GEN-2011-057
Impact Restudy for Generator Modification (Turbine Change)

February 2015
Generator Interconnection

Southwest Power Pool

Executive Summary

The GEN-2011-057 interconnection customer has requested a system impact restudy to determine the effects of changing wind turbine generators from the previously studied GE 1.6 MW (94 generators total) to Vestas V110 2.0MW wind turbine generators (75 machines total).

In this restudy the project uses seventy-five (75) Vestas V110 2.0MW wind turbine generators for an aggregate power of 150.0MW. The point of interconnection (POI) for GEN-2011-057 is at the Westar (WERE) Creswell 138 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 Vestas V110 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.

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 2011-002 are still valid and are listed in the Generator Interconnection Agreement for GEN-2011-057.

With the assumptions outlined in this report and with all the required network upgrades from the GEN-2011-057 GIA in place, GEN-2011-057 with the Vestas V110 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-2011-057 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 GE 1.6MW to Vestas V110 2.0MW wind turbines.

Table I-1: Interconnection Request

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2011-057	150	Vestas V110 2.0MW [seventy-five (75) generators]	Creswell 138kV (532981)

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-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-2013-029	300.0	Vestas V100	Renfrow 345kV (515543)
GEN-2014-001	200.6	GE 1.7 MW	Tap Wichita-Emporia 345kV (562476)
GEN-2011-057	150.0	Vestas V110	Creswell 138kV (532981)

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 2011-002 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-2011-057 generation interconnection request is shown in Figure II-1. The POI is the WERE Creswell 138kV substation.

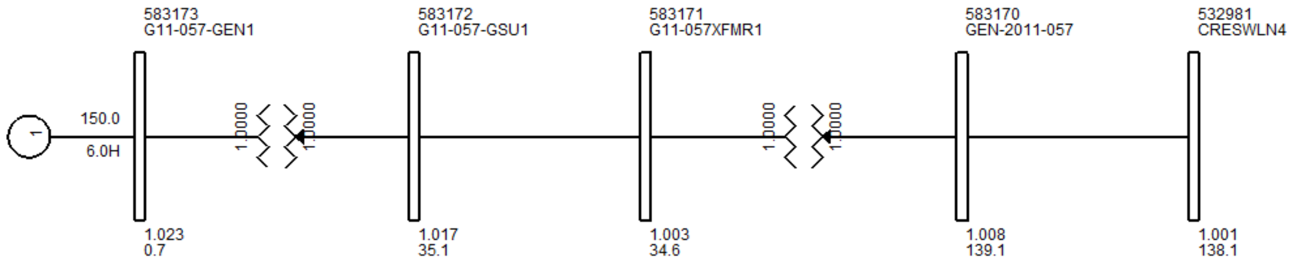

Figure II-1: GEN-2011-057 One-line Diagram

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_CRESWLN4_MIDLTNT4_138kV	3 phase fault on the Creswell (532981) to Middleton Tap (514804) 138kV line, at Creswell. a. Apply fault at the Creswell 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_CRESWLN4_MIDLTNT4_138kV	Single phase fault on the Creswell (532981) to Middleton Tap (514804) 138kV line, at Creswell. a. Apply fault at the Creswell 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_CRESWLN4_OXFORD4_138kV	3 phase fault on the Creswell (532981) to Oxford (532982) 138kV line, at Creswell. a. Apply fault at the Creswell 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_CRESWLN4_OXFORD4_138kV	Single phase fault on the Creswell (532981) to Oxford (532982) 138kV line, at Creswell. a. Apply fault at the Creswell 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_PECKHMT4_NEWKIRK4_138kV	3 phase fault on the Peckham Tap (515381) to Newkirk (514759) 138kV line, at Peckham Tap. a. Apply fault at the Peckham 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.
6	FLT_06_PECKHMT4_NEWKIRK4_138kV	Single phase fault on the Peckham Tap (515381) to Newkirk (514759) 138kV line, at Peckham Tap. a. Apply fault at the Peckham 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 III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
7	FLT_07_NEWKIRK4_NWKRKAT4_138kV	3 phase fault on the Newkirk (514759) to Newkirk Tap (514764) 138kV line, at Newkirk. a. Apply fault at the Newkirk 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_NEWKIRK4_NWKRKAT4_138kV	Single phase fault on the Newkirk (514759) to Newkirk Tap (514764) 138kV line, at Newkirk. a. Apply fault at the Newkirk 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_KILDARE4_CHIKASI4_138kV	3 phase fault on the Kildare (514760) to Chikaskia (514757) 138kV line, at Kildare. a. Apply fault at the Kildare 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.
10	FLT_10_KILDARE4_CHIKASI4_138kV	Single phase fault on the Kildare (514760) to Chikaskia (514757) 138kV line, at Kildare. a. Apply fault at the Kildare 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_OXFORD4_SUMNER4_138kV	3 phase fault on the Oxford (532982) to Sumner (532984) 138kV line, at Oxford. a. Apply fault at the Oxford 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_OXFORD4_SUMNER4_138kV	Single phase fault on the Oxford (532982) to Sumner (532984) 138kV line, at Oxford. a. Apply fault at the Oxford 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 III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
13	FLT_13_SUMNER4_TIMBJCT4_138kV	3 phase fault on the Sumner (532984) to Timber Junction (532992) 138kV line, at Sumner. a. Apply fault at the Sumner 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_SUMNER4_TIMBJCT4_138kV	Single phase fault on the Sumner (532984) to Timber Junction (532992) 138kV line, at Sumner. a. Apply fault at the Sumner 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_SUMNER4_SC10BEL4_138kV	3 phase fault on the Sumner (532984) to Belle Plaine (533063) 138kV line, at Sumner. a. Apply fault at the Sumner 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_SUMNER4_SC10BEL4_138kV	Single phase fault on the Sumner (532984) to Belle Plaine (533063) 138kV line, at Sumner. a. Apply fault at the Sumner 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_FARBER4_ELPASO4_138kV	3 phase fault on the Farber (533042) to El Paso (533039) 138kV line, at Farber. a. Apply fault at the Farber 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.
18	FLT_18_FARBER4_ELPASO4_138kV	Single phase fault on the Farber (533042) to El Paso (533039) 138kV line, at Farber. a. Apply fault at the Farber 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 III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
19	FLT_19_KILDARE4_WHEAGLE4_138kV	3 phase fault on the Kildare (514760) to White Eagle (532797) 138kV line, at Kildare. a. Apply fault at the Kildare 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.
20	FLT_20_KILDARE4_WHEAGLE4_138kV	Single phase fault on the Kildare (514760) to White Eagle (532797) 138kV line, at Kildare. a. Apply fault at the Kildare 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.
21	FLT_21_CRESWLN2_OAK2_69kV	3 phase fault on the Creswell (533543) to Oak (533547) 69kV line, at Creswell. a. Apply fault at the Creswell 69kV 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_CRESWLN2_OAK2_69kV	Single phase fault on the Creswell (533543) to Oak (533547) 69kV line, at Creswell. a. Apply fault at the Creswell 69kV 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_CRESWLN2_PARIS2_69kV	3 phase fault on the Creswell (533543) to Paris (533548) 69kV line, at Creswell. a. Apply fault at the Creswell 69kV 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_CRESWLN2_PARIS2_69kV	Single phase fault on the Creswell (533543) to Paris (533548) 69kV line, at Creswell. a. Apply fault at the Creswell 69kV 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_CRESWLN2_SC4ROME2_69kV	3 phase fault on the Creswell (533543) to Rome (533553) 69kV line, at Creswell. a. Apply fault at the Creswell 69kV bus. b. Clear fault after 5 cycles by tripping the faulted line c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
26	FLT_26_CRESWLN2_SC4ROME2_69kV	Single phase fault on the Creswell (533543) to Rome (533553) 69kV line, at Creswell. a. Apply fault at the Creswell 69kV 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.
27	FLT_27_TIMBJCT4_TIMBJCT2_138_69kV	3 phase fault on the Timber Junction (532992) 138/ (533558) 69/ (533120) 13.2kV transformer, near the Timber Junction 138kV bus. a. Apply fault at the Timber Junction 138kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer
28	FLT_28_CRESWLN4_CRESWLN2_138_69kV	3 phase fault on the Creswell (532981) 138/ (533543) 69/ (533080) 13.2kV transformer, near the Creswell 138kV bus. a. Apply fault at the Creswell 138kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer
29	FLT_29_CHIKASI4_CHIKASI2_138_69kV	3 phase fault on the Chikaskia (514757) 138/ (514756) 69/ (515713) 13.2kV transformer, near the Chikaskia 138kV bus. a. Apply fault at the Chikaskia 138kV 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 III-2. Based on the stability results and with all network upgrades in service, GEN-2011-057 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_CRESWLN4_MIDLTNT4_138kV	Stable	Stable	Stable
2	FLT_02_CRESWLN4_MIDLTNT4_138kV	Stable	Stable	Stable
3	FLT_03_CRESWLN4_OXFORD4_138kV	Stable	Stable	Stable
4	FLT_04_CRESWLN4_OXFORD4_138kV	Stable	Stable	Stable
5	FLT_05_PECKHMT4_NEWKIRK4_138kV	Stable	Stable	Stable
6	FLT_06_PECKHMT4_NEWKIRK4_138kV	Stable	Stable	Stable
7	FLT_07_NEWKIRK4_NWKRKAT4_138kV	Stable	Stable	Stable
8	FLT_08_NEWKIRK4_NWKRKAT4_138kV	Stable	Stable	Stable
9	FLT_09_KILDARE4_CHIKASI4_138kV	Stable	Stable	Stable
10	FLT_10_KILDARE4_CHIKASI4_138kV	Stable	Stable	Stable
11	FLT_11_OXFORD4_SUMNER4_138kV	Stable	Stable	Stable
12	FLT_12_OXFORD4_SUMNER4_138kV	Stable	Stable	Stable
13	FLT_13_SUMNER4_TIMBJCT4_138kV	Stable	Stable	Stable
14	FLT_14_SUMNER4_TIMBJCT4_138kV	Stable	Stable	Stable
15	FLT_15_SUMNER4_SC10BEL4_138kV	Stable	Stable	Stable
16	FLT_16_SUMNER4_SC10BEL4_138kV	Stable	Stable	Stable
17	FLT_17_FARBER4_ELPASO4_138kV	Stable	Stable	Stable
18	FLT_18_FARBER4_ELPASO4_138kV	Stable	Stable	Stable
19	FLT_19_KILDARE4_WHEAGLE4_138kV	Stable	Stable	Stable
20	FLT_20_KILDARE4_WHEAGLE4_138kV	Stable	Stable	Stable
21	FLT_21_CRESWLN2_OAK2_69kV	Stable	Stable	Stable
22	FLT_22_CRESWLN2_OAK2_69kV	Stable	Stable	Stable
23	FLT_23_CRESWLN2_PARIS2_69kV	Stable	Stable	Stable
24	FLT_24_CRESWLN2_PARIS2_69kV	Stable	Stable	Stable
25	FLT_25_CRESWLN2_SC4ROME2_69kV	Stable	Stable	Stable
26	FLT_26_CRESWLN2_SC4ROME2_69kV	Stable	Stable	Stable
27	FLT_27_TIMBJCT4_TIMBJCT2_138_69kV	Stable	Stable	Stable
28	FLT_28_CRESWLN4_CRESWLN2_138_69kV	Stable	Stable	Stable
29	FLT_29_CHIKASI4_CHIKASI2_138_69kV	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-2011-057 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 2011-002.

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-2011-057	150.0MW	Creswell 138kV (532981)	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-2011-057 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-2011-057	150	Vestas V110 2.0MW [seventy-five (75) generators]	Creswell 138kV (532981)

With all Base Case Network Upgrades in service, previously assigned Network Upgrades in service, and required capacitor banks in service, the GEN-2011-057 project was found to remain on line, and the transmission system was found to remain stable for all conditions studied.

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-2011-057 can be found in the original DISIS-2011-002 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 2011-002 remain valid.

APPENDIX C

PROJECT MODELS

GEN-2011-057 (Vestas V110 2.0MW)

PSS/E 32 Power Flow Data

```
@! ----------- Bus Data -----------
BAT_SPLT,532981,583170,'GEN-2011-057', 138.00,;
BAT_BUS_DATA_2,583170,1,536,1537,,138.00,,,'GEN-2011-057',;
BAT_BUS_DATA_2,583171,1,536,1537,, 34.50,,,'G11-057XFMR1',;
BAT_BUS_DATA_2,583172,1,536,1537,, 34.50,,,'G11-057-GSU1',;
BAT_BUS_DATA_2,583173,2,536,1537,,  0.69,,,'G11-057-GEN1',;
@!
@! ----------- Generator Data -----------
BAT_PLANT_DATA,583173,      0, 1.03,,;
@!100%
  BAT_MACHINE_DATA_2,583173,'1',1,,,,,0, 150.0,6.00, 6.00, 6.00, 150.0,  0.00, 150.0, 0.00500, 0.1991,,,,,,,, 1.00,;
@! 20%
@!BAT_MACHINE_DATA_2,583173,'1',1,,,,,0, 30.0,0.60, 0.60, 0.60, 150.0,  0.00, 150.0, 0.00500, 0.1991,,,,,,,, 1.00,;
@!
@! ----------- Transformer Data -----------
BAT_TWO_WINDING_DATA_3,583170,583171,'1',1,,,,,, 5,,,,1,0,1,2,1, 0.00250, 0.09997,  96.00,,,,,, 160.00, 160.00, 160.00,,,,,,,,,,,,,,;
BAT_TWO_WINDING_DATA_3,583172,583173,'1',1,,,,,, 5,,,,1,0,1,2,1, 0.0063, 0.07580, 157.50,,,,,, 157.50, 157.50, 157.50,,,,,,,,,,,,,,;
@!
@! ----------- Collector Cable Data-----------
BAT_BRANCH_DATA,583171,583172,'1',1,,,,,, 0.009706, 0.01181, 0.092495,,,,,,,,      ,,,,,;
@!
@! ----------- Transmission Line Data -----------
BAT_BRANCH_DATA,532981,583170,'1',1,,,,,, 0.00883, 0.02581, 0.00924,,,,,,,, 7.48,,,,,;
@!
@END
```

PSS/E 32 Dynamics Data

```
/ Vestas V110 VCSS 2.0 MW 60 Hz Mk10
/
583173 'USRMDL' '1'  'VWCOR6' 1 1 2 45 23 104 1 0
 2000.0000 690.0000 903.3041 700.0000 2.6200 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
 161.5343 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 583173 '1'  /
0 'USRMDL' 0 'VWLVR6' 8 0 3 65 10 35 583173 '1' 1
 0.9000 0.0010 0.1500 18.6316 74.5430 74.5430 74.5430
 0.5000 1.0000 2.6200 0.9676 1.2000 0.5000 690.0000
 903.3041 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 583173 '1' 0
 1.0000 0.5000 -0.5000 0.6988 0.8844 0.9800 0.9600
 0.2000 0.2000 1.0000 1.0000 0.0000 0.0000 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 583173 '1'
```

```
 2000.0000 422.2301 4736.7543 420.7500 83.5000 6188.8071 39.3992
 0.0000 0.0000 0.0000 /
0 'USRMDL' 0 'VWMEA6' 8 0 2 10 8 5 583173 '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 583173 '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 583173 '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-2011-057 POI (Creswell 532981) and five levels away

```
                    PSS®E ASCC SHORT CIRCUIT CURRENTS        WED, FEB 11 2015  10:46
2014 MDWG PASS 8   WITH 2013 MMWG
MDWG 2025S WITH MMWG 2024S

OPTIONS USED:
   - DC LINES AND FACTS DEVICES BLOCKED

                        THREE PHASE FAULT
X---------- BUS ----------X        /I+/    AN(I+)
514759 [NEWKIRK4    138.00] AMP     8879.0   -84.79
514760 [KILDARE4    138.00] AMP    10622.5   -85.19
514764 [NWKRKAT4    138.00] AMP    10306.2   -85.11
514804 [MIDLTNT4    138.00] AMP     8125.8   -84.81
515381 [PECKHMT4    138.00] AMP     8561.6   -84.76
515543 [RENFROW7    345.00] AMP    12020.0   -87.23
521198 [CHILOCCO4   138.00] AMP     6418.3   -82.75
529290 [OMNUKRK4    138.00] AMP     8784.1   -84.81
532792 [FR2EAST7    345.00] AMP     6268.1   -83.07
532796 [WICHITA7    345.00] AMP    24216.4   -89.36
532798 [VIOLA   7   345.00] AMP    13226.2   -87.29
532832 [VIOLA1X1    13.800] AMP    56501.5   -94.17
532981 [CRESWLN4    138.00] AMP     8086.7   -86.06
532982 [OXFORD 4    138.00] AMP     9099.1   -90.01
532984 [SUMNER 4    138.00] AMP     9985.6   -90.01
532985 [TCROCK 4    138.00] AMP     5314.4   -92.21
532992 [TIMBJCT4    138.00] AMP     5675.7   -92.03
533029 [59TH ST4    138.00] AMP    18819.7   -91.10
533036 [CLEARWT4    138.00] AMP    17237.7   -91.83
533039 [ELPASO 4    138.00] AMP    25316.8   -90.00
533042 [FARBER 4    138.00] AMP    16162.7   -91.57
533045 [GILL W 4    138.00] AMP    27599.8   -90.23
533046 [GILL S 4    138.00] AMP    27599.8   -90.23
533063 [SC10BEL4    138.00] AMP     9650.8   -90.11
533075 [VIOLA  4    138.00] AMP    20691.9   -91.32
533080 [CRESW1 1    13.200] AMP    12868.6   -96.30
533081 [CRESW2 1    13.200] AMP    19596.4   -97.59
533106 [GILL S 1    13.200] AMP    17475.2  -103.43
533107 [GILL S 2    13.200] AMP    17475.3  -103.43
533120 [TIMBJCT1    13.200] AMP    12043.6   -98.86
533541 [AKRON  2    69.000] AMP     6768.0   -92.66
533542 [ARKCITY2    69.000] AMP     6387.9   -89.06
533543 [CRESWLN2    69.000] AMP    10935.1   -89.01
533547 [OAK    2    69.000] AMP     7818.3   -88.46
533548 [PARIS  2    69.000] AMP     6708.0   -89.40
533549 [RAINBOW2    69.000] AMP     5825.1   -85.64
533552 [SC3MILL2    69.000] AMP     4743.8   -93.00
533553 [SC4ROME2    69.000] AMP     5503.0   -92.49
533554 [SC5SILV2    69.000] AMP     6326.9   -89.23
533555 [SC7CRES2    69.000] AMP    10798.3   -89.17
533556 [STROTHR2    69.000] AMP     6116.4   -88.57
533558 [TIMBJCT2    69.000] AMP     8209.9   -93.93
533559 [UDALL  2    69.000] AMP     7184.8   -94.62
533560 [WELLING2    69.000] AMP     4870.4   -92.30
533561 [WINFLD 2    69.000] AMP     6532.4   -87.66
533562 [PRAIRIE2    69.000] AMP     6348.5   -89.38
533563 [PRAIRIJ2    69.000] AMP     6909.7   -88.98
533564 [NWELLING2   69.000] AMP     4827.7   -92.51
533795 [GILL E 2    69.000] AMP    34152.7   -92.91
533796 [GILL W 2    69.000] AMP    34152.7   -92.91
```

539675 [MILANTP4 138.00] AMP 6598.0 -83.78
583170 [GEN-2011-057138.00] AMP 5660.5 -82.52
583171 [G11-057XFMR134.500] AMP 11706.0 -81.39
583172 [G11-057-GSU134.500] AMP 11314.3 -79.00
583480 [GEN-2012-040138.00] AMP 5959.7 -83.16
583481 [G12-040XFMR134.500] AMP 9124.8 -85.28
583482 [G12-040-GSU134.500] AMP 8760.4 -82.71

APPENDIX E

CHARGING CURRENT COMPENSATION ANALYSIS

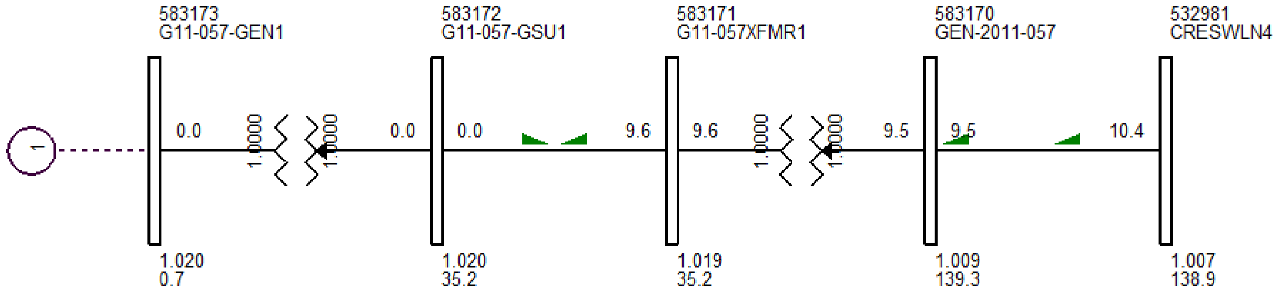

Figure E-1: GEN-2011-057 with generators off and no shunt reactors

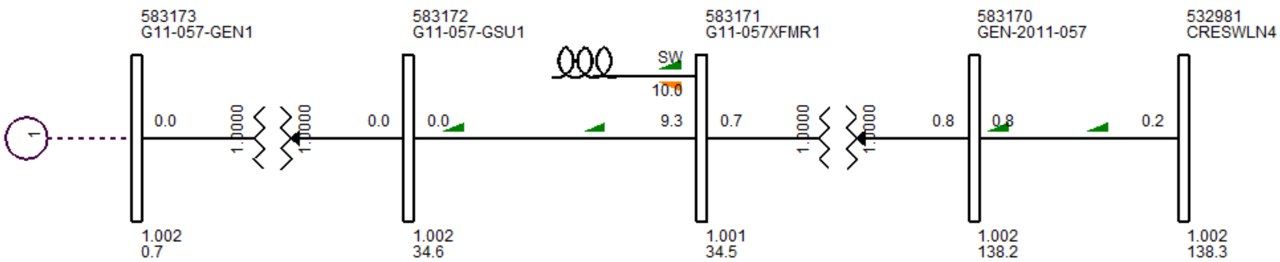

Figure E-2: GEN-2011-057 with generator turned off and shunt reactor added to the low side of the substation 138/34.5kV transformer