GEN-2008-047
Impact Restudy for Generator Modification (Turbine Change)

May 2014
Generator Interconnection

Southwest Power Pool

Executive Summary

The GEN-2008-047 interconnection customer has requested a system impact restudy to determine the effects of changing wind turbine generators from the previously studied GE 1.5MW wind turbine generators to GE 1.7MW wind turbine generators.

In this restudy the project uses one-hundred seventy-six (176) GE 1.7MW wind turbine generators for an aggregate power of 299.2MW. The point of interconnection (POI) for GEN-2008-047 is at the Oklahoma Gas and Electric (OKGE) Beaver County 345kV Substation. The interconnection customer has provided documentation that shows the GE 1.7MW wind turbine generators have a reactive capability of 0.90 lagging (providing VARS) and 0.90 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.

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 1.7MW 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. Additionally, the project will be required to install approximately 35.6Mvar of reactor shunts at its 345kV substation or provide an equivalent source of reactive compensation. 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. It is the customer’s responsibility to determine, with the reactive capabilities of the GE 1.7MW wind turbines, if the generation facility will require external capacitor banks, shunt reactors, or other reactive equipment to meet the power factor and MVAR flow requirements at the POI.

With the assumptions outlined in this report and with all the required network upgrades from the GEN-2008-047 GIA in place, GEN-2008-047 with the GE 1.7MW wind turbine generators should be able to reliably interconnect 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-2008-047 Impact Restudy is a generation interconnection study performed to evaluate the impacts of interconnecting the project shown in Table I-1. The in-service date assumed for the generation addition was December 31, 2014. This restudy is for a change from GE 1.5MW to GE 1.7MW wind turbines.

Table I-1: Interconnection Request

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2008-047	299.2	GE 1.7MW	Beaver County 345kV (580500)

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

Table I-2: Prior Queued Interconnection Requests

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2002-008	240	GE 1.5MW	Hitchland 345kV (523097)
GEN-2002-009	79.8	Suzlon S88 2.1MW	Hansford 115kV (523195)
GEN-2003-020	159.1	GE 1.5MW & 1.6MW	Martin 115kV (523928)
GEN-2006-020S	20	DeWind 2.0MW	Tap on the Hitchland – Lasley 115kV (523160)
GEN-2006-044	370	DeWind 2.0MW	Hitchland 345kV (523097)
GEN-2007-046	200	Vestas 2.0MW	Hitchland 115kV (523093)
GEN-2010-014	358.8	Siemens 2.3MW	Hitchland 345kV (523097)

The lower-queued requests shown in Table I-3 were included in this study and the wind and solar farms were dispatched to 100% of rated capacity.

Table I-3: Lower Queued Interconnection Requests

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2010-001	300	Vestas 2.0MW	Beaver County 345kV (580500)
ASGI-2011-002	20	DeWind 2.0MW	Herring 115kV (523359)
GEN-2011-014	201	Siemens 3.0MW	Beaver County 345kV (580500)
GEN-2011-022	299	Siemens 2.3MW	Hitchland 345kV (523097)
GEN-2013-030	300	Vestas 2.0MW	Beaver County 345kV (580500)

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.

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

In this restudy the project uses one-hundred seventy-six (176) GE 1.7MW wind turbine generators for an aggregate power of 299.2MW. The POI for GEN-2008-047 is at the OKGE Beaver County 345kV Substation. The interconnection customer has provided documentation that shows the GE 1.7MW wind turbine generators have a reactive capability of 0.90 lagging (providing VARS) and 0.90 leading (absorbing VARS) power factor.

A one-line drawing for the GEN-2008-047 generation interconnection request is shown in Figure II-1. The POI is the OG&E Beaver County 345kV substation.

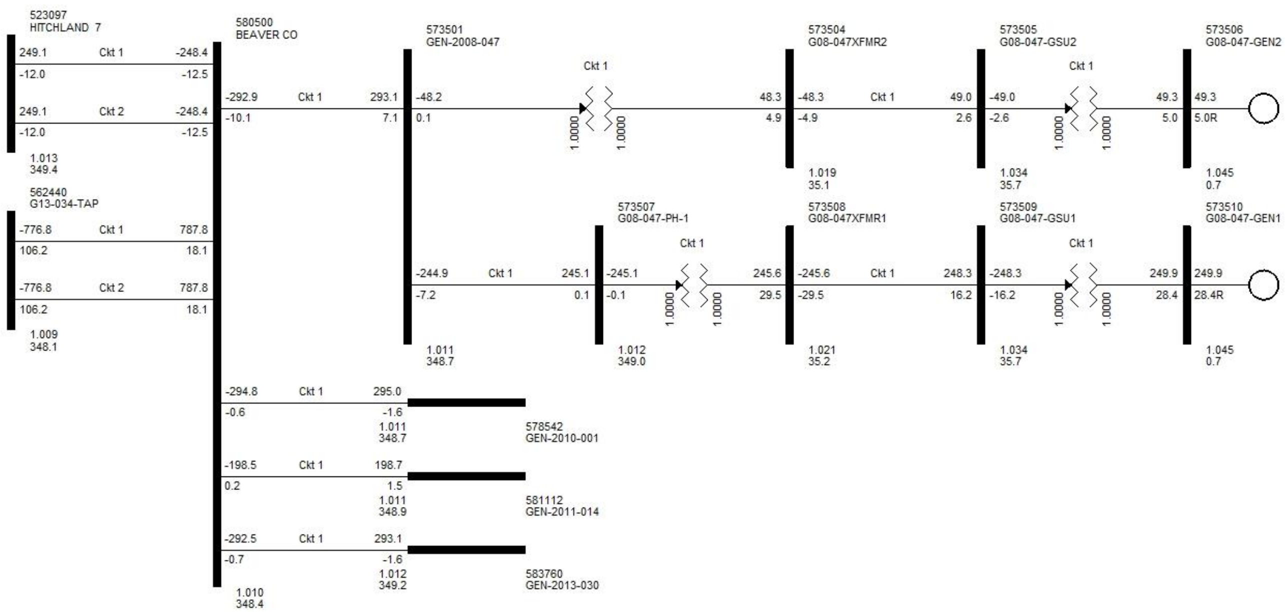

Figure II-1: GEN-2008-047 One-line Diagram

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, 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

One-hundred five (105) 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_HITCHLAND7_FINNEY7_345kV_3PH	3 phase fault on the Finney (523853) to Hitchland (523097) 345kV CKT near Hitchland. a. Apply fault at the Hitchland 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_HITCHLAND7_FINNEY7_345kV_1PH	Single phase fault and sequence like previous
3	FLT_03_FINNEY7_HOLCOMB7_345kV_3PH	3 phase fault on the Finney (523853) to Holcomb (531449) 345kV CKT near Finney. a. Apply fault at the Finney 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
4	FLT_04_FINNEY7_HOLCOMB7_345kV_1PH	Single phase fault and sequence like previous
5	FLT_05_HOLCOMB7_SETAB7_345kV_3PH	3 phase fault on the Holcomb (531449) to Setab (531465) 345kV CKT near Holcomb. a. Apply fault at the Holcomb 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
6	FLT_06_HOLCOMB7_SETAB7_345kV_1PH	Single phase fault and sequence like previous
7	FLT_07_HOLCOMB7_BUCKNER7_345kV_3PH	3 phase fault on the Buckner (531501) to Holcomb (531449) 345kV CKT near Holcomb. a. Apply fault at the Holcomb 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
8	FLT_08_HOLCOMB7_BUCKNER7_345kV_1PH	Single phase fault and sequence like previous
9	FLT_09_BUCKNER7_SPERVIL7_345kV_3PH	3 phase fault on the Buckner (531501) to Spearville (531469) 345kV CKT near Buckner. a. Apply fault at the Buckner 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
10	FLT_10_BUCKNER7_SPERVIL7_345kV_1PH	Single phase fault and sequence like previous
11	FLT_11_HITCHLAND7_POTTERCO7_345kV_3PH	3 phase fault on the Hitchland (523097) to Potter County (523961) 345kV CKT near Hitchland. a. Apply fault at the Hitchland 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_HITCHLAND7_POTTERCO7_345kV_1PH	Single phase fault and sequence like previous

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
13	FLT_13_HITCHLAND7_BEAVERCO_345kV_3PH	3 phase fault on the Beaver County (580500) to Hitchland (523097) 345kV CKT near Hitchland. a. Apply fault at the Hitchland 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_HITCHLAND7_BEAVERCO_345kV_1PH	Single phase fault and sequence like previous
15	FLT_15_BEAVERCO_HITCHLAND7_345kV_3PH	3 phase fault on the Beaver County (580500) to Hitchland (523097) 345kV CKT near Beaver County. a. Apply fault at the Beaver County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
16	FLT_16_BEAVERCO_HITCHLAND7_345kV_1PH	Single phase fault and sequence like previous
17	FLT_17_BEAVERCO_G13034TAP_345kV_3PH	3 phase fault on the Beaver County (580500) to GEN-2013-034-Tap (562440) 345kV CKT near Beaver County. a. Apply fault at the Beaver County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
18	FLT_18_BEAVERCO_G13034TAP_345kV_1PH	Single phase fault and sequence like previous
19	FLT_19_G13034TAP_WWRDEHV7_345kV_3PH	3 phase fault on the GEN-2013-034-Tap (562440) to Woodward (515375) 345kV CKT near GEN-2013-034-Tap. a. Apply fault at the GEN-2013-034-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.
20	FLT_20_G13034TAP_WWRDEHV7_345kV_1PH	Single phase fault and sequence like previous
21	FLT_21_WWRDEHV7_BORDER7_345kV_3PH	3 phase fault on the Border (515458) to Woodward (515375) 345kV CKT near Woodward. a. Apply fault at the Woodward 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_WWRDEHV7_BORDER7_345kV_1PH	Single phase fault and sequence like previous
23	FLT_23_WWRDEHV7_THISTLE7_345kV_3PH	3 phase fault on the Thistle (539801) to Woodward (515375) 345kV CKT near Woodward. a. Apply fault at the Woodward 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_WWRDEHV7_THISTLE7_345kV_1PH	Single phase fault and sequence like previous

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
25	FLT_25_THISTLE7_WICHITA7_345kV_3PH	3 phase fault on the Thistle (539801) to Wichita (532796) 345kV CKT near 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.
26	FLT_26_THISTLE7_WICHITA7_345kV_1PH	Single phase fault and sequence like previous
27	FLT_27_THISTLE7_CLARKCOUNTY7_345kV_3PH	3 phase fault on the Clark County (539800) to Thistle (539801) 345kV CKT near Thistle. a. Apply fault at the Thistle 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
28	FLT_28_THISTLE7_CLARKCOUNTY7_345kV_1PH	Single phase fault and sequence like previous
29	FLT_29_WWRDEHV7_G11051TAP_345kV_3PH	3 phase fault on the GEN-2011-051-Tap (562075) to Woodward (515375) 345kV CKT near Woodward. a. Apply fault at the Woodward 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_WWRDEHV7_G11051TAP_345kV_1PH	Single phase fault and sequence like previous
31	FLT_31_TATONGA7_NORTWST7_345kV_3PH	3 phase fault on the Northwest (514880) to Tatonga (515407) 345kV CKT near 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.
32	FLT_32_TATONGA7_NORTWST7_345kV_1PH	Single phase fault and sequence like previous
33	FLT_33_HOLCOMB7_HOLCOMB3_345_115kV_3PH	3 phase fault on the Holcomb 345kV (531449) to 115kV (531448)/13.8kV (531450) transformer at the 345kV bus. a. Apply fault at the Holcomb 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer
34	FLT_34_POTTERCO7_POTTERCO6_345_230kV_3PH	3 phase fault on the Potter County 345kV (523961) to 230kV (523959)/13.2kV (523957) transformer at the 345kV bus. a. Apply fault at the Potter County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer
35	FLT_35_HITCHLAND7_HITCHLAND6_345_230kV_3PH	3 phase fault on the Hitchland 345kV (523097) to 115kV (523095)/13.2kV (523091) transformer at the 345kV bus. a. Apply fault at the Hitchland 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer
36	FLT_36_WWRDEHV7_WWRDEHV4_345_138kV_3PH	3 phase fault on the Woodward 345kV (515375) to 138kV (515376)/13.8kV (515795) transformer at the 345kV bus. a. Apply fault at the Woodward 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
37	FLT_37_HITCHLAND6_OCHILTREE6_230kV_3PH	3 phase fault on the Hitchland (523095) to Ochiltree (523155) 230kV CKT near Hitchland. a. Apply fault at the Hitchland 230kV 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_HITCHLAND6_OCHILTREE6_230kV_1PH	Single phase fault and sequence like previous
39	FLT_39_HITCHLAND6_MOORECNTY6_230kV_3PH	3 phase fault on the Hitchland (523095) to Moore County (523309) 230kV CKT near Hitchland. a. Apply fault at the Hitchland 230kV 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_HITCHLAND6_MOORECNTY6_230kV_1PH	Single phase fault and sequence like previous
41	FLT_41_POTTERCO6_MOORECNTY6_230kV_3PH	3 phase fault on the Moore County (523309) to Potter County (523959) 230kV CKT near Potter County. a. Apply fault at the Potter County 230kV 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_POTTERCO6_MOORECNTY6_230kV_1PH	Single phase fault and sequence like previous
43	FLT_43_POTTERCO6_HARRNGEST6_230kV_3PH	3 phase fault on the Harrington East (523979) to Potter County (523959) 230kV CKT near Potter County. a. Apply fault at the Potter County 230kV 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_POTTERCO6_HARRNGEST6_230kV_1PH	Single phase fault and sequence like previous
45	FLT_45_POTTERCO6_ROLLHILLS6_230kV_3PH	3 phase fault on the Rolling Hills (524010) to Potter County (523959) 230kV CKT near Potter County. a. Apply fault at the Potter County 230kV 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_POTTERCO6_ROLLHILLS6_230kV_1PH	Single phase fault and sequence like previous
47	FLT_47_POTTERCO6_BUSHLAND6_230kV_3PH	3 phase fault on the Bushland (524267) to Potter County (523959) 230kV CKT near Potter County. a. Apply fault at the Potter County 230kV 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.
48	FLT_48_POTTERCO6_BUSHLAND6_230kV_1PH	Single phase fault and sequence like previous

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
49	FLT_49_POTTERCO6_PLANTX6_230kV_3PH	3 phase fault on the Plant X (525481) to Potter County (523959) 230kV CKT near Potter County. a. Apply fault at the Potter County 230kV 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.
50	FLT_50_POTTERCO6_PLANTX6_230kV_1PH	Single phase fault and sequence like previous
49a	FLT_49_POTTERCO6_NEWHART6_230kV_3PH	3 phase fault on the New Hart (525461) to Potter County (523959) 230kV CKT near Potter County. a. Apply fault at the Potter County 230kV 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.
50a	FLT_50_POTTERCO6_NEWHART6_230kV_1PH	Single phase fault and sequence like previous
51	FLT_51_MOORECNTY6_MOOREE3_230_115kV_3PH	3 phase fault on the Moore County 230kV (523309) to 115kV (523308)/13.2kV (523302) transformer at the 230kV bus. a. Apply fault at the Moore County 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer
52	FLT_52_POTTERCO6_POTTERCO3_230_115kV_3PH	3 phase fault on the Potter County 230kV (523959) to 115kV (523951)/13.2kV (523950) transformer at the 230kV bus. a. Apply fault at the Potter County 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer
52a	FLT_52_NEWHART6_NEWHART3_230_115kV_3PH	3 phase fault on the New Hart 230kV (525461) to 115kV (525460)/13.2kV (525459) transformer at the 230kV bus. a. Apply fault at the New Hart 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer
53	FLT_53_WWRDEHV4_WOODWRD4_138kV_3PH	3 phase fault on the Woodward (514785) to Woodward EHV (515376) 138kV CKT near Woodward EHV. a. Apply fault at the Woodward EHV 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.
54	FLT_54_WWRDEHV4_WOODWRD4_138kV_1PH	Single phase fault and sequence like previous
55	FLT_55_WWRDEHV4_IODINE4_138kV_3PH	3 phase fault on the Iodine (514786) to Woodward EHV (515376) 138kV CKT near Woodward EHV. a. Apply fault at the Woodward EHV 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.
56	FLT_56_WWRDEHV4_IODINE4_138kV_1PH	Single phase fault and sequence like previous
57	FLT_57_HANSFORD3_HITCHLAND3_115kV_3PH	3 phase fault on the Hansford (523195) to Hitchland (523093) 115 kV CKT near Hansford. a. Apply fault at the Hansford 115kV 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
58	FLT_58_HANSFORD3_HITCHLAND3_115kV_1PH	Single phase fault and sequence like previous
59	FLT_59_HANSFORD3_SPEARMAN3_115kV_3PH	3 phase fault on the Hansford (523195) to Spearman (523186) 115 kV CKT near Hansford. a. Apply fault at the Hansford 115kV 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.
60	FLT_60_HANSFORD3_SPEARMAN3_115kV_1PH	Single phase fault and sequence like previous
61	FLT_61_MARTIN3_HUTCHS3_115kV_3PH	3 phase fault on the Hutchinson South (523546) to Martin (523928) 115 kV CKT near Martin. a. Apply fault at the Martin 115kV 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.
62	FLT_62_MARTIN3_HUTCHS3_115kV_1PH	Single phase fault and sequence like previous
63	FLT_63_MARTIN3_PANTEXN3_115kV_3PH	3 phase fault on the Martin (523928) to Pantex North (523938) 115 kV CKT near Martin. a. Apply fault at the Martin 115kV 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.
64	FLT_64_MARTIN3_PANTEXN3_115kV_1PH	Single phase fault and sequence like previous
65	FLT_65_FRISCOWND3_HITCHLAND3_115kV_3PH	3 phase fault on the Frisco Wind (523160) to Hitchland (523093) 115 kV CKT near Frisco Wind. a. Apply fault at the Frisco Wind 115kV 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.
66	FLT_66_FRISCOWND3_HITCHLAND3_115kV_1PH	Single phase fault and sequence like previous
67	FLT_67_FRISCOWND3_LASLEY3_115kV_3PH	3 phase fault on the Frisco Wind (523160) to Lasley (523175) 115 kV CKT near Frisco Wind. a. Apply fault at the Frisco Wind 115kV 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.
68	FLT_68_FRISCOWND3_LASLEY3_115kV_1PH	Single phase fault and sequence like previous
69	FLT_69_HITCHLAND3_TEXASCNTY3_115kV_3PH	3 phase fault on the Hitchland (523093) to Texas County (523090) 115 kV line, at Hitchland. a. Apply fault at the Hitchland 115kV 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.
70	FLT_70_HITCHLAND3_TEXASCNTY3_115kV_1PH	Single phase fault and sequence like previous

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
71	FLT_71_HITCHLAND3_FRISCOWND3_115kV_3PH	3 phase fault on the Hitchland (523093) to Frisco Wind (523160) 115 kV line, at Hitchland. a. Apply fault at the Hitchland 115kV 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.
72	FLT_72_HITCHLAND3_FRISCOWND3_115kV_1PH	Single phase fault and sequence like previous
73	FLT_73_HITCHLAND3_HANSFORD3_115kV_3PH	3 phase fault on the Hansford (523195) to Hitchland (523093) 115 kV CKT near Hitchland. a. Apply fault at the Hitchland 115kV 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.
74	FLT_74_HITCHLAND3_HANSFORD3_115kV_1PH	Single phase fault and sequence like previous
75	FLT_75_HERRINGTP3_RBSNEED3_115kV_3PH	3 phase fault on the Herring Tap (523352) to Sneed (523366) 115 kV CKT near Herring Tap. a. Apply fault at the Herring Tap 115kV 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.
76	FLT_76_HERRINGTP3_RBSNEED3_115kV_1PH	Single phase fault and sequence like previous
77	FLT_77_HERRINGTP3_RIVERVIEW3_115kV_3PH	3 phase fault on the Herring Tap (523352) to River View (523377) 115 kV CKT near Herring Tap. a. Apply fault at the Herring Tap 115kV 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.
78	FLT_78_HERRINGTP3_RIVERVIEW3_115kV_1PH	Single phase fault and sequence like previous
79	FLT_79_HITCHLAND3_HITCHLAND6_115_230kV_3PH	3 phase fault on the Hitchland 230kV (523095) to 115kV (523093)/13.2kV (523092) transformer at the 115kV bus. a. Apply fault at the Hitchland 115kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer
80	FLT_80_P4BEAVHITCBEAV_G13034TAP_345kV_1PH	**Stuck Breaker at Beaver County 345kV.** Single phase fault on the Beaver County (580500) to GEN-2013-034-Tap (562440) 345KV CKT 1 near Beaver County. a. Apply fault at the Beaver County 345kV bus. b. Clear fault after 16 cycles by tripping the faulted line. c. Trip Beaver County (580500) to Hitchland (523097) 345kV CKT 1.
81	FLT_81_P4BEAVHITCHITC_HITCHLAND6_345_230kV_1PH	**Stuck Breaker at Hitchland 345kV.** Single phase fault on the Beaver County (580500) to Hitchland (523097) 345KV CKT 1 near Hitchland. a. Apply fault at the Hitchland 345kV bus. b. Clear fault after 16 cycles by tripping the faulted line. c. Trip Hitchland 345kV (523097) to 230kV (523095)/13.2kV (523091) Transformer.

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
82	FLT_82_P4BEAVG1334TG1334T_WWRDEHV7_345kV_1PH	**Stuck Breaker at GEN-2013-034-Tap 345kV.** Single phase fault on the Beaver County (580500) to GEN-2013-034-Tap (562440) 345KV CKT 1 near GEN-2013-034-Tap. a. Apply fault at the GEN-2013-034-Tap 345kV bus. b. Clear fault after 16 cycles by tripping the faulted line. c. Trip GEN-2013-034-Tap (562440) to Woodward (515375) 345kV CKT 1.
83	FLT_83_P4WWRDTHISWWRD_G11051TAP_345kV_1PH	**Stuck Breaker at Woodward 345kV.** Single phase fault on the GEN-2011-051-Tap (562075) to Woodward (515375) 345KV CKT 1 near Woodward. a. Apply fault at the Woodward 345kV bus. b. Clear fault after 16 cycles by tripping the faulted line. c. Trip Thistle (539801) to Woodward (515375) 345kV CKT 1.
84	FLT_84_P6DBLG13034TAP_BEAVERCO_345kV_3PH	**Prior Outage of Beaver County to GEN-2013-034-Tap 345kV CKT 1.** 3 phase fault on the Beaver County (580500) to GEN-2013-034-Tap 345KV (562440) CKT 2 near GEN-2013-034-Tap. a. Apply fault at the GEN-2013-034-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.
84a	FLT_84_P6DBLG13034TAP_BEAVERCO_345kV_3PH_Scaled	**Reduce area generation and Prior Outage of Beaver County to GEN-2013-034-Tap 345kV CKT 1.** 3 phase fault on the Beaver County (580500) to GEN-2013-034-Tap 345KV (562440) CKT 2 near GEN-2013-034-Tap. a. Apply fault at the GEN-2013-034-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.
85	FLT_85_P7DBLG13034TAP_BEAVERCO_345kV_1PH	**Outage of Beaver County to GEN-2013-034-Tap 345kV CKT 1 & 2.** Single phase fault on the Beaver County (580500) to GEN-2013-034-Tap (562440) 345KV CKT 1 & 2 near GEN-2013-034-Tap. a. Apply fault at the GEN-2013-034-Tap 345kV bus. b. Clear fault after 5 cycles by tripping the faulted lines. c. Wait 20 cycles, and then re-close the lines in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the lines in (b) and remove fault.
85a	FLT_85_P7DBLG13034TAP_BEAVERCO_345kV_1PH_Scaled	**Reduce area generation and Outage of Beaver County to GEN-2013-034-Tap 345kV CKT 1 & 2.** Single phase fault on the Beaver County (580500) to GEN-2013-034-Tap (562440) 345KV CKT 1 & 2 near GEN-2013-034-Tap. a. Apply fault at the GEN-2013-034-Tap 345kV bus. b. Clear fault after 5 cycles by tripping the faulted lines. c. Wait 20 cycles, and then re-close the lines in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the lines in (b) and remove fault.
86	FLT_86_P6DBLBEAVERCO_HITCHLAND7_345kV_3PH	**Prior Outage of Beaver County to Hitchland 345kV CKT 1.** 3 phase fault on the Beaver County (580500) to Hitchland (523097) 345KV CKT 2 near Beaver County. a. Apply fault at the Beaver County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
87	FLT_87_P7DBLBEAVERCO_HITCHLAND7_345kV_1PH	**Outage of Beaver County to Hitchland 345kV CKT 1 & 2.** Single phase fault on the Beaver County (580500) to Hitchland (532097) 345KV CKT 1 & 2 near Beaver County. a. Apply fault at the Beaver County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted lines. c. Wait 20 cycles, and then re-close the lines in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the lines in (b) and remove fault.
88	FLT_88_P6DBLG13034TAP_WWRDEHV7_345kV_3PH	**Prior Outage of GEN-2013-034-Tap to Woodward 345kV CKT 1.** 3 phase fault on the GEN-2013-034-Tap (562440) to Woodward (515375) 345KV CKT 2 near GEN-2013-034-Tap. a. Apply fault at the GEN-2013-034-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.
88a	FLT_88_P6DBLG13034TAP_WWRDEHV7_345kV_3PH_Scaled	**Reduce area generation and Prior Outage of GEN-2013-034-Tap to Woodward 345kV CKT 1.** 3 phase fault on the GEN-2013-034-Tap (562440) to Woodward (515375) 345KV CKT 2 near GEN-2013-034-Tap. a. Apply fault at the GEN-2013-034-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.
89	FLT_89_P7DBLG13034TAP_WWRDEHV7_345kV_1PH	**Outage of GEN-2013-034-Tap to Woodward 345kV CKT 1 & 2.** Single phase fault on the GEN-2013-034-Tap (562440) to Woodward (515375) 345KV CKT 1 & 2 near GEN-2013-034-Tap. a. Apply fault at the GEN-2013-034-Tap 345kV bus. b. Clear fault after 5 cycles by tripping the faulted lines. c. Wait 20 cycles, and then re-close the lines in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the lines in (b) and remove fault.
89a	FLT_89_P7DBLG13034TAP_WWRDEHV7_345kV_1PH_Scaled	**Reduce area generation and Outage of GEN-2013-034-Tap to Woodward 345kV CKT 1 & 2.** Single phase fault on the GEN-2013-034-Tap (562440) to Woodward (515375) 345KV CKT 1 & 2 near GEN-2013-034-Tap. a. Apply fault at the GEN-2013-034-Tap 345kV bus. b. Clear fault after 5 cycles by tripping the faulted lines. c. Wait 20 cycles, and then re-close the lines in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the lines in (b) and remove fault.
90	FLT_90_P6DBLWWRDEHV7_THISTLE7_345kV_3PH	**Prior Outage of Thistle to Woodward 345kV CKT 1.** 3 phase fault on the Thistle (539801) to Woodward (515375) 345KV CKT 2 near Woodward. a. Apply fault at the Woodward 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
91	FLT_91_P7DBLWWRDEHV7_THISTLE7_345kV_1PH	**Outage of Thistle to Woodward 345kV CKT 1 & 2.** Single phase fault on the Thistle (539801) to Woodward (515375) 345KV CKT 1 & 2 near Woodward. a. Apply fault at the Woodward 345kV bus. b. Clear fault after 5 cycles by tripping the faulted lines. c. Wait 20 cycles, and then re-close the lines in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the lines in (b) and remove fault.
92	FLT_92_P6DBLTHISTLE7_WICHITA7_345kV_3PH	**Prior Outage of Thistle to Wichita 345kV CKT 1.** 3 phase fault on the Thistle (539801) to Wichita (532796) 345KV CKT 2 near Thistle. a. Apply fault at the Thistle 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the lines in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the lines in (b) and remove fault.
93	FLT_93_P7DBLTHISTLE7_WICHITA7_345kV_1PH	**Outage of Thistle to Wichita 345kV CKT 1 & 2.** Single phase fault on the Thistle (539801) to Wichita (532796) 345KV CKT 1 & 2 near Thistle. a. Apply fault at the Thistle 345kV bus. b. Clear fault after 5 cycles by tripping the faulted lines. c. Wait 20 cycles, and then re-close the lines in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the lines in (b) and remove fault.
94	FLT_94_P6DBLTHISTLE7_CLARKCOUNTY7_345kV_3PH	**Prior Outage of Clark County to Thistle 345kV CKT 1.** 3 phase fault on the Clark County (539800) to Thistle (539801) 345KV CKT 2 near Thistle. a. Apply fault at the Thistle 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the lines in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the lines in (b) and remove fault.
95	FLT_95_P7DBLTHISTLE7_CLARKCOUNTY7_345kV_1PH	**Outage of Clark County to Thistle 345kV CKT 1 & 2.** Single phase fault on the Clark County (539800) to Thistle 345KV (539801) CKT 1 & 2 near Thistle. a. Apply fault at the Thistle 345kV bus. b. Clear fault after 5 cycles by tripping the faulted lines. c. Wait 20 cycles, and then re-close the lines in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the lines in (b) and remove fault.
96	FLT_96_P6DBLWWRDEHV7_WWRDEHV4_345_138kV_3PH	**Prior Outage of Woodward 345kV/138kV Transformer CKT 1.** 3 phase fault on the Woodward 345KV (515375) to 138kV (515376) to 13.8kV (515799) CKT 2 near Woodward 345kV. a. Apply fault at the Woodward 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
97	FLT_97_P7DBLWWRDEHV7_WWRDEHV4_345_138kV_1PH	**Outage of Woodward 345kV/138kV Transformer CKT 1 & 2.** Single phase fault on the Woodward 345kV (515375) to 138kV (515376) Transformer CKT 1 & 2 near Woodward 345kV. a. Apply fault at the Woodward 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformers.

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
98	FLT_98_P6TNGANWSTWWRD_BORDER7_345kV_3PH	**Prior Outage of Northwest (514880) to Tatonga (515407) 345kV CKT 1.** 3 phase fault on the Border (515458) to Woodward (515375) 345KV CKT 1 near Woodward. a. Apply fault at the Woodward 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.
99	FLT_99_P7TNGANWSTWWRD_BORDER7_345kV_1PH	**Prior Outage of Northwest (514880) to Tatonga (515407) 345kV CKT 1.** Single phase fault on the Border (515458) to Woodward (515375) 345KV CKT 1 near Woodward. a. Apply fault at the Woodward 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.
100	FLT_100_P6TNGANWSTWWRD_THISTLE7_345kV_3PH	**Prior Outage of Northwest (514880) to Tatonga (515407) 345kV CKT 1.** 3 phase fault on the Thistle (539801) to Woodward (515375) 345KV CKT 1 near Woodward. a. Apply fault at the Woodward 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.
101	FLT_101_P7TNGANWSTWWRD_THISTLE7_345kV_1PH	**Prior Outage of Northwest (514880) to Tatonga (515407) 345kV CKT 1.** Single phase fault on the Thistle (539801) to Woodward (515375) 345KV CKT 1 near Woodward. a. Apply fault at the Woodward 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.
102	FLT_102_P6TNGANWSTWWRD_G13034TAP_345kV_3PH	**Prior Outage of Northwest (514880) to Tatonga (515407) 345kV CKT 1.** 3 phase fault on the GEN-2013-034-Tap (562440) to Woodward (515375) 345KV CKT 1 near Woodward. a. Apply fault at the Woodward 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.
103	FLT_103_P7TNGANWSTWWRD_G13034TAP_345kV_1PH	**Prior Outage of Northwest (514880) to Tatonga (515407) 345kV CKT 1.** Single phase fault on the GEN-2013-034-Tap (562440) to Woodward (515375) 345KV CKT 1 near Woodward. a. Apply fault at the Woodward 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.
104	FLT_104_P6DBLWWRDEHV4_WOODWRD4_138kV_3PH	**Prior Outage of Woodward to Woodward EHV 138kV CKT 1.** 3 phase fault on the Woodward (514785) to Woodward EHV (515376) 138kV CKT 2 near Woodward EHV. a. Apply fault at the Woodward EHV 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
105	FLT_105_P7DBLWWRDEHV4_ WOODWRD4_138kV_1PH	**Outage of Woodward to Woodward EHV 138kV CKT 1 & 2.** Single phase fault on the Woodward (514785) to Woodward EHV (515376) 138kV CKT 1 & 2 near Woodward EHV. a. Apply fault at the Woodward EHV 138kV bus. b. Clear fault after 5 cycles by tripping the faulted lines. c. Wait 20 cycles, and then re-close the lines in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the lines in (b) and remove fault.

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-2008-047 did not cause any stability problems and remained stable for all single contingency faults studied. No generators tripped or went unstable, and voltages recovered to acceptable levels.

Oscillations were observed for multi-element faults along the Hitchland-Woodward 345kV corridor. It was determined that curtailment of generation would alleviate these oscillations. These oscillations are not caused by the request to modify wind generators.

Table III-2: Stability Analysis Results

	Contingency Number and Description	2014WP	2015SP	2024SP
1	FLT_01_HITCHLAND7_FINNEY7_345kV_3PH	OK	OK	OK
2	FLT_02_HITCHLAND7_FINNEY7_345kV_1PH	OK	OK	OK
3	FLT_03_FINNEY7_HOLCOMB7_345kV_3PH	OK	OK	OK
4	FLT_04_FINNEY7_HOLCOMB7_345kV_1PH	OK	OK	OK
5	FLT_05_HOLCOMB7_SETAB7_345kV_3PH	OK	OK	OK
6	FLT_06_HOLCOMB7_SETAB7_345kV_1PH	OK	OK	OK
7	FLT_07_HOLCOMB7_BUCKNER7_345kV_3PH	OK	OK	OK
8	FLT_08_HOLCOMB7_BUCKNER7_345kV_1PH	OK	OK	OK
9	FLT_09_BUCKNER7_SPERVIL7_345kV_3PH	OK	OK	OK
10	FLT_10_BUCKNER7_SPERVIL7_345kV_1PH	OK	OK	OK
11	FLT_11_HITCHLAND7_POTTERCO7_345kV_3PH	OK	OK	OK
12	FLT_12_HITCHLAND7_POTTERCO7_345kV_1PH	OK	OK	OK
13	FLT_13_HITCHLAND7_BEAVERCO_345kV_3PH	OK	OK	OK
14	FLT_14_HITCHLAND7_BEAVERCO_345kV_1PH	OK	OK	OK
15	FLT_15_BEAVERCO_HITCHLAND7_345kV_3PH	OK	OK	OK
16	FLT_16_BEAVERCO_HITCHLAND7_345kV_1PH	OK	OK	OK
17	FLT_17_BEAVERCO_G13034TAP_345kV_3PH	OK	OK	OK
18	FLT_18_BEAVERCO_G13034TAP_345kV_1PH	OK	OK	OK
19	FLT_19_G13034TAP_WWRDEHV7_345kV_3PH	OK	OK	OK
20	FLT_20_G13034TAP_WWRDEHV7_345kV_1PH	OK	OK	OK
21	FLT_21_WWRDEHV7_BORDER7_345kV_3PH	OK	OK	OK
22	FLT_22_WWRDEHV7_BORDER7_345kV_1PH	OK	OK	OK
23	FLT_23_WWRDEHV7_THISTLE7_345kV_3PH	OK	OK	OK
24	FLT_24_WWRDEHV7_THISTLE7_345kV_1PH	OK	OK	OK

Table III-2: Stability Analysis Results

	Contingency Number and Description	2014WP	2015SP	2024SP
25	FLT_25_THISTLE7_WICHITA7_345kV_3PH	OK	OK	OK
26	FLT_26_THISTLE7_WICHITA7_345kV_1PH	OK	OK	OK
27	FLT_27_THISTLE7_CLARKCOUNTY7_345kV_3PH	OK	OK	OK
28	FLT_28_THISTLE7_CLARKCOUNTY7_345kV_1PH	OK	OK	OK
29	FLT_29_WWRDEHV7_G11051TAP_345kV_3PH	OK	OK	OK
30	FLT_30_WWRDEHV7_G11051TAP_345kV_1PH	OK	OK	OK
31	FLT_31_TATONGA7_NORTWST7_345kV_3PH	OK	OK	OK
32	FLT_32_TATONGA7_NORTWST7_345kV_1PH	OK	OK	OK
33	FLT_33_HOLCOMB7_HOLCOMB3_345_115kV_3PH	OK	OK	OK
34	FLT_34_POTTERCO7_POTTERCO6_345_230kV_3PH	OK	OK	OK
35	FLT_35_HITCHLAND7_HITCHLAND6_345_230kV_3PH	OK	OK	OK
36	FLT_36_WWRDEHV7_WWRDEHV4_345_138kV_3PH	OK	OK	OK
37	FLT_37_HITCHLAND6_OCHILTREE6_230kV_3PH	OK	OK	OK
38	FLT_38_HITCHLAND6_OCHILTREE6_230kV_1PH	OK	OK	OK
39	FLT_39_HITCHLAND6_MOORECNTY6_230kV_3PH	OK	OK	OK
40	FLT_40_HITCHLAND6_MOORECNTY6_230kV_1PH	OK	OK	OK
41	FLT_41_POTTERCO6_MOORECNTY6_230kV_3PH	OK	OK	OK
42	FLT_42_POTTERCO6_MOORECNTY6_230kV_1PH	OK	OK	OK
43	FLT_43_POTTERCO6_HARRNGEST6_230kV_3PH	OK	OK	OK
44	FLT_44_POTTERCO6_HARRNGEST6_230kV_1PH	OK	OK	OK
45	FLT_45_POTTERCO6_ROLLHILLS6_230kV_3PH	OK	OK	OK
46	FLT_46_POTTERCO6_ROLLHILLS6_230kV_1PH	OK	OK	OK
47	FLT_47_POTTERCO6_BUSHLAND6_230kV_3PH	OK	OK	OK
48	FLT_48_POTTERCO6_BUSHLAND6_230kV_1PH	OK	OK	OK
49	FLT_49_POTTERCO6_PLANTX6_230kV_3PH	OK	N/A	N/A
50	FLT_50_POTTERCO6_PLANTX6_230kV_1PH	OK	N/A	N/A
49a	FLT_49_POTTERCO6_NEWHART6_230kV_3PH	N/A	OK	OK
50a	FLT_50_POTTERCO6_NEWHART6_230kV_1PH	N/A	OK	OK
51	FLT_51_MOORECNTY6_MOOREE3_230_115kV_3PH	OK	OK	OK
52	FLT_52_POTTERCO6_POTTERCO3_230_115kV_3PH	OK	OK	N/A
52a	FLT_52_NEWHART6_NEWHART3_230_115kV_3PH	N/A	N/A	OK
53	FLT_53_WWRDEHV4_WOODWRD4_138kV_3PH	OK	OK	OK
54	FLT_54_WWRDEHV4_WOODWRD4_138kV_1PH	OK	OK	OK
55	FLT_55_WWRDEHV4_IODINE4_138kV_3PH	OK	OK	OK
56	FLT_56_WWRDEHV4_IODINE4_138kV_1PH	OK	OK	OK
57	FLT_57_HANSFORD3_HITCHLAND3_115kV_3PH	OK	OK	OK
58	FLT_58_HANSFORD3_HITCHLAND3_115kV_1PH	OK	OK	OK
59	FLT_59_HANSFORD3_SPEARMAN3_115kV_3PH	OK	OK	OK
60	FLT_60_HANSFORD3_SPEARMAN3_115kV_1PH	OK	OK	OK
61	FLT_61_MARTIN3_HUTCHS3_115kV_3PH	OK	OK	OK
62	FLT_62_MARTIN3_HUTCHS3_115kV_1PH	OK	OK	OK
63	FLT_63_MARTIN3_PANTEXN3_115kV_3PH	OK	OK	OK
64	FLT_64_MARTIN3_PANTEXN3_115kV_1PH	OK	OK	OK
65	FLT_65_FRISCOWND3_HITCHLAND3_115kV_3PH	OK	OK	OK
66	FLT_66_FRISCOWND3_HITCHLAND3_115kV_1PH	OK	OK	OK
67	FLT_67_FRISCOWND3_LASLEY3_115kV_3PH	OK	OK	OK
68	FLT_68_FRISCOWND3_LASLEY3_115kV_1PH	OK	OK	OK
69	FLT_69_HITCHLAND3_TEXASCNTY3_115kV_3PH	OK	OK	OK
70	FLT_70_HITCHLAND3_TEXASCNTY3_115kV_1PH	OK	OK	OK
71	FLT_71_HITCHLAND3_FRISCOWND3_115kV_3PH	OK	OK	OK

Table III-2: Stability Analysis Results

	Contingency Number and Description	2014WP	2015SP	2024SP
72	FLT_72_HITCHLAND3_FRISCOWND3_115kV_1PH	OK	OK	OK
73	FLT_73_HITCHLAND3_HANSFORD3_115kV_3PH	OK	OK	OK
74	FLT_74_HITCHLAND3_HANSFORD3_115kV_1PH	OK	OK	OK
75	FLT_75_HERRINGTP3_RBSNEED3_115kV_3PH	OK	OK	OK
76	FLT_76_HERRINGTP3_RBSNEED3_115kV_1PH	OK	OK	OK
77	FLT_77_HERRINGTP3_RIVERVIEW3_115kV_3PH	OK	OK	OK
78	FLT_78_HERRINGTP3_RIVERVIEW3_115kV_1PH	OK	OK	OK
79	FLT_79_HITCHLAND3_HITCHLAND6_115_230kV_3PH	OK	OK	OK
80	FLT_80_P4BEAVHITCBEAV_G13034TAP_345kV_1PH	OK	OK	OK
81	FLT_81_P4BEAVHITCHITC_HITCHLAND6_345_230kV_1PH	OK	OK	OK
82	FLT_82_P4BEAVG1334TG1334T_WWRDEHV7_345kV_1PH	OK	OK	OK
83	FLT_83_P4WWRDTHISWWRD_G11051TAP_345kV_1PH	OK	OK	OK
84	FLT_84_P6DBLG13034TAP_BEAVERCO_345kV_3PH **Prior Outage of Beaver County to GEN-2013-034-Tap 345kV CKT 1.** 3 phase fault on the Beaver County (580500) to GEN-2013-034-Tap 345KV (562440) CKT 2 near GEN-2013-034-Tap.	Undamped Oscillations	Undamped Oscillations	Undamped Oscillations
84a	FLT_84_P6DBLG13034TAP_BEAVERCO_345kV_3PH **Reduce area generation and Prior Outage of Beaver County to GEN-2013-034-Tap 345kV CKT 1.** 3 phase fault on the Beaver County (580500) to GEN-2013-034-Tap 345KV (562440) CKT 2 near GEN-2013-034-Tap.	OK	OK	OK
85	FLT_85_P7DBLG13034TAP_BEAVERCO_345kV_1PH **Outage of Beaver County to GEN-2013-034-Tap 345kV CKT 1 & 2.** Single phase fault on the Beaver County (580500) to GEN-2013-034-Tap (562440) 345KV CKT 1 & 2 near GEN-2013-034-Tap.	Undamped Oscillations	Undamped Oscillations	OK
85a	FLT_85_P7DBLG13034TAP_BEAVERCO_345kV_1PH **Reduce area generation and Outage of Beaver County to GEN-2013-034-Tap 345kV CKT 1 & 2.** Single phase fault on the Beaver County (580500) to GEN-2013-034-Tap (562440) 345KV CKT 1 & 2 near GEN-2013-034-Tap.	OK	OK	OK
86	FLT_86_P6DBLBEAVERCO_HITCHLAND7_345kV_3PH	OK	OK	OK
87	FLT_87_P7DBLBEAVERCO_HITCHLAND7_345kV_1PH	OK	OK	OK
88	FLT_88_P6DBLG13034TAP_WWRDEHV7_345kV_3PH **Prior Outage of GEN-2013-034-Tap to Woodward 345kV CKT 1.** 3 phase fault on the GEN-2013-034-Tap (562440) to Woodward (515375) 345KV CKT 2 near GEN-2013-034-Tap.	Undamped Oscillations	Undamped Oscillations	OK
88a	FLT_88_P6DBLG13034TAP_WWRDEHV7_345kV_3PH **Reduce area generation and Prior Outage of GEN-2013-034-Tap to Woodward 345kV CKT 1.** 3 phase fault on the GEN-2013-034-Tap (562440) to Woodward (515375) 345KV CKT 2 near GEN-2013-034-Tap.	OK	OK	OK
89	FLT_89_P7DBLG13034TAP_WWRDEHV7_345kV_1PH **Outage of GEN-2013-034-Tap to Woodward 345kV CKT 1 & 2.** Single phase fault on the GEN-2013-034-Tap (562440) to Woodward (515375) 345KV CKT 1 & 2 near GEN-2013-034-Tap.	Undamped Oscillations	OK	OK
89a	FLT_89_P7DBLG13034TAP_WWRDEHV7_345kV_1PH **Reduce area generation and Outage of GEN-2013-034-Tap to Woodward 345kV CKT 1 & 2.** Single phase fault on the GEN-2013-034-Tap (562440) to Woodward (515375) 345KV CKT 1 & 2 near GEN-2013-034-Tap.	OK	OK	OK
90	FLT_90_P6DBLWWRDEHV7_THISTLE7_345kV_3PH	OK	OK	OK

Table III-2: Stability Analysis Results

Contingency Number and Description		2014WP	2015SP	2024SP
91	FLT_91_P7DBLWWRDEHV7_THISTLE7_345kV_1PH	OK	OK	OK
92	FLT_92_P6DBLTHISTLE7_WICHITA7_345kV_3PH	OK	OK	OK
93	FLT_93_P7DBLTHISTLE7_WICHITA7_345kV_1PH	OK	OK	OK
94	FLT_94_P6DBLTHISTLE7_CLARKCOUNTY7_345kV_3PH	OK	OK	OK
95	FLT_95_P7DBLTHISTLE7_CLARKCOUNTY7_345kV_1PH	OK	OK	OK
96	FLT_96_P6DBLWWRDEHV7_WWRDEHV4_345_138kV_3PH	OK	OK	OK
97	FLT_97_P7DBLWWRDEHV7_WWRDEHV4_345_138kV_1PH	OK	OK	OK
98	FLT_98_P6TNGANWSTWWRD_BORDER7_345kV_3PH	OK	OK	OK
99	FLT_99_P7TNGANWSTWWRD_BORDER7_345kV_1PH	OK	OK	OK
100	FLT_100_P6TNGANWSTWWRD_THISTLE7_345kV_3PH	OK	OK	OK
101	FLT_101_P7TNGANWSTWWRD_THISTLE7_345kV_1PH	OK	OK	OK
102	FLT_102_P6TNGANWSTWWRD_G13034TAP_345kV_3PH	OK	OK	OK
103	FLT_103_P7TNGANWSTWWRD_G13034TAP_345kV_1PH	OK	OK	OK
104	FLT_104_P6DBLWWRDEHV4_WOODWRD4_138kV_3PH	OK	OK	OK
105	FLT_105_P7DBLWWRDEHV4_WOODWRD4_138kV_1PH	OK	OK	OK

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 15, 17, and 86 in Table III-2 simulated the LVRT contingencies. GEN-2008-047 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 POIs 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. It is the customer's responsibility to determine, with the reactive capabilities of the GE 1.7MW wind turbines, if 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	
				Lagging [b]	Leading [c]
GEN-2008-047	299.2	GE 1.7MW	Beaver County 345kV (580500)	0.9500 [d]	0.9500

Notes:

a. For each plant, 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.

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. This reactive power injection is measured at the POI (Beaver County 345kV substation).

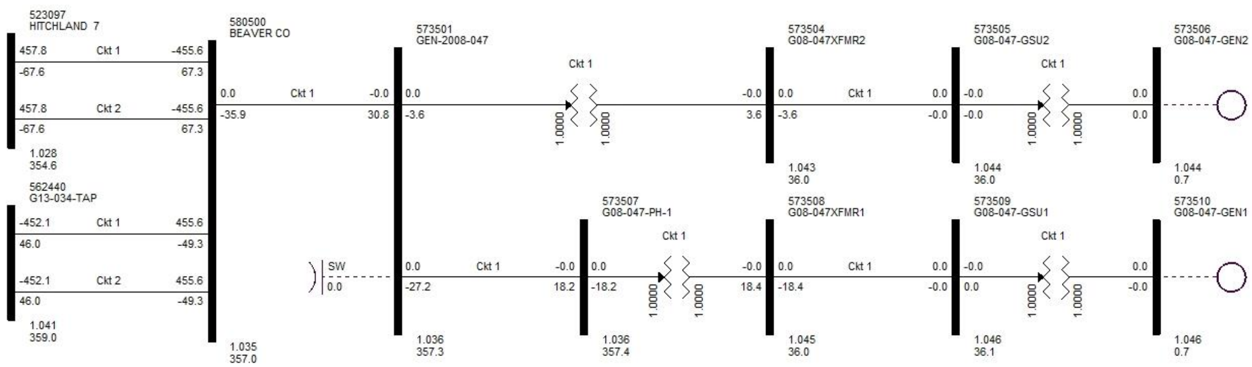

Figure IV-1: GEN-2008-047 with generators off and no shunt reactors

Shunt reactors were added at the study project 345kV substation to bring the Mvar flow into the POI down to approximately zero (Figure IV-2). Final shunt reactor requirement for this project is approximately 35.6Mvars. 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.

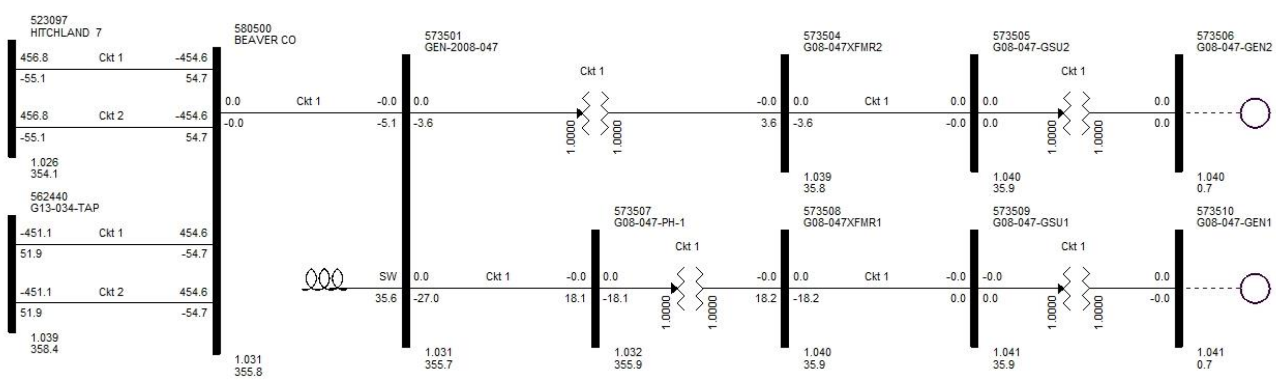

Figure IV-2: GEN-2008-047 with generators turned off and shunt reactors added to the customer 345kV substation

It is the customer's responsibility to determine, with the reactive capabilities of the GE 1.7MW wind turbines, if the generation facility will require external shunt reactors or other reactive equipment to meet the MVAR flow requirement at the POI.

V. Conclusion

The SPP GEN-2008-047 Impact Restudy evaluated the impact of interconnecting the project shown below.

Request	Size	Generator Type	Point of Interconnection	Gen Buses
GEN-2008-047	299.2	GE 1.7MW	Beaver County 345kV (580500)	573506 573510

With all Base Case Network Upgrades in service, previously assigned Network Upgrades in service, the GEN-2008-047 project was found to remain on line and the transmission system was found to remain stable for all conditions studied.

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. Additionally, the project will be required to install approximately 35.6Mvar of reactor shunts at its 345kV substation or provide an equivalent source of reactive compensation. 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. It is the customer's responsibility to determine, with the reactive capabilities of the GE 1.7MW wind turbines, if the generation facility will require external capacitor banks, shunt reactors, or other reactive equipment to meet the power factor and MVAR flow requirements at the POI.

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 upon request)

APPENDIX B

TRANSIENT VOLTAGE DETAILS
(Available upon request)

APPENDIX C

POWER FACTOR ANALYSIS

GEN-2008-047	2014 Winter POI Voltage = 1.035 pu				2015 Summer Voltage = 1.040 pu				2024 Summer Voltage = 1.046 pu			
Contingency Name	MW	Mvar	PF		MW	Mvar	PF		MW	Mvar	PF	
FLT_00_NoFault	299.2	60.1218	0.9804	LAG	299.2	53.3093	0.9845	LAG	299.2	46.1935	0.9883	LAG
FLT_01_HITCHLAND7_FINNEY7_345kV	299.2	130.1456	0.9170	LAG	299.2	113.1302	0.9354	LAG	299.2	92.5632	0.9553	LAG
FLT_03_FINNEY7_HOLCOMB7_345kV	299.2	129.5507	0.9177	LAG	299.2	125.6103	0.9220	LAG	299.2	103.5076	0.9450	LAG
FLT_05_HOLCOMB7_SETAB7_345kV	299.2	63.9433	0.9779	LAG	299.2	60.4623	0.9802	LAG	299.2	51.3832	0.9856	LAG
FLT_07_HOLCOMB7_BUCKNER7_345kV	299.2	80.3935	0.9657	LAG	299.2	75.2920	0.9698	LAG	299.2	61.9146	0.9793	LAG
FLT_09_BUCKNER7_SPERVIL7_345kV	299.2	87.0611	0.9602	LAG	299.2	80.3899	0.9657	LAG	299.2	67.0957	0.9758	LAG
FLT_11_HITCHLAND7_POTTERCO7_345kV	299.2	68.6421	0.9747	LAG	299.2	63.9462	0.9779	LAG	299.2	59.0178	0.9811	LAG
FLT_13_HITCHLAND7_BEAVERCO_345kV	299.2	60.3765	0.9802	LAG	299.2	49.4297	0.9866	LAG	299.2	40.7105	0.9909	LAG
FLT_15_BEAVERCO_HITCHLAND7_345kV	299.2	60.3765	0.9802	LAG	299.2	49.4297	0.9866	LAG	299.2	40.7105	0.9909	LAG
FLT_17_BEAVERCO_G13034TAP_345kV	299.2	96.1377	0.9521	LAG	299.2	86.5237	0.9606	LAG	299.2	75.5218	0.9696	LAG
FLT_19_G13034TAP_WWRDEHV7_345kV	299.2	70.3941	0.9734	LAG	299.2	62.4818	0.9789	LAG	299.2	53.5091	0.9844	LAG
FLT_21_WWRDEHV7_BORDER7_345kV	299.2	67.9792	0.9751	LAG	299.2	61.3608	0.9796	LAG	299.2	51.1819	0.9857	LAG
FLT_23_WWRDEHV7_THISTLE7_345kV	299.2	60.6564	0.9801	LAG	299.2	55.2273	0.9834	LAG	299.2	47.7274	0.9875	LAG
FLT_25_THISTLE7_WICHITA7_345kV	299.2	58.6245	0.9813	LAG	299.2	52.6739	0.9849	LAG	299.2	45.5338	0.9886	LAG
FLT_27_THISTLE7_CLARKCOUNTY7_345kV	299.2	64.8432	0.9773	LAG	299.2	57.3856	0.9821	LAG	299.2	49.8699	0.9864	LAG

GEN-2008-047	2014 Winter POI Voltage = 1.035 pu				2015 Summer Voltage = 1.040 pu				2024 Summer Voltage = 1.046 pu			
Contingency Name	MW	Mvar	PF		MW	Mvar	PF		MW	Mvar	PF	
FLT_29_WWRDEHV7_G110 51TAP_345kV	299.2	56.0496	0.9829	LAG	299.2	51.3547	0.9856	LAG	299.2	46.2372	0.9883	LAG
FLT_31_TATONGA7_NORT WST7_345kV	299.2	51.1036	0.9857	LAG	299.2	50.0332	0.9863	LAG	299.2	42.3174	0.9901	LAG
FLT_33_HOLCOMB7_HOLC OMB3_345_115kV	299.2	56.3097	0.9827	LAG	299.2	48.8356	0.9869	LAG	299.2	43.7763	0.9895	LAG
FLT_34_POTTERCO7_POTT ERCO6_345_230kV	299.2	65.7433	0.9767	LAG	299.2	61.8068	0.9793	LAG	299.2	57.9257	0.9818	LAG
FLT_35_HITCHLAND7_HITC HLAND6_345_230kV	299.2	60.6008	0.9801	LAG	299.2	51.9114	0.9853	LAG	299.2	45.6893	0.9885	LAG
FLT_36_WWRDEHV7_WWR DEHV4_345_138kV	299.2	59.9940	0.9805	LAG	299.2	51.3383	0.9856	LAG	299.2	44.0714	0.9893	LAG
FLT_37_HITCHLAND6_OCHI LTREE6_230kV	299.2	63.0193	0.9785	LAG	299.2	54.1742	0.9840	LAG	299.2	47.2292	0.9878	LAG
FLT_39_HITCHLAND6_MOO RECNTY6_230kV	299.2	62.7536	0.9787	LAG	299.2	53.7234	0.9843	LAG	299.2	50.2735	0.9862	LAG
FLT_41_POTTERCO6_MOO RECNTY6_230kV	299.2	60.1652	0.9804	LAG	299.2	53.7624	0.9842	LAG	299.2	47.6701	0.9875	LAG
FLT_43_POTTERCO6_HARR NGEST6_230kV	299.2	59.3589	0.9809	LAG	299.2	53.0237	0.9847	LAG	299.2	46.0711	0.9884	LAG
FLT_45_POTTERCO6_ROLL HILLS6_230kV	299.2	58.4892	0.9814	LAG	299.2	52.1495	0.9851	LAG	299.2	45.4399	0.9887	LAG
FLT_47_POTTERCO6_BUSH LAND6_230kV	299.2	59.6665	0.9807	LAG	299.2	53.5282	0.9844	LAG	299.2	46.8323	0.9880	LAG
FLT_49_POTTERCO6_PLAN TX6_230kV	299.2	63.3745	0.9783	LAG	299.2	55.5583	0.9832	LAG	299.2	47.7840	0.9875	LAG
FLT_51_MOORECNTY6_MO OREE3_230_115kV	299.2	60.3477	0.9803	LAG	299.2	48.2115	0.9873	LAG	299.2	44.6525	0.9890	LAG
FLT_52_POTTERCO6_POTT ERCO3_230_115kV	299.2	60.2762	0.9803	LAG	299.2	54.2445	0.9840	LAG	299.2	46.3628	0.9882	LAG
FLT_53_WWRDEHV4_WOO DWRD4_138kV	299.2	60.7791	0.9800	LAG	299.2	54.0037	0.9841	LAG	299.2	46.6675	0.9881	LAG

GEN-2008-047	2014 Winter POI Voltage = 1.035 pu				2015 Summer Voltage = 1.040 pu				2024 Summer Voltage = 1.046 pu			
Contingency Name	MW	Mvar	PF		MW	Mvar	PF		MW	Mvar	PF	
FLT_55_WWRDEHV4_IODINE4_138kV	299.2	59.6013	0.9807	LAG	299.2	52.9112	0.9847	LAG	299.2	45.8831	0.9884	LAG
FLT_57_HANSFORD3_HITCHLAND3_115kV	299.2	60.2959	0.9803	LAG	299.2	53.1631	0.9846	LAG	299.2	46.2221	0.9883	LAG
FLT_59_HANSFORD3_SPEARMAN3_115kV	299.2	62.5811	0.9788	LAG	299.2	55.7453	0.9831	LAG	299.2	49.1936	0.9868	LAG
FLT_61_MARTIN3_HUTCHS3_115kV	299.2	59.5303	0.9808	LAG	299.2	52.8198	0.9848	LAG	299.2	45.8679	0.9885	LAG
FLT_63_MARTIN3_PANTEXN3_115kV	299.2	60.7770	0.9800	LAG	299.2	53.7299	0.9843	LAG	299.2	46.5544	0.9881	LAG
FLT_65_FRISCOWND3_HITCHLAND3_115kV	299.2	61.7434	0.9794	LAG	299.2	52.6391	0.9849	LAG	299.2	46.1773	0.9883	LAG
FLT_67_FRISCOWND3_LASLEY3_115kV	299.2	62.2130	0.9791	LAG	299.2	53.1973	0.9846	LAG	299.2	46.7126	0.9880	LAG
FLT_69_HITCHLAND3_TEXASCNTY3_115kV	299.2	62.0305	0.9792	LAG	299.2	53.3489	0.9845	LAG	299.2	46.2129	0.9883	LAG
FLT_71_HITCHLAND3_FRISCOWND3_115kV	299.2	61.7434	0.9794	LAG	299.2	52.6391	0.9849	LAG	299.2	46.1773	0.9883	LAG
FLT_73_HITCHLAND3_HANSFORD3_115kV	299.2	60.2959	0.9803	LAG	299.2	53.1631	0.9846	LAG	299.2	46.2221	0.9883	LAG
FLT_75_HERRINGTP3_RBSNEED3_115kV	299.2	60.3255	0.9803	LAG	299.2	53.2755	0.9845	LAG	299.2	46.1033	0.9883	LAG
FLT_77_HERRINGTP3_RIVERVIEW3_115kV	299.2	60.2382	0.9803	LAG	299.2	53.3861	0.9845	LAG	299.2	46.3524	0.9882	LAG
FLT_79_HITCHLAND3_HITCHLAND6_115_230kV	299.2	58.0001	0.9817	LAG	299.2	53.6082	0.9843	LAG	299.2	45.9948	0.9884	LAG
FLT_80_P4BEAVHITCBEAV_G13034TAP_345kV	299.2	92.4239	0.9555	LAG	299.2	80.7328	0.9655	LAG	299.2	68.7599	0.9746	LAG
FLT_81_P4BEAVHITCHITC_HITCHLAND6_345_230kV	299.2	59.4124	0.9808	LAG	299.2	50.6260	0.9860	LAG	299.2	42.5482	0.9900	LAG
FLT_82_P4BEAVG1334TG1334T_WWRDEHV7_345kV	299.2	101.6598	0.9468	LAG	299.2	90.0116	0.9576	LAG	299.2	80.5711	0.9656	LAG

GEN-2008-047	2014 Winter POI Voltage = 1.035 pu				2015 Summer Voltage = 1.040 pu				2024 Summer Voltage = 1.046 pu			
Contingency Name	MW	Mvar	PF		MW	Mvar	PF		MW	Mvar	PF	
FLT_83_P4WWRDTHISWWRD_G11051TAP_345kV	299.2	56.2549	0.9828	LAG	299.2	54.1325	0.9840	LAG	299.2	49.5963	0.9865	LAG
FLT_84_P6DBLG13034TAP_BEAVERCO_345kV	299.2	188.4501	0.8462	LAG	299.2	171.7627	0.8673	LAG	299.2	145.7356	0.8990	LAG
FLT_86_P6DBLBEAVERCO_HITCHLAND7_345kV	299.2	-6.9371	0.9997	LEAD	299.2	-4.4798	0.9999	LEAD	299.2	-1.5340	1.0000	LEAD
FLT_88_P6DBLG13034TAP_WWRDEHV7_345kV	299.2	164.8158	0.8759	LAG	299.2	143.0980	0.9021	LAG	299.2	117.1139	0.9312	LAG
FLT_90_P6DBLWWRDEHV7_THISTLE7_345kV	299.2	63.8375	0.9780	LAG	299.2	58.8442	0.9812	LAG	299.2	47.5252	0.9876	LAG
FLT_92_P6DBLTHISTLE7_WICHITA7_345kV	299.2	52.6377	0.9849	LAG	299.2	46.4014	0.9882	LAG	299.2	41.0567	0.9907	LAG
FLT_94_P6DBLTHISTLE7_CLARKCOUNTY7_345kV	299.2	77.2272	0.9683	LAG	299.2	67.4337	0.9755	LAG	299.2	58.8911	0.9812	LAG
FLT_96_P6DBLWWRDEHV7_WWRDEHV4_345_138kV	299.2	63.9486	0.9779	LAG	299.2	53.6289	0.9843	LAG	299.2	44.9803	0.9889	LAG
FLT_98_P6TNGANWSTWWRD_BORDER7_345kV	299.2	55.4766	0.9832	LAG	299.2	55.8877	0.9830	LAG	299.2	45.0722	0.9888	LAG
FLT_100_P6TNGANWSTWWRD_THISTLE7_345kV	299.2	54.8828	0.9836	LAG	299.2	54.1327	0.9840	LAG	299.2	45.3649	0.9887	LAG
FLT_102_P6TNGANWSTWWRD_G13034TAP_345kV	299.2	56.8274	0.9824	LAG	299.2	54.0757	0.9841	LAG	299.2	45.9812	0.9884	LAG
FLT_104_P6DBLWWRDEHV4_WOODWRD4_138kV	299.2	62.6260	0.9788	LAG	299.2	56.1032	0.9829	LAG	299.2	47.9482	0.9874	LAG

APPENDIX D

PROJECT MODELS

GEN-2008-047 (GE 1.7 MW)

PSS/E 32 Power Flow Data

```
@! **************** GEN-2008-047 100% ****************
@! POI @ Beaver County 345kV 580500 (Tap Hitchland-Woodward 523097-515375)
@! GE 97.4m 1.7MW Wind Turbine Generator
@! Pmax=299.2MW | Phase I @ 249.9MW & II @ 49.3MW
@! 0.90PF Range
Version 32
@! ----------- Bus Data -----------
BAT_BUS_DATA_2,573501,1,,,, 345.00,,,'GEN-2008-047',;
BAT_BUS_DATA_2,573504,1,,,,  34.50,,,'G08-047XFMR2',;
BAT_BUS_DATA_2,573505,1,,,,  34.50,,,'G08-047-GSU2',;
BAT_BUS_DATA_2,573506,2,,,,   0.69,,,'G08-047-GEN2',;
BAT_BUS_DATA_2,573507,1,,,, 345.00,,,'G08-047-PH-1',;
BAT_BUS_DATA_2,573508,1,,,,  34.50,,,'G08-047XFMR1',;
BAT_BUS_DATA_2,573509,1,,,,  34.50,,,'G08-047-GSU1',;
BAT_BUS_DATA_2,573510,2,,,,   0.69,,,'G08-047-GEN1',;
@! ----------- Generator Data -----------
BAT_PLANT_DATA,573506,, 1.048,,;
BAT_PLANT_DATA,573510,, 1.048,,;
  BAT_MACHINE_DATA_2,573506,'1',1,,,,,0,  49.30,,  23.8770,  -23.8770,  49.30, 3.45,  53.012, 0.0000, 0.8000,,,,,,,, 1.00,;
  BAT_MACHINE_DATA_2,573510,'1',1,,,,,0, 249.90,, 121.0320, -121.0320, 249.90, 17.5, 268.716, 0.0000, 0.8000,,,,,,,, 1.00,;
@! ----------- Unit Transformers -----------
BAT_TWO_WINDING_DATA_3,573501,573504,'1',1,,,,,,33,,,,1,0,1,2,1, 0.001904, 0.07998,  36.00,,,,,,  60.00,  60.00,  60.00,,,,,,,,,,,,,,;
BAT_TWO_WINDING_DATA_3,573507,573508,'1',1,,,,,,33,,,,1,0,1,2,1, 0.001607, 0.08999, 180.00,,,,,,300.00,300.00,300.00,,,,,,,,,,,,,,;
BAT_TWO_WINDING_DATA_3,573505,573506,'1',1,,,,,, 5,,,,1,0,1,2,1, 0.007599, 0.05700,  53.65,,,,,,  53.65,  53.65,  53.65,,,,,,,,,,,,,,;
BAT_TWO_WINDING_DATA_3,573509,573510,'1',1,,,,,, 5,,,,1,0,1,2,1, 0.007599, 0.05700, 271.95,,,,,, 271.95, 271.95, 271.95,,,,,,,,,,,,,,;
@! ----------- Collector Cables -----------
BAT_BRANCH_DATA,573504,573505,'1',,,,,,, 0.029256, 0.053620, 0.033311,,,,,,,,      ,,,,,;
BAT_BRANCH_DATA,573508,573509,'1',,,,,,, 0.004616, 0.007806, 0.168285,,,,,,,,      ,,,,,;
@! ----------- Add Transmission Line from Substation to POI -----------
BAT_BRANCH_DATA,580500,573501,'1',,,,,,, 0.000226, 0.002220, 0.0482,,,,,,,, 5.00,,,,,;
BAT_BRANCH_DATA,573501,573507,'1',,,,,,, 0.000251, 0.002468, 0.0836,,,,,,,, 5.56,,,,,;
@END
```

PSS/E 32 Dynamics Data

```
/*********************************************************************************
/ ***** GEN-2008-047 *****
/ GE 97.4m 1.7 MW (gewt_p32_v600.lib)
/
/ Phase II
 573506 'USRMDL' 1  'GEWTG2'  1 1 4 18 3 5
      0  29      0      0
       1.7000     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    /
 573506 'USRMDL' 1  'GEWTE2'  4 0 12 67 18 9
        573506       0           0            1            0            0
           0       0           0            0            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           0.99999          0.99999          0.99999
      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
       10.000           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    /
 573506 'USRMDL' 1  'GEWTT1'       5    0    1    5    4    3   0
        4.3600      0.0000      0.0000      1.8800      2.3000    /
 0 'USRMDL'  0 'GEWGC1' 8    0    3    6    0    4
        573506      '1'  0
        9999.0      5.0000      30.000      9999.0      9999.0
        30.000    /
 0 'USRMDL'  0 'GEWTA1'       8    0    3    9    1    4
        573506      '1'    0
        20.000      0.0000      27.000      -4.0000      0.0000      1.2250
        48.7        89.220      1200.0    /
 0 'USRMDL'  0 'GEWTP1'       8    0    3    10    3    3
        573506      '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         573506      '1'     /
/ ZVRT_PSSe_495135_26SEP12
 0 'USRMDL'  0 'VTGDCA' 0 2 6 4 0 1  573506  573506  '1'  0 0 0  0.15  5.00  0.20  0.08 /
 0 'USRMDL'  0 'VTGDCA' 0 2 6 4 0 1  573506  573506  '1'  0 0 0  0.30  5.00  0.70  0.08 /
 0 'USRMDL'  0 'VTGDCA' 0 2 6 4 0 1  573506  573506  '1'  0 0 0  0.50  5.00  1.20  0.08 /
 0 'USRMDL'  0 'VTGDCA' 0 2 6 4 0 1  573506  573506  '1'  0 0 0  0.75  5.00  1.90  0.08 /
 0 'USRMDL'  0 'VTGDCA' 0 2 6 4 0 1  573506  573506  '1'  0 0 0  0.00  1.10  1.00  0.08 /
 0 'USRMDL'  0 'VTGDCA' 0 2 6 4 0 1  573506  573506  '1'  0 0 0  0.00  1.15  0.10  0.08 /
/
/ Phase I
 573510 'USRMDL' 1  'GEWTG2'  1 1 4 18 3 5
      0  147      0      0
       1.7000     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    /
 573510 'USRMDL' 1  'GEWTE2'  4 0 12 67 18 9
        573510       0           0            1            0            0
           0       0           0            0            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          0.99999          0.99999          0.99999
      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
       10.000          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   /
573510 'USRMDL' 1  'GEWTT1'       5    0    1    5    4    3   0
        4.3600      0.0000      0.0000      1.8800      2.3000    /
0 'USRMDL'  0 'GEWGC1' 8    0    3    6    0    4
        573510      '1'  0
        9999.0      5.0000      30.000      9999.0      9999.0
        30.000    /
0 'USRMDL'  0 'GEWTA1'      8    0    3    9    1    4
        573510      '1'    0
        20.000      0.0000      27.000      -4.0000      0.0000      1.2250
        48.7        89.220      1200.0    /
0 'USRMDL'  0 'GEWTP1'      8    0    3    10    3    3
        573510      '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        573510      '1'     /
/ ZVRT_PSSe_495135_26SEP12
0 'USRMDL'  0 'VTGDCA' 0 2 6 4 0 1  573510  573510  '1'  0 0 0  0.15  5.00  0.20  0.08 /
0 'USRMDL'  0 'VTGDCA' 0 2 6 4 0 1  573510  573510  '1'  0 0 0  0.30  5.00  0.70  0.08 /
0 'USRMDL'  0 'VTGDCA' 0 2 6 4 0 1  573510  573510  '1'  0 0 0  0.50  5.00  1.20  0.08 /
0 'USRMDL'  0 'VTGDCA' 0 2 6 4 0 1  573510  573510  '1'  0 0 0  0.75  5.00  1.90  0.08 /
0 'USRMDL'  0 'VTGDCA' 0 2 6 4 0 1  573510  573510  '1'  0 0 0  0.00  1.10  1.00  0.08 /
0 'USRMDL'  0 'VTGDCA' 0 2 6 4 0 1  573510  573510  '1'  0 0 0  0.00  1.15  0.10  0.08 /
/*******************************************************************************
```

APPENDIX E

TRANSMISSION ONE-LINES
(Available upon request)