Southwest Power Pool

GEN-2008-123N Impact Restudy for Generator Modification (Turbine Change)

SPP Generator
Interconnection Studies

GEN-2008-123N

August 2013

Executive Summary

This document reports on the findings of a restudy for the GEN-2008-123N interconnection request. The interconnection customer has requested this restudy to determine the effects of changing wind turbine generators from the previously studied Siemens VS 2.3MW wind turbine generators to the GE 1.7MW wind turbine generators.

In this restudy the modified project uses fifty-two (52) GE 1.7MW wind turbine generators for an aggregate power of 88.4MW and is located in Webster County, Nebraska. The interconnection request shows that the GE 1.7MW wind turbine generators will have the optional +/-0.90 power factor capabilities installed.

The restudy showed that no stability problems were found during the summer or 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 was performed in this study. The facility will be required to maintain a 95% lagging (providing VARs) and 95% leading (absorbing VARs) power factor at the point of interconnection.

With the assumptions outlined in this report and with all the required network upgrades from the GEN-2008-123N GIA in place, GEN-2008-123N 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 that can account for every operational situation. Additionally, the generator(s) 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(s) may be required to reduce their generation output to 0 MW 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. If the customer wishes to sell power from the facility, a separate request for transmission service shall be requested on Southwest Power Pool's OASIS by the Customer.

1.0 Introduction

The interconnection customer has requested this restudy to determine the effects of changing wind turbine generators from the previously studied Siemens VS 2.3MW wind turbine generators to the GE 1.7MW wind turbine generators.

In this study SPP monitored the generators and transmission lines in Areas 520, 524, 525, 526, 531, 534, 536, 640, 645, 650, and 652.

2.0 Purpose

The purpose of this impact restudy is to evaluate the effects of using GE 1.7MW wind turbine generators on the reliability of the Transmission System.

3.0 Facilities

3.1 Customer Facility

With fifty-two (52) GE 1.7MW wind turbine generators, the project has a maximum power output of 88.4MW. Figure 1 shows the facility one-line drawing.

3.2 Interconnection Facility

The point of interconnection (POI) is a new NPPD 115kV substation that taps the Pauline – Guide Rock 115kV transmission line located in Webster County, Nebraska (see Figure 1).

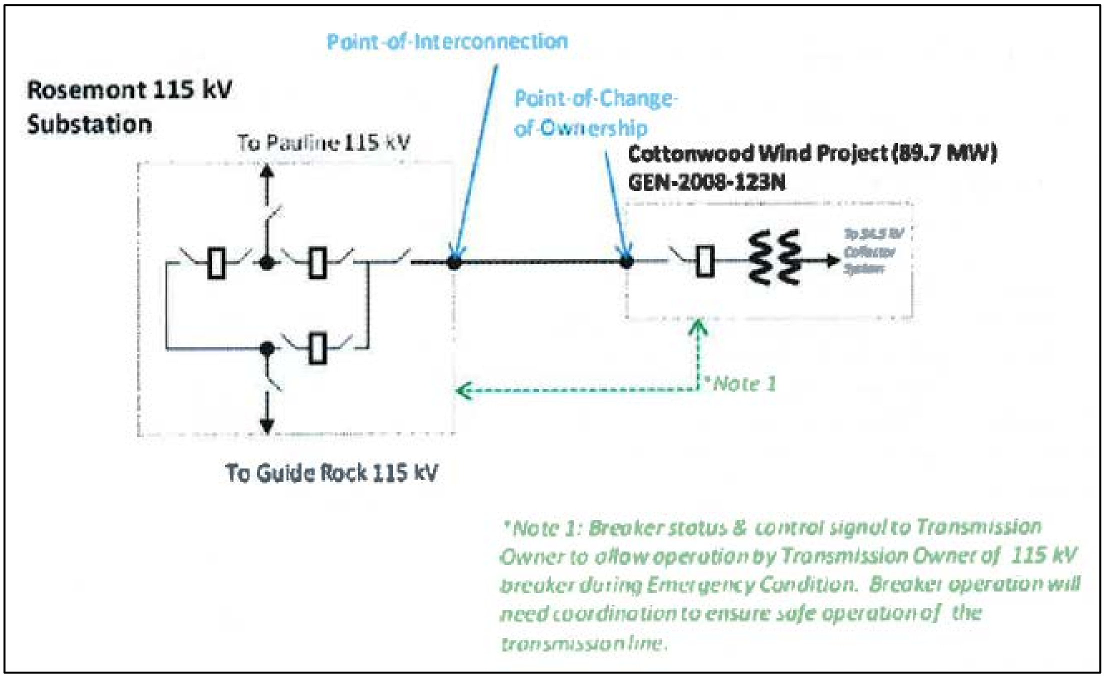

Figure 1: GEN-2008-123N Facility One-line Diagram

4.0 Stability Study Criteria

FERC Order 661A Low Voltage Ride-Through Provisions (LVRT), which went into effect January 1, 2006, requires that wind generating plants remain in-service during 3-phase faults at the point of interconnection. This order may require a Static VAR Compensator (SVC) or STATCOM device be specified at the Customer facility to keep the wind generator on-line for the fault. Dynamic Stability studies performed as part of the System Impact Study will provide additional guidance as to whether the reactive compensation can be static or a portion must be dynamic (such as a SVC or STATCOM).

5.0 Model Development

Transient stability analysis was performed using modified versions of the 2012 series of Model Development Working Group (MDWG) dynamic study models representing the Nebraska (Group 9/10) geographical study area or group within the SPP footprint.

This group contains the 2014 (summer and winter) seasonal models or cases. The cases are then adapted to resemble the power flow study cases with regards to prior queued generation requests and topology. Finally the prior queued and study generation is 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.

Siemens PSS/E Version 32.1 was used to perform the dynamic system impact restudy. For simulation purposes, the Customer's facility was simplified by using the equivalent model of the wind farm as shown in Figure 1. The data used to develop the equivalent wind farm model were supplied by the Customer.

The Customer also supplied the PSS/E Version 32.1 stability models for the GE 1.7MW wind turbine generators. The GE's reactive power capability was modeled as requested at +/-0.90pf.

Prior queued requests were included in the saved cases. The prior queued requests are shown in Table 1.

Table 1: Prior Queued Projects

Request	Size (MW)	Generator Dyre Model	Point of Interconnection
Beatrice Power Station	250.0	GENROU	BPS 115kV
Broken Bow	8.3	GENCLS	Broken Bow 115kV
Burwell	3.0	GENCLS	Ord 115kV
Cass	322.6	GENROU	S3740 345kV
Columbus (hydro)	45.0	GENSAL	Columbus 115kV
Cooper	874.4	GENROU	Cooper 345kV
Crete	15.7	GENCLS	Crete 115kV
Fairbury	15.3	GENCLS	Fairbury 115kV
Gavins Point (hydro)	13.9	GENSAL	Gavins Point 115kV
GEN-2003-021N	75.0	WTG1	Ainsworth Wind Tap 115kV

Table 1: Prior Queued Projects

Request	Size (MW)	Generator Dyre Model	Point of Interconnection
GEN-2004-005N	30.0	GEWTG2	St Francis 115kV
GEN-2006-020N	42.0	VWCOR4	Bloomfield 115kV
GEN-2006-037N1	75.0	GEWTG2	Broken Bow 115kV
GEN-2006-038N05	79.5	GEWTG2	Broken Bow 115kV
GEN-2006-038N19	79.5	WT3G1	North Petersburg 115kV
GEN-2006-044N	40.5	GEWTG2	North Petersburg 115kV
GEN-2007-011N08	81.0	VWCOR4	Bloomfield 115kV
GEN-2008-086N02	200.6	GEWTG2	Tap Ft Randall – Columbus 230kV (Madsion Co 230kV)
GEN-2008-119O	60.0	GEWTG2	S1399 161kV
GEN-2009-040	73.8	VWCOR4	Marshall 115kV
Hallam	52.0	GENROU	Sheldon 115kV
Hastings Energy Center	316.0	GENROU	Energy Center 115kV
Hebron	52.0	GENROU	Hebron North 115kV
NE City	1439.0	GENROU	S3458 345kV
Ord	10.8	GENCLS	Ord 115kV
Platte	108.4	GENROU	Sub-D 115kV
Rokeby	272.2	GENROU	Rokeby 115kV
Sheldon	256.0	GENROU	Sheldon 115kV
Stuart	2.1	GENCLS	Ainsworth 115kV
Terry Bundy (SVGS)	179.5	GENROU	TBGS 115kV

6.0 <u>Stability Study Analysis</u>

Twenty-eight (28) contingencies were considered for the transient stability simulations in this scenario. These contingencies included three phase faults and single phase line faults at locations defined by SPP. Single-phase line faults were simulated by applying a 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. The faults that were defined and simulated are listed in Table 2. The faults were simulated on both the summer peak and the winter peak models.

Table 2: Selected Faults for Dynamic Analysis

#	Contingency Name/Description
1	FLT_01_PAULINE_MOORE_345kV_3PH a. Apply 3ϕ fault at Pauline 345kV (640312) b. After 4.5 cycles, clear fault and trip Pauline – Moore (640277) 345kV
2	FLT_02_MOORE_COOPER_345kV_3PH a. Apply 3ϕ fault at Moore 345kV (640277) b. After 4.5 cycles, clear fault and trip Moore – Cooper (640139) 345kV

Table 2: Selected Faults for Dynamic Analysis

#	Contingency Name/Description
3	FLT_03_MOORE_MCCOOL_345kV_3PH a. Apply 3ϕ fault at Moore 345kV (640277) b. After 4.5 cycles, clear fault and trip Moore – Cooper (640271) 345kV
4	FLT_04_MOORE_NW68HOLDRG_345kV_3PH a. Apply 3ϕ fault at Moore 345kV (640277) b. After 4.5 cycles, clear fault and trip Moore – NW 6th & Holdredge (650114) 345kV
5	FLT_05_MOORE_103ROKEBY_345kV_3PH a. Apply 3ϕ fault at Moore 345kV (640277) b. After 4.5 cycles, clear fault and trip Moore – 103rd & Rokeby (650189) 345kV
6	FLT_06_MOORE_SHELDON_345_115kV_3PH a. Apply 3ϕ fault at Moore (640277) 345kV bus of the Moore 345/115kV transformer b. After 5.5 cycles, clear fault and trip Moore 345/115kV transformer
7	FLT_07_PAULINE_PAULINE_345_115kV_3PH a. Apply 3ϕ fault at Pauline (640312) 345kV bus of the Pauline 345/115kV transformer b. After 5.5 cycles, clear fault and trip Pauline 345/115kV transformer
8	FLT_08_PAULINE_AXTELL_345kV_3PH a. Apply 3ϕ fault at Pauline 345kV (640312) b. After 4.5 cycles, clear fault and trip Pauline – Axtell (640065) 345kV
9	FLT_09_G08123N_PAULINE_115kV_3PH a. Apply 3ϕ fault at GEN-2008-0123N 115kV (560137) b. After 6.5 cycles, clear fault and trip GEN-2008-123N – Pauline (640313) 115kV
10	FLT_10_G08123N_GUIDEROCK_115kV_3PH a. Apply 3ϕ fault at GEN-2008-0123N 115kV (560137) b. After 6.5 cycles, clear fault and trip GEN-2008-123N – Guide Rock (640206) 115kV
11	FLT_11_PAULINE_HASTINGS_115kV_3PH a. Apply 3ϕ fault at Pauline 115kV (640313) b. After 6.5 cycles, clear fault and trip Pauline – Hastings (640215) 115kV
12	FLT_12_PAULINE_HILDRETH_115kV_3PH a. Apply 3ϕ fault at Pauline 115kV (640313) b. After 6.5 cycles, clear fault and trip Pauline – Hildreth (640222) 115kV
13	FLT_13_NHEBRON_CARLJCT_115kV_3PH a. Apply 3ϕ fault at N Hebron 115kV (640218) b. After 6.5 cycles, clear fault and trip N Hebron – Carleton Junction (640105) 115kV
14	FLT_14_NHEBRON_FAIRBURY_115kV_3PH a. Apply 3ϕ fault at N Hebron 115kV (640218) b. After 6.5 cycles, clear fault and trip N Hebron – Fairbury (640169) 115kV
15	FLT_15_NHEBRON_CARLJCT_115kV_3PH_PQedOut a. Prior Outage GEN-2008-123N (560137) – Pauline (640313) 115kV. b. Apply 3ϕ fault at N Hebron 115kV (640218) c. After 6.5 cycles, clear fault and trip N Hebron – Carleton Junction (640105) 115kV
16	FLT_16_BPS_SHELDON_115kV_3PH a. Apply 3ϕ fault at BPS 115kV (640088) b. After 6.5 cycles, clear fault and trip BPS – Sheldon (640278) 115kV
17	FLT_17_BEATRICE_HARBINE_115kV_3PH a. Apply 3ϕ fault at Beatrice 115kV (640076) b. After 6.5 cycles, clear fault and trip Beatrice – Harbine (640208) 115kV
18	FLT_18_BPS_SHELDON_115kV_3PH_PQedOut a. Prior Outage BPS (640088) – Clatonia (640111) 115kV. b. Apply 3ϕ fault at BPS 115kV (640218) c. After 6.5 cycles, clear fault and trip BPS – Sheldon (640278) 115kV

Table 2: Selected Faults for Dynamic Analysis

#	Contingency Name/Description
19	FLT_19_ENRGCNTR_SUTTON_115kV_3PH a. Apply 3ϕ fault at Hastings Energy Center 115kV (641087) b. After 6.5 cycles, clear fault and trip Hastings Energy Center – Sutton (640372) 115kV
20	FLT_20_ENRGCNTR_HASTINGSCTY_115kV_3PH a. Apply 3ϕ fault at Hastings Energy Center 115kV (641087) b. After 6.5 cycles, clear fault and trip Hastings Energy Center – Hastings City (641088) 115kV
21	FLT_21_MOORE_MCCOOL_345kV_1PH_ClearAddtnl a. Apply 3ϕ fault at Moore 345kV (640277) b. After 4.5 cycles, trip McCool end of Moore – McCool (640271) 345kV c. After 8 additional cycles, clear fault, and trip Moore end of Moore – McCool 345kV d. Trip Moore – NW & Holdredge (650114) 345kV
22	FLT_22_MOORE_MCCOOL_345kV_1PH_ClearAddtnl2 a. Apply 3ϕ fault at Moore 345kV (640277) b. After 4.5 cycles, trip McCool end of Moore – McCool (640271) 345kV c. After 8 additional cycles, clear fault, and trip Moore end of Moore – McCool 345kV d. Trip Moore – 103rd & Rokeby (650189) 345kV
23	FLT_23_MOORE_COOPER_345kV_1PH_ClearAddtnl a. Apply 3ϕ fault at Moore 345kV (640277) b. After 4.5 cycles, trip Cooper end of Moore – Cooper (640139) 345kV c. After 8 additional cycles, clear fault, and trip Moore end of Moore – Cooper 345kV d. Trip Moore 345/115/13.8kV transformer
24	FLT_24_BEATRICE_HARBINE_115kV_1PH_ClearAddtnl a. Apply 3ϕ fault at Beatrice 115kV (640076) b. After 6.5 cycles, trip Harbine end of Beatrice – Harbine (640208) 115kV c. After 8 additional cycles, clear fault, and trip Beatrice end of Beatrice – Harbine 115kV d. Trip Beatrice – BPS (640088) 115kV
25	FLT_25_HOLDREDGE_AXTELL_115kV_3PH a. Apply 3ϕ fault at Holdredge 115kV (640224) b. After 6.5 cycles, clear fault and trip Holdredge – Axtell (640066) 115kV
26	FLT_26_JOHNSON_HOLDREDGE_115kV_3PH a. Apply 3ϕ fault at Johnson 115kV (640242) b. After 6.5 cycles, clear fault and trip Johnson – Holdredge (640224) 115kV
27	FLT_27_AXTELL_AXTELL_345_115kV_3PH a. Apply 3ϕ fault at Axtell (640065) 345kV bus of the Axtell 345/115kV transformer b. After 5.5 cycles, clear fault and trip Pauline 345/115kV transformer
28	FLT_28_HASTINGSCTY_HASTINGSCTY_115_230kV_3PH a. Apply 3ϕ fault at Hastings City (641088) 230kV bus of the Hastings City 230/115kV transformer b. After 5.5 cycles, clear fault and trip Hastings City 230/115kV transformer

7.0 Simulation Results

All faults were run for both summer and winter cases, and no tripping occurred in this study. Table 3 summarizes the results for all faults. Complete sets of plots for summer and winter cases are available on request.

Based on the dynamic results and with all network upgrades in service, GEN-2008-123N did not cause any stability problems and remained stable for all faults studied.

Additionally, the project wind farm was found to stay connected during the contingencies that were studied and therefore, meet the Low Voltage Ride Through (LVRT) requirements of FERC Order #661A.

Table 3: Selected Faults for Dynamic Analysis

No.	Contingency Name	Summer	Winter
1	FLT_01_PAULINE_MOORE_345kV_3PH	Stable	Stable
2	FLT_02_MOORE_COOPER_345kV_3PH	Stable	Stable
3	FLT_03_MOORE_MCCOOL_345kV_3PH	Stable	Stable
4	FLT_04_MOORE_NW68HOLDRG_345kV_3PH	Stable	Stable
5	FLT_05_MOORE_103ROKEBY_345kV_3PH	Stable	Stable
6	FLT_06_MOORE_SHELDON_345_115kV_3PH	Stable	Stable
7	FLT_07_PAULINE_PAULINE_345_115kV_3PH	Stable	Stable
8	FLT_08_PAULINE_AXTELL_345kV_3PH	Stable	Stable
9	FLT_09_G08123N_PAULINE_115kV_3PH	Stable	Stable
10	FLT_10_G08123N_GUIDEROCK_115kV_3PH	Stable	Stable
11	FLT_11_PAULINE_HASTINGS_115kV_3PH	Stable	Stable
12	FLT_12_PAULINE_HILDRETH_115kV_3PH	Stable	Stable
13	FLT_13_NHEBRON_CARLJCT_115kV_3PH	Stable	Stable
14	FLT_14_NHEBRON_FAIRBURY_115kV_3PH	Stable	Stable
15	FLT_15_NHEBRON_CARLJCT_115kV_3PH_PQedOut	Stable	Stable
16	FLT_16_BPS_SHELDON_115kV_3PH	Stable	Stable
17	FLT_17_BEATRICE_HARBINE_115kV_3PH	Stable	Stable
18	FLT_18_BPS_SHELDON_115kV_3PH_PQedOut	Stable	Stable
19	FLT_19_ENRGCNTR_SUTTON_115kV_3PH	Stable	Stable
20	FLT_20_ENRGCNTR_HASTINGSCTY_115kV_3PH	Stable	Stable
21	FLT_21_MOORE_MCCOOL_345kV_1PH_ClearAddtnl	Stable	Stable
22	FLT_22_MOORE_MCCOOL_345kV_1PH_ClearAddtnl2	Stable	Stable
23	FLT_23_MOORE_COOPER_345kV_1PH_ClearAddtnl	Stable	Stable
24	FLT_24_BEATRICE_HARBINE_115kV_1PH_ClearAddtnl	Stable	Stable
25	FLT_25_HOLDREDGE_AXTELL_115kV_3PH	Stable	Stable
26	FLT_26_JOHNSON_HOLDREDGE_115kV_3PH	Stable	Stable
27	FLT_27_AXTELL_AXTELL_345_115kV_3PH	Stable	Stable
28	FLT_28_HASTINGSCTY_HASTINGSCTY_115_230kV_3PH	Stable	Stable

8.0 <u>Power Factor Analysis</u>

A power factor analysis was performed in this study. Table 4 shows the power factor of the customer facility at the POI for various contingencies. The facility will be required to maintain a 95% lagging (providing VARs) and 95% leading (absorbing VARs) power factor at the point of interconnection.

Table 4: Selected Faults for Power Factor Analysis

CONTINGENCY	PF (Summer)		PF (Winter)	
FLT_01_PAULINE_MOORE_345kV_3PH	0.954	LEAD	0.957	LEAD

Table 4: Selected Faults for Power Factor Analysis

CONTINGENCY	PF (Summer)		PF (Winter)	
FLT_02_MOORE_COOPER_345kV_3PH	0.964	LEAD	0.963	LEAD
FLT_03_MOORE_MCCOOL_345kV_3PH	0.958	LEAD	0.959	LEAD
FLT_04_MOORE_NW68HOLDRG_345kV_3PH	0.963	LEAD	0.966	LEAD
FLT_05_MOORE_103ROKEBY_345kV_3PH	0.954	LEAD	0.957	LEAD
FLT_06_MOORE_SHELDON_345_115kV_3PH	0.956	LEAD	0.959	LEAD
FLT_07_PAULINE_PAULINE_345_115kV_3PH	0.954	LEAD	0.957	LEAD
FLT_08_PAULINE_AXTELL_345kV_3PH	0.954	LEAD	0.957	LEAD
FLT_09_G08123N_PAULINE_115kV_3PH	0.969	LEAD	0.961	LEAD
FLT_10_G08123N_GUIDEROCK_115kV_3PH	0.987	LEAD	0.981	LEAD
FLT_11_PAULINE_HASTINGS_115kV_3PH	0.987	LEAD	0.981	LEAD
FLT_12_PAULINE_HILDRETH_115kV_3PH	0.955	LEAD	0.963	LEAD
FLT_13_NHEBRON_CARLJCT_115kV_3PH	0.956	LEAD	0.960	LEAD
FLT_14_NHEBRON_FAIRBURY_115kV_3PH	0.951	LEAD	0.958	LEAD
FLT_15_NHEBRON_CARLJCT_115kV_3PH_PQedOut	0.952	LEAD	0.958	LEAD
FLT_16_BPS_SHELDON_115kV_3PH	0.985	LEAD	0.985	LEAD
FLT_17_BEATRICE_HARBINE_115kV_3PH	0.955	LEAD	0.958	LEAD
FLT_18_BPS_SHELDON_115kV_3PH_PQedOut	0.953	LEAD	0.955	LEAD
FLT_19_ENRGCNTR_SUTTON_115kV_3PH	0.962	LEAD	0.965	LEAD
FLT_20_ENRGCNTR_HASTINGSCTY_115kV_3PH	0.960	LEAD	0.963	LEAD
FLT_21_MOORE_MCCOOL_345kV_1PH_ClearAddtnl	0.956	LEAD	0.961	LEAD
FLT_22_MOORE_MCCOOL_345kV_1PH_ClearAddtnl2	0.959	LEAD	0.963	LEAD
FLT_23_MOORE_COOPER_345kV_1PH_ClearAddtnl	0.961	LEAD	0.964	LEAD
FLT_24_BEATRICE_HARBINE_115kV_1PH_ClearAddtnl	0.957	LEAD	0.958	LEAD
FLT_25_HOLDREDGE_AXTELL_115kV_3PH	0.953	LEAD	0.955	LEAD
FLT_26_JOHNSON_HOLDREDGE_115kV_3PH	0.955	LEAD	0.959	LEAD
FLT_27_AXTELL_AXTELL_345_115kV_3PH	0.954	LEAD	0.958	LEAD
FLT_28_HASTINGSCTY_HASTINGSCTY_115_230kV_3PH	0.954	LEAD	0.957	LEAD

Lowest leading power factor
Lowest lagging power factor

9.0 Conclusion

The findings of the restudy show that no stability problems were observed during the summer or the winter peak conditions due to the use of 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, meet the Low Voltage Ride Through (LVRT) requirements of FERC Order #661A.

A power factor analysis was performed in this study. The facility will be required to maintain a 95% lagging (providing VARs) and 95% leading (absorbing VARs) power factor at the point of interconnection.

With the assumptions outlined in this report and with all required network upgrades from the GEN-2008-123N GIA in place, GEN-2008-123N with the wind turbine generators described in the study should be able to reliably interconnect to the SPP transmission grid.