Southwest Power Pool

Facility Study For Generation Interconnection Request GEN-2010-044

SPP Generation Interconnection Studies

(#GEN-2010-044)

July 2012

Summary
Nebraska Public Power District (NPPD) performed a detailed Facility Study at the request of Southwest Power Pool (SPP) for Generation Interconnection request GEN-2010-044 (99MW/Wind). The originally proposed in-service date was November 1, 2012, however SPP has proposed a new in-service date that will be after the assigned Network Upgrades are completed. The request for interconnection was placed with SPP in accordance with SPP's Open Access Transmission Tariff, which covers new generation interconnections on SPP's transmission system.

Phases of Interconnection Service
It is not expected that interconnection service will require phases however, interconnection service will not be available until all interconnection facilities and network upgrades can be placed in service.

Interconnection Customer Interconnection Facilities
The Interconnection Customer will be responsible for all of the transmission facilities connecting the customer owned substation to the Point of Interconnection (POI), at the existing 115kV Harbine substation. The Customer will also be responsible for any equipment located at the Customer substation necessary to maintain a power factor of 0.95 lagging to 0.95 leading at the POI.

Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades
To allow interconnection the Transmission Owner will need to construct an additional circuit breaker terminal at the Harbine substation and associated equipment for acceptance of the Interconnection Customer's Interconnection Facilities. At this time the Customer is responsible for $18,000,000 of Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades.

Shared Network Upgrades
The interconnection customer was studied within the DIS-2011-002 Impact Study. At this time, the Interconnection Customer is allocated $0 for Shared Network Upgrades. If higher 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. All studies have been conducted on the basis of higher queued interconnection requests and the upgrades associated with those higher queued interconnection requests being placed in service.

Other Network Upgrades

Certain Other Network Upgrades are not the cost responsibility of the Customer but will be required for full Interconnection Service. This Network Upgrade is:

1. Sheldon – Folsom & Pleasant Hill 115kV circuit 2, rebuild, assigned to SPP ITP NT 2011 (NRIS Only)

Depending upon the status of higher or equally queued customers, the Interconnection Customer's in-service date is at risk of being delayed or their Interconnection Service is at risk of being reduced until the in-service date of these Other Network Upgrades.

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.

Conclusion

Interconnection Service for GEN-2010-044 will be delayed until the Transmission Owner Interconnection Facilities are constructed. The Customer is responsible for $18,000,000 of Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades. At this time, the Interconnection Customer is allocated $0 for Shared Network Upgrades. After all Interconnection Facilities and Network Upgrades have been placed into service, Interconnection Service for 99MW, as requested by GEN-2010-044, can be allowed. At this time the total allocation of costs of Interconnection Service for GEN-2010-044 are estimated at $18,000,000.

Appendix E. Cost Allocation Per Request

Interconnection Request and Upgrades	Upgrade Type	Allocated Cost	Upgrade Cost
GEN-2010-044			
GEN-2010-044 Interconnection Costs See Oneline Diagram.	Current Study	$800,000.00	$800,000.00
Harbine - Crete 115kV CKT 1 Build approximately 35 miles of 115kV from Harbine - Crete	Current Study	$17,200,000.00	$17,200,000.00
	Current Study Total	$18,000,000.00	
	TOTAL CURRENT STUDY COSTS:	**$18,000,000.00**	

* Withdrawal of higher queued projects will cause a restudy and may result in higher costs

DISIS-2011-002
GENERATION INTERCONNECTION
FACILITY STUDY

SPP GEN-2010-044 99.0 MW Wind Generation Facility at Harbine 115 kV

JUNE 2012

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
"Always there when you need us"

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Executive Summary

The *NPPD DISIS-2011-002 Facility Study* was performed to document the reliability impacts of a new wind generation facility interconnected to the NPPD transmission system. This wind generation project has developed through the SPP Definitive Interconnection System Impact Study process and has advanced to the facility study stage. SPP has requested that NPPD perform the Facility Study associated with the generation interconnection project listed below:

Project	MW	Point-of-Interconnection	Cluster
GEN-2010-044	99.0	Harbine 115 kV	9/10

This facility study provides the transmission interconnection plan to accommodate the interconnection of the wind generation project. 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 project and associated transmission. SPP evaluated this wind generation interconnection project in the DISIS-2011-002 system impact study and developed a list of transmission projects required to interconnect this generation facility to the NPPD transmission system at the requested point of interconnection. The required transmission network upgrade projects identified in the DISIS-2011-002 system impact study are listed below:

- Expansion of Harbine 115 kV substation
- Construct new ~27-mile 115 kV transmission line from the Harbine 115 kV substation to the Crete 115 kV substation.
- Upgrade the existing Harbine – Beatrice 115 kV line to at least a 240 MVA rating.

The DISIS-2011-002 facility study was conducted assuming all remaining DISIS-2011-001, DISIS-2010-002, 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, DISIS-2010-001, DISIS-2010-002, DISIS-2011-001 generation and associated transmission projects, then the DISIS-2011-002 transmission plan would need re-evaluated. Modifications to the DISIS-2009-001, DISIS-2010-001, DISIS-2010-002, DISIS-2011-001 generation and transmission projects could potentially affect the transmission interconnection costs assigned to the DISIS-2011-002 customers.

The DISIS-2011-002 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 addition 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 additional facility overloads or voltage violations that would require mitigation due to TPL-001 and TPL-002 contingencies.

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 Hoskins – Dixon County – Twin Church 230 kV line rating needed to be uprated to accommodate the increased loading requirements due to the previous DISIS-2011-001 projects. 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. The wind projects may be required to address flows on this constraint if not fully addressed by the Axtell – Post Rock – Spearville 345 kV line. Also, the Raun – Neal North 161 kV circuits were 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 10 transmission facilities was developed that would need prior outage generation limits established to ensure system operating limits are maintained for the potential loss of the next worst-case transmission facility.

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 future Nebraska City – Maryville – Sibley 345 kV line (Priority Project) is expected to improve congestion in this area of the system.

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 addition. The results of this analysis showed that there were no protective devices subject to replacement due to this study.

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 facility. Overall, the results showed that two PTDF flowgates, COOPER_S and WNE_WKS, were significantly impacted by the wind project. 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 project. Regional flowgate impacts due to the wind project will be further addressed in the delivery study following a request for transmission service.

Overall, the *NPPD DISIS-2011-002 Facility Study* documents the performance of the network following the addition of the wind generation interconnection project 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-2011-002 Interconnection Plan

- GEN-2010-044 Interconnection Facilities – Harbine 115 kV substation expansion to accommodate new 115 kV interconnection.
  $ 0.8 Million

- Harbine – Crete 115 kV Line – Construct new ~27-mile 115 kV transmission line from the Harbine 115 kV substation to the Crete 115 kV substation. Project includes substation expansions at both substations to accommodate the new transmission line.
  $ 17.2 Million

- Harbine – Beatrice 115 kV Facility Upgrade – Upgrade the Harbine – Beatrice 115 kV facility to accommodate a 240 MVA facility rating. **$ 4.6 Million**

Total Interconnection & Network Upgrades: $22.6 Million

1.0 Introduction

In March 2012, NPPD was notified that a generation interconnection request in the SPP generation interconnection queue had advanced to the facility study stage. The generation interconnection request was evaluated by SPP in the Definitive Interconnection System Impact Study (DISIS-2011-002). The generation interconnection request is listed below:

Project	MW	Point-of-Interconnection
GEN-2010-044	99.0	Harbine 115 kV

SPP entered into a Facility Atudy agreement with the generation interconnection customer and subsequently requested that NPPD perform the Facility Study for the GI request. In response to the SPP request, NPPD has performed a Facility Study for the generation interconnection request 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 the generation interconnection project is below:

- GEN-2010-044 Interconnection Facilities – Expansion of Harbine 115 kV substation to accommodate new interconnection.
- Harbine – Beatrice 115 kV line rebuild and terminal upgrades – Rebuild the Harbine – Beatrice 115 kV line and substation equipment upgrades at both ends of the line.
- Harbine – Crete 115 kV Line – Construct new ~27-mile 115 kV transmission line from the Harbine 115 kV substation to the Crete 115 kV substation, including terminal additions at both ends of the new line.

2.0 Study Scope

2.1 Overview

This Facility Study will evaluate a proposed wind generator interconnection project on the NPPD transmission system. This study will evaluate a generator interconnection request in the SPP Generator Interconnection Queue which was studied in the SPP Definitive Interconnection System Impact Study, SPP DISIS-2011-002, and progressed to the facilities study stage. The GI project on the NPPD transmission system included in the DISIS-2011-002 study is as follows:

Project	MW	Point-of-Interconnection
GEN-2010-044	99.0	Harbine 115 kV

This Facility Study will focus on the project requesting interconnection to the NPPD transmission system. The SPP DISIS-2011-002 system impact study did identify several transmission upgrades that would be required to interconnect the proposed generation facility. These transmission upgrades were required to mitigate impacts of the proposed generation project on the existing transmission system as identified in the DISIS-2011-002 study. These transmission upgrades are listed below:

- Harbine 115 kV substation expansion
- Harbine – Beatrice 115 kV rebuild & substation upgrades
- New Harbine – Crete 115 kV line & substation upgrades

At the time of this facility study, there were several active generation interconnection requests in the SPP GI queue in the Nebraska area. 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 withdraw from the SPP GI queue, then a re-study of this DISIS-2011-002 facility study will be required. The previously-queued GI projects and network upgrades in the NPPD area are as follows:

Previously queued GI projects		
GEN-2011-018 (Steele City)	=	73.6 MW (ia pending)
GEN-2011-027 (Dixon County)	=	120.0 MW (ia pending)
GEN-2006-044N (Petersburg.N)	=	40.5 MW (online)
GEN-2008-086N02 (Madison.Co)	=	200.0 MW (signed ia; on schedule)
GEN-2006-037N1 (Broken Bow)	=	75.0 MW (signed ia; on suspension)
GEN-2006-044N02 (Madison.Co)	=	100.8 MW (signed ia; on schedule)
GEN-2008-123N (Rosemont)	=	89.7 MW (signed ia; on suspension)
GEN-2010-051 (Dixon County)	=	200.0 MW (signed ia; on schedule)
		899.6 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
- Upgrade Madison County – Kelly 230 kV to 478 MVA
- Dixon County 230 kV substation
- Upgrade Twin Church – Dixon County 230 kV line

This facility study will assess the new system state with the proposed wind facility 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 facility 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 request 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 facility 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 interconnection.

The intent of the facility study is to perform a detailed assessment of the proposed generation interconnection facility 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 proposed generation interconnection facility 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 facility 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 project 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 project. 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 addition will be redispatched off-system. The purpose of this Phase will be to document sufficient generator outlet transmission capacity for the new wind generator 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 the southeast portion of Nebraska and exported into the surrounding MAPP & SPP regions. The following maximum accredited net generation levels will be modeled in this phase:

Southeast NE Cluster		
GEN-2010-044 (Harbine)	=	99.0 MW
GEN-2011-018 (Steele City)	=	73.6 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 Wind	=	60.0 MW
GEN-2010-041 (Flat Water exp.)	=	10.5 MW
GEN-2011-055 (Johnson County)	=	50.0 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 southeast 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 project. 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 proposed generation interconnection project 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 point (Harbine 115 kV Sub) of the wind project.

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 wind project on Nebraska flowgates. Distribution Factor (PTDF and OTDF) calculations will be performed to examine the incremental impacts of the wind project 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 project 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-2011-002 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 Bluffs 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-2008-123N (Rosemont)	=	89.7 MW
GEN-2010-051 (Dixon Co.)	=	200.0 MW
GEN-2011-018 (Steele City)	=	73.6 MW
GEN-2011-027 (Dixon Co.)	=	120.0 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 new generation interconnection project listed below was then added to the models and dispatched at 100%. The total output (99.0 MW) from the new generation interconnection project was dispatched off-system to all other balancing authorities within the SPP footprint on a pro rata basis.

GEN-2010-044 (Harbine)	=	99.0 MW

Wind Generation Models

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-2011-002) identified transmission upgrades that were required to accommodate the interconnection of the wind generation interconnection project 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:

Harbine – Crete 115 kV Line
R: 0.03072
X: 0.18976
B: 0.02906
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 project 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	111.2
659105	LELANDO3 345.00	659201	LELND1TY 345.00	1	SINGLE 871	250	117.7
659106	LELANDO4 230.00	659201	LELND1TY 345.00	1	SINGLE 871	250	117.6

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 greater than the 30-minute short-term emergency rating of 151 MVA. 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 wind projects may be required to mitigate flows on this constraint through re-dispatch or system upgrades.

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.

Phase 1 – 2017 Summer 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 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. 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	108.3
659105	LELANDO3 345.00	659201	LELND1TY 345.00	1	SINGLE 902	250	142.9
659106	LELANDO4 230.00	659201	LELND1TY 345.00	1	SINGLE 902	250	142.9

There were four additional facility overloads discovered during the ACCC analysis of the 2017 Summer Peak model with the wind generation additions. These additional 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	123.5
659105	LELANDO3 345.00	659201	LELND1TY 345.00	1	SINGLE 902	250	162.9
659106	LELANDO4 230.00	659201	LELND1TY 345.00	1	SINGLE 902	250	162.9
652473	ELKCRK 7 115.00	652490	RAPIDCY7 115.00	1	SINGLE 751	60	106.8
652477	ELSWRTH7 115.00	652490	RAPIDCY7 115.00	1	SINGLE 754	80	107.4

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.

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

The Phase 1 screening did not discover any transmission facility overloads on the NPPD system. All of the transmission facility overloads were found on external systems and would need further coordination and investigation with the affected party (WAPA).

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 three 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	105.4
640287	N.PLATT7 115.00	640365	STOCKVL7 115.00	1	TWR-GS-GRW	137	118.3
640326	REDWILO7 115.00	640365	STOCKVL7 115.00	1	TWR-GS-GRW	137	100.4

The North Platte – Stockville – McCook 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 wind projects may be required to mitigate flows on this constraint through re-dispatch or system upgrades.

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 addition. 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	103.1
531451	MINGO 7 345.00	640325	REDWILO3 345.00	1	CSPT-GS1-GS2	717	101.8
652572	SIDNEY 7 115.00	659238	COLTON 7 115.00	1	CSPT-SK-SO	120	109.0
652300	CHAPPEL7 115.00	659238	COLTON 7 115.00	1	CSPT-SK-SO	120	108.0
659135	STEGALL3 345.00	659207	STEGALTY 345.00	1	CSPT-SK-SO	400	104.0
640246	JULSTAP7 115.00	652300	CHAPPEL7 115.00	1	CSPT-SK-SO	120	104.6
652573	STEGALL4 230.00	659206	STGXFMR4 230.00	1	CSPT-SK-SO	400	102.9
659206	STGXFMR4 230.00	659207	STEGALTY 345.00	1	CSPT-SK-SO	400	100.8
635001	CBLUFFS5 161.00	635030	RIVRBND5 161.00	1	INT-CF-CSJ	199	115.1
635030	RIVRBND5 161.00	635031	BUNGE 5 161.00	1	INT-CF-CSJ	199	112.1
635031	BUNGE 5 161.00	635032	HASTING5 161.00	1	INT-CF-CSJ	199	107.0

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	107.6
640171	FIRTH 7 115.00	640278	SHELDON7 115.00	1	CB1263-BUS	76	111.5
640362	STERLNG7 115.00	647974	S974 8 69.000	1	CB1263-BUS	56	112.9

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 addition. Any bus voltage violations located in the NPPD area could be mitigated with system re-adjustments.

Category D Results (TPL-004):

There were five 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	%
640362	STERLNG7 115.00	647974	S974 8 69.000	1	OPPD_CIP20	56	109.7
640171	FIRTH 7 115.00	640278	SHELDON7 115.00	1	OPPD_CIP20	76	111.0
635001	CBLUFFS5 161.00	635030	RIVRBND5 161.00	1	INT-CF-CSJ	199	102.9
646201	S1201 5 161.00	646206	S1206 5 161.00	1	OPPD_CIP21	221	101.6
646201	S1201 5 161.00	646206	S1206 5 161.00	1	OPPD_CIP21	221	101.6

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 addition. 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	106.9

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 addition. Any bus voltage violations located in the NPPD area could be mitigated with system re-adjustments.

Category D Results (TPL-004):

There were five 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	108.0
640093	C.CREEK4 230.00	640286	N.PLATT4 230.00	1	CSPT-GS1-GS2	402	102.5
640238	JEFFREY7 115.00	640287	N.PLATT7 115.00	1	CSPT-GS1-GS2	160	103.6
640171	FIRTH 7 115.00	640278	SHELDON7 115.00	1	OPPD_CIP20	76	102.4
640103	CANADAY7 115.00	640161	ELMCRK_7 115.00	1	CSPT-SA-CCR	80	100.2

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 addition. 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.

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. A South-east NE cluster was established to evaluate the new request in this study. 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 – South 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 Peak – South East Cluster Maximum Generation model.

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 2011 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 43	225	104.4
560347	G10-51T 230.00	640386	TWIN CH4 230.00	1	SINGLE 45	225	105.9
640287	N.PLATT7 115.00	640365	STOCKVL7 115.00	1	SINGLE 347	137	115.1
659105	LELANDO3 345.00	659201	LELND1TY 345.00	1	SINGLE 872	250	112.9
659105	LELANDO3 345.00	659201	LELND1TY 345.00	1	SINGLE 876	250	112.9

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 DISIS-2011-001 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 wind projects may be required to mitigate flows on this constraint through re-dispatch or system upgrades.

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.

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 – 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 990 independent N-2 contingencies in the analysis of the south east cluster.

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. Steele City – Knob Hill 115 kV
2. BPS – Sheldon 115 kV
3. Beatrice – Steinauer 115 kV
4. Humboldt 161/115 kV Transformer
5. Humboldt – Steinauer 115 kV
6. North Hebron – Carleton Junction 115 kV
7. Pauline – Rosemont 115 kV
8. Moore 345/115 kV Transformer
9. Sheldon – 2^{nd} & N (Folsom & Pleasant Hill) 115 kV
10. Sheldon – 20^{th} & 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 97	137	103.1
640088	BPS SUB7 115.00	640111	CLATONA7 115.00	1	DOUBLE 397	137	107.9
640111	CLATONA7 115.00	640278	SHELDON7 115.00	1	DOUBLE 397	137	103.6
640088	BPS SUB7 115.00	640111	CLATONA7 115.00	1	DOUBLE 481	137	105.5
640111	CLATONA7 115.00	640278	SHELDON7 115.00	1	DOUBLE 481	137	101.2
640088	BPS SUB7 115.00	640111	CLATONA7 115.00	1	DOUBLE 482	137	107.5
640111	CLATONA7 115.00	640278	SHELDON7 115.00	1	DOUBLE 482	137	103.3
640169	FAIRBRY7 115.00	640208	HARBINE7 115.00	1	DOUBLE 521	99	106.4
640169	FAIRBRY7 115.00	640218	HEBRN N7 115.00	1	DOUBLE 521	99	113.9
640278	SHELDON7 115.00	650238	20PIONEERS7 115.00	1	DOUBLE 937	240	113.3
640362	STERLNG7 115.00	647974	S974 8 69.000	1	DOUBLE 937	56	102.9
640278	SHELDON7 115.00	650230	2&N 7 115.00	1	DOUBLE 938	240	113.9
640362	STERLNG7 115.00	647974	S974 8 69.000	1	DOUBLE 938	56	102.5

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. 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. The proposed wind generation interconnection project (99.0 MW total) and associated transmission upgrades were then added to the case. The new wind generation was exported off-system to other modeling areas in SPP on a pro rata basis. 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):

Fourteen 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	109.7
635001	CBLUFFS5 161.00	635030	RIVRBND5 161.00	1	LN-FAIRPORT	199	106.9
635030	RIVRBND5 161.00	635031	BUNGE 5 161.00	1	LN-FAIRPORT	199	103.9
541199	ST JOE 3 345.00	640139	COOPER 3 345.00	1	SINGLE 2	1073	111.5
635001	CBLUFFS5 161.00	635030	RIVRBND5 161.00	1	SINGLE 2	199	103.1
635030	RIVRBND5 161.00	635031	BUNGE 5 161.00	1	SINGLE 2	199	100.1
635001	CBLUFFS5 161.00	635030	RIVRBND5 161.00	1	SINGLE 5	199	108.2
635030	RIVRBND5 161.00	635031	BUNGE 5 161.00	1	SINGLE 5	199	105.1
635032	HASTING5 161.00	635031	BUNGE 5 161.00	1	SINGLE 5	199	100.1
635001	CBLUFFS5 161.00	635030	RIVRBND5 161.00	1	SINGLE 313	199	103.0
635030	RIVRBND5 161.00	635031	BUNGE 5 161.00	1	SINGLE 313	199	100.0
640287	N.PLATT7 115.00	640365	STOCKVL7 115.00	1	SINGLE 346	137	114.9
635201	RAUN 5 161.00	635203	NEAL N 5 161.00	2	SINGLE 47	335	106.5
635201	RAUN 5 161.00	635203	NEAL N 5 161.00	1	SINGLE 48	335	106.5

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-PostRock-Spearville 345 kV is scheduled for an in-service date of June 2013. The wind projects may be required to mitigate flows on this constraint through re-dispatch or system upgrades.

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 – Bunge 161 kV line was also overloaded above the 199 MVA rating for this contingency. The Council Bluffs – Riverbend – Bunge 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.

One new 115kV line was identified as being a necessary system addition due to the additional wind farm generation. Line routing, length, and design have not been completed and thus have been estimated based on NPPD minimum line construction standards.

Base System Model Additions

The 2012 base short circuit data file was updated with several additions to create a model for the DISIS-2011-002 short circuit study. These additions included the additions used in the revised DISIS-2009-001 (April 2011) short circuit study, the additions used in the revised DISIS-2010-001 (May 2011) short circuit study, the additions used in the DISIS-2010-002 short circuit study, the additions used in the DISIS-2011-001 short circuit study, planned work (NPPD and other) through 2014 that may have an effect on interrupting capabilities of equipment near the proposed wind farm locations, and the additions requested for the DISIS-2011-002 study. Some of the additions included in the previous DISIS studies are currently in-service and are not listed below. 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. Scheduled in-service is fall 2012.

    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 Vestas V90 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, T2-366 ACSR with 7/16 EHS neutral. This is the future Broken Bow I wind farm. Scheduled in-service is fall 2012.

    c. 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 75MW of Vestas V90 wind generation modeled as synchronous generators (lumped equivalent impedance of Elkhorn Ridge collector system less two turbines). This is connected to the Broken Bow 115kV bus by the same 8.75 mile line as Broken Bow I wind farm. This is the GEN-2006-037N1 Wind Farm (Broken Bow II wind farm).

d. 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.

e. 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 Vestas V90 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.

f. 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.

g. The addition of 136 miles of 345kV line from Axtell 345kV substation to Post Rock 345kV substation in Kansas. Scheduled in-service June 2013.

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 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.

d. 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. *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.

4. *DISIS-2011-001 additions*

   a. The addition of a 115/34.5 kV 50/66/82 MVA transformer ~ 2.5 miles from the Steele City 115kV Substation (impedances modeled after Elkhorn Ridge Main GSU scaled to 8.5% at 50MVA) with 73.6MW of wind generation modeled as synchronous generators (lumped equivalent impedance of Elkhorn Ridge generation scaled down to 92%). This is connected to the Steele City 115kV bus by 2.5 miles of 477 ACSR (Z1=0.1960+j0.7323 ohms/mile, Z0=0.4827+j2.6949 ohms/mile). This is the GEN-2011-018 Wind Farm.

   b. The addition of a 230/34.5kV 75/100/125MVA transformer at the new 230kV substation (Dixon County) on the Hoskins – Twin Church line (impedances modeled after Elkhorn Ridge Main GSU scaled to 8% at 75MVA) with 120MW of wind generation modeled as synchronous generators (lumped equivalent impedance of Elkhorn Ridge generation scaled to 150%). This is the GEN-2011-027 Wind Farm.

5. *Planned Work additions*

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

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

   c. New South Sioux City substation and new 115kV transmission lines L1297 and L1298 (Twin Church – South Sioux City). Scheduled to go in-service fall 2012.

   d. The addition of a 230/115 kV 180/300/336 MVA transformer at

Ogallala 230 kV Substation. This will replace the existing 100/167/187 MVA T-1 transformer at Ogallala. This is scheduled for a 2014 in-service date.

6. *DISIS-2011-002 additions*

   a. The addition of a 115/34.5kV transformer at Harbine 115kV substation with 99MW of wind generation modeled as synchronous generators (lumped equivalent impedance of Elkhorn Ridge generation scaled to 124%). Since no GSU transformer data has been provided, the GSU transformer is assumed to be as an 80/133 MVA transformer (impedances modeled after Elkhorn Ridge Main GSU scaled to 8% at 80MVA). This is the GEN-2010-044 Wind Farm.

   b. The addition of ~ 27 miles of 115 kV line connecting the Harbine and Crete 115 kV substations. This line was modeled as H frame, 477 ACSR, with 7/16 EHS neutral.

The Aspen One-liner data file for this configuration is "NPPD 2010 Dec 6 DISIS 2011-002.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 2014 in-service, the revised DISIS-2009-001 study additions, the revised DISIS-2010-001 study additions, the DISIS-2010-002 study additions, the DISIS-2011-001 study additions, and the DISIS-2011-002 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 100 protective devices were reviewed in ten (10) 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”. There where no devices that were found to be above

95% of their interrupting rating due to the addition of the DISIS-2011-002 projects.

6.4 Conclusions

Short Circuit Analysis found no interrupting devices where the available short circuit current will be above or near the interrupting rating. Section 6.5 contains the detailed interrupting data used to develop these conclusions for this facility study.

6.5 Detailed Short Circuit Analysis Results

SPP Wind Farm Analysis
Models: SPP Wind Farm \ NPPD 2010 Dec 6 DISIS-2011-002.olr

This document evaluates the regional area interupting device ratings due to:
-New 99 MW wind farm at Harbine 115kV substation - GEN-2010-044
-New 115kV Line between Harbine Substation and Crete 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 2011-002 Study	2011-002 Upgrades	Interupting Rating	Derate Value	Data Interupt	CT Max Available	Amp Rating	Speed	Reclose	Year	PO Cont	Interupting Device
Beatrice														
PCB1102	33%	6%	12545	13239	40000		40kA	2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1104	60%	6%	12545	13239	22000		22kA	1200/5	1200	3		1971	N70-11	General Electric FK-121-22000-2
PCB1106	33%	6%	12545	13239	40000		40kA	2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1108	33%	6%	12545	13239	40000		40kA	2000/5	2000	3		2002	00-10	Mitsubishi 100-SFMT-40HE
PCB1112	66%	6%	12545	13239	20000		20kA	1200/5	1200	3		1977	76-36	Allis Chalmers BZO-121-20-7
PCB1114	66%	6%	12545	13239	20000		20kA	1200/5	1200	3		1977	76-36	Allis Chalmers BZO-121-20-7
PCB1120	66%	6%	12545	13239	20000		20kA	1200/5	1200	3		1981	81-6	McGraw Edison AHF-48-121-20
PCB1122	66%	6%	12545	13239	20000		20kA	1200/5	1200	3		1981	81-6	McGraw Edison AHF-48-121-20
PCB302	53%	1%	11359	11480	21840	87%	1500 Asym	600/5	600	5	2	1954	542	Westinghouse GO-2-AS
PCB304	53%	1%	11359	11480	21840	87%	1500 Asym	600/5	600	5	2	1954	542	Westinghouse GO-2-AS
PCB306	53%	1%	11359	11480	21840	87%	1500 Asym	600/5	600	5	2	1954	542	Westinghouse GO-2-A
PCB308	53%	1%	11359	11480	21840	87%	1500 Asym	600/5	600	5	2	1954	542	Westinghouse GO-2-AS
PCB310	50%	1%	11359	11480	23000		23kA	1200/5	1200	3		1995	95-34	Siemens SPS-72.5-23-1
PCB312	29%	1%	11359	11480	40000		40kA	800/5, 1200/5	1200	3		2006		Siemens SPS-72.5-40-2
PCB314	36%	1%	11359	11480	31500		31.5kA	1200/5	2000	3		1995	E05386	ABB 72-PMI-31-20
PCB316	53%	1%	11359	11480	21840	87%	1500 Asym	600/5	1200	5	2	1965	681	Allis Chalmers TDO-34-1500
PCB318	53%	1%	11359	11480	21840	87%	1500 Asym	600/5	1200	5	2	1965	681	Allis Chalmers TDO-34-1500
PCB320	50%	1%	11359	11480	22844	91%	1500 Asym	600/5	1200	5	0	1965	681	Allis Chalmers TDO-34-1500
333-D2	66%	1%	11359	11480	17500		17.5kA							SMD-1A
329-D	66%	1%	11359	11480	17500		17.5kA							SMD-1A
331-D	66%	1%	11359	11480	17500		17.5kA							SMD-1A
117-D	94%	0%	5854	5871	6276		150 Sym							HSO - SSM
Beatrice Plant														
PCB1102	43%	3%	16892	17368	40000		40kA	500/5,	2000	3		2003		Mitsubishi 100-SFMT-

								2000/5						40HE
PCB1104	43%	3%	16892	17368	40000		40kA	500/5, 2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1108	43%	3%	16892	17368	40000		40kA	500/5, 2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1110	43%	3%	16892	17368	40000		40kA	500/5, 2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1112	43%	3%	16892	17368	40000		40kA	500/5, 2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1114	43%	3%	16892	17368	40000		40kA	500/5, 2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1116	43%	3%	16892	17368	40000		40kA	500/5, 2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1118	43%	3%	16892	17368	40000		40kA	500/5, 2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1120	43%	3%	16892	17368	40000		40kA	500/5, 2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1122	43%	3%	16892	17368	40000		40kA	500/5, 2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
PCB1124	43%	3%	16892	17368	40000		40kA	500/5, 2000/5	2000	3		2003		Mitsubishi 100-SFMT-40HE
Beatrice South														
CS1110	21%	2%	5093	5204	25000		25kA		1200			2002		S&C 2030
PCB302	24%	-19%	6427	5204	22000		22kA	1200/5	1200	5		1972	E71-20	Westinghouse 345-GS-1500
PCB304	23%	-19%	6427	5204	23000		23kA	1200/5	1200	3		1997	E12831	Siemens SPS-72.5-23-1
PCB306	24%	-19%	6427	5204	22000		22kA	1200/5	1200	5		1972	E71-20	Westinghouse 345-GS-1500
CS314	65%	-19%	6427	5204	8000		8kA		1200			1978		S&C IV-1
PCB316	24%	-19%	6427	5204	22000		22kA	1200/5	1200	5		1972	E71-20	Westinghouse 345-GS-1500
314-D	52%	-19%	6427	5204	10000		10kA							SMD-20
115-D	45%	0%	6237	6258	14000		14kA							SMD-20
119-D	45%	0%	6237	6258	14000		14kA							SMD-20
Carleton Jct. (115kV)		1%	5507	5563										
Clatonia (115kV)		1%	9961	10033										
Crete														
PCB1102	48%	25%	7628	9569	20000		20kA	1200/5	1200	3		1977	76-36	Allis Chalmers BZO-121-20-7
PCB1104	24%	25%	7628	9569	40000		40kA	1200/5	1200	3		2008		Mistsubishi 100-SFMT-40HE-1
CS1110	38%	25%	7628	9569	25000		25kA		1200			2008		S&C 2030
CS1112	38%	25%	7628	9569	25000		25kA		1200			2008		S&C 2030
PCB302	58%	8%	11798	12743	21840	87%	1500 Asym	600/5	1200	5	2	1966	882	Allis Chalmers TDO-34-1500
PCB304	58%	8%	11798	12743	21840	87%	1500 Asym	600/5	1200	5	2	1966	882	Allis Chalmers TDO-34-1500
PCB306	58%	8%	11798	12743	21840	87%	1500 Asym	600/5	1200	5	2	1966	882	Allis Chalmers TDO-34-1500
PCB308	32%	8%	11798	12743	40000		40kA	2000/5	2000	3		2006		Siemens SPS2-72.5-40-2
PCB310	56%	8%	11798	12743	22844	91%	1500 Asym	600/5	1200	5	1	1966	882	Allis Chalmers TDO-34-1500
PCB312	58%	8%	11798	12743	22000		22kA	1200/5	1200	5		1972	E71-20	Westinghouse 345-GS-1500
PCB314	40%	8%	11798	12743	31500		31.5kA	1200/5	2000	3		2008		ABB 72-PMI-31-20

PCB318	58%	8%	11798	12743	22000		22kA	1200/5	1200	5		1972	E77-23	Westinghouse 345-GS-1500
PCB320	32%	8%	11798	12743	40000		40kA	1200/5	2000	3		2009		Areva DT1-72.5 F1 FK
PCB322	51%	8%	11798	12743	25000		25kA	1200/5	1200			1990		Square D FBS-3122025
319-D	73%	8%	11798	12743	17500		17.5kA							SMD-1A
315-D	73%	8%	11798	12743	17500		17.5kA							SMD-1A
115-D	60%	3%	8224	8437	14000		14kA							SMD-20
117-D	60%	3%	8224	8437	14000		14kA							SMD-20
Fairbury														
PCB1102	29%	16%	4969	5779	19831	79%	5000 Asym	1200/5	1200	3	1	1962	320	General Electric FK-115-5000
CS1110	83%	16%	4969	5779	7000		7kA		1200			1977		S&C IV-1
PCB302	89%	5%	6486	6804	7615	91%	500 Asym	600/5	600	8	3	1951	650	General Electric FK-339-34.5-500-3
PCB306	34%	5%	6486	6804	20082	80%	1500 Asym	1200/5	1200	5	3	1965	681	Allis Charlmers TDO-34-1500
PCB308	31%	5%	6486	6804	22000		22kA	2000/5	1200	5		1974	73-45	General Electric FKA-38-22000-6
PCB310	81%	5%	6486	6804	8368	100%	500 Asym	600/5	600	8	1	1952	252	General Electric FK-439-34.5-500
CS314	170%	5%	6486	6804	4000		4kA		1200			1965		S&C G-1
314-D	68%	5%	6486	6804	10000		10kA							SMD-20
319-D	68%	5%	6486	6804	10000		10kA							SMD-20
320-D	68%	5%	6486	6804	10000		10kA							SMD-20
115-D	46%	2%	6258	6389	14000		14kA							SMD-20
Friend														
CS1110	23%	5%	5363	5648	25000		25kA		1200			2003		S&C 2030
PCB302	18%	1%	3822	3851	22000		22kA	1200/5	1200	5		1972	E77-23	Westinghouse 345-GS-1500
319-D	39%	1%	3822	3851	10000		10kA							SMD-20
115-D	30%	0%	4155	4174	14000		14kA							SMD-20
Geneva (115kV)		1%	9424	9497										
Harbine														
PCB1102	24%	44%	6716	9671	40000		40kA	2000/5	2000	3		2009	07-38A	Mitsubishi 100-SFMT-40HE-1
PCB1104	24%	44%	6716	9671	40000		40kA	2000/5	2000	3		2009	07-38	Mitsubishi 100-SFMT-40HE-1
PCB1106	24%	44%	6716	9671	40000		40kA	2000/5	2000	3		2008	07-38A	Mitsubishi 100-SFMT-40HE-1
Hebron (115kV)		2%	5525	5650										
Hebron North														
PCB1102	30%	2%	5827	5971	19831	79%	5000 Asym	1200/5	1200	3	1	1960	E58-37	Westinghouse GM-6B
PCB1104	30%	2%	5827	5971	19831	79%	5000 Asym	1200/5	1200	3	1	1960	E58-37	Westinghouse GM-6B
PCB1106	30%	2%	5827	5971	20000		20kA	1200/5	1200	3		1978	78-1	McGraw Edison AHF-48-121-20
CS1110	24%	2%	5827	5971	25000		25kA		1200			2008		S&C 2030
CS1114	75%	2%	5827	5971	8000		8kA		1200			1978		S&C IV-2
1114-D2	57%	2%	5827	5971	10500		10.5kA							SMD-2B
Knob Hill (Westar)		3%	4184	4305										
Sheldon (115kV)														
PCB1102	77%	2%	30283	30774	40000		40kA		1600			1973	E72-20	Westinghouse 121-GMA-40
PCB1104	77%	2%	30283	30774	40000		40kA		1600			1973	E72-20	Westinghouse 121-GMA-

													40
PCB1106	77%	2%	30283	30774	40000		40kA	1600			1973	E72-20	Westinghouse 121-GMA-40
PCB1108	77%	2%	30283	30774	40000		40kA	1600			1973	E72-20	Westinghouse 121-GMA-40
PCB1110	77%	2%	30283	30774	40000		40kA	1600			1973	E72-20	Westinghouse 121-GMA-40
PCB1112	77%	2%	30283	30774	40000		40kA	2000			2002		Mitsubishi 100-SFMT-40HE
PCB1114	77%	2%	30283	30774	40000		40kA	1600			1973	E72-20	Westinghouse 121-GMA-40
PCB1116	77%	2%	30283	30774	40000		40kA	1600			1973	E72-20	Westinghouse 121-GMA-40
PCB1118	77%	2%	30283	30774	40000		40kA	1600			1973	E72-20	Westinghouse 121-GMA-40
PCB1120	77%	2%	30283	30774	40000		40kA	1600			1973	E72-20	Westinghouse 121-GMA-40
PCB1122	77%	2%	30283	30774	40000		40kA	1600			1974	73-45	General Electric FK-121-40000-6
PCB1124	77%	2%	30283	30774	40000		40kA	2000			2002		Mitsubishi 100-SFMT-40HE
PCB1126	77%	2%	30283	30774	40000		40kA	1600			1973	E72-20	Westinghouse 121-GMA-40
PCB1132	74%	2%	30283	30774	41671	83%	10000 Asym	2000	3	0	1968	E68-6	Westinghouse 1150-GM-10000
PCB1134	81%	2%	30283	30774	38156	76%	10000 Asym	2000	3	1	1968	E68-6	Westinghouse 1150-GM-10000
PCB1136	81%	2%	30283	30774	38156	76%	10000 Asym	2000	3	1	1969	E68-6	Westinghouse 1150-GM-10000
PCB302	29%	0%	5775	5780	20000		20kA	1200			1991	81900	Square D FBS-3122020
PCB304	26%	0%	5775	5780	21840	87%	1500 Asym	1200	5	2	1961	967	General Electric FKA-34.5-1500-1
319-D	58%	0%	5775	5780	10000		10kA						SMD-20
Steele City													
PCB1102	15%	16%	5069	5892	40000		40kA	2000	3		2008		Mitsubishi 100-SFMT-40HE-1
PCB1104	15%	16%	5069	5892	40000		40kA	2000	3		2008		Mitsubishi 100-SFMT-40HE-1
PCB1108	15%	16%	5069	5892	40000		40kA	2000	3		2008		Mitsubishi 100-SFMT-40HE-1
PCB1114	15%	16%	5069	5892	40000		40kA	2000	3		2009		ABB 121-PMI-40-20
Steinauer (115kV)		0%	4288	4308									
Superior (115kV)		0%	3360	3375									

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 facility 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 the wind project.

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. Two PTDF flowgates, COOPER_S and WNE_WKS, were significantly impacted by the wind projects. COOPER_S was the highest impacted flowgate at over 27% DF. WNE_WKS was impacted at roughly 5% DF for the wind project at Harbine. 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 project 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 project 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 project.

Table 19. DFCALC Results

Type	Interface	2011 Spring Peak 99.0 MW GEN-2010-044 GEN-to-GEN (MW)
PTDF	COOPER_S	**27.1% (26.9 MW)**
	FTCAL_S	-6.1%
	GGS	-1.4%
	GRIS_LNC	-2.3%
	WNE_WKS	**5.0% (4.9 MW)**
OTDF	S1226TEKAMAH	1.9%
	RIVERBEND	**2.8% (2.8 MW)**
	KELLYTECH	**6.2% (6.1 MW)**
	TEKRNS3451RN	2.0%

** 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-2011-002 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-2010-044 Interconnection Facilities – Harbine 115 kV substation expansion to accommodate new 115 kV interconnection.
  $ 0.8 Million

- Harbine – Crete 115 kV Line – Construct new ~27-mile 115 kV transmission line from the Harbine 115 kV substation to the Crete 115 kV substation. Project includes substation expansions at both substations to accommodate the new transmission line.
  $ 17.2 Million

- Harbine – Beatrice 115 kV Facility Upgrade – Upgrade the Harbine – Beatrice 115 kV facility to accommodate a 240 MVA facility rating. **$ 4.6 Million**

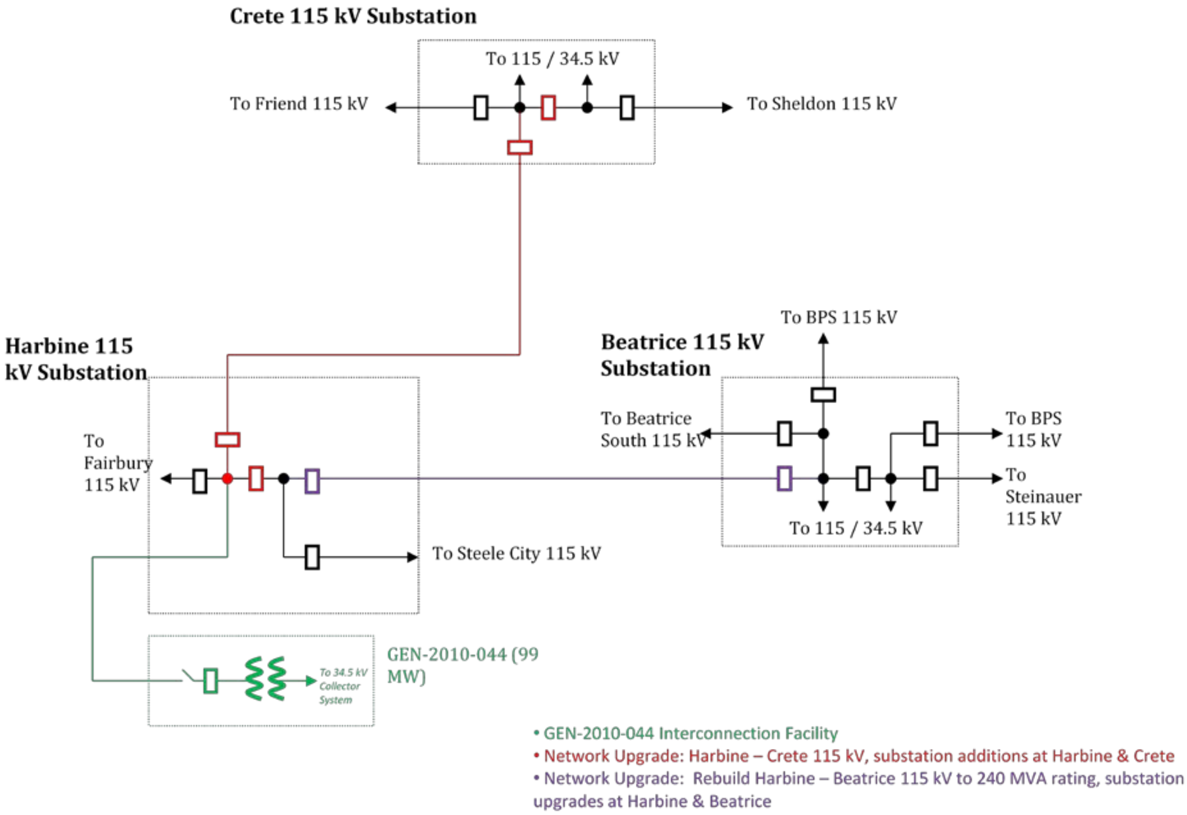
Total Interconnection & Network Upgrades: $22.6 Million

Proposed one-line diagrams of the interconnection and network upgrades are on the following pages. NPPD will work with the wind generation facility project 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 or longer 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.

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-2011-002 generation projects are dependent on the transmission upgrades/additions that are required as part of the DISIS-2011-001, DISIS-2010-002, DISIS-2010-001 and DISIS-2009-001 interconnection plans. If there are any modifications to the DISIS-2011-001, DISIS-2010-002, DISIS-2010-001 and DISIS-2009-001 generation or transmission projects, then the interconnection plan for the DISIS-2011-002 projects could be affected. This facility study would need to be re-studied and re-evaluated if for any reason any of the DISIS-2011-001, DISIS-2010-002, DISIS-2010-001 or DISIS-2009-001 generation or transmission projects do not move forward.

GEN-2010-044



Crete 115 kV Substation
To 115 / 34.5 kV
To Friend 115 kV
To Sheldon 115 kV
Harbine 115 kV Substation
To Fairbury 115 kV
To Steele City 115 kV
Beatrice 115 kV Substation
To BPS 115 kV
To Beatrice South 115 kV
To BPS 115 kV
To Steinauer 115 kV
To 115 / 34.5 kV
To 34.5 kV Collector System
GEN-2010-044 (99 MW)
• GEN-2010-044 Interconnection Facility
• Network Upgrade: Harbine – Crete 115 kV, substation additions at Harbine & Crete
• Network Upgrade: Rebuild Harbine – Beatrice 115 kV to 240 MVA rating, substation upgrades at Harbine & Beatrice