Southwest Power Pool

Limited Operation Impact Study For Generation Interconnection Request GEN-2008-124

SPP Generation Interconnection Studies

(#GEN-2008-124)

January 2011

Executive Summary

<OMITTED TEXT> (Customer) has requested a Limited Operation Impact Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnection of 200.1 MW of wind generation within the balancing authority of Sunflower Electric Power Corporation (SUNC) in Ford County, Kansas. The Interconnection Customer expects to request a Commercial Operation Date (COD) before all of the required network upgrades in DISIS-2009-001 can be completed. Therefore, Customer has requested this Limited Operation Impact Study to determine the impacts of interconnecting its generating facility to the transmission system before all required Network Upgrades identified in the DISIS-2009-001 posted on January 31, 2010 can be placed into service. Limited Operational Impact Studies are conducted in accordance with Section 5.9 of the SPP pro-forma GIA.

<u>This study assumed that only those projects with queue priority equal to or over GEN-2008-124, which are identified in Table 2 and Table 3 of this study, might go into service before the completion of all Network Upgrades identified in DISIS-2009-001</u>. This study also assumed that all other additional generation projects with queue priority equal to or over GEN-2008-124, those listed in Table 4 of this report, will NOT request commercial operation before the completion of all Network Upgrades identified in DISIS-2009-001 study process as required. If any of these projects requests commercial operation then this study must be conducted again to determine whether sufficient interim interconnection capacity exists to interconnect the GEN-2008-124 interconnection request in addition to all higher priority requests in operation or pending operation.

Power flow analysis studies included the prior queued projects listed in Table 2 and Table 3. The analysis showed that with system upgrades scheduled to be in-service prior to the requested in service date, the customer's wind facility can inject 200.1 MW of generation capacity into the SUNC transmission system. Powerflow analysis was based on both summer and winter peak conditions and light loading cases. If any project listed in Table 4 goes into service before the completion of network upgrades, a new study will need to be performed and the GEN-2008-124 interconnection request may be required to disconnect until such time that upgrades can be completed.

The power factor requirements for GEN-2008-124 are +/-95% at the point of interconnection (POI) per the DISIS-2009-001 Impact study and the SPP Tariff.

The stability study results show that the transmission system remains stable for all simulated contingencies and conditions studied for the Customer facility with prior queued projects listed in Table 2 and Table 3. Additionally, the stability study results show that the transmission system becomes unstable if prior queued projects listed in Table 4 are also included in the analysis. If the Customer changes generation technology, this study will be considered invalid and a new study will be required to determine if the Customer can interconnect before the network upgrades are completed.

The wind generation facility was studied with eighty-seven (87) Siemens 2.3 MW wind turbine generators. This Impact study addresses the thermal loading and dynamic stability effects of interconnecting the plant to the rest of the SUNC transmission system for the system condition as it will be on September 15, 2012. Two seasonal base cases were used in the study to analyze the stability impacts of the proposed generation facility. The cases studied were modified 2010 summer peak and 2010 winter peak cases that were adjusted to reflect system conditions at the requested in-service date. Each case was modified to include prior queued projects that are listed in the body of the report. Thirty-four (34) contingencies were identified for use in this study. The Siemens 2.3 MW wind turbines were modeled using information provided by the Customer.

The DISIS-2009-001 estimated costs for network upgrades and interconnection facilities are also applicable for interim operation at an estimate of $7,500,000.

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

<OMITTED TEXT> (Customer) has requested a Limited Operation Impact Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnection of 200.1 MW of wind generation within the balancing authority of Sunflower Electric Power Corporation (SUNC) in Ford County, Kansas. The Interconnection Customer expects to request a Commercial Operation Date (COD) before all of the required network upgrades in DISIS-2009-001 can be completed. Therefore, Customer has requested this Limited Operation Impact Study to determine the impacts of interconnecting its generating facility to the transmission system before all required Network Upgrades identified in the DISIS-2009-001 posted on January 31, 2010 can be placed into service. Limited Operational Impact Studies are conducted in accordance with Section 5.9 of the SPP pro-forma GIA.

This Impact study addresses the thermal loading and dynamic stability effects of interconnecting the generation to the rest of the SUNC transmission system for the system condition as it will be on September 15, 2012. The wind generation facility was studied with eighty-seven (87) Siemens 2.3 MW wind turbine generators. Two seasonal base cases were used in the study to analyze the stability impacts of the proposed generation facility. The cases studied were modified versions of the 2010 summer peak and 2010 winter peak to reflect the system conditions at the requested in-service date. Each case was modified to include prior queued projects that are listed in the body of the report. Thirty-four (34) contingencies were identified for this study.

2.0 Purpose

The purpose of this Interim Operational Impact Study (IOIS) is to evaluate the impact of the proposed interconnection on the reliability of the Transmission System. The IOIS considers the Base Case as well as all Generating Facilities (and with respect to (b) below, any identified Network Upgrades associated with such higher queued interconnection) that, on the date the IOIS is commenced:

a) are directly interconnected to the Transmission System;
b) are interconnected to Affected Systems and may have an impact on the Interconnection Request;
c) have a pending higher queued Interconnection Request to interconnect to the Transmission System listed in Table 2; or
d) have no Queue Position but have executed an LGIA or requested that an unexecuted LGIA be filed with FERC.

Any changes to these assumptions, for example, one or more of the previously queued projects not included in this study signing an interconnection agreement, may require a re-study of this request 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.

3.0 Facilities

3.1 Generating Facility

The project was modeled as two equivalent wind turbine generators of 101.2 MW and 98.9 MW output. The wind turbines are connected to equivalent 0.69/34.5KV generator step unit (GSU) The high side of each GSU is connected to the 34.5/345kV substation transformer. A 345kV transmission line connects the Customer's substation transformer to the POI.

3.2 Interconnection Facility

The Point of Interconnection (POI) will be at the Spearville 345kV substation. Figure 1 shows the facility and proposed POI at the proposed interim in-service date. Figure 2 shows the One Line to the Point of Interconnection.

Cost to interconnect on an Interim basis is estimated at $7,500,000.

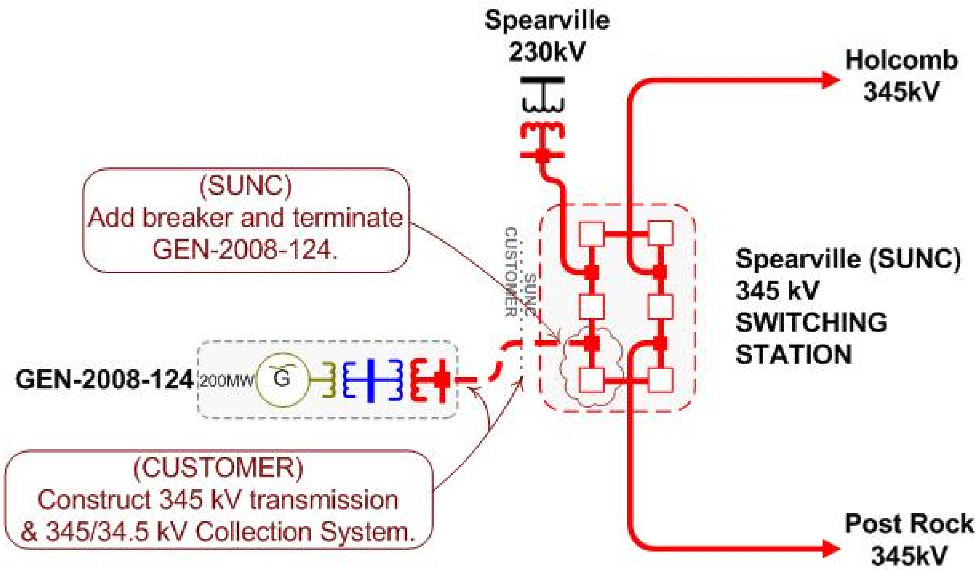

Figure 1: GEN-2008-124 Facility and Proposed Interconnection Configuration

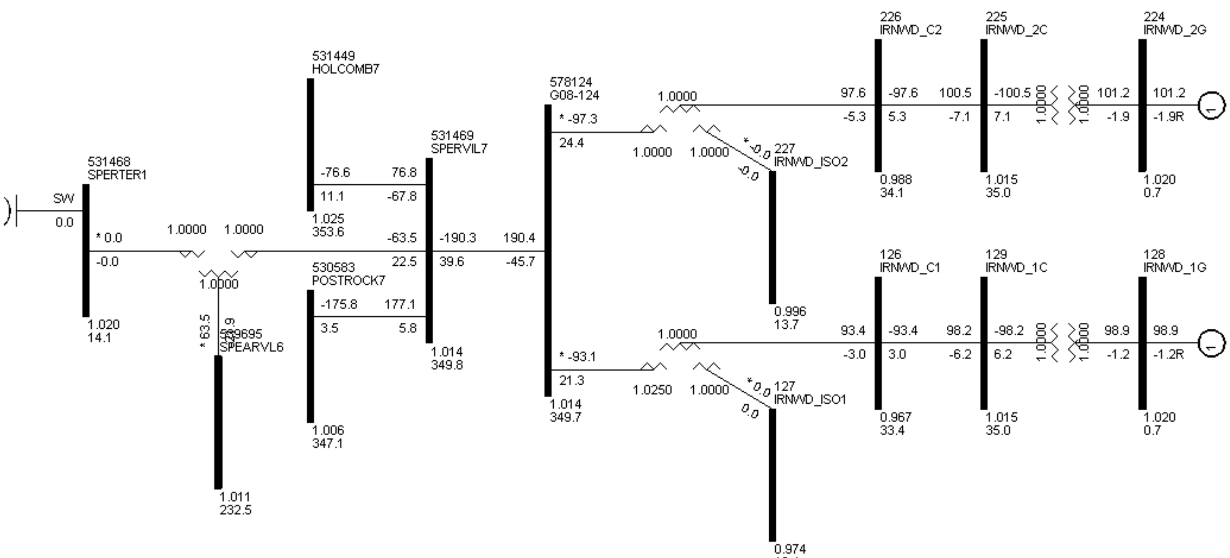

Figure 2: GEN-2008-124 One Line Bus Interconnection

4.0 Power Flow Analysis

A powerflow analysis was conducted for the Interconnection Customer's facility using a modified version of the 2011 summer and 2011 winter seasonal models. The output of the Interconnection Customer's facility was offset in the model by a reduction in output of existing online SPP generation. This method allows the request to be studied as an Energy Resource (ERIS) Interconnection Request. This analysis was conducted assuming that previous queued requests listed in Table 2 were in-service. The analysis was repeated while sequentially including the requests listed in Table 3 and Table 4 until voltage collapse occurred.

The Southwest Power Pool (SPP) Criteria states that:

> "The transmission system of the SPP region shall be planned and constructed so that the contingencies as set forth in the Criteria will meet the applicable NERC Reliability Standards for transmission planning. All MDWG power flow models shall be tested to verify compliance with the System Performance Standards from NERC Table 1 – Category A."

The ACCC function of PSS/E was used to simulate single contingencies in portions of or all of the control area of SUNC and other control areas within SPP and the resulting data analyzed. This satisfies the "more probable" contingency testing criteria mandated by NERC and the SPP criteria.

The ACCC analysis indicates that as a result of the Customer's project at full nameplate power the SUNC transmission system will not experience thermal overloads with higher queued projects listed in Table 2 modeled as in service. These analysis results are listed in Table 1. Thermal overloads occur with the inclusion of the higher queued projects listed in Table 3. Non converged scenarios, typically associated with voltage collapse, occur with the inclusion of higher queued project GEN-2006-006 listed in Table 4. If projects listed in Table 4 go into service before the completion of network upgrades, the GEN-2008-124 interconnection request may be required to disconnect until such time that upgrades can be completed.

Additional equally or higher queued projects listed in Table 4 were not modeled as in service. If any of these projects request service then this study will need to be performed again to determine if any limited interconnection service is available.

Table 1: ACCC Analysis

SCENARIO	SEASON	SOURCE	DIRECTION	MONTCOMMONNAME	RATEB	TDF	TC%LOADING	CONTNAME
3	11G	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21856	114.0608	'FINNEY SWITCHING STATION - Hitchland Interchange 345KV CKT 1'
3	11G	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21856	114.1052	'FINNEY SWITCHING STATION - HOLCOMB 345KV CKT 1'
3	11G	G08_124	'TO->FROM'	'MULLERGREN - SPEARVILLE 230KV CKT 1'	355.3	0.32451	101.359	'POSTROCK7 345.00 - SPEARVILLE 345KV CKT 1'
3	11G	G08_124	'TO->FROM'	'CIRCLE - MULLERGREN 230KV CKT 1'	319	0.2503	100.4724	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'
3	11G	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.27305	117.745	'HOLCOMB - SPEARVILLE 345KV CKT 1'
3	11G	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.23323	111.8044	'CIRCLE - MULLERGREN 230KV CKT 1'
3	11G	G08_124	'TO->FROM'	'MULLERGREN - SPEARVILLE 230KV CKT 1'	355.3	0.32451	101.3242	'POSTROCK7 345.00 (POSTROCK T1) 345/230/13.8KV TRANSFORMER CKT 1'
3	11G	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21856	114.4289	'SPP-SWPS-05'
3	11SP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.22135	116.0907	'FINNEY SWITCHING STATION - Hitchland Interchange 345KV CKT 1'
3	11SP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.22135	109.8126	'FINNEY SWITCHING STATION - HOLCOMB 345KV CKT 1'
3	11SP	G08_124	'TO->FROM'	'MULLERGREN - SPEARVILLE 230KV CKT 1'	355.3	0.32743	103.401	'POSTROCK7 345.00 - SPEARVILLE 345KV CKT 1'
3	11SP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.27627	113.6678	'HOLCOMB - SPEARVILLE 345KV CKT 1'
3	11SP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.2365	107.7114	'CIRCLE - MULLERGREN 230KV CKT 1'
3	11SP	G08_124	'TO->FROM'	'MULLERGREN - SPEARVILLE 230KV CKT 1'	355.3	0.32743	103.3629	'POSTROCK7 345.00 (POSTROCK T1) 345/230/13.8KV TRANSFORMER CKT 1'
3	11SP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.22135	109.1218	'SPP-SWPS-05'
3	11WP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21745	109.3502	'FINNEY SWITCHING STATION - Hitchland Interchange 345KV CKT 1'
3	11WP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21745	115.1996	'FINNEY SWITCHING STATION - HOLCOMB 345KV CKT 1'
3	11WP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.27189	120.885	'HOLCOMB - SPEARVILLE 345KV CKT 1'
3	11WP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.22867	112.6378	'CIRCLE - MULLERGREN 230KV CKT 1'
3	11WP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21745	116.1645	'SPP-SWPS-05'
4	11G	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21898	111.7182	'FINNEY SWITCHING STATION - Hitchland Interchange 345KV CKT 1'
4	11G	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21898	111.7282	'FINNEY SWITCHING STATION - HOLCOMB 345KV CKT 1'
4	11G	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.2736	113.4869	'HOLCOMB - SPEARVILLE 345KV CKT 1'
4	11G	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.23386	109.2929	'CIRCLE - MULLERGREN 230KV CKT 1'
4	11G	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21898	111.9403	'SPP-SWPS-05'
4	11SP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.22153	113.4987	'FINNEY SWITCHING STATION - Hitchland Interchange 345KV CKT 1'
4	11SP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.22153	107.2846	'FINNEY SWITCHING STATION - HOLCOMB 345KV CKT 1'
4	11SP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.27654	109.1999	'HOLCOMB - SPEARVILLE 345KV CKT 1'
4	11SP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.23672	105.0274	'CIRCLE - MULLERGREN 230KV CKT 1'
4	11SP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.22153	106.6481	'SPP-SWPS-05'
4	11WP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21782	106.54	'FINNEY SWITCHING STATION - Hitchland Interchange 345KV CKT 1'
4	11WP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21782	112.4148	'FINNEY SWITCHING STATION - HOLCOMB 345KV CKT 1'
4	11WP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.27232	116.4854	'HOLCOMB - SPEARVILLE 345KV CKT 1'
4	11WP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.22909	109.9898	'CIRCLE - MULLERGREN 230KV CKT 1'
4	11WP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21782	113.303	'SPP-SWPS-05'
5	11G	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21612	139.4516	'FINNEY SWITCHING STATION - Hitchland Interchange 345KV CKT 1'
5	11G	G08_124	'TO->FROM'	'CIRCLE - MULLERGREN 230KV CKT 1'	319	0.23146	111.5528	'FINNEY SWITCHING STATION - Hitchland Interchange 345KV CKT 1'
5	11G	G08_124	'TO->FROM'	'MULLERGREN - SPEARVILLE 230KV CKT 1'	355.3	0.22281	105.0699	'FINNEY SWITCHING STATION - Hitchland Interchange 345KV CKT 1'
5	11G	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21612	139.4882	'FINNEY SWITCHING STATION - HOLCOMB 345KV CKT 1'
5	11G	G08_124	'TO->FROM'	'CIRCLE - MULLERGREN 230KV CKT 1'	319	0.23146	111.5894	'FINNEY SWITCHING STATION - HOLCOMB 345KV CKT 1'
5	11G	G08_124	'TO->FROM'	'MULLERGREN - SPEARVILLE 230KV CKT 1'	355.3	0.22281	105.0741	'FINNEY SWITCHING STATION - HOLCOMB 345KV CKT 1'
5	11G	G08_124	'TO->FROM'	'MULLERGREN - SPEARVILLE 230KV CKT 1'	355.3	0.32123	131.4606	'POSTROCK7 345.00 - SPEARVILLE 345KV CKT 1'
5	11G	G08_124	'TO->FROM'	'CIRCLE - MULLERGREN 230KV CKT 1'	319	0.24746	129.7883	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'
5	11G	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.1957	112.1088	'MINGO - SETAB 345KV CKT 1'

SCENARIO	SEASON	SOURCE	DIRECTION	MONTCOMMONNAME	RATEB	TDF	TC%LOADING	CONTNAME
5	11G	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.22063	109.2255	'MINGO - RED WILLOW 345KV CKT 1'
5	11G	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.23062	136.4149	'CIRCLE - MULLERGREN 230KV CKT 1'
5	11G	G08_124	'TO->FROM'	'MULLERGREN - SPEARVILLE 230KV CKT 1'	355.3	0.32123	131.4232	'POSTROCK7 345.00 (POSTROCK T1) 345/230/13.8KV TRANSFORMER CKT 1'
5	11G	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21612	139.9076	'SPP-SWPS-05'
5	11G	G08_124	'TO->FROM'	'CIRCLE - MULLERGREN 230KV CKT 1'	319	0.23146	111.9553	'SPP-SWPS-05'
5	11G	G08_124	'TO->FROM'	'MULLERGREN - SPEARVILLE 230KV CKT 1'	355.3	0.22281	105.4726	'SPP-SWPS-05'
5	11G	G08_124		NCONV	1328	0.45314	39.73534	'HOLCOMB - SPEARVILLE 345KV CKT 1'
5	11SP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21975	139.0965	'FINNEY SWITCHING STATION - Hitchland Interchange 345KV CKT 1'
5	11SP	G08_124	'TO->FROM'	'CIRCLE - MULLERGREN 230KV CKT 1'	319	0.23452	103.066	'FINNEY SWITCHING STATION - Hitchland Interchange 345KV CKT 1'
5	11SP	G08_124	'TO->FROM'	'MULLERGREN - SPEARVILLE 230KV CKT 1'	355.3	0.2257	107.643	'FINNEY SWITCHING STATION - Hitchland Interchange 345KV CKT 1'
5	11SP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21975	130.7626	'SPP-SWPS-05'
5	11SP	G08_124	'TO->FROM'	'MULLERGREN - SPEARVILLE 230KV CKT 1'	355.3	0.2257	100.7603	'SPP-SWPS-05'
5	11SP	G08_124		NCONV	1328	0.4573	36.95098	'HOLCOMB - SPEARVILLE 345KV CKT 1'
5	11SP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21975	131.2732	'FINNEY SWITCHING STATION - HOLCOMB 345KV CKT 1'
5	11SP	G08_124	'TO->FROM'	'MULLERGREN - SPEARVILLE 230KV CKT 1'	355.3	0.2257	101.1252	'FINNEY SWITCHING STATION - HOLCOMB 345KV CKT 1'
5	11SP	G08_124	'TO->FROM'	'MULLERGREN - SPEARVILLE 230KV CKT 1'	355.3	0.32524	131.3345	'POSTROCK7 345.00 - SPEARVILLE 345KV CKT 1'
5	11SP	G08_124	'TO->FROM'	'CIRCLE - MULLERGREN 230KV CKT 1'	319	0.25145	116.7376	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'
5	11SP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.1994	113.4111	'MINGO - SETAB 345KV CKT 1'
5	11SP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.22468	111.5667	'MINGO - RED WILLOW 345KV CKT 1'
5	11SP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.23479	129.6107	'CIRCLE - MULLERGREN 230KV CKT 1'
5	11SP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.19098	101.8063	'GERALD GENTLEMAN STATION - RED WILLOW 345KV CKT 1'
5	11SP	G08_124	'TO->FROM'	'MULLERGREN - SPEARVILLE 230KV CKT 1'	355.3	0.32524	131.3794	'POSTROCK7 345.00 (POSTROCK T1) 345/230/13.8KV TRANSFORMER CKT 1'
5	11SP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.19118	103.6974	'SPEARVILLE (SPEARVL) 345/230/13.8KV TRANSFORMER CKT 1'
5	11WP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21521	130.425	'FINNEY SWITCHING STATION - Hitchland Interchange 345KV CKT 1'
5	11WP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21521	138.3708	'FINNEY SWITCHING STATION - HOLCOMB 345KV CKT 1'
5	11WP	G08_124	'TO->FROM'	'CIRCLE - MULLERGREN 230KV CKT 1'	319	0.2305	106.9957	'FINNEY SWITCHING STATION - HOLCOMB 345KV CKT 1'
5	11WP	G08_124	'TO->FROM'	'CIRCLE - MULLERGREN 230KV CKT 1'	319	0.24277	125.5438	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'
5	11WP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.19215	113.7204	'MINGO - SETAB 345KV CKT 1'
5	11WP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21691	112.3351	'MINGO - RED WILLOW 345KV CKT 1'
5	11WP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.22627	135.9364	'CIRCLE - MULLERGREN 230KV CKT 1'
5	11WP	G08_124	'FROM->TO'	'SMOKYHL6 230.00 - SUMMIT 230KV CKT 1'	319	0.21521	139.404	'SPP-SWPS-05'
5	11WP	G08_124	'TO->FROM'	'CIRCLE - MULLERGREN 230KV CKT 1'	319	0.2305	107.9514	'SPP-SWPS-05'
5	11WP	G08_124		NCONV	1328	0.46011	41.20319	'HOLCOMB - SPEARVILLE 345KV CKT 1'

5.0 Power Factor Analysis

All contingencies were tested in power flow to determine the power factor requirements for the wind farm study project to maintain scheduled voltage at the point of interconnection (POI). The voltage schedule was set equal to the voltage at the POI under no fault conditions, with a minimum of 1.0 per unit. A fictitious reactive power source was added to the study project to maintain scheduled voltage during all studied contingencies. The MW and Mvar injections from the study project at the POI were recorded and the resulting power factors were calculated for all contingencies for both summer peak and winter peak cases (see Appendix A for the data). 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 were less than 0.95 lagging, then the requirement would be set to 0.95 lagging. This limit was not reached for the study project. The limit for leading power factor requirement is also 0.95, and this limit was not reached for the study project.

6.0 Stability Analysis

The Stability Analysis was performed by American Earth and Environmental (AMEC). The entire analysis is attached in Appendix A

6.1 Contingencies Simulated

Thirty-four (34) contingencies were considered for the transient stability simulations. These contingencies included three phase and single phase transmission line faults and transformer 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 in Appendix A.

6.2 Further Model Preparation

The base cases contain higher or equally queued projects as shown in Table 2.

The wind generation from the study customer and the previously queued customers were dispatched into the SPP footprint.

Initial simulations were carried out on both base cases and cases with the added generation for a no-disturbance run of 20 seconds to verify the numerical stability of the model. All cases were confirmed to be stable.

Table 2: Prior Queued Projects Included

Project	MW
Montezuma	110
GEN-2002-025A	150
GEN-2004-014	150
GEN-2001-039M	99
GEN-2006-021	101
GEN-2003-019	250
GEN-2008-079	101

The projects listed in Table 3 and Table 4 list higher or equally queued projects that are sequentially considered in this analysis. These generators were included by request of the customer to determine the prior queued generation limit for voltage collapse.

Table 3: Prior Queued Projects Sequentially Considered for Inclusion

Project	MW
*GEN-2005-012	250
*GEN-2001-039A	105

**** Inclusion of these generators results in thermal overloads during contingencies.***

The projects in Table 4 are higher or equally queued projects that are <u>not</u> included in this analysis. If any of these projects request to come into service during interim operation, this study will need to be re-performed to determine if any interim capacity is available.

Table 4: Prior Queued Projects Not Included

Project	MW
**GEN-2006-006	206
GEN-2007-038	200
GEN-2007-040	200
GEN-2008-018	405

***** The inclusion of this generator causes voltage collapse.***

6.3 <u>Results</u>

Results of the stability analysis are in Appendix A – Interim Impact Study. The results indicate that for all contingencies studied the transmission system remains stable with the inclusion of equally or higher queued projects listed in Table 2 and Table 3. However the inclusion of equally or higher queued projects listed in Table 4 cause convergence issues typically associated with voltage instability.

7.0 Conclusion

<OMITTED TEXT> (Customer) has requested an Limited Operation Impact Study for interconnection service of 200.1 MW of wind generation within the balancing authority of Sunflower Electric Power Corporation in Ford County, Kansas, as allowed by Article 5.9 of the standard pro-forma GIA of the SPP OATT.

The results of this study show that the wind generation facility and the transmission system remain stable for all contingencies studied. Also, GEN-2008-124 is found to be in compliance with FERC Order #661A.

The power factor requirements for GEN-2008-124 are +/-95% at the POI per FERC and SPP Tariff requirements.

The projects in Table 4 are higher or equally queued projects that are not included in this analysis. If any of these projects come into service, this study will need to be re-performed to determine if any interim capacity is available.

The DISIS-2009-001 estimated costs for network upgrades and interconnection facilities are also applicable for limited operation at an estimate of $7,500,000.

The estimates do not include any costs associated with the deliverability of the energy to final customers. These costs are determined by separate studies if the Customer requests transmission service through Southwest Power Pool's OASIS. It should be noted that the models used for simulation do not contain all SPP transmission service.

APPENDIX A.

GEN-2008-124 Restudy

January 6, 2011

Submitted To:
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LEGAL NOTICE

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EXECUTIVE SUMMARY

The Southwest Power Pool (SPP) has a requested a restudy of a generator interconnection request for a 345 kV interconnection of a 200 MW wind farm in Southwestern Kansas. This wind farm will be interconnected at the existing Spearville 345 kV Substation. The interconnection customer has asked for a study case of 100% MW output (with dynamic reactive compensation if required). This substation is owned by Mid-Kansas Electric Company.

Request	Size (MW)	Wind Turbine Model	Point of Interconnection
GEN-2008-124	200	Siemens 2.3MW	Spearville (531469) 345kV

The case will contain the following previous queued and later queued requests. These projects will be monitored and their generating status shall be reported for each contingency. The projects are as follows:

Request	Size (MW)	Wind Turbine Model	Point of Interconnection
Montezuma	110	Vestas V47 0.66MW	Haggard 115kV (539667)
GEN-2001-039M	99	Vestas V90 3.0MW	Tap Leoti – City Services 115kV (531485)
GEN-2002-025A	150	G.E. 1.5MW	Spearville 230kV (539695)
GEN-2003-019	250	G.E. 1.5MW & Vestas V90 3.0MW	Smoky Hills 230kV (530592)
GEN-2004-014	50	G.E. 1.5MW	Spearville 230kV (539695)
GEN-2006-021	100	Clipper 2.5MW	Tap Harper – Medicine Lodge 138kV (539638)

SPP requested a stability analysis and a power factor analysis as part of the restudy of GEN-2008-124. SPP did not request an Available Transfer Capability (ATC) study as part of this study.

Transient stability analysis shows no problems with the dynamic response of study generation in the region of interest for the faults and clearing times studied. All generators in the monitored area remain stable during the studied faults.

GEN-2008-124 has the capability of pre-contingency voltage recovery. The 345 kV POI voltage recovered to between 0.9906 pu and 1.0263 pu for all faults studied.

Low Voltage Ride Through (LVRT) analysis that the GEN-2008-124 generators did not tripping due to low voltage for any of the faults studied. However previous project queue MONTEZUMA wind turbine generators did trip off line due to under voltage for several of the faults studied.

The power factor analysis indicated that no supplemental reactive capability would be necessary in order to meet the study requirements.

Additional simulations were run with additional project queue requests added to the cases. These additional project queue requests included:

Request	Size (MW)	Wind Turbine Model	Point of Interconnection

GEN-2004-014	100	GE 1.5MW	Spearville 230 kV (539695)
GEN-2005-012	250	Vestas CV90IG 3 MW	Spearville 345 kV (531469)
GEN-2001-039A	105	Clipper C93	Tap Fort Dodge-Greenburg (579025)
GEN-2006-006	206	GE GEDFA	Spearville 230 kV (539695)

Results of simulations run with additional project queue requests GEN-2004-014, GEN-2005-012, and GEN-2001-039A added to the cases indicate that no synchronous generators pulled out of synchronism with the grid. Previous project queue request MONTEZUMA tripped on under voltage for both the summer and winter cases. MONTEZUMA voltage protection was overridden and the simulations were re-run. No generators tripped due to over/under voltage or over/under frequency and no synchronous generators pulled out of synchronism with the grid with the MONTEZUMA voltage protection overridden.

Results of simulations run with additional project queue requests GEN-2004-014, GEN-2005-012, GEN-2001-039A, and GEN-2006-006 indicate that no synchronous generators pulled out of synchronism with the grid. Previous project queue request MONTEZUMA tripped on under voltage for both the summer and winter cases. MONTEZUMA voltage protection was overridden and the simulations were re-run. No generators tripped due to over/under voltage or over/under frequency and no synchronous generators pulled out of synchronism with the grid with the MONTEZUMA voltage protection overridden for the summer case. However GEN-2005-012 tripped off line in the winter case due to convergence issues typically associated with voltage instability. No other wind turbines tripped off line and no synchronous generators pulled out of synchronism with the grid.

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INTRODUCTION

The Southwest Power Pool (hereafter referred to as SPP) commissioned AMEC Earth and Environmental (hereafter referred to as AMEC) to restudy the impact of generator GEN-2008-124 in the SPP interconnection queue. The site studied is in Southwestern Kansas. This restudy is at the customer's request.

SPP did not request an Available Transfer Capability (ATC) study. The ATC study will be required when the generation companies request transmission service.

SPP requested a power factor analysis and stability analysis based on a list of faults provided by SPP. The results of this study

a. Determined the equivalent amount of reactive compensation required at the 345kV POI to maintain adequate post contingency voltage with GEN-2008-124 modeled at the 345kV POI bus with 0 Var output.

b. Determine the ability of the wind farm to meet FERC Order 661A (low voltage ride through and wind farm recovery to pre-fault voltage) with and without additional reactive power support.

c. Determine the ability of the generators to remain in synchronism following three- phase and single-line-to-ground faults.

STUDY METHODOLOGY

SPP provided 2010 summer peak and 2011 winter peak load flow cases in PSS/E format. Table 1 below shows the total demand and generation in the monitored areas.

Table 5: Description of Study Areas

Area No.	Area Name	2011 Summer Peak		2011 Winter Peak	
		Load (MW)	Generation (MW)	Load (MW)	Generation (MW)
520	AEPW	10247.3	9247.2	7880.2	6866.6
524	OKGE	5956.2	6793.3	4194.8	4578.9
525	WWFEC	1418.7	1220.5	1308.1	1059.3
526	SPS	5618.3	5414.4	4038.3	3950.9
531	MIDW	259.4	253.6	197.2	268.5
534	SUNC	544.1	714.4	447.1	692.4
536	WERE	5941.9	5807.2	3932.1	4103.8
640	NPPD	3425	3022.6	2722.5	2869.8
645	OPPD	2670.2	2882.9	2004.9	2235
650	LES	785.9	237.9	576.3	97.3
652	WAPA	3758.9	4992.7	197.2	268.5

1 POWER FACTOR ANALYSIS

A power factor analysis was performed to determine if additional reactive compensation was required to hold the voltage at the point of interconnection consistent with the voltage schedule in the base case or 1.0 PU, whichever is higher. The equivalent wind farm model of GEN-2008-124 was disconnected from the point of interconnection. There are no previously queued generation interconnection requests at the point of interconnection. A generator with the equivalent real power MW and no reactive capability was modeled at the POI. A var generator was modeled at the queued wind farm's substation high voltage bus POI. The var generator was set to hold a voltage schedule at the POI consistent with the voltage schedule provided in the base case or 1.0 PU voltage (whichever is higher).

A list of contingencies shown in Table 2 was simulated. Additional reactive compensation was modeled at the 115kV side of the POI of the wind farm collector substation to maintain 1.00 PU post contingency bus voltage.

Table 6: Steady-State Contingency Descriptions

Cont No.	Description
FLT03	Spearville (531469) to Holcomb (531449) 345kV line
FLT05	Fort Dodge (539671) to Dodge City Beef (539645) 115kV line
FLT09	Holcomb 345kV / 115kV autotransformer
FLT15	Spearville 345kV / 230kV autotransformer
FLT17	Fort Dodge (539671) to Greenburg (539664) 115kV line
FLT19	Spearville 230kV / 115kV autotransformer
FLT21	Spearville (539695) to Mullergren (539679) 230kV line
FLT23	Mullergren (539679) to South Hays (530582) 230kV line
FLT25	Mullergren (539679) to Circle (532871) 230kV line
FLT35	Fort Dodge (539671) to North Fort Dodge (539771) 115kV line
FLT37	Spearville (531469) to Post Rock (530583) 345kV line
FLT41	Post Rock 345kV / 230kV autotransformer
FLT49	Cimarron River Tap (539652) to Cimarron Plant (539654) 115kV line
FLT51	Cimarron River Tap (539652) to East Liberal (539672) 115kV line
FLT55	Spearville (539694) to North Fort Dodge (539771) 115kV line
FLT57	Finney (523854) to Holcomb (531449) 345kV line
FLT59	Setab (531465) to Holcomb (531449) 345kV line

Tables 3 contains the results of the powerflow analysis for each of the fault conditions specified in Table 2 for the summer and winter conditions. The table contains bus voltage at the POI and the supplemental reactive support from the equivalent var generator modeled at the POI 115kV substation bus.

Table 7: Voltage at POI and Supplemental Reactive

Cont. No.	GEN-2008-124							
	Summer				Winter			
	Voltage	P	Additional	Net	Voltage	P	Additional	Net

	(PU)	(MW)	Mvar	PF	(PU)	(MW)	Mvar	PF
Base Case	1.024	200	0	1.0	1.027	200	0	1.0
FLT03	1.006	200	0	1.0	1.007	200	0	1.0
FLT05	1.023	200	0	1.0	1.028	200	0	1.0
FLT09	1.028	200	0	1.0	1.035	200	0	1.0
FLT15	1.037	200	0	1.0	1.041	200	0	1.0
FLT17	1.021	200	0	1.0	1.025	200	0	1.0
FLT19	1.030	200	0	1.0	1.033	200	0	1.0
FLT21	1.017	200	0	1.0	1.021	200	0	1.0
FLT23	1.023	200	0	1.0	1.027	200	0	1.0
FLT25	1.023	200	0	1.0	1.030	200	0	1.0
FLT35	1.022	200	0	1.0	1.024	200	0	1.0
FLT37	1.024	200	0	1.0	1.028	200	0	1.0
FLT41	1.025	200	0	1.0	1.029	200	0	1.0
FLT49	1.024	200	0	1.0	1.027	200	0	1.0
FLT51	1.024	200	0	1.0	1.027	200	0	1.0
FLT55	1.030	200	0	1.0	1.032	200	0	1.0
FLT57	1.015	200	0	1.0	1.022	200	0	1.0
FLT59	1.023	200	0	1.0	1.023	200	0	1.0

2 DYNAMIC ANALYSIS

The study areas shown in Table 1 were monitored in the dynamic analysis. The transmission line and transformer faults were simulated and synchronous machine rotor angles and wind turbine generator speeds were monitored to check whether synchronism of the synchronous machines is maintained and whether the wind turbine generators trip offline during the disturbance.

Following is a summary of the faults simulated in this analysis.

Table 8: Fault Descriptions

Cont. No.	Cont. Name	Description
1	FLT3-3PH	*3 phase fault on the Spearville (531469) to Holcomb (531449) 345kV lines, near Spearville. a. Apply fault at the Spearville 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	FLT4-1PH	*Single phase fault and sequence like previous*
3	FLT5-3PH	*3 phase fault on the Fort Dodge (539671) to Dodge City Beef (539645) 115kV line, near Fort Dodge. a. Apply fault at the Fort Dodge 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.*
4	FLT6-1PH	*Single phase fault and sequence like previous*
5	FLT9-3PH	*3 phase fault on the Holcomb 345kV / 115kV autotransformer near the 345 kV bus (531449). a. Apply fault at the Holcomb 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.*
6	FLT10-1PH	*Single phase fault and sequence like previous*
7	FLT15-3PH	*3 phase fault on the Spearville 345kV / 230kV autotransformer near the 345 kV bus (531469). a. Apply fault at the Spearville 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.*
8	FLT16-1PH	*Single phase fault and sequence like previous*
9	FLT17-3PH	*3 phase fault on the Fort Dodge (539671) to Greenburg (539664) 115kV line, near Fort Dodge. a. Apply fault at the Fort Dodge 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.*
10	FLT18-1PH	*Single phase fault and sequence like previous*

Cont. No.	Cont. Name	Description
11	FLT19-3PH	*3 phase fault on the Spearville 230kV / 115kV autotransformer near the 230 kV bus (539695).* *a. Apply fault at the Spearville 230kV bus.* *b. Clear fault after 5 cycles by tripping the faulted transformer.*
12	FLT20-1PH	*Single phase fault and sequence like previous*
13	FLT21-3PH	*3 phase fault on the Spearville (539695) to Mullergren (539679) 230kV line, near Spearville.* *a. Apply fault at the Spearville 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.*
14	FLT22-1PH	*Single phase fault and sequence like previous*
15	FLT23-3PH	*3 phase fault on the Mullergren (539679) to South Hays (530582) 230kV line, near Mullergren.* *a. Apply fault at the Mullergren 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.*
16	FLT24-1PH	*Single phase fault and sequence like previous*
17	FLT25-3PH	*3 phase fault on the Mullergren (539679) to Circle (532871) 230kV line, near Mullergren.* *a. Apply fault at the Mullergren 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	FLT26-1PH	*Single phase fault and sequence like previous*
19	FLT35-3PH	*3 phase fault on the Fort Dodge (539671) to North Fort Dodge (539771) 115kV line, near Fort Dodge.* *a. Apply fault at the Fort Dodge 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	FLT36-1PH	*Single phase fault and sequence like previous*
21	FLT37-3PH	*3 phase fault on the Spearville (531469) to Post Rock (530583) 345kV line, near Spearville.* *a. Apply fault at the Spearville 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.*

Cont. No.	Cont. Name	Description
22	FLT38-1PH	*Single phase fault and sequence like previous*
23	FLT41-3PH	*3 phase fault on the Post Rock 345kV / 230kV autotransformer near the 345 kV bus (530583).* *a. Apply fault at the Post Rock 345kV bus.* *b. Clear fault after 5 cycles by tripping the faulted transformer.*
24	FLT42-1PH	*Single phase fault and sequence like previous*
25	FLT49-3PH	*3 phase fault on the Cimarron River Tap (539652) to Cimarron Plant (539654) 115kV line, near Cimarron River Tap.* *a. Apply fault at the Cimarron River 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.*
26	FLT50-1PH	*Single phase fault and sequence like previous*
27	FLT51-3PH	*3 phase fault on the Cimarron River Tap (539652) to East Liberal (539672) 115kV line, near Cimarron River Tap.* *a. Apply fault at the Cimarron River 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.*
28	FLT52-1PH	*Single phase fault and sequence like previous*
29	FLT55-3PH	*3 phase fault on the Spearville (539694) to North Fort Dodge (539771) 115kV line, near Spearville.* *a. Apply fault at the Spearville 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.*
30	FLT56-1PH	*Single phase fault and sequence like previous*
31	FLT57-3PH	*3 phase fault on the Finney (523854) to Holcomb (531449) 345kV line, 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.*
32	FLT58-1PH	*Single phase fault and sequence like previous*

Cont. No.	Cont. Name	Description
33	FLT59-3PH	*3 phase fault on the Setab (531465) to Holcomb (531449) 345kV line, near Setab.* *a. Apply fault at the Setab 345kV bus.* *b. Clear fault after 5 cycles by tripping the faulted line.* *c. Wait 20 cycles, and then re-close the line in (b) back into the fault.* *d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.*
34	FLT60-1PH	*Single phase fault and sequence like previous*

In order to simulate 1PH faults, equivalent shunt Mvar[1] were determined to be applied at the faulted buses. Table 5 presents equivalent reactors used in the transient stability study.

Table 9: Equivalent Shunt Mvar at Faulted Bus for Single-Line-to-Ground Faults

Fault No.	Faulted Bus No.	2011 Summer Peak (Mvar)	2011 Winter Peak (Mvar)
FLT4-1PH	531469	-2226.6	-2100.9
FLT6-1PH	539671	-1126.7	-697.1
FLT10-1PH	531449	-2705.3	-2622.9
FLT16-1PH	531469	-2226.6	-2100.9
FLT18-1PH	539671	-1126.7	-697.1
FLT20-1PH	539695	-1966.3	-1828.7
FLT22-1PH	539695	-1966.3	-1828.7
FLT24-1PH	539679	-1727.1	-1644.8
FLT26-1PH	539679	-1727.1	-1644.8
FLT36-1PH	539671	-1126.7	-697.1
FLT38-1PH	531469	-2226.6	-2100.9
FLT42-1PH	530583	-1634.4	-1573.0
FLT50-1PH	539652	-594.6	-481.3
FLT52-1PH	539652	-594.6	-481.3
FLT56-1PH	539694	-1128.9	-973.4
FLT58-1PH	523853	-2683.0	-2602.6
FLT60-1PH	531465	-2272.8	-2250.1

Another important aspect of the dynamic analysis was to check FERC Order 661A compliance. The turbine generators were monitored to determine whether they stayed connected to the grid (Low Voltage Ride Through -

[1] The equivalent shunt Mvar causes the voltage at the faulted bus to drop to 0.60 PU.

LVRT) following the faults defined in Table 5. The wind farm capability of post-fault voltage recovery at the POI was also checked.

PROJECT DESCRIPTION

Following is a table of the proposed wind farms in the restudy.

Table 10: Points of Interconnection Gen-2006-020

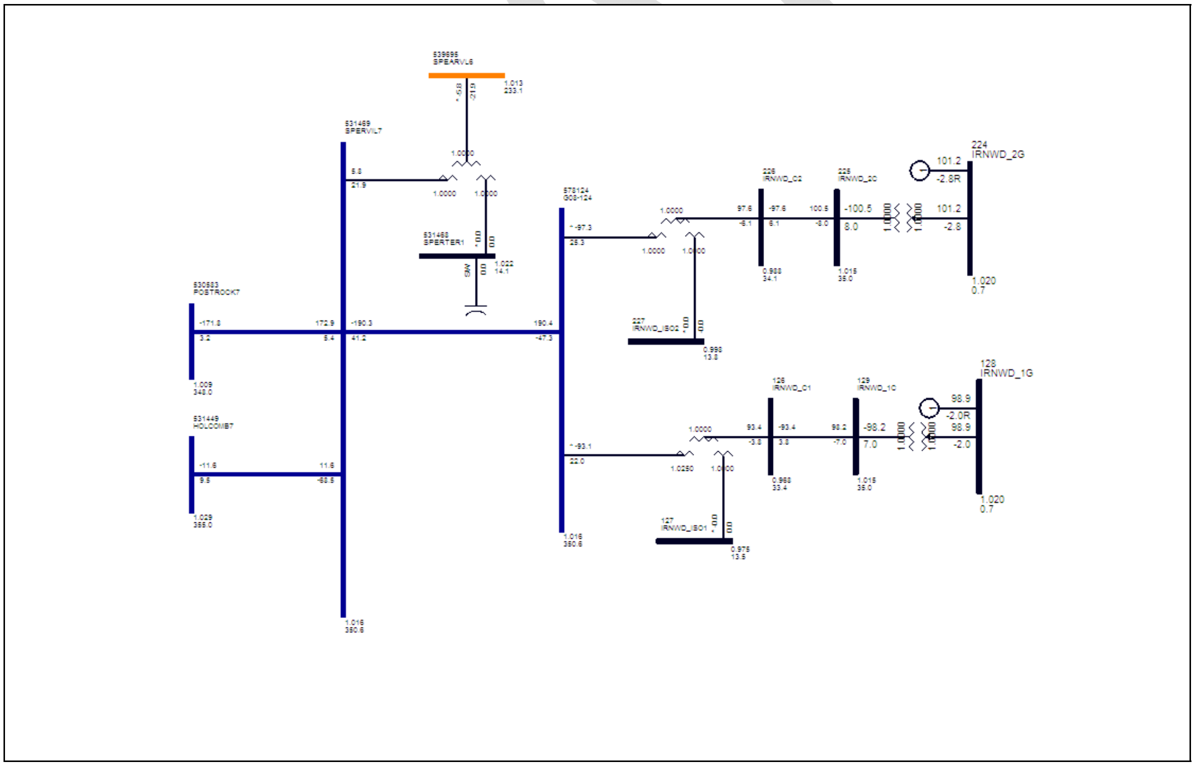
Request	Size (MW)	Turbine Model	Point Of Interconnection	
			Bus No.	Bus Name in model
GEN-2008-124	200	Siemens 2.3 MW	578124	SPRVIL7 345

The one-line diagram of GEN-2008-124 in Figure 1 uses the following color codes for nominal voltages:

Black **less than 40 kV**
Orange 230 kV
Blue **345 kV**

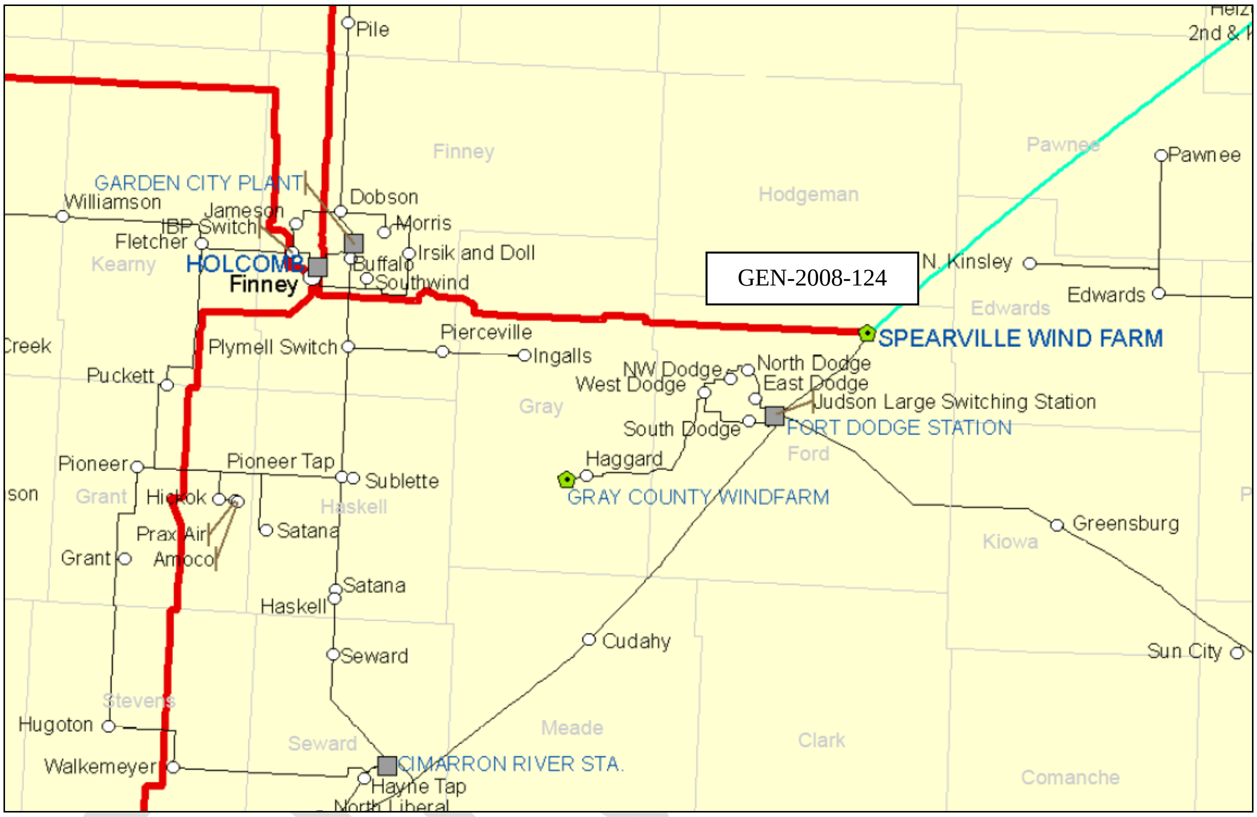
All voltages and line flows are from the 2011 summer peak base case.

Figure 3: GEN-2008-124 Interconnection One-Line Diagram



As illustrated below, GEN-2008-124 is located in Southwestern Kansas.

Figure 4: Geographical Location of GEN-2008-124 Project



The following is the detailed description of the wind project in GEN-2008-124.

GEN-2008-124

- Wind farm rating
  - Active power capability: 200.1 MW
  - Reactive power capability: +/- 96.9 MVAR
- Interconnection:
  - Voltage: 345 kV
  - Location: Spearville 345 kV substation
  - Transformer: Two step-up transformers connecting to the 345 kV
    - MVA: 69/100
    - Voltage: 345/34.5 kV
    - R: 0.20% on a 69 MVA base
    - X: 13.5% on a 69 MVA base
- Wind turbine:
  - Number: 87
  - Manufacturer: Siemens
  - Type: Asynchronous generator
  - Machine terminal voltage: 0.690 kV
  - Rated power: 2.3 MW
  - Frequency: 60Hz
  - Generator step-up transformer
    - MVA: 2.6
    - Voltage: 34.5/0.690 kV
    - R: 0.84% on a 2.6 MVA base
    - X: 6.0% on a 2.6 MVA base
- Generator protection
  - Undervoltage
    - Relay trips when V_{bus} = 0.15 pu for t = 0.65 s with 0.1 s time delay
      V_{bus} < 0.50 pu for t = 1.735 s with 0.1s time delay
      V_{bus} < 0.90 pu for t = 3.00 s with 0.1 s time delay
  - Over voltage
    - Relay trips when V_{bus} > 1.10 pu for t = 1.00 s with 0.1 s time delay
      V_{bus} > 1.20 pu for t = 0.20 s with 0.0 s time delay
  - Under frequency
    - Relay trips when F_{bus} < 0.94 pu for t = 0.10 s with 0.0 s time delay
      F_{bus} < 0.95 pu for t = 10.0 s with 0.0 s time delay
  - Over frequency
    - Relay trips when F_{bus} > 1.04 pu for t = 0.1 s with 0.0 s time delay

POWER FACTOR RESULTS

The proposed GEN-2008-124 wind farm (200 MW) will be comprised of 87 Siemens 2.3 MW wind turbine generators. GEN-2008-124 was modeled as an equivalent 200 MW generator with 0 var capability at the 345kV

POI at the Spearville 345kV Substation. A continuously variable var generator was modeled at the 345kV POI and scheduled to maintain 1.00 PU post contingency voltages at the Spearville 345kV bus.

A contingency analysis was run for 2011 summer and winter peak conditions considering all of the faults described in Table 2.

The results listed in Tables 3 indicate that no additional reactive compensation is required at the 345kV POI to maintain 1.00 PU post contingency voltages.

VOLTAGE RECOVERY RESULTS

Dynamic simulations were performed using each fault Included in Table 5. Voltage recovery as determined via dynamic simulation was checked against all contingencies. If the post-fault voltage recovers to a steady-state level consistent with the steady-state simulation, the generator interconnection is considered acceptable from a voltage recovery standpoint.

In these dynamic simulations, real loads are modeled as constant current and reactive loads are modeled as constant admittance; i.e. MW loads are proportional to voltage and Mvar loads are proportional to voltage squared. In contrast, loads are modeled as constant MW and constant Mvar in steady-state simulations. Therefore, due to differences in load modeling, minor differences in voltages are to be expected between dynamic and steady-state simulations.

The dynamic simulation showed that GEN-2008-124 generators did not trip during any of the contingencies tested. That is, the wind farm GEN-2008-124 meets FERC Order 661A (low voltage ride through and wind farm recovery to pre-fault voltage). Table 7 lists the post-fault voltages at POI calculated with no reactive compensation on either side of the POI.

Table 11: Post-Fault Voltage Recovery by Dynamic Simulation

Fault Name	Voltage @ GEN-2008-124 POI (pu)	
	Summer Peak	Winter Peak
FLT3-3PH	0.99826	1.0011
FLT4-1PH	0.99062	0.99205
FLT5-3PH	1.0179	1.0230
FLT6-1PH	1.0116	1.0167
FLT9-3PH	1.0153	1.0263
FLT10-1PH	1.0149	1.0197
FLT15-3PH	1.0212	1.0243
FLT16-1PH	1.0193	1.0224
FLT17-3PH	1.0165	1.0200
FLT18-1PH	1.0165	1.0128
FLT19-3PH	1.0181	1.0200
FLT20-1PH	1.0170	1.0195
FLT21-3PH	1.0121	1.0161

Fault Name	Voltage @ GEN-2008-124 POI (pu)	
	Summer Peak	Winter Peak
FLT22-1PH	1.0060	1.0088
FLT23-3PH	1.0122	1.0147
FLT24-1PH	1.0124	1.0153
FLT25-3PH	1.0116	1.0166
FLT26-1PH	1.0119	1.0172
FLT35-3PH	1.0218	1.0248
FLT36-1PH	1.0218	1.0249
FLT37-3PH	1.0174	1.0210
FLT38-1PH	1.0118	1.0141
FLT41-3PH	1.0127	1.0211
FLT42-1PH	1.0126	1.0156
FLT49-3PH	1.0132	1.0156
FLT50-1PH	1.0132	1.0162
FLT51-3PH	1.0131	1.0155
FLT52-1PH	1.0131	1.0160
FLT55-3PH	1.0177	1.0196
FLT56-1PH	1.0166	1.0192
FLT57-3PH	1.0030	1.0140
FLT58-1PH	1.0035	1.0088
FLT59-3PH	1.0118	1.0103
FLT60-1PH	1.0121	1.0108

Figure 3 below shows the lowest and highest post-fault voltage at the POI resulting from FLT4-1PH (lowest) and FLT36-1PH (highest) for the summer case.

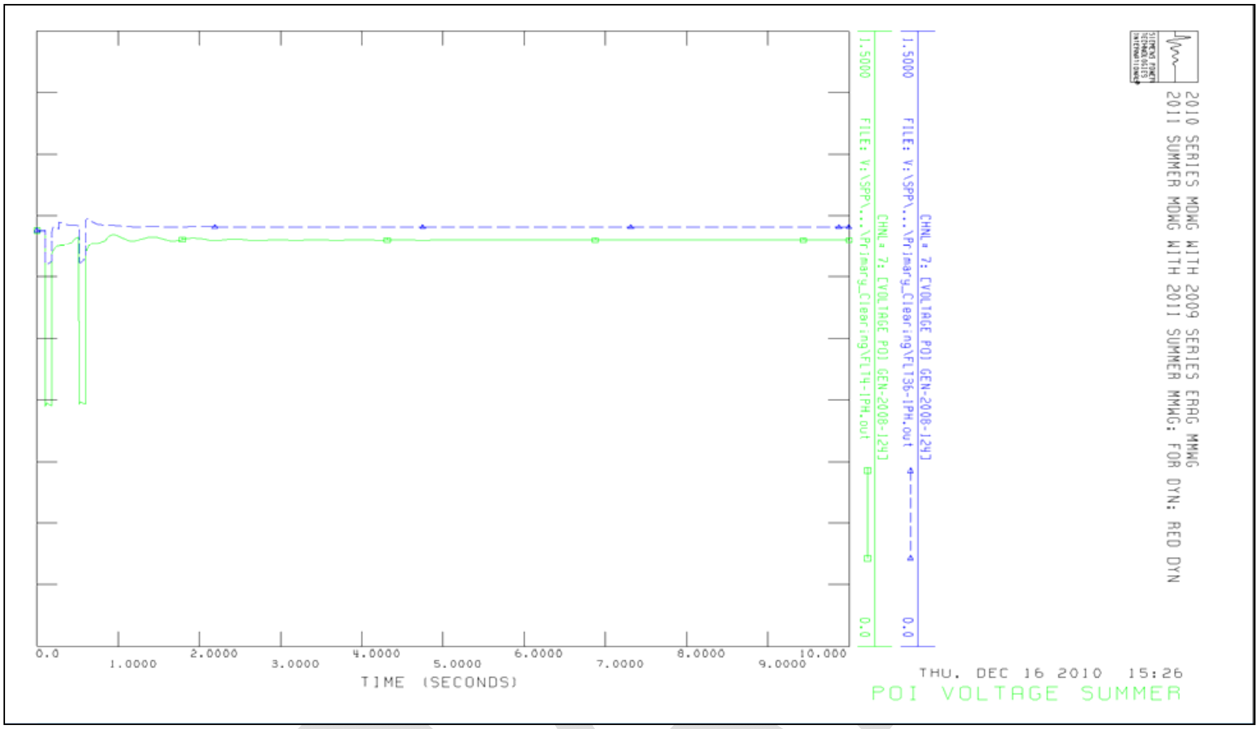


Figure 5: POI Voltage Recovery for FLT4-1PH and FLT36-1PH, Summer Peak

Figure 4 below shows the lowest and highest post-fault voltage at the POI resulting from FLT4-1PH (lowest) and FLT36-1PH (highest) for the winter case.

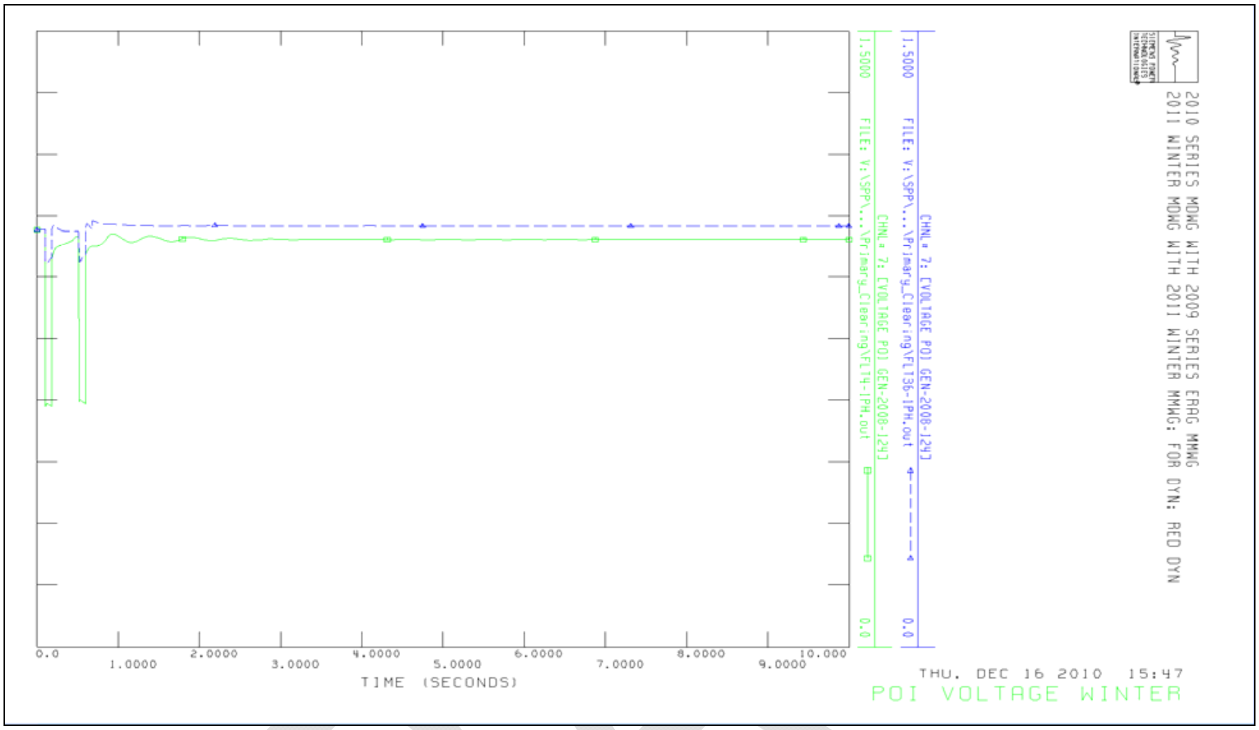


Figure 6: POI Voltage Recovery for FLT4-1PH and FLT36-1PH, Winter Peak

TRANSIENT STABILITY RESULTS

Based on the dynamics results, GEN-2008-124 did not cause any new stability problems. For the faults studied, the three-phase faults are relatively more severe than the corresponding single-line-to-ground fault. No synchronous generators pulled out of synchronism with the grid. Previous project queue request MONTEZUMA tripped on under voltage for the following faults:

Summer Case	Winter Case
FLT3-3PH	-----
FLT5-3PH	FLT5-3PH
-----	FLT9-3PH
FLT15-3PH	FLT15-3PH
FLT17-3PH	FLT17-3PH
FLT18-1PH	-----
FLT19-3PH	FLT19-3PH
FLT21-3PH	FLT21-3PH
FLT35-3PH	FLT35-3PH
FLT36-1PH	FLT36-1PH
FLT37-3PH	FLT37-3PH
-----	FLT41-3PH
FLT55-3PH	FLT55-3PH
-----	FLT57-3PH

MONTEZUMA voltage protection was overridden and the simulations for the above faults were re-run. No generators tripped due to over/under voltage or over/under frequency and no synchronous generators pulled out of synchronism with the grid with the MONTEZUMA voltage protection overridden.

Following are plots of the rotor angles (two lumped equivalent machines) for GEN-2008-124 for the most severe faults: FLT3-3PH (most severe) and FLT37-3PH (next most severe). These faults are for faults on the 345 kV lines from the POI to Holcomb and from the POI to Post Rock, respectively. In the summer and winter cases, the over speed of the two equivalent machines approached 1.14 pu, but did not result in any tripping for over frequency.

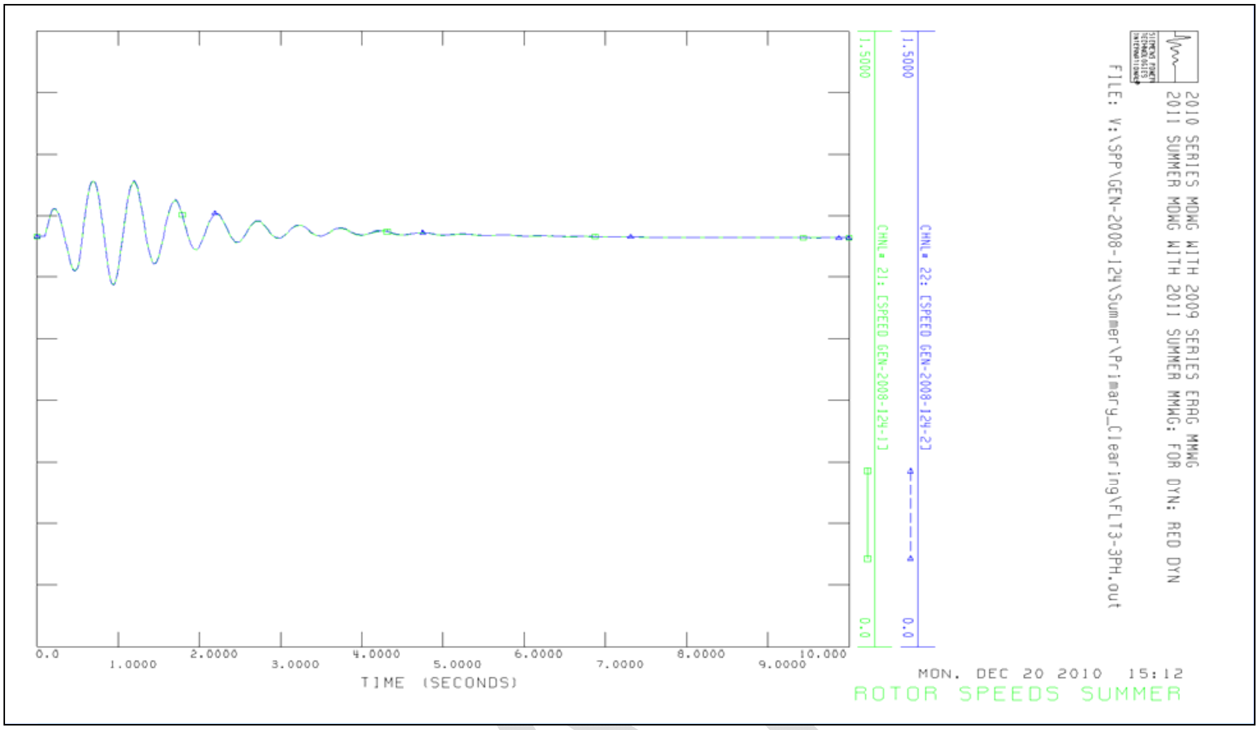


Figure 7: Response of GEN-2008-124 Wind Turbine Generator Rotor Speeds to FLT3-3PH, Summer Peak

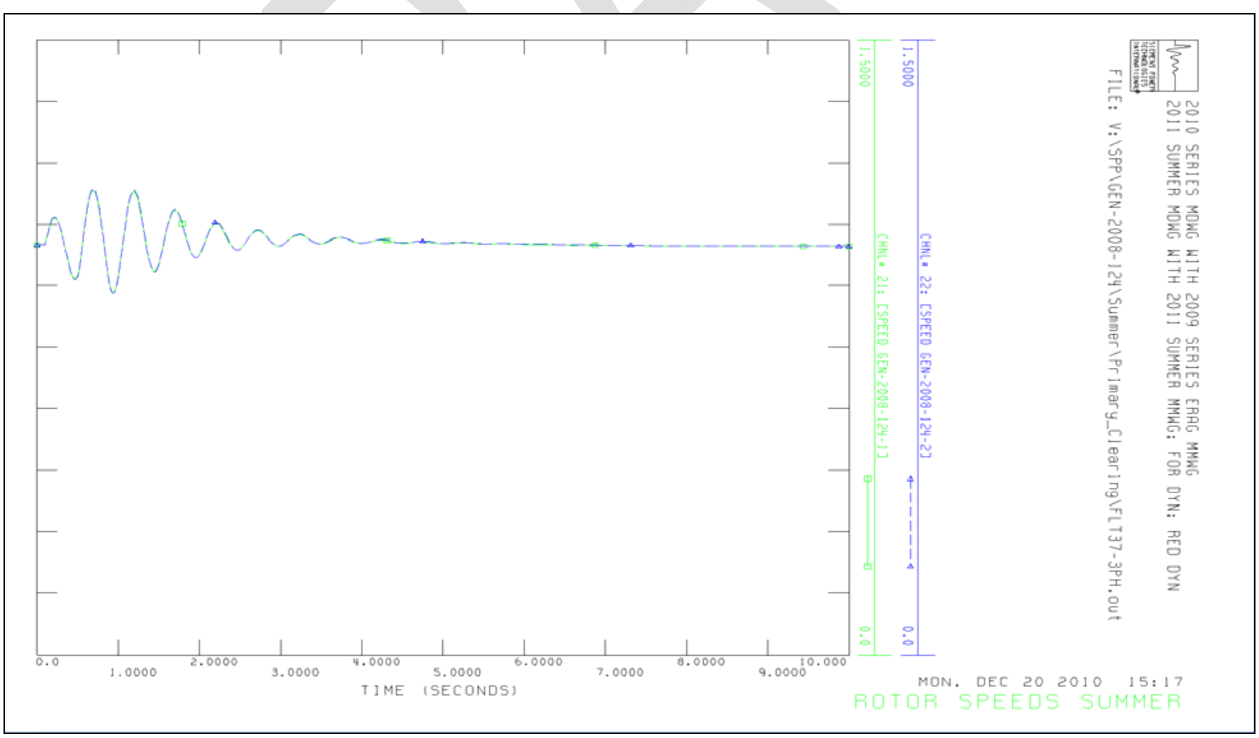


Figure 8: Response of GEN-2008-124 Wind Turbine Generator Rotor Speeds to FLT37-3PH, Summer Peak

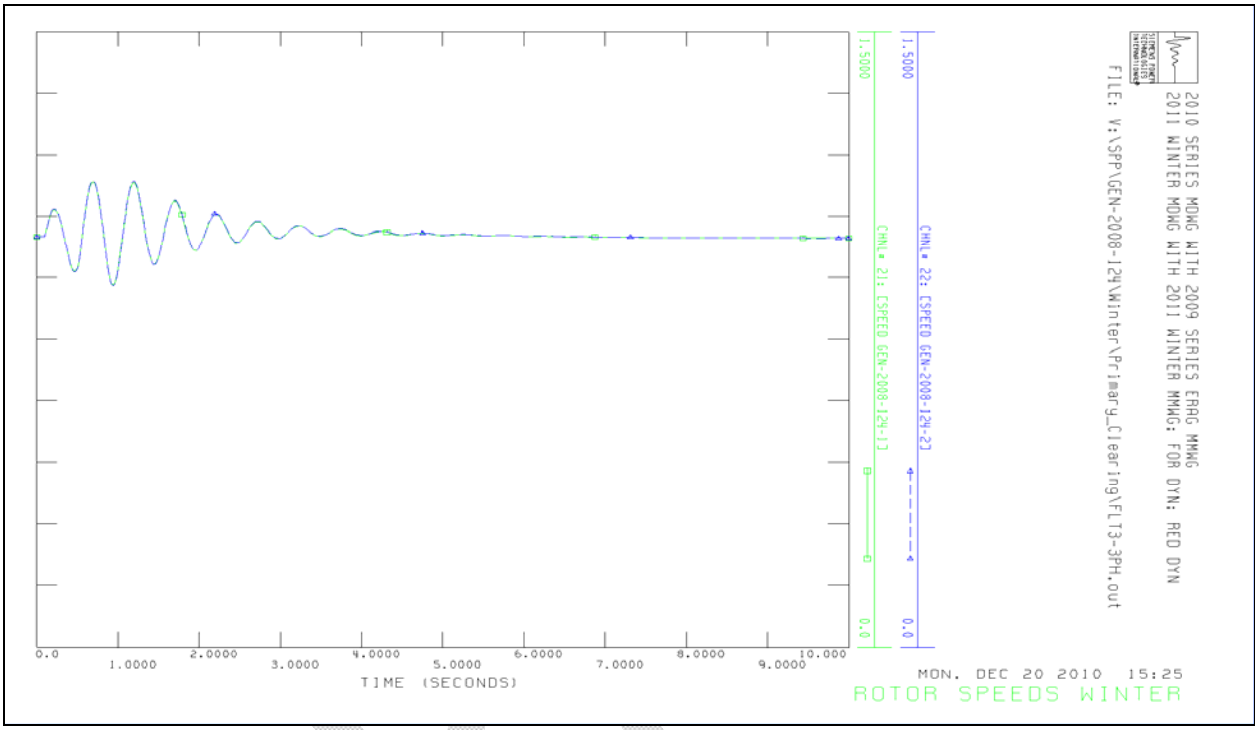


Figure 9: Response of GEN-2008-124 Wind Turbine Generator Rotor Angle to FLT3-3PH, Winter Peak

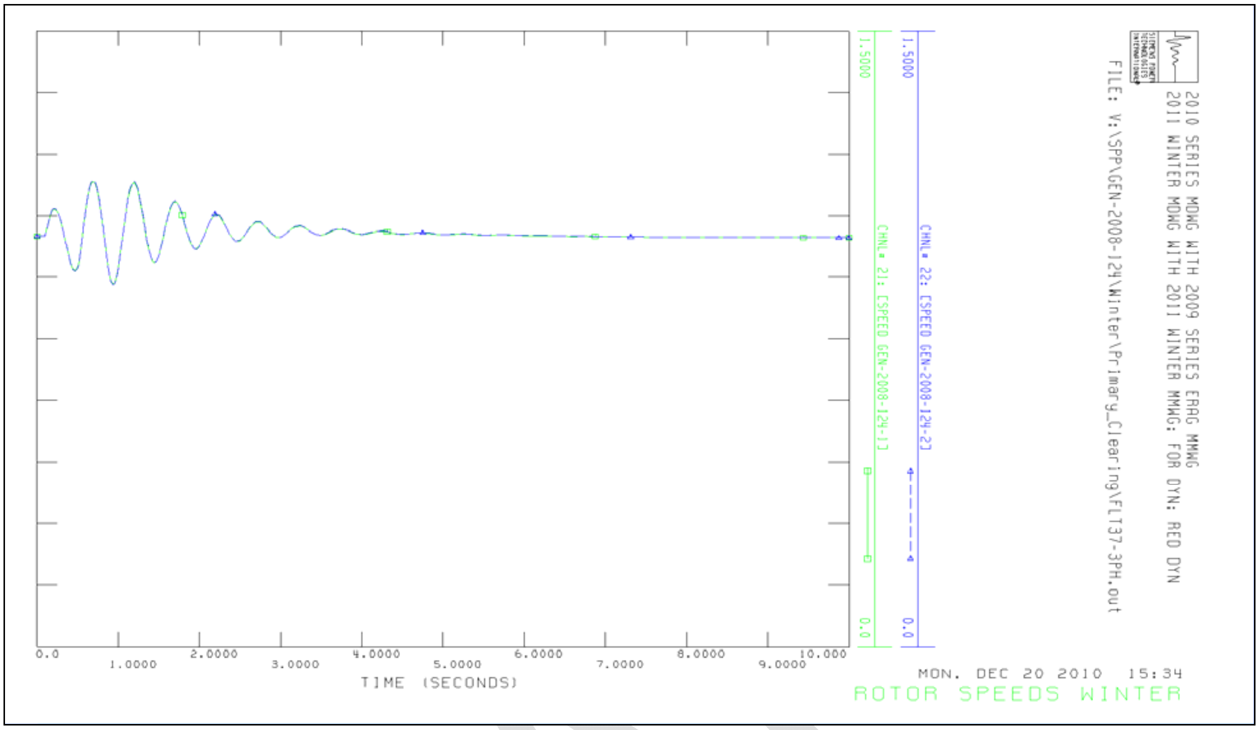


Figure 10: Response of GEN-2008-124 Wind Turbine Generator Rotor Angle to FLT37-3PH, Winter Peak

As indicated previously, the worst case fault was determined to be FLT3-3PH. To determine sensitivity on transient stability of project queue requests beyond those included in the present study, additional simulations were run utilizing worst case fault FLT3-3PH.

These additional simulations were performed on the summer and winter cases with the following project queue requests were added to the summer and winter cases:

Request	Size (MW)	Wind Turbine Model	Point of Interconnection
GEN-2004-014	100	GE 1.5MW	Spearville 230 kV (539695)
GEN-2005-012	250	Vestas CV90IG 3 MW	Spearville 345 kV (531469)
GEN-2001-039A	105	Clipper C93	Tap Fort Dodge-Greenburg (579025)

Also, simulations were performed on the summer and winter cases with the following project queue request added, including the above project queue requests, for a total of four project queue requests added to the summer and winter cases:

Request	Size (MW)	Wind Turbine Model	Point of Interconnection
GEN-2006-006	206	GE GEDFA	Spearville 230 kV (539695)

Based on the dynamics results of these additional simulations, GEN-2008-124 did not cause any new stability problems for the additional cases which included GEN-2004-014, GEN-2005-012, and GEN-2001-039A. No synchronous generators pulled out of synchronism with the grid. Previous project queue request MONTEZUMA tripped on under voltage for both the summer and winter cases. MONTEZUMA voltage protection was overridden and the simulations were re-run. No generators tripped due to over/under voltage or over/under frequency and no synchronous generators pulled out of synchronism with the grid with the MONTEZUMA voltage protection overridden.

Figures 9 and 10 contain plots the rotor speed response of GEN-2008-124 to FLT3-3PH for the summer and winter cases including GEN-2004-014, GEN-2005-012, and GEN-2001-039A.

For the cases where including GEN-2004-014, GEN-2005-012, GEN-2001-039A, and GEN-2006-006 were added, no synchronous generators pulled out of synchronism with the grid. Previous project queue request MONTEZUMA tripped on under voltage for both the summer and winter cases. MONTEZUMA voltage protection was overridden and the simulations were re-run. For the summer case so generators tripped due to over/under voltage or over/under frequency and no synchronous generators pulled out of synchronism with the grid with the MONTEZUMA voltage protection overridden.

However, for the corresponding winter case the GEN-2005-012 wind turbine tripped off line not due to its voltage or frequency protection but due to model’s inability to converge to a solution, which is typically related to voltage instability.

Figures 11 and 12 contain plots the rotor speed response of GEN-2008-124 to FLT3-3PH for the summer and winter cases including GEN-2004-014, GEN-2005-012, GEN-2001-039A, and GEN-2006-006.

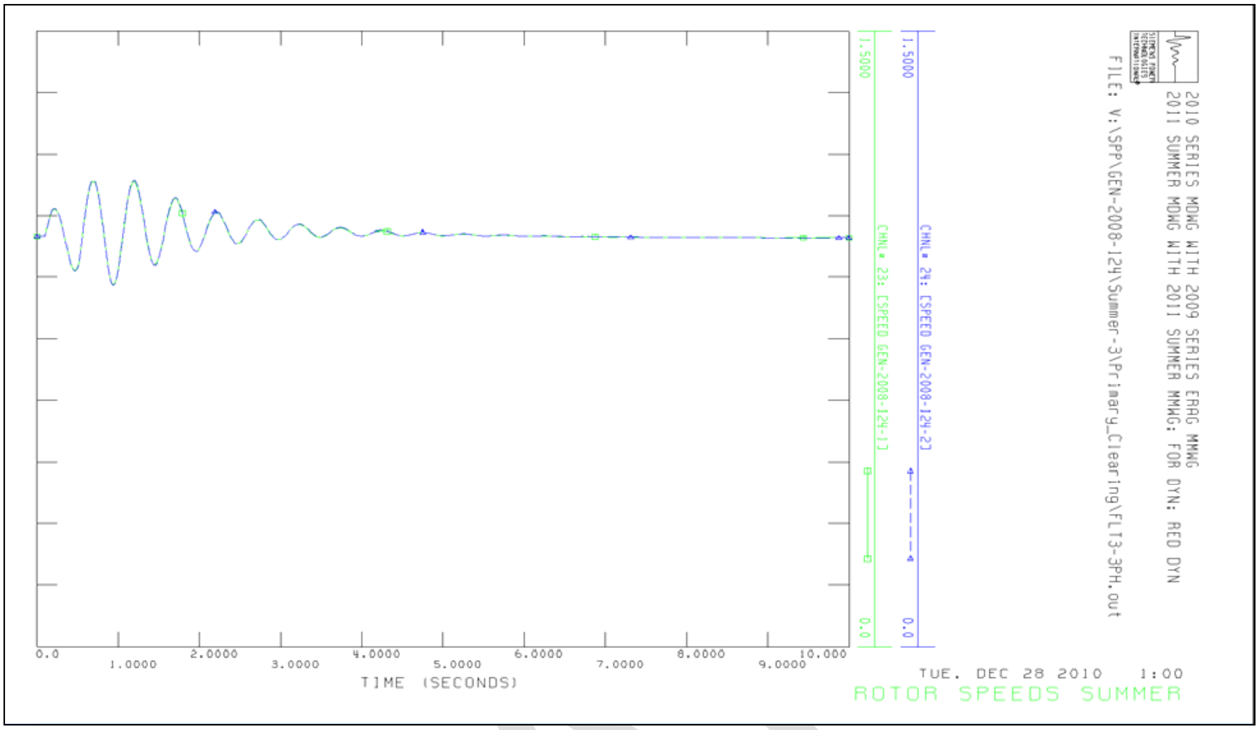


Figure 11: Response of GEN-2008-124 Wind Turbine Generator Rotor Speeds to FLT3-3PH, Summer Peak Plus Queues GEN-2004-014, GEN-2005-012, and GEN-2001-039A

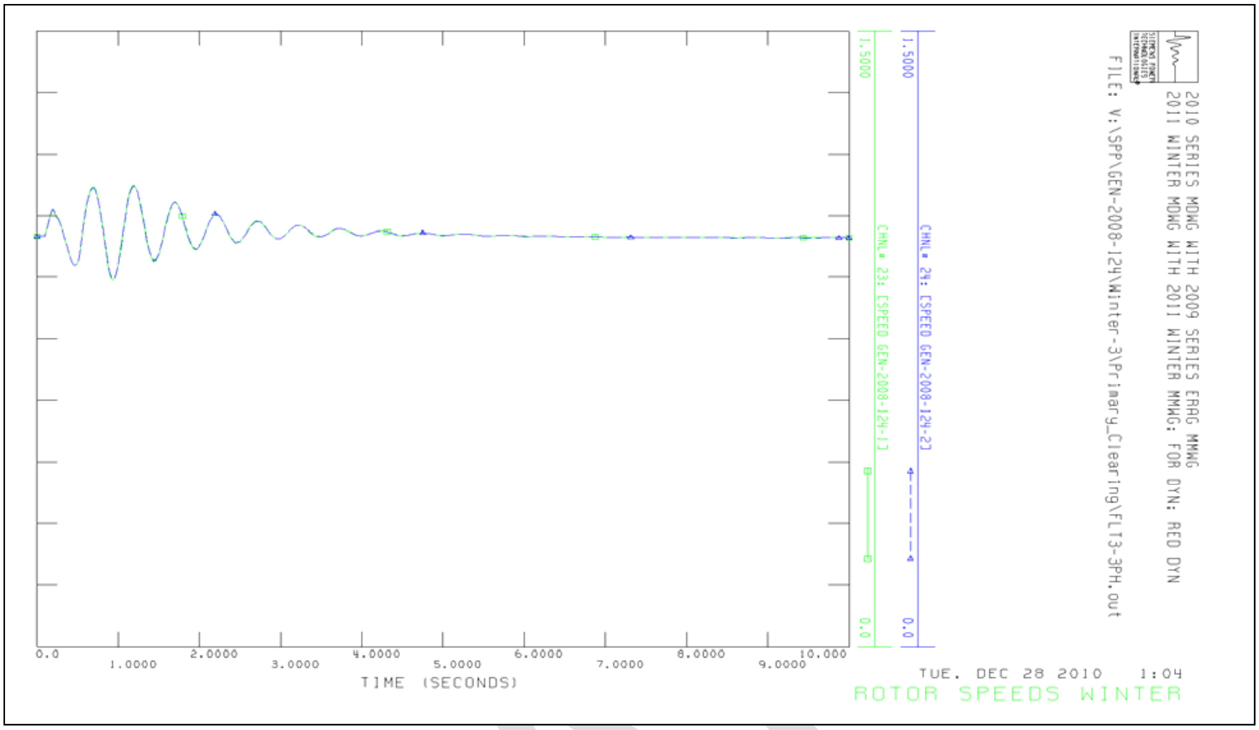


Figure 12: Response of GEN-2008-124 Wind Turbine Generator Rotor Speeds to FLT3-3PH, Winter Peak Plus Queues GEN-2004-014, GEN-2005-012, and GEN-2001-039A

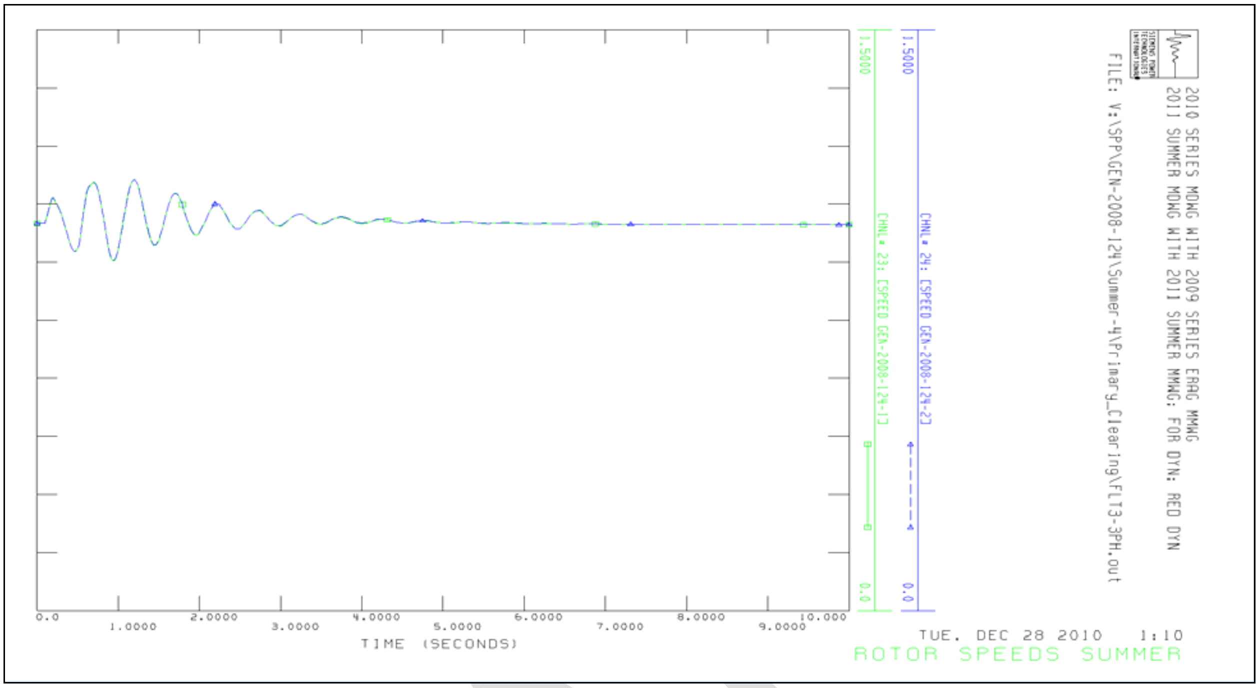


Figure 13: Response of GEN-2008-124 Wind Turbine Generator Rotor Speeds to FLT3-3PH, Summer Peak Plus Queues GEN-2004-014, GEN-2005-012, GEN-2001-039A, and GEN-2006-006

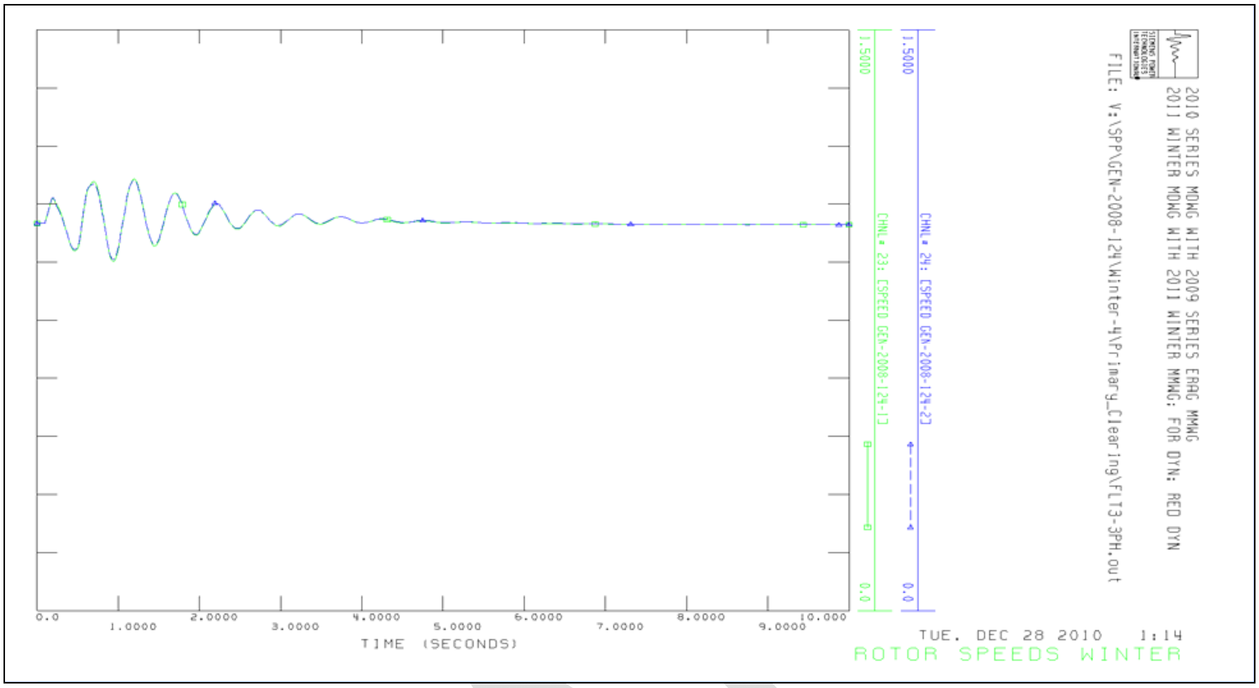


Figure 14: Response of GEN-2008-124 Wind Turbine Generator Rotor Speeds to FLT3-3PH, Winter Peak Plus Queues GEN-2004-014, GEN-2005-012, GEN-2001-039A, and GEN-2006-006

CONCLUSIONS

Based on the results of the GEN-2008-124 restudy, the following findings had been observed:

- No additional reactive compensation is required to maintain post contingency POI bus voltage at 1.00 PU with GEN-2008-124 on line.
- GEN-2008-124 meets LVRT requirements.
- GEN-2008-124 had the capability of recovering to the pre-contingency voltage following the fault disturbance.
- None of the synchronous machines in the studied areas suffered from instability for the faults studied.
- Results of simulations run with additional project queue requests GEN-2004-014, GEN-2005-012, and GEN-2001-039A added to the cases indicate that no synchronous generators pulled out of synchronism with the grid. Previous project queue request MONTEZUMA tripped on under voltage for both the summer and winter cases. MONTEZUMA voltage protection was overridden and the simulations were re-run. No generators tripped due to over/under voltage or over/under frequency and no synchronous generators pulled out of synchronism with the grid with the MONTEZUMA voltage protection overridden.
- Results of simulations run with additional project queue requests GEN-2004-014, GEN-2005-012, GEN-2001-039A, and GEN-2006-006 indicate that no synchronous generators pulled out of synchronism with the grid. Previous project queue request MONTEZUMA tripped on under voltage for both the summer and winter cases. MONTEZUMA voltage protection was overridden and the simulations were re-run. However, GEN-2005-012 tripped off line in the winter case due to convergence issues typically associated with voltage instability. No other wind turbines tripped off line and no synchronous generators pulled out of synchronism with the grid.