GEN-2013-029
Impact Restudy for Generator Modification (Turbine Change)

February 2015
Generator Interconnection

Southwest Power Pool

Executive Summary

The GEN-2013-029 interconnection customer has requested a system impact restudy to determine the effects of changing wind turbine generators from the previously studied Vestas V100 2.0MW wind turbine generators (150 machines total) to GE 2.3 MW wind turbine generators (66 machines total) and Vestas V100 2.0MW wind turbine generators (74 machines total).

In this restudy the project uses sixty-six (66) GE 2.3MW wind turbine generators and seventy-four (74) Vestas V100 2.0MW wind turbine generators for an aggregate power of 299.8MW. The point of interconnection (POI) for GEN-2013-029 is at the Oklahoma Gas and Electric (OKGE) Renfrow 345 kV Substation.

This study was performed to determine whether the request for modification is considered Material. To determine this, study models that included Interconnection Requests through DISIS-2014-001 were used that analyzed the timeframes of 2015 summer, 2015 winter, and 2025 summer models.

The restudy showed that no stability problems were found during the summer and the winter peak conditions as a result of changing to the GE 2.3MW wind turbine generators and Vestas V100 2.0MW 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. The requested modification is not considered Material.

A low-wind/no-wind condition analysis was performed for this modification request. The project will be required to install approximately 10 Mvar of reactor shunts 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.

Power factor analysis was not performed again for this study. Results from DISIS 2013-002 are still valid and are listed in the Generator Interconnection Agreement for GEN-2013-029.

With the assumptions outlined in this report and with all the required network upgrades from the GEN-201-029 GIA in place, GEN-2013-029 with the GE 2.3MW wind turbine generators and Vestas V100 2.0MW wind turbine generators should be able to interconnect reliably to the SPP transmission grid.

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 transmission service or delivery rights. If the customer wishes to obtain deliverability to final customers, a separate request for transmission service must be requested on Southwest Power Pool's OASIS by the customer.

I. Introduction

GEN-2013-029 Impact Restudy is a generation interconnection study performed to study the impacts of interconnecting the project shown in Table I-1. This restudy is for a change from 150 Vestas V100 2.0MW to 66 GE 2.3MW wind turbines and 74 Vestas V100 2.0MW wind turbines.

Table I-1: Interconnection Request

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2013-029	299.8	GE 2.3MW [sixty-six (66) generators] and Vestas V100 2.0MW [seventy-four (74) generators]	Renfrow 345kV (515543)

The prior-queued, equally-queued and lower queued requests shown in Table I-2 were included in this study and the wind farms were dispatched to 100% of rated capacity.

Table I-2: Prior and Later Queued Interconnection Requests

Request	Capacity (MW)	Generator Model	Point of Interconnection
ASGI-2010-006	150.0	GE 1.5MW	Remington 138kV (301369)
GEN-2002-004	199.5	GE 1.5MW	Lathams 345kV (532800)
GEN-2005-013	199.8	Vestas V90	Caney River 345kV (532780)
GEN-2007-025	299.2	GE 1.6 MW	Viola 345kV (532798)
GEN-2008-013	299.04	GE 1.68 MW	Hunter 345kV (515476)
GEN-2008-098	100.0	Gamesa 2.0 MW	Waverly 345kV (532799)
GEN-2009-025	59.8	Siemens 2.3MW	Nardins 69kV (515528)
GEN-2010-003	100.0	Gamesa 2.0 MW	Waverly 345kV (532799)
GEN-2010-005	299.2	GE 1.6 MW	Viola 345kV (532798)
GEN-2011-057	150.0	Vestas V110 2.0 MW	Creswell 138kV (532981)
GEN-2012-027	150.66	GE 1.62 MW	Shidler 138kV (510403)
GEN-2012-032	298.275	Vestas 3.075 MW	Tap Rose Hill-Sooner 345kV (515621)
GEN-2012-033	98.82	GE 1.62 MW	Breckinridge 138kV (514815)
GEN-2012-040	76.5	GE 1.7 MW	Chilocco 138kV (521198)
GEN-2014-001	200.6	GE 1.7 MW	Tap Wichita-Emporia 345kV (562476)
GEN-2013-029	148.0	Vestas V100 2.0 MW	Renfrow 345kV (515543)
GEN-2013-029	151.8	GE 2.3 MW	Renfrow 345kV (515543)

The study included a stability analysis of the interconnection request. Contingencies that resulted in a prior-queued project tripping off-line, if any, were re-run with the prior-queued project's voltage and frequency tripping relays disabled. Also a low-wind/no-wind analysis was performed on this project since it is a wind farm. The analyses were performed on three seasonal models, the modified versions of the 2015 summer peak, the 2015 winter peak, and the 2025 summer peak cases.

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 three-phase faults and the single line-to-ground faults listed in Table III-1 were used in the stability analysis.

Power factor analysis was not re-run. Results from DISIS 2013-002 are still valid.

The low-wind/no-wind analysis determines the capacitive effect at the POI caused by the project's collector system and transmission line capacitance. A shunt reactor size was determined to offset the capacitive effect and to maintain zero Mvar flow at the POI when the plant generators and capacitors are off-line such as might be seen in low-wind or no-wind conditions.

II. Facilities

A one-line drawing for the GEN-2013-029 generation interconnection request is shown in Figure II-1. The POI is the OKGE Renfrow 345kV substation.

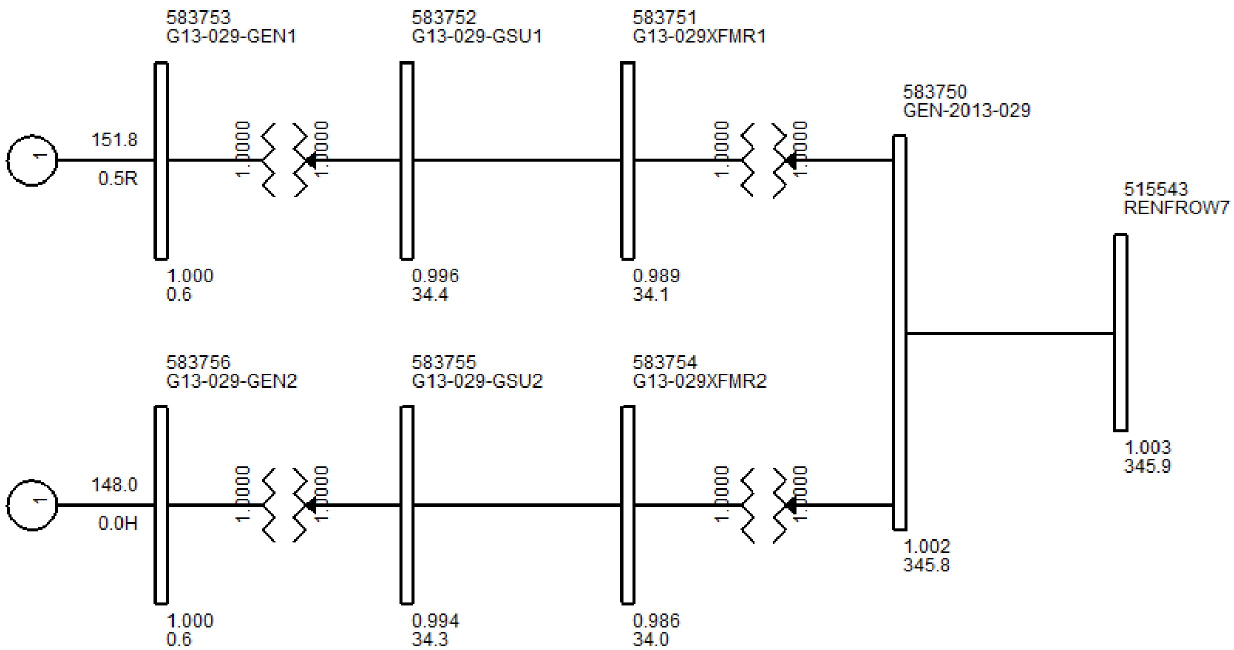

Figure II-1: GEN-2013-029 One-line Diagram

III. 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 2014 series of Model Development Working Group (MDWG) dynamic study models including the 2015 summer peak, the 2015 winter 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-nine (29) contingencies were identified for use in this study and are listed in Table III-1. These contingencies included three-phase faults and single-phase line faults at locations defined by SPP. 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 a 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)

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
1	FLT_01_RENFROW7_VIOLA7_345kV	3 phase fault on the Renfrow (515543) to Viola (532798) 345kV line, at Renfrow. a. Apply fault at the Renfrow 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	FLT_02_RENFROW7_VIOLA7_345kV	Single phase fault on the Renfrow (515543) to Viola (532798) 345kV line, at Renfrow. a. Apply fault at the Renfrow 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.
3	FLT_03_RENFROW7_HUNTERS7_345kV	3 phase fault on the Renfrow (515543) to Hunter (515476) 345kV line, at Renfrow. a. Apply fault at the Renfrow 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	FLT_04_RENFROW7_HUNTERS7_345kV	Single phase fault on the Renfrow (515543) to Hunter (515476) 345kV line, at Renfrow. a. Apply fault at the Renfrow 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.
5	FLT_05_VIOLA7_WICHITA7_345kV	3 phase fault on the Viola (532798) to Wichita (532796) 345kV line, at Viola. a. Apply fault at the the Viola 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	FLT_06_VIOLA7_WICHITA7_345kV	Single phase fault on the Viola (532798) to Wichita (532796) 345kV line, at Viola. a. Apply fault at the Viola 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 III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
7	FLT_07_WICHITA7_THISTLE7_345kV	3 phase fault on the Wichita (532796) to Thistle (539801) 345kV line, at Wichita. a. Apply fault at the Wichita 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.
8	FLT_08_WICHITA7_THISTLE7_345kV	Single phase fault on the Wichita (532796) to Thistle (539801) 345kV line, at Wichita. a. Apply fault at the Wichita 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.
9	FLT_09_WICHITA7_RENO7_345kV	3 phase fault on the Wichita (532796) to Reno (532771) 345kV line, at Wichita. a. Apply fault at the Wichita 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.
10	FLT_10_WICHITA7_RENO7_345kV	Single phase fault on the Wichita (532796) to Reno (532771) 345kV line, at Wichita. a. Apply fault at the Wichita 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	FLT_11_WICHITA7_BENTON7_345kV	3 phase fault on the Wichita (532796) to Benton (532791) 345kV line, at Wichita. a. Apply fault at the Wichita 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	FLT_12_WICHITA7_BENTON7_345kV	Single phase fault on the Wichita (532796) to Benton (532791) 345kV line, at Wichita. a. Apply fault at the Wichita 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 III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
13	FLT_13_G14001TAP_EMPEC7_345kV	3 phase fault on the GEN-2014-001 Tap (562476) to Emporia Energy Center (532768) 345kV line, at GEN-2014-001 Tap. a. Apply fault at the GEN-2014-001 Tap 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.
14	FLT_14_G14001TAP_EMPEC7_345kV	Single phase fault on the GEN-2014-001 Tap (562476) to Emporia Energy Center (532768) 345kV line, at GEN-2014-001 Tap. a. Apply fault at the GEN-2014-001 Tap 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.
15	FLT_15_WOODRNG7_SOONER7_345kV	3 phase fault on the Woodring (514715) to Sooner (514803) 345kV line, at Woodring. a. Apply fault at the Woodring 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	FLT_16_WOODRNG7_SOONER7_345kV	Single phase fault on the Woodring (514715) to Sooner (514803) 345kV line, at Woodring. a. Apply fault at the Woodring 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.
17	FLT_17_SOONER7_CLEVLND7_345kV	3 phase fault on the Sooner (514803) to Cleveland (512694) 345kV line, at Sooner. a. Apply fault at the Sooner 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	FLT_18_SOONER7_CLEVLND7_345kV	Single phase fault on the Sooner (514803) to Cleveland (512694) 345kV line, at Sooner. a. Apply fault at the Sooner 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 III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
19	FLT_19_MATHWSN7_CIMARON7_345kV	3 phase fault on the Mathewson (515497) to Cimarron (514901) 345kV line, at Mathewson. a. Apply fault at the Mathewson 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	FLT_20_MATHWSN7_CIMARON7_345kV	Single phase fault on the Mathewson (515497) to Cimarron (514901) 345kV line, at Mathewson. a. Apply fault at the Mathewson 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	FLT_21_MATHWSN7_NORTWST7_345kV (25SP ONLY)	3 phase fault on the Mathewson (515497) to Northwest (514880) 345kV line, at Mathewson. a. Apply fault at the Mathewson 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.
22	FLT_22_MATHWSN7_NORTWST7_345kV (25SP ONLY)	Single phase fault on the Mathewson (515497) to Northwest (514880) 345kV line, at Mathewson. a. Apply fault at the Mathewson 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.
23	FLT_23_MATHWSN7_TATONGA7_345kV (25SP ONLY)	3 phase fault on the Mathewson (515497) to Tatonga (515407) 345kV line, at Mathewson. a. Apply fault at the Mathewson 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.
24	FLT_24_MATHWSN7_TATONGA7_345kV (25SP ONLY)	Single phase fault on the Mathewson (515497) to Tatonga (515407) 345kV line, at Mathewson. a. Apply fault at the Mathewson 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 III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
25	FLT_25_RENFROW7_HUNTERS7_345kV	**Renfrow Stuck Breaker** a. Apply single phase fault at the Renfrow (515543) 345kV bus on the Renfrow – Hunter (515476) 345kV line. b. Wait 16 cycles, and then drop Renfrow (515543) 345/ (515544) 138/ (515545) 13.8kV transformer ckt 1. c. Trip Renfrow to Hunter 345kV and remove the fault.
26	FLT_26_RENFROW7_RENFROW4_345_138kV	3 phase fault on the Renfrow (515543) 345/ (515544) 138/ (515545) 13.8kV transformer, near the Renfrow 345kV bus. a. Apply fault at the Renfrow 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer
27	FLT_27_VIOLA7_VIOLA4_345_138kV (25SP ONLY)	3 phase fault on the Viola (532798) 345/ (533075) 138/ (532832) 13.8kV transformer, near the Viola 345kV bus. a. Apply fault at the Viola 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer
28	FLT_28_WICHITA7_EVANSN4_345_138kV	3 phase fault on the Wichita (532796) 345/ Evans (533040) 138/ Wichita (532830) 13.8kV transformer, near the Wichita 345kV bus. a. Apply fault at the Wichita 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer
29	FLT_29_WOODRNG7_WOODRNG4_345_138kV	3 phase fault on the Woodring (514715) 345/ (514714) 138/ (515770) 13.8kV transformer, near the Woodring 345kV bus. a. Apply fault at the Woodring 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer
30	FLT_05_VIOLA7_WICHITA7_345kV	**Prior outage of the Hunter (515476) to Woodring (514715) 345kV line**, then 3 phase fault on the Viola (532798) to Wichita (532796) 345kV line near Viola. a. Prior outage Hunter – Woodring 345kV (solve for steady state). b. Apply fault at the Viola 345kV bus on the Viola (532798) to Wichita (532796) 345kV line. 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.
31	FLT_06_VIOLA7_WICHITA7_345kV	**Prior outage of the Hunter (515476) to Woodring (514715) 345kV line**, then single phase fault on the Viola (532798) to Wichita (532796) 345kV line near Viola. a. Prior outage Hunter – Woodring 345kV (solve for steady state). b. Apply fault at the Viola 345kV bus on the Viola (532798) to Wichita (532796) 345kV line. 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.

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
32	FLT_07_WICHITA7_THISTLE7_345kV	**Prior outage of the Wichita (532796) to Thistle (539801) 345kV line ckt2**, then 3 phase fault on the Wichita (532796) to Thistle (539801) 345kV line ckt1, at Wichita. a. Prior outage Wichita – Thistle 345kV ckt1 (solve for steady state). b. Apply fault at the Wichita 345kV bus on the Wichita (532796) to Thistle (539801) 345kV line ckt1. 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.
33	FLT_08_WICHITA7_THISTLE7_345kV	**Prior outage of the Wichita (532796) to Thistle (539801) 345kV line ckt2**, then 3 phase fault on the Wichita (532796) to Thistle (539801) 345kV line ckt1, at Wichita. a. Prior outage Wichita – Thistle 345kV ckt1 (solve for steady state). b. Apply fault at the Wichita 345kV bus on the Wichita (532796) to Thistle (539801) 345kV line ckt1. 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.

Results

The stability analysis was performed and the results are summarized in Table III-2. Based on the stability results and with all network upgrades in service, GEN-2013-029 did not cause any stability problems and remained stable for all faults studied. No generators tripped or went unstable, and voltages recovered to acceptable levels.

Complete sets of plots for the stability analysis are available on request.

Table III-2: Stability Analysis Results

	Contingency Number and Name	2015SP	2015WP	2025SP
1	FLT_01_RENFROW7_VIOLA7_345kV	Stable	Stable	Stable
2	FLT_02_RENFROW7_VIOLA7_345kV	Stable	Stable	Stable
3	FLT_03_RENFROW7_HUNTERS7_345kV	Stable	Stable	Stable
4	FLT_04_RENFROW7_HUNTERS7_345kV	Stable	Stable	Stable
5	FLT_05_VIOLA7_WICHITA7_345kV	Stable	Stable	Stable
6	FLT_06_VIOLA7_WICHITA7_345kV	Stable	Stable	Stable
7	FLT_07_WICHITA7_THISTLE7_345kV	Stable	Stable	Stable
8	FLT_08_WICHITA7_THISTLE7_345kV	Stable	Stable	Stable
9	FLT_09_WICHITA7_RENO7_345kV	Stable	Stable	Stable
10	FLT_10_WICHITA7_RENO7_345kV	Stable	Stable	Stable
11	FLT_11_WICHITA7_BENTON7_345kV	Stable	Stable	Stable
12	FLT_12_WICHITA7_BENTON7_345kV	Stable	Stable	Stable
13	FLT_13_G14001TAP_EMPEC7_345kV	Stable	Stable	Stable
14	FLT_14_G14001TAP_EMPEC7_345kV	Stable	Stable	Stable
15	FLT_15_WOODRNG7_SOONER7_345kV	Stable	Stable	Stable
16	FLT_16_WOODRNG7_SOONER7_345kV	Stable	Stable	Stable
17	FLT_17_SOONER7_CLEVLND7_345kV	Stable	Stable	Stable
18	FLT_18_SOONER7_CLEVLND7_345kV	Stable	Stable	Stable
19	FLT_19_MATHWSN7_CIMARON7_345kV	Stable	Stable	Stable
20	FLT_20_MATHWSN7_CIMARON7_345kV	Stable	Stable	Stable
21	FLT_21_MATHWSN7_NORTWST7_345kV	NA	NA	Stable
22	FLT_22_MATHWSN7_NORTWST7_345kV	NA	NA	Stable
23	FLT_23_MATHWSN7_TATONGA7_345kV	NA	NA	Stable
24	FLT_24_MATHWSN7_TATONGA7_345kV	NA	NA	Stable
25	FLT_25_RENFROW7_HUNTERS7_345kV	Stable	Stable	Stable
26	FLT_26_RENFROW7_RENFROW4_345_138kV	Stable	Stable	Stable
27	FLT_27_VIOLA7_VIOLA4_345_138kV	NA	NA	Stable
28	FLT_28_WICHITA7_EVANSN4_345_138kV	Stable	Stable	Stable
29	FLT_29_WOODRNG7_WOODRNG4_345_138kV	Stable	Stable	Stable
30	FLT_05_VIOLA7_WICHITA7_345kV	Stable	Stable	Stable
31	FLT_06_VIOLA7_WICHITA7_345kV	Stable	Stable	Stable
32	FLT_07_WICHITA7_THISTLE7_345kV	Stable	Stable	Stable
33	FLT_08_WICHITA7_THISTLE7_345kV	Stable	Stable	Stable

NOTE: “- NA -“means the contingency is not applicable

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.

Contingencies 1 and 2 in Table III-2 simulated the LVRT contingencies. GEN-2013-029 met the LVRT requirements by staying on line and the transmission system remaining stable.

IV. Power Factor Analysis

Refer to Appendix P for Group 8 in the original posting of DISIS 2013-002.

V. Reduced Generation Analysis

Interconnection requests for wind generation projects that interconnect on the SPP system are analyzed for the capacitive charging effects during reduced generation conditions (unsuitable wind speeds, curtailment, etc.) at the generation site.

Model Preparation

The project generators and capacitors (if any), and all other wind projects that share the same POI, were turned off in the base case. The resulting reactive power injection into the transmission network comes from the capacitance of the project's transmission lines and collector cables. This reactive power injection is measured at the POI. Shunt reactors were added at the study project substation low voltage bus to bring the Mvar flow into the POI down to approximately zero.

Results

A final shunt reactor requirement for each of the studied interconnection requests is shown in **Table V-1**. One line drawings used in the analysis are shown in **Appendix E: Charging Current Compensation Analysis Results**.

Table V-1: Summary of Shunt Reactor Requirements

Request	Capacity	POI	Approximate Shunt Reactor Required
GEN-2013-029	299.8MW	Renfrow 345kV (515543)	10Mvar

The results shown are for the 2025 summer case. The other two cases (2015 summer and 2015 winter) were almost identical since the generation plant design is the same in all cases.

VI. Short Circuit Analysis

The short circuit analysis was performed on the 2025 Summer Peak power flow case 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. The following pages list the results of the analysis.

Results

The results of the short circuit analysis are shown in **Table D-1** in **Appendix D: Short Circuit Analysis Results.**

VII. Conclusion

The SPP GEN-2013-029 Impact Restudy evaluated the impact of interconnecting the project shown below in Table VII-1.

Table VII-1: Interconnection Request

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2013-029	299.8	GE 2.3MW [sixty-six (66) generators] and Vestas V100 2.0MW [seventy-four (74) generators]	Renfrow 345kV (515543)

With all Base Case Network Upgrades in service, previously assigned Network Upgrades in service, and required capacitor banks in service, the GEN-2013-029 project was found to remain on line, and the transmission system was found to remain stable for all conditions studied. The requested modification is not considered Material.

A low-wind/no-wind condition analysis was performed for this modification request. The project will be required to install a total of approximately 10Mvar of reactor shunts on its substation 34.5kV buses. This is necessary to offset the capacitive effect on the transmission network cause by the project's transmission line and collector system during low-wind or no-wind conditions.

The power factor analysis was not performed again for this study. The power factor requirements for GEN-2013-029 can be found in the original DISIS-2013-002 Impact Study and in its Generator Interconnection Agreement.

Low Voltage Ride Through (LVRT) analysis showed the study generators did not trip offline due to low voltage when all Network Upgrades are in service.

All generators in the monitored areas remained stable for all of the modeled disturbances.

Any changes to the assumptions made in this study, for example, one or more of the previously queued requests withdraw, may require a re-study at the expense of the Customer.

Nothing in this System Impact Study constitutes a request for transmission service or confers upon the Interconnection Customer any right to receive transmission service.

APPENDIX A

PLOTS

Available on request

APPENDIX B

POWER FACTOR ANALYSIS

Power Factor Analysis was not performed again. Initial results from DISIS 2013-002 remain valid.

APPENDIX C

PROJECT MODELS

GEN-2013-029 (GE 2.3MW and Vestas V100 2.0MW)

PSS/E 32 Power Flow Data

```
@! ----------- Bus Data -----------
BAT_SPLT,515543,583750,'GEN-2013-029', 345.00,;
BAT_BUS_DATA_2,583750,1,524,566,, 345.00,,,'GEN-2013-029',;
BAT_BUS_DATA_2,583751,1,524,566,,  34.50,,,'G13-029XFMR1',;
BAT_BUS_DATA_2,583752,1,524,566,,  34.50,,,'G13-029-GSU1',;
BAT_BUS_DATA_2,583753,2,524,566,,  0.575,,,'G13-029-GEN1',;
BAT_BUS_DATA_2,583754,1,524,566,,  34.50,,,'G13-029XFMR2',;
BAT_BUS_DATA_2,583755,1,524,566,,  34.50,,,'G13-029-GSU2',;
BAT_BUS_DATA_2,583756,2,524,566,,  0.575,,,'G13-029-GEN2',;
@!
@! ----------- Generator Data -----------
BAT_PLANT_DATA,583753,     0, 1.000,,;
BAT_PLANT_DATA,583756,     0, 1.000,,;
@! 100%
  BAT_MACHINE_DATA_2,583753,'1',1,,,,,0, 151.80, 0.0, 73.5201, -73.5201, 151.80, 0.00, 157.410, 0.0000, 0.8000,,,,,,,, 1.00,;
  BAT_MACHINE_DATA_2,583756,'1',1,,,,,0, 148.00, 0.0,  0.0000,   0.0000, 148.00, 0.00, 156.000, 0.0050, 0.1991,,,,,,,, 1.00,;
@!  20%
@!BAT_MACHINE_DATA_2,583753,'1',1,,,,,0,  30.36, 0.0, 73.5201, -73.5201, 151.80, 0.00, 157.410, 0.0000, 0.8000,,,,,,,, 1.00,;
@!BAT_MACHINE_DATA_2,583756,'1',1,,,,,0,  29.60, 0.0,  0.0000,   0.0000, 148.00, 0.00, 156.000, 0.0050, 0.1991,,,,,,,, 1.00,;
@!
@! ----------- Unit Transformers -----------
BAT_TWO_WINDING_DATA_3,583750,583751,'1',1,,,,,,33,,,,1,0,1,2,1, 0.00458, 0.10990, 100.00,,,,,, 167.00, 167.00,,,,,,,,,,,,,,,;
BAT_TWO_WINDING_DATA_3,583750,583754,'1',1,,,,,,33,,,,1,0,1,2,1, 0.00458, 0.10990, 100.00,,,,,, 167.00, 167.00,,,,,,,,,,,,,,,;
BAT_TWO_WINDING_DATA_3,583752,583753,'1',1,,,,,, 5,,,,1,0,1,2,1, 0.00597, 0.05970, 165.00,,,,,, 165.00, 165.00,,,,,,,,,,,,,,,;
BAT_TWO_WINDING_DATA_3,583755,583756,'1',1,,,,,, 5,,,,1,0,1,2,1, 0.00916, 0.07444, 155.40,,,,,, 155.40, 155.40,,,,,,,,,,,,,,,;
@!
@! ----------- Collector Cables -----------
BAT_BRANCH_DATA,583751,583752,'1',1,,,,,, 0.00479, 0.00487, 0.03150,,,,,,,,      ,,,,,;
BAT_BRANCH_DATA,583754,583755,'1',1,,,,,, 0.00535, 0.00653, 0.03395,,,,,,,,      ,,,,,;
@!
@! ----------- Add Transmission Line from Substation to POI -----------
BAT_BRANCH_DATA,515543,583750,'1',1,,,,,, 0.00039, 0.00220, 0.03034,,,,,,,,  4.00,,,,,;
@!
@END
```

PSS/E 32 Dynamics Data

```
/ GE 2.3MW (gewt_p32_v600.lib)
/
583753 'USRMDL' 1  'GEWTG2'  1 1 4 18 3 5
       0   66       0       0
        2.3000     0.80000     0.50000     0.90000     1.2200       1.2000
        2.0000     0.40000     0.80000     10.000       0.20000E-01   0.0000
        0.0000     0.50000     0.16700     0.90000     0.92500      0.0000    /
583753 'USRMDL' 1  'GEWTE2'  4 0 12 67 18 9
       583753       0            0             1             0             0
           0        0            0             1             0             0
       0.15000      2.000      1.0000      0.0000      0.0000      0.50000E-01   3.0000
       0.60000      1.1200     0.40000E-01  0.43600     -0.43600     1.1000       0.20000E-01
       0.45000          -0.45000        60.000          0.10000          0.90000
       1.1000          40.000          0.50000         1.4500           0.50000E-01
       0.50000E-01       1.0000          0.15000         0.96000          0.99600
       1.0040           1.0400          1.00000         1.0000           1.00000
       0.40000           1.0000          0.20000         1.0000           0.25000
      -1.0000           14.0000         25.000          3.0000           -0.90000
       8.0000           0.2000          10.000          1.0000           1.7000
       1.22             1.2500          5.0000          0.0000           0.0000
```

```
       0.000              0.25000E-02      1.0000           5.5000            0.10000
      -1.0000             0.10000          0.0000           0.10000           -0.10000
       0.70000            0.12000         -0.12000    /
583753 'USRMDL' 1  'GEWTT1'        5    0    1    5    4    3   0
        3.2174       0.0000       0.0000       1.8800       1.5000    /
 0 'USRMDL'  0 'GEWGC1' 8    0    3    6    0    4
           583753      '1 ' 0
        9999.0       5.0000       30.000       9999.0       9999.0
        30.000    /
 0 'USRMDL'  0 'GEWTA1'       8    0    3    9    1    4
           583753      '1 '   0
        20.000       0.0000       27.000      -4.0000       0.0000       1.2250
        53.500       104.00       1200.0    /
 0 'USRMDL'  0 'GEWTP1'       8    0    3    10    3    3
        583753      '1 '   0
        0.30000     150.00       25.000       3.0000     30.000
       -4.0000       27.000     -10.000      10.000       1.0000    /
 0 'USRMDL'  0 'GEWPLT' 8  0  2  0  0  17        583753       '1 '     /
/ ZVRT
0 'USRMDL'  0  'VTGTPA' 0 2 6 4 0 1  583753 583753 '1'  0 0 0  0.20000 5.0000  1.000 0.08000/
0 'USRMDL'  0  'VTGTPA' 0 2 6 4 0 1  583753 583753 '1'  0 0 0  0.40000 5.0000  1.700 0.08000/
0 'USRMDL'  0  'VTGTPA' 0 2 6 4 0 1  583753 583753 '1'  0 0 0  0.60000 5.0000  2.200 0.08000/
0 'USRMDL'  0  'VTGTPA' 0 2 6 4 0 1  583753 583753 '1'  0 0 0  0.75000 5.0000  3.000 0.08000/
0 'USRMDL'  0  'VTGTPA' 0 2 6 4 0 1  583753 583753 '1'  0 0 0  0.85000 5.0000  10.00 0.08000/
0 'USRMDL'  0  'VTGTPA' 0 2 6 4 0 1  583753 583753 '1'  0 0 0  0.90000 5.0000  600.0 0.08000/
0 'USRMDL'  0  'VTGTPA' 0 2 6 4 0 1  583753 583753 '1'  0 0 0  0.00000 1.1010  1.000 0.08000/
0 'USRMDL'  0  'VTGTPA' 0 2 6 4 0 1  583753 583753 '1'  0 0 0  0.00000 1.1500  0.500 0.08000/
0 'USRMDL'  0  'VTGTPA' 0 2 6 4 0 1  583753 583753 '1'  0 0 0  0.00000 1.1750  0.200 0.08000/
0 'USRMDL'  0  'VTGTPA' 0 2 6 4 0 1  583753 583753 '1'  0 0 0  0.00000 1.2000  0.100 0.08000/
0 'USRMDL'  0  'VTGTPA' 0 2 6 4 0 1  583753 583753 '1'  0 0 0  0.00000 1.3000  0.010 0.08000/
/
/
/ Vestas V100 VCSS 2.00MW (VestasWT_7_6_0_PSSE32.lib)
/
583756 'USRMDL' '1'  'VWCOR6' 1 1 2 45 23 104 1 0
 2000.0000 690.0000 1514.6603 700.0000 1.5625 0.9676 0.0232
 1.9807 8.3333 1.9807 8.3333 30.0000 0.2000 1.2000
 0.1000 0.0012 0.9925 0.0474 1.6118 0.0000 351.8584
 313.4245 0.0300 0.0000 0.0300 0.3000 0.0000 1.0000
 0.3183 4.9736 2812227.1900 43.2960 90.0120 600000.0000 3.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000/
0 'USRMDL' 0 'VWVAR6' 8 0 2 0 0 30 583756 '1'  /
0 'USRMDL' 0 'VWLVR6' 8 0 3 65 10 35 583756 '1' 1
 0.9000 0.0010 0.2000 44.4555 11.1114 44.4555 44.4555
 0.5000 1.0000 1.5625 0.9676 1.2000 0.5000 690.0000
1514.6603 0.3500 0.0500 0.2500 0.0200 3.0000 4.0000
 9999.0000 0.0232 0.9000 0.9000 0.0500 0.0000 0.0100
 0.0000 2.0000 0.0000 1.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 /
0 'USRMDL' 0 'VWPWR6' 8 0 3 30 7 10 583756 '1' 0
 1.0000 0.5000 -0.5000 0.6988 0.8844 0.9800 0.9600
 0.2000 0.2000 1.3000 0.0500 0.5000 0.5000 0.1000
 0.1000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 /
0 'USRMDL' 0 'VWMEC6' 8 0 2 10 8 0 583756 '1'
```

```
 2000.0000 351.8584 5684.1051 569.9822 106.4850 7976.7600 50.7400
 0.0000 0.0000 0.0000 /
0 'USRMDL' 0 'VWMEA6' 8 0 2 10 8 5 583756 '1'
 0.1000 0.1000 0.1000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000/
0 'USRMDL' 0 'VWVPR6' 0 2 7 30 0 18 583756 '1'  1 1 0 0 0
 0.8500 11.0000 0.8500 11.0000 0.9000 60.0000 1.1000
 60.0000 1.1500 2.0000 1.2000 0.0800 1.2500 0.0050
 1.2500 0.0050 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.1500 0.8000 2.7000 0.8500 3.5000
 0.9000 5.0000 /
0 'USRMDL' 0 'VWFPR6' 0 2 3 12 0 7 583756 '1'  0
 56.4000 0.2000 56.4000 0.2000 56.4000 0.2000 63.6000
 0.2000 63.6000 0.2000 63.6000 0.2000 /
/
```

APPENDIX D

SHORT CIRCUIT ANALYSIS

Table D-1: Short Circuit Currents at GEN-2013-029 POI (Renfrow 515543) and five levels away

```
                    PSS®E ASCC SHORT CIRCUIT CURRENTS        WED, FEB 25 2015  11:06
2014 MDWG PASS 8   WITH 2013 MMWG
MDWG 2025S WITH MMWG 2024S

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+)
515543 [RENFROW7    345.00] AMP    12023.7   -84.71
515476 [HUNTERS7    345.00] AMP    12131.2   -84.67
515544 [RENFROW4    138.00] AMP    13456.7   -84.70
515545 [RENFRO11    13.800] AMP    48196.2   -87.17
532798 [VIOLA   7   345.00] AMP    13236.9   -85.42
583750 [GEN-2013-029345.00] AMP    10667.5   -84.23
514715 [WOODRNG7    345.00] AMP    16292.6   -84.75
515477 [CHSHLMV7    345.00] AMP    12115.1   -84.67
515546 [GRANTCO4    138.00] AMP     6660.2   -81.26
515569 [MDFRDTP4    138.00] AMP    11176.6   -83.34
520409 [SAND RDG_138138.00] AMP     9908.2   -82.97
532792 [FR2EAST7    345.00] AMP     6337.1   -85.79
532796 [WICHITA7    345.00] AMP    23709.3   -86.28
532832 [VIOLA1X1    13.800] AMP    55949.6   -85.77
533075 [VIOLA  4    138.00] AMP    20427.1   -85.84
583751 [G13-029XFMR134.500] AMP    23183.2   -86.68
583754 [G13-029XFMR234.500] AMP    22385.2   -86.46
514714 [WOODRNG4    138.00] AMP    17101.9   -83.08
514803 [SOONER 7    345.00] AMP    21956.5   -86.50
515479 [CHSHMVE1    34.500] AMP    17507.8   -88.59
515482 [CHSHMVET    13.200] AMP    37712.1   -88.82
515484 [CHSHMVW1    34.500] AMP    17730.6   -88.57
515485 [CHSHMVWT    13.200] AMP    37647.5   -88.82
515497 [MATHWSN7    345.00] AMP    28752.6   -86.11
515547 [GRANTCO2    69.000] AMP     7465.3   -80.45
515548 [GRANTC11    13.800] AMP     7902.1   -84.70
515581 [COYOTE 4    138.00] AMP     7771.1   -80.03
515770 [WOODRNG1    13.800] AMP    24068.2   -89.24
520205 [WAKITA_138  138.00] AMP     5476.1   -79.80
532771 [RENO   7    345.00] AMP    12116.8   -86.28
532791 [BENTON 7    345.00] AMP    18697.2   -85.76
532795 [FR2WEST7    345.00] AMP     5109.3   -85.82
532829 [WICH11 1    13.800] AMP    50309.8   -87.27
532830 [WICH12 1    13.800] AMP    50487.2   -87.65
532984 [SUMNER 4    138.00] AMP     9855.9   -82.76
533036 [CLEARWT4    138.00] AMP    16966.1   -84.85
533040 [EVANS N4    138.00] AMP    40975.0   -87.19
533046 [GILL S 4    138.00] AMP    26939.9   -85.12
533127 [F2EAST11    13.800] AMP    58493.7   -85.48
533128 [F2EAST21    13.800] AMP    58502.7   -85.50
533131 [FR2ELV11    34.500] AMP    14226.9   -88.38
533132 [FR2ELV21    34.500] AMP    14176.0   -88.37
```

539801 [THISTLE7 345.00] AMP 15374.3 -85.82
562476 [G14-001-TAP 345.00] AMP 10499.4 -85.19
583752 [G13-029-GSU134.500] AMP 22973.3 -86.26
583755 [G13-029-GSU234.500] AMP 22060.0 -85.88
512694 [CLEVLND7 345.00] AMP 14393.1 -86.33
514708 [OTTER 4 138.00] AMP 8328.9 -81.63
514709 [FRMNTAP4 138.00] AMP 15882.0 -82.70
514711 [WAUKOTP4 138.00] AMP 14160.2 -81.40
514719 [CLYDE 2 69.000] AMP 4562.1 -73.45
514733 [MARSHL 4 138.00] AMP 7623.1 -80.54
514739 [MEDFORD2 69.000] AMP 5413.1 -76.45
514757 [CHIKASI4 138.00] AMP 8747.9 -78.96
514802 [SOONER 4 138.00] AMP 30892.1 -86.84
514806 [SOONER2G 20.000] AMP 198447.9 -88.64
514880 [NORTWST7 345.00] AMP 29365.5 -86.11
514881 [SPRNGCK7 345.00] AMP 21286.6 -85.58
514901 [CIMARON7 345.00] AMP 29863.5 -85.93
515375 [WWRDEHV7 345.00] AMP 19852.5 -86.07
515407 [TATONGA7 345.00] AMP 16146.6 -86.58
515486 [CHSHMVE1-GSU34.500] AMP 15816.1 -85.63
515487 [CHSHMVW1-GSU34.500] AMP 15985.8 -85.56
515576 [RANCHRD7 345.00] AMP 12149.5 -86.70
515760 [SOONER 1 13.800] AMP 43000.9 -87.60
520204 [SANDY_CN_138138.00] AMP 5393.5 -79.79
520206 [WAKITA_13.8 13.800] AMP 9085.1 -86.62
521085 [WAKITA 2 69.000] AMP 5187.0 -80.79
532721 [EEC U1 16.000] AMP 77921.9 -88.56
532722 [EEC U2 24.000] AMP 113349.3 -88.66
532729 [EVAN SVC 8.0000] AMP 140024.9 -88.33
532739 [GILL SVC 8.0000] AMP 93718.5 -87.89
532768 [EMPEC 7 345.00] AMP 16755.2 -86.15
532773 [SUMMIT 7 345.00] AMP 10961.9 -86.10
532794 [ROSEHIL7 345.00] AMP 18021.8 -85.80
532797 [WOLFCRK7 345.00] AMP 15925.5 -86.83
532807 [RENO 1X1 14.400] AMP 45040.7 -87.92
532810 [RENO 2X1 14.400] AMP 44831.9 -87.96
532821 [BENTN1 1 13.800] AMP 23669.9 -88.67
532822 [BENTN2 1 13.800] AMP 45029.5 -87.32
532982 [OXFORD 4 138.00] AMP 8984.7 -82.84
532986 [BENTON 4 138.00] AMP 27867.8 -85.80
532992 [TIMBJCT4 138.00] AMP 5600.2 -83.23
533029 [59TH ST4 138.00] AMP 18502.1 -83.61
533041 [EVANS S4 138.00] AMP 40975.0 -87.19
533045 [GILL W 4 138.00] AMP 26939.9 -85.12
533063 [SC10BEL4 138.00] AMP 9535.3 -81.61
533065 [SG12COL4 138.00] AMP 22485.0 -85.63
533106 [GILL S 1 13.200] AMP 17364.6 -89.57
533107 [GILL S 2 13.200] AMP 17364.6 -89.57
533129 [F2WEST11 13.800] AMP 53656.4 -85.53
533130 [F2WEST21 13.800] AMP 53415.9 -85.56
533133 [FR2WLV11 34.500] AMP 13754.1 -88.30
533134 [FR2WLV21 34.500] AMP 13733.1 -88.28
533135 [ECLCT1 1 34.500] AMP 12482.5 -87.16
533136 [ECLCT2 1 34.500] AMP 12405.8 -87.06
533390 [MAIZEW 4 138.00] AMP 27458.5 -85.43
533416 [RENO 3 115.00] AMP 29649.6 -86.45
533795 [GILL E 2 69.000] AMP 33175.6 -85.25
533796 [GILL W 2 69.000] AMP 33175.6 -85.25
539675 [MILANTP4 138.00] AMP 6529.5 -74.97
539800 [CLARKCOUNTY7345.00] AMP 12375.8 -85.60
539802 [THISTLE T1 13.800] AMP 8108.3 -88.41

539804 [THISTLE4 138.00] AMP 16241.1 -86.30
581005 [GEN-2011-007345.00] AMP 9373.3 -83.99
583850 [GEN-2014-001345.00] AMP 7831.7 -85.01
300138 [4CLEVLND 138.00] AMP 16394.4 -85.55
509852 [T.NO.--7 345.00] AMP 23086.1 -86.29
512817 [CLEVLND1 13.800] AMP 12903.8 -89.62
514703 [FAIRMNT4 138.00] AMP 10307.1 -83.37
514704 [MILLERT4 138.00] AMP 20062.8 -85.65
514707 [PERRY 4 138.00] AMP 10642.4 -83.29
514710 [WAUKOMI4 138.00] AMP 9215.0 -80.29
514713 [WRVALLY4 138.00] AMP 8257.5 -82.01
514731 [SO4TH 4 138.00] AMP 13774.7 -80.68
514736 [4CORNER2 69.000] AMP 4063.7 -69.66
514740 [NUMAOGE2 69.000] AMP 4553.9 -73.73
514756 [CHIKASI2 69.000] AMP 10046.4 -78.97
514760 [KILDARE4 138.00] AMP 10531.6 -79.46
514798 [SNRPMPT4 138.00] AMP 20111.5 -85.63
514801 [MINCO 7 345.00] AMP 15489.7 -85.04
514805 [SOONER1G 22.000] AMP 173591.2 -88.34
514827 [CTNWOOD4 138.00] AMP 16119.5 -80.59
514879 [NORTWST4 138.00] AMP 41463.3 -85.98
514882 [SPGCK1&2 13.800] AMP 111032.1 -89.52
514883 [SPGCK3&4 13.800] AMP 75449.1 -89.31
514885 [NORTWS41 13.800] AMP 49765.4 -88.35
514898 [CIMARON4 138.00] AMP 40405.2 -85.08
514908 [ARCADIA7 345.00] AMP 24941.4 -86.52
514934 [DRAPER 7 345.00] AMP 20923.4 -85.32
515376 [WWRDEHV4 138.00] AMP 25265.7 -85.29
515447 [MORISNT4 138.00] AMP 13201.0 -83.11
515448 [CRSRDSW7 345.00] AMP 11447.8 -85.65
515458 [BORDER 7345.00] AMP 4918.5 -86.17
515610 [FSHRTAP7 345.00] AMP 15885.1 -85.10
515621 [OPENSKY7 345.00] AMP 11118.3 -86.70
515713 [CHIKASI1 13.200] AMP 15628.6 -82.84
515714 [CIMARO11 13.800] AMP 37412.8 -88.57
515715 [CIMARO21 13.800] AMP 52100.5 -87.61
515742 [NORTWS21 13.800] AMP 47915.6 -87.27
515743 [NORTWS31 13.800] AMP 49765.4 -88.35
515795 [WWDEHV31 13.800] AMP 60651.2 -87.74
515799 [WWDEHV21 13.800] AMP 60308.2 -87.68
520203 [BYRON_138 138.00] AMP 4156.9 -79.44
520938 [HAZLTNJ2 69.000] AMP 2711.0 -56.42
521006 [MARSHAL4 138.00] AMP 7588.3 -80.49
521008 [NASH 2 69.000] AMP 2649.3 -74.83
531469 [SPERVIL7 345.00] AMP 14201.4 -85.79
532723 [EEC GT1 13.800] AMP 50256.3 -89.24
532724 [EEC GT2 13.800] AMP 50292.5 -89.24
532725 [EEC GT3 18.000] AMP 67629.1 -89.37
532733 [GEC U3 14.400] AMP 87798.5 -88.12
532734 [GEC U4 14.400] AMP 70864.6 -88.76
532740 [EMPEC121 13.800] AMP 60855.3 -89.87
532741 [EMPEC341 13.800] AMP 60855.3 -89.87
532742 [EMPEC5 1 18.000] AMP 85182.0 -89.65
532743 [EMPEC6 1 18.000] AMP 85182.0 -89.65
532744 [EMPEC7 1 18.000] AMP 85182.0 -89.65
532751 [WCGS U1 25.000] AMP 207404.7 -88.00
532767 [GEARY 7 345.00] AMP 9811.8 -86.35
532769 [LANG 7 345.00] AMP 16557.5 -86.14
532770 [MORRIS 7 345.00] AMP 12511.9 -85.51
532774 [SWISVAL7 345.00] AMP 16057.1 -85.34
532799 [WAVERLY7 345.00] AMP 14732.5 -86.54

532800 [LATHAMS7 345.00] AMP 10312.0 -85.57
532813 [SUMMIT 1 14.400] AMP 30613.3 -87.12
532826 [ROSEH1 1 13.800] AMP 39125.8 -88.54
532827 [ROSEH5 1 13.800] AMP 38888.5 -88.54
532831 [ROSEH3 1 13.800] AMP 39062.5 -88.54
532873 [SUMMIT 6 230.00] AMP 13581.6 -85.51
532981 [CRESWLN4 138.00] AMP 7999.1 -81.95
532985 [TCROCK 4 138.00] AMP 5242.6 -83.23
532988 [BELAIRE4 138.00] AMP 18536.9 -84.71
532990 [MIDIAN 4 138.00] AMP 10141.1 -80.55
533015 [BENTLEY4 138.00] AMP 12244.0 -84.35
533024 [29TH 4 138.00] AMP 19297.8 -85.03
533035 [CHISHLM4 138.00] AMP 22197.1 -84.73
533039 [ELPASO 4 138.00] AMP 24853.3 -84.14
533042 [FARBER 4 138.00] AMP 15915.0 -83.72
533044 [GILL E 4 138.00] AMP 26939.9 -85.12
533053 [LAKERDG4 138.00] AMP 18932.5 -85.54
533054 [MAIZE 4 138.00] AMP 23121.5 -85.10
533062 [ROSEHIL4 138.00] AMP 30715.6 -86.07
533072 [WACO 4 138.00] AMP 22667.8 -85.04
533074 [45TH ST4 138.00] AMP 27837.3 -85.59
533120 [TIMBJCT1 13.200] AMP 11725.6 -86.23
533137 [WCLCT1 1 34.500] AMP 12255.0 -87.27
533138 [WCLCT2 1 34.500] AMP 12232.9 -87.08
533413 [CIRCLE 3 115.00] AMP 29231.0 -86.58
533415 [DAVIS 3 115.00] AMP 9142.7 -82.80
533429 [MOUNDRG3 115.00] AMP 9739.7 -83.21
533438 [WMCPHER3 115.00] AMP 15899.8 -85.75
533558 [TIMBJCT2 69.000] AMP 7992.3 -83.96
533653 [WOLFCRK2 69.000] AMP 5904.6 -87.21
533798 [GILLJCT2 69.000] AMP 21730.4 -81.91
533804 [HAYSVLJ2 69.000] AMP 14182.7 -78.18
533812 [LIN 2 69.000] AMP 9680.1 -83.50
533813 [MACARTH2 69.000] AMP 22461.0 -80.87
533830 [PECK 2 69.000] AMP 6506.0 -83.84
533850 [BASICCH2 69.000] AMP 20273.8 -84.26
539638 [FLATRDG3 138.00] AMP 14611.3 -85.28
539668 [HARPER 4 138.00] AMP 5541.6 -78.95
539676 [MILAN 4 138.00] AMP 3501.6 -70.44
539803 [IRONWOOD7 345.00] AMP 13733.3 -85.75
539805 [ELMCREEK7 345.00] AMP 5716.3 -85.76
560000 [G11-14-TAP 345.00] AMP 13229.9 -86.31
562075 [G11-051-TAP 345.00] AMP 16546.9 -86.42
579253 [G07-21&14-02345.00] AMP 13402.5 -86.35
579268 [G07-44&14-03345.00] AMP 9053.1 -85.26
579351 [GEN-2007-062345.00] AMP 8514.1 -86.01
581006 [G11-007XFMR134.500] AMP 20877.2 -87.40
581007 [G11-007XFMR234.500] AMP 19744.4 -87.30
582008 [GEN-2011-008345.00] AMP 9955.0 -75.05
582019 [GEN-2011-019345.00] AMP 19852.5 -86.07
582020 [GEN-2011-020345.00] AMP 19852.5 -86.07
583370 [GEN-2012-024345.00] AMP 9849.8 -83.01
583490 [GEN-2012-041345.00] AMP 10830.1 -86.56
583851 [G14-001XFMR134.500] AMP 13383.3 -87.74
583854 [G14-001XFMR234.500] AMP 13393.9 -87.75

APPENDIX E

CHARGING CURRENT COMPENSATION ANALYSIS

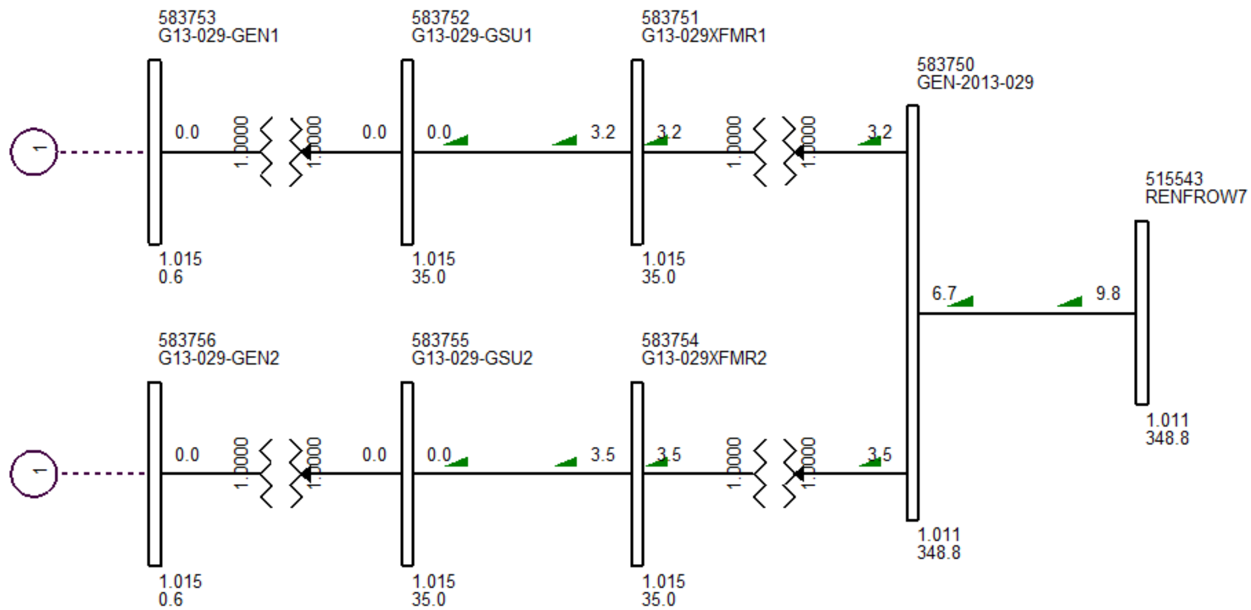

Figure E-1: GEN-2013-029 with generators off and no shunt reactors

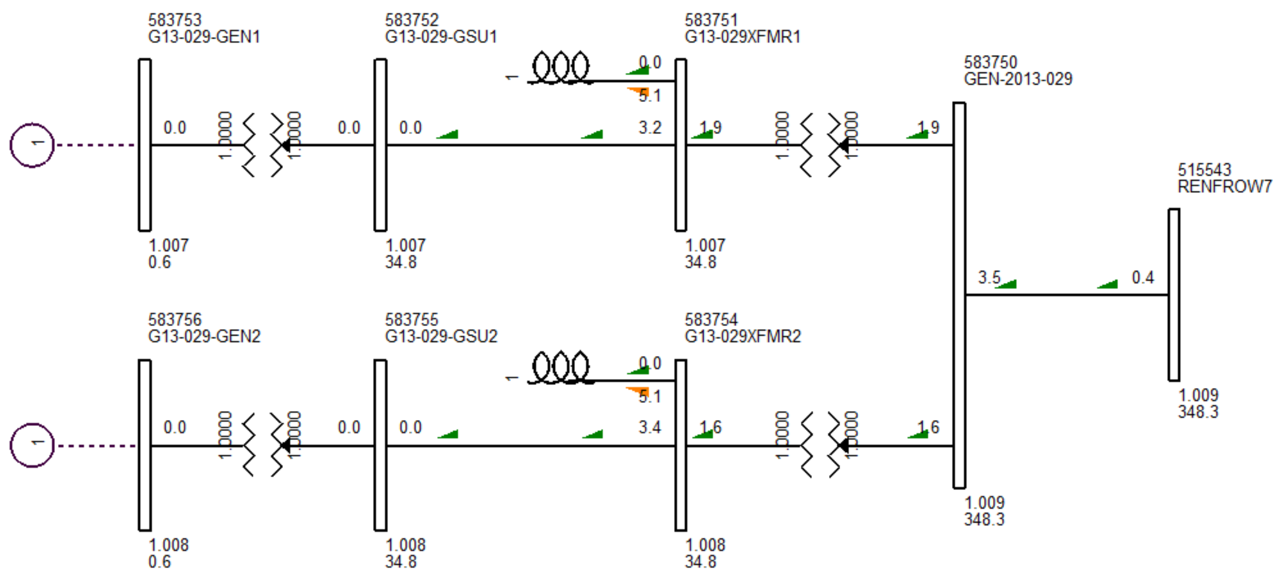

Figure E-2: GEN-2013-029 with generator turned off and shunt reactor added to the low side of the substation 345/34.5kV transformer