GEN-2011-054 Impact Restudy for Generator Modification (Turbine Change)

March 2014
Generator Interconnection

Southwest Power Pool

Executive Summary

The GEN-2011-054 interconnection customer has requested a system impact restudy to determine the effects of changing wind turbine generators from the previously studied Siemens 2.3MW wind turbine generators (130 machines total) to a combination of Vestas V100 VCSS 2.0 MW and V110 VCSS 2.0MW wind turbine generators.

In this restudy the project uses fifty (50) Vestas V110 VCSS 2.0MW and ninety-nine (99) Vestas V100 VCSS 2.0 MW wind turbine generators for an aggregate power of 298.0MW. The point of interconnection (POI) for GEN-2011-054 is at the Oklahoma Gas and Electric Company (OG&E) Cimarron 345 kV Substation. The interconnection customer has provided documentation that shows the Vestas V100 and V110 VCSS 2.0MW wind turbine generators have a reactive capability of 0.98 lagging (providing VARS) and 0.96 leading (absorbing VARS) power factor.

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-2013-002 were used that analyzed the timeframes of 2014 winter, 2015 summer, and 2024 summer models. Additionally a sensitivity analysis for Limited Operation was performed that removed certain upgrades and certain higher queued Interconnection Requests that are not planned to be in service prior to the Customer's in-service date. These upgrades are listed in Table I-4 and the prior queued Interconnection Requests are listed in Table I-3.

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 V100 and V110 VCSS 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 power factor analysis and a low-wind/no-wind condition analysis were performed for this modification request. The facility will be required to maintain a 95% lagging (providing VARs) and 95% leading (absorbing VARs) power factor at the POI. Since the Vestas V100 and V110 VCSS 2.0MW wind turbines have limited reactive capability, the generation facility will need external capacitor banks or other reactive equipment to meet the power factor requirement at the POI. Additionally, the project will be required to install approximately 24Mvar 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.

With the assumptions outlined in this report and with all the required network upgrades from the GEN-2011-054 GIA in place, GEN-2011-054 with the Vestas V100 and V110 VCSS 2.0MW wind turbine generators should be able to interconnect reliably to the SPP transmission grid.

It should be noted that although this study analyzed many of the most probable contingencies, it is not an all-inclusive list and cannot account for every operational situation. Because of this, 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-2011-054 Impact Restudy is a generation interconnection study performed to study the impacts of interconnecting the project shown in Table I-1. The in-service date assumed for the generation addition was June 30, 2015. This restudy is for a change from GE to Vestas wind turbines.

Table I-1: Interconnection Request

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2011-054	298	Vestas 2.0MW (99 x V100 and 50 x V110 for a total of 298MW)	Cimarron 345kV (514901)

The prior-queued and equally-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 Queued Interconnection Requests

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2001-014	94.5	Suzlon 2.1MW	Fort Supply 138kV (520920)
GEN-2001-037	102	GE 1.5MW	Moorland – Woodward 138kV (515785)
GEN-2005-008	120	GE 1.5MW	Woodward 138kV (514785)
GEN-2006-024S	18.9	Suzlon 2.1MW	Buffalo Bear 69kV (521120)
GEN-2006-046	132	Mitsubishi 2.4MW	Dewey 138kV (514787)
GEN-2007-021	200	GE 1.6MW	Tatonga 345kV (515407)
GEN-2007-043	200	GE 1.6	Minco 345kV (514801)
GEN-2007-044	299.2	GE 1.6MW	Tatonga 345kV (515407)
GEN-2007-050	170.2	Siemens 2.3MW	Woodward 138kV (515376)
GEN-2007-062	765	GE 1.5MW	Woodward 345kV (515375)
GEN-2008-003	101.2	Siemens 2.3MW	Woodward 138kV (515376)
GEN-2008-019	300	Mitsubishi 2.4MW	Tatonga 345kV (515407)
GEN-2008-029	250.5	GE 1.5MW	Woodward 138kV (515376)
GEN-2008-044	197.8	Siemens SWT 2.3MW	Tatonga 345kV (515407)
GEN-2010-011	29.7	Siemens SWT 2.3MW	Tatonga 345kV (515407) (Addition to Gen-2008-044 34.5kV bus (515450)
GEN-2010-040	298.5	RePower 2.05MW & Mitsubishi 2.4MW	Cimarron 345kV (514901)

Table I-2: Prior Queued Interconnection Requests

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2011-007	250.2	RePower 2.05MW	Mathewson 345kV (515497)
GEN-2011-010	100.8	GE 1.6MW	Minco 345kV (514801)
GEN-2011-019	299	Siemens 2.3MW	Woodward 345kV (515375)
GEN-2011-020	299	Siemens 2.3MW	Woodward 345kV (515375)
GEN-2011-051	104.4	Vestas V90 1.8MW	Tap on the Woodward - Tatonga 345kV line (G11_051-TAP, 562075)
GEN-2012-016	280 Summer 312 Winter	GENROU	Tap Woodward-Thistle 345kV (562286)
GEN-2012-031	200.1	Siemens 2.3 (SWTVS4)	Cimarron 345kV (514901)
GEN-2013-003	328 Summer 360 Winter (see note)	GENROU (583323,583326)	Tap Woodward (515375)-Thistle (539801) 345kV line (562286)
GEN-2013-025	50	Vestas V100 2.0MW	Mathewson 345kV (515497)
GEN-2013-034	72.5	Siemens 2.3MW	Tap Woodward (515375)-Beaver (580500) 345kV double circuit (562440)

NOTE: GEN-2013-003 is a 48MW increase to GEN-2012-016.

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 power factor analysis and a low-wind/no-wind analysis were performed on this project since it is a wind farm. The analyses were performed on three seasonal models, the modified versions of the 2014 winter peak, the 2015 summer peak, and the 2024 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.

The power factor analysis determines the power factor at the point of interconnection for the wind interconnection project for pre-contingency and post-contingency conditions. The contingencies used in the power factor analysis were a subset of the stability analysis contingencies shown in Table III-1.

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.

Limited Operation

Additional sensitivities for 2014 winter peak and 2015 summer peak were performed. These sensitivities did not include the upgrades in Table I-3 or the prior queued projects in Table I-4. These sensitivities are to accommodate limited operation prior to the in-service date of all upgrades.

Table I-3: Prior Queued Interconnection Requests NOT included in Sensitivity Analysis

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2011-019	299	Siemens 2.3MW	Woodward 345kV (515375)
GEN-2011-020	299	Siemens 2.3MW	Woodward 345kV (515375)
GEN-2011-051	104.4	Vestas V90 1.8MW	Tap on the Woodward - Tatonga 345kV line (G11_051-TAP, 562075)
GEN-2012-016	280 Summer 312 Winter	GENROU	Tap Woodward-Thistle 345kV (562286)
GEN-2012-031	200.1	Siemens 2.3 (SWTVS4)	Cimarron 345kV (514901)
GEN-2013-003	328 Summer 360 Winter (see note)	GENROU (583323,583326)	Tap Woodward (515375)-Thistle (539801) 345kV line (562286)
GEN-2013-025	50	Vestas V100 2.0MW	Mathewson 345kV (515497)
GEN-2013-034	72.5	Siemens 2.3MW	Tap Woodward (515375)-Beaver (580500) 345kV double circuit (562440)

Table I-4: Upgrades NOT included in Sensitivity Analysis

Woodward – Tatonga – Mathewson – Cimarron 345kV, Circuit 2
Beaver – Buckner 345kV, Circuit 1

It should be noted that although this study analyzed many of the most probable contingencies, it is not an all-inclusive list and cannot account for every operational situation. Because of this, 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.

II. Facilities

A one-line drawing for the GEN-2011-054 generation interconnection request is shown in Figure II-1. The POI is the OG&E Cimarron 345kV substation.

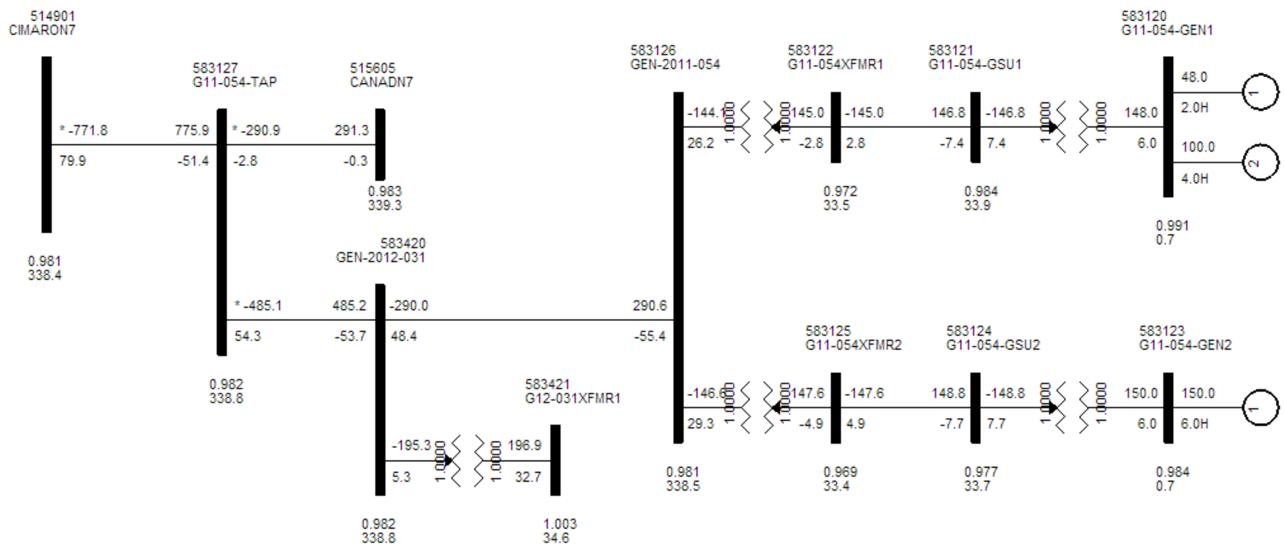

Figure II-1: GEN-2011-054 One-line Diagram

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 2013 series of Model Development Working Group (MDWG) dynamic study models including the 2014 winter peak, the 2015 summer peak, and the 2024 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

Fifty-four (54) 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)

The control areas monitored are 520, 524, 525, 526, 531, 534, and 536.

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
1	FLT_01_CIMARON7_MINCO7_345kV_3PH	3 phase fault on the Cimarron (514901) to Minco (514801) 345kV line, at Cimarron. a. Apply fault at the Cimarron 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_CIMARON7_MINCO7_345kV_1PH	Single phase fault and sequence like previous
3	FLT_03_CIMARON7_NORTWST7_345kV_3PH	3 phase fault on the Cimarron (514901) to Northwest (514880) 345kV line, at Cimarron. a. Apply fault at the Cimarron 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_CIMARON7_NORTWST7_345kV_1PH	Single phase fault and sequence like previous
5	FLT_05_CIMARON7_DRAPER7_345kV_3PH	3 phase fault on the Cimarron (514901) to Draper (514934) 345kV line, at Cimarron. a. Apply fault at the Cimarron 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_CIMARON7_DRAPER7_345kV_1PH	Single phase fault and sequence like previous
7	FLT_07_CIMARON7_MATHWSN7_345kV_3PH	3 phase fault on the Cimarron (514901) to Mathewson (515497) 345kV line, at Cimarron. a. Apply fault at the Cimarron 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_CIMARON7_MATHWSN7_345kV_1PH	Single phase fault and sequence like previous
9	FLT_09_MINCO7_GRACMNT7_345kV_3PH	3 phase fault on the Minco (514801) to Gracemont (515800) 345kV line, at Minco. a. Apply fault at the Minco 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_MINCO7_GRACMNT7_345kV_1PH	Single phase fault and sequence like previous

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
11	FLT_11_GRACMNT7_LES7_345kV_3PH	3 phase fault on Gracemont (515800) to Lawton Eastside (511468) 345kV line, at Gracemont. a. Apply fault at the Gracemont 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_GRACMNT7_LES7_345kV_1PH	Single phase fault and sequence like previous
13	FLT_13_NORTWST7_SPRNGCK7_345kV_3PH	3 phase fault on Northwest (514880) to Spring Creek (514881) 345kV line, at Northwest. a. Apply fault at the Northwest 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_NORTWST7_SPRNGCK7_345kV_1PH	Single phase fault and sequence like previous
15	FLT_15_NORTWST7_ARCADIA7_345kV_3PH	3 phase fault on Northwest (514880) to Arcadia (514908) 345kV line, at Northwest. a. Apply fault at the Northwest 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_NORTWST7_ARCADIA7_345kV_1PH	Single phase fault and sequence like previous
17	FLT_17_NORTWST7_MATHWSN7_345kV_3PH[1]	3 phase fault on Northwest (514880) to Mathewson (515497) 345kV line, at Northwest. a. Apply fault at the Northwest 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_NORTWST7_MATHWSN7_345kV_1PH[1]	Single phase fault and sequence like previous
19	FLT_19_SPRNGCK7_SOONER7_345kV_3PH	3 phase fault on Spring Creek (514881) to Sooner (514803) 345kV line, at on Spring Creek. a. Apply fault at the on Spring Creek 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_SPRNGCK7_SOONER7_345kV_1PH	Single phase fault and sequence like previous

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
21	FLT_21_DRAPER7_SEMINOL7_345kV_3PH	3 phase fault on the Draper (514934) to Seminole (515045) 345kV line, at Draper. a. Apply fault at the Draper 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_DRAPER7_SEMINOL7_345kV_1PH	Single phase fault and sequence like previous
23	FLT_23_SEMINOL7_PITTSB7_345kV_3PH	3 phase fault on the Seminole (515045) to Pittsburg (510907) 345kV line, at Seminole. a. Apply fault at the Seminole 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_SEMINOL7_PITTSB7_345kV_1PH	Single phase fault and sequence like previous
25	FLT_25_SEMINOL7_ARCADIA7_345kV_3PH	3 phase fault on the Seminole (515045) to Arcadia (510908) 345kV line, at Seminole. a. Apply fault at the Seminole 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.
26	FLT_26_SEMINOL7_ARCADIA7_345kV_1PH	Single phase fault and sequence like previous
27	FLT_27_SEMINOL7_MUSKOGE7_345kV_3PH	3 phase fault on the Seminole (515045) to Muskogee (515224) 345kV line, at Seminole. a. Apply fault at the Seminole 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.
28	FLT_28_SEMINOL7_MUSKOGE7_345kV_1PH	Single phase fault and sequence like previous
29	FLT_29_MATHWSN7_WOODRNG7_345kV_3PH	3 phase fault on the Mathewson (515497) to Woodring (514715) 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.
30	FLT_30_MATHWSN7_WOODRNG7_345kV_1PH	Single phase fault and sequence like previous

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
31	FLT_31_MATHWSN7_TATONGA7_345kV_3PH[1]	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.
32	FLT_32_MATHWSN7_TATONGA7_345kV_1PH[1]	Single phase fault and sequence like previous
33	FLT_33_TATONGA7_G11051TAP_345kV_3PH	3 phase fault on the Tatonga (515407) to G1105TAP (562075) 345kV line, at Tatonga. a. Apply fault at the Tatonga 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.
34	FLT_34_TATONGA7_G11051TAP_345kV_1PH	Single phase fault and sequence like previous
35	FLT_35_CIMARON4_TUTCONT4_138kV_3PH	3 phase fault on the Cimarron (514898) to TUTCONT (511425) 138kV line ckt1, at 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.
36	FLT_36_CIMARON4_TUTCONT4_138kV_1PH	Single phase fault and sequence like previous
37	FLT_37_CIMARON4_ELRENO4_138kV_3PH	3 phase fault on the Cimarron (514898) to El Reno (514819) 138kV line ckt1, at 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.
38	FLT_38_CIMARON4_ELRENO4_138kV_1PH	Single phase fault and sequence like previous
39	FLT_39_CIMARON4_JENSENT4_138kV_3PH	3 phase fault on the Cimarron (514898) to Jensen Tap (514820) 138kV line ckt1, at 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.
40	FLT_40_CIMARON4_JENSENT4_138kV_1PH	Single phase fault and sequence like previous

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
41	FLT_41_CIMARON4_HAYMAKR4_138kV_3PH	3 phase fault on the Cimarron (514898) to Haymaker (514863) 138kV line ckt1, at 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.
42	FLT_42_CIMARON4_HAYMAKR4_138kV_1PH	Single phase fault and sequence like previous
43	FLT_43_CIMARON4_CZECHAL4_138kV_3PH	3 phase fault on the Cimarron (514898) to Czech Hall (514894) 138kV line ckt1, at 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.
44	FLT_44_CIMARON4_CZECHAL4_138kV_1PH	Single phase fault and sequence like previous
45	FLT_45_CIMARON4_SARA4_138kV_3PH	3 phase fault on the Cimarron (514898) to Sara (514895) 138kV line ckt1, at 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.
46	FLT_46_CIMARON4_SARA4_138kV_1PH	Single phase fault and sequence like previous
47	FLT_47_CIMARON7_CIMARON4_345_138kV_3PH	3 phase fault on the Cimarron 345kV (514901) to 138kV (514898)/13.8kV (515714) transformer at the 345kV bus. a. Apply fault at the Cimarron 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer
48	FLT_48_NORTWST7_NORTWST4_345_138kV_3PH	3 phase fault on the Northwest 345kV (514880) to 138kV (514879)/13.8kV (515742) transformer at the 345kV bus. a. Apply fault at the Northwest 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer
49	FLT_49_DRAPER7_DRAPER4_345_138kV_3PH	3 phase fault on the Draper 345kV (514934) to 138kV (514933)/13.8kV (515792) transformer at the 345kV bus. a. Apply fault at the Draper 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer
50	FLT_50_PLSNTHILL3_PLSNTHILL6_115_230kV_3PH	3 phase fault on the Pleasant Hill 115kV (524768) to 230kV (524770)/13.2kV (524767) transformer at the 115kV bus. a. Apply fault at the Pleasant Hill 115kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
51	FLT_51_CIMARON7_MATHWSN7_345 kV_3PH[1]	3 phase double circuit fault on the Cimarron (514901) to Mathewson (515497) 345kV line, at Cimarron. a. Apply fault at the Cimarron 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line, both ckt 1 and ckt 2.
52	FLT_52_MATHWSN7_TATONGA7_345 kV_3PH[1]	3 phase double circuit 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, both ckt 1 and ckt 2.
53	FLT_53_TATONGA7_NORTWST7_345 kV_3PH[2]	3 phase fault on the Tatonga (515407) to Northwest (514880) 345kV line, at Tatonga. a. Apply fault at the Tatonga 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.
54	FLT_54_TATONGA7_NORTWST7_345 kV_1PH[2]	Single phase fault and sequence like previous

NOTES:

1. Contingency not used in sensitivity analysis (upgrades in Table 1-4 are in service)
2. Contingency used only in sensitivity analysis (upgrades in Table 1-4 are not in service)

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-2011-054 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.

Limited Operation - Table III-2 also shows the results of the sensitivity analysis for upgrades not in service (Table I-4) and prior queued interconnection requests not in service (Table I-3). The results show that GEN-2011-054 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.

Figures III-1, III-2, and III-3 show sample plots of the network response to a three phase fault at the POI and subsequent clearing action (tripping of the Cimarron to Minco 345kV line). Complete sets of plots for the stability analysis are available on request.

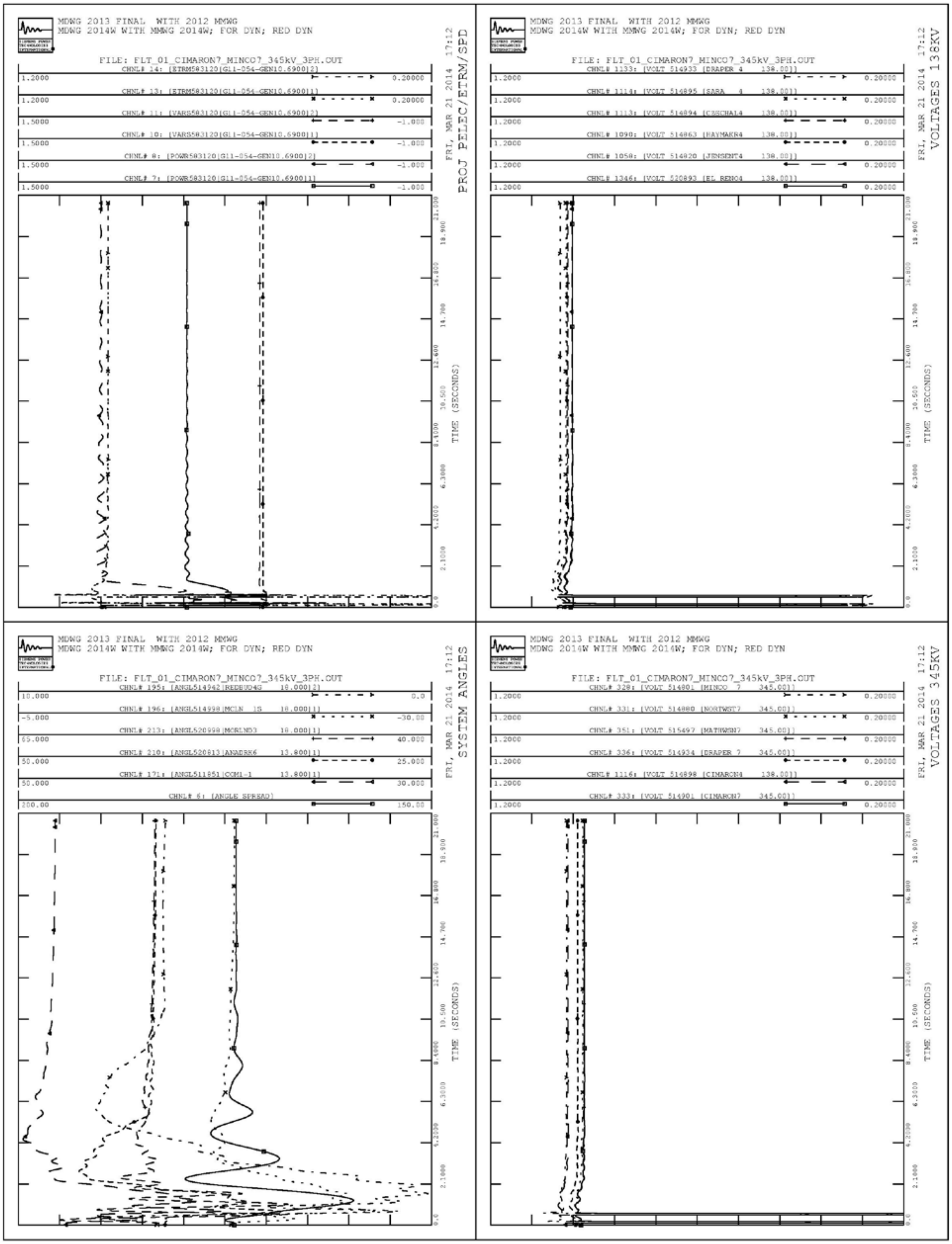

Figure III-1: Plot for Cimarron to Minco 345kV Contingency (fault near Cimarron) – 2014 Winter Peak

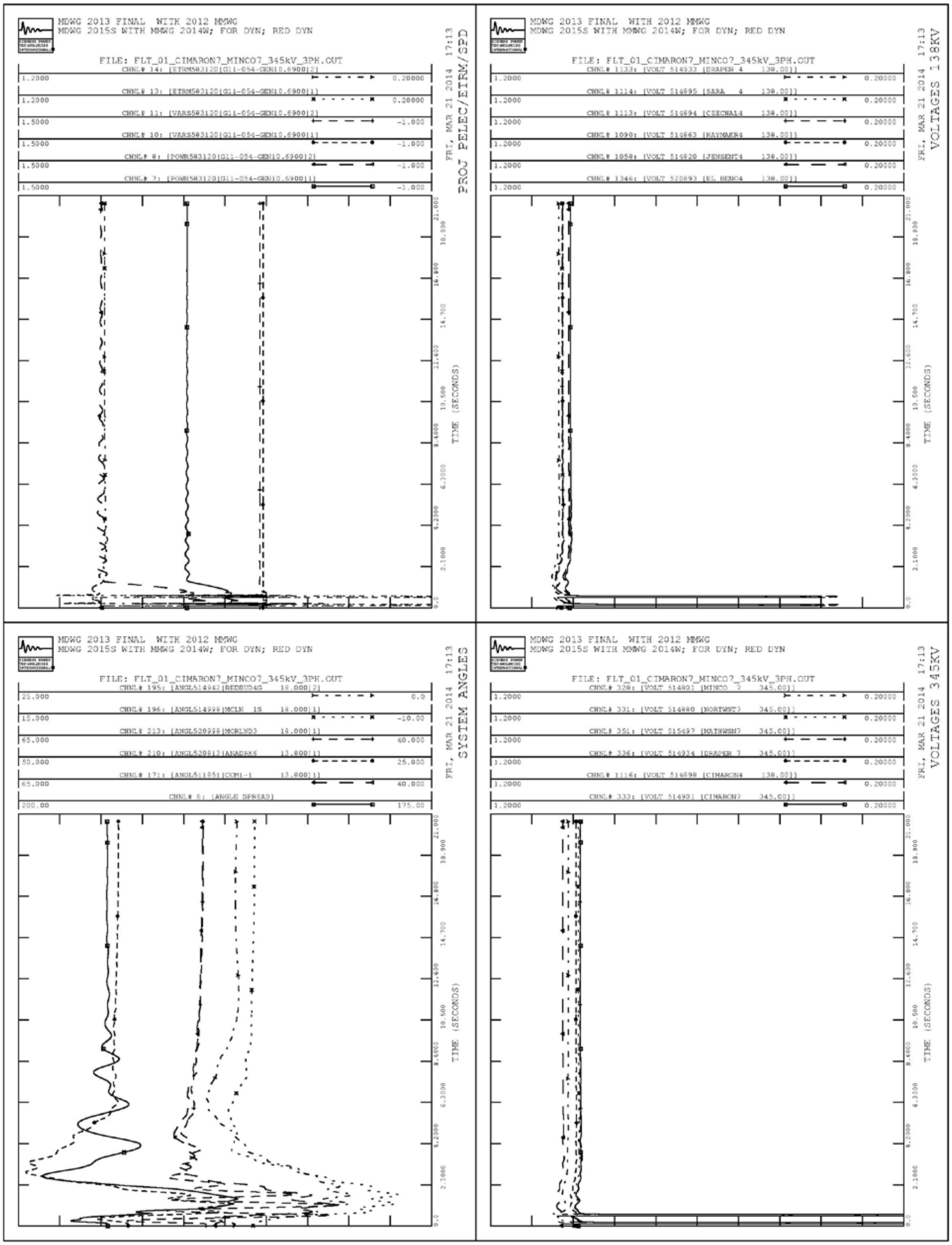

Figure III-2: Plot for Cimarron to Minco 345kV Contingency (fault near Cimarron) – 2015 Summer Peak

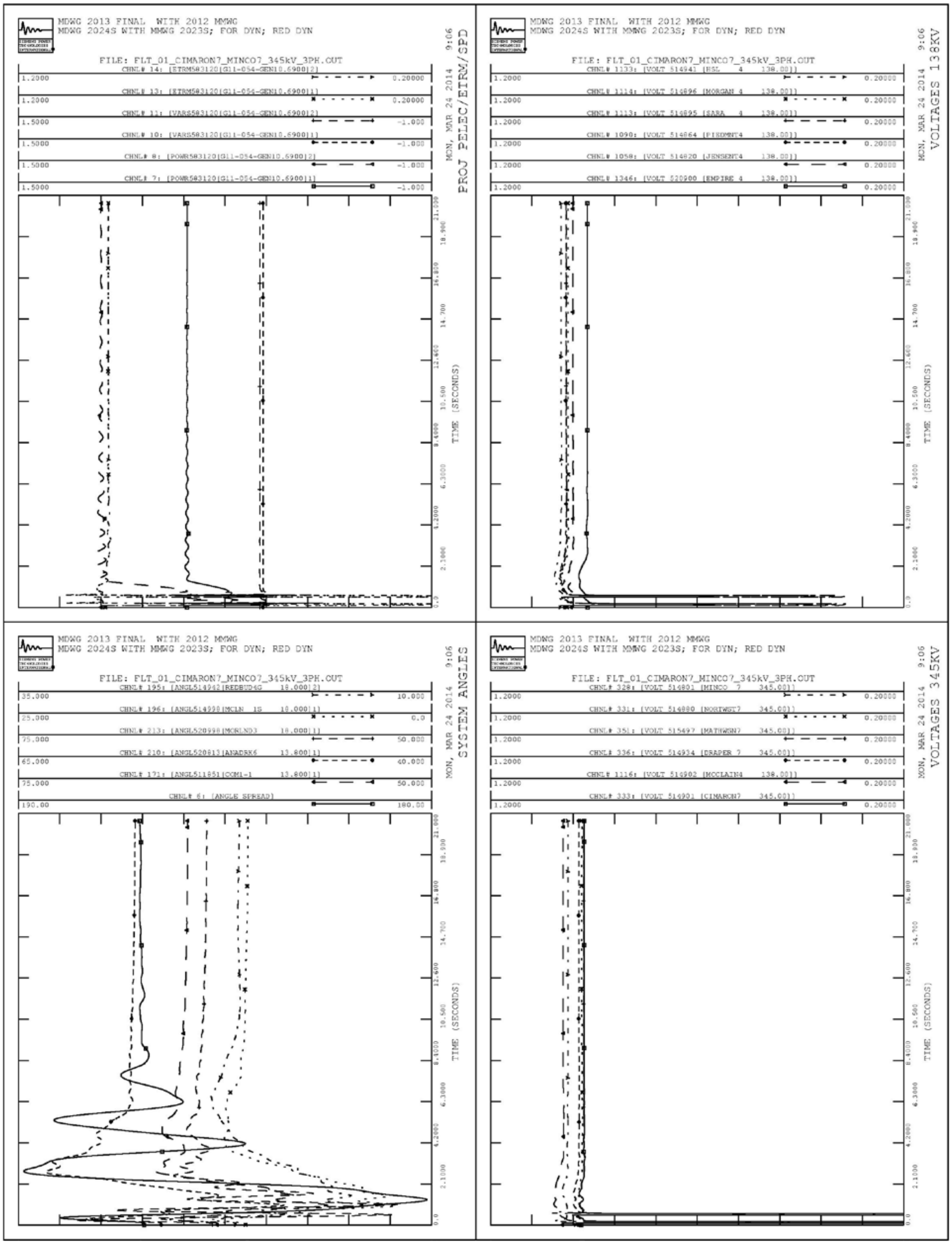

Figure III-3: Plot for Cimarron to Minco 345kV Contingency (fault near Cimarron) – 2024 Summer Peak

Table III-2: Stability Analysis Results

		With upgrades listed in Table I-4 and prior queued interconnection requests in Table I-2 in service			Limited Operation Without upgrades listed in Table I-4 and prior queued interconnection requests in Table I-3 not in service	
Contingency Number and Name		2014WP	2015SP	2024SP	2014WP	2015SP
1	FLT_01_CIMARON7_MINCO7_345kV_3PH	OK	OK	OK	OK	OK
2	FLT_02_CIMARON7_MINCO7_345kV_1PH	OK	OK	OK	OK	OK
3	FLT_03_CIMARON7_NORTWST7_345kV_3PH	OK	OK	OK	OK	OK
4	FLT_04_CIMARON7_NORTWST7_345kV_1PH	OK	OK	OK	OK	OK
5	FLT_05_CIMARON7_DRAPER7_345kV_3PH	OK	OK	OK	OK	OK
6	FLT_06_CIMARON7_DRAPER7_345kV_1PH	OK	OK	OK	OK	OK
7	FLT_07_CIMARON7_MATHWSN7_345kV_3PH	OK	OK	OK	OK	OK
8	FLT_08_CIMARON7_MATHWSN7_345kV_1PH	OK	OK	OK	OK	OK
9	FLT_09_MINCO7_GRACMNT7_345kV_3PH	OK	OK	OK	OK	OK
10	FLT_10_MINCO7_GRACMNT7_345kV_1PH	OK	OK	OK	OK	OK
11	FLT_11_GRACMNT7_LES7_345kV_3PH	OK	OK	OK	OK	OK
12	FLT_12_GRACMNT7_LES7_345kV_1PH	OK	OK	OK	OK	OK
13	FLT_13_NORTWST7_SPRNGCK7_345kV_3PH	OK	OK	OK	OK	OK
14	FLT_14_NORTWST7_SPRNGCK7_345kV_1PH	OK	OK	OK	OK	OK
15	FLT_15_NORTWST7_ARCADIA7_345kV_3PH	OK	OK	OK	OK	OK
16	FLT_16_NORTWST7_ARCADIA7_345kV_1PH	OK	OK	OK	OK	OK
17	FLT_17_NORTWST7_MATHWSN7_345kV_3PH	OK	OK	OK	- NA -	- NA -
18	FLT_18_NORTWST7_MATHWSN7_345kV_1PH	OK	OK	OK	- NA -	- NA -
19	FLT_19_SPRNGCK7_SOONER7_345kV_3PH	OK	OK	OK	OK	OK
20	FLT_20_SPRNGCK7_SOONER7_345kV_1PH	OK	OK	OK	OK	OK
21	FLT_21_DRAPER7_SEMINOL7_345kV_3PH	OK	OK	OK	OK	OK
22	FLT_22_DRAPER7_SEMINOL7_345kV_1PH	OK	OK	OK	OK	OK
23	FLT_23_SEMINOL7_PITTSB7_345kV_3PH	OK	OK	OK	OK	OK
24	FLT_24_SEMINOL7_PITTSB7_345kV_1PH	OK	OK	OK	OK	OK

Table III-2: Stability Analysis Results

		With upgrades listed in Table I-4 and prior queued interconnection requests in Table I-2 in service			***Limited Operation*** ***Without upgrades listed in Table I-4 and prior queued interconnection requests in Table I-3 not in service***	
	Contingency Number and Name	2014WP	2015SP	2024SP	2014WP	2015SP
25	FLT_25_SEMINOL7_ARCADIA7_345kV_3PH	OK	OK	OK	OK	OK
26	FLT_26_SEMINOL7_ARCADIA7_345kV_1PH	OK	OK	OK	OK	OK
27	FLT_27_SEMINOL7_MUSKOGE7_345kV_3PH	OK	OK	OK	OK	OK
28	FLT_28_SEMINOL7_MUSKOGE7_345kV_1PH	OK	OK	OK	OK	OK
29	FLT_29_MATHWSN7_WOODRNG7_345kV_3PH	OK	OK	OK	OK	OK
30	FLT_30_MATHWSN7_WOODRNG7_345kV_1PH	OK	OK	OK	OK	OK
31	FLT_31_MATHWSN7_TATONGA7_345kV_3PH	OK	OK	OK	- NA -	- NA -
32	FLT_32_MATHWSN7_TATONGA7_345kV_1PH	OK	OK	OK	- NA -	- NA -
33	FLT_33_TATONGA7_G11051TAP_345kV_3PH	OK	OK	OK	OK	OK
34	FLT_34_TATONGA7_G11051TAP_345kV_1PH	OK	OK	OK	OK	OK
35	FLT_35_CIMARON4_TUTCONT4_138kV_3PH	OK	OK	OK	OK	OK
36	FLT_36_CIMARON4_TUTCONT4_138kV_1PH	OK	OK	OK	OK	OK
37	FLT_37_CIMARON4_ELRENO4_138kV_3PH	OK	OK	OK	OK	OK
38	FLT_38_CIMARON4_ELRENO4_138kV_1PH	OK	OK	OK	OK	OK
39	FLT_39_CIMARON4_JENSENT4_138kV_3PH	OK	OK	OK	OK	OK
40	FLT_40_CIMARON4_JENSENT4_138kV_1PH	OK	OK	OK	OK	OK
41	FLT_41_CIMARON4_HAYMAKR4_138kV_3PH	OK	OK	OK	OK	OK
42	FLT_42_CIMARON4_HAYMAKR4_138kV_1PH	OK	OK	OK	OK	OK
43	FLT_43_CIMARON4_CZECHAL4_138kV_3PH	OK	OK	OK	OK	OK
44	FLT_44_CIMARON4_CZECHAL4_138kV_1PH	OK	OK	OK	OK	OK
45	FLT_45_CIMARON4_SARA4_138kV_3PH	OK	OK	OK	OK	OK
46	FLT_46_CIMARON4_SARA4_138kV_1PH	OK	OK	OK	OK	OK
47	FLT_47_CIMARON7_CIMARON4_345_138kV_3PH	OK	OK	OK	OK	OK
48	FLT_48_NORTWST7_NORTWST4_345_138kV_3PH	OK	OK	OK	OK	OK
49	FLT_49_DRAPER7_DRAPER4_345_138kV_3PH	OK	OK	OK	OK	OK
50	FLT_50_PLSNTHILL3_PLSNTHILL6_115_230kV_3PH	OK	OK	OK	OK	OK

Table III-2: Stability Analysis Results

		With upgrades listed in Table I-4 and prior queued interconnection requests in Table I-2 in service			***Limited Operation*** ***Without upgrades listed in Table I-4 and prior queued interconnection requests in Table I-3 not in service***	
Contingency Number and Name		2014WP	2015SP	2024SP	2014WP	2015SP
51	FLT_51_CIMARON7_MATHWSN7_345kV_3PH	OK	OK	OK	OK	OK
52	FLT_52_MATHWSN7_TATONGA7_345kV_3PH	OK	OK	OK	OK	OK
53	FLT_53_TATONGA7_NORTWST7_345kV_3PH	- NA -	- NA -	- NA -	OK	OK
54	FLT_54_TATONGA7_NORTWST7_345kV_1PH	- NA -	- NA -	- NA -	OK	OK

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, 3, 5, 7, 46, 50 and 52 in Table III-2 simulated the LVRT contingencies. GEN-2011-054 met the LVRT requirements by staying on line and the transmission system remaining stable.

IV. Power Factor Analysis

A subset of the stability faults was used as power flow contingencies to determine the power factor requirements for the wind farm to maintain scheduled voltage at the POI. The voltage schedule was set equal to the voltages at the POI before the project is added, with a minimum of 1.0 per unit. A fictitious reactive power source replaced the study project to maintain scheduled voltage during all studied contingencies. The MW and Mvar injections from the study project at the POI were recorded and the resulting power factors were calculated for all contingencies for summer peak and winter peak cases. The most leading and most lagging power factors determine the minimum power factor range capability that the study project must install before commercial operation.

Per FERC and SPP Tariff requirements, if the power factor needed to maintain scheduled voltage is less than 0.95 lagging, then the requirement is limited to 0.95 lagging. The lower limit for leading power factor requirement is also 0.95. If a project never operated leading under any contingency, then the leading requirement is set to 1.0. The same applies on the lagging side.

The power factor analysis showed a need for reactive capability by the study project at the POI. The final power factor requirement in the Generator Interconnection Agreement (GIA) will be the pro-forma 0.95 lagging to 0.95 leading at the POI, and this requirement is shown in Table IV-1. The detailed power factor analysis tables are in Appendix B. Since the Vestas V100 and V110 VCSS 2.0MW wind turbines have limited reactive capability (0.98 lagging and 0.96 leading), the generation facility will require external capacitor banks or other reactive equipment to meet the power factor requirement at the POI.

Table IV-1: Power Factor Requirements [a]

Request	Size (MW)	Generator Model	Point of Interconnection	Final PF Requirement at POI	
				Lagging [b]	Leading [c]
GEN-2011-054	298	Vestas 2.0MW (99 x V100 and 50 x V110 for a total of 298MW)	Cimarron 345kV (514901)	0.95[d]	0.95[e]

Notes:

a. The table shows the minimum required power factor capability at the point of interconnection that must be designed and installed with the plant. The power factor capability at the POI includes the net effect of the generators, transformers, line impedances, and any reactive compensation devices installed on the plant side of the meter. Installing more capability than the minimum requirement is acceptable.

b. Lagging is when the generating plant is supplying reactive power to the transmission grid, like a shunt capacitor. In this situation, the alternating current sinusoid “lags” behind the alternating voltage sinusoid, meaning that the current peaks shortly after the voltage.

c. Leading is when the generating plant is taking reactive power from the transmission grid, like a shunt reactor. In this situation, the alternating current sinusoid “leads” the alternating voltage sinusoid, meaning that the current peaks shortly before the voltage.

d. Electrical need is lower, but PF requirement limited to 0.95 by FERC order.

e. The most leading power factor determined through analysis was 1.00.

In a separate test, the effect of low-wind/no-wind conditions at the wind farm is analyzed. The project generators and capacitors (if any) were turned off in the base case (Figure IV-1). The resulting reactive power injection into the transmission network comes from the capacitance of the project's transmission lines and collector cables. Normally, this reactive power injection is measured at the POI (Cimarron 345kV substation). However, GEN-2011-054 injects power into the transmission network through a tap on the existing transmission line from GEN-2010-040 (which the customer owns) to the POI. It is at this tap (G11-054-TAP in Figure IV-1) that the reactive power injection is measured.

Shunt reactors were added at the study project substation 34.5 kV buses to bring the Mvar flow into the tap on the GEN-2010-040 to Cimarron 345kV line down to approximately zero (G11-054-TAP in Figure IV-2). Final shunt reactor requirement for this project is approximately 24Mvars. The one-line diagram in Figure IV-2 shows actual Mvar output at the specific voltages in the base case. The results shown are for the 2014WP case. The other two cases (2015SP and 2024SP) were almost identical since the plant design is the same in all cases.

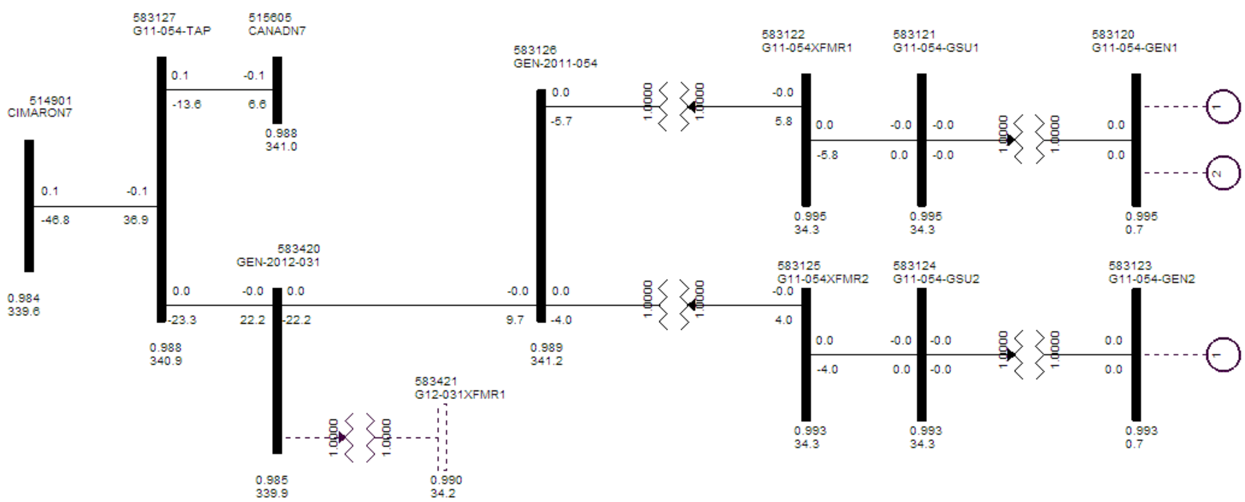

Figure IV-1: GEN-2011-054 with generators off and no shunt reactors

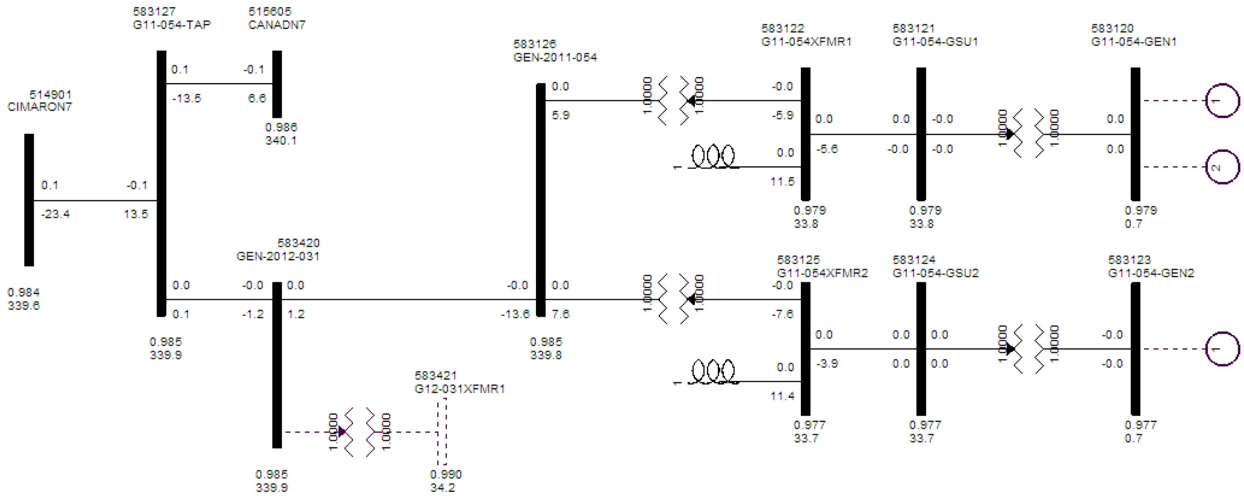

Figure IV-2: GEN-2011-054 with generators turned off and shunt reactors added to the low side of the substation 345/34.5kV transformers

V. Conclusion

The SPP GEN-2011-054 Impact Restudy evaluated the impact of interconnecting the project shown below.

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2011-054	298	Vestas 2.0MW (99 x V100 and 50 x V110 for a total of 298MW)	Cimarron 345kV (514901)

With all Base Case Network Upgrades in service, previously assigned Network Upgrades in service, and required capacitor banks in service, the GEN-2011-054 project was found to remain on line, and the transmission system was found to remain stable for all conditions studied.

Additionally a sensitivity analysis for upgrades not in service (Table I-4) and prior queued interconnection requests not in service (Table I-3) was performed. The results show that GEN-2011-054 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.

A power factor analysis and a low-wind/no-wind condition analysis were performed for this modification request. The facility will be required to maintain a 95% lagging (providing VARs) and 95% leading (absorbing VARs) power factor at the POI. Since the Vestas V100 and V110 VCSS 2.0MW wind turbines have limited reactive capability, the generation facility will require external capacitor banks or other reactive equipment to meet the power factor requirement at the POI.

Additionally, the project will be required to install approximately 24Mvar of reactor shunts on its substation 34.5kV bus. 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.

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

APPENDIX B

POWER FACTOR ANALYSIS

GEN-2011-054 POI: Cimarron 345kV (514901) POI voltage for all seasons is 1.0PU	2014 Winter Peak				2015 Summer Peak				2024 Summer Peak			
	MW	Mvar	PF		MW	Mvar	PF		MW	Mvar	PF	
FLT_00_NoFault	298.0	113.4	0.935	LAG	298.0	64.2	0.978	LAG	298.0	109.6	0.939	LAG
FLT_01_CIMARON7_MINCO7_345kV	298.0	136.3	0.909	LAG	298.0	83.5	0.963	LAG	298.0	131.6	0.915	LAG
FLT_03_CIMARON7_NORTWST7_345kV	298.0	104.5	0.944	LAG	298.0	63.2	0.978	LAG	298.0	102.7	0.945	LAG
FLT_05_CIMARON7_DRAPER7_345kV	298.0	140.6	0.904	LAG	298.0	83.0	0.963	LAG	298.0	120.9	0.927	LAG
FLT_07_CIMARON7_MATHWSN7_345kV	298.0	110.8	0.937	LAG	298.0	64.7	0.977	LAG	298.0	106.0	0.942	LAG
FLT_09_MINCO7_GRACMNT7_345kV	298.0	130.7	0.916	LAG	298.0	77.8	0.968	LAG	298.0	122.7	0.925	LAG
FLT_11_GRACMNT7_LES7_345kV	298.0	112.3	0.936	LAG	298.0	70.6	0.973	LAG	298.0	108.4	0.940	LAG
FLT_13_NORTWST7_SPRNGCK7_345kV	298.0	132.2	0.914	LAG	298.0	101.2	0.947	LAG	298.0	147.8	0.896[a]	LAG
FLT_15_NORTWST7_ARCADIA7_345kV	298.0	132.1	0.914	LAG	298.0	73.6	0.971	LAG	298.0	122.3	0.925	LAG
FLT_17_NORTWST7_MATHWSN7_345kV	298.0	144.2	0.900	LAG	298.0	90.1	0.957	LAG	298.0	138.2	0.907	LAG
FLT_19_SPRNGCK7_SOONER7_345kV	298.0	130.6	0.916	LAG	298.0	76.1	0.969	LAG	298.0	123.8	0.923	LAG
FLT_21_DRAPER7_SEMINOL7_345kV	298.0	123.5	0.924	LAG	298.0	73.1	0.971	LAG	298.0	122.2	0.925	LAG
FLT_23_SEMINOL7_PITTSB7_345kV	298.0	112.9	0.935	LAG	298.0	61.5	0.979	LAG	298.0	112.3	0.936	LAG
FLT_25_SEMINOL7_ARCADIA7_345kV	298.0	119.1	0.929	LAG	298.0	68.3	0.975	LAG	298.0	111.0	0.937	LAG
FLT_27_SEMINOL7_MUSKOGE7_345kV	298.0	111.9	0.936	LAG	298.0	62.7	0.979	LAG	298.0	108.9	0.939	LAG
FLT_29_MATHWSN7_WOODRNG7_345kV	298.0	144.9	0.899	LAG	298.0	93.1	0.954	LAG	298.0	135.4	0.910	LAG
FLT_31_MATHWSN7_TATONGA7_345kV	298.0	147.7	0.896	LAG	298.0	92.8	0.955	LAG	298.0	138.1	0.907	LAG
FLT_33_TATONGA7_G11051TAP_345kV	298.0	41.8	0.990	LAG	298.0	8.6	1.000[b]	LAG	298.0	104.0	0.944	LAG
FLT_35_CIMARON4_TUTCONT4_138kV	298.0	109.5	0.939	LAG	298.0	59.0	0.981	LAG	298.0	103.3	0.945	LAG
FLT_37_CIMARON4_ELRENO4_138kV	298.0	111.3	0.937	LAG	298.0	61.6	0.979	LAG	298.0	106.9	0.941	LAG
FLT_39_CIMARON4_JENSENT4_138kV	298.0	111.5	0.937	LAG	298.0	62.0	0.979	LAG	298.0	107.2	0.941	LAG
FLT_41_CIMARON4_HAYMAKR4_138kV	298.0	115.4	0.933	LAG	298.0	63.9	0.978	LAG	298.0	109.7	0.938	LAG
FLT_43_CIMARON4_CZECHAL4_138kV	298.0	115.8	0.932	LAG	298.0	61.5	0.979	LAG	298.0	108.1	0.940	LAG
FLT_45_CIMARON4_SARA4_138kV	298.0	115.4	0.933	LAG	298.0	62.4	0.979	LAG	298.0	108.1	0.940	LAG
FLT_47_CIMARON7_CIMARON4_345_138kV	298.0	101.7	0.946	LAG	298.0	55.4	0.983	LAG	298.0	101.6	0.946	LAG
FLT_48_NORTWST7_NORTWST4_345_138kV	298.0	113.2	0.935	LAG	298.0	64.8	0.977	LAG	298.0	106.4	0.942	LAG

GEN-2011-054 POI: Cimarron 345kV (514901) POI voltage for all seasons is 1.0PU	2014 Winter Peak				2015 Summer Peak				2024 Summer Peak			
	MW	Mvar	PF		MW	Mvar	PF		MW	Mvar	PF	
FLT_49_DRAPER7_DRAPER4_345_138kV	298.0	114.4	0.934	LAG	298.0	63.6	0.978	LAG	298.0	110.1	0.938	LAG
FLT_50_PLSNTHILL3_PLSNTHILL6_115_230kV	298.0	113.5	0.935	LAG	298.0	64.2	0.978	LAG	298.0	109.7	0.938	LAG

NOTE:

a. Lowest lagging (supplying vars) power factor requirement for all three seasons
b. Lowest leading (absorbing vars) power factor requirement for all three seasons

APPENDIX C

PROJECT MODELS

GEN-2011-054 (Vestas V100 and V110 2.0 MW)

PSS/E 32 Power Flow Data

```
TEXT GEN-2011-054 (Vestas V100 and V110 2.0 MW)
RDCH
1
583120,'G11-054-GEN1',   0.6900,2, 524, 569,   1,0.99127,  47.0897
583121,'G11-054-GSU1',  34.5000,1, 524, 569,   1,0.98362,  41.8902
583122,'G11-054XFMR1',  34.5000,1, 524, 569,   1,0.97216,  41.4739
583123,'G11-054-GEN2',   0.6900,2, 524, 569,   1,0.98444,  47.3633
583124,'G11-054-GSU2',  34.5000,1, 524, 569,   1,0.97685,  42.0910
583125,'G11-054XFMR2',  34.5000,1, 524, 569,   1,0.96943,  41.6681
583126,'GEN-2011-054', 345.0000,1, 524, 569,   1,0.98125,  32.2875
583127,'G11-054-TAP ', 345.0000,1, 524, 566, 524,0.98206,  31.0633
0 / END OF BUS DATA, BEGIN LOAD DATA
0 / END OF LOAD DATA, BEGIN FIXED SHUNT DATA
0 / END OF FIXED SHUNT DATA, BEGIN GENERATOR DATA
583120,'1 ',    48.000,     2.000,     2.000,     2.000,1.00000,     0,    48.000, 5.00000E-3, 1.99100E-1, 0.00000E+0, 0.00000E+0,1.00000,1,
100.0,    48.000,     0.000,   1,1.0000
583120,'2 ',   100.000,     4.000,     4.000,     4.000,1.00000,     0,   100.000, 5.00000E-3, 1.99100E-1, 0.00000E+0,
0.00000E+0,1.00000,1,  100.0,   100.000,     0.000,   1,1.0000
583123,'1 ',   150.000,     6.000,     6.000,     6.000,1.00000,     0,   150.000, 5.00000E-3, 1.99100E-1, 0.00000E+0,
0.00000E+0,1.00000,1,  100.0,   150.000,     0.000,   1,1.0000
0 / END OF GENERATOR DATA, BEGIN BRANCH DATA
514901,583127,'1 ', 6.54900E-4, 6.11830E-3,   0.10251,  956.00,  956.00,    0.00,  0.00000,  0.00000,  0.00000,  0.00000,1,1,  12.09,
524,1.0000
515605,583127,'1 ', 4.55100E-4, 4.25170E-3,   0.07124,  956.00,  956.00,    0.00,  0.00000,  0.00000,  0.00000,  0.00000,1,2,   8.41,
524,1.0000
583121,583122,'1 ', 7.82900E-3, 4.49000E-3,   0.05839,    0.00,    0.00,    0.00,  0.00000,  0.00000,  0.00000,  0.00000,1,1,   0.00,
1,1.0000
583124,583125,'1 ', 5.06300E-3, 4.50000E-3,   0.04066,    0.00,    0.00,    0.00,  0.00000,  0.00000,  0.00000,  0.00000,1,1,   0.00,
1,1.0000
583126,583420,'1 ', 7.60000E-4, 5.76000E-3,   0.12734,    0.00,    0.00,    0.00,  0.00000,  0.00000,  0.00000,  0.00000,1,2,  12.67,
524,1.0000
583127,583420,'1 ', 7.60000E-5, 7.08000E-4,   0.01180,    0.00,    0.00,    0.00,  0.00000,  0.00000,  0.00000,  0.00000,1,1,   1.40,
524,1.0000
0 / END OF BRANCH DATA, BEGIN TRANSFORMER DATA
583121,583120,     0,'1 ',1,2,1, 0.00000E+0, 0.00000E+0,2,'            ',1,   1,1.0000
 8.40000E-3, 9.31200E-2,   155.40
1.00000,   0.000,   0.000,   148.00,   148.00,     0.00, 0,      0, 1.10000, 0.90000, 1.10000, 0.90000,   5, 0, 0.00000, 0.00000,  0.000
1.00000,   0.000
583122,583126,     0,'1 ',1,2,1, 0.00000E+0, 0.00000E+0,2,'            ',1,   1,1.0000
 4.37100E-3, 1.04910E-1,   100.00
1.00000,   0.000,   0.000,   167.00,   167.00,   167.00, 0,      0, 1.10000, 0.90000, 1.10000, 0.90000,  33, 0, 0.00000, 0.00000,  0.000
1.00000,   0.000
583124,583123,     0,'1 ',1,2,1, 0.00000E+0, 0.00000E+0,2,'            ',1,   1,1.0000
 8.40000E-3, 9.31200E-2,   157.50
1.00000,   0.000,   0.000,   150.00,   150.00,     0.00, 0,      0, 1.10000, 0.90000, 1.10000, 0.90000,   5, 0, 0.00000, 0.00000,  0.000
1.00000,   0.000
583125,583126,     0,'1 ',1,2,1, 0.00000E+0, 0.00000E+0,2,'            ',1,   1,1.0000
 4.37100E-3, 1.04910E-1,   100.00
1.00000,   0.000,   0.000,   167.00,   167.00,   167.00, 0,      0, 1.10000, 0.90000, 1.10000, 0.90000,  33, 0, 0.00000, 0.00000,  0.000
1.00000,   0.000
0 / END OF TRANSFORMER DATA, BEGIN AREA DATA
0 / END OF AREA DATA, BEGIN TWO-TERMINAL DC DATA
0 / END OF TWO-TERMINAL DC DATA, BEGIN VSC DC LINE DATA
0 / END OF VSC DC LINE DATA, BEGIN IMPEDANCE CORRECTION DATA
0 / END OF IMPEDANCE CORRECTION DATA, BEGIN MULTI-TERMINAL DC DATA
0 / END OF MULTI-TERMINAL DC DATA, BEGIN MULTI-SECTION LINE DATA
```

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0 / END OF MULTI-SECTION LINE DATA, BEGIN ZONE DATA
0 / END OF ZONE DATA, BEGIN INTER-AREA TRANSFER DATA
0 / END OF INTER-AREA TRANSFER DATA, BEGIN OWNER DATA
0 / END OF OWNER DATA, BEGIN FACTS DEVICE DATA
0 / END OF FACTS DEVICE DATA, BEGIN SWITCHED SHUNT DATA
0 / END OF SWITCHED SHUNT DATA, BEGIN GNE DATA
0 / END OF GNE DATA
Q
```

PSS/E 32 Dynamics Data

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/*******************************************************************************
/
/ ***** GEN-2011-054 Project *****
/
/
/
/
/ Vestas 2.0MW V100 VCSS 2.0 MW 60 Hz Mk10 & Vestas 2.0MW V110 VCSS 2.0 MW 60 Hz Mk10 (VestasWT_7_6_0_PSSE32.lib)
/ V100 VCSS 2.0 MW 60 Hz Mk10
583120 '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 583120 '1'  /
0 'USRMDL' 0 'VWLVR6' 8 0 3 65 10 35 583120 '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 583120 '1' 1
 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 583120 '1'
 2000.0000 422.2301 4736.7543 569.9822 106.4850 7976.7600 50.7400
 0.0000 0.0000 0.0000 /
0 'USRMDL' 0 'VWMEA6' 8 0 2 10 8 5 583120 '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 583120 '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 583120 '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 /
/ V110 VCSS 2.0 MW 60 Hz Mk10
583120 'USRMDL' '2'  '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 583120 '2'  /
0 'USRMDL' 0 'VWLVR6' 8 0 3 65 10 35 583120 '2' 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 583120 '2' 1
 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 583120 '2'
 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 583120 '2'
 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 583120 '2'  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 583120 '2'  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 /
/ V100 VCSS 2.0 MW 60 Hz Mk10
583123 '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 583123 '1'  /
0 'USRMDL' 0 'VWLVR6' 8 0 3 65 10 35 583123 '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 583123 '1' 1
 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 583123 '1'
 2000.0000 422.2301 4736.7543 569.9822 106.4850 7976.7600 50.7400
 0.0000 0.0000 0.0000 /
0 'USRMDL' 0 'VWMEA6' 8 0 2 10 8 5 583123 '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 583123 '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 583123 '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 /
/*****************************************************************************
```