GEN-2014-020 Impact Restudy for Generator Modification (Turbine Change)

March 2017
Generator Interconnection

Revision History

Date	Author	Change Description
3/20/2017	SPP	GEN-2014-020 Impact Restudy for Generator Modification Report Issued
3/22/2017	SPP	GEN-2014-020 Impact Restudy for Generator Modification Report reposted for the POI change

SPP Southwest Power Pool

Executive Summary

The GEN-2014-020 Interconnection Customer has requested a modification to its Generator Interconnection Request to change wind turbine generators for its project. Originally, it consisted of fifty (50) Vestas V110 VCSS 2.0MW wind turbines for a total of 100.0 MW. The requested change is for seventeen (17) Gamesa G114 2.0MW wind turbines and thirty-one (31) Gamesa G114 2.1MW wind turbines for a total of 99.1 MW. The point of interconnection (POI) is the new American Electric Power West (AEPW) Leonard 138kV Substation.

The study models used were the 2016 winter, 2017 summer, and 2025 summer models that included Interconnection Requests through DISIS-2015-002.

The restudy showed that there were instability issues for the prior outage FLT_22 and may require the generator to reduce its MW amount to keep from tripping offline. The rest of the stability analysis has determined with all previously assigned Network Upgrades in service, generators in the monitored areas remained stable and within the pre-contingency, voltage recovery, and post fault voltage recovery criterion of 0.7pu to 1.2pu for the entire modeled disturbances. 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.

Power factor analysis for each generation project was performed on the current study 2016 winter peak, 2017 summer peak, and 2025 summer peak cases with identified system upgrades. As reactive power is required for GEN-2014-020, the final requirement in the GIA will be the pro-forma 95% lagging to 95% leading at the point of interconnection.

A reduced generation analysis was conducted to determine reactor inductive amounts to compensate the capacitive effects on the transmission system during low or reduced wind conditions caused by the interconnecting project's generator lead transmission line and collector systems. The interconnection customer's facility is required to install a reactor that is approximately 6Mvar on the low side of its 138/34.5kV transformer.

Short Circuit analysis was conducted using the current study upgrade 2017 summer peak and 2025 summer peak cases.

With the assumptions outlined in this report and with all the required network upgrades from the DISIS 2015-002 in place, GEN-2014-020 with the Gamesa G114 2.0MW and Gamesa G114 2.1MW wind turbine generators should be able to interconnect reliably to the SPP transmission grid. The change in wind turbine generator is not a Material Modification.

It should be noted that this study analyzed the requested modification to change generator technology, manufacturer, and layout. Powerflow analysis was not performed. 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 delivery or transmission service. If the customer wishes to sell power from the facility, a separate request for transmission service must be requested on Southwest Power Pool's OASIS by the Customer.

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1. Introduction

The GEN-2014-020 Interconnection Customer has requested a modification to its Generator Interconnection Request to change its generators from Vestas V110 VCSS 2.0 MW wind turbines to Gamesa G114 2.0 MW and Gamesa G114 2.1 MW wind turbines. Originally, it consisted of fifty (50) Vestas V110 VCSS 2.0MW wind turbines for a total 100.0 MW. The requested change is shown in **Table 1-1**.

Table 1-1: Interconnection Request

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2014-020	99.1	17 x Gamesa G114 2.0MW = 34.0MW, and 31 x Gamesa G114 2.1MW = 65.1MW	Leonard 138kV (561000)

The POI is the new AEPW Leonard 138kV Substation. Other queued generation projects in the model are listed in **Table 1-2**.

Table 1-2: Other Queued Interconnection Requests in the Model

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2001-014	94.5	Suzlon S88 2.1MW	Ft Supply 138kV (520920)
GEN-2001-037	102	GE 1.5MW	FPL Mooreland Tap 138kV (515785)
GEN-2005-008	120	GE 1.5MW	Woodward 138kV (514785)
GEN-2006-024S	18.9	Suzlon S88 2.1MW	Buffalo Bear Tap 69kV (521120)
GEN-2006-046	130	Mitsubishi MWT95 2.4MW	Dewey 138kV (514787)
GEN-2007-021	200	GE 1.79MW	Tatonga 345kV (515407)
GEN-2007-043	200	GE 1.6MW	Minco 345KV (514801)
GEN-2007-044	300	GE 1.79MW	Tatonga 345kV (515407)
GEN-2007-050	170.2	Siemens 2.3MW	Woodward EHV 138kV (515376)
GEN-2007-062	425	Vestas V100 2.0MW (63) Vestas V117 3.3MW (30) GE 2.4MW (83)	Woodward EHV 345kV (515375)
GEN-2008-003	101.2	Siemens 2.3MW	Woodward EHV 138kV (515376)
GEN-2008-044	197.8	Siemens 2.3MW (86)	Tatonga 345kV (515407)
GEN-2010-011 (addition to GEN-2008-044)	29.7	Siemens 2.3MW (9) Siemens 3.0MW (3)	Tatonga 345kV (515407)
GEN-2010-040	300	Mitsubishi MWT102 2.4MW (62) Repower MM92 2.05MW (73)	Cimarron 345kV (514901)
GEN-2011-010	100.8	GE 1.69MW	Minco 345KV (514801)
GEN-2011-019	175	Vestas V100 2.0MW (87)	Woodward EHV 345kV (515375)
GEN-2011-020	165	GE 2.4MW (69)	Woodward EHV 345kV (515375)
GEN-2011-054	300	Vestas V100 2.0MW	Cimarron 345kV (514901)
GEN-2014-002 (uprate to GEN-2007-021)	10.53	GE 1.79MW	Tatonga 345kV (515407)
GEN-2014-003 (uprate to GEN-2007-044)	15.04	GE 1.79MW	Tatonga 345kV (515407)

Table 1-2: Other Queued Interconnection Requests in the Model

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2014-005 (uprate to GEN-2011-010)	5.67	GE 1.69MW	Tap Wichita to Emporia Energy Center 345kV (562476)
GEN-2014-056	250	GE 2.0MW	Minco 345KV (514801)
GEN-2015-029	161	GE 2.3MW	Tatonga 345kV (515407)
GEN-2015-048	200	Vestas V110 2.0MW	Cleo Corner 138kV (514778)
GEN-2015-057	100	GE 2.0MW	Minco 345KV (514801)
GEN-2015-060	250.5	GE 1.5MW	Woodward EHV 138kV (515376)
GEN-2015-081	180	Vestas V110 2.0MW	Tap Woodward to Tatonga 345kV (562075)
GEN-2015-093	250	GE 2.0MW	Gracemont 345kV (515800)

A stability analysis was performed for the change in wind turbines. The analysis was performed on three (3) seasonal models including 2016 winter peak (16WP), the 2017 summer peak (17SP), and the 2025 summer peak (25SP) cases. These cases are modified versions of the 2015 model series of Model Development Working Group (MDWG) dynamic study models that included upgrades and Interconnection Requests through DISIS-2015-002.

The stability analysis determines the impacts of the new interconnecting project on the stability and voltage recovery of the nearby systems and the ability of the interconnecting project to meet FERC Order 661A. If problems with stability or voltage recovery are identified, the need for reactive compensation or system upgrades is investigated. The contingencies listed in **Table 3-1** were used in the stability analysis.

The power factor analysis determines the power factor at the point of interconnection (POI) for the wind interconnection projects for pre-contingency and post-contingency conditions. The contingencies used in the power factor analysis are a subset of the stability analysis contingencies shown in **Table 3-1**.

A reduced (low wind/no wind) generation analysis was performed to determine reactor inductive amounts to compensate for the capacitive effects on the transmission system caused by the interconnecting project's generator lead transmission line and collector systems during low or reduced wind conditions.

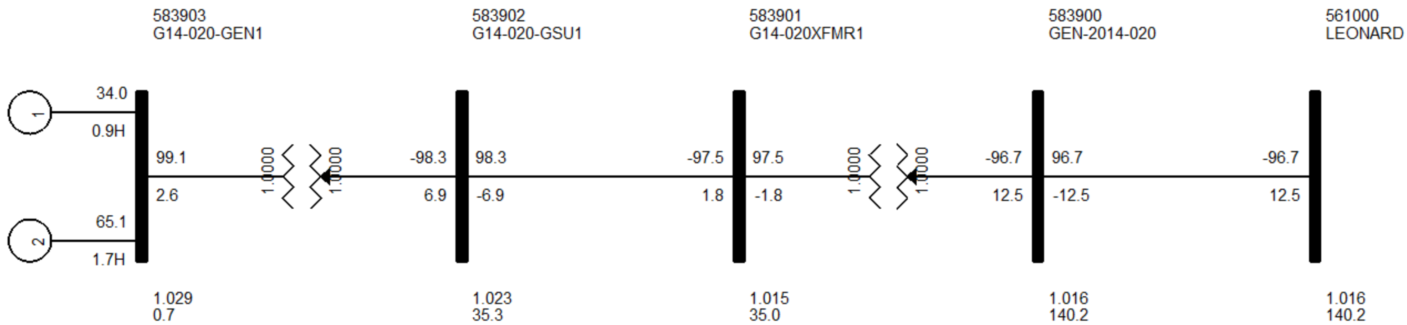
Short Circuit analysis was conducted using the current study upgrade 2017 summer peak and 2025 summer peak cases. The results from the Short circuit analysis are shown in Appendix F.

Nothing in this System Impact Study constitutes a request for transmission service or grants the Interconnection Customer any rights to transmission service. If the customer wishes to sell power from the facility, a separate request for transmission service must be requested on Southwest Power Pool's OASIS by the Customer.

2. Facilities

A one-line PSS/E slider drawing from the 16WP case is shown in **Figure 2-1** for GEN-2014-020. The POI is the new AEPW Leonard 138kV substation.

Figure 2-1*:* GEN-2014-020 One-line Diagram



3. Stability Analysis

Transient stability analysis is used to determine if the transmission system can maintain angular stability and ensure bus voltages stay within planning criteria bandwidth during and after a disturbance while considering the addition of a generator interconnection request.

Model Preparation

Transient stability analysis was performed using modified versions of the 2015 series of Model Development Working Group (MDWG) dynamic study models including the 2016 winter peak, 2017 summer peak, and the 2025 summer peak seasonal models. The cases are then loaded with prior queued interconnection requests and network upgrades assigned to those interconnection requests. Finally the prior queued and study generation are dispatched into the SPP footprint. Initial simulations are then carried out for a no-disturbance run of twenty (20) seconds to verify the numerical stability of the model.

Disturbances

Twenty-five (25) contingencies were identified for use in this study and are listed in **Table 3-1**. These contingencies are faults at locations defined by SPP Generation Interconnection Staff. These contingencies include three-phase and single-phase N-1. Single-phase line faults were simulated by applying fault impedance to the positive sequence network at the fault location to represent the effect of the negative and zero sequence networks on the positive sequence network. The fault impedance was computed to give a positive sequence voltage at the specified fault location of approximately 60% of pre-fault voltage. This method is in agreement with SPP current practice.

Except for transformer faults, the typical sequence of events for a three-phase and single-phase fault is as follows:

1. apply fault at particular location
2. continue fault for five (5) cycles, clear the fault by tripping the faulted facility
3. after an additional twenty (20) cycles, re-close the previous facility back into the fault
4. continue fault for five (5) additional cycles
5. trip the faulted facility and remove the fault

Transformer faults are typically modeled as three-phase faults, unless otherwise noted. The sequence of events for a transformer fault is as follows:

1. apply fault for five (5) cycles
2. clear the fault by tripping the affected transformer facility (unless otherwise noted there will be no re-closing into a transformer fault)

The SPP areas monitored during the stability analysis were:

- 520: American Electric Power (AEPW)
- 524: Oklahoma Gas and Electric Company (OKGE)
- 525: Western Farmers Electric Cooperative (WFEC)
- 527: Oklahoma Municipal Power Authority (OMPA)

Table 3-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
0	FLT_000_NOFAULT	No Fault Conditions
1	FLT_01_LEONARD_ TUTTLE4_138kV_3PH	3 phase fault on the Leonard (561000) to Tuttle (511501) 138kV line, near Leonard. a. Apply fault at the Leonard 138kV 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	FLT_02_ LEONARD _CORNVIL4_138kV_3PH	3 phase fault on the Leonard (561000) to Cornville (511449) 138kV line, near Leonard. a. Apply fault at the Leonard 138kV 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	FLT_03_TUTTLE4_TUTCONT4_138kV_3PH	3 phase fault on the Tuttle (511501) to Tuttle Conoco Tap (511425) 138kV line, near Tuttle. a. Apply fault at the Tuttle 138kV 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	FLT_04_CORNVIL4_NORGE4_138kV_3PH	3 phase fault on the Cornville (511449) to Norge (511483) 138kV line, near Cornville. a. Apply fault at the Cornville 138kV 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	FLT_05_CORNVIL4_SANTAFE4_138kV_3PH	3 phase fault on the Cornville (511449) to Santa Fe (511492) 138kV line, near Cornville. a. Apply fault at the Cornville 138kV 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	FLT_06_CORNVIL4_N29CHIK4_138kV_3PH	3 phase fault on the Cornville (511449) to N29Chik (511502) 138kV line, near Cornville. a. Apply fault at the Cornville 138kV 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.
7	FLT_07_CORNVIL4_BLANCHD4_138kV_3PH	3 phase fault on the Cornville (511449) to Blanchard (511508) 138kV line, near Cornville. a. Apply fault at the Cornville 138kV 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.
8	FLT_08_CORNVIL4_CORNTP4_138kV_3PH	3 phase fault on the Cornville (511449) to Cornville Tap (520867) 138kV line, near Cornville. a. Apply fault at the Cornville 138kV 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.
9	FLT_09_TUTCONT4_CIMARON4_138kV_3PH	3 phase fault on the Tuttle Conoco Tap (511425) to Cimarron (514898) 138kV line, near Tuttle Conoco Tap. a. Apply fault at the Tuttle Conoco Tap 138kV 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 3-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
10	FLT_10_CIMARON4_ELRENO4_138kV_3PH	3 phase fault on the Cimarron (514898) to El Reno (514819) 138kV line, near Cimarron. a. Apply fault at the Cimarron 138kV 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	FLT_11_CIMARON4_JENSENT4_138kV_3PH	3 phase fault on the Cimarron (514898) to Jensen Tap (514820) 138kV line, near Cimarron. a. Apply fault at the Cimarron 138kV 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	FLT_12_CIMARON4_HAYMAKR4_138kV_3PH	3 phase fault on the Cimarron (514898) to Haymaker (514863) 138kV line, near Cimarron. a. Apply fault at the Cimarron 138kV 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	FLT_13_CIMARON4_CZECHAL4_138kV_3PH	3 phase fault on the Cimarron (514898) to Czech Hall (514894) 138kV line, near Cimarron. a. Apply fault at the Cimarron 138kV 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.
14	FLT_14_CIMARON4_SARA4_138kV_3PH	3 phase fault on the Cimarron (514898) to Sara (514895) 138kV line, near Cimarron. a. Apply fault at the Cimarron 138kV 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.
15	FLT_15_CORNTP4_SEQUOYAHJ4_138kV_3PH	3 phase fault on the Cornville Tap (520867) to Sequoyah Junction (520422) 138kV line, near Cornville Tap. a. Apply fault at the Cornville Tap 138kV 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	FLT_16_CORNTP4_NAPLESTP_138kV_3PH	3 phase fault on the Cornville Tap (520867) to Naples Tap (520510) 138kV line, near Cornville Tap. a. Apply fault at the Cornville Tap 138kV 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.
17	FLT_17_LES7_OKU7SB_345kV_1PH	**Single phase fault with stuck breaker** on the LES (511468) to OKU (511456) 345kV line, near LES. a. Apply fault at the LES 345kV bus. b. Clear fault after 16 cycles by tripping the faulted line.
18	FLT_18_CIMARON4_CZECHAL4SB_138kV_1PH	**Single phase fault with stuck breaker** on the Cimarron (514898) to Czech Hall (514894) 138kV line, near Cimarron. a. Apply fault at the Cimarron 138kV bus. b. Clear fault after 16 cycles by tripping the faulted line.
19	FLT_19_CIMARON4_HAYMAKR4SB_138kV_1PH	**Single phase fault with stuck breaker** on the Cimarron (514898) to Haymaker (514863) 138kV line, near Cimarron. a. Apply fault at the Cimarron 138kV bus. b. Clear fault after 16 cycles by tripping the faulted line.

Table 3-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
20	FLT_20_CORNVIL4_NORGE4SB_138kV_1PH	**Single phase fault with stuck breaker** on the Cornville (511449) to Norge (511483) 138kV line, near Cornville. a. Apply fault at the Cornville 138kV bus. b. Clear fault after 16 cycles by tripping the faulted line.
21	FLT_21_CORNVIL4_N29CHIK4SB_138kV_1PH	**Single phase fault with stuck breaker** on the Cornville (511449) to N29Chik (511502) 138kV line, near Cornville. a. Apply fault at the Cornville 138kV bus. b. Clear fault after 16 cycles by tripping the faulted line.
22	FLT_22_CIMARON4_CZECHAL4PO_138kV_3PH	**Prior outage** on the Leonard (561000) to Cornville (511449) 138kV line: 3 phase fault on the Cimarron (514898) to Czech Hall (514894) 138kV line, near Cimarron 138kV. a. Prior Outage Leonard to Cornville 138kV. b. Apply fault at the Cimarron 138kV bus. c. Clear fault after 5 cycles by tripping 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.
23	FLT_23_LEONARD_CORNVIL4PO_138kV_3PH	**Prior outage** on the Cimarron (514898) to Czech Hall (514894) 138kV line: 3 phase fault on the Leonard (561000) to Cornville (511449) 138kV line, near Leonard 138kV. a. Prior Outage Cimarron to Czech Hall 138kV. b. Apply fault at the Leonard 138kV bus. c. Clear fault after 5 cycles by tripping 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.
24	FLT_24_CIMARON7_CIMARON4_345_138kV_3PH	3 phase fault on the Cimarron 345kV (514901) to Cimarron 138kV (514898) to Cimarron 13.8kV (515714) transformer, near Cimarron 345kV. a. Apply fault at the Cimarron 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
25	FLT_25_GRACMNT7_GRACMNT4_345_138kV_3PH	3 phase fault on the Gracemont 345kV (515800) to Gracemont 138kV (515802) to Gracemont 13.8kV (515801) transformer, near Gracemont 345kV. a. Apply fault at the Gracemont 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.

Results

The stability analysis was performed and the results are summarized in **Table 3-2**. The stability plots will be available upon customer request.

Table 3-2: Results

Contingency Number and Name		2016WP	2017SP	2025SP
0	FLT_000_NOFAULT	STABLE	STABLE	STABLE
1	FLT_01_LEONARD_ TUTTLE4_138kV_3PH	STABLE	STABLE	STABLE
2	FLT_02_ LEONARD _CORNVIL4_138kV_3PH	STABLE	STABLE	STABLE
3	FLT_03_TUTTLE4_TUTCONT4_138kV_3PH	STABLE	STABLE	STABLE
4	FLT_04_CORNVIL4_NORGE4_138kV_3PH	STABLE	STABLE	STABLE
5	FLT_05_CORNVIL4_SANTAFE4_138kV_3PH	STABLE	STABLE	STABLE
6	FLT_06_CORNVIL4_N29CHIK4_138kV_3PH	STABLE	STABLE	STABLE
7	FLT_07_CORNVIL4_BLANCHD4_138kV_3PH	STABLE	STABLE	STABLE
8	FLT_08_CORNVIL4_CORNTP4_138kV_3PH	STABLE	STABLE	STABLE

Contingency Number and Name		2016WP	2017SP	2025SP
9	FLT_09_TUTCONT4_CIMARON4_138kV_3PH	STABLE	STABLE	STABLE
10	FLT_10_CIMARON4_ELRENO4_138kV_3PH	STABLE	STABLE	STABLE
11	FLT_11_CIMARON4_JENSENT4_138kV_3PH	STABLE	STABLE	STABLE
12	FLT_12_CIMARON4_HAYMAKR4_138kV_3PH	STABLE	STABLE	STABLE
13	FLT_13_CIMARON4_CZECHAL4_138kV_3PH	STABLE	STABLE	STABLE
14	FLT_14_CIMARON4_SARA4_138kV_3PH	STABLE	STABLE	STABLE
15	FLT_15_CORNTP4_SEQUOYAHJ4_138kV_3PH	STABLE	STABLE	STABLE
16	FLT_16_CORNTP4_NAPLESTP_138kV_3PH	STABLE	STABLE	STABLE
17	FLT_17_LES7_OKU7SB_345kV_1PH	STABLE	STABLE	STABLE
18	FLT_18_CIMARON4_CZECHAL4SB_138kV_1PH	STABLE	STABLE	STABLE
19	FLT_19_CIMARON4_HAYMAKR4SB_138kV_1PH	STABLE	STABLE	STABLE
20	FLT_20_CORNVIL4_NORGE4SB_138kV_1PH	STABLE	STABLE	STABLE
21	FLT_21_CORNVIL4_N29CHIK4SB_138kV_1PH	STABLE	STABLE	STABLE
22	FLT_22_CIMARON4_CZECHAL4PO_138kV_3PH	UNSTABLE	UNSTABLE	UNSTABLE
23	FLT_23_ LEONARD _CORNVIL4PO_138kV_3PH	STABLE	STABLE	STABLE
24	FLT_24_CIMARON7_CIMARON4_345_138kV_3PH	STABLE	STABLE	STABLE
25	FLT_25_GRACMNT7_GRACMNT4_345_138kV_3PH	STABLE	STABLE	STABLE

FERC LVRT Compliance

FERC Order 661A places specific requirements on wind farms through its Low Voltage Ride Through (LVRT) provisions. For Interconnection Agreements signed after December 31, 2006, wind farms shall stay on line for faults at the POI that draw the voltage down at the POI to 0.0 pu. The faults listed below in **Table *3-3*** were tested to meet Order 661A LVRT provisions. GEN-2014-020 was found to be in compliance with FERC Order 661A.

Table 3-3: LVRT Contingencies

Contingency Number and Name	Description
FLT_01_LEONARD_ TUTTLE4_138kV_3PH	3 phase fault on the Leonard (561000) to Tuttle (511501) 138kV line, near Leonard. a. Apply fault at the Leonard 138kV 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.
FLT_02_ LEONARD _CORNVIL4_138kV_3PH	3 phase fault on the Leonard (561000) to Cornville (511449) 138kV line, near Leonard. a. Apply fault at the Leonard 138kV 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. Power Factor Analysis

The power factor analysis was performed for each project included in this study and is designed to demonstrate the reactive power requirements at the point of interconnection (POI) using the current study upgrade cases. For all projects that require reactive power, the final requirement in the GIA will be the pro-forma 95% lagging to 95% leading at the POI.

Model Preparation

For each project included in this study, as well as previous queued projects modeled at the same POI, the projects were turned off for the power factor analysis. The projects were replaced by an equivalent generator located at the POI producing the total MW of the project at that POI and 0.0 Mvar capability.

A Mvar generator without limits was modeled at the interconnection project POI to hold a voltage schedule at the POI consistent with the greater of the voltage schedule in the base case or unity (1.0 pu) voltage.

Disturbances

Each N-1 contingency evaluated in the Stability Analysis found in **Table 3-1** was also included in the determination of the power factor requirements.

Results

The power factor ranges are summarized in **Table 4-1** and the resultant ranges are shown **Table D-1**. The analysis showed that reactive power is required for the study project, the final requirement in the Generation Interconnection Agreement (GIA) for each project will be the pro-forma 95% lagging to 95% leading at the POI.

For analyzing power factor results a positive Q (Mvar) output indicates that the equivalent generator is supplying reactive power to the system, implying a lagging power factor. A negative Q (Mvar) output indicts that the equivalent generator is absorbing reactive power from the system, implying a leading power factor.

Table 4-1*: Summary of Power Factor Analysis at the POI*

Request	Capacity (MW)	Point of Interconnection (POI)	Fuel	Generator	Lagging (providing Mvars)	Leading (absorbing Mvars)
GEN-2014-020	99.1	Leonard 138kV (561000)	Wind	17 x Gamesa G114 2.0MW = 34.0MW, and 31 x Gamesa G114 2.1MW = 65.1MW	0.95	0.95

NOTE: As reactive power is required for the project, the final requirement in the GIA will be the pro-forma 95% lagging to 95% leading at the point of interconnection.

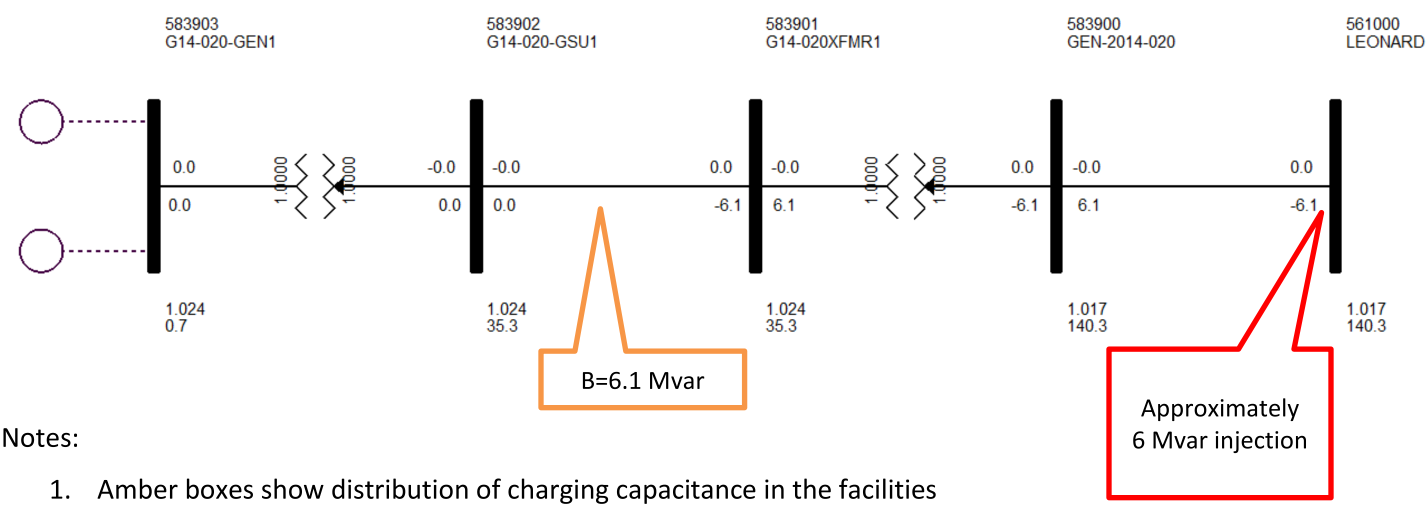
5. Reduced Wind Generation Analysis

A low wind analysis was performed for GEN-2014-020. SPP performed this low wind analysis to determine the capacitive charging current injected at the POI.

The project generators and capacitors (if any) were turned off in the base case. **Figure 5-1** shows the resulting reactive power injection (approximately 6Mvar) at the POI that is due to the capacitance of the project's transmission lines and collector cables. Also, the figure shows how the capacitance is distributed throughout the project. In this impact restudy GEN-2014-020 is responsible for a 6Mvar reactor needed to offset the capacitive effects of the collector system (6.1Mvar) and of the transmission lead (0Mvar) that connects into the transmission system under no/reduced generating conditions. The 6Mvar reactor will be required and would normally be installed on the low side of the 138/34.5kV transformer. The Interconnection Customer may use wind turbine manufacturing options for providing reactive power under no/reduced generation conditions.

A shunt reactor was added at the GEN-2014-020 project substation 34.5 kV bus to bring the Mvar flow into the POI down to approximately zero as shown in **Figure E-1**. A reactor of approximately 6Mvar will negate the capacitive effect of the project at the POI. This is shown for information only and not as a requirement.

Figure 5-1*:* GEN-2014-020 with generators turned off



Notes:

1. Amber boxes show distribution of charging capacitance in the facilities
2. Red box shows the net effect of all the charging capacitances at the POI

6. Short Circuit Analysis

The short circuit analysis was performed on the 2017 & 2025 Summer Peak power flow cases using the PSS/E ASCC program. Since the power flow model does not contain negative and zero sequence data, only three-phase symmetrical fault current levels were calculated at the point of interconnection up to and including five levels away.

Short Circuit Analysis was conducting using flat conditions with the following PSS/E ASCCC program settings:

- BUS VOLTAGES SET TO 1 PU AT 0 PHASE ANGLE
- GENERATOR P=0, Q=0
- TRANSFORMER TAP RATIOS=1.0 PU and PHASE ANGLES=0.0
- LINE CHARGING=0.0 IN +/-/0 SEQUENCE
- LOAD=0.0 IN +/- SEQUENCE, CONSIDERED IN ZERO SEQUENCE
- LINE/FIXED/SWITCHED SHUNTS=0.0 AND MAGNETIZING ADMITTANCE=0.0 IN +/-/0 SEQUENCE
- DC LINES AND FACTS DEVICES BLOCKED
- TRANSFORMER ZERO SEQUENCE IMPEDANCE CORRECTIONS IGNORED

Results

The results of the short circuit analysis are shown in **Appendix F, Table F-1** ***GEN-2014-020 Short Circuit Analysis Results (2017SP)*** and **Table F-2** ***GEN-2014-020 Short Circuit Analysis Results (2025SP)***.

7. Conclusion

The GEN-2014-020 Interconnection Customer has requested a modification to its Generator Interconnection Request to change its generators from Vestas V110 VCSS 2.0 MW wind turbines to Gamesa G114 2.0 MW and Gamesa G114 2.1 MW wind turbines. Originally, it consisted of fifty (50) Vestas V110 VCSS 2.0MW wind turbines for a total of 100.0 MW. The requested change is seventeen (17) Gamesa G114 2.0MW wind turbines and thirty-one (31) Gamesa G114 2.1MW wind turbines for a total of 99.1 MW. The point of interconnection (POI) is the new American Electric Power West (AEPW) Leonard 138kV Substation.

The restudy showed that there were instability issues for the prior outage FLT_22 and may require the generator to reduce its MW amount to keep from tripping offline. The rest of the stability analysis has determined that with all previously assigned Network Upgrades in service, generators in the monitored areas remained stable and within the pre-contingency, voltage recovery, and post fault voltage recovery criterion of 0.7pu to 1.2pu for the entire modeled disturbances. 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 wind turbine modification request. As reactive power is required for GEN-2014-020, the final requirement in the GIA will be the pro-forma 95% lagging to 95% leading at the POI.

A reduced generation analysis was conducted to determine reactor size necessary to compensate the capacitive effects on the transmission system during low or reduced wind conditions caused by the interconnecting project's generator lead transmission line and collector systems. The interconnection customer's facility is required to install a reactor that is approximately 6Mvar on the low side of its 138/34.5kV transformer.

Short Circuit analysis was conducted using the current study upgrade 2017 summer peak and 2025 summer peak cases.

With the assumptions outlined in this report and with all the required network upgrades from the DISIS 2015-002 in place, GEN-2014-020 with the Gamesa G114 2.0MW and Gamesa G114 2.1MW wind turbine generators should be able to interconnect reliably to the SPP transmission grid. The change in wind turbine generator is not a Material Modification.

It should be noted that this study analyzed the requested modification to change generator technology, manufacturer, and layout. Power flow analysis was not performed. 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 delivery or transmission service. If the customer wishes to sell power from the facility, a separate request for transmission service must be requested on Southwest Power Pool's OASIS by the Customer.

Appendix A – 2016 Winter Peak Stability Plots

(Available on request)

Appendix B – 2017 Summer Peak Stability Plots

(Available on request)

Appendix C – 2025 Summer Peak Stability Plots

(Available on request)

Appendix D – Power Factor Analysis Results

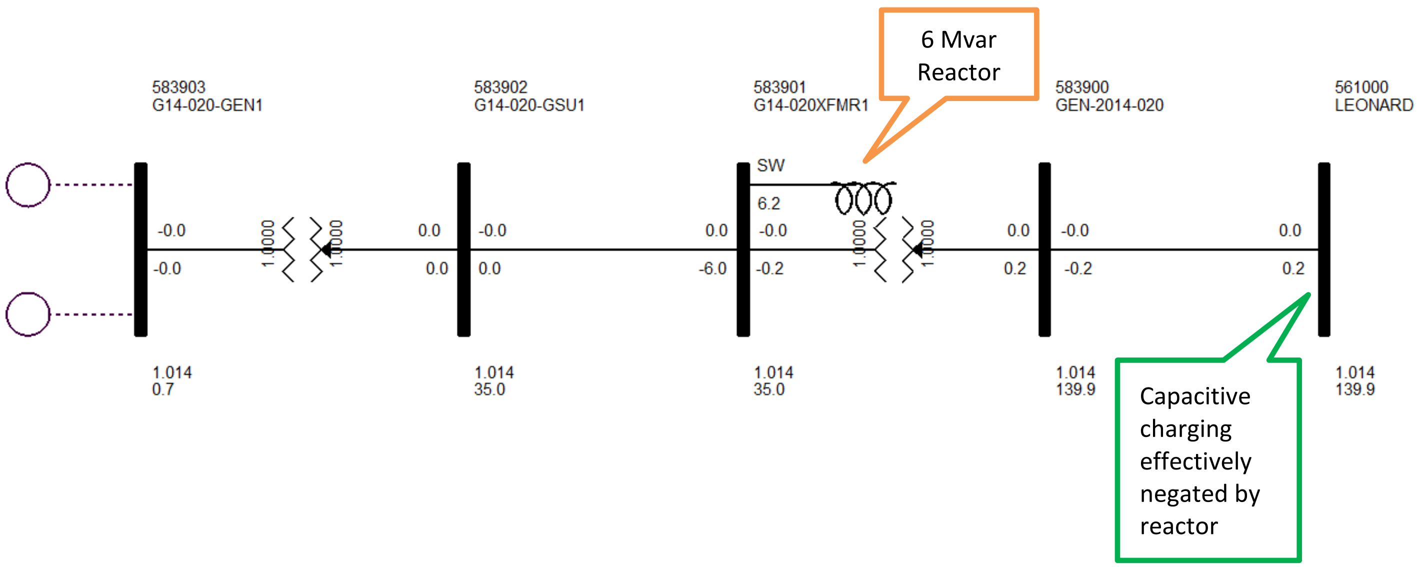
Table D-1: GEN-2014-020 Power Factor Analysis Results

Leading power factor is absorbing vars; Lagging power factor is providing vars										
	GEN-2014-020 POI: Leonard 138 kV (561000) Power at POI (MW): 99.1	2016 Winter Peak POI Voltage = 1.014 pu			2017 Summer Peak POI Voltage = 1.015 pu			2025 Summer Peak POI Voltage = 1.013 pu		
	Contingency Name	Mvars at POI	Power Factor		Mvars at POI	Power Factor		Mvars at POI	Power Factor	
0	FLT_00_NoFault	-16.6364	0.9862	LEAD	-17.0418	0.98553	LEAD	-16.9315	0.98572	LEAD
1	FLT_01_LEONARD_ TUTTLE4_138kV	-6.45866	0.99788	LEAD	0.334608	0.99999	LAG	3.243231	0.99947	LAG
2	FLT_02_ LEONARD _CORNVIL4_138kV	-22.7483	0.97465	LEAD	-30.1295	0.95676	LEAD	-32.7847	0.9494	LEAD
3	FLT_03_TUTTLE4_TUTCONT4_138kV	-5.73318	0.99833	LEAD	1.664736	0.99986	LAG	4.74545	0.99886	LAG
4	FLT_04_CORNVIL4_NORGE4_138kV	-16.017	0.98719	LEAD	-16.0106	0.9872	LEAD	-15.7792	0.98756	LEAD
5	FLT_05_CORNVIL4_SANTAFE4_138kV	-17.19	0.98529	LEAD	-17.7075	0.98441	LEAD	-17.3877	0.98495	LEAD
6	FLT_06_CORNVIL4_N29CHIK4_138kV	-13.0187	0.99148	LEAD	-11.4777	0.99336	LEAD	-10.1421	0.99480	LEAD
7	FLT_07_CORNVIL4_BLANCHD4_138kV	-12.8271	0.99173	LEAD	-14.672	0.98922	LEAD	-14.4769	0.9895	LEAD
8	FLT_08_CORNVIL4_CORNTP4_138kV	-20.7138	0.97885	LEAD	-18.7212	0.98262	LEAD	-18.975	0.98216	LEAD
9	FLT_09_TUTCONT4_CIMARON4_138kV	-2.86008	0.99958	LEAD	4.635061	0.99891	LAG	7.746366	0.99696	LAG
10	FLT_10_CIMARON4_ELRENO4_138kV	-17.5939	0.98460	LEAD	-18.1956	0.98356	LEAD	-18.0239	0.98386	LEAD
11	FLT_11_CIMARON4_JENSENT4_138kV	-17.2858	0.98513	LEAD	-17.8735	0.98412	LEAD	-17.7892	0.98427	LEAD
12	FLT_12_CIMARON4_HAYMAKR4_138kV	-15.1224	0.98856	LEAD	-16.2525	0.98682	LEAD	-16.6347	0.98620	LEAD
13	FLT_13_CIMARON4_CZECHAL4_138kV	-12.6298	0.99198	LEAD	-16.0489	0.98714	LEAD	-16.7857	0.98596	LEAD
14	FLT_14_CIMARON4_SARA4_138kV	-15.5621	0.98789	LEAD	-17.9142	0.98405	LEAD	-17.2415	0.9852	LEAD
15	FLT_15_CORNTP4_SEQUOYAHJ4_138kV	-11.6436	0.99317	LEAD	-11.766	0.99303	LEAD	-10.9317	0.99397	LEAD
16	FLT_16_CORNTP4_NAPLESTP_138kV	-23.2705	0.97352	LEAD	-22.4642	0.97526	LEAD	-22.7901	0.97456	LEAD
17	FLT_17_LES7_OKU7SB_345kV	-14.4599	0.98952	LEAD	-16.6063	0.98625	LEAD	-16.6591	0.98616	LEAD
18	FLT_18_CIMARON4_CZECHAL4SB_138kV	-12.6298	0.99198	LEAD	-16.0489	0.98714	LEAD	-16.7857	0.98596	LEAD
19	FLT_19_CIMARON4_HAYMAKR4SB_138kV	-15.1224	0.98856	LEAD	-16.2525	0.98682	LEAD	-16.6347	0.98620	LEAD
20	FLT_20_CORNVIL4_NORGE4SB_138kV	-16.017	0.98719	LEAD	-16.0106	0.9872	LEAD	-15.7792	0.98756	LEAD
21	FLT_21_CORNVIL4_N29CHIK4SB_138kV	-13.0187	0.99148	LEAD	-11.4777	0.99336	LEAD	-10.1421	0.99480	LEAD
22	FLT_22_CIMARON4_CZECHAL4PO_138kV	-12.6298	0.99198	LEAD	-16.0489	0.98714	LEAD	-16.7857	0.98596	LEAD
23	FLT_23_ LEONARD _CORNVIL4PO_138kV	-22.7483	0.97465	LEAD	-30.1295	0.95676	LEAD	-32.7847	0.9494	LEAD
24	FLT_24_CIMARON7_CIMARON4_345_138kV	-17.8561	0.98415	LEAD	-13.6486	0.99065	LEAD	-12.3199	0.99236	LEAD
25	FLT_25_GRACMNT7_GRACMNT4_345_138kV	-16.9489	0.98569	LEAD	-17.2032	0.98527	LEAD	-16.6601	0.98616	LEAD

Appendix E – Reduced Wind Generation Analysis Results

Below figure is from the 2016WP model with identified upgrades in-service. The other two cases (2017SP and 2025SP) were almost identical since the Interconnection Request facilities design is the same in all cases.

Figure E-1*:* GEN-2014-020 with generators turned off and shunt reactor added to the 34.5kV side of the customer substation



Appendix F – Short Circuit Analysis Results

Table F-1: GEN-2014-020 Short Circuit Analysis Results (2017SP)

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                              PSS®E-32.2.0 ASCC SHORT CIRCUIT CURRENTS          TUE, MAR 21 2017  11:25
2015 MDWG FINAL WITH 2013 MMWG, UPDATED WITH 2014 SERC & MRO
MDWG 17S WITH MMWG 15S, MRO 16W TOPO/16S PROF, SERC 16S

OPTIONS USED:
    - FLAT CONDITIONS
    - BUS VOLTAGES SET TO 1 PU AT 0 PHASE ANGLE
    - GENERATOR P=0, Q=0
    - TRANSFOMRER TAP RATIOS=1.0 PU and PHASE ANGLES=0.0
    - LINE CHARGING=0.0 IN +/-/0 SEQUENCE
    - LOAD=0.0 IN +/- SEQUENCE, CONSIDERED IN ZERO SEQUENCE
    - LINE/FIXED/SWITCHED SHUNTS=0.0 AND MAGNETIZING ADMITTANCE=0.0 IN +/-/0 SEQUENCE
    - DC LINES AND FACTS DEVICES BLOCKED
    - TRANSFORMER ZERO SEQUENCE IMPEDANCE CORRECTIONS IGNORED

                                   THREE PHASE FAULT
X---------- BUS ----------X          /I+/    AN(I+)
561000 [LEONARD     138.00] AMP    10242.8   -80.69
511449 [CORNVIL4    138.00] AMP    15884.1   -77.71
511501 [TUTTLE4     138.00] AMP    10318.7   -80.75
583900 [GEN-2014-020138.00] AMP    10242.8   -80.69
511418 [CORNV2-1    13.800] AMP     8421.3   -88.31
511425 [TUTCONT4    138.00] AMP    10443.8   -80.80
511450 [CORNVIL2    69.000] AMP     6476.9   -84.36
511483 [NORGE--4    138.00] AMP    11017.9   -75.48
511492 [SANTAFE4    138.00] AMP     8340.0   -78.05
511502 [N29CHIK4    138.00] AMP    10061.3   -79.67
511508 [BLANCHD4    138.00] AMP     5779.5   -68.35
511516 [ALEX BR4    138.00] AMP     6223.0   -80.90
520867 [CORN TP4    138.00] AMP    13538.7   -77.11
583901 [G14-020XFMR134.500] AMP    16221.9   -84.73
511421 [VERDEN 4    138.00] AMP     9432.7   -80.58
511424 [T-CONCO4    138.00] AMP     6818.8   -74.78
511451 [CYRIL--2    69.000] AMP     4616.1   -75.05
511477 [S.W.S.-4    138.00] AMP    26846.5   -83.57
511491 [RUSHSPT4    138.00] AMP     8001.2   -77.79
511515 [TEXAS  4    138.00] AMP     5694.0   -80.68
511562 [ROUNDCK4    138.00] AMP     6561.5   -78.97
514898 [CIMARON4    138.00] AMP    42010.9   -84.99
515055 [MAUD   4    138.00] AMP    19551.4   -79.34
520422 [SEQUOYAHJ4  138.00] AMP    21393.4   -81.53
520510 [NAPLESTP    138.00] AMP     8570.9   -76.16
583100 [GEN-2011-050138.00] AMP     6803.7   -79.27
583902 [G14-020-GSU134.500] AMP    15728.8   -83.83
510948 [EARLSBORO  4138.00] AMP     7416.5   -72.22
511413 [SWS#1--1    13.800] AMP     6286.0   -87.19
511423 [FLE TAP4    138.00] AMP     8275.1   -81.06
511426 [RUSHSP 4    138.00] AMP     6870.8   -77.32
511427 [RUSHNG 4    138.00] AMP     4687.6   -79.07
511445 [CARNEG-4    138.00] AMP     7407.6   -80.85
511476 [S.W.S.-2    69.000] AMP     4151.6   -87.44
511487 [ELGINJT2    69.000] AMP     8384.0   -81.50
511514 [PHILPS 4    138.00] AMP     5683.5   -80.58
511560 [GRADY  4    138.00] AMP     5902.6   -79.96
511563 [ELSWORTH   4138.00] AMP     9565.2   -81.08
511846 [SWS1-1      14.400] AMP    26374.0   -86.77
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511847 [SWS2-1      14.400] AMP    26374.0   -86.77
511848 [SWS3-1      24.000] AMP    84353.5   -87.45
511849 [SWS NG4     13.800] AMP    24017.4   -88.39
511850 [SWS NG5     13.800] AMP    24064.1   -88.36
514819 [EL-RENO4    138.00] AMP    15217.2   -80.01
514820 [JENSENT4    138.00] AMP    14994.4   -79.44
514863 [HAYMAKR4    138.00] AMP    26003.7   -82.45
514894 [CZECHAL4    138.00] AMP    28009.6   -82.98
514895 [SARA   4    138.00] AMP    18579.9   -84.10
514901 [CIMARON7    345.00] AMP    29712.8   -85.76
515044 [SEMINOL4    138.00] AMP    39082.5   -85.70
515054 [MAUD   2    69.000] AMP    11678.3   -79.11
515075 [FRSTHIL4    138.00] AMP    13604.5   -77.05
515714 [CIMARO11    13.800] AMP    37565.5   -88.58
515715 [CIMARO21    13.800] AMP    52243.1   -87.61
515736 [MAUD   1    13.200] AMP    19997.7   -86.50
520604 [NAPLES      138.00] AMP     6076.3   -74.14
520814 [ANADARK4    138.00] AMP    27936.6   -84.09
520888 [PAYNE       138.00] AMP     8871.7   -76.54
521089 [WASHITA4    138.00] AMP    24255.6   -83.82
529307 [OMMARLO4    138.00] AMP     6166.6   -72.24
583101 [G11-050XFMR134.500] AMP    15735.5   -85.07
510877 [FIXCT4      138.00] AMP     7018.2   -71.73
511412 [ELGJT1-1    13.800] AMP    10175.7   -88.25
511422 [FLETCHR4    138.00] AMP     7592.6   -80.48
511443 [BING-TP2    69.000] AMP     2640.0   -76.07
511463 [HOB-JCT4    138.00] AMP     6369.1   -77.73
511467 [L.E.S.-4    138.00] AMP    22995.2   -84.43
511473 [PO.HILL2    69.000] AMP     5762.3   -77.34
511486 [ELGINJT4    138.00] AMP     9638.5   -81.08
511513 [LWATER 4    138.00] AMP     4215.5   -80.97
514801 [MINCO  7    345.00] AMP    16167.5   -85.15
514818 [ELRENO 2    69.000] AMP     7202.1   -78.40
514821 [JENSEN 4    138.00] AMP    10527.1   -79.40
514823 [ROMNOSE4    138.00] AMP     4121.0   -74.29
514853 [DVISION4    138.00] AMP    35470.0   -83.30
514880 [NORTWST7    345.00] AMP    29352.6   -86.05
514893 [XEROX  4    138.00] AMP    29364.4   -82.99
514934 [DRAPER 7    345.00] AMP    20372.9   -85.15
515040 [SEMINL1G    20.900] AMP   188172.0   -88.42
515045 [SEMINOL7    345.00] AMP    25902.8   -86.18
515053 [PEARSNT2    69.000] AMP     4439.7   -69.51
515073 [ERLSBOR2    69.000] AMP     8301.6   -69.74
515074 [FRSTHIL2    69.000] AMP    11028.5   -78.79
515100 [PAOLI- 4    138.00] AMP     9989.6   -79.43
515178 [PARKLN 4    138.00] AMP    15667.0   -81.41
515286 [STRLGTP4    138.00] AMP    13515.0   -76.97
515481 [STHLAKE4    138.00] AMP    20605.8   -84.63
515496 [KNAWATP2    69.000] AMP     4457.3   -65.38
515497 [MATHWSN7    345.00] AMP    27532.7   -85.77
515503 [LTRIVRT2    69.000] AMP     4758.4   -74.49
515531 [VANOSTP4    138.00] AMP    12901.1   -78.60
515610 [FSHRTAP7    345.00] AMP    15918.0   -85.09
515722 [EL RENO1    13.200] AMP     9680.5   -83.90
515725 [FRSTHIL1    13.800] AMP    13388.9   -87.06
515756 [SEMINO11    14.400] AMP    37126.8   -88.54
515757 [SEMINO21    14.400] AMP    23289.8   -87.80
515802 [GRACMNT4    138.00] AMP    25653.2   -84.72
520810 [ANADARK2    69.000] AMP    15384.9   -82.11
520811 [ANADRK4     13.800] AMP    53911.7   -88.89
520812 [ANADRK5     13.800] AMP    53971.8   -88.87
520813 [ANADRK6     13.800] AMP    53909.6   -88.85
520849 [ELGIN4      138.00] AMP     9491.6   -80.99
520868 [CRINER      138.00] AMP     8179.0   -77.13
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520923 [GEORGIA4    138.00] AMP    16106.7   -80.64
521017 [ONEY   4    138.00] AMP    10063.9   -82.62
521023 [PAOLI  4    138.00] AMP     6968.4   -75.71
521031 [POCASET4    138.00] AMP     7455.5   -80.74
521088 [WASHITA2    69.000] AMP     9243.1   -79.91
521101 [GENCO1 4    13.800] AMP    31866.8   -88.16
521102 [GENCO2 4    13.800] AMP    31927.9   -88.12
521110 [ORME1       13.800] AMP    49920.1   -88.78
521111 [ORME2       13.800] AMP    49920.1   -88.78
521112 [ORME3       13.800] AMP    49920.1   -88.78
521113 [SLICKHILLS4 138.00] AMP     7271.0   -85.98
521129 [BLUCAN5 4   138.00] AMP     4791.2   -77.96
521179 [WASHTERT    13.800] AMP    10033.3   -87.64
521181 [ADRKTERT    13.800] AMP    20150.3   -85.84
529344 [OMDUNE-4    138.00] AMP     5858.2   -70.20
583102 [G11-050-GSU134.500] AMP    15595.0   -84.98
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Table F-2: GEN-2014-020 Short Circuit Analysis Results (2025SP)

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                               PSS®E-32.2.0 ASCC SHORT CIRCUIT CURRENTS          TUE, MAR 21 2017  11:25
2015 MDWG FINAL WITH 2013 MMWG, UPDATED WITH 2014 SERC & MRO
MDWG 2025S WITH MMWG 2024S, MRO & SERC 2025 SUMMER

OPTIONS USED:
    - FLAT CONDITIONS
    - BUS VOLTAGES SET TO 1 PU AT 0 PHASE ANGLE
    - GENERATOR P=0, Q=0
    - TRANSFOMRER TAP RATIOS=1.0 PU and PHASE ANGLES=0.0
    - LINE CHARGING=0.0 IN +/-/0 SEQUENCE
    - LOAD=0.0 IN +/- SEQUENCE, CONSIDERED IN ZERO SEQUENCE
    - LINE/FIXED/SWITCHED SHUNTS=0.0 AND MAGNETIZING ADMITTANCE=0.0 IN +/-/0 SEQUENCE
    - DC LINES AND FACTS DEVICES BLOCKED
    - TRANSFORMER ZERO SEQUENCE IMPEDANCE CORRECTIONS IGNORED

                                    THREE PHASE FAULT
X---------- BUS ----------X          /I+/    AN(I+)
561000 [LEONARD     138.00] AMP    10328.2   -80.66
511449 [CORNVIL4    138.00] AMP    16474.6   -77.53
511501 [TUTTLE4     138.00] AMP    10396.1   -80.73
583900 [GEN-2014-020138.00] AMP    10328.2   -80.66
511418 [CORNV2-1    13.800] AMP     8437.6   -88.32
511425 [TUTCONT4    138.00] AMP    10518.3   -80.77
511450 [CORNVIL2    69.000] AMP     6525.5   -84.37
511483 [NORGE--4    138.00] AMP    11386.5   -75.28
511492 [SANTAFE4    138.00] AMP     8459.3   -77.98
511502 [N29CHIK4    138.00] AMP    10403.2   -79.61
511508 [BLANCHD4    138.00] AMP     5829.3   -68.22
511516 [ALEX BR4    138.00] AMP     6303.1   -80.88
520867 [CORN TP4    138.00] AMP    13944.5   -76.94
583901 [G14-020XFMR134.500] AMP    16248.9   -84.73
511421 [VERDEN 4    138.00] AMP     9867.6   -80.59
511424 [T-CONCO4    138.00] AMP     6850.1   -74.74
511451 [CYRIL--2    69.000] AMP     4642.1   -75.02
511477 [S.W.S.-4    138.00] AMP    33581.5   -84.61
511491 [RUSHSPT4    138.00] AMP     8110.2   -77.72
511515 [TEXAS  4    138.00] AMP     5757.5   -80.66
511562 [ROUNDCK4    138.00] AMP     6638.6   -78.92
514898 [CIMARON4    138.00] AMP    42568.6   -85.06
515055 [MAUD   4    138.00] AMP    19611.8   -79.27
520422 [SEQUOYAHJ4  138.00] AMP    23071.8   -81.55
520510 [NAPLESTP    138.00] AMP     8678.0   -76.05
583100 [GEN-2011-050138.00] AMP     6876.3   -79.22
583902 [G14-020-GSU134.500] AMP    15752.2   -83.83
510948 [EARLSBORO  4138.00] AMP     7499.9   -72.10
511413 [SWS#1--1    13.800] AMP     6315.5   -87.23
511423 [FLE TAP4    138.00] AMP     8528.8   -81.04
511426 [RUSHSP 4    138.00] AMP     6950.9   -77.25
511427 [RUSHNG 4    138.00] AMP     4726.8   -79.04
511445 [CARNEG-4    138.00] AMP     7706.1   -80.98
511476 [S.W.S.-2    69.000] AMP     4216.5   -87.56
511487 [ELGINJT2    69.000] AMP     8472.4   -81.51
511514 [PHILPS 4    138.00] AMP     5746.1   -80.55
511560 [GRADY  4    138.00] AMP     5967.4   -79.93
511563 [ELSWORTH   4138.00] AMP     9849.2   -81.06
511846 [SWS1-1      14.400] AMP    58591.6   -88.58
511847 [SWS2-1      14.400] AMP    58591.6   -88.58
511848 [SWS3-1      24.000] AMP    88686.9   -87.76
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511849 [SWS NG4     13.800] AMP    61548.1   -89.41
511850 [SWS NG5     13.800] AMP    61595.9   -89.40
514819 [EL-RENO4    138.00] AMP    15303.4   -80.03
514820 [JENSENT4    138.00] AMP    15078.8   -79.44
514863 [HAYMAKR4    138.00] AMP    26157.9   -82.46
514894 [CZECHAL4    138.00] AMP    27942.1   -83.01
514895 [SARA   4    138.00] AMP    18651.0   -84.10
514901 [CIMARON7    345.00] AMP    31188.1   -85.95
515044 [SEMINOL4    138.00] AMP    39235.2   -85.67
515054 [MAUD   2    69.000] AMP    11698.9   -79.08
515075 [FRSTHIL4    138.00] AMP    13540.0   -77.03
515714 [CIMARO11    13.800] AMP    37605.0   -88.59
515715 [CIMARO21    13.800] AMP    52357.0   -87.62
515736 [MAUD   1    13.200] AMP    20010.4   -86.50
520604 [NAPLES      138.00] AMP     6129.6   -74.05
520814 [ANADARK4    138.00] AMP    30952.3   -84.40
520888 [PAYNE       138.00] AMP     8952.7   -76.44
521089 [WASHITA4    138.00] AMP    27481.2   -84.23
529307 [OMMARLO4    138.00] AMP     6225.8   -72.13
583101 [G11-050XFMR134.500] AMP    15783.7   -85.08
510877 [FIXCT4      138.00] AMP     7123.4   -71.61
511412 [ELGJT1-1    13.800] AMP    10201.0   -88.27
511422 [FLETCHR4    138.00] AMP     7805.5   -80.44
511443 [BING-TP2    69.000] AMP     2666.4   -76.03
511463 [HOB-JCT4    138.00] AMP     6463.6   -77.66
511467 [L.E.S.-4    138.00] AMP    23606.1   -84.36
511473 [PO.HILL2    69.000] AMP     5796.9   -77.31
511486 [ELGINJT4    138.00] AMP     9918.6   -81.05
511513 [LWATER 4    138.00] AMP     4248.5   -80.95
514801 [MINCO  7    345.00] AMP    16541.3   -85.20
514818 [ELRENO 2    69.000] AMP     7315.5   -78.43
514821 [JENSEN 4    138.00] AMP    10575.3   -79.39
514823 [ROMNOSE4    138.00] AMP     4124.0   -74.28
514853 [DVISION4    138.00] AMP    35688.2   -83.32
514880 [NORTWST7    345.00] AMP    30589.2   -86.09
514893 [XEROX  4    138.00] AMP    29207.1   -83.02
514934 [DRAPER 7    345.00] AMP    20560.0   -85.12
515040 [SEMINL1G    20.900] AMP   188375.9   -88.41
515045 [SEMINOL7    345.00] AMP    26094.6   -86.15
515053 [PEARSNT2    69.000] AMP     4442.4   -69.50
515073 [ERLSBOR2    69.000] AMP     8317.7   -69.72
515074 [FRSTHIL2    69.000] AMP    11015.5   -78.76
515100 [PAOLI- 4    138.00] AMP    10001.8   -79.41
515178 [PARKLN 4    138.00] AMP    15709.9   -81.39
515286 [STRLGTP4    138.00] AMP    13422.4   -76.96
515481 [STHLAKE4    138.00] AMP    20652.1   -84.62
515496 [KNAWATP2    69.000] AMP     4459.8   -65.36
515497 [MATHWSN7    345.00] AMP    29724.3   -86.08
515503 [LTRIVRT2    69.000] AMP     4765.4   -74.47
515531 [VANOSTP4    138.00] AMP    12924.2   -78.57
515610 [FSHRTAP7    345.00] AMP    16284.9   -85.15
515722 [EL RENO1    13.200] AMP     9726.2   -83.92
515725 [FRSTHIL1    13.800] AMP    13385.8   -87.05
515756 [SEMINO11    14.400] AMP    37141.2   -88.54
515757 [SEMINO21    14.400] AMP    23295.5   -87.80
515802 [GRACMNT4    138.00] AMP    27937.5   -84.83
520810 [ANADARK2    69.000] AMP    19683.7   -83.76
520811 [ANADRK4     13.800] AMP    54242.3   -88.93
520812 [ANADRK5     13.800] AMP    54303.8   -88.91
520813 [ANADRK6     13.800] AMP    54240.2   -88.89
520849 [ELGIN4      138.00] AMP     9771.2   -80.96
520868 [CRINER      138.00] AMP     8232.9   -77.05
520923 [GEORGIA4    138.00] AMP    17071.2   -80.63
521017 [ONEY   4    138.00] AMP    10517.7   -82.72
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521023 [PAOLI  4    138.00] AMP     7014.1   -75.64
521031 [POCASET4    138.00] AMP     7577.4   -80.71
521088 [WASHITA2    69.000] AMP     9730.9   -79.55
521101 [GENCO1 4    13.800] AMP    32173.7   -88.22
521102 [GENCO2 4    13.800] AMP    32236.1   -88.18
521110 [ORME1       13.800] AMP    50249.1   -88.82
521111 [ORME2       13.800] AMP    50249.1   -88.82
521112 [ORME3       13.800] AMP    50249.1   -88.82
521113 [SLICKHILLS4 138.00] AMP     7367.0   -86.02
521129 [BLUCAN5 4   138.00] AMP     4849.6   -77.88
521179 [WASHTERT    13.800] AMP    10162.7   -87.63
521181 [ADRKTERT    13.800] AMP    21276.4   -86.37
529344 [OMDUNE-4    138.00] AMP     5906.9   -70.08
583102 [G11-050-GSU134.500] AMP    15640.3   -84.98
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