GEN-2009-020 Impact Restudy for Generator Modification (Turbine Change)

February 2014
Generator Interconnection

Southwest Power Pool

Executive Summary

This document reports on the findings of a restudy for the GEN-2009-020 interconnection request. The Interconnection Customer has requested this restudy to determine the effects on post-fault voltage recovery of utilizing an additional controls package “SWT WeakGrid Control“ for the previously studied Siemens SWT2.3-108 2.3MW wind turbine generators.

The GEN-2009-020 interconnection request, using Vestas V90-1.8MW wind turbine generators, was initially studied in the DISIS-2010-001 Definitive Impact Study which was posted in July 2010. The Customer requested a second study which was posted in February 2011 to determine the effects of changing from the Vestas V90-1.8MW wind turbine generators to the GE 1.6MW wind turbine generators. The Customer requested a third study which was posted in March 2013 to determine the effects of changing from the GE 1.6MW wind turbine generators to the Siemens SWT2.3-108 2.3MW wind turbine generators.

The March 2013 study indicated a requirement for additional dynamic reactive power equipment for post fault voltage recovery. For this current study, the project is analyzed using twenty-one (21) Siemens SWT-2.3-108 2.3MW wind turbine generators with the “SWT WeakGrid Control” option. The facility is rated for 48.3MW aggregate and is located in Rush County, Kansas. The project has one 34.5/69kV substation transformer that will connect the Customer’s 69kV transmission line to the Point of Interconnection (POI), a new switching station on the Midwest Energy (MIDW) Bazine to Nekoma 69kV transmission line. The interconnection customer has provided documentation that shows the Siemens SWT-2.3-108 2.3MW wind turbine generators have a reactive capability of 0.90 lagging (providing VARS) and 0.90 leading (absorbing VARS) power factor.

The restudy showed that, with the controls package “SWT WeakGrid Control“, the generation facility will no longer require the 4.8MVAR capacitor bank and an 8MVAR Static Condenser device (STATCON/STATCOM) on the 34.5kV bus of the generation facility’s 34.5/69kV substation for post-fault voltage recovery. With the specified controls package in service, no stability problems were found during the summer and the winter peak conditions as a result of changing to the Siemens SWT-2.3-108 2.3MW 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 was not performed in this study. The power factor analysis results from the restudy posted February 2011 are still valid, and the facility will be required to maintain a 95% lagging (providing VARs) and 95% leading (absorbing VARs) power factor at the point of interconnection. While the capacitor bank and Static Condenser device are no longer required for voltage recovery conditions, the Customer is still responsible for maintaining a 95% power factor at the point of interconnection. Additional capacitor banks or other reactive equipment may be required to meet this requirement depending on the design of the Generating Facility and its collector system.

With the assumptions outlined in this report and with all the required network upgrades from the GEN-2009-020 Generator Interconnection Agreement (GIA) in place, the GEN-2009-020 request should be able to reliably interconnect to the SPP transmission grid.

Nothing within this System Impact Study constitutes a request for transmission service or confers upon the Interconnection Customer any right to receive transmission service rights. Should the Customer require transmission service, those rights should be requested through SPP's Open Access Same-Time Information System (OASIS).

This study did not analyze powerflow situations. For powerflow constraints, please refer to the latest version of DISIS-2010-001. At times, the generator may not be able to inject any power onto the Transmission System due to constraints that fall below the threshold of mitigation for a Generator Interconnection request. Because of this, it is likely that the Customer may be required to reduce its generation output to **0 MW** under certain system conditions to allow system operators to maintain the reliability of the transmission network.

I. Introduction

GEN-2009-020 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 October 2014. This restudy is for a change from GE 1.6MW wind turbine generators to the Siemens SWT2.3-108 2.3MW wind turbine generators with the "SWT WeakGrid Control" option.

Table I-1: Interconnection Request

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2009-020	48.3	Siemens 108m 2.3MW with SWT WeakGrid Control	Tap on the Bazine (530585) – Nekoma (530564) 69kV (560306)

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-2001-039M	99	Vestas V90VCRS 3.0MW	Central Plains 115kV (531485)
GEN-2003-006A	201	Vestas V90VCRS	Elm Creek 230kV (539639)
GEN-2003-019	249.3	GE 1.5MW & Vestas 3.0MW	Smoky Hills 230kV (530592)
GEN-2006-031	75	Gas (GENSAL)	Knoll 115kV (530561)
GEN-2006-040	108	Acciona AW1500 1.5MW	Mingo 115kV (531429)
GEN-2007-011	135	Acciona AW1500 1.5MW	Syracuse 115kV (531437)
GEN-2008-017	300	GE 1.5MW	Setab 345kV (531465)
GEN-2008-092	201	GE 1.5MW	Knoll 230kV (530558)
GEN-2009-008	198.9	GE 1.7MW	South Hays 230kV (530582)
GEN-2010-048	70	Nordex 2.5MW	Tap on the Ross Beach to Redline 115kV line (560366)

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 was performed on this project since it is a wind farm. The stability analysis was 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.

Nothing in this System Impact Study constitutes a request for transmission service or grants the Interconnection Customer any rights to transmission service.

II. Facilities

The GEN-2009-020 project is to be located in Rush County, Kansas and is comprised of twenty-one (21) Siemens SWT-2.3-108 2.3MW wind turbine generators with the controls package “SWT WeakGrid Control” for a maximum nameplate capacity of 48.3MW. Each turbine will be connected to a 34.5kV collector system that feeds a 34.5/69kV substation transformer. This transformer will connect the Customer’s 69kV transmission line to the Point of Interconnection (POI), a new switching station on the Bazine to Nekoma 69kV transmission line. A one-line drawing for the GEN-2009-020 generation interconnection request is shown in Figure II-1.

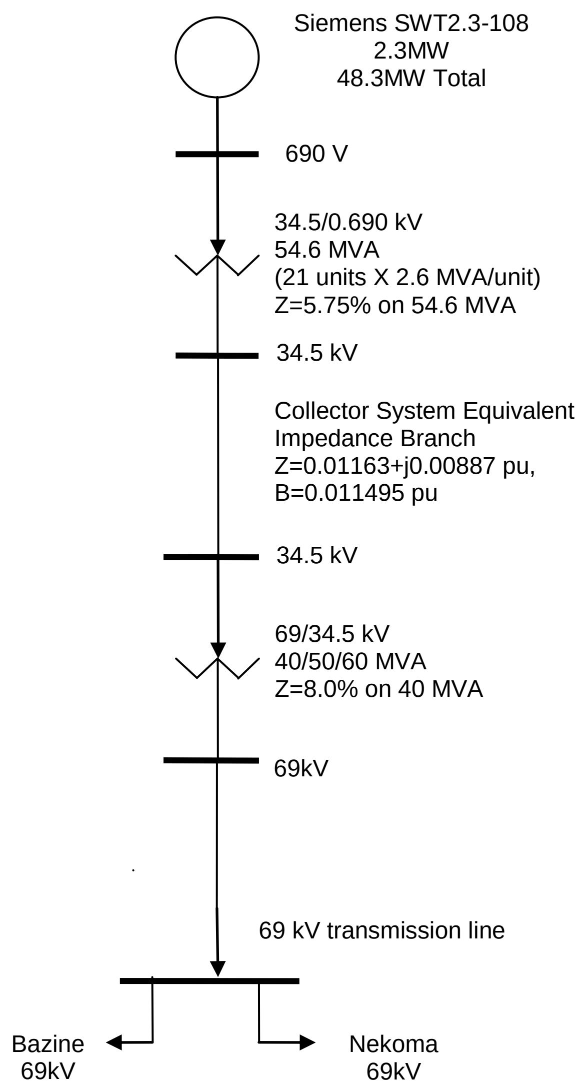

Figure II-1: GEN-2009-020 One-line Diagram

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

Fifty-two (52) 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, 536, 539, 544, 640, 645, and 650.

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
1	FLT_01_SHAYS6_POSTROCK6_230kV_3PH	3 phase fault on South Hays 230kV Bus 530582 to Post Rock 230KV Bus 530584 CKT 1, near South Hays. a. Apply fault at the South Hays 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.
2	FLT_02_SHAYS6_POSTROCK6_230kV_1PH	*Single phase fault and sequence like previous*
3	FLT_03_SHAYS6_GREATBEND6_230kV_3PH	3 phase fault on the South Hays 230kV Bus 530582 to Great Bend 230KV Bus 539679 CKT 1, near South Hays. a. Apply fault at the South Hays 230kV. 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_SHAYS6_GREATBEND6_230kV_1PH	*Single phase fault and sequence like previous*
5	FLT_05_POSTROCK6_KNOLL6_230kV_3PH	3 phase fault on the Post Rock 230kV Bus 530584 to Knoll 230kV Bus 530558 CKT 1, near Post Rock. a. Apply fault at the Post Rock 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.
6	FLT_06_POSTROCK6_KNOLL6_230kV_1PH	*Single phase fault and sequence like previous*
7	FLT_07_GREATBEND6_HEIZER6_230kV_3PH	3 phase fault on the Great Bend 230kV Bus 539679 to Heizer 230kV Bus 530680 CKT 1, near Great Bend. a. Apply fault at the Great Bend 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.
8	FLT_08_GREATBEND6_HEIZER6_230kV_1PH	*Single phase fault and sequence like previous*
9	FLT_09_GREATBEND6_CIRCLE6_230kV_3PH	3 phase fault on the Great Bend 230kV Bus 539679 to Circle 230kV Bus 532871 CKT 1, near Great Bend. a. Apply fault at the Great Bend 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.
10	FLT_10_GREATBEND6_CIRCLE6_230kV_1PH	*Single phase fault and sequence like previous*
11	FLT_11_GREATBEND6_SPEARVILLE6_230kV_3PH	3 phase fault on the Great Bend 230kV Bus 539679 to Spearville 230kV Bus 539695 CKT 1, near Great Bend. a. Apply fault at the Great Bend 230V 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_GREATBEND6_SPEARVILLE6_230kV_1PH	*Single phase fault and sequence like previous*

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
13	FLT_13_POSTROCK7_ SPEARVILLE7_345kV_3PH	3 phase fault on the Post Rock 345KV Bus 530583 to Spearville 345KV Bus 531469 CKT 1, near Post Rock. a. Apply fault at the Post Rock 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_POSTROCK7_G11017POI _345kV_1PH	*Single phase fault and sequence like previous*
15	FLT_15_POSTROCK7_AXTELL_345 kV_3PH	3 phase fault on the Post Rock 345KV Bus 530583 to Axtell 345kV Bus 64005 CKT 1, near Post Rock. a. Apply fault at the Post Rock 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_POSTROCK7_AXTELL_345 kV_1PH	*Single phase fault and sequence like previous*
17	FLT_17_KNOLL6_SMOKEYHILL6_2 30kV_3PH	3 phase fault on the Knoll 230kV Bus 530558 to Smokey Hill 230V Bus 530592 CKT 1, near Knoll. a. Apply fault at the Knoll 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.
18	FLT_18_KNOLL6_SMOKEYHILL6_2 30kV_1PH	*Single phase fault and sequence like previous*
19	FLT_19_KNOLL3_SALINE_115kV_ 3PH	3 phase fault on the Knoll 115kV Bus 530558 to Saline 115kV Bus 530551 CKT 1, near Knoll. a. Apply fault at the Knoll 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.
20	FLT_20_KNOLL3_SALINE_115kV_ 1PH	*Single phase fault and sequence like previous*
21	FLT_21_KNOLL3_NHAYS3_115kV _3PH	3 phase fault on the Knoll 115kV Bus 530558 to North Hays 115kV Bus 530581 CKT 1, near Knoll. a. Apply fault at the Knoll 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.
22	FLT_22_KNOLL3_NHAYS3_115kV _1PH	*Single phase fault and sequence like previous*
23	FLT_23_KNOLL3_REDLINE_115kV _3PH	3 phase fault on the Knoll 115kV Bus 530558 to Redline 115kV Bus 530605 CKT 1, near Knoll. a. Apply fault at the Knoll 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.
24	FLT_24_KNOLL3_REDLINE_115kV _1PH	*Single phase fault and sequence like previous*

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
25	FLT_25_G09020TAP2_NEKOMA2_69kV_3PH	3 phase fault on the GEN-2009-020 TAP 69kV Bus 560306 to Nekoma 69kV Bus 530564 CKT 1, near GEN-2009-020 TAP. a. Apply fault at the GEN-2009-020 TAP 69kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
26	FLT_26_G09020TAP2_NEKOMA2_69kV_1PH	*Single phase fault and sequence like previous*
27	FLT_27_G09020TAP2_BAZINE2_69kV_3PH	3 phase fault on the GEN-2009-020 TAP 69kV Bus 560306 to Bazine 69kV Bus 530585 CKT 1, near GEN-2009-020 TAP. a. Apply fault at the GEN-2009-020 TAP 69kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
28	FLT_28_G09020TAP2_BAZINE2_69kV_1PH	*Single phase fault and sequence like previous*
29	FLT_29_SEWARD2_HUDSON2_69kV_3PH	3 phase fault on the Seward 69kV Bus 530565 to Hudson 69kV Bus 530576 CKT 1, near Seward. a. Apply fault at the Seward 69kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
30	FLT_30_SEWARD2_HUDSON2_69kV_1PH	*Single phase fault and sequence like previous*
31	FLT_31_SEWARD2_GREATBENDS6_69kV_3PH	3 phase fault on the Seward 69kV Bus 530565 to Great Bend 69kV Bus 530569 CKT 1, near Seward. a. Apply fault at the Seward 69kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
32	FLT_32_SEWARD2_GREATBENDS6_69kV_1PH	*Single phase fault and sequence like previous*
33	FLT_33_NEKOMA3_ALEXANDER3_115kV_3PH	3 phase fault on the Nekoma 115kV Bus 530588 to Alexander 115kV Bus 530606 CKT 1, near Nekoma. a. Apply fault at the Nekoma 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.
34	FLT_34_NEKOMA3_ALEXANDER3_115kV_1PH	*Single phase fault and sequence like previous*
35	FLT_35_NEKOMA3_LACROSSTAP3_115kV_3PH	3 phase fault on the Nekoma 115kV Bus 530588 to Lacross Tap 115kV Bus 530602 CKT 1, near Nekoma. a. Apply fault at the Nekoma 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.
36	FLT_36_NEKOMA3_LACROSSTAP3_115kV_1PH	*Single phase fault and sequence like previous*

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
37	FLT_37_NESSCITY3_RANSOM3_115kV_3PH	3 phase fault on the Ness City 115kV Bus 531456 to Ransom 115kV Bus 530607 CKT 1, near Ness City. a. Apply fault at the Ness City 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.
38	FLT_38_NESSCITY3_RANSOM3_115kV_1PH	*Single phase fault and sequence like previous*
39	FLT_39_NESSCITY3_BEELER_115kV_3PH	3 phase fault on the Ness City 115kV Bus 531456 to Beeler 115kV Bus 531359 CKT 1, near Ness City. a. Apply fault at the Ness City 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.
40	FLT_40_NESSCITY3_BEELER_115kV_1PH	*Single phase fault and sequence like previous*
41	FLT_41_SHAYS6_SHAYS3_230_115kV_3PH	3 phase fault on the South Hays 230KV Bus 530582 to South Hays 115kV Bus 530553 to South Hays 12.47kV Bus 530632 CKT 1, near South Hays 230kV. a. Apply fault at the South Hays 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
42	FLT_42_POSTROCK3_POSTROCK7_230_345kV_3PH	3 phase fault on the Post Rock 230KV Bus 530584 to Post Rock 345kV Bus 530583 to Post Rock 13.8kVkV Bus 530673 CKT 1, near Post Rock 230 kV. a. Apply fault at the Post Rock 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
43	FLT_43_GREATBEND6_GREATBEND3_115kV_3PH	3 phase fault on the Great Bend 230kV Bus 539679 to Great Bend 115kV Bus 539678 to Great Bend 13.8kVkV Bus 539920 CKT 1, near Great Bend 230 kV. a. Apply fault at the Great Bend 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
44	FLT_44_KNOLL6_KNOLL3_230_115kV_3PH	3 phase fault on the Knoll 230kV Bus 530558 to Knoll 115kV Bus 530561 to Knoll 11.49kV Bus 530629 CKT 1, near Knoll 230 kV. a. Apply fault at the Knoll 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
45	FLT_45_NEKOMA2_NEKOMA3_69_115kV_3PH	3 phase fault on the Nekoma 69kV Bus 530564 to Nekoma 115kV Bus 530608 to Nekoma 12.5kV Bus 530630 CKT 2, near Nekoma 69 kV. a. Apply fault at the Nekoma 69kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
46	FLT_46_HEIZER2_HEIZER3_69_115kV_3PH	3 phase fault on the Heizer 69kV Bus 530563 to Heizer 115kV Bus 530601 to Heizer 12.5kV Bus 530627 CKT 2, near Heizer 69 kV. a. Apply fault at the Heizer 69kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
47	FLT_47_SEWARD2_SEWARD3_69_115kV_3PH	3 phase fault on the Seward 69kV Bus 530565 to Seward 115kV Bus 530679 to Seward 12.5kV Bus 530631 CKT 2, near Seward 69 kV. a. Apply fault at the Seward 69kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
48	FLT_48_HEIZER3_HEIZER6_115_230kV_3PH	3 phase fault on the Heizer 115kV Bus 530601 to Heizer 230kV Bus 530680 to Heizer 12.5kV Bus 530626 CKT 1, near Heizer 115kV. a. Apply fault at the Heizer 115kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
49	FLT_49_PO_SEWARD2_SEWARD3_69_115kV_G09020TAP_NEKOMA2_69kV_3PH	**Prior Outage of Seward 115kV to 69kV Transformer.** 3 phase fault on the GEN-2009-020 TAP 69kV Bus 560306 to Nekoma 69kV Bus 530564 CKT 1, near GEN-2009-020 TAP. a. Apply fault at the GEN-2009-020 TAP 69kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
50	FLT_50_PO_SEWARD2_SEWARD3_69_115kV_G09020TAP_NEKOMA2_69kV_1PH	*Single phase fault and sequence like previous*
51	FLT_51_PO_NEKOMA2_NEKOMA3_69_115kV_G09020TAP_BAZINE2_69kV_3PH	**Prior Outage of Nekoma 115kV to 69kV Transformer.** 3 phase fault on the GEN-2009-020 TAP 69kV Bus 560306 to Bazine 69kV Bus 530585 CKT 1, near GEN-2009-020 TAP. a. Apply fault at the GEN-2009-020 TAP 69kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
52	FLT_52_PO_NEKOMA2_NEKOMA3_69_115kV_G09020TAP_BAZINE2_69kV_1PH	*Single phase fault and sequence like previous*

Results

The stability analysis was performed and the results are summarized in Table III-2.

A short circuit analysis was not performed again for this study; the results from the GEN-2009-020 turbine restudy posted in March 2013 are still valid. These results indicate that the short circuit ratio for the GEN-2009-020 POI to Nekoma 69kV line outage is very small, 1.46. Most wind turbines will not operate effectively with this short circuit ratio without some additional reactive support or network upgrades. This restudy has determined that the Siemens Wind Turbine Generators with the controls package “SWT WeakGrid Control” installed, the project will have adequate post-fault voltage recovery for the outage of the GEN-2009-020 POI to Nekoma 69kV line.

Based on the dynamic results and with all project and network upgrades in service, there were no stability problems found during any of the simulations. No generators tripped or went unstable, and voltages recovered to acceptable levels.

Table III-2: Stability Analysis Results

	Contingency Number and Name	2014WP	2015SP	2024SP
1	3 phase fault on South Hays 230kV Bus 530582 to Post Rock 230KV Bus 530584 CKT 1, near South Hays.	OK	OK	OK
2	*Single phase fault and sequence like previous*	OK	OK	OK
3	3 phase fault on the South Hays 230kV Bus 530582 to Great Bend 230KV Bus 539679 CKT 1, near South Hays.	OK	OK	OK
4	*Single phase fault and sequence like previous*	OK	OK	OK
5	3 phase fault on the Post Rock 230kV Bus 530584 to Knoll 230kV Bus 530558 CKT 1, near Post Rock.	OK	OK	OK
6	*Single phase fault and sequence like previous*	OK	OK	OK
7	3 phase fault on the Great Bend 230kV Bus 539679 to Heizer 230kV Bus 530680 CKT 1, near Great Bend.	OK	OK	OK
8	*Single phase fault and sequence like previous*	OK	OK	OK
9	3 phase fault on the Great Bend 230kV Bus 539679 to Circle 230kV Bus 532871 CKT 1, near Great Bend.	OK	OK	OK
10	*Single phase fault and sequence like previous*	OK	OK	OK
11	3 phase fault on the Great Bend 230kV Bus 539679 to Spearville 230kV Bus 539695 CKT 1, near Great Bend.	OK	OK	OK
12	*Single phase fault and sequence like previous*	OK	OK	OK
13	3 phase fault on the Post Rock 345KV Bus 530583 to Spearville 345KV Bus 531469 CKT 1, near Post Rock.	OK	OK	OK
14	*Single phase fault and sequence like previous*	OK	OK	OK
15	3 phase fault on the Post Rock 345KV Bus 530583 to Axtell 345kV Bus 64005 CKT 1, near Post Rock.	OK	OK	OK
16	*Single phase fault and sequence like previous*	OK	OK	OK
17	3 phase fault on the Knoll 230kV Bus 530558 to Smokey Hill 230V Bus 530592 CKT 1, near Knoll.	OK	OK	OK
18	*Single phase fault and sequence like previous*	OK	OK	OK
19	3 phase fault on the Knoll 115kV Bus 530558 to Saline 115kV Bus 530551 CKT 1, near Knoll.	OK	OK	OK
20	*Single phase fault and sequence like previous*	OK	OK	OK
21	3 phase fault on the Knoll 115kV Bus 530558 to North Hays 115kV Bus 530581 CKT 1, near Knoll.	OK	OK	OK
22	*Single phase fault and sequence like previous*	OK	OK	OK
23	3 phase fault on the Knoll 115kV Bus 530558 to Redline 115kV Bus 530605 CKT 1, near Knoll.	OK	OK	OK
24	*Single phase fault and sequence like previous*	OK	OK	OK
25	3 phase fault on the GEN-2009-020 TAP 69kV Bus 560306 to Nekoma 69kV Bus 530564 CKT 1, near GEN-2009-020 TAP.	OK	OK	OK
26	*Single phase fault and sequence like previous*	OK	OK	OK
27	3 phase fault on the GEN-2009-020 TAP 69kV Bus 560306 to Bazine 69kV Bus 530585 CKT 1, near GEN-2009-020 TAP.	OK	OK	OK
28	*Single phase fault and sequence like previous*	OK	OK	OK
29	3 phase fault on the Seward 69kV Bus 530565 to Hudson 69kV Bus 530576 CKT 1, near Seward.	OK	OK	OK
30	*Single phase fault and sequence like previous*	OK	OK	OK
31	3 phase fault on the Seward 69kV Bus 530565 to Great Bend 69kV Bus 530569 CKT 1, near Seward.	OK	OK	OK
31A	*Single phase fault and sequence like previous*	OK	OK	OK
32	3 phase fault on the Nekoma 115kV Bus 530588 to Alexander 115kV Bus 530606 CKT 1, near Nekoma.	OK	OK	OK
33	*Single phase fault and sequence like previous*	OK	OK	OK

Table III-2: Stability Analysis Results

	Contingency Number and Name	2014WP	2015SP	2024SP
34	3 phase fault on the Nekoma 115kV Bus 530588 to Lacross Tap 115kV Bus 530602 CKT 1, near Nekoma.	OK	OK	OK
35	*Single phase fault and sequence like previous*	OK	OK	OK
36	3 phase fault on the Ness City 115kV Bus 531456 to Ransom 115kV Bus 530607 CKT 1, near Ness City.	OK	OK	OK
37	*Single phase fault and sequence like previous*	OK	OK	OK
38	3 phase fault on the Ness City 115kV Bus 531456 to Beeler 115kV Bus 531359 CKT 1, near Ness City.	OK	OK	OK
39	*Single phase fault and sequence like previous*	OK	OK	OK
40	3 phase fault on the South Hays 230KV Bus 530582 to South Hays 115kV Bus 530553 to South Hays 12.47kV Bus 530632 CKT 1, near South Hays 230kV.	OK	OK	OK
41	3 phase fault on the Post Rock 230KV Bus 530584 to Post Rock 345kV Bus 530583 to Post Rock 13.8kVkV Bus 530673 CKT 1, near Post Rock 230 kV.	OK	OK	OK
42	3 phase fault on the Great Bend 230kV Bus 539679 to Great Bend 115kV Bus 539678 to Great Bend 13.8kVkV Bus 539920 CKT 1, near Great Bend 230 kV.	OK	OK	OK
43	3 phase fault on the Knoll 230kV Bus 530558 to Knoll 115kV Bus 530561 to Knoll 11.49kV Bus 530629 CKT 1, near Knoll 230 kV.	OK	OK	OK
44	3 phase fault on the Nekoma 69kV Bus 530564 to Nekoma 115kV Bus 530608 to Nekoma 12.5kV Bus 530630 CKT 2, near Nekoma 69 kV.	OK	OK	OK
45	3 phase fault on the Heizer 69kV Bus 530563 to Heizer 115kV Bus 530601 to Heizer 12.5kV Bus 530627 CKT 2, near Heizer 69 kV.	OK	OK	OK
46	3 phase fault on the Seward 69kV Bus 530565 to Seward 115kV Bus 530679 to Seward 12.5kV Bus 530631 CKT 2, near Seward 69 kV.	OK	OK	OK
47	3 phase fault on the Heizer 115kV Bus 530601 to Heizer 230kV Bus 530680 to Heizer 12.5kV Bus 530626 CKT 1, near Heizer 115kV.	OK	OK	OK
48	3 phase fault on South Hays 230kV Bus 530582 to Post Rock 230KV Bus 530584 CKT 1, near South Hays.	OK	OK	OK
49	**Prior Outage of Seward 115kV to 69kV Transformer.** 3 phase fault on the GEN-2009-020 TAP 69kV Bus 560306 to Nekoma 69kV Bus 530564 CKT 1, near GEN-2009-020 TAP.	OK	OK	OK
50	*Single phase fault and sequence like previous*	OK	OK	OK
51	**Prior Outage of Nekoma 115kV to 69kV Transformer.** 3 phase fault on the GEN-2009-020 TAP 69kV Bus 560306 to Bazine 69kV Bus 530585 CKT 1, near GEN-2009-020 TAP.	OK	OK	OK
52	*Single phase fault and sequence like previous*	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 25, 27, 49 and 51 in Table III-2 simulated the LVRT contingencies. GEN-2009-020 met the LVRT requirements by staying on line and the transmission system remained stable.

IV. Power Factor Analysis[1]

A power factor analysis was not performed in this study. The power factor analysis results from the restudy posted February 2011 are still valid, and the facility will be required to maintain a 95% lagging (providing VARs) and 95% leading (absorbing VARs) power factor at the point of interconnection. While the capacitor bank is no longer required for voltage recovery conditions, the Customer is still responsible for maintaining a 95% power factor at the point of interconnection and additional capacitor banks may be required depending on the design of the Generating Facility and its collector system.

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 final power factor requirements are shown in Table IV-1 below. These are only the minimum power factor ranges based on steady-state analysis.

Table IV-1: Power Factor Requirements [a]

Request	Size (MW)	Generator Model	Point of Interconnection	Final PF Requirement	
				Lagging [b]	Leading [c]
GEN-2009-020	48.3	Siemens 108m 2.3MW with SWT WeakGrid Control	Tap on the Bazine (530585) – Nekoma (530564) 69kV (560306)	0.999	0.977

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.

[1] Power Factor Analysis performed by Excel Engineering

V. Conclusion

The SPP GEN-2009-020 Impact Restudy evaluated the impact of interconnecting the project shown below.

Request	Size	Generator Type	Point of Interconnection	Gen Buses
GEN-2009-020	48.3	Siemens 108m 2.3MW with SWT WeakGrid Control	Tap on the Bazine (530585) – Nekoma (530564) 69kV (560306)	575044

With all Base Case Network Upgrades in service, previously assigned Network Upgrades in service, and the controls package “SWT WeakGrid Control“ in-service, the GEN-2009-020 project was found to remain on line, and the transmission system was found to remain stable for all conditions studied.

The power factor analysis showed that the GEN-2009-020 project is required to maintain a power factor requirement of the pro-forma standard 0.95 leading (absorbing) to 0.95 lagging (supplying) at the Point of Interconnection.

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

(Additional Plots Available upon request)

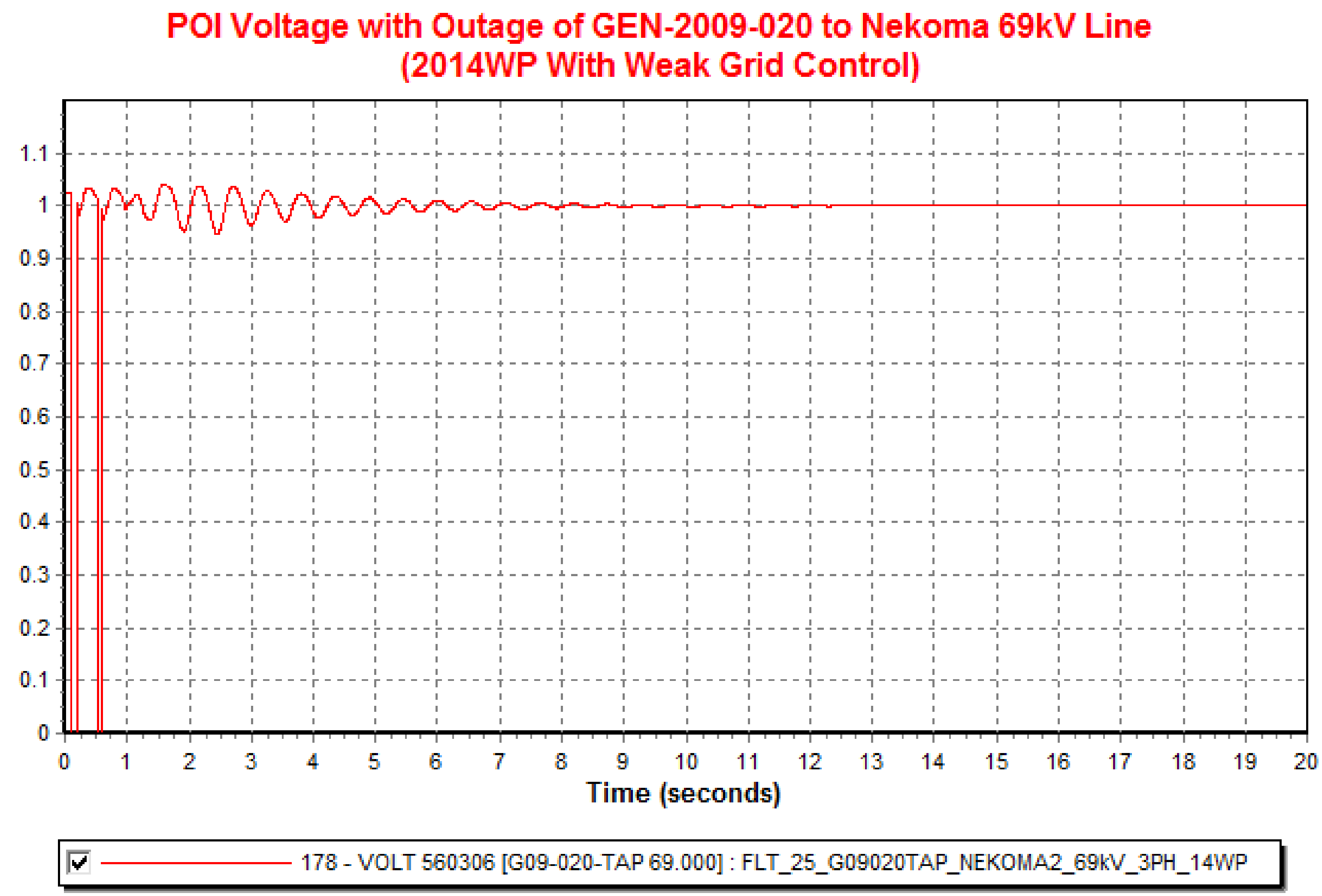

Figure A-1: GEN-2009-020 POI Voltage with Outage of GEN-2009-020 to Nekoma 69kV Line (2014WP with SWT WeakGrid Control)

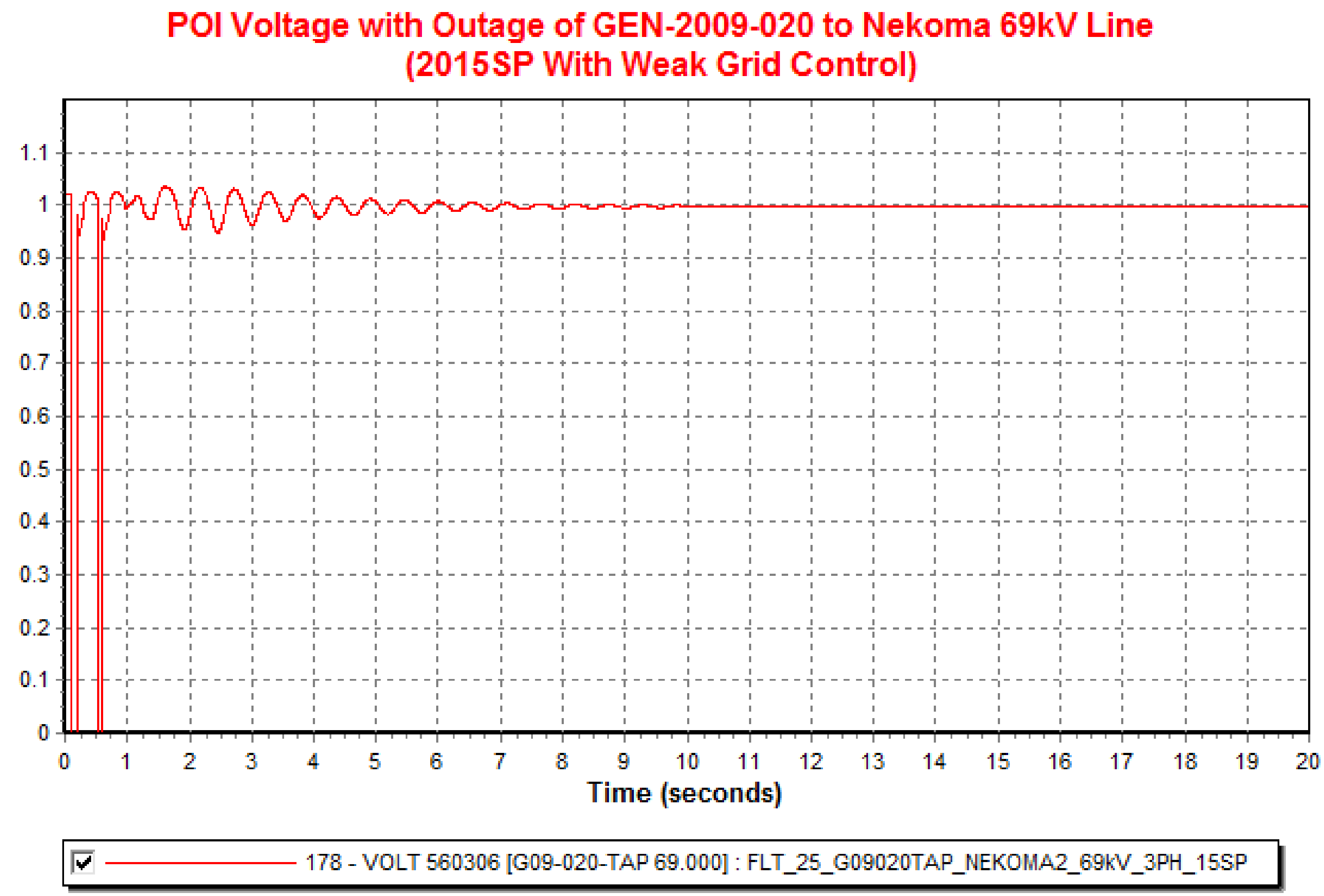

Figure A-2: GEN-2009-020 POI Voltage with Outage of GEN-2009-020 to Nekoma 69kV Line (2015SP with SWT WeakGrid Control)

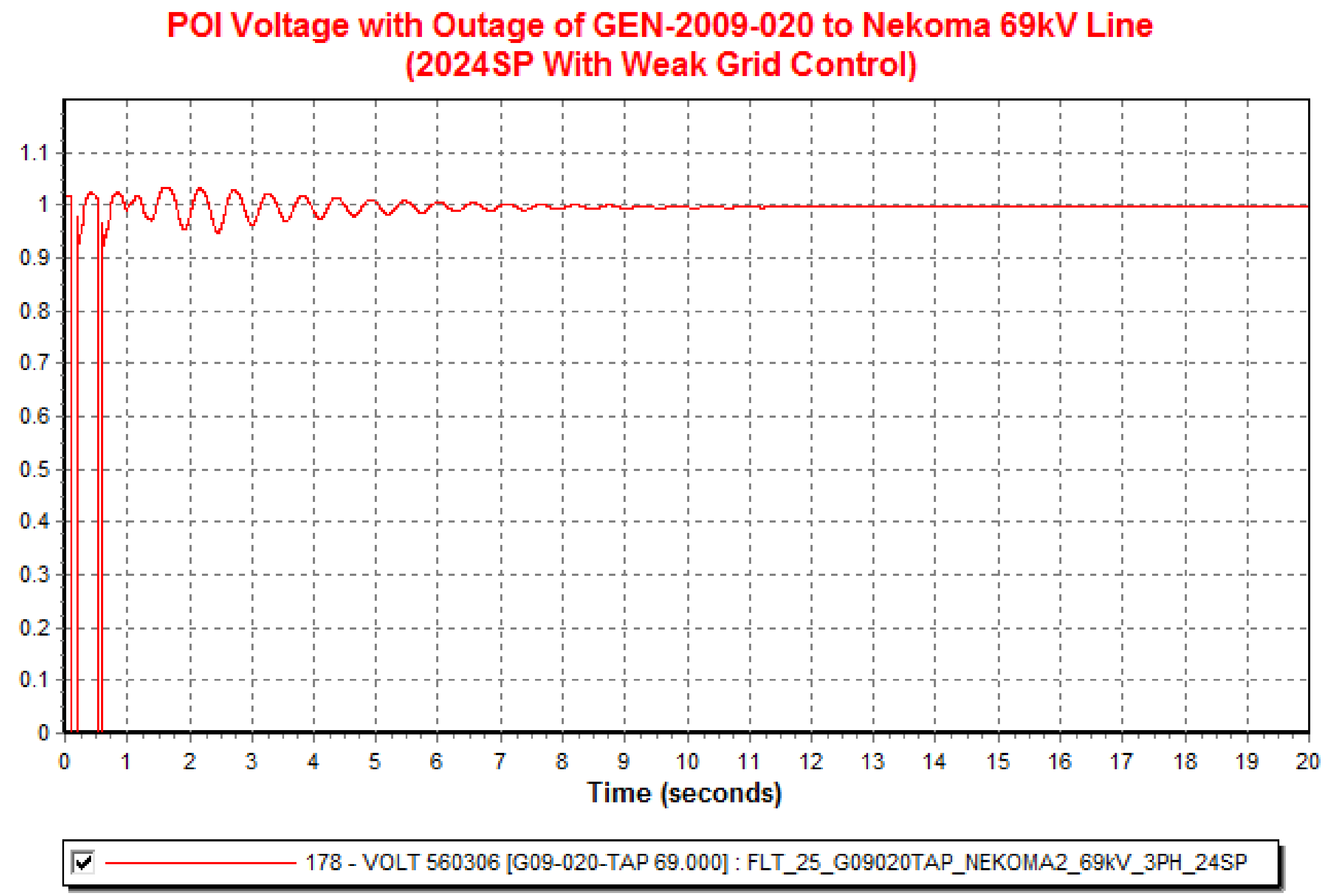

Figure A-3: GEN-2009-020 POI Voltage with Outage of GEN-2009-020 to Nekoma 69kV Line (2024SP with SWT WeakGrid Control)

APPENDIX B

TRANSIENT VOLTAGE DETAILS
(Available upon request)

APPENDIX C

POWER FACTOR ANALYSIS
(Refer to Restudy Posted February 2011)

APPENDIX D

PROJECT MODELS

GEN-2009-020 (Siemens SWT 2.3MW, 108m Wind Turbine Generator with SWT WeakGrid Control)

PSS/E 32 Power Flow Data

```
@! **************** GEN-2009-020 100% ****************
@! POI @ Tap Nekoma-Bazine 69kV 560306 (530564-530585)
@! Siemens SWT 2.3MW, 108m  Wind Turbine Generator with SWT WeakGrid Control
@! Pgen=48.30MW
@! 0.90PF Range
@! ----------- Bus Data -----------
BAT_BUS_DATA_2,575041,1,,,,  69.00,,,'GEN-2009-020',;
BAT_BUS_DATA_2,575042,1,,,,  34.50,,,'G09-020XFMR1',;
BAT_BUS_DATA_2,575043,1,,,,  34.50,,,'G09-020-GSU1',;
BAT_BUS_DATA_2,575044,2,,,,   0.69,,,'G09-020-GEN1',;
@! ----------- Generator Data -----------
BAT_PLANT_DATA,575044,, 1.035,,;
@! 100%
  BAT_MACHINE_DATA_2,575044,'1',1,,,,,0,  48.30,    , 23.3927,-23.3927,  48.30, 0.00,  48.30, 0.0000, 0.6415,,,,,,,, 1.00,;
@! ----------- Unit Transformers -----------
BAT_TWO_WINDING_DATA_3,575041,575042,'1',1,,,,,,33,,,,1,0,1,2,1, 0.00235, 0.07997,  40.00,,,,,,  60.00,  60.00,  60.00,,,,,,,,,,,,,,,;
BAT_TWO_WINDING_DATA_3,575043,575044,'1',1,,,,,, 5,,,,1,0,1,2,1, 0.00840, 0.06000,  54.60,,,,,,  54.60,  54.60,  54.60,,,,,,,,,,,,,,,;
@! ----------- Collector Cables -----------
BAT_BRANCH_DATA,575042,575043,'1',1,,,,,,  0.01163, 0.00887, 0.01495,,,,,,,,      ,,,,,;
@! ----------- Transmission Line from Substation to POI -----------
BAT_BRANCH_DATA,560306,575041,'1',1,,,,,, 0.00000, 0.00010, 0.00000,,,,,,,,      ,,,,,;
@END
```

PSS/E 32 Dynamics Data

```
/********************************************************************************
/ GEN-2009-020
/
/ Siemens 2.3MW SWTVD4  V1.1, 2.3 MW  108 m;  60 Hz  (SWTVD4_Model_PSSE_Ver_32.obj)
/ with SWT WeakGrid Control (SWP_WTCFRT_SWTVS4_Ver_Beta_03_Ver_32.OBJ)
/
575044 'USRMDL' 1 'SWTVD4'  1  1    26  160  31  107
  2 1 4 0 1 1 0 0 1 1 1 1 1 1 1 0 0 0 1 1 0 0 0 1 1 1 54.62 1.0927 18.3875 0.1458 128.61 1.2471 1.1814 1.0661 1.0003 1.1111 1.40 1.10
0.10 1.1 1.1 22
  100000 2.00 100000 1 0.1 1.1 2.0 1.0000 0.9920 1.0420 0.010 0.10 0.40 0.6 0.05 0.090 0.090 0.30 3.0 0.955 0.70 0.002 0.5 3 200
0.25 0.25 0.1 1
  0.9 1.0 0.0283 0.10 11.47 22.91 1 1.00 2.93 58.59 0.55 0.020 10 0.00 1.836 0.174 -0.174 1 0.0 1 0.5 25 1.1027 0.05 0.0014 0.1415
0.06
  0.875 0.040 2.10 0.70 1.20 0.70 1.75 1.2 0.80 0.5 0.40 4.0 1.225 15 1.00 2.0 0.055 25.0 0.276 1.0069
  13.05 -87.00 -48.33 0.15 7.0 -8.0 45.0 -4.0 2.0 0.060 0.9655 -4.7283 -0.6755 0.2174 0.2174 1.0 100 2.0 5.5 10.0 0.90 200 0.05 0.85
11.00 0.05
  0.70 2.60 0.05 0.40 1.60 0.05 0.15 0.85 0.05 0.10 1.00 0.05 0.10 1.00 0.05 0.10 1.00 0.05 1.10 1.00 0.05 1.20 0.15 0.05 1.45 1.00
0.05
  1.45 1.00 0.05 1.45 1.00 0.05 0.95 10.00 0.05 0.95 0.20 0.05 1.03 0.20 0.05 /
/
///SWP/Jny 19 July 2012
//* WT FRT Post Fault Active Power Controller module 19 July 2012 use with SWP_WTCFRT_SWTVS4_Ver_Beta_03.OBJ
  0 'USRMDL' 0 'WGOVS4'  8 0  1  3  0  100
  575044
  0.6  1.1  2.000/
/********************************************************************************
```

APPENDIX E

TRANSMISSION ONE-LINES
(Available upon request)