GEN-2011-008 Impact Restudy for Generator Modification (Turbine Change)

June 2016
Generator Interconnection

Southwest Power Pool

Revision History

Date	Author	Change Description
6/16/2016	SPP	GEN-2011-008 Impact Restudy for Generator Modification (Turbine Change) issued.

Executive Summary

The GEN-2011-008 Interconnection Customer has requested a modification to its Generator Interconnection Request to change from three hundred seventy-five (375) GE 1.6 MW wind turbine generators (aggregate power of 600.0 MW) to three hundred (300) Vestas V110 VCSS 2.0 MW wind turbine generators (aggregate power of 600.0 MW). The point of interconnection (POI) is the ITC-Great Plains (ITC-GP) Clark County Substation 345 kV. Mitsubishi Electric Power Products, Inc. (MEPPI) performed the study for this modification request, and MEPPI's report on the study follows this summary.

The study models used were the 2016 winter, the 2017 summer, and the 2025 summer cases and included Interconnection Requests through DISIS-2015-001. The study showed that no stability problems were found with the contingencies studied during the summer and the winter peak conditions as a result of changing to the Vestas V110 VCSS 2.0 MW wind turbine generators. Additionally, the project wind farm was found to stay connected during the contingencies that were studied and, therefore, will meet the Low Voltage Ride Through (LVRT) requirements of FERC Order #661A.

A power factor analysis was performed for the study and it was found that GEN-2011-008 will be required to meet the 0.95 power factor lagging (providing vars) and 0.95 power factor leading (absorbing vars) at the POI. A short circuit analysis was performed and is detailed in the MEPPI report.

A low-wind/no-wind condition analysis was performed for this modification request. The project will be required to install a total of approximately 39 Mvars of shunt reactors on its substation 34.5kV bus(es). This is necessary to offset the capacitive effect on the transmission network caused by the project's transmission line and collector system during low-wind/no-wind conditions.

With the assumptions outlined in this report and with all required network upgrades in place, GEN-2011-008 with the Vestas V110 VCSS 2.0 MW wind turbine generators should be able to reliably interconnect to the SPP transmission grid.

It should be noted that this study analyzed the requested modification to change generator technology, manufacturer, and layout. This study analyzed many of the most probable contingencies, but it is not an all-inclusive list and cannot account for every operational situation. It is likely that the customer may be required to reduce its generation output to 0 MW, also known as curtailment, under certain system conditions to allow system operators to maintain the reliability of the transmission network.

Nothing in this study should be construed as a guarantee of transmission service. If the Customer wishes to obtain deliverability to a specific customer, a separate request for transmission service shall be requested on Southwest Power Pool's OASIS.

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Southwest Power Pool, Inc. (SPP)

Impact Restudy for Generator Modification GEN-2011-008

Final Report

PXE-1270
Revision #00

June 2016

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Title: **Impact Restudy for Generator Modification GEN-2011-008: Final Report PXE-1270**
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EXECUTIVE SUMMARY

SPP requested an Impact Restudy for GEN-2011-008 Generator Modification. The Impact Restudy required a Stability Analysis, Short Circuit Analysis, Power Factor Analysis, and Low Wind/No Wind Analysis detailing the impacts of the interconnecting projects as shown in Table ES-1.

Table ES-1
Interconnection Projects Evaluated

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2011-008	600.0	Vestas V110 2.0MW generators (300 generators)	Clark County 345kV (539800)

SUMMARY OF STABILITY ANALYSIS

The Stability Analysis determined that there were no contingencies that resulted in system instability or generation tripping offline for the 2016 Winter Peak, 2017 Summer Peak, and 2025 Summer Peak seasons when the generation interconnection request was at 100% output. Post contingent steady-state voltage violations were observed during one contingency for the 2016 Winter Peak, 2017 Summer Peak, and 2025 Summer Peak conditions. However, these violations were mitigated by switching-out certain reactors and adjusting the tap of a three-winding transformer.

SUMMARY OF THE SHORT CIRCUIT ANALYSIS

The short circuit analysis was performed on the 2017 Summer Peak and 2025 Summer Peak power flow for all study projects. Refer to Table ES-2 and ES-3 for a list of maximum fault currents observed for each study project for the 2017 Summer Peak and 2025 Summer Peak Scenarios, respectively.

Table ES-2
List of Maximum Fault Currents Observed in 2017 Summer Peak Power Flow for Each Study Project

Study Project	Fault Current at POI (kA)	Maximum Fault Current (kA)	Fault Location	Bus Voltage (kV)
GEN-2011-008	12.63	36.61	EVANS S4, EVANS N4	138

Table ES-3
List of Maximum Fault Currents Observed in 2025 Summer Peak Power Flow for Each Study Project

Study Project	Fault Current at POI (kA)	Maximum Fault Current (kA)	Fault Location	Bus Voltage (kV)
GEN-2011-008	12.72	41.55	EVANS N4, EVANS S4	138

SUMMARY OF POWER FACTOR ANALYSIS

Study Generator GEN-2011-008

The Power Factor Analysis shows that GEN-2011-008 has a power factor range of 0.974 lagging (supplying) to 1.00 (unity) for the 2016 Winter Peak conditions, a power factor range of 0.969 to 0.998 lagging (supplying) for the 2017 Summer Peak conditions, and a power factor range of 0.971 to 0.999 lagging (supplying) for the 2025 Summer Peak conditions.

SUMMARY OF LOW WIND/NO WIND ANALYSIS

The amount of reactive power injected into the transmission network was recorded at the point of interconnection for the study generator. The reactance needed for zero Mvar flow was 38.95 Mvar for the collector/transmission line system connecting GEN-2011-008 to the Clark County 345 kV (539800) POI. This requirement was identical for all three seasonal conditions (2016 Winter Peak, 2017 Summer Peak, and 2025 Summer Peak conditions).

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SECTION 1: OBJECTIVES

The objective of this report is to provide Southwest Power Pool, Inc. (SPP) with the deliverables for the "Impact Restudy for Generator Modification (GEN-2011-008)." SPP requested an Interconnection System Impact Restudy for one generation interconnection for 2016 Winter Peak, 2017 Summer Peak, and 2025 Summer Peak, which requires a Stability Analysis, Short Circuit Analysis, Power Factor Analysis, Low Wind/No Wind Analysis, and an Impact Study Report.

SECTION 2: BACKGROUND

The Siemens Power Technologies, Inc. PSS/E power system simulation program Version 32.2.0 was used for this study. The stability database cases and list of contingencies examined for this study were created by MEPPI for the "Impact Restudy for Generator Modification (GEN-2012-024)" study (Report PXE-1227). The stability database cases represented the 2016 Winter Peak, 2017 Summer Peak, and 2025 Summer Peak conditions. The models include the study projects shown in Table 2-1 and the previously queued projects listed in Table 2-2. Refer to Appendix A for the steady-state and dynamic model data for the study project. A power flow one-line diagram for the generation interconnection project is shown in Figure 2-1. Note that the one-line diagram represents the 2025 Summer Peak case.

The Stability Analysis determined the impacts of the new interconnecting projects 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 will be investigated. Three-phase faults and single line-to-ground faults will be examined as listed in Table 2-3.

A Short Circuit Analysis was performed on the 2017 Summer Peak and 2025 Summer Peak study year for the study generator. The study was performed five buses out from the study generator's point of interconnection and results were documented.

The Power Factor Analysis determined the power factor at the point of interconnection for the wind interconnection project for pre-contingency and post-contingency conditions. The N-1, three-phase contingencies listed in Table 2-3 were examined in the Power Factor analysis.

The Low Wind/No Wind Analysis was completed for the wind farm interconnection. This analysis determined if reactive support is needed to have an Mvar flow of approximately zero at the point of interconnection (POI).

Table 2-1
Interconnection Projects Evaluated

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2011-008	600.0	Vestas V110 2.0MW generators (300 generators)	Clark County 345kV (539800)

Table 2-2
Prior Queued Projects

Request	Size (MW)	Wind Turbine Model	Point of Interconnection
GEN-2001-039A	104.0	GE 1.6MW	Shooting Star 115kV (539763)
GEN-2002-025A	150.0	GE 1.5 MW	Spearville 230kV (539695)
GEN-2004-014	154.5	GE 1.5 MW	Spearville 230kV (539695)
GEN-2005-012	250.7	Siemens 2.3MW	Ironwood 345kV (539803)
GEN-2006-021	100.0	Clipper 2.5MW	Flat Ridge 138kV (539638)
GEN-2007-040	200.1	Siemens 2.3MW	Buckner 345kV (531501)
GEN-2008-018	250.0	GE 1.85 MW	Finney 345kV (523853)
GEN-2008-079	98.9	Siemens 2.3MW	CRKCK 115kV line (539783)
GEN-2008-124	200.1	Siemens 2.3MW	Ironwood 345kV (539803)
GEN-2010-009	165.6	Siemens 2.3MW	Buckner 345kV (531501)
GEN-2010-045	197.8	Siemens 2.3MW	Buckner 345kV (531501)
GEN-2011-008	600.0	GE 1.6MW	Clark County 345kV (539800)
GEN-2011-016	200.1	Siemens 2.3MW	Ironwood 345kV
GEN-2012-007	96.0 Summer 120.0 Winter	GENSAL	Rubart 115kV (531200)
ASGI-2012-006	20.74 Summer 21.21 Winter	GENSAL	ABBK 69kV (531494)

Table 2-2
Prior Queued Projects

Request	Size (MW)	Wind Turbine Model	Point of Interconnection
GEN-2012-024	178.2	Vestas V117 3.3MW (54 generators)	Clark County 345kV (539800)
GEN-2013-010	99.0	Siemens 3.0MW (583603)	GEN-2013-010 Tap 345kV (562334) (Tap on Spearville to Post Rock 345kV line)
GEN-2015-021	20.0	AE 1000NX 1MW PV Inverter (584633)	Johnson Corner 115kV (531424)

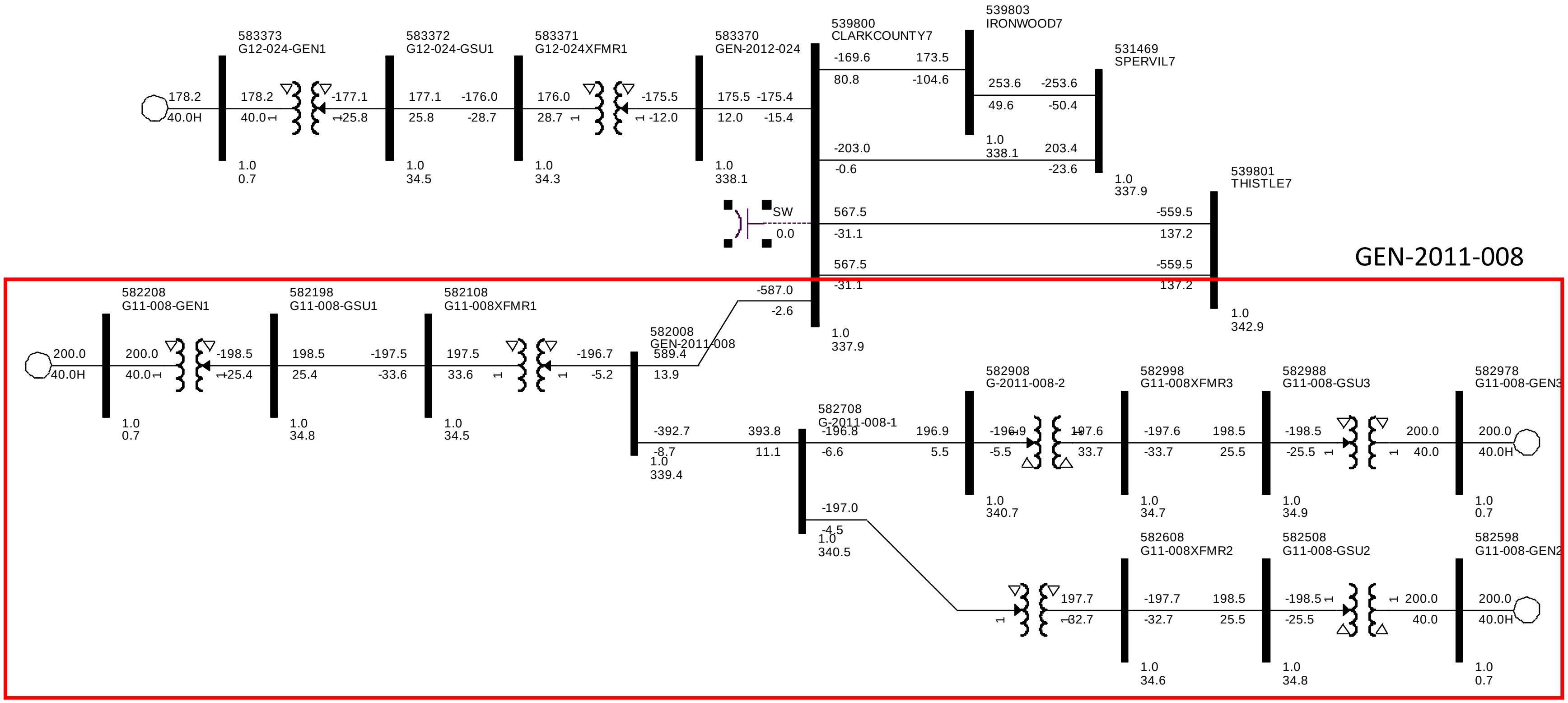

Figure 2-1: Power flow one-line diagram for interconnection project at the Clark County 345 kV POI (GEN-2011-008).

Table 2-3
Case List with Contingency Description

Cont. No.	Cont. Name	Description
1	FLT01-3PH	3 phase fault on the Thistle 345KV (539801) to Woodward 345KV (515375) CKT 1, near Thistle. a. Apply fault at the Thistle 345KV 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 Thistle 345KV (539801) to Woodward 345KV (515375) CKT 1 and 2, near Thistle. a. Apply fault at the Thistle 345KV bus. b. Clear fault after 5 cycles by tripping the faulted lines (CKT 1 and 2). c. Wait 20 cycles, and then re-close the lines in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the lines in (b) and remove fault.
3	FLT03-3PH	3 phase fault on the Thistle 345KV (539801) to GEN-2015-024 &GEN-2015-025 Tap 345KV (560033) CKT 1, near Thistle. a. Apply fault at the Thistle 345KV 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.
4	FLT04-3PH	3 phase fault on the Thistle 345KV (539801) to GEN-2015-024 &GEN-2015-025 Tap 345KV (560033) CKT 1 and 2, near Thistle. a. Apply fault at the Thistle 345KV bus. b. Clear fault after 5 cycles by tripping the faulted lines (CKT 1 and 2). c. Wait 20 cycles, and then re-close the lines in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the lines in (b) and remove fault.
5	FLT05-3PH	3 phase fault on the Thistle 345KV (539801) to Clark County 345KV (539800) CKT 1, near Clark County. a. Apply fault at the Thistle 345KV 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.
6	FLT06-3PH	3 phase fault on the Thistle 345KV (539801) to Clark County 345KV (539800) CKT 1 and 2, near Thistle. a. Apply fault at the Thistle 345KV bus. b. Clear fault after 5 cycles by tripping the faulted lines (CKT 1 and 2). 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.
7	FLT07-3PH	3 phase fault on the Thistle 345KV (539801) to Thistle 138kV (539804) to Thistle 13.8kV (539802) XMFR CKT 1, near Thistle 345kV. a. Apply fault at the Thistle 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
8	FLT08-3PH	3 phase fault on the G13-010 Tap 345KV (562334) to Spearville (531469) 345KV (531469) CKT 1 near Spearville. a. Apply fault at the Spearville 345KV 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 2-3
Case List with Contingency Description

Cont. No.	Cont. Name	Description
9	FLT09-3PH	3 phase fault on the Post Rock 345KV (530583) to Post Rock 230kV (530584) to Post Rock 13.8kV (530673) XMFR CKT 1, near Post Rock 345kV. a. Apply fault at the Post Rock 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
10	FLT10-3PH	3 phase fault on the Spearville 345KV (531469) to Buckner 345KV (531501) CKT 1 near Spearville. a. Apply fault at the Spearville 345KV 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.
11	FLT11-3PH	3 phase fault on the Ironwood 345KV (539803) to Clark County 345KV (539800) CKT 1 near Clark County a. Apply fault at the Clark County 345KV 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.
12	FLT12-3PH	3 phase fault on the Spearville 345KV (531469) to Ironwood 345KV (539803) CKT 1 near Spearville. a. Apply fault at the Spearville 345KV 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.
13	FLT13-3PH	3 phase fault on the Spearville 345KV (531469) to Spearville 230kV (539695) to Spearville 13.8kV (531468) XMFR CKT 1, near Spearville 345kV. a. Apply fault at the Spearville 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
14	FLT14-3PH	3 phase fault on the Spearville 345KV (531469) to Spearville 115kv (539759) to Spearville 13.8kV (539960) XMFR CKT 1, near Spearville 345kV. a. Apply fault at the Spearville 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
15	FLT15-3PH	3 phase fault on the Buckner 345KV (531501) to Holcomb 345KV (531449) CKT 1 near Buckner. a. Apply fault at the Buckner 345KV 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.
16	FLT16-3PH	3 phase fault on the Clark County 345KV (539800) to Ironwood 345KV (539803) CKT 1 near Clark County. a. Apply fault at the Clark County 345KV 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 2-3
Case List with Contingency Description

Cont. No.	Cont. Name	Description
17	FLT17-3PH	3 phase fault on the Holcomb 345KV (531449) to Finney 345KV (523853) CKT 1 near Holcomb. a. Apply fault at the Holcomb 345KV 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.
18	FLT18-3PH	16WP: 3 phase fault on the Finney 345KV (523853) to Hitchland 345KV (523097) CKT 1 near Finney. 17SP & 25 SP: 3 phase fault on the Finney 345KV (523853) to WalkTap 345KV (531521) CKT 1 near Finney. a. Apply fault at the Finney 345KV 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.
19	FLT19-3PH	3 phase fault on the Setab 345KV (531465) to Mingo 345KV (531451) CKT 1 near Setab. a. Apply fault at the Setab 345KV 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 Mingo 345KV (531451) to Red Willow 345KV (640325) CKT 1 near Mingo. a. Apply fault at the Mingo 345KV 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.
21	FLT21-PO	**Prior outage on the Thistle – Clark County 345kV CKT 1** 3 phase fault on Thistle (539801) to Woodward (515375) 345kV CKT 1 a. Prior outage Thistle (539801) to Clark County (539800) 345kV CKT 1 (solve network for steady state solution) b. 3 phase fault on the Thistle (539801) to Woodward (515375) 345kV CKT 1 near Thistle c. Clear fault after 5 cycles and trip the faulted line. 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.
22	FLT22-PO	**Prior outage on the Spearville – Buckner 345kV line** 3 phase fault on GEN 2013-010-TAP (562334) to Post Rock (530583) a. Prior outage the Spearville (531469) to Buckner (531501) 345kV line (solve network for steady state solution) b. 3 phase fault on the GEN 2013-010-TAP (562334) to Post Rock (530583) 345kV line near GEN 2013-010-TAP c. Clear fault after 5 cycles and trip the faulted line. 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.

Table 2-3
Case List with Contingency Description

Cont. No.	Cont. Name	Description
23	FLT23-SB	**Clark County 345kV Stuck Breaker** a. Apply single phase fault at the Clark County (539800) 345kV bus b. Wait 16 cycles, and then drop Ironwood – Clark County - Thistle (539801) –345kV circuit 1 and remove fault.
24	FLT24-SB	**Thistle 345kV Stuck Breaker** a. Apply single phase fault at the Thistle (539801) 345kV bus b. Wait 16 cycles, and then trip Thistle (539801) – GEN-2015-024 & GEN-2015-025 Tap (560033) 345kV circuit 1 and remove fault
25	FLT25-SB	**Spearville 345kV Stuck Breaker** a. Apply single phase fault at the Spearville (531469) 345kV bus b. Wait 16 cycles, and then trip Spearville (531469) – Ironwood (539803) 345kV circuit 1 and remove fault
26	FLT26-PO	**Prior outage on the Spearville- Ironwood 345kV CKT 1** 3 phase fault on Thistle (539801) to Woodward (515375) 345kV CKT 1 a. Prior outage Spearville (531469) to Ironwood (539803) 345kV CKT 1 (solve network for steady state solution) b. 3 phase fault on the Thistle (539801) to Woodward (515375) 345kV CKT 1 near Thistle c. Clear fault after 5 cycles and trip the faulted line. 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.
27	FLT27-SB	**Stuck Breaker on Thistle – Woodward 345 kV line** a. Apply single-phase fault at Thistle (539801) 345 kV bus on the Thistle – Woodward 345 kV line b. After 16 cycles, trip the Thistle (539801) – Clark County (539800) 345 kV line c. Trip the Thistle (539801) – Woodward (515375) line, and remove the fault.
28	FLT28-SB	**Stuck Breaker on Ironwood – Clark County 345 kV line** a. Apply single-phase fault at Ironwood (539803) 345 kV bus on the Ironwood – Clark County 345 kV line. b. After 16 cycles, trip the Ironwood (539803) – GEN08-124 (579480) 345 kV line. c. Trip the Ironwood (539803) – Clark County (539800) line, and remove the fault.
29	FLT29-SB	**Stuck Breaker on Spearville – Buckner 345 kV line** a. Apply single-phase fault at Spearville (531469) 345 kV bus on the Spearville – Buckner 345 kV line. b. After 16 cycles, trip the Ironwood (539803) – Spearville (531469) 345 kV line. c. Trip the Spearville (531469) – Buckner (531501) line, and remove the fault.
30	FLT30-SB	**Stuck Breaker on Clark County – Thistle 345 kV line** a. Apply single-phase fault at Clark County (539800) 345 kV bus on the Clark County – Thistle 345 kV line. b. After 16 cycles, trip the Thistle (539801) – Woodward (515375) 345 kV line CKT 2. c. Trip the Clark County (539800) – Thistle (531501) line CKT 1, and remove the fault.

Table 2-3
Case List with Contingency Description

Cont. No.	Cont. Name	Description
31	FLT31-PO	**Prior outage on the Thistle – G1524&G1525T 345kV CKT 1** 3 phase fault on Clark County (539800) to Ironwood (539803) 345kV CKT 1 a. Prior outage Thistle (539801) to G1524&G1525T (560033) 345kV CKT 1 (solve network for steady state solution) b. 3 phase fault on the Clark County (539800) to Ironwood (539803) 345kV CKT 1 near Thistle c. Clear fault after 5 cycles and trip the faulted line. 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.
32	FLT32-PO	**Prior outage on the Thistle – Clark County 345kV CKT 1** 3 phase fault on Clark County (539800) to Spearville (531469) 345kV CKT 1 a. Prior outage Thistle (539801) to Clark County (539800) 345kV CKT 1 (solve network for steady state solution) b. 3 phase fault on the Clark County (539800) to Spearville (531469) 345kV CKT 1 near Thistle c. Clear fault after 5 cycles and trip the faulted line. 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.
33	FLT33-PO	**Prior outage on the Buckner – Holcomb 345kV CKT 1** 3 phase fault on Clark County (539800) to G11-008 (531469) 345kV CKT 1 a. Prior outage Buckner (531501) to Holcomb (531449) 345kV CKT 1 (solve network for steady state solution) b. 3 phase fault on the Clark County (539800) to G11-008 (531469) 345kV CKT 1 near Clark County c. Clear fault after 5 cycles and trip the faulted line. 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.
34	FLT34-PO	**Prior outage on the Buckner – CIMRRN 345kV CKT 1** 3 phase fault on Clark County (539800) to Ironwood (539803) 345kV CKT 1 a. Prior outage Buckner (531501) to CIMRRN (531502) 345kV CKT 1 (solve network for steady state solution) b. 3 phase fault on the Clark County (539800) to Ironwood (539803) 345kV CKT 1 near Clark County c. Clear fault after 5 cycles and trip the faulted line. 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.
35	FLT35-3PH	3 phase fault on the G11-016 Tap 345KV (582016) to Spearville 345KV (531469) CKT 1 near Spearville. a. Apply fault at the Spearville 345KV 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 2-3
Case List with Contingency Description

Cont. No.	Cont. Name	Description
36	FLT36-3PH	3 phase fault on the G11-008 Tap 345KV (582708) to Clark County 345KV (539800) CKT 1 near Clark County. a. Apply fault at the Clark County 345KV 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.
37	FLT37-3PH	3 phase fault on the CIMRRN 345KV (531502) to Buckner 345KV (531501) CKT 1 near Buckner. a. Apply fault at the Buckner 345KV 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.
38	FLT38-3PH	3 phase fault on the CIMWD2 345KV (531504) to Buckner 345KV (531501) CKT 1 near Buckner. a. Apply fault at the Buckner 345KV 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.
39	FLT39-3PH	3 phase fault on the Holcomb 345KV (531449) to Holcomb 115kV (531448) to Holcomb 13.8kV (531450) XMFR CKT 1, near Holcomb 345kV. a. Apply fault at the Holcomb 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
40	FLT40-3PH	3 phase fault on the Ironwood 345KV (539803) to Ironwood 34.5kv (539808) to Ironwood 13.8kV (539807) XMFR CKT 1, near Ironwood 345kV. a. Apply fault at the Ironwood 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.

SECTION 3: STABILITY ANALYSIS

The objective of the Stability Analysis was to determine the impacts of the generator interconnections 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 system upgrades were investigated.

3.1 Approach

MEPPI performed this analysis with the following three power flow cases from the GEN-2012-024 study:

- 2016 Winter Peak
- 2017 Summer Peak
- 2025 Summer Peak

Each case was examined prior to the Stability Analysis to ensure the case contained the proposed study project and any previously queued projects listed in Tables 2-1 and 2-2, respectively. There was no suspect power flow data in the study area. The dynamic datasets were also verified and stable initial system conditions (i.e., “flat lines”) were achieved. Three-phase and single phase-to-ground faults listed in Table 2-3 were examined. 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 3-1 for a list of the calculated single-phase fault impedances used for GEN-2011-008.

Table 3-1
Calculated Single-Phase Fault Impedances for GEN-2011-008

Cont. No.*	Cont. Name	Single-Phase Fault Impedance (MVA)		
		2015 Summer	2015 Winter	2025 Summer
23	FLT23-SB	-4031.3	-4234.4	-4437.5
24	FLT24-SB	-5250.0	-5656.3	-6062.5
25	FLT25-SB	-4843.8	-4843.8	-4843.8
27	FLT27-SB	-5250.0	-5656.3	-6062.5
28	FLT28-SB	-4843.8	-4843.8	-4843.8
29	FLT29-SB	-4843.8	4843.8	-4843.8
30	FLT30-SB	-5250.0	-5656.3	-6062.5

*Refer to Table 2-3 for a description of the contingency scenerio

Bus voltages, machine rotor angles, and previously queued generation in the study area were monitored. Requested and previously queued generation outside the study area was also monitored.

The results of the analysis determined if reactive compensation or system upgrades were required to obtain acceptable system performance. If additional reactive compensation was required, the size, type, and location were determined. The proposed reactive reinforcements would ensure the wind or solar farm meets FERC Order 661A low voltage requirements and return the wind or solar farm to its pre-disturbance operating voltage. If the results indicated the need for fast responding reactive support, dynamic support such as an SVC or STATCOM was investigated. If tripping of the prior queued projects was observed during the stability analysis (for under/over voltage or under/over frequency) the simulations were re-ran with the prior queued project's voltage and frequency tripping disabled.

3.2 Stability Analysis Results

The Stability Analysis determined that there were no contingencies that resulted in system instability or generation tripping offline for 2016 Winter Peak, 2017 Summer Peak, and 2025 Summer Peak conditions when GEN-2011-008, and the prior queued projects, were at 100% output. However, several contingencies resulted in post contingent steady-state voltage violations below 0.9 p.u.

Refer to Table 3-2 for a summary of the Stability Analysis results for the contingencies listed in Table 2-3 that correspond to the GEN-2011-008 Stability Analysis. Table 3-2 is a summary of the stability results for the 2016 Winter Peak, 2017 Summer Peak, and 2025 Summer Peak conditions and states whether the system remained stable or generation tripped offline and if acceptable voltage recovery was observed after the fault was cleared. 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 0.9 p.u. If high or low voltages were observed the number of buses failing the voltage criteria was listed.

Refer to Appendix B, Appendix C, and Appendix D for a complete set of plots for all the GEN-2011-008 analysis contingencies for 2016 Winter Peak, 2017 Summer Peak, and 2025 Summer Peak conditions, respectively.

Contingency #6 (FLT06-3PH) resulted in steady-state voltages less than 0.9 p.u. for the 2016 Winter Peak, 2017 Summer Peak, and 2025 Summer Peak conditions. The low voltages occurred at Heizer 230 kV (530680) and Great Bend 230 kV (539679). Refer to Figure 3-1 for voltage plots of the Heizer 230 kV and Great Bend 230 kV buses in 2025 Summer Peak conditions prior to mitigating actions. Figure 3-2 shows voltage profiles at the same locations after mitigating actions. The following actions were taken to mitigate the under voltage violations:

(1) Switch out in-line reactors at Spearville 345 kV (531469), G13-010 TAP 345 kV (562334), Postrock 345 kV (530583), Axtel 345 kV (640065), and Buckner 345 kV (531501) 2 seconds after the fault is cleared.
(2) Adjusted winding #1 of the three winding transformer at Spearville 230 kV (539695) from 1.0 p.u. to 1.1 p.u.

After implementing the above actions, the voltages at Heizer 230 kV and Great Bend 230 kV recovered to above 0.9 p.u. for post-fault conditions.

Table 3-2
GEN-2011-008: Stability Analysis Summary of Results for 2016 Winter, 2017 Summer, and 2025 Summer Peak Conditions

Cont. No.	Cont. Name	2016 Winter Peak				2017 Summer Peak				2025 Summer Peak			
		Voltage Recovery		Post-Fault Steady State Voltage > 0.9 p.u.	Stable?	Voltage Recovery		Post-Fault Steady State Voltage > 0.9 p.u.	Stable?	Voltage Recovery		Post-Fault Steady State Voltage > 0.9 p.u.	Stable?
		Less than .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	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
2	FLT02-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
3	FLT03-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
4	FLT04-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
5	FLT05-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
6	FLT06-3PH	No	No	No (2)	Yes	No	No	No (2)	Yes	No	No	No (2)	Yes
7	FLT07-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
8	FLT08-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
9	FLT09-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
10	FLT10-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
11	FLT11-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
12	FLT12-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
13	FLT13-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
14	FLT14-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
15	FLT15-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
16	FLT16-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
17	FLT17-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
18	FLT18-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
19	FLT19-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
20	FLT20-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
21	FLT21-PO	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
22	FLT22-PO	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
23	FLT23-SB	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
24	FLT24-SB	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
25	FLT25-SB	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
26	FLT26-PO	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
27	FLT27-SB	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
28	FLT28-SB	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
29	FLT29-SB	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
30	FLT30-SB	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
31	FLT31-PO	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
32	FLT32-PO	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
33	FLT33-PO	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
34	FLT34-PO	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
35	FLT35-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
36	FLT36-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
37	FLT37-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
38	FLT38-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
39	FLT39-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
40	FLT40-3PH	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes

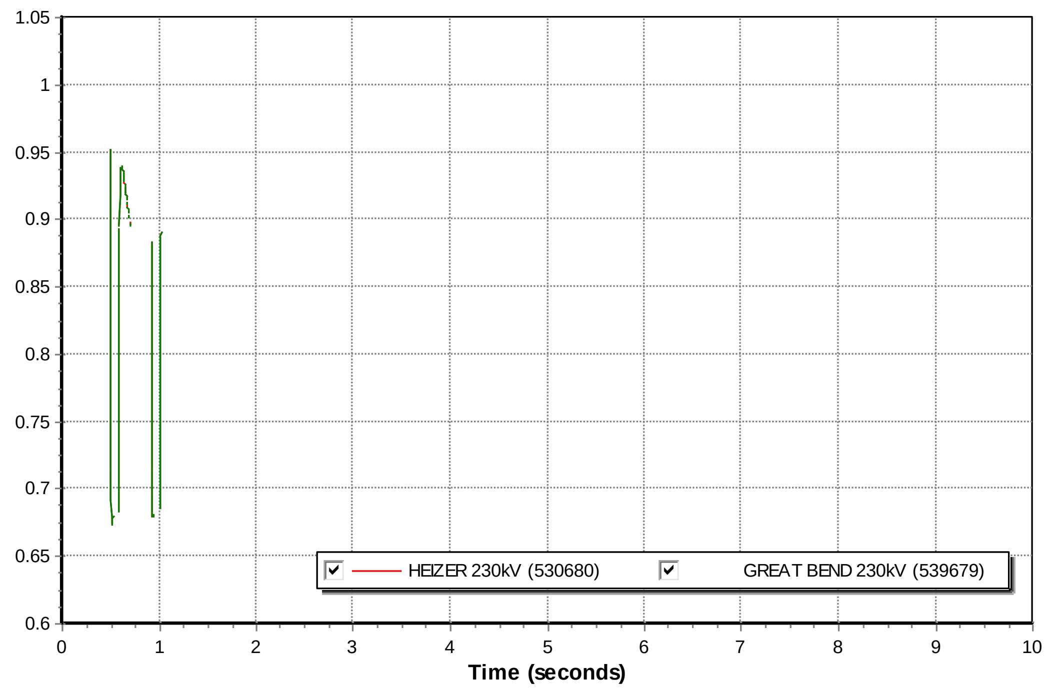

Figure 3-1: Voltage profiles at Heizer 230 kV and Great Bend 230 kV for 2025 Summer Peak conditions prior to mitigations.

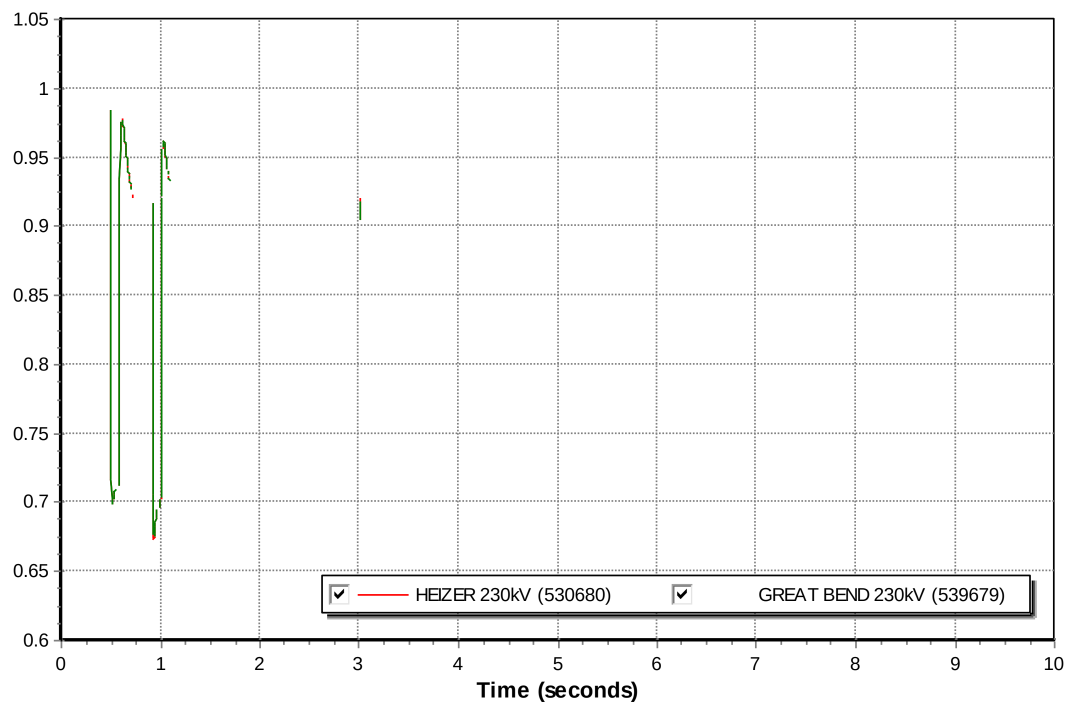

Figure 3-2: Voltage profiles at Heizer 230 kV and Great Bend 230 kV for 2025 Summer Peak conditions after mitigations.

SECTION 4: SHORT CIRCUIT ANALYSIS

The objective of this task is to quantify the three-phase to ground fault currents for the 2017 Summer Peak and 2025 Summer Peak seasons for the interconnecting generator.

4.1 Approach

The short-circuit analysis will assess breaker adequacy and fault duties for the generator interconnection bus and five buses away from the point of interconnection. MEPPI will assume no outages to find maximum short-circuit currents that flow through the breaker. The Automatic Sequencing Fault Calculation (ASCC) function in PSS/E was utilized to perform this task. FLAT conditions were applied to pre-fault conditions and the following adjustments were utilized:

- All synchronous and asynchronous machine P and Q output was set to zero
- All transformer tap ratios were set to 1.0 p.u. and all phase shift angles were set to zero
- All generator reactance’s were fixed to the subtransient reactance
- All line charging was set to zero
- All shunts were set to zero
- All loads were set to zero
- All pre-fault bus voltages were set to 1.0 p.u. and a phase shift angle of zero

4.2 Short Circuit Results

The maximum fault current for each bus is provided for the 2017 and 2025 Summer Peak conditions. The following tables show the short circuit results for the study generators:

- Table 4-1: Short Circuit Analysis for GEN-2011-008 (2017 Summer Peak)
- Table 4-2: Short Circuit Analysis for GEN-2011-008 (2025 Summer Peak)

Table 4-1
Short Circuit Analysis for Study Project GEN-2011-008 (2017 Summer Peak)

Study Generator GEN-2011-008											
Bus Number	Bus Name	Bus Voltage (kV)	Fault Current 3-LG (kA)	Bus Number	Bus Name	Bus Voltage (kV)	Fault Current 3-LG (kA)	Bus Number	Bus Name	Bus Voltage (kV)	Fault Current 3-LG (kA)
514785	WOODWRD4	138	19.14	531512	WALKTAP7	345	7.90	539801	THISTLE7	345	15.53
514787	DEWEY 4	138	7.10	532768	EMPEC 7	345	16.80	539803	IRONWOOD7	345	12.86
514796	IODINE-4	138	7.12	532771	RENO 7	345	10.53	539804	THISTLE4	138	16.34
514880	NORTWST7	345	26.39	532773	SUMMIT 7	345	9.99	560000	G11-14-TAP	345	13.69
515363	CENT 4	138	3.26	532791	BENTON 7	345	18.46	560010	G14-037-TAP	345	16.14
515375	WWRDEHV7	345	17.42	532792	FR2EAST7	345	5.87	560027	G14-074-TAP	345	5.97
515376	WWRDEHV4	138	22.96	532794	ROSEHIL7	345	17.90	560033	G1524&G1525T	345	18.72
515394	KEENAN 4	138	8.02	532796	WICHITA7	345	23.09	562075	G11-051-TAP	345	11.03
515398	OUSPRT 4	138	8.80	532797	WOLFCRK7	345	15.89	562334	G13-010-TAP	345	7.50
515407	TATONGA7	345	9.85	532798	VIOLA 7	345	10.99	562476	G14-001-TAP	345	10.84
515448	CRSRDSW7	345	7.76	532871	CIRCLE 6	230	8.45	575010	GEN-2009-008	230	4.51
515458	BORDER 7	345	4.97	532872	EMCPHER6	230	7.60	578542	GEN-2010-001	345	12.52
515543	RENFROW7	345	10.77	532986	BENTON 4	138	27.43	579470	GEN-2008-092	230	7.90
515554	BVRCNTY7	345	15.18	533040	EVANS N4	138	36.61	579480	GEN-2008-124	345	12.43
515582	SLNGWND7	345	6.77	533041	EVANS S4	138	36.61	580049	GEN-2010-045	345	6.92
515585	MAMTHPW7	345	8.79	533065	SG12COL4	138	20.02	581112	GEN-2011-014	345	10.22
515590	PALDR2W7	345	12.79	533390	MAIZEW 4	138	25.70	582008	GEN-2011-008	345	10.48
515599	NBUFFRG7	345	8.12	533413	CIRCLE 3	115	17.91	582016	GEN-2011-016	345	7.42
515785	WINDFRM4	138	18.73	533416	RENO 3	115	21.33	582019	GEN-2011-019	345	17.42
523118	BUFF_DUNES 7	345	6.26	539001	ANTHONY4	138	3.47	582020	GEN-2011-020	345	17.42
523853	FINNEY 7	345	10.51	539631	FLATRWD4	138	9.70	582708	G-2011-008-1	345	8.85
525830	TUCO_INT 6	230	18.88	539638	FLATRDG4	138	14.66	582908	G-2011-008-2	345	8.20
525832	TUCO_INT 7	345	9.63	539642	ELLSWTP3	115	3.92	583090	G1149&G1504	345	4.55
530553	S HAYS 3	115	8.79	539645	DCBEEF3	115	8.22	583110	GEN-2011-051	345	11.03
530558	KNOLL 6	230	10.70	539666	GBENDTP3	115	7.49	583370	GEN-2012-024	345	10.85
530582	S HAYS6	230	8.57	539668	HARPER 4	138	5.66	583600	GEN-2013-010	345	7.50
530583	POSTROCK7	345	7.80	539671	FTDODGE3	115	12.38	583760	GEN-2013-030	345	11.65
530584	POSTROCK6	230	10.87	539674	BARBER 4	138	7.98	583850	GEN-2014-001	345	7.46
530601	HEIZER 3	115	12.34	539675	MILANTP4	138	6.03	583990	GEN-2014-049	345	7.78
530680	HEIZER 6	230	8.04	539678	GRTBEND3	115	12.50	584659	G15024G15025	345	6.05
530686	RICE 6	230	4.60	539679	GRTBEND6	230	8.08	584660	GEN-2015-024	345	4.91
531379	JONES3	115	10.99	539681	N-GBEND3	115	8.17	584670	GEN-2015-025	345	5.96
531393	PLYMELL3	115	7.72	539684	OTISSUB3	115	2.94	584700	GEN-2015-029	345	7.04
531420	FLETCHR3	115	6.82	539688	S-DODGE3	115	8.35	599074	NTHBUF_EHV2	345	6.29
531445	GRDNCTY3	115	14.19	539694	SPEARVL3	115	10.35	599950	LAMAR7	345	2.42
531448	HOLCOMB3	115	21.91	539695	SPEARVL6	230	12.31	640065	AXTELL 3	345	8.73
531449	HOLCOMB7	345	10.60	539699	W-DODGE3	115	5.45	640066	AXTELL 7	115	13.85
531451	MINGO 7	345	5.94	539758	FORD 3	115	5.57	640312	PAULINE3	345	7.60
531464	SETAB 3	115	10.68	539759	SPRVL 3	115	11.51	640374	SWEET W3	345	9.68
531465	SETAB 7	345	7.10	539760	BARBER 3	115	7.86				
531469	SPERVIL7	345	13.29	539763	SSTARTP3	115	4.02				
531501	BUCKNER7	345	9.79	539771	NFTDODG3	115	12.42				
531502	CIMRRN 7	345	7.64	539783	CRKCK 3	115	4.32				
531504	CIMWD2 7	345	7.81	539800	CLARKCOUNTY7	345	12.63				

Table 4-2
Short Circuit Analysis for Study Project GEN-2011-008 (2025 Summer Peak)

Study Generator GEN-2011-008											
Bus Number	Bus Name	Bus Voltage (kV)	Fault Current 3-LG (kA)	Bus Number	Bus Name	Bus Voltage (kV)	Fault Current 3-LG (kA)	Bus Number	Bus Name	Bus Voltage (kV)	Fault Current 3-LG (kA)
514785	WOODWRD4	138	19.71	531504	CIMWD2 7	345	7.84	539771	NFTDODG3	115	12.44
514787	DEWEY 4	138	7.13	531512	WALKTAP7	345	7.93	539783	CRKCK 3	115	4.32
514796	IODINE-4	138	7.18	532768	EMPEC 7	345	16.92	539800	CLARKCOUNTY7	345	12.72
515363	CENT 4	138	3.28	532771	RENO 7	345	11.33	539801	THISTLE7	345	15.89
515375	WWRDEHV7	345	19.79	532773	SUMMIT 7	345	10.37	539803	IRONWOOD7	345	12.93
515376	WWRDEHV4	138	23.96	532791	BENTON 7	345	18.84	539804	THISTLE4	138	16.57
515394	KEENAN 4	138	8.13	532792	FR2EAST7	345	6.31	560000	G11-14-TAP	345	14.06
515398	OUSPRT 4	138	8.95	532794	ROSEHIL7	345	18.22	560010	G14-037-TAP	345	16.33
515407	TATONGA7	345	15.87	532796	WICHITA7	345	24.09	560027	G14-074-TAP	345	6.44
515448	CRSRDSW7	345	11.08	532797	WOLFCRK7	345	15.96	560033	G1524&G1525T	345	19.27
515458	BORDER 7	345	5.09	532798	VIOLA 7	345	13.11	562075	G11-051-TAP	345	16.30
515497	MATHWSN7	345	28.54	532871	CIRCLE 6	230	9.46	562334	G13-010-TAP	345	7.52
515543	RENFROW7	345	11.59	532872	EMCPHER6	230	8.41	562476	G14-001-TAP	345	10.95
515554	BVRCNTY7	345	15.45	532986	BENTON 4	138	28.00	575010	GEN-2009-008	230	4.52
515582	SLNGWND7	345	8.97	533040	EVANS N4	138	41.55	578542	GEN-2010-001	345	12.70
515585	MAMTHPW7	345	13.22	533041	EVANS S4	138	41.55	579470	GEN-2008-092	230	7.92
515590	PALDR2W7	345	12.98	533065	SG12COL4	138	21.37	579480	GEN-2008-124	345	12.49
515599	NBUFFRG7	345	8.50	533075	VIOLA 4	138	21.76	580049	GEN-2010-045	345	6.95
515785	WINDFRM4	138	18.87	533390	MAIZEW 4	138	27.62	581112	GEN-2011-014	345	10.42
523118	BUFF_DUNES 7	345	6.29	533413	CIRCLE 3	115	22.58	582008	GEN-2011-008	345	10.54
523853	FINNEY 7	345	10.59	533416	RENO 3	115	24.87	582016	GEN-2011-016	345	7.44
525830	TUCO_INT 6	230	22.06	539000	RAGO 4	138	3.60	582019	GEN-2011-019	345	19.79
525832	TUCO_INT 7	345	11.88	539001	ANTHONY4	138	3.61	582020	GEN-2011-020	345	19.79
526936	YOAKUM_345	345	8.87	539631	FLATRWD4	138	9.79	582708	G-2011-008-1	345	8.88
530553	S HAYS 3	115	8.81	539638	FLATRDG4	138	14.86	582908	G-2011-008-2	345	8.23
530558	KNOLL 6	230	10.75	539642	ELLSWTP3	115	3.95	583090	G1149&G1504	345	4.65
530582	S HAYS6	230	8.61	539645	DCBEEF3	115	8.23	583110	GEN-2011-051	345	16.30
530583	POSTROCK7	345	7.83	539666	GBENDTP3	115	7.54	583370	GEN-2012-024	345	10.92
530584	POSTROCK6	230	10.92	539668	HARPER 4	138	5.95	583600	GEN-2013-010	345	7.52
530601	HEIZER 3	115	12.47	539671	FTDODGE3	115	12.39	583760	GEN-2013-030	345	11.80
530680	HEIZER 6	230	8.16	539674	BARBER 4	138	8.03	583850	GEN-2014-001	345	7.50
530686	RICE 6	230	4.79	539675	MILANTP4	138	7.07	583990	GEN-2014-049	345	7.86
531379	JONES3	115	11.06	539678	GRTBEND3	115	12.64	584659	G15024G15025	345	6.10
531393	PLYMELL3	115	7.73	539679	GRTBEND6	230	8.21	584660	GEN-2015-024	345	4.94
531420	FLETCHR3	115	6.83	539681	N-GBEND3	115	8.23	584670	GEN-2015-025	345	6.00
531445	GRDNCTY3	115	14.45	539684	OTISSUB3	115	2.94	584700	GEN-2015-029	345	9.58
531448	HOLCOMB3	115	22.08	539688	S-DODGE3	115	8.35	599074	NTHBUF_EHV2	345	6.50
531449	HOLCOMB7	345	10.69	539694	SPEARVL3	115	10.37	599950	LAMAR7	345	2.43
531451	MINGO 7	345	6.22	539695	SPEARVL6	230	12.36	640065	AXTELL 3	345	8.75
531464	SETAB 3	115	10.72	539699	W-DODGE3	115	5.45	640066	AXTELL 7	115	13.86
531465	SETAB 7	345	7.21	539758	FORD 3	115	5.57	640312	PAULINE3	345	7.61
531469	SPERVIL7	345	13.36	539759	SPRVL 3	115	11.52	640374	SWEET W3	345	9.72
531501	BUCKNER7	345	9.84	539760	BARBER 3	115	7.90				
531502	CIMRRN 7	345	7.67	539763	SSTARTP3	115	4.03				

SECTION 5: POWER FACTOR ANALYSIS

The objective of this task is to quantify the power factor at the point of interconnection for renewable energy projects during base case and system contingencies. SPP transmission planning practice requires interconnecting generation projects to maintain the power factor (pf) at the Point of Interconnection (POI) within +/- 0.95 pf for system intact conditions and for post-contingency conditions. This is analyzed by having the renewable energy plant maintain a prescribed voltage schedule at the point of interconnection of 1.0 p.u. voltage, or if the pre-project voltage is higher than 1.0 p.u., to maintain the pre-project voltage schedule.

The 2016 Winter Peak, 2017 Summer Peak, and 2025 Summer Peak power flows were examined prior to the Power Factor Analysis to ensure they contained the proposed study project modeled at 100% of the nameplate rating and any previously queued projects listed in Table 2-2. There was no suspect power flow data in the study area. The proposed study project and any previously queued projects at the same point of interconnection were turned off during the power factor analysis. The renewable energy plants were then replaced by a generator modeled at the high side bus with the same real power (MW) capability as the plant and open limits for the reactive power set points (Mvar). The generator was set to hold the POI scheduled bus voltage or 1.0 p.u., whichever was greater. All N-1, three-phase fault contingencies from Table 2-3 were then applied and the reactive power required to maintain the bus voltage was recorded.

5.1 Approach

GEN-2011-008 was disabled and a generator was placed at the study project's high side voltage bus. The generator was modeled with PGEN = 600 MW, Qmin = -999 Mvar, and Qmax = 999 Mvar. GEN-2012-024 was also disabled and a generator was placed at the project's high side voltage bus. The generator was modeled with PGEN = 178.2 MW, Qmin = -999 Mvar, and Qmax = 999 Mvar. All buses, transformers, and equivalent lines connected from the study project's high side voltage bus to GEN-2011-008 and GEN-2012-024 were disabled. The scheduled voltage was set to 1.00 p.u. for all three study years. The one line diagram in Figure 5-1 describes the system configuration for the power factor analysis.

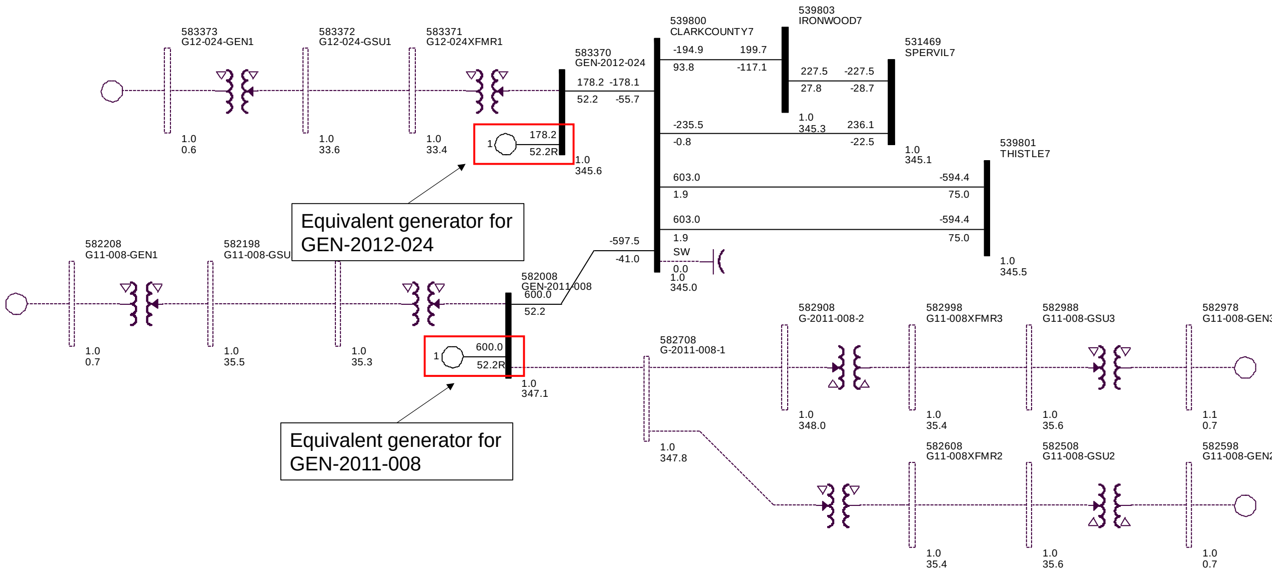

Figure 5-1: Power factor one-line illustration for GEN-2011-008

5.2 Power Factor Analysis Results

The power factor was calculated for the 2016 Summer Peak, 2017 Summer Peak, and 2025 Summer Peak condition. Refer to Table 5-1 for the results of the Power Factor Analysis.

Note that a positive Q (Mvar) output illustrates that the generator is absorbing reactive power from the system, implying a leading power factor; a negative Q (Mvar) illustrates that the generator is supplying reactive power to the system, implying a lagging power factor.

Study Generator GEN-2011-008

The Power Factor Analysis shows that GEN-2011-008 has a power factor range of 0.974 lagging (supplying) to 1.00 (unity) for the 2016 Winter Peak conditions, a power factor range of 0.969 to 0.998 lagging (supplying) for the 2017 Summer Peak conditions, and a power factor range of 0.971 to 0.999 lagging (supplying) for the 2025 Summer Peak conditions.

Table 5-1
Power Factor Analysis: GEN-2011-008

Reference Number	Case	16 Winter Peak			17 Summer Peak			25 Summer Peak		
		Power Factor		Q (MVAR)	Power Factor		Q (MVAR)	Power Factor		Q (MVAR)
0	**Base**	0.996	Lagging	-52.16	0.989	Lagging	-88.89	0.993	Lagging	-73.29
1	**FLT01-3PH**	0.996	Lagging	-55.79	0.989	Lagging	-91.37	0.993	Lagging	-73.28
2	**FLT02-3PH**	0.996	Lagging	-55.79	0.989	Lagging	-91.37	0.993	Lagging	-73.28
3	**FLT03-3PH**	0.995	Lagging	-57.91	0.988	Lagging	-93.23	0.992	Lagging	-76.89
5	**FLT05-3PH**	0.985	Lagging	-105.94	0.974	Lagging	-138.69	0.979	Lagging	-124.12
7	**FLT07-3PH**	0.996	Lagging	-51.80	0.990	Lagging	-86.61	0.993	Lagging	-71.26
8	**FLT08-3PH**	0.983	Lagging	-113.30	0.970	Lagging	-150.68	0.977	Lagging	-130.98
9	**FLT09-3PH**	0.996	Lagging	-52.16	0.989	Lagging	-88.89	0.993	Lagging	-73.29
10	**FLT10-3PH**	1.000	Lagging	-13.83	0.995	Lagging	-61.03	0.996	Lagging	-53.39
11	**FLT11-3PH**	0.998	Lagging	-34.15	0.995	Lagging	-57.13	0.997	Lagging	-43.22
12	**FLT12-3PH**	0.993	Lagging	-71.29	0.986	Lagging	-100.71	0.990	Lagging	-87.08
13	**FLT13-3PH**	0.997	Lagging	-46.45	0.998	Lagging	-37.15	0.999	Lagging	-21.23
14	**FLT14-3PH**	0.996	Lagging	-53.31	0.988	Lagging	-93.12	0.992	Lagging	-76.90
15	**FLT15-3PH**	0.981	Lagging	-118.56	0.969	Lagging	-152.71	0.971	Lagging	-146.77
16	**FLT16-3PH**	0.998	Lagging	-34.15	0.995	Lagging	-57.13	0.997	Lagging	-43.22
17	**FLT17-3PH**	0.988	Lagging	-95.71	0.982	Lagging	-114.51	0.985	Lagging	-104.81
18	**FLT18-3PH**	0.974	Lagging	-138.18	0.989	Lagging	-88.89	0.993	Lagging	-73.29
19	**FLT19-3PH**	0.992	Lagging	-75.42	0.982	Lagging	-113.82	0.987	Lagging	-96.46
20	**FLT20-3PH**	0.992	Lagging	-76.46	0.984	Lagging	-109.66	0.988	Lagging	-92.45
35	**FLT35-3PH**	1.000	Lagging	-17.40	0.995	Lagging	-59.60	0.997	Lagging	-45.65
36	**FLT36-3PH**	0.996	Lagging	-52.16	0.989	Lagging	-88.89	0.993	Lagging	-73.29
37	**FLT37-3PH**	0.999	Lagging	-24.22	0.994	Lagging	-64.03	0.996	Lagging	-50.46
38	**FLT38-3PH**	1.000	Lagging	-18.38	0.995	Lagging	-58.53	0.997	Lagging	-45.54
39	**FLT39-3PH**	0.997	Lagging	-43.03	0.991	Lagging	-82.04	0.994	Lagging	-66.72
40	**FLT40-3PH**	1.000	Lagging	-1.11	0.997	Lagging	-43.38	0.999	Lagging	-29.64

SECTION 6: LOW WIND/NO WIND ANALYSIS

The objective of this task is to determine the impact of low wind or no wind conditions on the study generator. The 2016 Winter Peak, 2017 Summer Peak, and 2025 Summer Peak power flows provided by SPP, and corresponding updates, were examined for this analysis.

6.1 Approach

Low wind or no wind conditions was examined for the study generator. Generators were disabled (independently), but the collector systems remained in-service. In order to maintain generation and load balance in the SPP area, the generation was scaled after disabling the respective generator. The amount of reactive power injected into the transmission network was recorded at the respective point of interconnection. This reactive power comes from the capacitance of the project's transmission lines and collector cables. A shunt reactor was added at the high side bus to bring the Mvar flow into the POI down to approximately zero.

6.2 Low Wind/No Wind Analysis Results

The reactance needed to bring the Mvar flow into the point of interconnect to zero Mvar was recorded for each season. Refer to Table 6-1 for the Low Wind/No Wind Analysis results. The table lists the generators examined and the amount of reactive power needed for zero Mvar flow into the POI for each season.

Table 6-1
Low Wind/No Wind Analysis

Request	Size (MW)	Point of Interconnection	Reactor Size (Mvar)		
			16WP	17SP	25SP
GEN-2011-008	600	Clark County 345 kV	39.0	39.0	39.0

A shunt reactor requirement of 38.85 Mvar was determined for the 2016 Winter Peak, 2017 Summer Peak, and 2025 Summer Peak conditions.

SECTION 7: CONCLUSIONS

SUMMARY OF STABILITY ANALYSIS

The Stability Analysis determined that there were no contingencies that resulted in system instability or generation tripping offline for the 2016 Winter Peak, 2017 Summer Peak, and 2025 Summer Peak seasons when the generation interconnection request was at 100% output. Post contingent steady-state voltage violations were observed during one contingency for the 2016 Winter Peak, 2017 Summer Peak, and 2025 Summer Peak conditions. However, these violations were mitigated by switching-out certain reactors and adjusting the tap of a three-winding transformer.

SUMMARY OF THE SHORT CIRCUIT ANALYSIS

The short circuit analysis was performed on the 2017 Summer Peak and 2025 Summer Peak power flow for all study projects. Refer to Tables 7-1 and 7-2 for a list of maximum fault currents observed for each study project for the 2017 Summer Peak and 2025 Summer Peak Scenarios, respectively.

Table 7-1
List of Maximum Fault Currents Observed in 2017 Summer Peak Power Flow for Each Study Project

Study Project	Fault Current at POI (kA)	Maximum Fault Current (kA)	Fault Location	Bus Voltage (kV)
GEN-2011-008	12.63	36.61	EVANS S4, EVANS N4	138

Table 7-2
List of Maximum Fault Currents Observed in 2025 Summer Peak Power Flow for Each Study Project

Study Project	Fault Current at POI (kA)	Maximum Fault Current (kA)	Fault Location	Bus Voltage (kV)
GEN-2011-008	12.72	41.55	EVANS N4, EVANS S4	138

SUMMARY OF POWER FACTOR ANALYSIS

Study Generator GEN-2011-008

The Power Factor Analysis shows that GEN-2011-008 has a power factor range of 0.974 lagging (supplying) to 1.00 (unity) for the 2016 Winter Peak conditions, a power factor range of 0.969 to

0.998 lagging (supplying) for the 2017 Summer Peak conditions, and a power factor range of 0.971 to 0.999 lagging (supplying) for the 2025 Summer Peak conditions.

SUMMARY OF LOW WIND/NO WIND ANALYSIS

The amount of reactive power injected into the transmission network was recorded at the point of interconnection for the study generator. The reactance needed for zero Mvar flow was 38.95 Mvar for the collector/transmission line system connecting GEN-2011-008 to the Clark County 345 kV (539800) POI. This requirement was identical for all three seasonal conditions (2016 Winter Peak, 2017 Summer Peak, and 2025 Summer Peak conditions).