SPP Southwest Power Pool

Expedited Impact Study For Generation Interconnection Request GEN-2005-003

SPP Tariff Studies

(#GEN-2005-003)

August, 2005

1 Executive Summary

<OMITTED TEXT> (Customer) has requested that Southwest Power Pool (SPP) conduct a generator interconnection feasibility and impact study through the SPP Tariff for a 138kV interconnection for an additional 30.6 MW (the "study" project) to a previously studied 194.05 MW wind farm facility near Apache, Oklahoma. This wind farm would be interconnected to the Washita switch station owned by Western Farmers Electric Cooperative (WFEC). This would make the Phase I and Phase II wind farm 224.65 MW. The Customer has asked to study the project as 100% case only. The Phase I wind farm is using 45 NEG Micon NM72 IEC I (1.65 MW). The Phase II wind farm (151.2 MW) will now consist of 84 Vestas V80 (1.8 MW). The proposed in-service date is December 1st, 2005.

Two base cases were used in the study: 2006 summer and winter peak. For the impact study, an additional 2010 summer peak case was used. Each base case was modified to include the prior queued projects with the total MW distributed across the SPP member footprint. The prior queued projects include: GEN 2004-023; GEN2003-005, GEN 2003-022, and GEN 2004-020. In the event that another request for a generation interconnection with a higher priority withdraws then this request may have to be re-evaluated to determine the local Network Constraints. The previously studied 194.05 MW project were modeled at 100% output in the base case. The study project is dispatched only into SPP member AEPW.

For the feasibility study:

Load flow analysis was conducted with and without the study project to identify the proposed generator's impact on the local area. For the contingency tests, SPP members WFEC and AEPW are monitored. Only overloads that are greater than base case overloads + 3% are included in this report.

No interconnection facility costs are included since the study project is interconnecting the same facility as the earlier studied projects. In Table 5, a value of Available Transfer Capability (ATC) associated with any overloaded facilities is included. These values may be used by the Customer to determine lower generation capacity levels that may be installed. When transmission service associated with this interconnection is evaluated, the loading of the facilities listed in this table may be greater due to higher priority reservations. These interconnection costs do not include any cost that may be associated with short circuit analysis.

The required interconnection costs listed in Table 3, and other upgrades associated with Network Constraints listed in Table 4, do not include all 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 SPP's OASIS.

For the impact study:

Sixteen (16) contingencies were considered for the transient stability simulations which included three phase faults, as well as single phase line faults. 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 Phase I generators were modeled with manufacturer standard voltage and frequency ride-through protection. The Phase II generators were modeled with Vestas' Advanced Grid Option 4 (AGO-4) voltage and frequency ride-through protection using the appropriate settings.

Table 9 shows the list of simulated contingencies. The table also shows the fault clearing time and the time delay before re-closing for all the study contingencies. The stability simulation shows that the study plant would not degrade the stability performance of the system. Certain generating units are tripped during specific contingencies as summarized in Table 9, but the system remains stable and all oscillations remain well damped. The impact study finds that the study project addition shows stable performance of the SPP system for the contingencies tested on the base cases.

The Phase I machines that have only the manufacturer's standard voltage and frequency ride-through protection are shown to trip off more frequently than the Phase II machines which contain the AGO-4 package. The customer shall take proper action to insure the tripping of the Phase I machines does not cause the Phase II machines to inadvertently trip.

A sensitivity study was performed to review the impact of the study project without Gen-2003-005 in the queue. The results of the sensitivity study show similar system stability performance in the case with and without Gen-2003-005 as summarized in Table 9. The prior conclusion remains valid, that the study project shows stable performance of the SPP system for the contingencies tested on the supplied bases cases.

2 Project Overview

<OMITTED TEXT> (Customer) has requested that Southwest Power Pool (SPP) conduct a generator interconnection feasibility and impact study through the SPP Tariff for a 138kV interconnection for an additional 30.6 MW (the "study" project) to a previously studied 194.05 MW wind farm facility near Apache, Oklahoma. This wind farm would be interconnected to the Washita switch station owned by Western Farmers Electric Cooperative (WFEC). This would make the Phase I and Phase II wind farm 225.25 MW. The Customer has asked to study the project as 100% case only. The Phase I wind farm is using 45 NEG Micon NM72 IEC I (1.65 MW). The Phase II wind farm (151.2 MW) will now consist of 84 Vestas V80 (1.8 MW) as summarized in Table 1. and shown in Figure 1. The power factor correction of the wind turbines is modeled but not shown in the figure for clarity reasons. The proposed in-service date is December 1st, 2005.

Description	**Queued#**	**Interconnection point**	**MODEL**	**TOTAL MW (Feasibility Study) - note 1**	**TOTAL MW (Impact Study) - note 1**
Phase-2 (STUDY Plant)	GEN-005-003	Apache Oklahoma, 138kV Washita (Bus #56089)	Vesta V80 Turbine 1.8 MW	30.6	30.6
Phase-2 (previously studied)	GEN-2004-023	same as above	Vesta V80 Turbine 1.8 MW	20.6	19.8
Phase-2 (previously studied)	GEN-2003-004	same as above	Vesta V80 Turbine 1.8 MW	100	100.8
Phase-1	GEN-2001-026	same as above	NEG-MICON NM72 1.65 MW	74.25	74.25
Total Phase 2 (previously studied + the study plant)				151.2	151.2
Total Phase 1 and 2				225.45	225.45
Total Previously studied Project Phase 1 + 2 (old)				194.85	194.85

Note 1: For the study plant and Gen-2003-004, the MW used in the feasibility study and impact study are slightly different. In the feasibility study, the MW value of the study project represents the increment over the previously studied projects. In the impact study, the MW value represents the number of whole wind farm units (each unit sized 1.8 MW) as an increment to the previously studied Phase 2 wind farm units.

Table 1. Summary of the Phase-1 and Phase-2 Wind Generators Projects

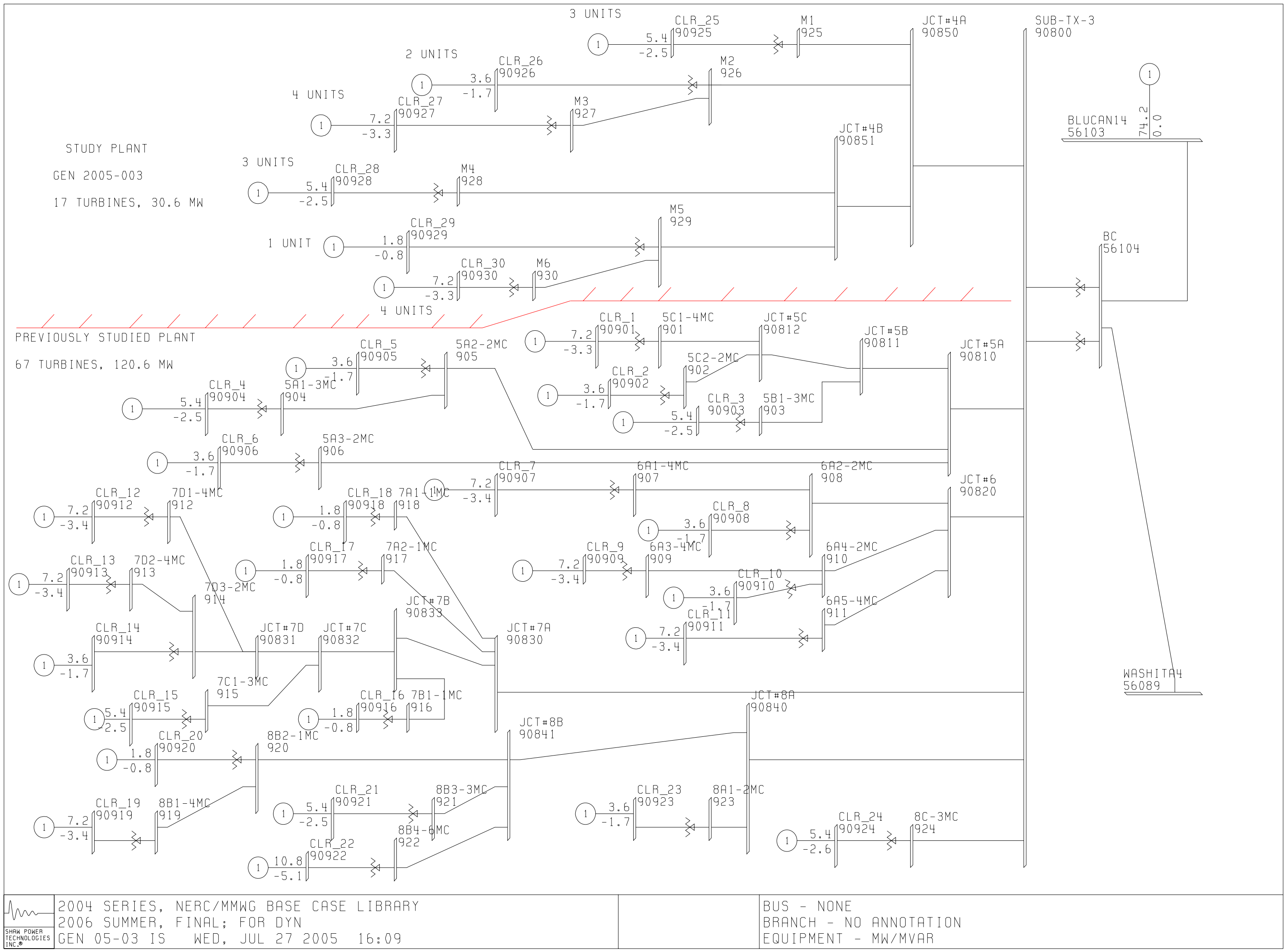


Figure 1. One Line Diagrams of the Study Plant

3 Feasibility Study

3.1 Interconnection Facilities

The Feasibility Study assesses the practicality and costs involved to incorporate the study project into the SPP Transmission System. The analysis is limited to load flow analysis of the more probable contingencies within the Transmission Owner's control area and key adjacent areas.

The Feasibility Study is intended to identify attachment facilities and other direct assignment facilities needed to accept power into the grid at the interconnection receipt point. This wind farm would be interconnected to the Washita switch station owned by Western Farmers Electric Cooperative (WFEC).

No interconnection facility costs are included since the study project is interconnecting the same facility as the original projects. Other Network Constraints in the WFEC and AEPW system that were identified are listed in Table 4. These estimates will be refined during the development of the impact study based on the final designs.

Facility	Estimated Cost
Customer – 138-34.5 kV Substation facilities.	*
Total	*

*Estimates of cost to be determined by Customer.

Table 2: Direct Assignment Facilities

Facility	Estimated Cost
None	$0
Total	$0

Table 3: Required Interconnection Network Upgrade Facilities

Facility

Note: (1) Network Upgrade description will be determined at the request of the Customer.

Table 4: Network Constraints

Facility	Model and Contingency	Facility Loading[1]	ATC (MW)	Date Required

Table 5: Contingency Analysis Results

3.2 Power Flow Analysis

Load flow analysis was conducted with and without the study project to identify the study project's impact on the local area. In the power flow, the 30.6 MW study plant was added to the base case as new source with capacity of 30.6 MW delivering to the Washita 138 kV bus.

	Description	**Queued#**	**TOTAL MW (Feasibility Study)**
Study Plant	New, Study Plant	GEN 2005-003	30.6
Prior Queued Projects	Phase-2	GEN-2004-023	20.6
	Phase-2 (previously studied)	GEN-2003-004	100
	Phase-1	GEN-2001-026	74.25
	Added to base case	GEN-2003-005	100
		GEN-2003-022	120
		GEN-2004-020	27

Table 6. Summary of the Study Plant and Queued Projects

The results of load flow analysis include power flow magnitudes under probable contingency conditions. The results of the load flow study are used to identify equipment overloads that may be encountered due to the addition of new generation. Probable contingencies comprise of single contingencies in the study area and their impact on transmission elements in the monitored area.

Two base cases were used in the study: 2006 summer and winter peak.

Each base case was modified to include the prior queued projects with the total MW redispatched across the SPP member footprint. The prior queued projects are summarized in Table 6.

The study project (30.6 MW) is dispatched only into SPP member AEPW. For the contingency tests, SPP members WFEC and AEPW are monitored. Only overloads that are greater than base case overloads + 3% are included in this report.

3.3 Methodology

The SPP criteria applied to the Feasibility Study 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

1. 'B' Rating

the applicable NERC Planning Standards for System Adequacy and Security – Transmission System Table 1, and its applicable standards and measurements."

The analysis was conducted by assessing single contingencies in AEPW and WFEC using power flows. This is consistent with the more probable contingency testing criteria mandated by NERC and the SPP.

3.4 Conclusion

No interconnection facility costs are included since the study project is interconnecting the same facility as the original projects.

In Table 5, a value of Available Transfer Capability (ATC) associated with any overloaded facilities is included. These values may be used by the Customer to determine lower generation capacity levels that may be installed. When transmission service associated with this interconnection is evaluated, the loading of the facilities listed in this table may be greater due to higher priority reservations.

These interconnection costs do not include any cost that may be associated with short circuit analysis. The required interconnection costs listed in Table 3 and other upgrades associated with Network Constraints listed in Table 4 do not include all 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 SPP's OASIS.

4 Impact Study

4.1 Objective

The objective of the impact study is to determine the impact on system stability of connecting the proposed GEN-2005-003 wind farm to SPP's 138 kV transmission system.

4.2 Modeling of the Wind Turbines in the Load Flow

In order to simplify the model of the wind farm while capturing the effect of the different impedances of cables (due to change of the conductor size and length), the wind turbines connected to the same 34.5kV feeder end points were aggregated into one equivalent unit. An equivalent impedance of that feeder is represented in the load flow database by taking the equivalent series impedances of the different feeders connecting the wind turbines. Using this approach, the wind farm was modeled with equivalent units as shown in Figure 2. The number of individual wind turbines that are aggregated at each bus is shown. As noted in Section 2, the power factor correction of the wind turbines is modeled but not shown in the figure for clarity reasons. Appendix A shows the data used in the study for the 34.5kV feeders to the wind turbines.

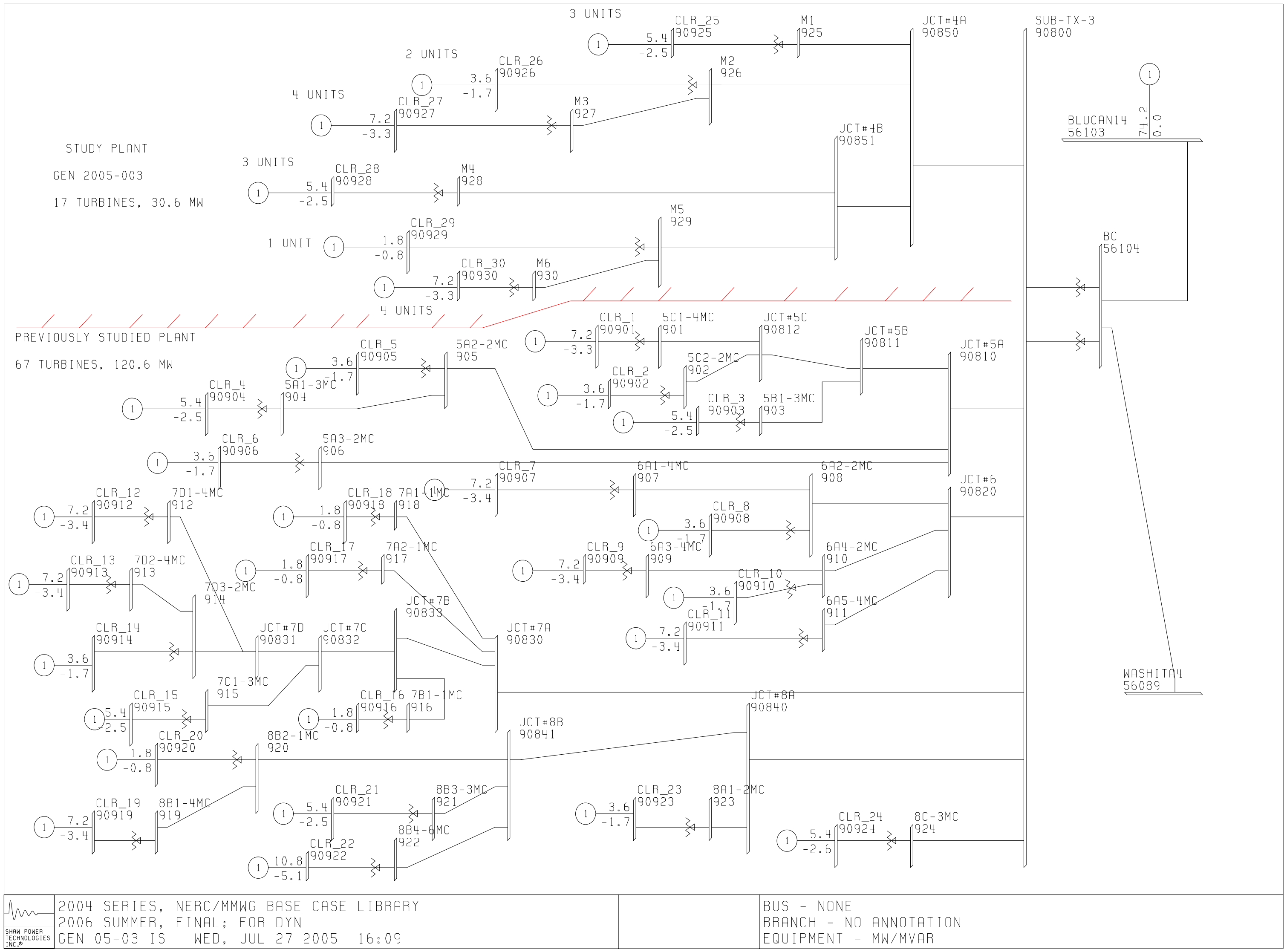


Figure 2. Wind Farm Equivalent representation in Load Flow for Stability Simulation/Impact Study

4.3 Modeling of the Wind Turbines for the Stability Simulation

Vestas V80 1.8 MW wind turbine generators were modeled for the study plant. Table 7. shows the model parameters of an equivalent generator at collector bus (90925). Note that the same models and setup are applied to all the equivalent units for the study plant (90926, 90927, 90928, 90929 and 90930).

Parameter	Value
BASE KV	0.690
WTG MBASE	2.0
TRANSFORMER MBASE	1.85
TRANSFORMER R ON TRANSFORMER BASE	0.0000
TRANSFORMER X ON TRANSFORMER BASE	0.075
GTAP	1.0
PMAX	1.8
PMIN	0.0
RA	0.0048897
LA	0.12602
LM	6.8399
R_ROT_MACH	0.004419
L1	0.18084
INERTIA	0.644
DAMPING	0.0

Table 7. Vestas 1.8 MW Wind Generator Data

For the study plant (GEN 2005-03), previous study GEN 2004-023 plant, and the original Phase 2 study plant (GEN 2003-04) the manufacturer's Advanced Grid Option 4 (AGO4) voltage and frequency protection were used. The voltage protection settings provided by the manufacturer are as follows:

- Voltage below 50%: 0.20 seconds: trip the generator and the power factor correction
- Voltage below 75%: 0.80 seconds, trip the generator and the power factor correction
- Voltage below 80%: 2 seconds, trip the generator and the power factor correction
- Voltage below 90%: 300 seconds, trip the generator and the power factor correction
- Voltage 90% to 110%: continuous
- Voltage above 110%: 60 seconds, trip the generator and the power factor correction
- Voltage above 111%: 0.08 second, trip the power factor correction
- Voltage above 115%: 30 seconds, trip the generator and the power factor correction
- Voltage above 120%: 2 seconds, trip the generator and the power factor correction
- Voltage above 125%: 0.08 second; trip the generator and power factor correction.

The frequency protection settings provided by the manufacturer are as following:

- Monitor bus: collector bus
- Frequency below 55.5 Hz: 0.02 seconds, trip the generator and the power factor correction
- Frequency below 56.6 Hz: 0.35 seconds, trip the generator and the power factor correction
- Frequency below 57.0 Hz: 2.0 seconds, trip the generator and the power factor correction
- Frequency 57.0 to 61.5 Hz: continuous
- Frequency above 61.5 Hz: 90 seconds, trip the generator and the power factor correction
- Frequency above 63.0 Hz: 0.02 seconds, trip the generator and the power factor correction

4.4 Stability Models for Queued Projects

There are several queued projects which were added to the stability base case as summarized in Table 8:

	Description	**Queued#**	**TOTAL MW (Impact Study)**
Study Plant	Phase-2 Stage 3	GEN 2005-003	30.6
Prior Queued Projects	Phase-2 Stage 2	GEN 2004-023	19.8
	Phase -2 Stage 1	GEN-2003-004	100.8
	Phase-1 Added to base case	GEN-2001-026	74.25
		GEN-2003-005	100
		GEN-2003-022	120
		GEN-2004-020	27

Table 8. Summary of Prior Queued projects

4.5 Contingencies Simulated

Sixteen (16) contingencies were considered for the transient stability simulations which included three phase faults, as well as single phase line faults, at the 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. Table 9. shows the list of simulated contingencies. The table also shows the fault clearing time and the time delay before re-closing for all the study contingencies.

Table 9: List of Contingencies and Results Summary for Impact Study

Units Trip Legend

- A = GEN2005-003 Study Plant (Vestas 1.8 MW, total 30.6MW)
- B= Phase II GEN2004-023/19.8 MW & 2003-004/100.8MW (Vestas 1.8 MW, total 120.6 MW)
- C = 2003-005 (GE 1.5 MW, total 100 MW)
- D = Phase I (NEG Micon 1.65 MW, total 74.25 MW)
- E = 2003-022 & 2004-020 (GE 1.5 MW, total 147 MW)

	Cont. Name	***Description***	***Case-1:** 2006 Summer Peak (With Gen-2003-005)*	***Case-2:** 2006 Summer Peak (Without Gen-2003-005)*	***Case-3:** 2006 Winter Peak (With Gen-2003-005)*	***Case-4:** 2006 Winter Peak (Without Gen-2003-005)*	***Case-5:** 2010 Summer Peak (With Gen-2003-005)*	***Case-6:** 2010 Summer Peak (Without Gen-2003-005)*
1	05-03C1	3 Phase Fault on the Washita (56089) – Wind Farm (56103), 138kV line, near the Wind Farm. a. Apply Fault at the Wind Farm Bus (56103). b. Clear Fault after 5 cycles by removing the line from 56089 -56103. c. Wait 20 cycles, and then re-close the line in (b) into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	Stable (Trip A+ B +D)	Stable (Trip A+ B+D)	Stable (Trip A+ B +D)	Stable (Trip A+ B +D)	Stable (Trip A+ B +D)	Stable (Trip A + B + D)
2	05-03C2	*Single phase fault and sequence like Cont. No. 1*	Stable (Trip A+ B +D)	Stable (Trip A+ B +D)	Stable (Trip A+ B +D)	Stable (Trip A+ B +D)	Stable (Trip A+ B +D)	Stable (Trip A+ B +D)
3	05-03C3	3-phase fault Fault on the Washita (56089) – Anadarko (55814), 138kV line, near Anadarko. a. Apply fault at the Anadarko bus (55814). Clear fault after 5 cycles by removing the line	Stable (Trip C+D)	Stable (Trip D)	Stable (Trip C+D)	Stable (Trip D)	Stable (Trip C+D)	Stable (Trip D)

	Cont. Name	***Description***	***Case-1:* 2006 Summer Peak (With Gen-2003-005)**	***Case-2:* 2006 Summer Peak (Without Gen-2003-005)**	***Case-3:* 2006 Winter Peak (With Gen-2003-005)**	***Case-4:* 2006 Winter Peak (Without Gen-2003-005)**	***Case-5:* 2010 Summer Peak (With Gen-2003-005)**	***Case-6:* 2010 Summer Peak (Without Gen-2003-005)**
		from 56089- 55814.						
4	05-03C4	*Single phase fault and sequence like Cont. No. 3*	Stable	Stable	Stable	Stable	Stable	Stable
5	05-03C5	Three phase fault on the Anadarko (55814) – Southwester Station (54140) 138 kV line, near Southwester Station. a. Apply fault at the Southwester Station bus (54140). b. Clear fault after 5 cycles by removing the line from 55814 – 54140. c. Wait 20 cycles, and then re-close line in (b) into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	Stable (Trip C + D)	Stable (Trip D)	Stable (Trip C + D)	Stable (Trip D)	Stable (Trip C + D)	Stable (Trip D)
6	05-03C6	*Single phase fault and sequence like Cont. No. 5*	Stable (Trip D)	Stable (Trip D)	Stable	Stable	Stable (Trip D)	Stable (Trip D)
7	05-03C7	3-phase Fault Fault on the Fort Cobb (54117) – Southwester Station (54140) 115 kV line, near Fort Cobb a. Apply fault at the Fort Cobb (54117). b. Clear fault after 5 cycles by removing the line from 54117 – 54140) c. Wait 20 cycles, and then re-close lines in (b) into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	Stable (Trip D)	Stable (Trip D)	Stable	Stable	Stable (Trip D)	Stable (Trip D)

	Cont. Name	*Description*	***Case-1:*** *2006 Summer Peak (With Gen-2003-005)*	***Case-2:*** *2006 Summer Peak (Without Gen-2003-005)*	***Case-3:*** *2006 Winter Peak (With Gen-2003-005)*	***Case-4:*** *2006 Winter Peak (Without Gen-2003-005)*	***Case-5:*** *2010 Summer Peak (With Gen-2003-005)*	***Case-6:*** *2010 Summer Peak (Without Gen-2003-005)*
8	05-03C8	*Single phase fault and sequence like Cont. No. 7*	Stable	Stable	Stable	Stable	Stable	Stable
9	05-03C9	FLT93PH-3-phase Fault *Fault on the Fletcher tap (54086) – Southwester Station (54140) 138 kV line, near Fletcher tap* *a. Apply fault at the Fletcher tap (54086).* *b. Clear fault after 5 cycles by removing the line from 54086 to 54140.* *c. Wait 30 cycles, and then re-close the line in (b) and remove fault.* *d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.*	Stable	Stable	Stable	Stable	Stable	Stable
10	05-03D10	*Single phase fault and sequence like Cont. No. 9*	Stable	Stable	Stable	Stable	Stable	Stable
11	05-03C11	FLT113PH – 3-phase fault Fault on the Washita (56089) – Oney (56017) 138kV line, near Oney. a. Apply fault at the Oney bus (56017). b. Clear fault after 5 cycles by removing line from 56089 – 56017. c. Wait 20 cycles, and then re-close line in (b) into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	Stable (Trip D)	Stable (Trip D)	Stable (Trip D)	Stable (Trip D)	Stable (Trip D)	Stable (Trip D)

	Cont. *Name*	*Description*	***Case-1:*** *2006 Summer Peak (With Gen-2003-005)*	***Case-2:*** *2006 Summer Peak (Without Gen-2003-005)*	***Case-3:*** *2006 Winter Peak (With Gen-2003-005)*	***Case-4:*** *2006 Winter Peak (Without Gen-2003-005)*	***Case-5:*** *2010 Summer Peak (With Gen-2003-005)*	***Case-6:*** *2010 Summer Peak (Without Gen-2003-005)*
12	05-03C12	*Single phase fault and sequence like Cont. No. 11*	Stable	Stable	Stable	Stable	Stable	Stable
13	05-03C13	3-phase fault Fault on the Oney (56017) – Binger Niject (55827) 138 kV line, near Binger Niject a. Apply fault at the Binger Niject bus (55827). b. Clear fault after 5 cycles by removing line from 56017 – 55827. c. Wait 20 cycles, and then re-close line in (b) into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.	Stable	Stable	Stable	Stable	Stable	Stable
14	05-03C14	*Single phase fault and sequence like Cont. No. 13*	Stable	Stable	Stable	Stable	Stable	Stable
15	05-3C15	FLT153PH-3-phase Fault *Fault on the NEW line Washita (56089) – Southwester Station (54140) 138 kV line, near Washita.* *a. Apply fault at the Washita (56089).* *b. Clear fault after 5 cycles by removing the line from 56089 to 54140.* *c. Wait 30 cycles, and then re-close the line in (b) and remove fault.* *d. Leave fault on for 5 cycles, then trip the line*	Stable (Trip A+B+ D)	Stable (Trip A+B+D)	Stable (Trip D)	Stable (Trip D)	Stable (Trip A+B+ D)	Stable (Trip A+B+D)

	Cont. ***Name***	***Description***	***<u>Case-1:</u> 2006 Summer Peak (With Gen-2003-005)***	***<u>Case-2:</u> 2006 Summer Peak (Without Gen-2003-005)***	***<u>Case-3:</u> 2006 Winter Peak (With Gen-2003-005)***	***<u>Case-4:</u> 2006 Winter Peak (Without Gen-2003-005)***	***<u>Case-5:</u> 2010 Summer Peak (With Gen-2003-005)***	***<u>Case-6:</u> 2010 Summer Peak (Without Gen-2003-005)***
		in (b) and remove fault.						
16	05-03C16	*Single phase fault and sequence like Cont. No. 15*	Stable (Trip D)	Stable (Trip D)	Stable	Stable	Stable (Trip D)	Stable (Trip D)

4.6 Conclusion

The stability simulation shows that the study plant would not degrade the stability performance of the system. Certain generating machines are tripped during specific contingencies as summarized in Table 9 (mostly due to undervoltage conditions), but the system remains stable and all oscillations remain well damped. The impact study finds that the proposed project addition shows stable performance of the SPP system for the contingencies tested on the base cases.

The Vestas turbines of the Phase II plant (GEN03-04, GEN04-023, and GEN 05-03) will be required to include the Vestas AGO4 voltage/frequency protection package which allows the turbines to withstand many of the contingencies that the Phase I plant (NEG MICON turbines) are not able to withstand. The customer shall make necessary arrangements in its internal relaying scheme to insure that the Phase I plant's turbines do not trip off the Phase II plant's turbines for the contingencies listed in which the Phase I plant trips but the Phase II does not.

A sensitivity study was performed to review the impact of the study project without Gen-2003-005 in the queue. The results of the sensitivity study show similar system stability performance in the case with and without Gen-2003-005. The prior conclusion remains valid, that the study project shows stable performance of the SPP system for the contingencies tested on the supplied bases cases.

Appendix A

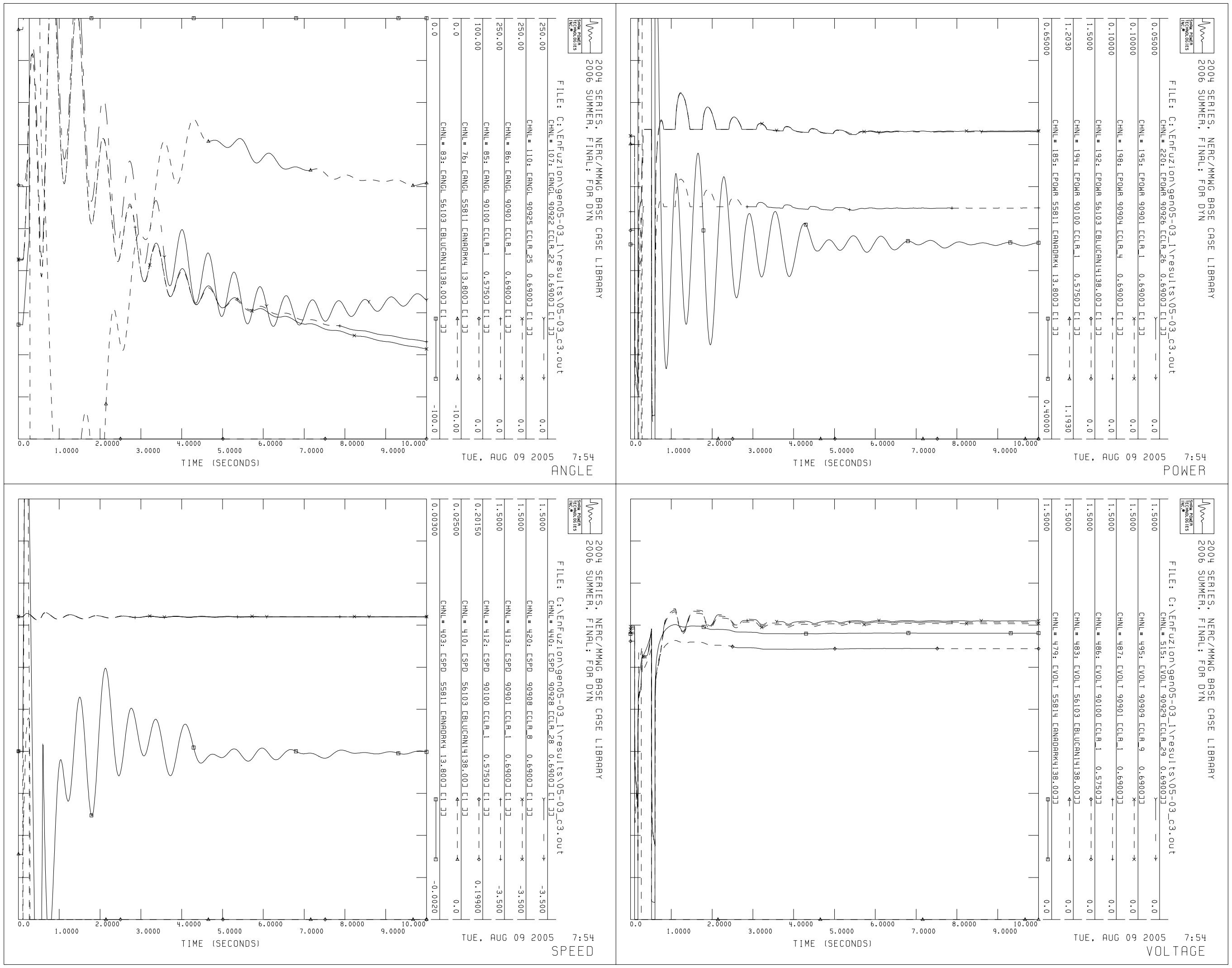
Wind Turbine Feeders

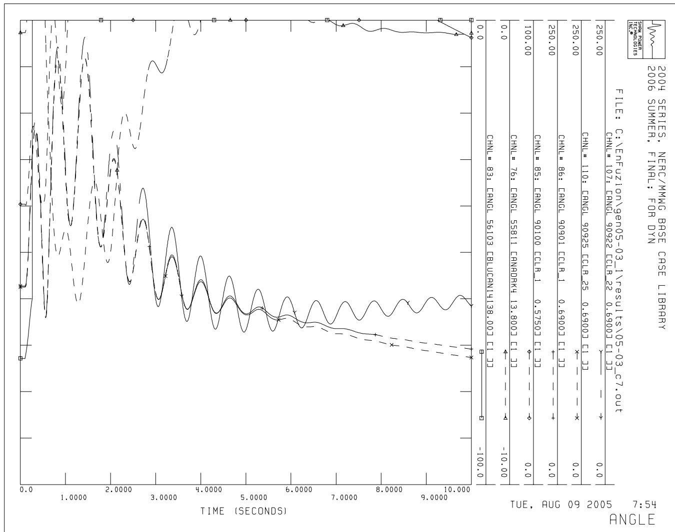
CABLING DATA FOR (GEN 2005-003)											
Cables used in project											
Cable	R(ohms)	X(ohms)	Y	/1000 FT							
1000kcm	0.028	0.037	0.000031								
500kcm	0.047	0.042	0.000024								
350kcm	0.066	0.045	0.000021								
4/0 AWG	0.107	0.049	0.000018								
1/0 AWG	0.212	0.055	0.000014								
Bus #		Name									
TO	**FROM**	**TO**	**FROM**	**Cable**	**Length**	**R**	**X**	**Y**	**R(pu)**	**X(pu)**	**Y(pu)**
90800	90850	main	jct 4A	1000 mcm	25085	0.70238	0.928145	0.0007776	**0.059024**	**0.077995**	**0.009253857**
		jct4a	w4a	4/0	105	0.011235	0.005145	1.89E-06	0.000944	0.000432	0.000022491
		w4a	w5a	4/0	700	0.0749	0.0343	0.0000126	0.006294	0.002882	0.00014994
90850	926	total							**0.007238**	**0.003315**	**0.000172431**
		w5a	w6a	1/0	740	0.15688	0.0407	1.036E-05	0.013183	0.00342	0.000123284
		w6a	w7a	1/0	695	0.14734	0.038225	9.73E-06	0.012382	0.003212	0.000115787
		w7a	w8a	1/0	720	0.15264	0.0396	1.008E-05	0.012827	0.003328	0.000119952
		w8a	w9a	1/0	660	0.13992	0.0363	9.24E-06	0.011758	0.00305	0.000109956
926	927	total							**0.05015**	**0.013011**	**0.000468979**
		jct4a	w3a	1/0	765	0.16218	0.042075	1.071E-05	0.013629	0.003536	0.000127449
		w3a	w2	1/0	695	0.14734	0.038225	9.73E-06	0.012382	0.003212	0.000115787
		w2	w1	1/0	1235	0.26182	0.067925	1.729E-05	0.022002	0.005708	0.000205751
90850	925	total							**0.048012**	**0.012456**	**0.000448987**
90850	90851	jct4a	jct4b	500mcm	3895	0.183065	0.16359	9.348E-05	**0.015384**	**0.013747**	**0.001112412**
		jct4b	w108	1/0	1270	0.26924	0.06985	1.778E-05	0.022625	0.00587	0.000211582
		w108	w118	1/0	655	0.13886	0.036025	9.17E-06	0.011669	0.003027	0.000109123
		w118	w128	1/0	695	0.14734	0.038225	9.73E-06	0.012382	0.003212	0.000115787
90851	928	total							**0.046676**	**0.012109**	**0.000436492**
90851	929	jct 4b	w138	4/0	3255	0.348285	0.159495	5.859E-05	**0.029268**	**0.013403**	**0.000697221**
		w138	w148	1/0	925	0.1961	0.050875	1.295E-05	0.016479	0.004275	0.000154105
		w148	w158	1/0	705	0.14946	0.038775	9.87E-06	0.01256	0.003258	0.000117453
		w158	w168	1/0	715	0.15158	0.039325	1.001E-05	0.012738	0.003305	0.000119119
		w168	w178	1/0	1040	0.22048	0.0572	1.456E-05	0.018528	0.004807	0.000173264
929	930	total							**0.060304**	**0.015645**	**0.000563941**

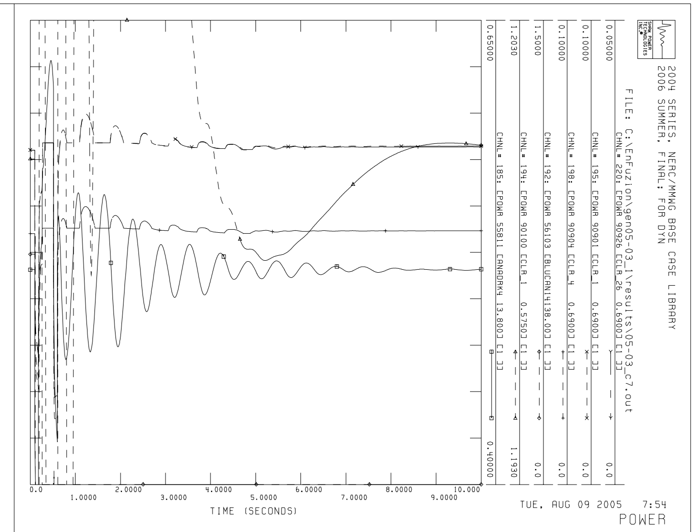
Appendix B

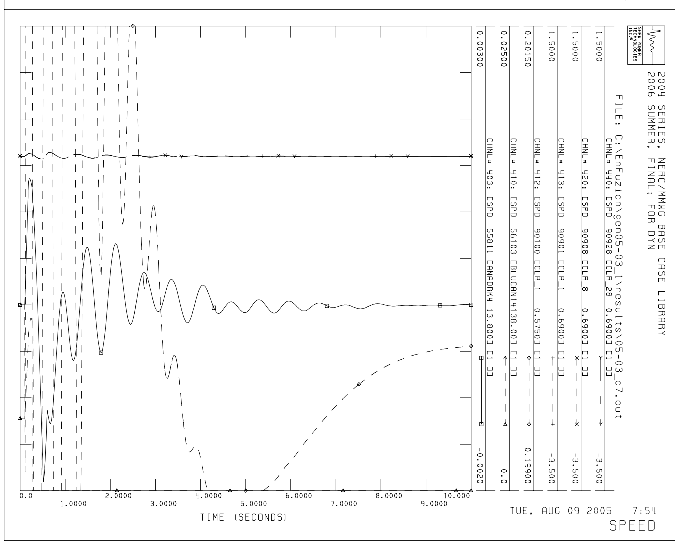
Example PLOTS

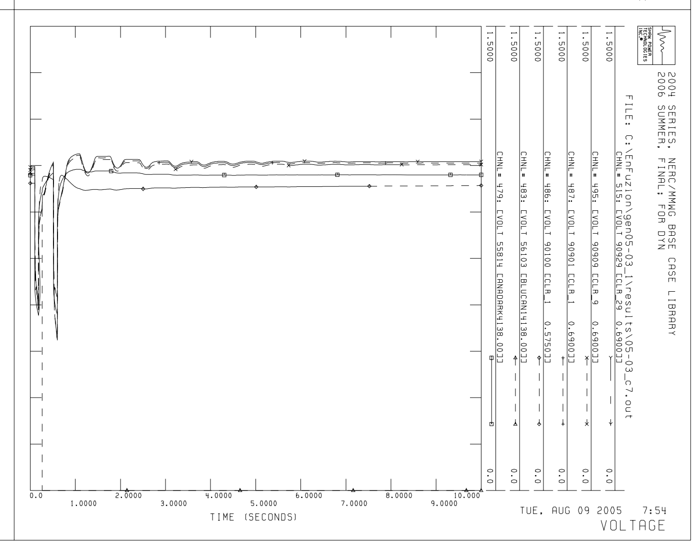
- B2 – 2006 Summer Peak (Case 1 – Contingency 3); System Stable; Phase I trips due to undervoltage; GEN 2003-005 trips due to undervoltage
- B3 – 2006 Summer Peak (Case 1 – Contingency 7); System Stable; Phase I trips due to undervoltage
- B4 – 2006 Summer Peak (Case 1 – Contingency 9); System Stable
- B5 – 2006 Winter Peak (Case 3 – Contingency 5); System Stable; Phase I trips due to undervoltage; GEN 2003-005 trips due to undervoltage
- B6 – 2010 Summer Peak (Case 5 – Contingency 3) ; System Stable; Phase I trips due to undervoltage

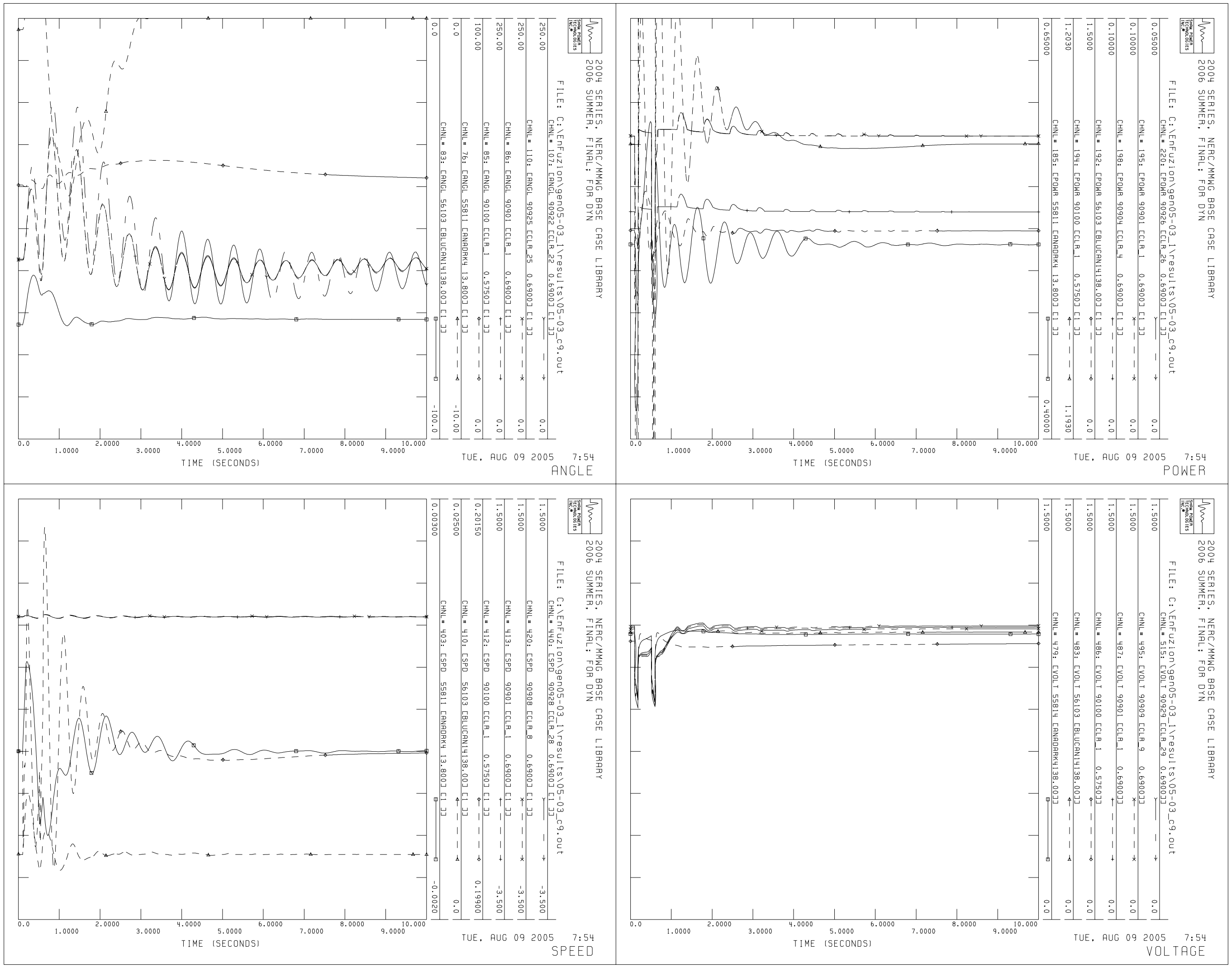

2004 SERIES, NERC/MMWG BASE CASE LIBRARY
2006 SUMMER, FINAL; FOR DYN
FILE: C:\EnFuzion\gen05-03_1\results\05-03_c3.out
TIME (SECONDS)
TUE, AUG 09 2005 7:54
ANGLE
POWER
SPEED
VOLTAGE

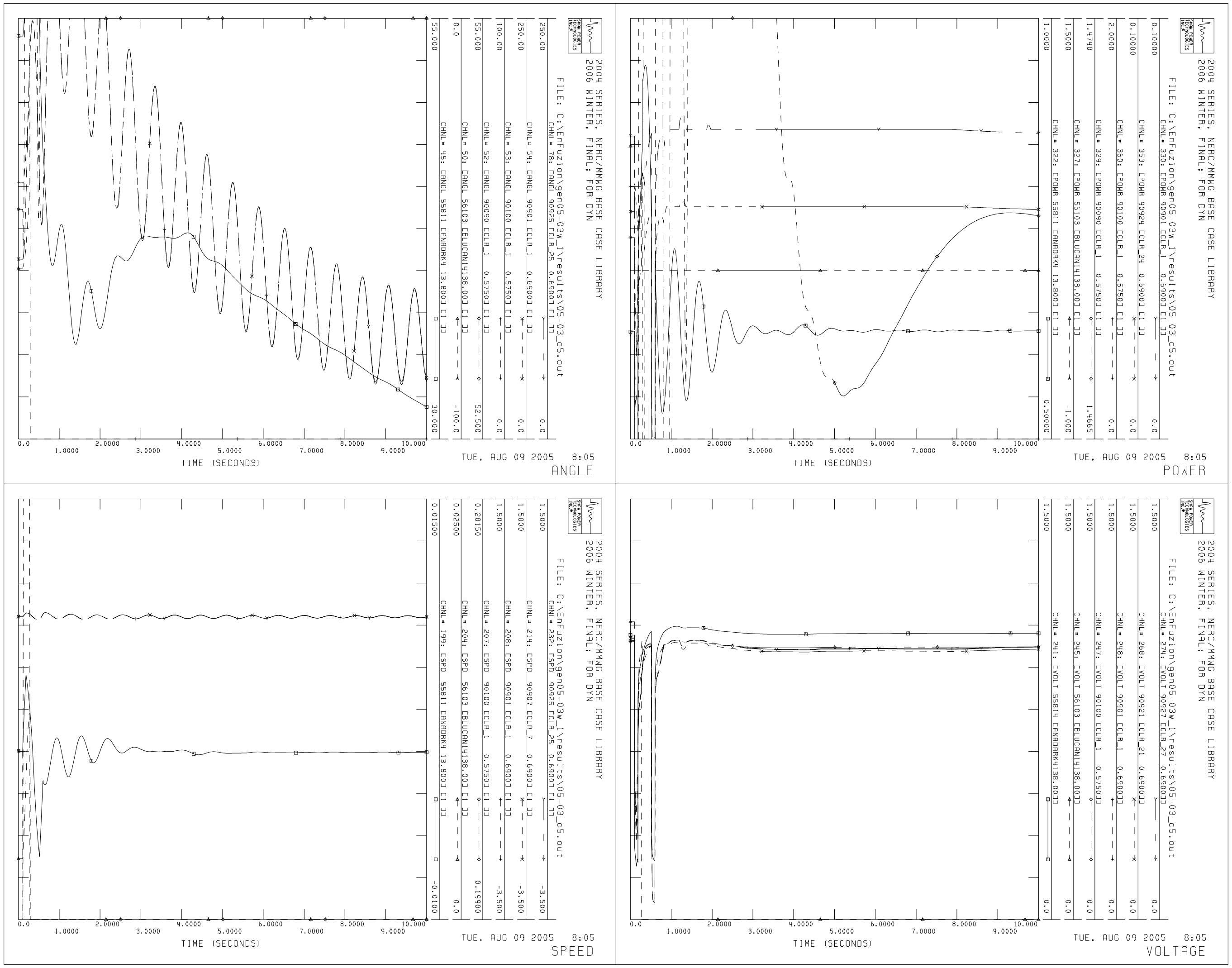

2004 SERIES, NERC/MMWG BASE CASE LIBRARY
2006 SUMMER, FINAL; FOR DYN
FILE: C:\EnFuzion\gen05-03_1\results\05-03_c7.out
TIME (SECONDS)
TUE, AUG 09 2005 7:54
ANGLE

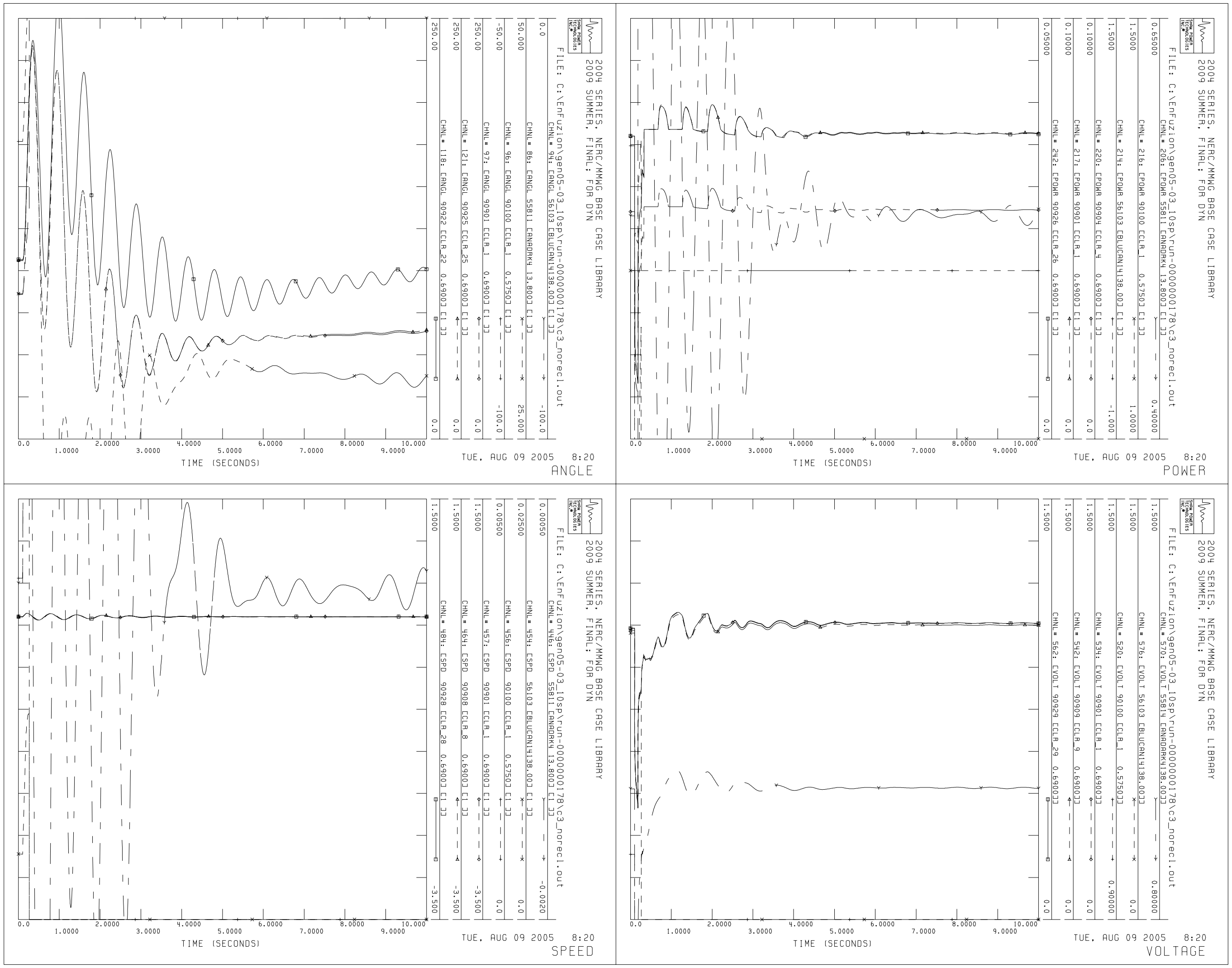

2004 SERIES, NERC/MMWG BASE CASE LIBRARY
2006 SUMMER, FINAL; FOR DYN
FILE: C:\EnFuzion\gen05-03_1\results\05-03_c7.out
TIME (SECONDS)
TUE, AUG 09 2005 7:54
POWER


2004 SERIES, NERC/MMWG BASE CASE LIBRARY
2006 SUMMER, FINAL; FOR DYN
FILE: C:\EnFuzion\gen05-03_1\results\05-03_c7.out
TIME (SECONDS)
TUE, AUG 09 2005 7:54
SPEED


2004 SERIES, NERC/MMWG BASE CASE LIBRARY
2006 SUMMER, FINAL; FOR DYN
FILE: C:\EnFuzion\gen05-03_1\results\05-03_c7.out
TIME (SECONDS)
TUE, AUG 09 2005 7:54
VOLTAGE


2004 SERIES, NERC/MMWG BASE CASE LIBRARY
2006 SUMMER, FINAL; FOR DYN
FILE: C:\EnFuzion\gen05-03_1\results\05-03_c9.out
TIME (SECONDS)
TUE, AUG 09 2005 7:54
ANGLE
POWER
SPEED
VOLTAGE


2004 SERIES, NERC/MMWG BASE CASE LIBRARY
2006 WINTER, FINAL; FOR DYN
FILE: C:\EnFuzion\gen05-03w_1\results\05-03_c5.out
TIME (SECONDS)
TUE, AUG 09 2005 8:05
ANGLE
POWER
SPEED
VOLTAGE


2004 SERIES, NERC/MMWG BASE CASE LIBRARY
2009 SUMMER, FINAL; FOR DYN
FILE: C:\EnFuzion\gen05-03_10sp\run-0000000178\c3_norecl.out
TIME (SECONDS)
TUE, AUG 09 2005 8:20
ANGLE
POWER
SPEED
VOLTAGE