEN-2017-069 Interim Service = 3.6 MW	Sagamore Output @ Gen Terminals = 350 MW Crossroads Cumulative Output = 650 MW GEN-2017-069 Interim Service = 3.6 MW	Sagamore Output @ Gen Terminals = 350 MW Crossroads Cumulative Output = 650 MW GEN-2017-069 Interim Service = 3.6 MW
64	FLT58-SB	Sagamore Output @ Gen Terminals = 400 MW Crossroads Cumulative Output = 700 MW GEN-2017-069 Interim Service = 3.6 MW or Enable Sagamore Wind RAS	Sagamore Output @ Gen Terminals = 400 MW Crossroads Cumulative Output = 700 MW GEN-2017-069 Interim Service = 3.6 MW or Enable Sagamore Wind RAS	Sagamore Output @ Gen Terminals = 400 MW Crossroads Cumulative Output = 700 MW GEN-2017-069 Interim Service = 3.6 MW or Enable Sagamore Wind RAS
65	FLT59-PO	Compliant	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW
66	FLT60-PO	Compliant	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW
67	FLT61-PO	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW
68	FLT62-PO	Compliant	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW
69	FLT63-PO	Compliant	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW
70	FLT64-PO	Compliant	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW

Table 4-5: Required Mitigation/Generation Curtailment for the Normal Dispatch Scenario (cont.)

Cont. No.	Cont. Name	2017 Winter Peak Mitigation	2018 Summer Peak Mitigation	2026 Summer Peak Mitigation
71	FLT65-PO	Compliant	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW
72	FLT66-PO	Voltage instability after disabling Roosevelt Tripping Reduce Crossroads generation to 576 MW, reduction of 246 MW	Voltage instability after disabling Roosevelt Tripping Reduce Crossroads generation to 526 MW, reduction of 296 MW	Voltage instability after disabling Roosevelt Tripping Reduce Crossroads generation to 526 MW, reduction of 296 MW
73	FLT67-PO	Voltage instability after disabling Roosevelt Tripping Reduce Crossroads generation to 576 MW, reduction of 246 MW	Crossroads 345kV > 1.2pu after disabling Roosevelt Tripping Reduce Crossroads generation to 576 MW, reduction of 246 MW	Voltage instability after disabling Roosevelt Tripping Reduce Crossroads generation to 576 MW, reduction of 246 MW
85	FLT79-PO	Voltage instability after disabling Roosevelt Tripping Reduce Crossroads generation to 576 MW, reduction of 246 MW	Voltage instability after disabling Roosevelt Tripping Reduce Crossroads generation to 526 MW, reduction of 296 MW	Voltage instability after disabling Roosevelt Tripping Reduce Crossroads generation to 526 MW, reduction of 296 MW
86	FLT80-PO	Voltage instability after disabling Roosevelt Tripping Reduce Crossroads generation to 576 MW, reduction of 246 MW	Voltage instability after disabling Roosevelt Tripping Reduce Crossroads generation to 576 MW, reduction of 246 MW	Voltage instability after disabling Roosevelt Tripping Reduce Crossroads generation to 526 MW, reduction of 296 MW
87	FLT81-PO	Crossroads 345kV > 1.2pu after disabling Roosevelt Tripping Reduce Crossroads generation to 576 MW, reduction of 246 MW	Crossroads 345kV > 1.2pu after disabling Roosevelt Tripping Reduce Crossroads generation to 576 MW, reduction of 246 MW	Voltage instability after disabling Roosevelt Tripping Reduce Crossroads generation to 526 MW, reduction of 296 MW
88	FLT82-PO	Crossroads 345kV > 1.2pu after disabling Roosevelt Tripping Reduce Crossroads generation to 576 MW, reduction of 246 MW	Voltage instability after disabling Roosevelt Tripping Reduce Crossroads generation to 576 MW, reduction of 246 MW	Voltage instability after disabling Roosevelt Tripping Reduce Crossroads generation to 526 MW, reduction of 296 MW
89	FLT83-PO	Crossroads 345kV > 1.2pu after disabling Roosevelt Tripping Reduce Crossroads generation to 576 MW, reduction of 246 MW	Voltage instability after disabling Roosevelt Tripping Reduce Crossroads generation to 576 MW, reduction of 246 MW	Voltage instability after disabling Roosevelt Tripping Reduce Crossroads generation to 576 MW, reduction of 246 MW

Stability limits and system adjustments were investigated to determine the maximum amount of generation that can be interconnected while observing acceptable voltage and generator response pursuant to SPP Performance Criteria. The following is a summary of the results.

- High post-fault steady-state voltage at Oklaunion 345kV
    - Mitigation: Trip the Oklaunion HVDC reactive equipment at Oklaunion 345kV simultaneously with blocking of the Oklaunion HVDC tie
- Event resulting in outage of Crossroads to Eddy County 345kV circuit
    - Voltage instability is observed with a combined Roosevelt, Milo, and Sagamore output at 822 MW
    - Stability is maintained when Sagamore Wind output does not exceed 392 MW at Crossroads 345kV or combined Roosevelt, Milo, and Sagamore output does not exceed 685 MW at Crossroads 345kV; without RAS that trips the Sagamore facility for this event enabled or
    - Stability is maintained when a RAS that trips the Sagamore facility for this event is enabled (**full interconnection capacity of Roosevelt, Milo and Sagamore facilities when RAS is enabled**)
- Event resulting in outage of Crossroads 345 kV to Tolk 345kV circuit or Tolk 345/230 kV transformer #1 (and #2 once in-service)
    - Voltage instability is observed with a combined Roosevelt, Milo, and Sagamore output at 822 MW
    - Stability is maintained when Sagamore Wind output does not exceed 336 MW (stability margin calculation will include 300 MW from Roosevelt and Milo wind facilities) at Crossroads 345kV or when the combined Roosevelt, Milo, and Sagamore output does not exceed 636 MW at Crossroads 345kV with normal system configuration, all breakers in-service or
    - Stability is maintained when Crossroads 345 kV substation breaker configuration results in a trip of the Sagamore facility for these events (**full interconnection capacity of Roosevelt, Milo and Sagamore facilities with the breaker configuration in-place**)
- Prior outage events resulting in voltage instability with a combined Roosevelt, Milo, and Sagamore output at 822 MW
    - Loss of Crossroads to Tolk 345kV transmission line
        - Stability is maintained when Sagamore Wind output does not exceed 216 MW (stability margin calculation will include 300 MW from Roosevelt and Milo wind facilities) at Crossroads 345kV or when the combined Roosevelt, Milo, and Sagamore output does not exceed 516 MW at Crossroads 345kV
    - Loss of Crossroads to Eddy County 345kV transmission line
        - Stability is maintained when Sagamore Wind output does not exceed 266 MW (stability margin calculation will include 300 MW from Roosevelt

and Milo wind facilities) at Crossroads 345kV or when the combined Roosevelt, Milo, and Sagamore output does not exceed 566 MW at Crossroads 345kV

It was observed that NERC Category P1 and P6 events near Oklaunion 345kV and Tuco 345kV, with the exclusion of the AEP OKU RAS retirement, resulted in high post-fault steady-state voltages at Oklaunion 345kV. The limiting NERC Category P1 contingency was FLT05-3PH, a three-phase fault at Oklaunion 345kV resulting in the loss of the Oklaunion to Lawton Eastside 345kV line and simultaneous blocking of the Oklaunion HVDC line. Following the clearing of the fault, the Oklaunion 345kV voltage has a post-fault steady-state voltage above 1.10 p.u. due to the Oklaunion HVDC capacitive support at Oklaunion. It is recommended the capacitive support be included in the simultaneous blocking of the HVDC line prior to the OKU RAS retirement. Refer to Figure 4-1 for a representative voltage plot at Oklaunion and Tuco 345kV substations comparing the original fault event to the fault event including the tripping of the capacitive support. These events are no longer valid and do not require mitigation due to the RAS retirement.

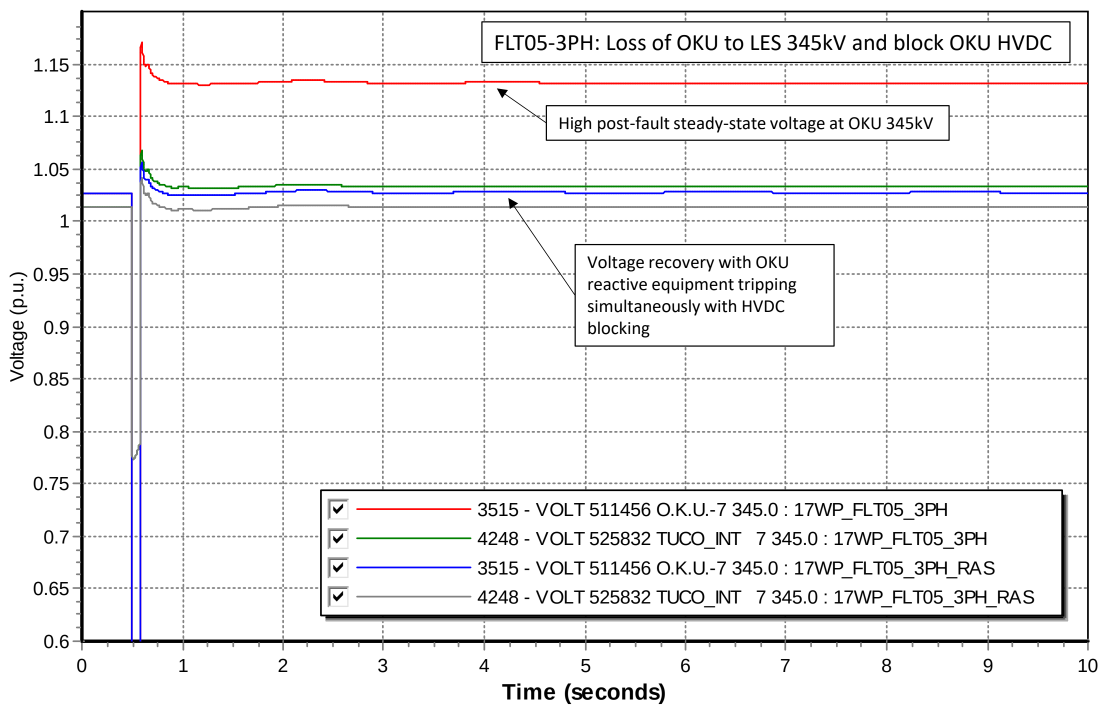

Figure 4-1: Representative voltage plot for FLT05-3PH for 2017 Winter Peak conditions.

There were several P1 and P4 events involving circuits connected to Crossroads 345kV that resulted in voltage instability and Sagamore Wind tripping offline for all three seasons prior to system adjustments and model updates. For P1 and P4 events, the most severe event was the loss of the Crossroads to Tolk 345kV line. This fault resulted in voltage instability and the Crossroads 345kV wind generation entering and exiting low voltage ride through mode with the full interconnection capability of Sagamore, Roosevelt, and Milo wind facilities (822 MW). It was determined that reducing the combined output of Sagamore, Roosevelt, and Milo Wind at Crossroads 345 kV to 650 MW at the generator terminals (636 MW at Crossroads 345kV) would result in acceptable system recovery and acceptable response of Sagamore Wind and nearby generation prior to any updates to breaker configuration at Crossroads 345 kV. Refer to Table 4-6 for various outputs of Sagamore Wind and Roosevelt-Milo Wind that determined the new System Operating Limit of 636 MW at Crossroads 345kV.

Table 4-6: Crossroads 345kV System Operating Limit Results

Reference Number	Crossroads Flow MW	Roosevelt - Milo MW	Sagamore MW	System Result
1	802.7 MW	299.65 MW	522 MW	Unstable
2	636 MW	299.65 MW	350 MW	Stable
3	636 MW	238 MW	412 MW	Stable
4	636 MW	128 MW	522 MW	Stable
5	509.3 MW	0 MW	522 MW	Stable

Refer to Figure 4-2 for a representative voltage plot comparing area bus voltages with Sagamore Wind at full output (522 MW) and with Sagamore Wind at reduced output (350 MW) at the generator terminals. Refer to Figure 4-3 for a representative plot of the real power of the Sagamore Wind units. Note the voltage transient following the fault clear event is shown to exceed 1.2 p.u. voltage at Crossroads 345kV. The voltage spike is not considered a violation but rather a limitation to the PSS/E program's calculations. For a more accurate response of the voltage transient, a detailed PSCAD analysis may be performed.

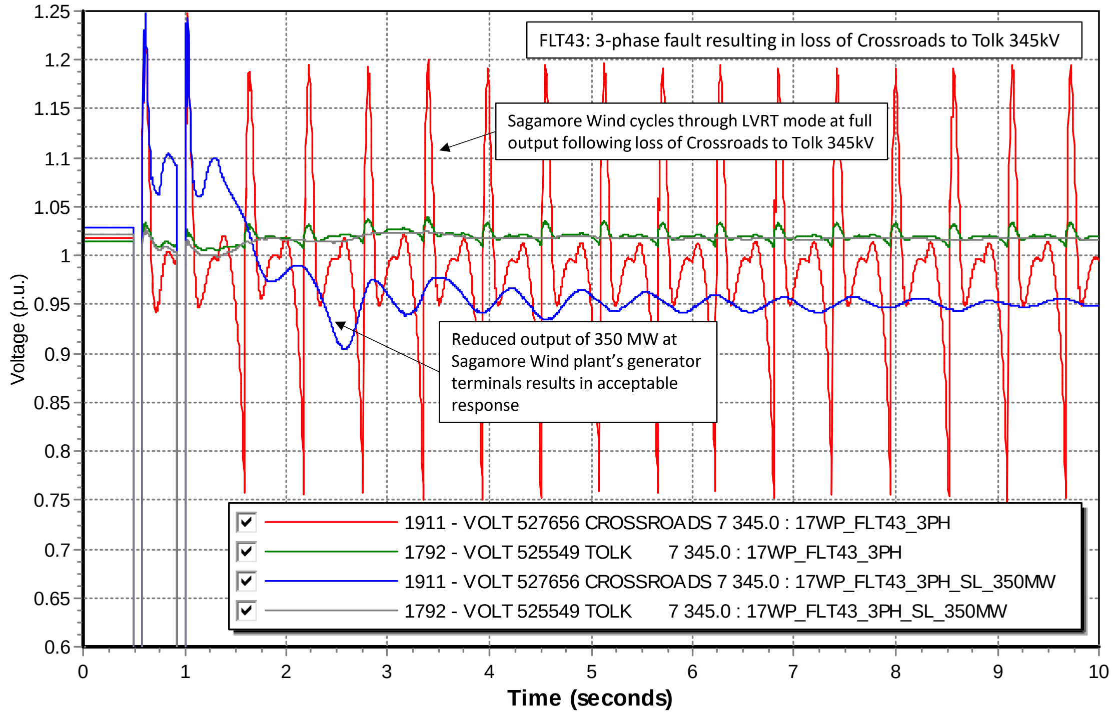

Figure 4-2: Representative voltage plot for FLT43-3PH for 2017 Winter Peak conditions.

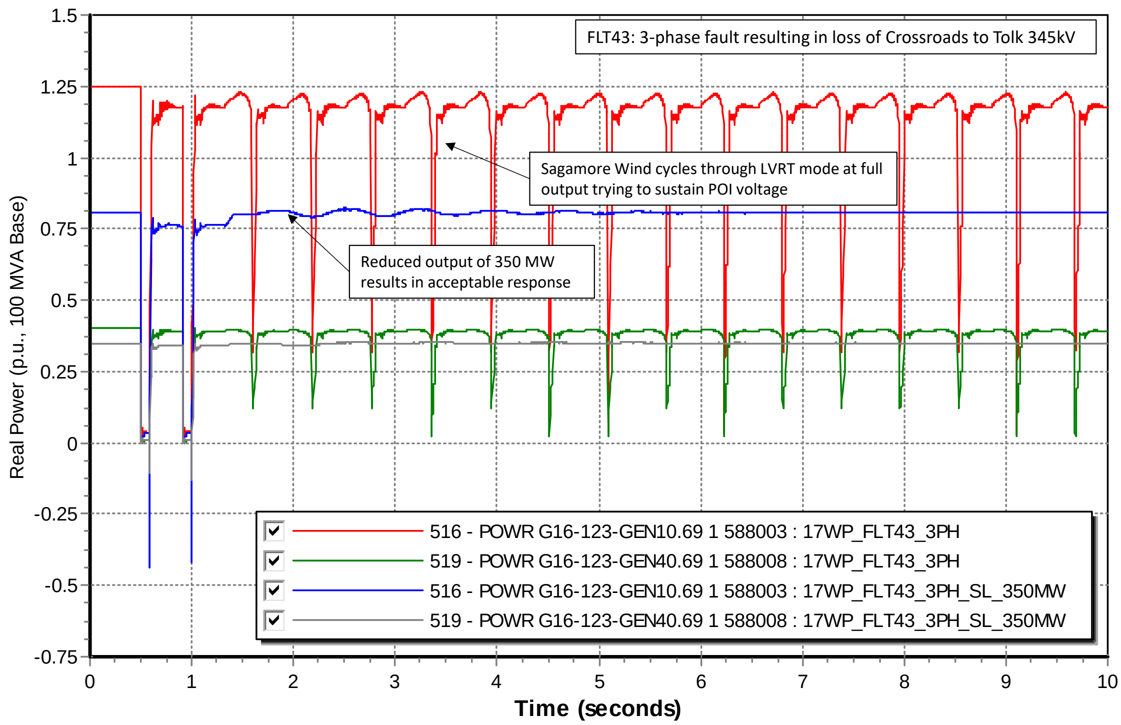

Figure 4-3: Representative real power plot for FLT43-3PH for 2017 Winter Peak conditions.

Refer to Figure 4-4 for a representative voltage plot showing the bus voltage response for FLT43-3PH for the alternate dispatches of Sagamore, Roosevelt, and Milo Wind shown in Table 4-6 (reference numbers 3 – 5). Refer to Figure 4-5 for a representative real power response of Sagamore Wind and Roosevelt-Milo Wind for reference numbers 3 through 5 in Table 4-6. The voltage response and real power response observed for 17WP conditions confirm the System Operating Limit of 650 MW at the generator terminals (636 MW at Crossroads 345kV). A combined output of 650 MW at the generator terminals (636 MW at Crossroads 345kV) from Sagamore, Roosevelt, and Milo Wind result in system stability and no generation tripping offline.

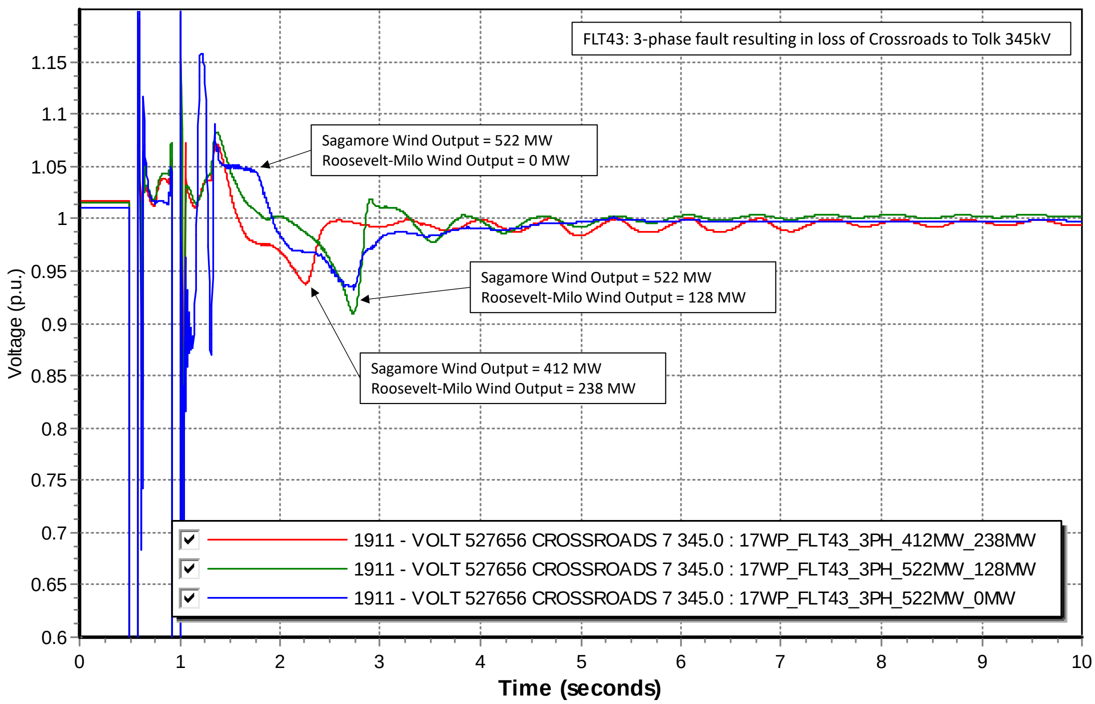

Figure 4-4: Representative voltage plot for FLT43-3PH for 2017 Winter Peak conditions for various Crossroads wind dispatches.

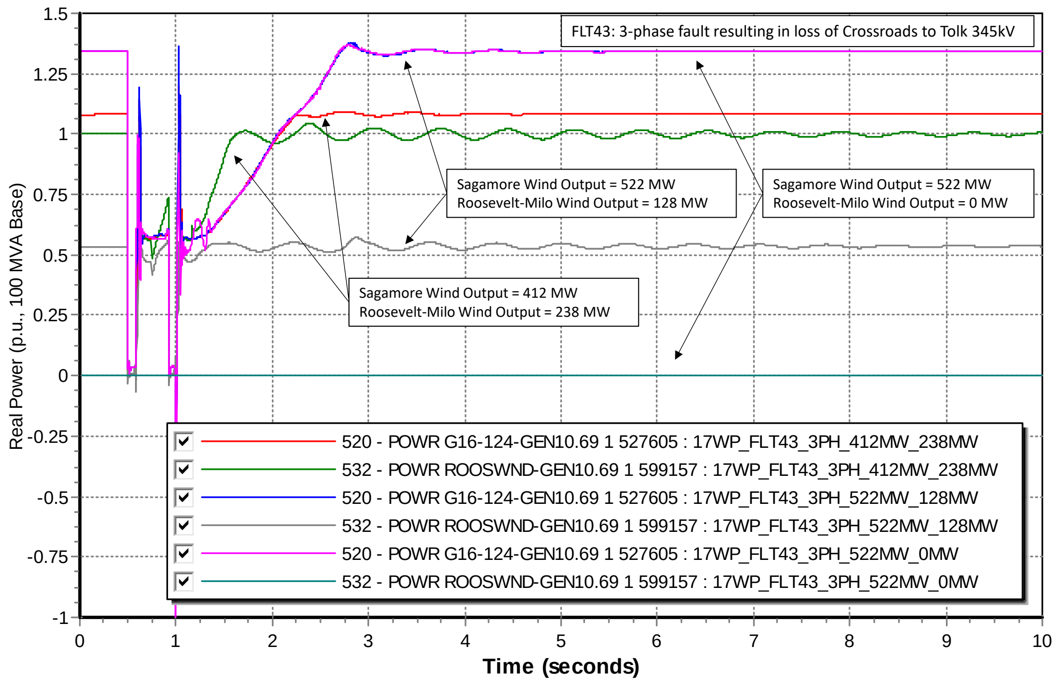

Figure 4-5: Representative real power plot for FLT43-3PH for 2017 Winter Peak conditions for various Crossroads wind dispatches.

After determining this event resulted in voltage instability and after discussion with the Transmission Owner, the breaker configuration at Crossroads 345kV was updated to result in a trip of Crossroads to Sagamore circuit including the wind facility for loss of Crossroads to Tolk 345 kV circuit. Refer to Figure 4-6 for a representative voltage plot for area bus voltages following the event of a fault on Crossroads to Tolk 345 kV. Note to meet SPP Performance Criteria for steady-state post-fault voltages, the capacitor bank at Crossroads was switched from 2 stages (100 MVAR total) to one stage (50 MVAR total) in-service. Refer to Figure 4-7 for a representative plot of the active power response for nearby generation facilities.

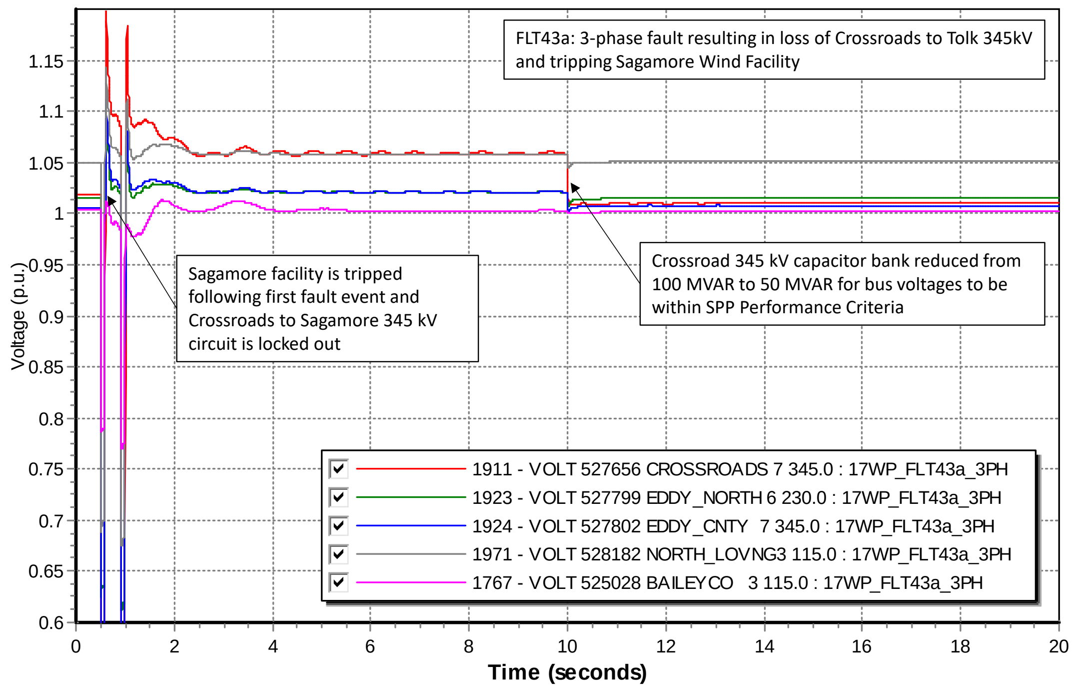

Figure 4-6: Representative voltage plot for FLT43a-3PH for 2017 Winter Peak conditions with updated breaker configuration at Crossroads 345 kV.

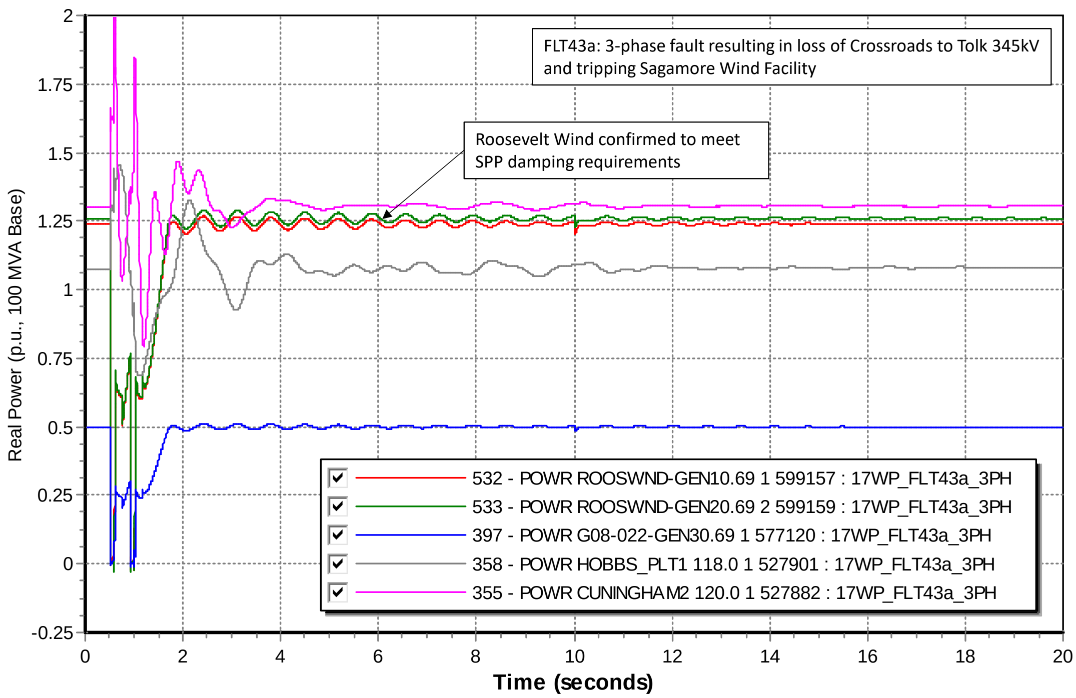

Figure 4-7: Representative real power plot for FLT43a-3PH for 2017 Winter Peak conditions with updated breaker configuration at Crossroads 345 kV.

A Remedial Action Scheme has been designed for Sagamore Wind for the loss of the Crossroads to Eddy County 345kV line in order to limit the flow across the Tolk 345/230kV transformer. The RAS will trip the Sagamore Wind plant when the Crossroads to Tolk 345kV line exceeds 478 MVA for 21 seconds or 556 MVA for 30 cycles plus a 1 cycle timer. The impact of this RAS was analyzed in this study by tripping the Sagamore Wind plant 31 cycles after the first instance of Crossroads to Eddy County 345kV is taken out-of-service. To determine the stability of the system with and without the RAS, this analysis was performed both with the RAS in-service and with the RAS out-of-service.

FLT45-3PH, a three-phase fault resulting in the loss of Crossroads to Eddy County 345kV, was analyzed to determine the impact of the RAS. Without the RAS enabled, the stability limit was determined to be 400 MW at the Sagamore Wind generator terminals. With the RAS in operation, there were no adverse impacts observed as a result of the RAS tripping Sagamore Wind. Refer to Figure 4-8 for a representative voltage plot of area voltages for 2018 Summer Peak conditions comparing Sagamore Wind at full output with the RAS disabled, Sagamore Wind at the identified stability limit (400 MW), and Sagamore Wind at full output with the RAS enabled (tripping Sagamore Wind). Refer to Figure 4-9 for a plot of the MVA through the Crossroads to Tolk 345kV line and the activation of the RAS.

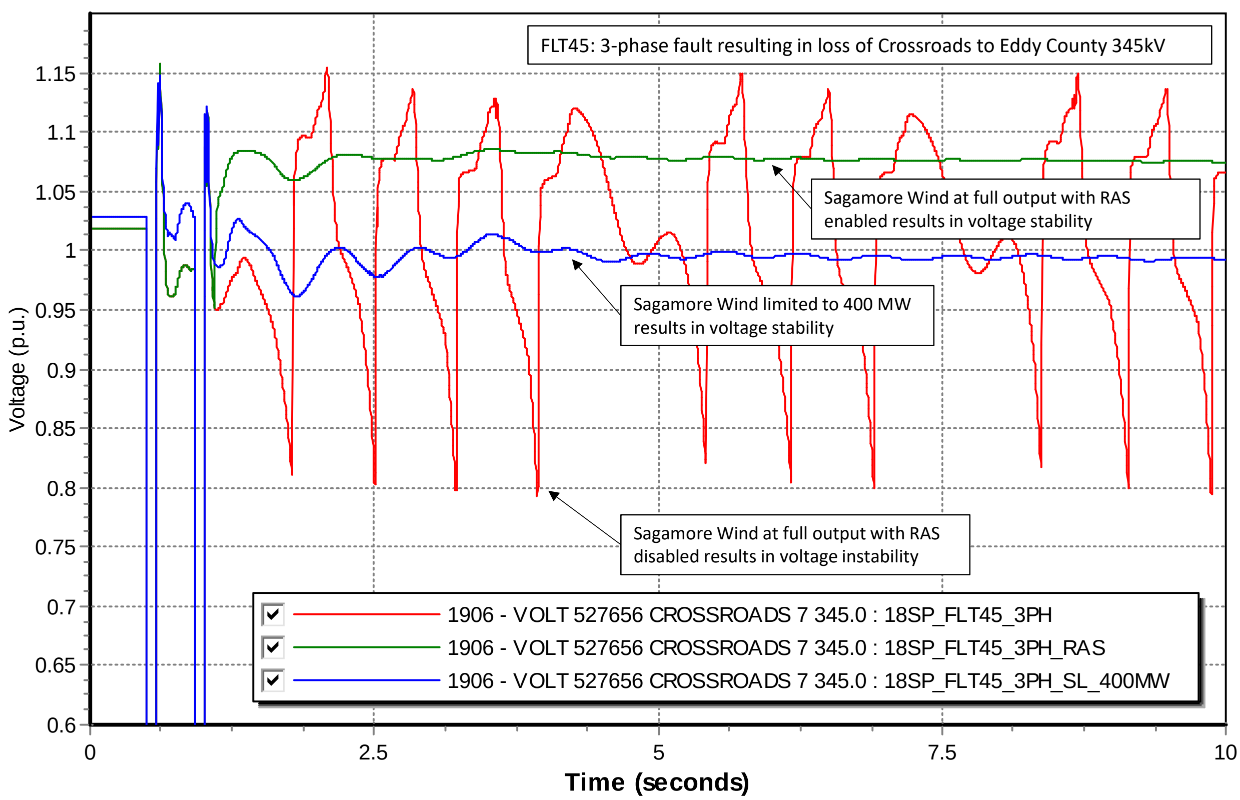

Figure 4-8: Representative voltage plot for FLT45-3PH for 2018 Summer Peak conditions.

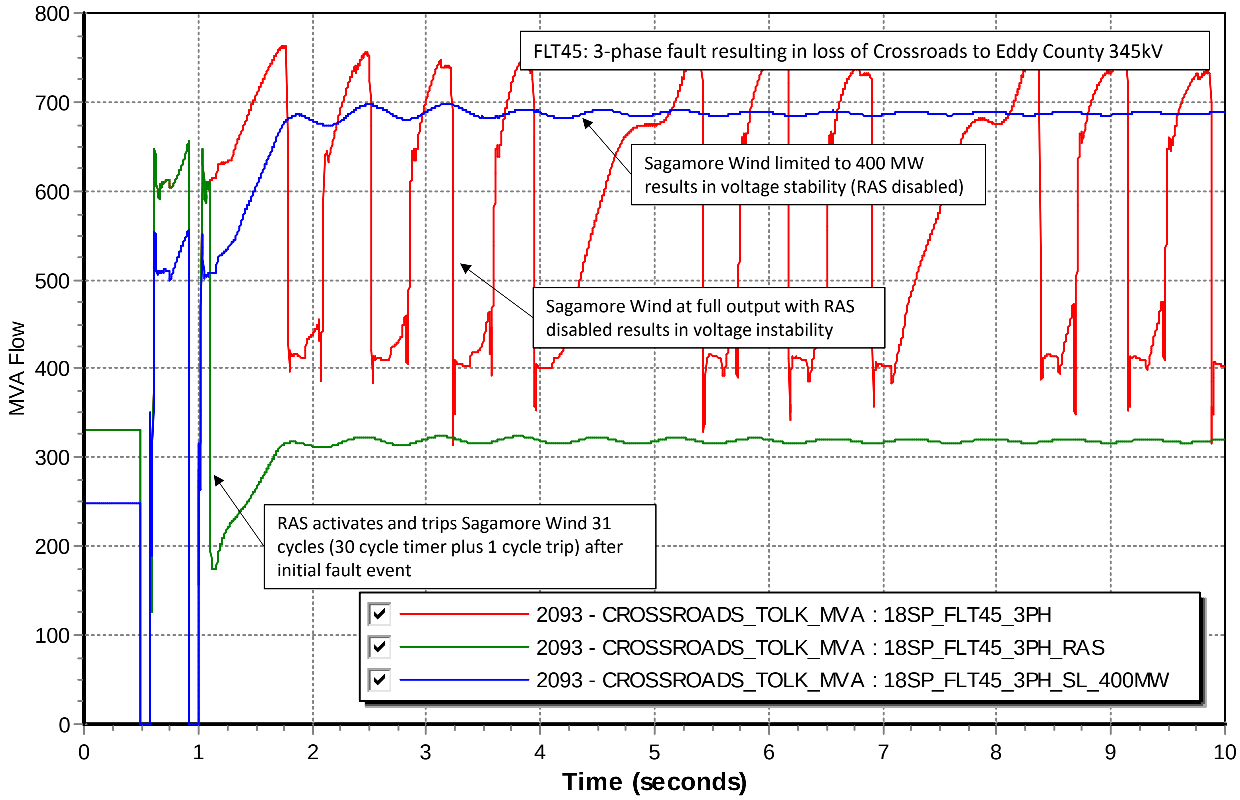

Figure 4-9: Plot of the MVA flow through Crossroads to Tolk 345kV for FLT45-3PH for 2018 Summer Peak conditions.

FLT58-SB, a stuck breaker fault resulting in the loss of Crossroads to Eddy County 345kV and Eddy County 345/230kV transformer resulted in voltage instability without enabling the SPS Sagamore Wind RAS. It was determined that the stability limit with the RAS disabled is 400 MW for Sagamore Wind at the generator terminals (as identified for the P1 event). With the RAS in operation, there was no adverse impacts observed as a result of the RAS and all local units remained online. Refer to Figure 4-10 for a representative voltage plot of Crossroads 345kV bus voltage for 2018 Summer Peak conditions comparing Sagamore Wind at full output with the RAS disabled, Sagamore Wind at the identified stability limit (400 MW), and Sagamore Wind at full output with the RAS enabled. Refer to Figure 4-11 for a plot of the MVA through the Crossroads to Tolk 345kV line and the activation of the RAS.

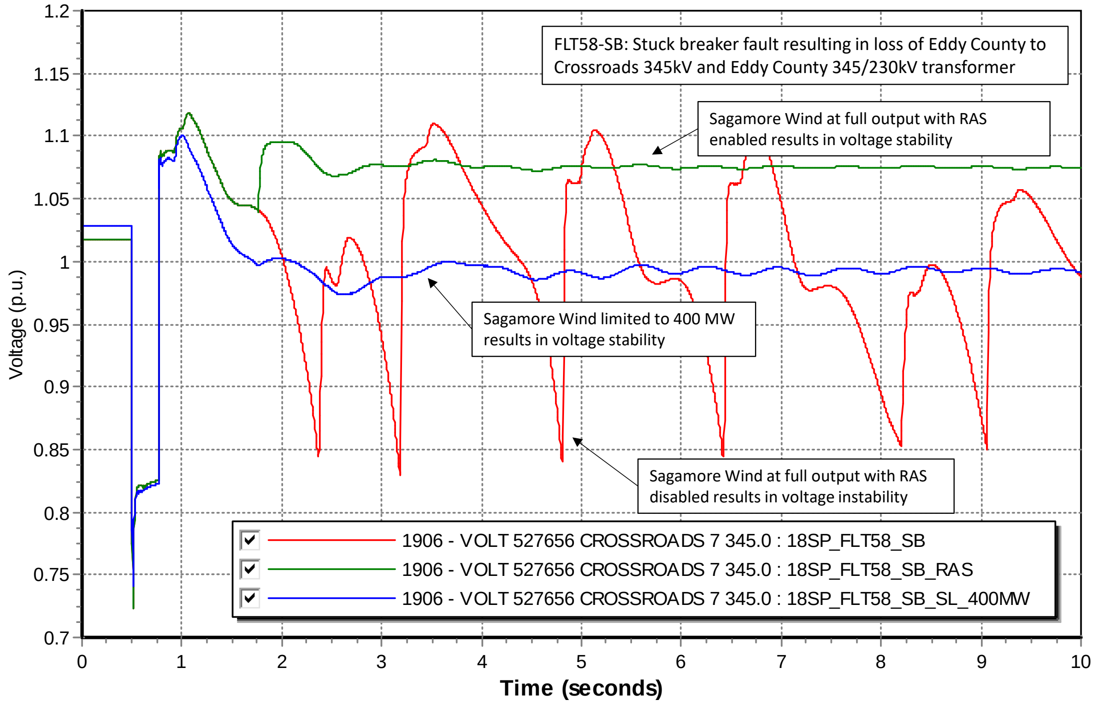

Figure 4-10: Representative voltage plot for FLT58-SB for 2018 Summer Peak conditions.

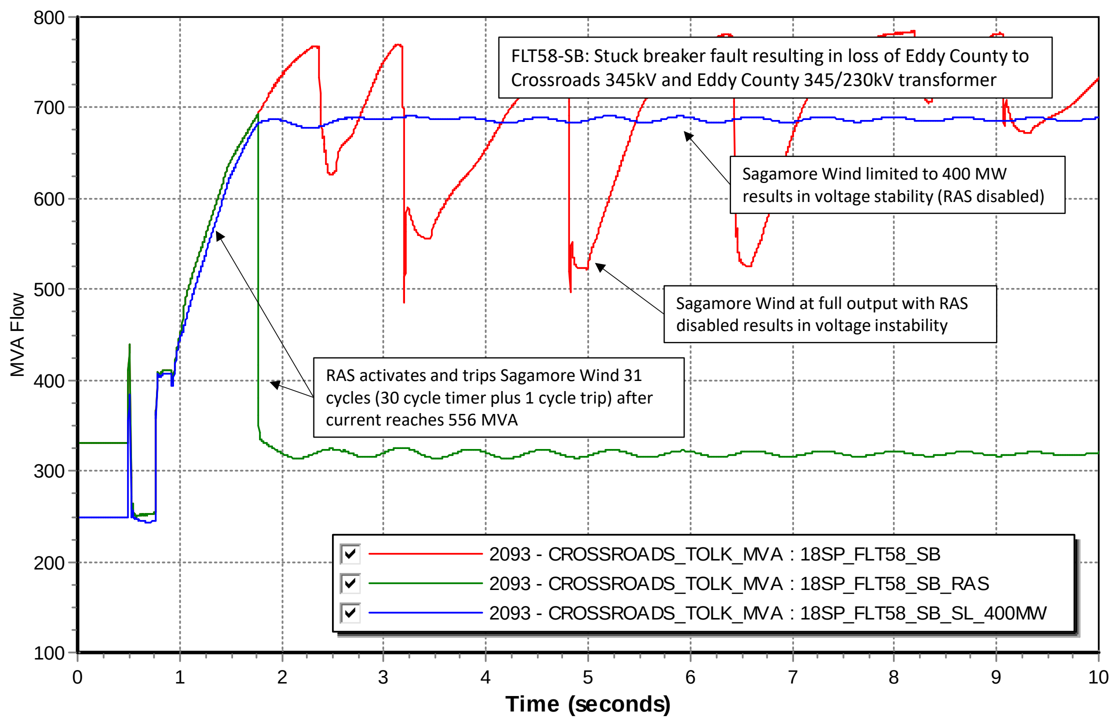

Figure 4-11: Plot of the MVA flow through Crossroads to Tolk 345kV for FLT58-SB for 2018 Summer Peak conditions.

4.2.1 Curtailment for P6 Events for the Normal Dispatch Scenario

The limiting NERC Category P6 contingencies involved the outage of either the Crossroads to Tolk 345kV line or the Crossroads to Eddy County 345kV line for all seasons. Voltage instability exists for a prior outage of either line out of Crossroads 345kV followed by a local three-phase fault and was determined that curtailing generation at Crossroads 345kV was required. It was determined that curtailing approximately 246 MW at the generator terminals (GEN-2008-022, GEN-2016-123, GEN-2016-124, & GEN-2016-125) or reducing total MW injection at Crossroads 345kV to 566 MW results in stable conditions for the prior outage of Crossroads to Eddy County 345kV and curtailing approximately 296 MW at the generator terminals (516 MW injection at Crossroads 345kV) for the prior outage of Crossroads to Tolk 345kV. The limiting prior outage contingency was the prior outage of Crossroads to Tolk 345kV followed by the loss of the Eddy County to Kiowa 345kV line (FLT66-PO). Refer to Figure 4-12 for a representative plot of area bus voltages without generation reduction and with generation reduction of 296 MW at Crossroads 345kV. Refer to Figure 4-13 for a plot of the real power output of one aggregated machine for Sagamore Wind. It can be observed that when Sagamore Wind and Roosevelt Wind have a combined output of approximately 526 MW at the generator terminals (516 MW at Crossroads 345kV) system stability is maintained and recovers within SPP Performance Criteria.

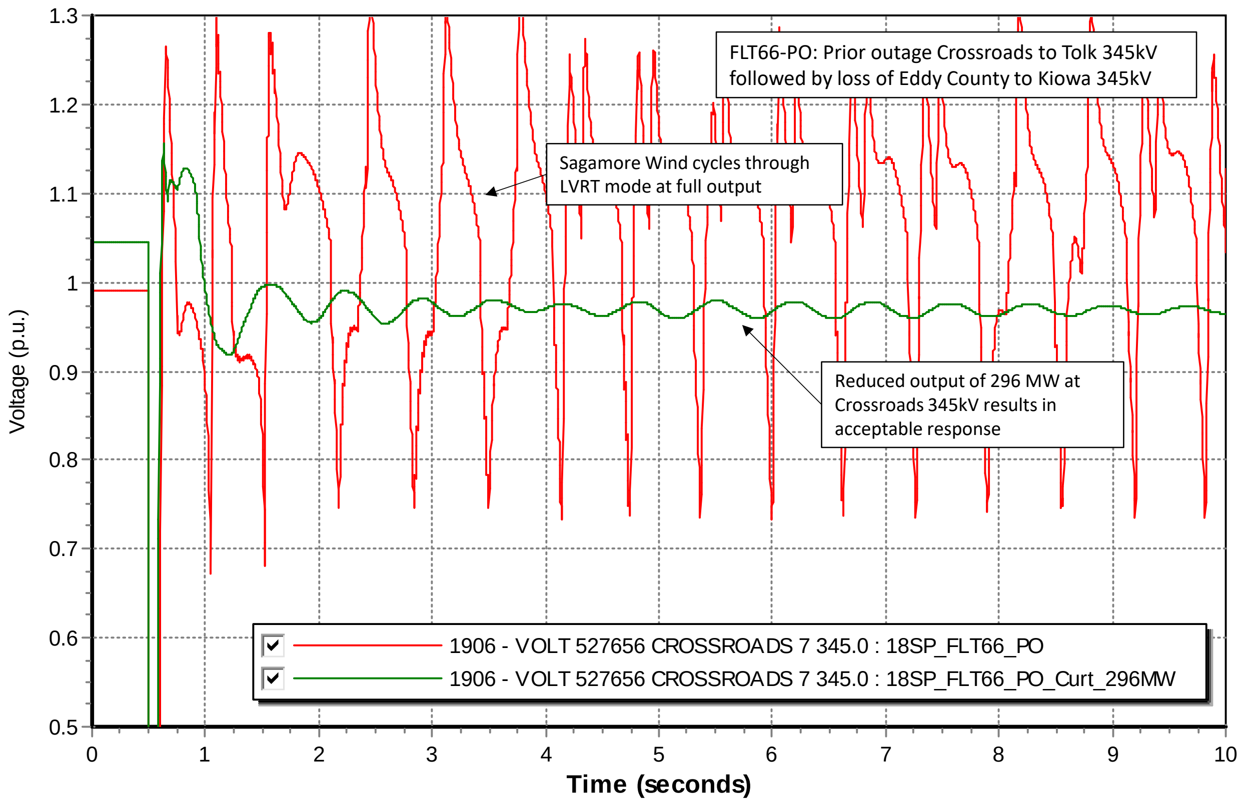

Figure 4-12: Representative voltage plot for FLT66-PO for 2018 Summer Peak conditions.

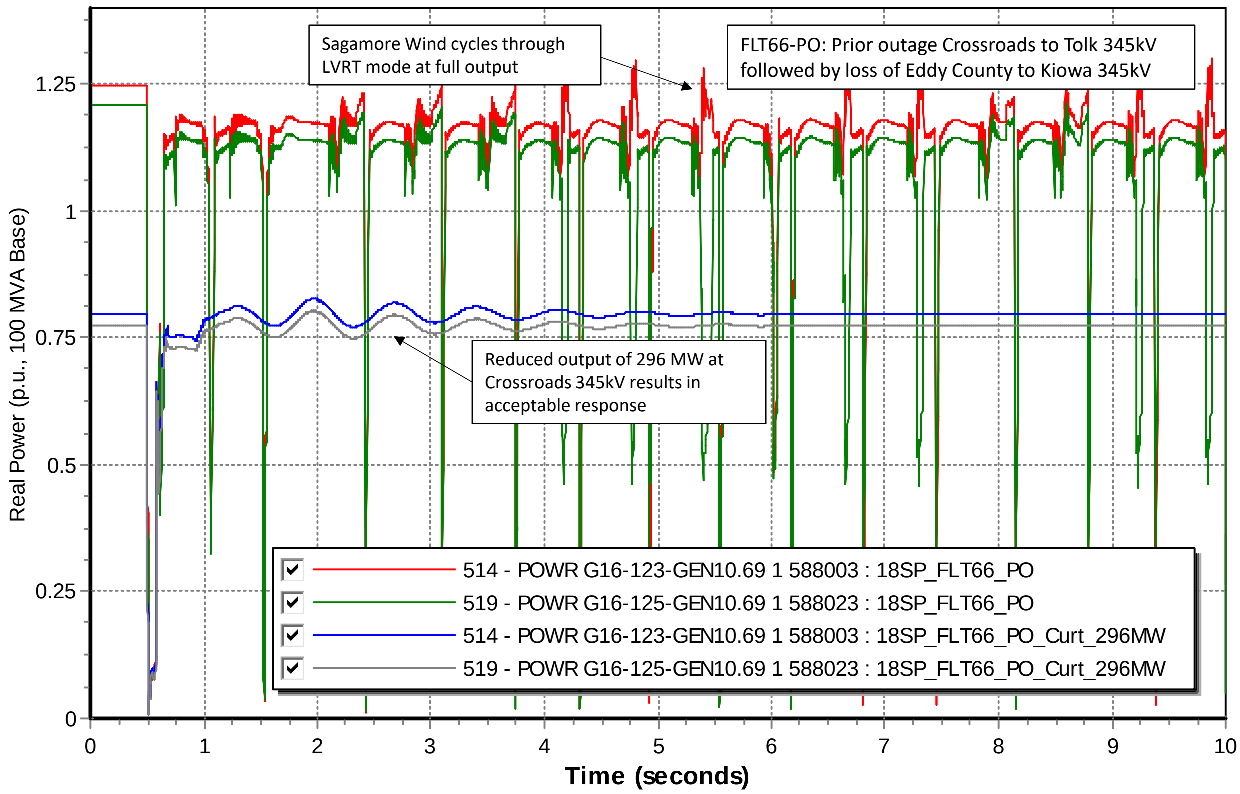

Figure 4-13: Representative real power plot for FLT66-PO for 2018 Summer Peak conditions.

4.2.2 Summary of the Normal Dispatch Scenario Results

The analysis of the Normal Dispatch Scenario determined generation curtailment is required to alleviate high post-fault steady-state voltages, voltage instability, and generation tripping offline in the Crossroads 345kV vicinity for P6 events near Crossroads and Eddy County 345kV. It was determined that tripping the Oklaunion reactive support at the Oklaunion substation under system conditions with the HVDC tie being blocked, enabling the SPS Sagamore RAS and curtailing area generation by up to approximately 296 MW adjusted by losses on interconnection facilities would alleviate the voltage violation concerns.

4.3 Sensitivity Stability Analysis Results

The sensitivity dispatch stability analysis determined there were multiple P1, P4, and P6 contingencies that resulted either high post-fault steady-state voltages, voltage instability, and/or generation tripping across all seasons when all generation interconnection requests were at 100% output.

Refer to Table 4-7 for a summary of the stability analysis results for the sensitivity dispatch scenario and Table 4-7 for a summary of the mitigation/generation curtailment required. Note the generation dispatch values in Table 4-8 represent the gross generation capacity observed at the generator terminals. Table 4-7 is a summary of the stability results for the 17WP, 18SP, and 26SP conditions and states whether the system remained stable or generation tripped offline, if acceptable voltage recovery was observed after the fault was cleared, and if the voltage recovered to above 0.9 p.u. and below 1.1 p.u. post fault steady-state conditions. Voltage recovery criteria includes ensuring that the transient voltage recovery is between 0.7 p.u. and 1.2 p.u. and ending in a steady-state voltage (for N-1 contingencies) at the pre-contingent level or at least above 0.9 p.u. and below 1.1. p.u.

Table 4-7: Summary of Results for 17WP, 18SP, and 26SP Conditions for the Sensitivity Dispatch Scenario

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
1	FLT01-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
2	FLT02-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
3	FLT03-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
4	FLT04-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
8	FLT08-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
9	FLT09-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
10	FLT10-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
11	FLT11-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
12	FLT14-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
13	FLT15-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
14	FLT18-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
15	FLT21-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
16	FLT22-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
17	FLT23-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
18	FLT24-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
19	FLT25-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
20	FLT26-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
21	FLT27-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
22	FLT28-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
23	FLT29-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
24	FLT30-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
25	FLT31-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
26	FLT32-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable

Table 4-7: Summary of Results for 17WP, 18SP, and 26SP Conditions for Sensitivity Dispatch Scenario (cont.)

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
27	FLT33-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
28	FLT34--SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
29	FLT35--SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
30	FLT36-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
31	FLT37-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
32	FLT38-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
33	FLT39-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
34	FLT40-PO	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
35	FLT41-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
36	FLT42-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
37	FLT43-3PH	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
38	FLT43a-3PH*	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
39	FLT44-3PH	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
40	FLT44a-3PH*	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
41	FLT45-3PH	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
42	FLT46-3PH*	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
43	FLT47-3PH*	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
44	FLT48-3PH*	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
45	FLT49-3PH*	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
46	FLT50-3PH*	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
47	FLT51-3PH*	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable

*As-built Vestas V7.5.8 Model Parameters Utilized

Table 4-7: Summary of Results for 17WP, 18SP, and 26SP Conditions for Sensitivity Dispatch Scenario (cont.)

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
48	FLT52-3PH*	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
49	FLT53-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
50	FLT54-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
51	FLT55-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
52	FLT56-SB	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
53	FLT57-SB	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
54	FLT57a-SB*	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
55	FLT58-SB	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
56	FLT59-PO	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
57	FLT60-PO	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
58	FLT61-PO	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
59	FLT62-PO	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
60	FLT63-PO	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
61	FLT64-PO	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
62	FLT65-PO	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
63	FLT66-PO	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
64	FLT67-PO	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability	-	-	Oscillatory voltages	Instability
65	FLT68-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
66	FLT69-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
67	FLT70-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable

*As-built Vestas V7.5.8 Model Parameters Utilized

Table 4-7: Summary of Results for 17WP, 18SP, and 26SP Conditions for Sensitivity Dispatch Scenario (cont.)

Cont. No.	Cont. Name	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.			Less than .70 p.u.	Greater than 1.20 p.u.		
68	FLT71-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
69	FLT72-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
70	FLT73-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
71	FLT74-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
72	FLT75-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
73	FLT76-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
74	FLT77-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
75	FLT78-3PH	-	-	Compliant	Stable	-	-	Compliant	Stable	-	-	Compliant	Stable
76	FLT79-PO	-	-	Compliant	Gen Trip Crossroads	-	-	Compliant	Gen Trip Crossroads	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads
77	FLT80-PO	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads
78	FLT81-PO	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads
79	FLT82-PO	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads
80	FLT83-PO	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads	-	-	Crossroads 345kV V > 1.1	Gen Trip Crossroads

Table 4-8: Required Mitigation/Generation Curtailment for the Sensitivity Dispatch Scenario

Cont. No.	Cont. Name	2017 Winter Peak Mitigation	2018 Summer Peak Mitigation	2026 Summer Peak Mitigation
37	FLT43-3PH	Sagamore Output @ Gen Terminals = 350 MW Crossroads Cumulative Output = 650 MW GEN-2017-069 Interim Service = 3.6 MW	Sagamore Output @ Gen Terminals = 350 MW Crossroads Cumulative Output = 650 MW GEN-2017-069 Interim Service = 3.6 MW	Sagamore Output @ Gen Terminals = 350 MW Crossroads Cumulative Output = 650 MW GEN-2017-069 Interim Service = 3.6 MW
39	FLT44-3PH	Sagamore Output @ Gen Terminals = 350 MW Crossroads Cumulative Output = 650 MW GEN-2017-069 Interim Service = 3.6 MW	Sagamore Output @ Gen Terminals = 350 MW Crossroads Cumulative Output = 650 MW GEN-2017-069 Interim Service = 3.6 MW	Sagamore Output @ Gen Terminals = 350 MW Crossroads Cumulative Output = 650 MW GEN-2017-069 Interim Service = 3.6 MW
41	FLT45-3PH	Sagamore Output @ Gen Terminals = 400 MW Crossroads Cumulative Output = 700 MW GEN-2017-069 Interim Service = 3.6 MW or Enable Sagamore Wind RAS	Sagamore Output @ Gen Terminals = 400 MW Crossroads Cumulative Output = 700 MW GEN-2017-069 Interim Service = 3.6 MW or Enable Sagamore Wind RAS	Sagamore Output @ Gen Terminals = 400 MW Crossroads Cumulative Output = 700 MW GEN-2017-069 Interim Service = 3.6 MW or Enable Sagamore Wind RAS
53	FLT57-SB	Sagamore Output @ Gen Terminals = 350 MW Crossroads Cumulative Output = 650 MW GEN-2017-069 Interim Service = 3.6 MW	Sagamore Output @ Gen Terminals = 350 MW Crossroads Cumulative Output = 650 MW GEN-2017-069 Interim Service = 3.6 MW	Sagamore Output @ Gen Terminals = 350 MW Crossroads Cumulative Output = 650 MW GEN-2017-069 Interim Service = 3.6 MW
55	FLT58-SB	Sagamore Output @ Gen Terminals = 400 MW Crossroads Cumulative Output = 700 MW GEN-2017-069 Interim Service = 3.6 MW or Enable Sagamore Wind RAS	Sagamore Output @ Gen Terminals = 400 MW Crossroads Cumulative Output = 700 MW GEN-2017-069 Interim Service = 3.6 MW or Enable Sagamore Wind RAS	Sagamore Output @ Gen Terminals = 400 MW Crossroads Cumulative Output = 700 MW GEN-2017-069 Interim Service = 3.6 MW or Enable Sagamore Wind RAS
56	FLT59-PO	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW
57	FLT60-PO	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW
58	FLT61-PO	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW
59	FLT62-PO	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW
60	FLT63-PO	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW
61	FLT64-PO	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW
62	FLT65-PO	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW
63	FLT66-PO	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 526 MW, reduction of 296 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 526 MW, reduction of 296 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 500 MW, reduction of 300 MW

Table 4-8: Required Mitigation/Generation Curtailment for the Sensitivity Dispatch Scenario (cont.)

Cont. No.	Cont. Name	2017 Winter Peak Mitigation	2018 Summer Peak Mitigation	2026 Summer Peak Mitigation
64	FLT67-PO	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW
76	FLT79-PO	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 526 MW, reduction of 296 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 526 MW, reduction of 296 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 500 MW, reduction of 300 MW
77	FLT80-PO	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW
78	FLT81-PO	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW
79	FLT82-PO	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW
80	FLT83-PO	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW	Reduce flow on Tolk transformer to 100%. Reduce Crossroads generation to 576 MW, reduction of 246 MW

The Sensitivity Dispatch Scenario identified similar response and results to the Normal Dispatch Scenario. It was determined that curtailing area generation by up to approximately 296 MW adjusted by losses on interconnection facilities would alleviate the voltage violation concerns for prior outage conditions of Tolk to Crossroads 345kV.

The Sensitivity Dispatch Scenario analyzed the dispatch of local generation to their Pmax values which included the Tolk Unit #1 dispatched at full output (586 MW gross output) for 2017 Winter Peak conditions instead of as a synchronous condenser as modeled in Normal Dispatch Scenario. The same amount of curtailment for prior outage conditions is required of the Crossroads 345kV generation (Sagamore Wind and Roosevelt Wind) with Tolk Unit #1 dispatched at full output or dispatched as a synchronous condenser.

4.3.1 Summary of the Sensitivity Dispatch Scenario Results

The analysis of the sensitivity dispatch scenario determined there are no violation concerns, incremental from the fault events evaluated. All fault events resulted in acceptable voltage, rotor angle, and power oscillation recovery applicable to SPP Performance Criteria with Sagamore operating at full interconnection capability for P1, P4, and P6 events. It was determined from the sensitivity faults evaluated that Sagamore Wind and GEN-2017-069 do not have an adverse impacts on the generation interconnected within the same vicinity of SPS and neighboring transmission systems.

SECTION 5: CONCLUSION

Summary of Power Flow Analysis

The power flow analysis determined a limited operation amount for GEN-2016-123, GEN-2016-124, and GEN-2016-125 and the available interim service for GEN-2017-069. It was determined, with appropriate system adjustments to voltage schedules and ensure power factor requirements are met (Scenario 3), GEN-2016-123, GEN-2016-124, and GEN-2016-125 can connect at full output and Interim Request GEN-2017-069 can connect at full Interim Service. In the event Scenario 3 is determined to be invalid by SPP Management Staff, Sagamore Wind would have a Limited Operation of 274 MW at the generator terminals (272 MW at Crossroads 345kV) and GEN-2017-069 would not have interim service available (0 MW)(Scenario 2).

Summary of Stability Analysis

The stability analysis determined that there were multiple P1, P4, and P6 contingencies that resulted either high post-fault steady-state voltages, voltage instability, and/or generation tripping across all seasons when all generation interconnection requests were at 100% output.

- High post-fault steady-state voltage at Oklaunion 345kV
    - Mitigation: Trip the Oklaunion HVDC reactive equipment at Oklaunion 345kV simultaneously with blocking of the Oklaunion HVDC tie
- Event resulting in outage of Crossroads to Eddy County 345kV circuit
    - Voltage instability is observed with a combined Roosevelt, Milo, and Sagamore output at 822 MW
    - Stability is maintained when Sagamore Wind output does not exceed 392 MW at Crossroads 345kV or combined Roosevelt, Milo, and Sagamore output does not exceed 685 MW at Crossroads 345kV; without RAS that trips the Sagamore facility for this event enabled or
    - Stability is maintained when a RAS that trips the Sagamore facility for this event is enabled (**full interconnection capacity of Roosevelt, Milo and Sagamore facilities when RAS is enabled**)
- Event resulting in outage of Crossroads 345 kV to Tolk 345kV circuit or Tolk 345/230 kV transformer #1 (and #2 once in-service)
    - Voltage instability is observed with a combined Roosevelt, Milo, and Sagamore output at 822 MW
    - Stability is maintained when Sagamore Wind output does not exceed 336 MW (stability margin calculation will include 300 MW from Roosevelt and Milo wind facilities) at Crossroads 345kV or when the combined Roosevelt, Milo, and Sagamore output does not exceed 636 MW at Crossroads 345kV with normal system configuration, all breakers in-service or

    - Stability is maintained when Crossroads 345 kV substation breaker configuration results in a trip of the Sagamore facility for these events (**full interconnection capacity of Roosevelt, Milo and Sagamore facilities with the breaker configuration in-place**)
- Prior outage events resulting in voltage instability with a combined Roosevelt, Milo, and Sagamore output at 822 MW
    - Loss of Crossroads to Tolk 345kV transmission line
        - Stability is maintained when Sagamore Wind output does not exceed 216 MW (stability margin calculation will include 300 MW from Roosevelt and Milo wind facilities) at Crossroads 345kV or when the combined Roosevelt, Milo, and Sagamore output does not exceed 516 MW at Crossroads 345kV
    - Loss of Crossroads to Eddy County 345kV transmission line
        - Stability is maintained when Sagamore Wind output does not exceed 266 MW (stability margin calculation will include 300 MW from Roosevelt and Milo wind facilities) at Crossroads 345kV or when the combined Roosevelt, Milo, and Sagamore output does not exceed 566 MW at Crossroads 345kV

Additionally, a sensitivity of dispatching local generation to Crossroads 345kV and Norton 115kV did not result in any adverse impacts to system response from the results above.

The stability analysis from this Limited Operation and Interim Availability study determined the following with identified system adjustments:

- GEN-2016-123, GEN-2016-124, GEN-2016-125 can interconnect at full requested capability.
- GEN-2017-069 can interconnect at full requested capability.

The stability analysis was evaluated with two separate model parameter sets for Sagamore Wind facility which include preliminary model parameters and as-built model parameters. Additionally, the Roosevelt-Milo Wind facilities represented with Vestas user-written generator models without a Power Plant Controller (PPC). Results presented in this report are based on the exclusion of the power plant controller and represent a conservative scenario. Inclusion of a PPC is anticipated to provide improved voltage control and inclusion in a subsequent analysis has potential to resolve the stability issues observed in this study.

It should be noted that while this Limited Operation and Interim Availability study analyzed many of the most probable contingencies, it is not an all-inclusive list that can account for every operation situation. Additionally, the study requests 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, it is likely that the Customers may be required to reduce their generation output to 0 MW under certain system conditions to allow system operators to maintain the reliability of the transmission network.

APPENDIX A: STABILITY ANALYSIS STEADY STATE AND DYNAMIC MODEL DATA

Base Cases

Three base case power flow models were provided to MEPPI by SPP:

- MDWG16-17W_DIS16022_G06.sav
- MDWG16-18S_DIS16022_G06.sav
- MDWG16-26S_DIS16022_G06.sav

Three dynamic files were provided to MEPPI by SPP:

- MDWG16-17W_DIS16022_G06.dyr
- MDWG16-18S_DIS16022_G06.dyr
- MDWG16-26S_DIS16022_G06.dyr

Updates Applied to Base Case

Addition of:

- Upgrade Carlisle 230/115kV transformer
- Yoakum to Hobbs 345kV
- Yoakum 345/230kV transformer
- Hobbs 345/230kV transformer
- Rebuild Plant X to Tolk 230kV circuits #1 and #2
- Upgrade existing Tuco 345/230kV transformer
- Tuco to Yoakum 345kV circuit #1
- Eddy to Kiowa 345kV circuit #1
- GEN-2017-069 (increase Caprock Solar from 25 MW to 28.6 MW)
- Switch off TUCO in-line reactors on the TUCO to Yoakum 345kV line
- Switch off the Border in-line reactors on the Border to Woodward 345kV line
- Adjust the low voltage setting for the Woodward transformer tertiary shunt reactors.
- Adjust Hale County Wind, Antelope, and TUCO SVC to control TUCO 230 kV at 1.02 p.u
- Adjust Hale County Wind main power transformers to maintain normal voltages at 34.5 kV.
- Adjust Elk 1 & 2 to control TUCO 345 kV at 1.00725 p.u.
- Adjust Bethel Wind generation to control Castro County 115 kV at 1.02 p.u.
- Model Tolk Unit #1 as synchronous condenser (+/-300 MVA) for 2017 Winter Peak conditions

Removal of:

- SPP Withdrawn requests:
  - GEN-2001-033 (reduced from 180 MW to 120 MW)
  - GEN-2011-049
  - GEN-2015-004
  - GEN-2015-099
  - GEN-2016-023

- GEN-2016-029
- GEN-2016-037
- GEN-2016-096
- GEN-2016-121

Request Data:

GEN-2017-069

- Solar Farm Size: 3.6 MW (addition to Cap Rock Solar GEN-2013-022)
- Interconnection:
  - Voltage: 115kV
  - POI: Norton 115kV
  - Transformer: 115/34.5 kV step-up transformer
    - Z: 8.5% on 16.6 Winding MVA
- Collector System Equivalent Model:
  - Transmission Line:
    - R = 0.001415 p.u.
    - X = 0.0137 p.u.
    - B = 0.0027 p.u.
- Solar Farm Parameters
  - SMA Sunny Central
  - Machine Terminal Voltage: 0.55 kV
  - Rated Power: 3.6 MW (28.6 MW total)
  - Generator Step-Up Transformer:
    - Z: 5.8% on 26 Winding MVA

The following is the dynamic data for GEN-2013-022 and GEN-2017-069:

```
524491 'USRMDL' 1 'SMASC139' 1 1 0 120 25 200
 1.0   1.000  0.123 0.8 1.0 0.0 1.0 0.0 0.35
 1.0 0.0 5.0 0.5 2.0
 0.0 0.9 0.5 1.0 0.9 0.9
 0.0 0.2 0.05 0.4
 1.0 1.0
 2.0 2.0 2.0 2.0 0.1 0.1 0.1 0.1 0.1 0.1
 0.01 0.0 20.0 0.01 0.2 0.0 0.0
 0.0 0.125 0.1
 1.22 5.0 1.21 1.0 1.2 10.0 1.18 9.5 1.15 9.0 0.88 12.0 0.8 10.0 0.7 9.0 0.6 2.0 0.5 0.2
 67.0 0.05 66.8 0.08 66.0 0.09 65.0 0.1 64.0 1.0 62.5 3.0 58.3 5.0 57.0 3.0 50.0 0.1 49.0 0.09 48.5 0.08 48.0 0.05
 30.0 1.0 100.0 30.0 0.0 0.0 5.0 0.3
 0.0 20.0 1.0 1.0
 0.0 360.0 0.5 0.01 0.05 0.0 0.5 1.0
 1.0 1.0 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0/
52449101 'VTGTPAT' 524491 524491 1  0.00  1.15  3.0   0.01 /
52449102 'VTGTPAT' 524491 524491 1  0.00  1.30  1.0   0.01 /
52449103 'VTGTPAT' 524491 524491 1  0.00  1.40  0.001 0.01 /
52449104 'VTGTPAT' 524491 524491 1  0.80  2.00  5.0   0.01 /
52449105 'VTGTPAT' 524491 524491 1  0.40  2.00  2.0   0.01 /
52449106 'FRQTPAT' 524491 524491 1 40.00 63.00 60.0   0.01 /
52449107 'FRQTPAT' 524491 524491 1 57.00 80.00 60.0   0.01 /
/
```

GEN-2016-123, GEN-2016-124, GEN-2016-125

- Wind Farm Size: 522 MW
- Interconnection:
  - Voltage: 345kV
  - POI: Crossroads 345kV
  - Transformer (x4): 345/34.5 kV step-up transformer
    - Z: 10% on 94 Winding MVA
- Collector System Equivalent Model:
  - Transmission Line #1:
    - R = 0.00577 p.u.
    - X = 0.00789 p.u.
    - B = 0.09615 p.u.
  - Transmission Line #2:
    - R = 0.00907 p.u.
    - X = 0.01352 p.u.
    - B = 0.14434 p.u.
  - Transmission Line #3:
    - R = 0.00706 p.u.
    - X = 0.00999 p.u.
    - B = 0.09247 p.u.
  - Transmission Line #4:
    - R = 0.00708 p.u.
    - X = 0.00972 p.u.
    - B = 0.10428 p.u.
- Wind Farm Parameters
  - Vestas V110 and V120 VCS turbines
  - Machine Terminal Voltage: 0.69 kV
  - Rated Power of the Plant: 522 MW
  - Generator Step-Up Transformer #1:
    - Aggregated MW: 40 MW
    - Z: 9.75% on 41.2 Winding MVA
  - Generator Step-Up Transformer #2:
    - Aggregated MW: 105.6 MW
    - Z: 9.75% on 98.88 Winding MVA
  - Generator Step-Up Transformer #3:
    - Aggregated MW: 12 MW
    - Z: 9.75% on 12.36 Winding MVA
  - Generator Step-Up Transformer #4:
    - Aggregated MW: 110.0 MW
    - Z: 9.75% on 103 Winding MVA

- Generator Step-Up Transformer #5:
    - Aggregated MW: 121 MW
    - Z: 9.75% on 113.3 Winding MVA
- Generator Step-Up Transformer #6:
    - Aggregated MW: 134.2 MW
    - Z: 9.75% on 125.66 Winding MVA

The following is the dynamic data for GEN-2016-123, GEN-2016-124, and GEN-2016-125 initially used for the analysis (assumed parameters):

GEN-2016-123_124_125.dyr

The following is the as-built dynamic data for GEN-2016-123, GEN-2016-124, and GEN-2016-125:

GEN-2016-123_124_125_As-Built.dyr

APPENDIX B: PLOTS FOR 2017 WINTER PEAK CONDITIONS WITH NORMAL DISPATCH

Plots available upon request

APPENDIX C: PLOTS FOR 2018 SUMMER PEAK CONDITIONS WITH NORMAL DISPATCH

Plots available upon request

APPENDIX D: PLOTS FOR 2026 SUMMER PEAK CONDITIONS WITH NORMAL DISPATCH

Plots available upon request

APPENDIX E: PLOTS FOR 2017 WINTER PEAK CONDITIONS WITH SENSITIVITY DISPATCH

Plots available upon request

APPENDIX F: PLOTS FOR 2018 SUMMER PEAK CONDITIONS WITH SENSITIVITY DISPATCH

Plots available upon request

APPENDIX G: PLOTS FOR 2026 SUMMER PEAK CONDITIONS WITH SENSITIVITY DISPATCH

Plots available upon request