Southwest Power Pool

Facility Study For Generation Interconnection Request GEN-2010-047 GEN-2010-051

SPP Generation Interconnection Studies

July 2011

Summary

Nebraska Public Power District (NPPD) performed the following Study at the request of the Southwest Power Pool (SPP) for Generation Interconnection requests Gen-2010-047 and GEN-2010-051. The requests for interconnection were placed with SPP in accordance SPP's Open Access Transmission Tariff, which covers new generation interconnections on SPP's transmission system. Pursuant to the tariff, NPPD was asked to perform a detailed Facility Study of the generation interconnection request to satisfy the Facility Study Agreement executed by the requesting customers and SPP.

Interconnection Customer Interconnection Facilities

Each Interconnection Customer will be responsible for its 115kV (GEN-2010-047) or 230kV (GEN-2010-051) transmission facilities from its point of interconnection to its 115/34.5kV (GEN-2010-047) or 230/34.5kV (GEN-2010-051) substation that will contain its step down transformers and wind turbine collector feeders. In addition, each Customer will be responsible for reactive power compensation equipment to maintain 95% lagging (providing vars) and 95% leading (absorbing vars) power factor at the point of interconnection.

Transmission Owner Interconnection Facilities, Non Shared Network Upgrades, and Shared Network Upgrades

The interconnection customers were studied within the DISIS-2010-002 Impact Study. The Interconnection Customers are responsible for the costs shown on the next page. If a customer is not assigned the entire cost of a particular upgrade, that upgrade is considered a "shared upgrade". If equally queued interconnection customers withdraw from the queue, suspend or terminate their GIA, restudies will have to be conducted to determine the Interconnection Customers' allocation of shared network upgrades.

Contingent Upgrades

At this time, there are no contingent upgrades in which GEN-2010-047 and GEN-2010-051 are dependant upon.

Affected System Facilities

There were possible Western Area Power Administration (WAPA) and MidAmerican Energy Company (MEC) Affected System Facilities were identified in the Phase 1 through Phase 4 Loadflow Analysis of the Facility Study. SPP will contact WAPA and MEC to determine what mitigation is required for each of the Affected System Facilities.

E. Cost Allocation Per Request

(Including Perviously Allocated Network Upgrades*)

Interconnection Request and Upgrades	Upgrade Type	Allocated Cost	Upgrade Cost
GEN-2010-047			
Gage County - Harbine 115kV CKT 1 Rebuild approximately 5 miles of 115kV between Gage County and Harbine	Current Study	$3,200,000.00	$3,200,000.00
GEN-2010-047 Interconnection Costs See Oneline Diagram.	Current Study	$4,000,000.00	$4,000,000.00
	Current Study Total	$7,200,000.00	
GEN-2010-051			
GEN-2010-051 Interconnection Costs See Oneline Diagram.	Current Study	$6,700,000.00	$6,700,000.00
Twin Church - Dixon County 230kV CKT 1 Increase clearances on Twin Church - Dixon County 230kV line	Current Study	$100,000.00	$100,000.00
	Current Study Total	$6,800,000.00	
	TOTAL CURRENT STUDY COSTS:	**$14,000,000.00**	

DISIS-2010-002
GENERATION INTERCONNECTION
FACILITY STUDY

SPP GEN-2010-047 **72 MW Wind Generation Facility at Gage Co. 115 kV**

SPP GEN-2010-051 **200 MW Wind Generation Facility at Dixon Co. 230 kV**

JUNE 2011

PREPARED FOR:
SOUTHWEST POWER POOL

PREPARED BY:
NEBRASKA PUBLIC POWER DISTRICT OPERATIONS
TRANSMISSION ASSET PLANNING
T&D ASSET MANAGEMENT
T&D ENGINEERING

Nebraska Public Power District
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Executive Summary

The *NPPD DISIS-2010-002 Facility Study* was performed to document the reliability impacts of two new wind generation facilities interconnected to the NPPD transmission system. These two wind generation projects have developed through the SPP Definitive Interconnection System Impact Study process and have advanced to the facility study stage. SPP has requested that NPPD perform the Facility Study associated with the two generation interconnection projects listed below:

Project	MW	Point-of-Interconnection	Cluster
GEN-2010-047	72	Gage Co. Sub on Beatrice – Harbine 115 kV	13
GEN-2010-051	200	Dixon Co. Sub on Twin Church – Hoskins 230kV	9
	272		

This facility study provides the transmission interconnection plan to accommodate the interconnection of the two wind generation projects. This study report was performed to assess the future system state in accordance with NERC TPL standards and NPPD's Facility Connection Requirements Document. This facility study was performed in multiple phases to address a wide range of operating conditions to adequately assess the future system state with the proposed wind generation interconnection projects and associated transmission. SPP evaluated these two wind generation interconnection projects as two separate clusters in the DISIS-2010-002 system impact study and developed a list of transmission projects required to interconnect these generation facilities to the NPPD transmission system at the requested points of interconnection. The required transmission network upgrade projects identified in the DISIS-2010-002 system impact study are listed below:

- New Dixon County 230 kV substation on Twin Church – Hoskins 115 kV line
- New Gage County 115 kV substation on Beatrice – Harbine 115 kV line
- Upgrade of Gage County – Harbine 115 kV line section to at least 1200 Amp rating

The DISIS-2010-002 facility study was conducted assuming all remaining DISIS-2010-001, DISIS-2009-001 generation and associated transmission projects associated with NPPD's system move forward and are constructed. If any changes are made to the DISIS-2009-001 and DISIS-2010-001 generation and associated transmission projects, then the DISIS-2010-002 transmission plan would need re-evaluated. Modifications to the DISIS-2009-001 and DISIS-2010-001 generation and transmission projects could potentially affect the transmission interconnection costs assigned to the DISIS-2010-002 customers.

The DISIS-2010-002 Facility Study includes a loadflow analysis, short circuit analysis, and regional flowgate impact analysis.

The loadflow analysis documents the steady-state performance of the network following the wind generation facility additions and the associated transmission facility upgrades. The loadflow analysis was split into four phases.

Phase 1 of the loadflow analysis was a system intact and N-1 contingency analysis of the expected system state following the wind generation & transmission additions performed in accordance with NERC Standards TPL-001 and TPL-002. The results of the Phase 1 portion of the loadflow analysis revealed no facilities on the NPPD system that would need mitigation.

Phase 2 of the loadflow analysis involved a comprehensive multiple element contingency analysis of the Nebraska transmission system. The results of the Phase 2 contingency analysis revealed no additional facility overloads or voltage violations that would require mitigation due to TPL-003 and TPL-004 contingencies.

Phase 3 of the loadflow analysis evaluated the local area transmission capacity with respect to delivering the fully accredited generating capability out of the area at Spring load levels. The Phase 3 loadflow analysis was performed to evaluate the system state for the worst-case N-1, stuck breaker, and N-2 contingencies in the area of the wind projects. Based on the Phase 3 N-1 results, it was determined that the Dixon County – Twin Church 230 kV line rating needed to be restored to the 320 MVA facility rating. This line was recently derated due to conductor clearance issues. Increasing conductor clearances on this line would mitigate the N-1 issue. There were several other facility overloads discovered in this phase that may require mitigation. North Platte – Stockville 115 kV line was overloaded for loss of the GGS – Red Willow 345 kV line. This facility is associated with the WNE_WKS flowgate and the Axtell – Post Rock – Spearville 345 kV Balanced Portfolio project is expected to help mitigate the loading on this line for this contingency. Also, the Raun – Neal North 161 kV circuits would found to overload for loss of the parallel 161 kV circuit. This overload would need to be coordinated with the facility owner to determine if mitigation would be required. Based on the Phase 3 N-2 results, a list of 4 transmission facilities was developed that would need prior outage generation limits established in the north east area (GEN-2010-051) to ensure system operating limits are maintained for the potential loss of the next worst-case transmission facility. Also, a list of 11 transmission facilities was developed that would need prior outage generation limits established in the south east area (GEN-2010-047) to ensure system operating limits are maintained.

Phase 4 of the loadflow analysis evaluated the transmission system with respect to worst-case north-to-south transfer conditions across Nebraska. The Phase 4 analysis was performed to evaluate worst-case N-1 contingencies under these highly stressed transfer conditions. Overall, there were several transmission facility overloads discovered in the Phase 4 screening that were associated with north-south transfer limitations in western and eastern Nebraska. It should also be noted that the additional wind generation interconnections in Nebraska continue to have an adverse impact on these north-south flowgates and transmission limitations. Increased generation on the north end of these constraints will continue to increase congestion and number of hours in curtailment. The

Axtell – Post Rock – Spearville 345 kV line will help mitigate the issues associated with the WNE_WKS flowgate, but additional studies are required to determine the relief this project will provide. Additional points of congestion were noted on several 161 kV paths in Iowa and Kansas as well as on the Cooper-St.Joe 345 kV line.

The short circuit analysis was performed to evaluate the fault interrupting capability of existing devices in the area and protection coordination issues following the interconnection of the proposed wind generation additions. The results of this analysis showed that three protective devices were subject to replacement, but none were the cost responsibility of the wind projects. The study did find that there would be protection coordination issues associated with the new interconnection substations (Dixon County and Gage County) that would require protection system modifications to accommodate interconnections.

The regional flowgate impact analysis was performed to determine if flows on any defined flowgates in Nebraska would be significantly affected by the wind generation facilities. Overall, the results showed that three PTDF flowgates, COOPER_S, FTCAL_S and WNE_WKS, were significantly impacted by the wind projects. Two OTDF flowgates, the Council Bluffs – River Bend 161 kV FLO Cooper – St. Joe 345 kV and Kelly – Tecumsah Hill 161 kV FLO Cooper – St. Joe 345 kV flowgates were significantly impacted by the wind projects. Regional flowgate impacts due to the wind projects will be further addressed in the delivery study following a request for transmission service.

Overall, the *NPPD DISIS-2010-002 Facility Study* documents the performance of the network following the addition of the three wind generation interconnection projects and associated transmission. The Facility Study has documented the transmission plan required for interconnection to the NPPD transmission system and the details are listed on the following page.

DISIS-2010-002 Interconnection Plan

- GEN-2010-047 Interconnection Facilities – Gage County 115 kV substation addition on Beatrice – Harbine 115 kV to accommodate new 115 kV interconnection. Includes protection system modifications and communication path (fiber) to accommodate new interconnection substation.
  $ 4.0 Million

- GEN-2010-051 Interconnection Facilities – Dixon County 230 kV substation addition on Twin Church – Hoskins 230 kV line to accommodate new 230 kV interconnection.
  $ 6.7 Million

- Gage County - Harbine 115 kV Line Rebuild – Rebuild ~5-miles of 115 kV line from Gage County to Harbine and associated substation upgrades to at least 1200 Amp.
  $ 3.2 Million

- Twin Church – Dixon County 230 kV Line Upgrade – Increase clearances on Twin Church – Dixon County 230 kV line to accommodate 320 MVA facility rating to address N-1 contingency loading issues identified in DISIS-2010-002 Facility Study.
  $ 0.1 Million

Total Interconnection & Network Upgrades: $14.0 Million

1.0 Introduction

In March 2011, NPPD was notified that two generation interconnection requests in the SPP generation interconnection queue had advanced to the facility study stage. Also in March 2011, NPPD was notified by SPP that DISIS-2009-001 and DISIS-2010-001 was being re-studied due to previously queued generation interconnection requests withdrawing from the SPP generation interconnection queue. Along with these withdrawn generation interconnection requests, there were several significant network upgrades which were removed from the DISIS-2009-001 and DISIS-2010-001 transmission interconnection plans. Due to these material modifications, NPPD was requested to perform facility re-studies for both DISIS-2009-001 and DISIS-2010-001. Due to this completely new network topology and subsequent re-studies, the facility study for DISIS-2010-002 was delayed until the re-studies for DISIS-2009-001 and DISIS-2010-001 were completed and posted. Each of the two generation interconnection requests were evaluated by SPP in the Definitive Interconnection System Impact Study (DISIS-2010-002) as clusters in Group 9 and Group 13. The two generation interconnection requests are listed below:

Project	MW	Point-of-Interconnection	Cluster
GEN-2010-047	72	Gage Co. Sub on Beatrice – Harbine 115 kV	13
GEN-2010-051	200	Dixon Co. Sub on Twin Church – Hoskins 230kV	9
	272		

SPP entered into a facility study agreement with each of the two generation interconnection customers and subsequently requested that NPPD perform the Facility Study for each request. In response to the SPP request, NPPD has performed a Facility Study for all of the generation interconnection requests which included a detailed loadflow analysis, short circuit analysis and regional flowgate impact analysis. The Facility Study also includes detailed cost estimates and estimated project schedules for the interconnection and network upgrades identified in the System Impact Study and Facility Study. A list of interconnection and network upgrades identified in the System Impact Study as required for these two generation interconnection projects is below:

- GEN-2010-047 Interconnection Facilities – Development of new Gage County 115 kV substation to accommodate new 115 kV interconnection on Beatrice – Harbine 115 kV line.

- GEN-2010-051 Interconnection Facilities – Development of new Dixon County 230 kV substation to accommodate new 230 kV interconnection on Twin Church – Hoskins 230 kV line.

- Gage County – Harbine 115 kV Line Upgrade – Reconductor of 115 kV Gage County – Harbine 115 kV line.

2.0 Study Scope

2.1 Overview

This Facility Study will evaluate two proposed wind generator interconnection projects on the NPPD transmission system. This study will evaluate two generator interconnection requests in the SPP Generator Interconnection Queue which were studied in the SPP Definitive Interconnection System Impact Study, SPP DISIS-2010-002, and progressed to the facilities study stage. The two GI projects on the NPPD transmission system included in the DISIS-2010-002 study are as follows:

Project	MW	Point-of-Interconnection
GEN-2010-051	200.0	New Dixon Co. Sub on Twin Church - Hoskins 230 kV
GEN-2010-047	72.0	New Gage Co. Sub on Beatrice – Harbine 115 kV
	272.0	

This Facility Study will focus on the two projects requesting interconnection to the NPPD transmission system. The SPP DISIS-2010-002 system impact study did identify several transmission upgrades that would be required to interconnect the two proposed generation facilities. These transmission upgrades were required to mitigate impacts of the proposed generation projects on the existing transmission system as identified in the DISIS-2010-002 study. These transmission upgrades are listed below:

- New Dixon County 230 kV substation
- New Gage County 115 kV substation
- Re-Build of Gage County – Harbine 115 kV line

At the time of this facility study, there were several active generation interconnection requests in the SPP GI queue in the Nebraska area. These GI projects are currently at the generation interconnection agreement negotiation stage in the SPP GI process. Due to time constraints, this facility study must proceed assuming the following generation interconnection projects and associated network upgrades remain active projects in the SPP GI process. If any of these GI projects or network upgrades withdrawal from the SPP GI queue, then a re-study of this DISIS-2010-002 facility study may be required. The previously queued GI projects and network upgrades in the NPPD area are as follows:

Previously queued GI projects		
GEN-2006-044N (Petersburg.N)	=	40.5 MW
GEN-2008-086N02 (Madison.Co)	=	200.0 MW
GEN-2006-037N1 (Broken Bow)	=	75.0 MW
GEN-2006-044N02 (Madison.Co)	=	100.8 MW

GEN-2010-010 (Madison.Co)	=	100.5 MW
GEN-2008-123N (Rosemont)	=	89.7 MW

Previously allocated interconnection facilities & network upgrades

- Upgrade Neligh–Petersburg.N–Petersburg–Albion 115 kV to 137 MVA
- Upgrade Ft. Randall–Madison County–Kelly 230 kV to 320 MVA
- Madison County 230 kV substation
- Rosemont 115 kV substation
- Madison County – Hoskins 230 kV line
- Upgrade Madison County – Kelly 230 kV to 478 MVA

This facility study will assess the new system state with the proposed wind facilities and associated transmission upgrades. The facility study will also identify any additional transmission issues that would require mitigation to meet mandatory NERC reliability standards following the addition of the new generation facilities and associated transmission projects. The Facility Study will include the following study phases:

1. Loadflow Analysis
2. Short Circuit Analysis
3. Regional Flowgate Impact Analysis

The loadflow analysis will be an assessment of the transmission system following the addition of the proposed generation requests and associated transmission projects. The loadflow analysis will evaluate the transmission system for compliance with NERC Reliability Standards and identify any thermal and voltage issues that would require mitigation. The short circuit analysis will evaluate the impacts of the wind facilities and associated transmission on existing fault currents in the area and determine if the capability of existing fault interrupting devices are adequate. A regional flowgate impact analysis will also be included to identify any regional flowgates impacted by the proposed generator interconnections.

The intent of the facility study is to perform a detailed assessment of the proposed generation interconnection facilities and associated transmission and validate adherence to system reliability criteria. This study will be performed in accordance with NERC Reliability Standards and the criteria set forth under those standards. This facility study will document the required transmission facility interconnection plan for the two proposed generation interconnection facilities and be performed in accordance with the methodologies described in NPPD's Facility Connection Requirements Document.

2.2 Loadflow Analysis

NPPD Transmission Planning will perform a loadflow analysis to screen the steady state performance of the network following the addition of the wind facilities and associated transmission. The powerflow models used for the loadflow analysis will be 2011 Series SPP MDWG models (Build 1). These models will represent system conditions close to the expected in-service date of the proposed wind projects and will adequately represent a variety of worst-case seasonal conditions. The powerflow models utilized for the analysis will be:

2011 Spring Peak Load Case
2017 Summer 100% Peak Load Case
2017 Winter 100% Peak Load Case

The base SPP MDWG powerflow models will be updated with planned transmission facility additions in the 2011 – 2017 timeframe and other system changes consistent with the latest SPP / MAPP Regional Plan.

The loadflow study will be split into four phases:

Phase 1 : System-wide Single Contingency N-1 Analysis

Phase 2 : System-wide Multiple Element Contingency N-2 Analysis

Phase 3 : Local Area Full Accredited Generation Capacity N-1 & N-2 Contingency Analysis

Phase 4 : System-wide Single Contingency N-1 Analysis under heavy transfer conditions

PHASE 1: This Phase is considered a comprehensive single contingency analysis of the entire Nebraska subregion. Every single element rated from 115 kV – 345 kV in the NPPD, OPPD, LES, MEC and WAPA areas will be outaged and monitored through activity ACCC. The results of the contingency screening will be assessed and documented. Phase 1 will also further investigate all critical contingencies identified from the ACCC contingency screening. Phase 1 will be utilized to document the performance characteristics of the system in accordance with NERC Reliability Standards, TPL-001 and TPL-002.

PHASE 2: This Phase is considered a comprehensive multiple element contingency analysis of the entire Nebraska region. Multiple element contingencies rated from 115 kV – 345 kV will be outaged and monitored through activity ACCC. The multiple element contingencies consist of stuck breaker contingencies and double circuit tower contingencies identified by Nebraska transmission owners and utilized during MRO and SPP screening processes. The results of the contingency screening will be assessed and documented. Phase 2 will also further investigate all critical contingencies identified from the ACCC contingency screening comparison. Phase 2 will be utilized to document the performance characteristics of the system in accordance with NERC Reliability Standards, TPL-003 and TPL-004.

PHASE 3: This Phase will evaluate the impacts of worst case N-1 single contingency and independent N-2 double contingency conditions for the local area transmission outlet paths associated with the wind projects. The 2011 Series 2011 Spring Peak load case will be utilized to show the impacts of the worst case local area contingencies. All of the local area generation including the wind additions will be redispatched off-system. The purpose of this Phase will be to document sufficient generator outlet transmission capacity for the new wind generators concurrent with the existing approved accredited generation in the area.

This Phase will be used to evaluate the Nebraska area transmission capacity with respect to delivering the fully accredited generating capability out of the local area resources for load levels at and above 70% of peak. The Spring Peak Load case is approximately 65% of summer peak for the Nebraska region. To stress the generation outlet capacity, the maximum accredited generation is modeled in two separate cluster areas and exported into the surrounding MAPP & SPP regions. The following maximum accredited net generation levels will be modeled in this phase:

<u>Northeast NE Cluster</u>		
GEN-2010-051 (Dixon.Co)	=	200.0 MW
GEN-2006-044N02 (Madison.Co)	=	100.8 MW
GEN-2010-010 (Madison.Co)	=	100.5 MW
GEN-2006-037N1 (Broken Bow)	=	75.0 MW
GEN-2006-044N (Petersburg.N)	=	40.5 MW
GEN-2008-086N02 (Madison.Co)	=	200.0 MW
Petersburg Wind	=	80.0 MW
Broken Bow Wind	=	80.0 MW
Bloomfield Crofton Hills Wind	=	42.0 MW
Bloomfield Elkhorn Ridge Wind	=	81.0 MW
Monroe Hydro	=	4.0 MW
Ainsworth Wind	=	75.0 MW
Gavins Point #1-3	=	102.0 MW
Ft. Randall #1-6	=	360.0 MW
Neal #1-4	=	1680.0 MW
Columbus Hydro #1-3	=	45.0 MW
Columbus ADM Co-Gen #1	=	75.0 MW
Emerson	=	12.0 MW
West Point	=	7.4 MW

<u>Southeast NE Cluster</u>		
GEN-2010-047 (Gage.Co)	=	72.0 MW
GEN-2008-123N (Rosemont)	=	89.7 MW
Hebron #1	=	52.0 MW
Deshler Units #1-4	=	2.3 MW
Belleville Units #4-8	=	13.9 MW
Fairbury Units #2-3	=	15.3 MW
Red Cloud Units #1-5	=	4.0 MW
Sheldon #1	=	105.0 MW
Sheldon #2	=	120.0 MW
Hallam #1	=	52.0 MW
Beatrice Power Station #1	=	80.0 MW
Beatrice Power Station #2	=	80.0 MW
Beatrice Power Station #3	=	90.0 MW
Cooper #1	=	850.0 MW
Nebraska City #1	=	646.0 MW
Nebraska City #2	=	700.0 MW
Cass County #1	=	160.0 MW
Cass County #2	=	160.0 MW
Flat Water #1	=	60.0 MW
Flat Water #2 (GEN-2010-041)	=	10.5 MW

All of the incremental generation adjustments were made to external Nebraska resources to effect these schedules. Additional non-firm schedules into the MAPP and SPP regions made up the transfers. This type of operational mode is highly unlikely, but was utilized to demonstrate the transmission capacity available to deliver the fully accredited generation out of the Nebraska area under emergency conditions.

This Phase will include one-line powerflow plots showing flows and voltages in the area for system intact and N-1 conditions. This Phase will also evaluate critical stuck breaker outages, double circuit transmission line outages and independent N-2 contingencies which could be affected by the wind projects. Powerflow plots will be included and any required operating limitations will be documented.

PHASE 4: This Phase is considered a comprehensive single contingency analysis of the entire Nebraska subregion under transfer conditions. This Phase will assess the performance of the NPPD transmission system under heavy north-to-south transfer conditions. Transfer cases will be established to evaluate north-to-south transfer limits with the wind generation interconnection projects at maximum output levels. Every single element rated from 115 kV – 345 kV in the NPPD, OPPD, LES, MEC and WAPA areas will be outaged and monitored through activity ACCC. The results of the contingency screening will be assessed and documented. Phase 4 will also further investigate all critical contingencies identified from the ACCC contingency screening. Phase 4 will be utilized to document the performance characteristics of the system in accordance with NERC Reliability Standards, TPL-001 and TPL-002.

2.3 Short Circuit Analysis

The purpose of the Short Circuit Analysis will be to evaluate the two proposed generation interconnection projects and associated transmission on the existing substation equipment fault duty ratings in the area. The substations to be evaluated are those electrically close to the interconnection points (Gage County 115 kV Sub and Dixon County 230 kV Sub) of the wind projects.

The Short Circuit Analysis will include short circuit calculations, an evaluation of the adequacy of existing circuit breaker interrupting ratings and an evaluation of the adequacy of the fault withstand capability of other substation equipment located at the monitored substations. The Short Circuit Analysis will be performed by NPPD Engineering Protection & Control personnel.

2.4 Regional Flowgate Impact Analysis

A Regional Flowgate Impact Analysis (DF Analysis) will be performed to assess the impacts of the two wind projects on Nebraska flowgates. Distribution Factor (PTDF and OTDF) calculations will be performed to examine the incremental impacts of the wind projects on currently defined constrained interfaces in the Nebraska area transmission system. The results of the DF screening will flag any impacts on Nebraska area flowgates for delivery of the wind projects outside of the Nebraska subregion. Any constrained interfaces identified as being impacted by greater than the allowable thresholds will be noted.

2.5 Detailed Cost Estimates & Project Schedule

NPPD Engineering, Asset Management, and Project Management departments will review the transmission upgrades identified in the SPP DISIS-2010-002 study. Detailed cost estimates and project schedules will be developed by these groups to implement the proposed transmission upgrades using standard NPPD construction and procurement practices. If any additional transmission upgrades are identified in this facility study, a detailed cost estimate and project schedule for these additional upgrades will also be developed and provided as required.

3.0 Model Development

This study was conducted using Rev 32.1 of Power Technology Inc.'s (PTI's) Power System Simulator (PSS/E) software package and the following SPP MDWG 2011 series build 1 powerflow models:

2011 Spring Peak Load Case
2017 Summer 100% Peak Load Case
2017 Winter 100% Peak Load Case

The powerflow models were updated based on previously approved generation interconnection projects in the area. The following generation interconnection projects were included in the base powerflow models:

Petersburg Wind	=	80.0 MW
Broken Bow Wind	=	80.0 MW
Bloomfield Crofton Hills Wind	=	42.0 MW
Bloomfield Elkhorn Ridge Wind	=	81.0 MW
Ainsworth Wind	=	75.0 MW
Gavins Point #1-3	=	92.0 MW
Ft. Randall #1-6	=	347.0 MW
GEN-2006-044N (Petersburg.N)	=	40.5 MW
GEN-2008-086N02 (Madison.Co)	=	200.0 MW
GEN-2006-037N1 (Broken Bow)	=	75.0 MW
GEN-2006-044N02 (Madison.Co)	=	100.8 MW
GEN-2010-010 (Madison.Co)	=	100.5 MW
GEN-2008-123N (Rosemont)	=	89.7 MW

The previously approved generation resources listed above were dispatched at 100% and other generation resources in the same balancing authority (BA) were reduced to account for the increased generation. The two new generation interconnection projects listed below were then added to the models and dispatched at 100%. The total output (272 MW) from the new generation interconnection projects was dispatched off-system to all other balancing authorities within the SPP footprint on a pro rata basis.

GEN-2010-051 (Dixon Co.)	=	200.0 MW
GEN-2010-047 (Gage Co.)	=	72.0 MW

<u>Wind Generation Models</u>

Each of the new wind generation interconnection projects were modeled with a +/- 0.95 power factor range with voltage control capability at the designated point-of-interconnection. Some of the new projects may have a larger reactive power range available, but the reactive capability of each generation interconnection project was limited to +/- 0.95 power factor to be conservative in this study.

Base Transmission Upgrades

The SPP definitive generation interconnection study (DISIS-2010-002) identified a transmission upgrade that was required to accommodate the interconnection of the wind generation interconnection projects on the NPPD system. This transmission upgrade project was modeled as a base transmission upgrade in this facility study. The impedance characteristics and facility ratings modeled for this project in this facility study are documented below:

Gage County - Harbine 115 kV Line Rebuild
R: 0.00480
X: 0.02965
B: 0.00454
RateA: 240 MVA (Normal)
RateB: 240 MVA (Long-term Emergency)
RateC: 264 MVA (Short-term Emergency)

4.0 Study Criteria

Facility Loading Criteria

Overloads of equipment are defined as greater than 100% of the normal continuous rating (Rate A).

Voltage Criteria

Normal steady-state voltage levels are defined as 0.95 to 1.05 pu. Emergency steady-state voltage levels are defined as 0.90 – 1.10 pu and may be utilized for less than 30 minutes.

5.0 Loadflow Analysis

5.1 Phase 1 Results (System-wide N-1 Screening)

PSS/E activity ACCC was used as a screening tool on each of the base cases to identify those contingencies which deserve closer study. ACCC analyzed the system by sequentially taking each transmission element greater than 100kV in the NPPD, OPPD, LES, MEC, and WAPA control areas out of service. Transmission facilities in the NPPD, OPPD, LES, MEC, and WAPA control areas were then monitored for violations of loading or bus voltage criteria. Contingencies which resulted in facility loadings or bus voltages outside of acceptable limits will be discussed in the summary of each case. The Phase 1 ACCC analysis is performed to assess the performance of the transmission system following the addition of the wind generation interconnection projects according to TPL-001 and TPL-002 standards.

Phase 1 analysis further addressed contingencies flagged in the screened ACCC run with additional AC powerflow analysis as required. In the NPPD area, there are loadflow solution issues associated with voltage regulation bandwidths. Consequently, most of the capacitors and reactors are modeled as fixed mode switched shunts, which must be manually switched to achieve optimal voltage profiles.

Powerflow activities VCHK and RATE were used to identify voltage and loading issues in the NPPD, OPPD, LES, WAPA, and MEC control areas for the full AC solution contingency runs. Activity VCHK produced a listing of those buses whose voltage magnitude was greater than 1.10 PU, followed by a listing of buses whose voltage was less than 0.90 PU. Activity RATE reported any branch whose current loading, including line charging and line connected shunt components, exceeded the specified percentage of RATE A.

<u>Phase 1 – 2011 Spring Peak</u>

System Intact Results (TPL-001):

There were no transmission facility overloads or bus voltages outside of limits under system intact or base case conditions for the 2011 Spring model.

N-1 Contingency Results (TPL-002):

Three overloaded transmission facilities were discovered in the monitored study areas in the N-1 ACCC analysis of the 2011 Spring Peak case with the wind facility additions and reported in the table. The post-contingency facility overloads that were discovered are summarized in Table 1 below.

Table 1. 2011 Spring Peak: N-1 Facility Overloads

From Bus	From Bus Name	To Bus	To Bus Name	CKT	CONTINGENCY	RATING	%
640287	N.PLATT7 115.00	640365	STOCKVL7 115.00	1	SINGLE 346	137	106.4
659105	LELANDO3 345.00	659201	LELND1TY 345.00	1	SINGLE 871	250	118.7
659106	LELANDO4 230.00	659201	LELND1TY 345.00	1	SINGLE 871	250	118.7

The North Platte – Stockville 115 kV line was overloaded for loss of the GGS – Red Willow 345 kV line. This contingency / monitored element pair are the limiting elements associated with the WNE_WKS PTDF flowgate. The post-contingency loading on the North Platte – Stockville 115 kV line is less than the 30-minute short-term emergency rating of 151 MVA.

The Leland Olds 345/230 kV transformer was found to load above its 250 MVA rating for loss of the parallel 345/230 kV transformer. The post-contingency loading of this facility would need further review and coordination by the facility owner (BEPC) and the transmission planner (WAPA UGP) for this facility.

There were several bus voltage violations identified in the monitored study areas in the N-1 ACCC screening analysis. Any bus voltage violations located in the NPPD area could be mitigated with existing switched shunt devices and/or transformer tap adjustments. The remaining bus voltage violation issues are outside of the NPPD system and would need to be coordinated with external entities for further review.

<u>Phase 1 – 2017 Summer Peak</u>

System Intact Results (TPL-001):

There were no transmission facility overloads or bus voltages outside of limits under system intact or base case conditions for the 2017 Summer Peak model.

N-1 Contingency Results (TPL-002):

Four overloaded transmission facilities were discovered in the monitored study areas in the N-1 ACCC analysis of the 2017 Summer Peak case with the wind generation additions and reported in the table. None of the facility overloads were on the NPPD transmission system. The post-contingency facility overloads that were discovered are summarized in Table 2 below.

Table 2. 2017 Summer Peak: N-1 Facility Overloads

From Bus	From Bus Name	To Bus	To Bus Name	CKT	CONTINGENCY	RATING	%
652405	FTPECK 4 230.00	652406	FTPECK 7 115.00	1	SINGLE 627	67	107.2
652477	ELSWRTH7 115.00	652485	NUNDRWD7 115.00	1	SINGLE 754	80	109.2
659105	LELANDO3 345.00	659201	LELND1TY 345.00	1	SINGLE 902	250	142.2
659106	LELANDO4 230.00	659201	LELND1TY 345.00	1	SINGLE 902	250	142.2

There were four facility overloads discovered during the ACCC analysis of the 2017 Summer Peak model with the wind generation additions. The facility overloads are all located in the WAPA area and this would require further coordination with WAPA to determine if any mitigation is required of the proposed wind generation facility additions.

There were several bus voltage violations identified in the monitored study areas in the N-1 ACCC screening analysis of the 2017 Summer Peak model with the wind additions. Any bus voltage violations located in the NPPD area could be mitigated with existing switched shunt devices and/or transformer tap adjustments. The remaining bus voltage violation issues are outside of the NPPD system and would need to be coordinated with external entities for further review.

Phase 1 – 2017 Winter Peak

System Intact Results (TPL-001):

There were no transmission facility overloads or bus voltages outside of limits under system intact or base case conditions for the 2017 Winter Peak model.

N-1 Contingency Results (TPL-002):

Six overloaded transmission facilities were discovered in the monitored study areas in the N-1 ACCC analysis of the 2017 Winter Peak case with the wind generation additions and reported in the table. None of the facility overloads were on the NPPD transmission system. The post-contingency facility overloads that were discovered are summarized in Table 3 below.

Table 3. 2017 Winter Peak: N-1 Facility Overloads

From Bus	From Bus Name	To Bus	To Bus Name	CKT	CONTINGENCY	RATING	%
652405	FTPECK 4 230.00	652406	FTPECK 7 115.00	1	SINGLE 627	67	101.3
652477	ELSWRTH7 115.00	652485	NUNDRWD7 115.00	1	SINGLE 754	80	123.2
659105	LELANDO3 345.00	659201	LELND1TY 345.00	1	SINGLE 902	250	161.8
659106	LELANDO4 230.00	659201	LELND1TY 345.00	1	SINGLE 902	250	161.8
652473	ELKCRK 7 115.00	652490	RAPIDCY7 115.00	1	SINGLE 751	60	106.6
652477	ELSWRTH7 115.00	652490	RAPIDCY7 115.00	1	SINGLE 754	80	107.1

There were six additional facility overloads discovered during the ACCC analysis of the 2017 Winter Peak model with the wind generation additions. The facility overloads are located in the WAPA area and this would require further coordination with WAPA to determine if any mitigation is required of the proposed wind generation facility additions.

It should be noted that the loading on the Twin Church – Dixon County 230 kV line was flagged at 93.1% loading on the 225 MVA facility rating for loss of the Raun – Sioux City 345 kV line. This facility is limited by conductor clearances and may need addressed to accommodate the new generation interconnection.

There were several bus voltage violations identified in the monitored study areas in the N-1 ACCC screening analysis of the 2017 Winter Peak model with the wind additions. Any bus voltage violations located in the NPPD area could be mitigated with existing switched shunt devices and/or transformer tap adjustments. The remaining bus voltage violation issues are outside of the NPPD system and would need to be coordinated with external entities for further review.

Phase 1 Results Summary

Overall, there were no transmission facility overloads discovered in the Phase 1 screening that were in the immediate vicinity of the proposed generation interconnection projects. All of the transmission facility overloads were found on external systems and would need further coordination and investigation with the affected party (WAPA).

The Phase 1 screening discovered high post-contingency loadings on the Twin Church – Dixon County 230 kV line that may require mitigation. Loading on this facility will continue to be monitored in subsequent study phases to determine if further mitigation is required.

5.2 Phase 2 Results (System-wide Multiple Element Screening)

PSS/E activity ACCC was used as a screening tool on each of the base cases to identify those multiple element contingencies which deserve closer study. ACCC analyzed the system by sequentially taking select multiple element contingencies in the Nebraska area out-of-service. Transmission facilities in the NPPD, OPPD, LES, WAPA and MEC control areas were then monitored for violations of loading or bus voltage criteria. The Phase 2 ACCC analysis is performed to assess the performance of the transmission system following the addition of the wind generation interconnection projects according to TPL-003 and TPL-004 standards.

Phase 2 – 2011 Spring Peak

Category C Results (TPL-003):

There were two facility overloads discovered in the Category C ACCC analysis of the 2011 Spring Peak case with the wind generation interconnection facilities and reported in the table. The post-contingency facility overloads that were discovered are summarized in Table 5 below.

Table 5. 2011 Spring Peak: Category C Facility Overloads

From Bus	From Bus Name	To Bus	To Bus Name	CKT	CONTINGENCY	RATING	%
640183	GENTLMN3 345.00	640184	GENTLMN4 230.00	2	BKR-GGS-3304	336	104.4
640287	N.PLATT7 115.00	640365	STOCKVL7 115.00	1	TWR-GS-GRW	137	113.5

The North Platte – Stockville 115 kV line was overloaded for loss of the GGS – Red Willow 345 kV and GGS – Sweetwater 345 kV #2 double circuit. This contingency / monitored element pair are some of the limiting elements associated with the WNE_WKS PTDF flowgate. Loading on this facility would be limited in real-time operations to the TTC of the WNE_WKS flowgate. The Axtell-PostRock-Spearville 345 kV is expected to help mitigate this constraint which is scheduled for an in-service date of June 2013.

The Gentleman 345/230 kV transformer was overloaded for loss of the parallel Gentleman 345/230 kV transformer and GGS Unit #2 GSU for a stuck breaker outage. This constraint is a known limitation and the dispatch of GGS Unit #1 can be adjusted within 30 minutes to reduce the loading on this transformer to within normal limits. The overload does not exceed the 30-minute emergency rating of 420 MVA.

There were several bus voltage violations identified in the monitored study areas in the screening analysis of the 2011 Spring Peak model with the wind additions. Any bus voltage violations located in the NPPD area could be mitigated with existing switched shunt devices and/or transformer tap adjustments.

Category D Results (TPL-004):

There were eleven facility overloads discovered in the Category D ACCC analysis of the 2011 Spring Peak case with the wind generation interconnection facilities and reported in the table. The post-contingency facility overloads that were discovered are summarized in Table 6 below.

Table 6. 2011 Spring Peak: Category D Facility Overloads

From Bus	From Bus Name	To Bus	To Bus Name	CKT	CONTINGENCY	RATING	%
640103	CANADAY7 115.00	640161	ELMCRK_7 115.00	1	CSPT-GS1-GS2	80	105.6
640161	ELMCRK_7 115.00	640250	KEARNEY7 115.00	1	CSPT-GS1-GS2	80	100
652572	SIDNEY 7 115.00	659238	COLTON 7 115.00	1	CSPT-SK-SO	120	108.3
652300	CHAPPEL7 115.00	659238	COLTON 7 115.00	1	CSPT-SK-SO	120	107.3
659135	STEGALL3 345.00	659207	STEGALTY 345.00	1	CSPT-SK-SO	400	104.3
640246	JULSTAP7 115.00	652300	CHAPPEL7 115.00	1	CSPT-SK-SO	120	103.9
652573	STEGALL4 230.00	659206	STGXFMR4 230.00	1	CSPT-SK-SO	400	103.2
659206	STGXFMR4 230.00	659207	STEGALTY 345.00	1	CSPT-SK-SO	400	101.1
635001	CBLUFFS5 161.00	635030	RIVRBND5 161.00	1	INT-CF-CSJ	199	109
635030	RIVRBND5 161.00	635031	BUNGE 5 161.00	1	INT-CF-CSJ	199	106
635031	BUNGE 5 161.00	635032	HASTING5 161.00	1	INT-CF-CSJ	199	100.9

There were several facility overloads identified for the CSPT-GS1-GS2 (GGS – Sweetwater 345 kV ckt 1 and GGS – Sweetwater 345 kV ckt 2) contingency. This contingency would require generation reductions at GGS, LRS and DC tie limitations in western NE/SD.

There were several facility overloads identified for the CSPT-SK-SO (Sidney – Keystone 345 kV & Sidney – Ogallala 230 kV) contingency. This contingency would require generation reductions at LRS and DC tie limitations in western NE/SD.

There were several facility overloads identified for the INT-CF-CSJ (Cooper – Fairport 345 kV and Cooper – St. Joe 345 kV) contingency. The limiting facilities are in the MEC system and are scheduled to be upgraded in the future.

There were several bus voltage violations identified in the monitored study areas in the screening analysis of the 2011 Spring Peak model with the wind additions. Any bus voltage violations located in the NPPD area could be mitigated with system re-adjustments.

Phase 2 – 2017 Summer Peak

Category C Results (TPL-003):

There were three facility overloads discovered in the Category C ACCC analysis of the 2017 Summer Peak case with the wind generation interconnection facilities are reported in the table. The post-contingency facility overloads that were discovered are summarized in Table 7 below.

Table 7. 2017 Summer Peak: Category C Facility Overloads

From Bus	From Bus Name	To Bus	To Bus Name	CKT	CONTINGENCY	RATING	%
640173	FREMONT7 115.00	647976	S976 8 69.000	4	CBFREM-A	56	106.9
640171	FIRTH 7 115.00	640278	SHELDON7 115.00	1	CB1263-BUS	76	101.4
640362	STERLNG7 115.00	647974	S974 8 69.000	1	CB1263-BUS	56	101.3

There were several bus voltage violations identified in the monitored study areas in the screening analysis of the 2017 Summer Peak model with the wind additions. Any bus voltage violations located in the NPPD area could be mitigated with system re-adjustments.

Category D Results (TPL-004):

There were three facility overloads discovered in the Category D ACCC analysis of the 2017 Summer Peak case with the wind generation interconnection facilities and reported in the table. The post-contingency facility overloads that were discovered are summarized in Table 8 below.

Table 8. 2017 Summer Peak: Category D Facility Overloads

From Bus	From Bus Name	To Bus	To Bus Name	CKT	CONTINGENCY	RATING	%
640171	FIRTH 7 115.00	640278	SHELDON7 115.00	1	OPPD_CIP20	76	102.8
646201	S1201 5 161.00	646206	S1206 5 161.00	1	OPPD_CIP21	221	101.8
646201	S1201 5 161.00	646206	S1206 5 161.00	1	OPPD_CIP21	221	101.8

There were several bus voltage violations identified in the monitored study areas in the screening analysis of the 2017 Summer Peak model with the wind additions. Any bus voltage violations located in the NPPD area could be mitigated with system re-adjustments.

Phase 2 – 2017 Winter Peak

Category C Results (TPL-003):

There was one facility overload discovered in the Category C ACCC analysis of the 2016 Winter Peak case with the wind generation interconnection facilities and reported in the table. The post-contingency facility overload that was discovered is summarized in Table 9 below.

Table 9. 2017 Winter Peak: Category C Facility Overloads

From Bus	From Bus Name	To Bus	To Bus Name	CKT	CONTINGENCY	RATING	%
640171	FIRTH 7 115.00	640278	SHELDON7 115.00	1	CB1263-BUS	76	104.7

There were several bus voltage violations identified in the monitored study areas in the screening analysis of the 2017 Winter Peak model with the wind additions. Any bus voltage violations located in the NPPD area could be mitigated with system re-adjustments.

Category D Results (TPL-004):

There were four facility overloads discovered in the Category D ACCC analysis of the 2017 Winter Peak case with the wind generation interconnection facilities and reported in the table. The post-contingency facility overloads that were discovered are summarized in Table 10 below.

Table 10. 2017 Winter Peak: Category D Facility Overloads

From Bus	From Bus Name	To Bus	To Bus Name	CKT	CONTINGENCY	RATING	%
640103	CANADAY7 115.00	640161	ELMCRK_7 115.00	1	CSPT-GS1-GS2	80	108.9
640093	C.CREEK4 230.00	640286	N.PLATT4 230.00	1	CSPT-GS1-GS2	402	103.6
640238	JEFFREY7 115.00	640287	N.PLATT7 115.00	1	CSPT-GS1-GS2	160	104.3
640103	CANADAY7 115.00	640161	ELMCRK_7 115.00	1	CSPT-SA-CCR	80	100.9

There were several bus voltage violations identified in the monitored study areas in the screening analysis of the 2017 Winter Peak model with the wind additions. Any bus voltage violations located in the NPPD area could be mitigated with system re-adjustments.

Phase 2 Results Summary

Overall, there were several transmission facility overloads discovered in the Phase 2 screening for NERC category C and D contingencies. The North Platte – Stockville 115 kV facility overload for loss of the GGS – Red Willow 345 kV and GGS – Sweetwater 345 kV ckt 2 double circuit was the only overload discovered above 110% of the facility rating.

5.3 Phase 3 Results (Local Area Full Accredited Generation Capacity N-1 & N-2 Contingency Analysis)

5.3.1 Phase 3 – N-1 Contingency Screening Analysis Results

PSS/E activity ACCC was used as a screening tool on the maximum generation powerflow model to identify those contingencies which deserve closer study. It should be noted that the powerflow models utilized in this phase of the loadflow study represent extreme worst-case generation outlet conditions. The powerflow models represent a highly unlikely maximum simultaneous generation dispatch scenario of generation facilities in the area. In order to evaluate the new generation interconnection requests, separate clusters were dispatched to evaluate worst-case generation outlet conditions for each new request. North-east NE and south-east NE clusters were established to evaluate the new requests. ACCC was utilized to analyze the system by sequentially taking contingencies in the NPPD, LES, OPPD, WAPA, and MEC areas out-of-service and monitoring facilities in the NPPD, LES, OPPD, WAPA and MEC areas for violations of loading or bus voltage criteria.

Phase 3 – 2011 Spring Peak – North East Cluster (N-1)

System Intact Results (TPL-001):

There were no transmission facility overloads or bus voltages outside of limits under system intact or base case conditions for the 2011 Spring model with maximum north east cluster generation.

N-1 Contingency Results (TPL-002):

Five overloaded transmission facilities were discovered in the monitored study areas in the N-1 ACCC analysis of the 2010 Spring Peak North East Cluster Maximum Generation case with the wind facility additions. The post-contingency facility overloads that were discovered are summarized in Table 13 below.

Table 13. 2011 Spring Peak (north east cluster max gen): N-1 Facility Overloads

From Bus	From Bus Name	To Bus	To Bus Name	CKT	CONTINGENCY	RATING	%
640287	N.PLATT7 115.00	640365	STOCKVL7 115.00	1	SINGLE 346	137	114.3
635201	RAUN 5 161.00	635203	NEAL N 5 161.00	2	SINGLE 48	335	103.6
635201	RAUN 5 161.00	635203	NEAL N 5 161.00	1	SINGLE 49	335	103.6
659105	LELANDO3 345.00	659201	LELND1TY 345.00	1	SINGLE 871	250	114.8
659106	LELANDO4 230.00	659201	LELND1TY 345.00	1	SINGLE 871	250	114.8

The North Platte – Stockville 115 kV line was overloaded for loss of the GGS – Red Willow 345 kV line. This contingency / monitored element pair are the limiting elements associated with the WNE_WKS PTDF flowgate. The post-contingency loading on the North Platte – Stockville 115 kV line is less than the 30-minute short-term emergency rating of 151 MVA.

The Raun – Neal North 161 kV circuits 1 & 2 were found to load above the 335 MVA rating for loss of either parallel 161 kV circuit. The post-contingency loading of this facility would need further review and coordination by the transmission planner (MEC) for this facility.

The Leland Olds 345/230 kV transformer was found to load above its 250 MVA rating for loss of the parallel 345/230 kV transformer. The post-contingency loading of this facility would need further review and coordination by the transmission planner (WAPA UGP) for this facility.

There were several bus voltage violations identified in the monitored study areas in the N-1 ACCC screening analysis. Any bus voltage violations located in the NPPD area could be mitigated with existing switched shunt devices and/or transformer tap adjustments. The remaining bus voltage violation issues are outside of the NPPD system and would need to be coordinated with external entities for further review.

<u>Phase 3 – 2011 Spring Peak – South East Cluster (N-1)</u>

System Intact Results (TPL-001):

There were no transmission facility overloads or bus voltages outside of limits under system intact or base case conditions for the 2011 Spring Peak – South East Cluster Maximum Generation model.

N-1 Contingency Results (TPL-002):

Eight overloaded transmission facilities were discovered in the monitored study areas in the N-1 ACCC analysis of the 2010 Spring Peak South Central Cluster Maximum Generation case with the wind facility additions. The full ACCC results are summarized in Appendix C. The post-contingency facility overloads that were discovered are summarized in Table 14 below.

Table 14. 2011 Spring Peak (south east cluster max gen): N-1 Facility Overloads

From Bus	From Bus Name	To Bus	To Bus Name	CKT	CONTINGENCY	RATING	%
560347	G10-51T 230.00	640386	TWIN CH4 230.00	1	SINGLE 44	225	103.3
560347	G10-51T 230.00	640386	TWIN CH4 230.00	1	SINGLE 46	225	105.2
640287	N.PLATT7 115.00	640365	STOCKVL7 115.00	1	SINGLE 346	137	113.4
659105	LELANDO3 345.00	659201	LELND1TY 345.00	1	SINGLE 872	250	112.4
659105	LELANDO3 345.00	659201	LELND1TY 345.00	1	SINGLE 876	250	112.4

The Dixon County (G10-51T) – Twin Church 230 kV line was found to overload above the 225 MVA rating for loss of the Raun – Hoskins 345 kV and Raun – Sioux City 345 kV lines. The facility rating on this line is limited by conductor clearances and would need mitigated to accommodate interconnection of the proposed wind projects.

The North Platte – Stockville 115 kV line was overloaded for loss of the GGS – Red Willow 345 kV. This contingency / monitored element pair are the limiting elements associated with the WNE_WKS PTDF flowgate. Loading on this facility would be limited in real-time operations to the TTC of the WNE_WKS flowgate. The Axtell-PostRock-Spearville 345 kV is expected to help mitigate this constraint which is scheduled for an in-service date of June 2013.

The Leland Olds 345/230 kV transformer was found to load above its 250 MVA rating for loss of the parallel 345/230 kV transformer. The post-contingency loading of this facility would need further review and coordination by the facility owner (BEPC) and the transmission planner (WAPA UGP) for this facility.

There were several bus voltage violations identified in the monitored study areas in the N-1 ACCC screening analysis. Any bus voltage violations located in the NPPD area could be mitigated with existing switched shunt devices and/or transformer tap adjustments. The remaining bus voltage violation issues are outside of the NPPD system and would need to be coordinated with external entities for further review.

5.3.2 Phase 3 – Multiple Element Contingency Analysis Results

This phase of the analysis evaluated all worst-case stuck breaker and double circuit contingencies in the local areas with the wind facility additions. PSS/E activity ACCC was used as a screening tool on each of the maximum generation base cases with the additions to identify those contingencies which deserve closer study. ACCC analyzed the system by sequentially taking stuck breaker and double circuit contingencies in the areas near the wind generation additions and monitoring facilities in the NPPD, OPPD, LES, MEC, and WAPA areas for violations of loading or bus voltage criteria.

The stuck breaker and double circuit contingencies that were evaluated in this analysis are listed below.

North East Cluster
Stuck PCB at Hoskins 230 kV
Stuck PCB 3302 at Hoskins 345 kV
Stuck PCB 3308 at Hoskins 345 kV
Stuck PCB 3310 at Hoskins 345 kV
Stuck PCB 3312 at Hoskins 345 kV
Stuck PCB at Hoskins 115 kV north bus
Stuck PCB at Hoskins 115 kV south bus
Stuck PCB at Twin Church 230 kV north bus
Stuck PCB at Twin Church 230 kV south bus
Stuck PCB at Twin Church 115 kV
Stuck PCB at Twin Church 115 kV

South East Cluster
Stuck PCB at Hastings NPPD 115 kV
Stuck PCB at Hastings City 115 kV
Stuck PCB at Bypass 115 kV
Stuck PCB at Geneva 115 kV
Stuck PCB at Pauline 115 kV
Stuck PCB at Pauline 345 kV
Stuck PCB at North Hastings 115 kV
Stuck PCB at Grand Island 230 kV (GI-Hastings 230 kV & GI-Riverdale 230 kV)
Stuck PCB at Grand Island 230 kV (GI-Hastings 230 kV & GI 230/115 kV T5)
Stuck PCB at Hebron 115 kV
Double Circuit: Axtell–Pauline 345 kV & Hast.NPPD–Pauline 115 kV ckt 1
Double Circuit: Hast.NPPD–Pauline 115kV ckt 2 & Pauline–Rosemont 115kV
Double Circuit: Pauline–Moore 345kV & Pauline–Rosemont 115kV
Stuck PCB at Beatrice 115 kV east bus
Stuck PCB at Beatrice 115 kV west bus
Stuck PCB at Beatrice Power Station 115 kV
Stuck PCB at Beatrice Power Station 115 kV
Stuck PCB at Beatrice Power Station 115 kV
Double Circuit: Beatrice-BeatriceSouth 115 kV & Beatrice-Gage County 115 kV

Phase 3 – 2011 Spring Peak – North East Cluster (Stuck PCB / Double Circuit)

There were no transmission facility overloads or bus voltages outside of limits for the studied stuck PCB or double circuit contingency conditions for the 2011 Spring Peak – North East Cluster Maximum Generation model.

Phase 3 – 2011 Spring Peak – South East Cluster (Stuck PCB / Double Circuit)

There were no transmission facility overloads or bus voltages outside of limits for the multiple element contingencies evaluated using the 2011 Spring Peak – South Central Cluster Maximum Generation model.

5.3.3 Phase 3 – Independent N-2 Contingency Analysis Results

This phase of the analysis evaluated select set of independent N-2 contingencies in the areas with the wind facility additions. PSS/E activity ACCC was used as a screening tool on the 2011 Spring Peak Maximum Generation powerflow models with the wind facility additions to identify those contingencies which deserve closer study. ACCC analyzed the system by sequentially taking out all independent N-2 contingencies in the cluster areas and monitoring facilities in the NPPD, OPPD, LES, WAPA, and MEC areas for violations of loading or bus voltage criteria. A total of 595 independent N-2 contingencies were evaluated in the analysis of the north east cluster and 861 independent N-2 contingencies in the analysis of the south east cluster.

Phase 3 – 2010 Spring Peak – North Central Cluster (Independent N-2)

There were a number of overloaded transmission facilities discovered in the monitored study areas in the independent N-2 ACCC analysis of the 2011 Spring Peak North East Cluster case with the wind facility additions. The worst-case facility overloads identified in the ACCC analysis are summarized in Table 15 below. It should be noted that the Dixon County – Twin Church 230 kV line rating was assumed to be upgraded to 320 MVA following the line clearance corrections required in the N-1 contingency screening. Prior outage generation restrictions would be required to ensure the transmission system is able to be operated reliably when certain transmission lines are taken out-of-service. The wind project curtailments will be subject to “first on, last off” curtailment priorities and operating guides will need to be developed to ensure the transmission system is operated in accordance with mandatory reliability standards. Based on a review of the N-2 contingencies that were flagged in the ACCC analysis, the following list was prepared of transmission facilities that would need detailed prior outage review or operating guides established. These transmission facilities were found to be part of an N-2 contingency pairing that resulted in a facility overload on the NPPD transmission system.

Limiting Prior Outage Facilities
1. Hoskins – Madison County 230 kV
2. Kelly – Madison County 230 kV
3. Twin Church – Dixon County 230 kV
4. Hoskins 345/230 kV Transformer

Table 15. 2011 Spring Peak (north east max gen): Independent N-2 Facility Overloads

From Bus	From Bus Name	To Bus	To Bus Name	CKT	CONTINGENCY	RATING	%
640227	HOSKINS4 230.00	640228	HOSKINS7 115.00	1	DOUBLE 41	187	109.9
640227	HOSKINS4 230.00	640228	HOSKINS7 115.00	1	DOUBLE 191	187	100.1
643000	MADISONCNTY4230.00	652509	FTRANDL4 230.00	1	DOUBLE 196	320	122.2

There were several bus voltage violations identified in the monitored study areas in the N-2 ACCC screening analysis. Any bus voltage violations located in the NPPD area could be mitigated with existing switched shunt devices and/or transformer tap adjustments. The remaining bus voltage violation issues are outside of the NPPD system and would need to be coordinated with external entities for further review.

Phase 3 – 2011 Spring Peak – South East Cluster (Independent N-2)

There were a number of overloaded transmission facilities discovered in the monitored study areas in the independent N-2 ACCC analysis of the 2011 Spring Peak South East Cluster case with the wind facility addition. The worst-case facility overloads identified in the ACCC analysis are summarized in Table 16 below. Prior outage generation restrictions would be required to ensure the transmission system is able to be operated reliably when certain transmission lines are taken out-of-service. The wind project curtailments will be subject to “first on, last off” curtailment priorities and operating guides will need to be developed to ensure the transmission system is operated in accordance with mandatory reliability standards. Based on a review of the N-2 contingencies that were flagged in the ACCC analysis, the following list was prepared of transmission facilities that would need detailed prior outage review or operating guides established. These transmission facilities were found to be part of an N-2 contingency pairing that resulted in a facility overload on the NPPD transmission system.

Limiting Prior Outage Facilities

1. Pauline – Rosemont 115 kV
2. North Hebron – Carleton Junction 115 kV
3. Gage County – Harbine 115 kV
4. BPS – Sheldon 115 kV
5. Harbine – Steele City 115 kV
6. Beatrice – Steinauer 115 kV
7. Steinauer – Humboldt 115 kV
8. Humboldt 161/115 kV Transformer
9. Moore 345/115 kV Transformer
10. Sheldon – 2nd & N (Folsom & Pleasant Hill) 115 kV
11. Sheldon – 20th & Pioneers (Folsom & Pleasant Hill) 115 kV

Table 16. 2010 Spring Peak (south east max gen): Independent N-2 Facility Overloads

From Bus	From Bus Name	To Bus	To Bus Name	CKT	CONTINGENCY	RATING	%
640088	BPS SUB7 115.00	640111	CLATONA7 115.00	1	DOUBLE 302	137	105.4
640111	CLATONA7 115.00	640278	SHELDON7 115.00	1	DOUBLE 302	137	101.2
640088	BPS SUB7 115.00	640111	CLATONA7 115.00	1	DOUBLE 374	137	105.6
640111	CLATONA7 115.00	640278	SHELDON7 115.00	1	DOUBLE 374	137	101.4
640088	BPS SUB7 115.00	640111	CLATONA7 115.00	1	DOUBLE 383	137	102.6
640088	BPS SUB7 115.00	640111	CLATONA7 115.00	1	DOUBLE 384	137	105
640111	CLATONA7 115.00	640278	SHELDON7 115.00	1	DOUBLE 384	137	100.8
640169	FAIRBRY7 115.00	640208	HARBINE7 115.00	1	DOUBLE 422	99	106.6
640088	BPS SUB7 115.00	640111	CLATONA7 115.00	1	DOUBLE 50	137	120.5
640111	CLATONA7 115.00	640278	SHELDON7 115.00	1	DOUBLE 50	137	116.3
640278	SHELDON7 115.00	650238	20PIONEERS7 115.00	1	DOUBLE 808	240	101
640278	SHELDON7 115.00	650230	2&N 7 115.00	1	DOUBLE 809	240	101.5

There were several bus voltage violations identified in the monitored study areas in the N-2 ACCC screening analysis. Any bus voltage violations located in the NPPD area could be mitigated with existing switched shunt devices and/or transformer tap adjustments. The remaining bus voltage violation issues are outside of the NPPD system and would need to be coordinated with external entities for further review.

5.4 Phase 4 Results (System-wide N-1 Screening w/ transfer conditions)

The Phase 4 ACCC analysis is performed to assess the performance of the transmission system under stressed heavy transfer conditions following the addition of the wind generation interconnection projects according to TPL-001 and TPL-002 standards. This phase utilized the 2011 Spring Peak case as the base system topology. The proposed wind generation interconnection projects (272 MW total) and associated transmission upgrades were added to the case. The new wind generation was exported off-system to other modeling areas in SPP on a pro rata basis. Generation in western Nebraska and Iowa were then increased to stress the existing north-south flowgates (WNE_WKS & COOPER_S) in Nebraska to existing transfer limits. PSS/E activity ACCC was then used as a screening tool on the base case to identify those contingencies which deserve closer study. ACCC analyzed the system by sequentially taking each transmission element greater than 100kV in the NPPD, OPPD, LES, MEC, and WAPA control areas out of service. Transmission facilities in the NPPD, OPPD, LES, MEC, and WAPA control areas were then monitored for violations of loading or bus voltage criteria. Contingencies which resulted in facility loadings or bus voltages outside of acceptable limits will be discussed in the summary of each case.

System Intact Results (TPL-001):

There were no transmission facility overloads or bus voltages outside of limits under system intact or base case conditions for the 2011 Spring Peak case with transfers.

N-1 Contingency Results (TPL-002):

Twelve overloaded transmission facilities were discovered in the monitored study areas in the N-1 ACCC analysis of the 2011 Spring Peak case with transfers and the wind facility additions and reported in the table. The post-contingency facility overloads that were discovered are summarized in Table 17 below.

Table 17. 2011 Spring Peak (w/ transfers): N-1 Facility Overloads

From Bus	From Bus Name	To Bus	To Bus Name	CKT	CONTINGENCY	RATING	%
541199	ST JOE 3 345.00	640139	COOPER 3 345.00	1	LN-FAIRPORT	1073	108.7
635001	CBLUFFS5 161.00	635030	RIVRBND5 161.00	1	LN-FAIRPORT	199	106.7
635030	RIVRBND5 161.00	635031	BUNGE 5 161.00	1	LN-FAIRPORT	199	103.7
541199	ST JOE 3 345.00	640139	COOPER 3 345.00	1	SINGLE 2	1073	110.6
635001	CBLUFFS5 161.00	635030	RIVRBND5 161.00	1	SINGLE 2	199	102.9
635001	CBLUFFS5 161.00	635030	RIVRBND5 161.00	1	SINGLE 312	199	102.9
635030	RIVRBND5 161.00	635031	BUNGE 5 161.00	1	SINGLE 312	199	100
640287	N.PLATT7 115.00	640365	STOCKVL7 115.00	1	SINGLE 344	137	113.2
635201	RAUN 5 161.00	635203	NEAL N 5 161.00	2	SINGLE 47	335	106.6
635201	RAUN 5 161.00	635203	NEAL N 5 161.00	1	SINGLE 48	335	106.6
635001	CBLUFFS5 161.00	635030	RIVRBND5 161.00	1	SINGLE 5	199	107.8
635030	RIVRBND5 161.00	635031	BUNGE 5 161.00	1	SINGLE 5	199	104.8

The North Platte – Stockville 115 kV line was overloaded for loss of the GGS – Red Willow 345 kV line. This contingency / monitored element pair are the limiting elements associated with the WNE_WKS PTDF flowgate. The post-contingency loading on the North Platte – Stockville 115 kV line is above 110% of the facility rating. The Axtell – Post Rock – Spearville 345 kV line will help mitigate congestion associated with the WNE_WKS PTDF flowgate. The Axtell – Post Rock – Spearville 345 kV line is scheduled to be in-service by June 2013.

The Cooper – St. Joe 345 kV line was overloaded above the 1073 MVA rating for loss of the Cooper – Fairport – St. Joe 345 kV line. The Council Bluffs – Riverbend 161 kV line was also overloaded above the 199 MVA rating for this contingency. The Council Bluffs – Riverbend 161 kV line is scheduled to be upgraded to a higher facility rating in the near future.

The Raun – Neal North 161 kV circuits 1 & 2 were found to load above the 335 MVA rating for loss of either parallel 161 kV circuit. The post-contingency loading of this facility would need further review and coordination by the transmission planner (MEC) for this facility.

There were several bus voltage violations identified in the monitored study areas in the screening analysis of the 2010 Spring Peak model with transfers. Any bus voltage violations located in the NPPD area could be mitigated with system re-adjustments. Bus voltage violations outside of the NPPD system would need to be coordinated with external entities for further review.

Phase 4 Results Summary

Overall, there were several transmission facility overloads discovered in the Phase 4 screening that were associated with north-south transfer limitations in western and eastern Nebraska. It should also be noted that the additional wind generation interconnections in Nebraska continue to have an adverse impact on these north-south flowgates and transmission limitations. Increased generation on the north end of these constraints will continue to increase congestion and number of hours in curtailment. The Axtell – Post Rock – Spearville 345 kV line will help mitigate the issues associated with the WNE_WKS flowgate, but additional studies are required to determine the relief this project will provide. Additional points of congestion were noted on several 161 kV paths in Iowa and Kansas as well as on the Cooper-St.Joe 345 kV line.

6.0 Short Circuit Analysis

6.1 Model Development

Computer Programs

The Aspen One-liner software program (V11.7 October 29, 2010) was utilized to perform short circuit simulations and studies on the transmission system. The data files (transmission lines/transformer/generator constants) for the Aspen Oneliner program are updated by NPPD numerous times per year as transmission system changes and additions occur across Nebraska. The short circuit data information (system equivalent impedances) for transmission system interconnections to non-Nebraska utilities was updated in 2005. The Aspen One-liner software program calculates the symmetrical (alternating current component) short circuit currents in physical amps or per unit values. If asymmetrical currents (alternating current component plus direct current component) are required, these values have to be separately calculated and based on the X/R ratio at the fault location and the protective device operating time.

Due to the numerous short circuit models being performed for future conditions, the Aspen Oneliner software is configured to calculate short circuit magnitudes based on all generator source voltages being at 1.0 per unit (Flat conditions). The Aspen Oneliner short circuit program has the ability to solve a load flow (generator voltages not set at 1.0 per unit) prior to performing short circuit calculations; however this option will not be utilized due to the time requirements to convert data from the load flow software (PSS/E) to Aspen Oneliner. The program is configured to utilize the generator sub transient impedance (X”d) for short circuit calculations. This is standard for conducting short circuit studies on the transmission system. When conducting short circuit studies for buses where generators are directly connected, the generator transient impedance (X’d) is typically utilized.

The Aspen Oneliner short circuit program does not have a specific induction generator module to model the wind generation transient short circuit current contributions for short circuits on the transmission system. Turbine, distribution transformer, and step up transformer data have not been provided by the developers to date. To model the induction generator short circuit contributions, equivalent synchronous generator constants for the Bloomfield 80MW wind farm and the White Horse 40MW wind farm were used. An equivalent synchronous generator was used in the modeling of future wind farms. Equivalent transformers to those installed at Bloomfield (80MW wind farm) will be used to simulate symmetrical fault contributions from these various new wind farm additions unless specific transformer information is currently available.

Base System Model Additions

The 2010 base short circuit data file was updated with several additions to create a model for the DISIS-2010-002 short circuit study. These additions included the additions used in the revised DISIS-2009-001 (April 2010) short circuit study, the additions used in the revised DISIS-2010-001 (May 2010) short circuit study, planned work (NPPD and other) through 2012 that may have an effect on interrupting capabilities of equipment near the proposed wind farm locations, and the additions requested for the DISIS-2010-002 study. Below is the list of additions included in this short circuit study.

1. *DISIS-2009-001 additions (revised April 2010)*

   a. The addition of a 115/34.5 kV 30/50/56 MVA transformer at the Bloomfield 115 kV Substation with 40MW of Vestas V90 wind generation modeled as synchronous generators with 3.16MVA turbine step up transformers. The VAR control system details are estimated based on the Ainsworth wind farm design. The grounding transformer details are estimated based on the Elkhorn Ridge wind farm. This is the future Crofton Hills Wind Farm. This wind farm is modeled the same as the 2009 study.

   b. The addition of a 115/34.5 kV 57/76/95 MVA transformer ~ 9 miles from the Broken Bow 115kV Substation (impedances modeled after Elkhorn Ridge Main GSU) with 80MW of GE wind generation modeled as (lumped equivalent impedance of Elkhorn Ridge collector system). This is connected to the Broken Bow 115kV bus by 8.75 miles of H Frame, 477 ACSR with 7/16 EHS neutral.

   c. The addition of a 115/34.5kV Wye/Delta/Wye 27/36/45 MVA transformer at Petersburg 115kV Substation with 27 GE 1.5MW turbines (40.5MW total). This is the future White Horse Wind Farm (GEN-2006-044N). This wind farm is modeled with the information supplied by the owner.

   d. The addition of a 115/34.5 kV 57/76/95 MVA transformer at Broken Bow 115kV Substation (impedances modeled after Elkhorn Ridge Main GSU) with 75MW of GE wind generation modeled as synchronous generators (lumped equivalent impedance of Elkhorn Ridge collector system less two turbines). This is the GEN-2006-037N1 Wind Farm. This wind farm is modeled the same as the 2009 study.

   e. The addition of a new 230kV substation on the Kelly – Ft. Randall existing line (L-2301). This was modeled at 41.62 miles from Kelly, 86.23 miles from Ft. Randall.

f. The addition of a 230/34.5kV 140/233MVA 9.5% impedance transformer at the new 230kV substation on the Kelly – Ft. Randall line with 200MW of GE wind generation modeled as synchronous generators (lumped equivalent impedance of Elkorn Ridge collector system scaled by 250%). This is the GEN-2008-086N02 Wind Farm. This wind farm is modeled the same as the 2009 study.

g. The addition of a 115/34.5kV 15/28MVA transformer at Spalding 115kV Substation. The scheduled in-service for this transformer is June 2012. This transformer is model the same as the 2009 study.

h. The addition of 136 miles of 345kV line from Axtell 345kV substation to Post Rock 345kV substation in Kansas.

2. *DISIS-2010-001 additions (revised May 2011)*

a. The addition of a 230/34.5 kV 70/92/115 MVA transformer at the Madison County 230 kV Substation (impedances modeled after Columbus West 230/34.5 kV 30/56 MVA scaled to a 70 MVA base) with 100.8MW of GE xle wind generation modeled as synchronous generators (lumped equivalent impedance of Elkhorn Ridge generation scaled by 126%) This is the future GEN-2006-044N02.

b. The addition of a 230/34.5 kV 72/96/120 MVA transformer at the Madison County 230 kV substation (impedances modeled after Columbus West 230/34.5 kV 30/56 MVA scaled to a 72 MVA base) with 100.5 MW of wind generation modeled as synchronous generators (lumped equivalent impedance of Elkhorn Ridge generation scaled by 126%). This is the future GEN-2010-010.

c. The addition of ~ 30 miles of 230 kV line connecting the Madison County and Hoskins 230 kV substations. This line was modeled as H frame, T2-477 ACSR, with 7/16 EHS neutral.

d. The addition of a Rosemont 115 kV substation located on the Pauline to Guide Rock 115 kV line. This substation is located 8.25 miles from Pauline and 12.74 miles from Guide Rock.

e. The addition of a 115/34.5 kV 61/80/100 MVA transformer at new Rosemont 115 kV substation (impedances modeled after Elkhorn Ridge Main GSU scaled to 8.5% at 61 MVA) with 89.7 MW of wind generation modeled as synchronous generators (lumped equivalent impedance of Elkhorn Ridge generation scaled by 112%). This is the future GEN-2008-123N.

3. *Planned Work additions*

a. The rebuild of 115kV transmission line L1159A (Energy Control Center – Hastings). This line is scheduled to be rebuilt in 2011 with 954 ACSR & 3/8 EHS.

b. New 115kV transmission line L1369 (St. Libory – GI Sub F) is scheduled to go in-service in 2012.

c. The rebuild of 115 kV transmission line L1063A (GI Sub F – GI Sub C). This line is scheduled to be rebuilt in 2012.

d. New South Sioux City substation and new 115kV transmission lines L1297 and L1298 (Twin Church – South Sioux City). Scheduled to go in-service late 2011 or early 2012.

4. *DISIS-2010-002 additions*

a. The addition of a new Dixon County 230 kV substation located on the Hoskins to Twin Church 230 kV line (Line 2308). This substation is modeled at 33.43 miles from Hoskins and 21.92 miles from Twin Church.

b. The addition of a 230/34.5kV 138/230MVA transformer at the new 230kV substation on the Hoskins – Twin Church line (impedances modeled after Columbus West 230/34.5 kV 30/56 MVA scaled to a 138 MVA base) with 200MW of wind generation modeled as synchronous generators (lumped equivalent impedance of White Horse collector system scaled by 500%). This is the GEN-2010-051 Wind Farm.

c. The addition of a new Gage County 115 kV substation located on the Harbine to Beatrice 115 kV line (Line 1175C). This substation is modeled at 5.00 miles from Harbine and 9.08 miles from Beatrice.

d. The addition of a 115/34.5kV 48/64/80MVA 9% impedance transformer at the new 115kV substation on the Harbine – Beatrice line with 72MW wind generation modeled as synchronous generators (lumped equivalent impedance of White Horse collector system scaled by 180%). This is the GEN-2010-047 Wind Farm.

The Aspen One-liner data file for this configuration is “NPPD 2010 Dec 6 DISIS 2010-002.olr”. Other system additions necessary for the transmission of power due to the addition of these wind farms may be identified and have not been included in this short circuit study.

6.2 Study Methodology

The interrupting rating of protective devices (breakers, circuit switchers, fuses, etc) is being reviewed at selected buses where the additional wind facilities and lines may have a significant affect on the available short circuit currents. The Aspen One-liner software program is being utilized to determine the maximum short circuit current magnitudes.

This short circuit study will evaluate the adequacy of the individual protective device interrupting ratings for NPPD transmission and tap substations adjacent to the new wind facilities and lines and corresponding remote buses.

For single breaker/single bus configurations, the maximum bus short circuit current (three phase fault or single line to ground fault) will be utilized to evaluate whether the existing protective device interrupting rating is adequate. If the breaker is over 75% of the interrupting rating, a more detail fault study will be performed to individually review the specific fault current through the breaker/fuse in question.

An equivalent symmetrical rating will be calculated for Oil Circuit breakers manufactured prior to 1971 that have only an asymmetrical interrupting rating. For asymmetrical rated breakers, the interrupting rating is based on the number of faults the breaker is subjected to over a 15 minute period. Reference C37.07-1969 for the derating factors used on breakers with an asymmetrical rating in the interrupting study.

The breaker interrupting ratings will be evaluated for future system configuration with all known future changes through 2012 in-service, the revised DISIS-2009-001 study additions, the revised DISIS-2010-001 study additons, and the DISIS-2010-002 study estimations for the studied wind farms for comparison.

The accuracy of the short circuit study for future conditions will have a possible error factor due to utilizing estimated line constants/lengths as well as estimated transformer/generator impedance values. Utilizing flat case short circuit study without solving a load flow case with the generators voltages at 1.0 per unit also introduces an additional error factor. To accommodate for these errors all protective devices within 90% of their interrupting rating will be identified. It is recommended that all breakers/fuses within 95% of the nameplate interrupting rating be replaced unless otherwise noted.

6.3 Results

The interrupting rating for approximately 150 protective devices were reviewed in eleven (11) substations which NPPD owns protective devices in. The Aspen One-liner short circuit software was utilized to determine the maximum short circuit currents for the future case without the studied wind farms and lines, and with the studied wind farms and lines. For a complete list of future additions that were put in-service for analysis, see 6.1 “Base System Model Additions”. Table 18 lists all devices that were found to be above 95% of their interrupting rating, and the effective change in duty due to the wind farms being added to the system.

Table 18. Facilities above 95% of rating in DISIS-2010-002

Substation	Device Number	Circuit	% of Rating	Δ
Beatrice	329-D*	34.5kV West Bus PT fuse	138%	1%
Hoskins	339-D	Furnace Bus PT fuse	100%	1%
Twin Church	1127-D2	Transformer 3 Primary fuse	114%	4%

* Beatrice 329-D fuse may have already been replaced, waiting on field verification to comfirm placement.

For more details on the specific breakers that were reviewed, please refer to Section 6.5.

6.4 Conclusions

The Short Circuit Analysis found three interrupting devices where the available short circuit current will be above or near the interrupting rating as listed in Table 18. The replacement of the three interrupting devices should not be charged to the transmission system changes required to serve the new wind farms to be constructed since these devices are currently above the 95% suggested replacement level. There are also additional protection related issues that need further consideration:

1. The relay/communication scheme from the new Gage County sub to Harbine and Beatrice will need to be changed due to the addition of the Gage County substation and wind generation. DTT capability will be installed and associated communication paths (fiber) will be required.

2. The relay/communication scheme from the new Dixon County sub to Hoskins and Twin Church will need to be modified due to the addition of the Dixon County substation and wind generation.

6.5 Detailed Short Circuit Analysis Results

SPP Wind Farm Analysis

Models: SPP Wind Farm \ NPPD 2010 Dec 6 DISIS-2010-002.olr

This document evaluates the regional area interupting device ratings due to:
-New 230kV Dixon County substation on Hoskins - Twin Church line
-New 200 MW wind farm at new Dixon County 230kV substation - GEN-2010-051
-New 115kV Gage County substation on the Harbine - Beatrice line
-New 72 MW wind farm at new Gage County substation

Planning area will need to provide updated load capabilities that are required in the regional area so the lines and subs area can review equipment load ratings and the protection area can review CT and breaker load ratings as needed.

NOTES

Current interrupting capabilities were verified for substations 2 buses out, or where fault currents rose by more than 10% due to the installation of the system upgrades.
-faults taken on the bus unless interrupting rating is found to be close to or below the bus fault value

Issues or possible issues in red

unknown loading capacity requirements in green

Not owned by NPPD

	Faults % of Rating	Δ	Pre 2010-002 Study	2010-002 Upgrades	Interupting Rating	Derate Value	Data Interupt	CT Max Available	Amp Rating	Speed	Reclose	Year	PO Cont	Interupting Device
Beatrice														
PCB1102	32%	4%	12414	12961	40000		40kA	2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1104	59%	4%	12414	12961	22000		22kA	1200/5	1200	3		1971	N70-11	General Electric FK-121-22000-2
PCB1106	32%	4%	12414	12961	40000		40kA	2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1108	32%	4%	12414	12961	40000		40kA	2000/5	2000	3		2002	00-10	Mitsubishi 100-SFMT-40HE
PCB1112	65%	4%	12414	12961	20000		20kA	1200/5	1200	3		1977	76-36	Allis Chalmers BZO-121-20-7
PCB1114	65%	4%	12414	12961	20000		20kA	1200/5	1200	3		1977	76-36	Allis Chalmers BZO-121-20-7
PCB1120	65%	4%	12414	12961	20000		20kA	1200/5	1200	3		1981	81-6	McGraw Edison AHF-48-121-20
PCB1122	65%	4%	12414	12961	20000		20kA	1200/5	1200	3		1981	81-6	McGraw Edison AHF-48-121-20
PCB302	58%	1%	11528	11631	20082	80%	1500 Asym	600/5	600	5	3	1954	542	Westinghouse GO-2-AS
PCB304	58%	1%	11528	11631	20082	80%	1500 Asym	600/5	600	5	3	1954	542	Westinghouse GO-2-AS
PCB306	58%	1%	11528	11631	20082	80%	1500 Asym	600/5	600	5	3	1954	542	Westinghouse GO-2-A
PCB308	58%	1%	11528	11631	20082	80%	1500 Asym	600/5	600	5	3	1954	542	Westinghouse GO-2-AS
PCB310	51%	1%	11528	11631	23000		23kA	1200/5	1200	3		1995	95-34	Siemens SPS-72.5-23-1
PCB312	29%	1%	11528	11631	40000		40kA	800/5, 1200/5	1200	3		2006		Siemens SPS-72.5-40-2

PCB314	37%	1%	11528	11631	31500		31.5kA	1200/5	2000	3		1995	E05386	ABB 72-PMI-31-20
PCB316	58%	1%	11528	11631	20082	80%	1500 Asym	600/5	1200	5	3	1965	681	Allis Chalmers TDO-34-1500
PCB318	58%	1%	11528	11631	20082	80%	1500 Asym	600/5	1200	5	3	1965	681	Allis Chalmers TDO-34-1500
PCB320	51%	1%	11528	11631	22844	91%	1500 Asym	600/5	1200	5	0	1965	681	Allis Chalmers TDO-34-1500
117-D	94%	0%	5878	5891	6276		150 Sym							HSO - SSM
333-D2	66%	1%	11528	11631	17500		17.5kA							SMD-1A
329-D	138%	1%	11528	11631	8450		8.45kA							SMD-20
331-D	66%	1%	11528	11631	17500		17.5kA							SMD-1A
Beatrice Plant														
PCB1102	43%	3%	16664	17134	40000		40kA	500/5, 2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1104	43%	3%	16664	17134	40000		40kA	500/5, 2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1108	43%	3%	16664	17134	40000		40kA	500/5, 2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1110	43%	3%	16664	17134	40000		40kA	500/5, 2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1112	43%	3%	16664	17134	40000		40kA	500/5, 2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1114	43%	3%	16664	17134	40000		40kA	500/5, 2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1116	43%	3%	16664	17134	40000		40kA	500/5, 2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1118	43%	3%	16664	17134	40000		40kA	500/5, 2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1120	43%	3%	16664	17134	40000		40kA	500/5, 2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1122	43%	3%	16664	17134	40000		40kA	500/5, 2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1124	43%	3%	16664	17134	40000		40kA	500/5, 2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
Beatrice South														
CS1110	21%	2%	5069	5161	25000		25kA		1200			2002		S&C 2030
PCB302	29%	1%	6440	6484	22000		22kA	1200/5	1200	5		1972	E71-20	Westinghouse 345-GS-1500
PCB304	28%	1%	6440	6484	23000		23kA	1200/5	1200	3		1997	E12831	Siemens SPS-72.5-23-1
PCB306	29%	1%	6440	6484	22000		22kA	1200/5	1200	5		1972	E71-20	Westinghouse 345-GS-1500
CS314	81%	1%	6440	6484	8000		8kA		1200			1978		S&C IV-1
PCB316	29%	1%	6440	6484	22000		22kA	1200/5	1200	5		1972	E71-20	Westinghouse 345-GS-1500
314-D	77%	1%	6440	6484	8450		8.45kA							SMD-20

115-D	45%	0%	6250	6266	14000		14kA							SMD-20
119-D	45%	0%	6250	6266	14001		14kA							SMD-20
Belden														
PCB1104	27%	1%	5846	5884	22091	88%	3500 Asym	600/5	1200	5	1	1952	580	GE FK-439-115-3500-3
PCB1106 (WAPA)	15%	1%	5846	5884	40000		40kA	1200/5	1200	3	1	2002		Mistsubishi 100-SFMT-40HE
PCB1108	29%	1%	5846	5884	20082	80%	5000 Asym	1200/5	1200	3	1	1969	738	ITE 115-KM-5000-12B
PCB1112 T1 Pri	86%	1%	5846	5884	6853	91%	1500 Asym	600/5, 1200/5	800	5	0	1957	923	GE FK-439-115-1500-3
PCB602	9%	0%	3719	3726	40000		40kA	2000/5	2000	3	3	2007		Siemens SPS2-72.5-40-20
PCB606	9%	0%	3719	3726	40000		40kA	1200/5	2000	5	3	2004		ABB 72-PM-40-20
PCB608	16%	0%	3719	3726	23000		23kA	1200/5	1200	3	3	1995	95-34	Siemens SPS-72.5-23-1
PCB610	9%	0%	3719	3726	40000		40kA	2000/5	2000	3	1	2007		Siemens SPS2-72.5-40-2
CS614	93%	0%	3719	3726	4000		4000		1200		0	1967		S&C G
614-D	43%	0%	3719	3726	8750									SMD-1A
619-D	43%	0%	3719	3726	8750									SMD-1A
627-D	43%	0%	3719	3726	8750									SMD-1A
115-D	28%	0%	3868	3870	14000									SMD-20
Emerson														
PCB1102	24%	1%	5274	5344	22000		22kA	2000/5	1600	3		1969		ITE 115-KM-5000-16B
PCB1104	27%	1%	5274	5344	20000		20kA	1200/5	1200	3		1999		Siemens SPS2-121-20-1
CS1110	76%	1%	5274	5344	7000		7kA		1200			1978		S&C V
PCB602	9%	0%	3772	3788	40000		40kA	400/5, 800/5	2000	3		2009		Areva DT1-72.5 F1 FK
PCB604	21%	0%	3772	3788	17781	85%	2500 Asym	1200/5	1200	5	2	1963	439-A	Penn CF-48-69-2500
CS614	95%	0%	3772	3788	4000		4kA		1200			1966		S&C G
614-D	43%	0%	3772	3788	8750		8.75kA							SMD-1A
619-D	43%	0%	3772	3788	8750		8.75kA							SMD-1A
115-D	80%	0%	4996	5003	6276		150 Sym							HSO SSM
Fairbury														
PCB1102	24%	4%	4583	4773	19831	79%	5000 Asym	1200/5	1200	3	1	1962	320	General Electric FK-115-5000

CS1110	68%	4%	4583	4773	7000		7kA		1200			1977		S&C IV-1
PCB302	85%	1%	6401	6494	7615	91%	500 Asym	600/5	600	8	3	1951	650	General Electric FK-339-34.5-500-3
PCB306	32%	1%	6401	6494	20082	80%	1500 Asym	1200/5	1200	5	3	1965	681	Allis Charlmers TDO-34-1500
PCB308	30%	1%	6401	6494	22000		22kA	2000/5	1200	5		1974	73-45	General Electric FKA-38-22000-6
PCB310	78%	1%	6401	6494	8368	100%	500 Asym	600/5	600	8	1	1952	252	General Electric FK-439-34.5-500
CS314	162%	1%	6401	6494	4000		4kA		1200			1965		S&C G-1
314-D	77%	1%	6401	6494	8450		8.45kA							SMD-20
319-D	77%	1%	6401	6494	8450		8.45kA							SMD-20
320-D	77%	1%	6401	6494	8450		8.45kA							SMD-20
115-D	45%	1%	6236	6272	14000		14kA							SMD-20
Harbine														
PCB1102	17%	8%	6104	6615	40000		40kA	2000/5	2000	3		2009	07-38A	Mitsubishi 100-SFMT-40HE-1
PCB1104	17%	8%	6104	6615	40000		40kA	2000/5	2000	3		2009	07-38	Mitsubishi 100-SFMT-40HE-1
PCB1106	17%	8%	6104	6615	40000		40kA	2000/5	2000	3		2008	07-38A	Mitsubishi 100-SFMT-40HE-1
Hoskins														
PCB3302	25%	2%	9681	9878	40000		40kA	2000/5, 1600/5	3000	2		2007	07-15	ABB 362-PMI-40-30
PCB3308	25%	2%	9681	9878	40000		40kA	2000/5, 1600/5	3000	2		2007	07-15	ABB 362-PMI-40-30
PCB3310	25%	2%	9681	9878	40000		40kA	2000/5, 1600/5	3000	2		2007	07-15	ABB 362-PMI-40-30
PCB3312	25%	2%	9681	9878	40000		40kA	2000/5, 1600/5	3000	2		2007	?	ABB 362-PMI-40-30
PCB2202	38%	4%	11381	11847	31500		31.5kA	2000/5	1600	3		1973	E72-20	McGraw Edison RHE-84-242-31.5
PCB2210	30%	4%	11381	11847	40000		40kA	2000/5	3000	2		2007	07-15A	Mitsubishi 200-SFMT-40HF
PCB2212	30%	4%	11381	11847	40000		40kA	2000/5	3000	2		2007	07-15A	Mitsubishi 200-SFMT-40HF
CS2218	59%	4%	11381	11847	20000		20kA/4kA secondary					1997	E12170	S & C 2030
PCB1102	47%	1%	18414	18679	40000		40kA	2000/5	2000	3		2008	4500088135	Mitsubishi 100SFMT-40HE-1
PCB1104	47%	1%	18414	18679	40000		40kA	2000/5	2000	3		2009	460000071	Mitsubishi 100SFMT-40HE-1
PCB1106	47%	1%	18414	18679	40000		40kA	2000/5	2000	3		2008	4500091256	Mitsubishi 100SFMT-40HE-1
PCB1108	47%	1%	18414	18679	40000		40kA	2000/5	2000	3		2009	460000071	Mitsubishi 100SFMT-40HE-1
PCB1110	47%	1%	18414	18679	40000		40kA	2000/5	2000	3		2009	460000071	Mitsubishi 100SFMT-40HE-1

PCB1112	47%	1%	18414	18679	40000		40kA	2000/5	2000	3	2009	4500091256	Mitsubishi 100SFMT-40HE-1
PCB1118	47%	1%	18414	18679	40000		40kA	2000/5	2000	3	2009	4500091256	Mitsubishi 100SFMT-40HE-1
PCB1120	47%	1%	18414	18679	40000		40kA	2000/5	2000	3	2007	07-38	Mitsubishi 100SFMT-40HE
PCB1122	47%	1%	18414	18679	40000		40kA	2000/5	2000	3	2009	460000071	Mitsubishi 100SFMT-40HE-1
PCB302	39%	0%	15547	15596	40000		40kA	1200/5, 800/5	1200	3	2006	4500053994	Siemens SPS-72.5-40-2
PCB304	39%	0%	15547	15596	40000		40kA	1200/5, 800/5	1200	3	2006	4500055794	Siemens SPS-72.5-40-2
PCB320	39%	0%	15547	15596	40000		40kA	1200/5, 800/5	1200	3	2006	4500053994	Siemens SPS-72.5-40-2
PCB322	32%	1%	9893	9951	31500		31.5kA	2000/5	2000	3	1997	58635	ABB 72-PM-31-20
PCB324	32%	1%	9893	9951	31500		31.5kA	2000/5	2000	3	1997	58635	ABB 72-PM-31-20
PCB326	32%	1%	9893	9951	31500		31.5kA	2000/5	2000	3	1997	58635	ABB 72-PM-31-20
PCB328	32%	1%	9893	9951	31500		31.5kA	2000/5	2000	3	1997	58635	ABB 72-PM-31-20
PCB330	32%	1%	9893	9951	31500		31.5kA	2000/5	2000	3	1997	58635	ABB 72-PM-31-20
PCB332	32%	1%	9893	9951	31500		31.5kA	2000/5	2000	3	1997	58635	ABB 72-PM-31-20
ACB102	59%	0%	16961	16987	28555	91%	750 Asym		2000	5	1978	78-36	Westinghouse DHP
SW104	68%	0%	16961	16987	25000		25kA	1200/5	2000	3	2009	04-35	ABB RMAG
SW106	68%	0%	16961	16987	25000		25kA	1200/5	2000	3	2009	04-35	ABB RMAG
329-D	89%	0%	15547	15596	17500		17.5kA						SMD-1A
339-D	100%	1%	9893	9951	10000		10kA						SMD-20
315-D	89%	0%	15547	15596	17500		17.5kA						SMD-1A
322-D	89%	0%	15547	15596	17500		17.5kA						SMD-1A
Shell Creek													
PCB3302	23%	1%	9148	9233	40000		40kA	1600/5. 2000/5	3000	2	2007	07-15	ABB 362-PMI-40-30
PCB3304	23%	1%	9148	9233	40000		40kA	1600/5. 2000/5	3000	2	2007	07-15	ABB 362-PMI-40-30
PCB3306	23%	1%	9148	9233	40000		40kA	1600/5. 2000/5	3000	2	2007	07-15	ABB 362-PMI-40-30
PCB2202	26%	0%	10471	10516	40000		40kA	2000/5	3000	2	2008	07-15A	Mitsubishi 200-SFMT-40HF
119-D	77%	0%	26182	26205	34000		34kA						SM-5
Sioux City		2%	18127	18401									

Steele City														
PCB1102	11%	4%	4300	4471	40000		40kA		2000	3		2008		Mitsubishi 100-SFMT-40HE-1
PCB1104	11%	4%	4300	4471	40000		40kA		2000	3		2008		Mitsubishi 100-SFMT-40HE-1
PCB1108	11%	4%	4300	4471	40000		40kA		2000	3		2008		Mitsubishi 100-SFMT-40HE-1
PCB1114	11%	4%	4300	4471	40000		40kA		2000	3		2009		ABB 121-PMI-40-20
Twin Church														
PCB2202	29%	8%	7884	8485	29370	78%	15000 Asym	2000/5	1600	3	1	1971	N70-11	McGraw Edison RHE-84-230-15000
PCB2204	21%	8%	7884	8485	40000		40kA	2000/5	3000	3		2008		Mitsubishi 200-SFMT-40HF
PCB2210	27%	8%	7884	8485	31500		31.5kA	2000/5	1600	3		1973	E72-20	McGraw Edison RHE-84-242-31.5
PCB2212	21%	8%	7884	8485	40000		40kA	2000/5	3000	3		2008		Mitsubishi 200-SFMT-40HF
PCB2220	27%	8%	7884	8485	31500		31.5kA	2000/5	1600	3		1973	E72-20	McGraw Edison RHE-84-242-31.5
PCB1102	54%	4%	11498	11952	22000		22kA	1200/5	1200	3		1970	W69-2	General Electric FK-121-22000-2
PCB1104	60%	4%	11498	11952	20082	80%	5000 Asym	1200/5	1200	3	1	1969	738	ITE 115-KM-5000-12B
PCB1106	60%	4%	11498	11952	20082	80%	5000 Asym	1200/5	1200	3	1	1967	937	Westinghouse 1150-GM-5000
PCB1108	57%	4%	11498	11952	20835	83%	5000 Asym	1200/5	1200	3	0	1969	738	ITE 115-KM-5000-12B
PCB1110	54%	4%	11498	11952	22000		22kA	1200/5	1200	3		1971	N70-11	General Electric FK-121-22000-2
PCB1112	30%	4%	11498	11952	40000		40kA	2000/5	2000	3		2007		Mitsubishi 100-SFMT-40HE
PCB602	22%	2%	8531	8665	40000		40kA	800/5 1200/5	2000	3		2008		Siemens SPS2-72.5-40-2
PCB604	38%	2%	8531	8665	23000		23kA	1200/5	1200	3		1990	89-37	Siemens SP-72.5-23-3
PCB606	43%	2%	8531	8665	20000		20kA	1200/5	1200	5		1977	10969	McGraw Edison CG-48-72.5-20
PCB608	38%	2%	8531	8665	23000		23kA		1200	3		1991		Siemens SP-72.5-23-3
PCB610	38%	2%	8531	8665	23000		23kA	1200/5	1200	3		1990	89-37	Siemens SP-72.5-23-3
PCB612	38%	2%	8531	8665	23000		23kA	1200/5	1200	3		1990	89-37	Siemens SP-72.5-23-3
CS614	217%	2%	8531	8665	4000		4kA		1200			1970		S&C II
614-D2	83%	2%	8531	8665	10500		10.5kA							SMD-2B
PCB620	22%	2%	8531	8665	40000		40kA	1200/5	2000	3		2011		Areva DTI-72.5 F1
PCB302	34%	0%	2582	2586	7615	91%	500 Asym	600/5	600	8	3	1950	C23321	Westinghouse GO-2-A
115-D	31%	0%	4277	4285	14000		14kA							SMD-20
117-D	31%	0%	4277	4285	14000		14kA							SMD-20

1127-D2	114%	4%	11498	11952	10500	10.5kA	SMD-2B
327-D	26%	0%	2582	2586	10000	10kA	SMD-20

7.0 Regional Flowgate Impact Analysis

7.1 Overview

Power Transfer Distribution Factors (PTDF)s and Outage Transfer Distribution Factors (OTDF)s were calculated for all flowgates in the Nebraska area utilizing the DFCALC IPLAN program. MAPP DRS criteria were utilized to determine if a defined flowgate was significantly affected by the addition of the wind facilities and potential deliveries. If a PTDF flowgate was impacted by greater than 5.0% and 1 MW or an OTDF flowgate was impacted by greater than 3.0% and 1 MW, the flowgate was considered significantly affected by the addition and mitigation may be required for firm transmission service if AFC is unavailable. The 2011 Spring Peak cases were utilized as the base case models for this analysis. A GEN-to-GEN dispatch was evaluated for each of the wind facilities.

For the GEN-to-GEN evaluation, the incremental generation associated with the new wind generation facilities was dispatched to all other online generation in all other SPP areas. Dispatching the units in this manner best shows the overall impact of dispatching the wind facilities to the entire SPP footprint. The dispatch utilized in the DF analysis was the same dispatch that was utilized in the loadflow analysis portion of the study.

7.2 Results

Utilizing the DFCALC IPLAN routine, PTDF and OTDF calculations were performed on each of the generation re-dispatch cases. Table 19 below summarizes the DF results (%) for each flowgate in the Nebraska area.

Overall, the results were fairly consistent for each of the generation interconnection projects. Four PTDF flowgates, COOPER_S, FTCAL_S and WNE_WKS, were significantly impacted by the wind projects. COOPER_S was the highest impacted flowgate at over 30% DF for each of the wind projects. FTCAL_S was impacted at roughly 18% DF for the wind project in Dixon County. WNE_WKS was impacted at roughly 9% DF for the wind projects in Dixon County and Gage County. The Council Bluffs – River Bend 161 kV FLO Cooper – St. Joe 345 kV and Kelly – Tecumsah Hill 161 kV FLO Cooper – St. Joe 345 kV OTDF flowgates were impacted by over 3% by each of the wind projects. Regional flowgate impacts due to the wind projects will be further addressed in the Delivery study. This DF analysis evaluates the impacts on regional flowgates to understand the potential impacts of these future resources on known regional constraints. Ultimately, the transmission service or delivery study will evaluate the final impacts of any deliveries from the wind projects on the regional flowgates. The delivery study will determine if sufficient AFC is available or if any mitigation is required on the regional flowgates due to the impact of the wind projects.

Table 19. DFCALC Results

Type	Interface	2011 Spring Peak	
		72 MW GEN-2010-047	200 MW GEN-2010-051
		GEN-to-GEN (MW)	GEN-to-GEN (MW)
PTDF	COOPER_S	**31.8% (22.9 MW)**	**30.8% (61.6 MW)**
	FTCAL_S	-4.9%	**17.8% (35.7 MW)**
	GGS	-0.8%	1.0%
	GRIS_LNC	-4.0%	-4.4%
	WNE_WKS	**8.6% (6.2 MW)**	**9.0% (18.0 MW)**
OTDF	S1226TEKAMAH	1.0%	-8.4%
	RIVERBEND	**3.4% (2.4 MW)**	**3.6% (7.3 MW)**
	KELLYTECH	**7.1% (5.1 MW)**	**3.1% (6.3 MW)**
	TEKRNS3451RN	1.2%	-3.6%

** Significant Impacts greater than 5% PTDF or 3% OTDF and greater than 1 MW are highlighted in **BOLD**.*

8.0 Detailed Cost Estimates & Project Schedule

NPPD's Engineering, Asset Management, and Project Management groups have reviewed the list of interconnection facilities and network upgrades that are required for interconnection of the three wind generation projects. Detailed cost estimates have been prepared for each of the interconnection facilities and network upgrades that were identified in the SPP DISIS-2010-002 system impact study and this facility study. It should be noted that the costs associated with any radial transmission facilities required to connect remote generation interconnection facilities to the designated point-of-interconnection to the NPPD transmission system are NOT included in these estimates. The project costs and schedule associated with any radial transmission facilities will be developed during the development of the generation interconnection agreement with the interconnection customer. The prepared cost estimates are budgetary level estimates (+75%/-25%) and assume implementation of standard NPPD construction and procurement practices. The cost estimates for the interconnection facilities and network upgrades are below:

- GEN-2010-047 Interconnection Facilities – Gage County 115 kV substation addition on Beatrice – Harbine 115 kV to accommodate new 115 kV interconnection. Includes protection system modifications and communication path (fiber) to accommodate new interconnection substation.
  $ 4.0 Million

- GEN-2010-051 Interconnection Facilities – Dixon County 230 kV substation addition on Twin Church – Hoskins 230 kV line to accommodate new 230 kV interconnection.
  $ 6.7 Million

- Gage County - Harbine 115 kV Line Rebuild – Rebuild ~5-miles of 115 kV line from Gage County to Harbine and associated substation upgrades. **$ 3.2 Million**

- Twin Church – Dixon County 230 kV Line Upgrade – Increase clearances on Twin Church – Dixon County 230 kV line to accommodate 320 MVA facility rating to address N-1 contingency loading issues identified in DISIS-2010-002 Facility Study.
  $ 0.1 Million

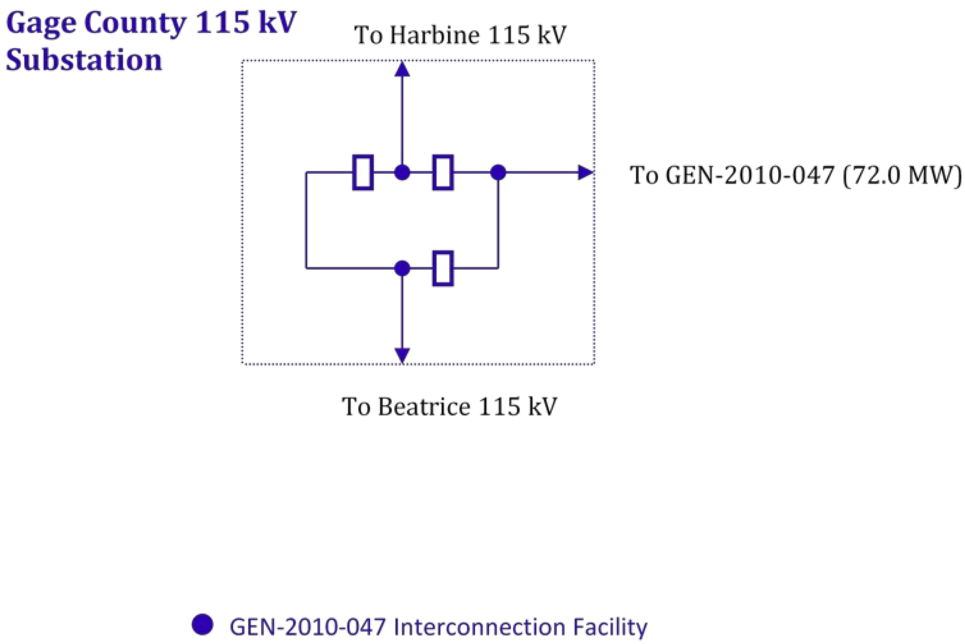
Total Interconnection & Network Upgrades: $14.0 Million

Proposed one-line diagrams of the interconnection and network upgrades are on the following pages. NPPD will work with the wind generation facility projects to develop project schedules for the interconnection facilities and network upgrade projects listed above during the development of the generation interconnection agreement. Typical implementation schedules for new transmission lines (≥ 115 kV) are roughly 4 years to accommodate the public routing process and construction schedules. Substation additions require less land acquisition and typically can be implemented in less time or approximately 2-3 years. Project schedule details will be further discussed in the development of the generator interconnection agreement (GIA) and the milestones associated with the generation interconnection projects. Based on these preliminary estimates, the earliest energization date for the DISIS-2010-002 interconnection and network upgrades would be end of 2014.

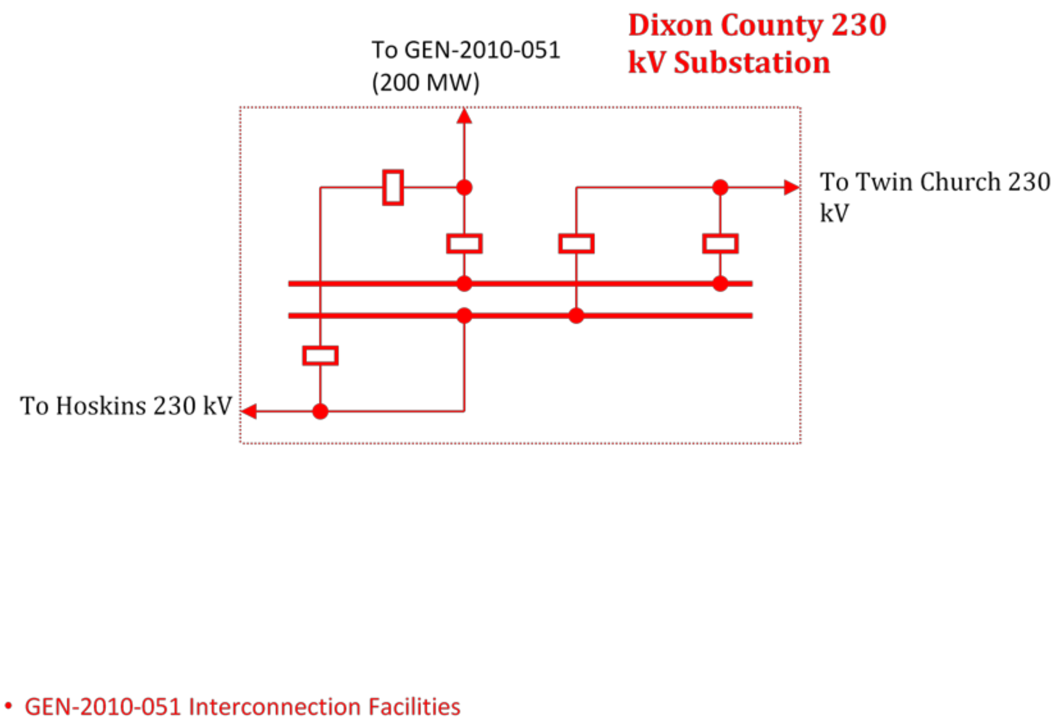
It should be noted that the projects listed above do not include any third party facilities that were identified as overloaded in the facility study. SPP will need to coordinate the results of this facility study with these external entities to determine the appropriate mitigations and necessary transmission upgrades. Detailed costs and project schedules would then be developed by SPP and the external entity and communicated to the wind generation interconnection customers.

It should also be noted that the interconnection plan for the DISIS-2010-002 generation projects are dependent on the transmission upgrades/additions that are required as part of the DISIS-2010-001 and DISIS-2009-001 interconnection plan. If there are any modifications to the DISIS-2010-001 and DISIS-2009-001 generation or transmission projects, then the interconnection plan for the DISIS-2010-002 projects could be affected. This issue would need to be re-studied and evaluated if for any reason any of the DISIS-2010-001 or DISIS-2009-001 generation or transmission projects to not move forward.

GEN-2010-047


Gage County 115 kV
Substation
To Harbine 115 kV
To GEN-2010-047 (72.0 MW)
To Beatrice 115 kV
GEN-2010-047 Interconnection Facility

GEN-2010-051


Dixon County 230
kV Substation
To GEN-2010-051
(200 MW)
To Twin Church 230
kV
To Hoskins 230 kV
• GEN-2010-051 Interconnection Facilities