
# Facility Study
# For
# Generator Interconnection
# Request
# GEN-2013-032

***SPP Generator***
***Interconnection Studies***

***(#GEN-2013-032)***

**June 2014**

# Revision History

| Date | Author | Change Description |
|---|---|---|
| 06/25/2014 | SPP | Facility Study Report Issued |

**Summary**
Nebraska Public Power District (NPPD), performed a detailed Facility Study at the request of Southwest Power Pool (SPP) for Generation Interconnection request GEN-2013-032 (204.0 MW) located in Antelope County, Nebraska. SPP has proposed the in-service date will be after the assigned Interconnection Facilities and Non-Shared Network Upgrades are completed. Full Interconnection Service will require the Network Upgrades listed in the "Other Network Upgrades" section. 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 NPPD owned 115 kV bus at the planned Neligh East Substation. The Interconnection 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 expand the proposed Neligh East substation 115 kV substation to allow for the addition of one (1) 115 kV line terminal to accept the Interconnection Customer's Interconnection Facilities. The required Network Upgrades include adding two (2) 115 kV breakers to the proposed Neligh East substation. NPPD has proposed a lead time of approximately twenty-four (24) to thirty-six (36) months for the completion of the Interconnection Facilities and all Non-Shared Network Upgrades. At this time GEN-2013-032 is responsible for $2,500,000 of Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades.

**Shared Network Upgrades**
The Interconnection Customer was studied within the DISIS-2013-002 Impact Study. At this time, the Interconnection Customer is allocated $0.00 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. At this time, the Interconnection Customer is allocated the following cost for Shared Network Upgrade:

- None at this time

**Other Network Upgrades**

Certain Other Network Upgrades are currently not the cost responsibility of the Customer but will be required for full Interconnection Service. Currently, the following Other Network Upgrades are required:

- Broken Bow Wind – Ord – North Loup 115 kV, assigned as a 2014 ITPNT Reliability Upgrade with an unknown In-Service Date (ISD)
- Neligh CS1114-D2 Capacitor Bank #1 Primary Fuse Replacement, assigned to DISIS-2013-001 Customer(s) with an estimated 7/2018 ISD
- Meadow Grove – Norfolk South 230 kV, assigned to DISIS-2013-001 Customer(s) with an estimated 7/2018 ISD
- Meadow Grove 230/115 kV and Meadow Grove – Petersburg North 115 kV, assigned to DISIS-2013-001 Customer(s) with an estimated 7/2018 ISD
- Hoskins – Neligh East 345 kV, assigned to DISIS-2013-001 Customer(s) with an estimated 7/2018 ISD

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.

**Conclusion**

Interconnection Service for GEN-2013-032 will be delayed until the Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades are constructed. The Interconnection Customer is responsible for $2,500,000 of Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades. At this time, the Interconnection Customer is allocated $0.00 for Shared Network Upgrades. After all Interconnection Facilities and Network Upgrades have been placed into service, Interconnection Service for 204.0 MW, as requested by GEN-2013-032, can be allowed. At this time the total allocation of costs assigned to GEN-2013-032 for Interconnection Service are estimated at $2,500,000.

# DISIS-2013-002b
# GENERATION INTERCONNECTION FACILITY STUDY

**SPP GEN-2013-032 204.0 MW at Neligh East (Antelope) 345-115 kV Substation**

## JUNE 2014

**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"*

# Table of Contents

# Executive Summary

The *NPPD DISIS-2013-002b Facility Study* was performed to document the reliability impacts of a generation project that is proposed to interconnect to the NPPD transmission system. This 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 projects listed below:

| Project | MW | Type | Point-of-Interconnection |
|---|---|---|---|
| GEN-2013-021 | 229.5 | Wind | Ogallala 230 kV Substation |
| GEN-2013-032 | 204.0 | Wind | Neligh East 115 kV Substation (Antelope) |
| | 433.5 | | |

SPP entered into a facility study agreement with each of the generation interconnection customers and subsequently requested that NPPD perform the Facility Study for each request. SPP also requested the NPPD facility study address the impacts of GEN-2013-021 on the GGS flowgate. In response to the SPP request, NPPD has performed a Facility Study for each of the generation interconnection requests separately due to the complex nature of GEN-2013-021 which impacts the GGS flowgate and associated special protection system (SPS). This facility study (DISIS-2013-002b) focused on the impacts of **GEN-2013-032** which included a detailed loadflow analysis and short circuit analysis. The Facility Study also includes detailed cost estimates and estimated project schedules for the interconnection and network upgrades identified in the System Impact and Facility Study.

The DISIS-2013-002b Facility Study includes a loadflow analysis and short circuit analysis.

The Loadflow Analysis documents the steady-state performance of the network following the generation interconnection project. 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 Nebraska transmission system in accordance with NERC Standards TPL-001 and TPL-002. The Phase 1 screening identified the Petersburg North – Petersburg – Albion 115 kV line as limiting for two N-1 contingencies in the 2014 Summer Peak case. The 2014 ITP-NT project of the Broken Bow Wind – Ord 115 kV line was found to mitigate the loading issue to below 100% and this project is expected to be in-service by Summer 2018 and would be required for the GEN-2013-032 to interconnect. The Phase 1 screening did not discover any impacted bus voltages outside of limits for system intact or N-1 conditions (NERC Category A & B).

Phase 2 of the loadflow analysis involved a comprehensive multiple element contingency analysis of the Nebraska transmission system. The Neligh East – County Line – Battle Creek 115 kV line and Petersburg North – Petersburg 115 kV lines were found to overload for a number of Category C and Category D contingencies in the Phase 2

screening. No pre-contingency mitigation would be required for these contingencies; however, post-contingency mitigation would be required of the generation interconnection to address these overload conditions. There were no impacted bus voltages outside of limits discovered in the Phase 2 screening for NERC Category C and D 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 off-peak 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 generation project. The results of the Phase 3 portion of the loadflow analysis revealed no additional facility overloads or voltage violations that would require mitigation due to TPL-001, TPL-002, TPL-003, and TPL-004 contingencies. This phase did identify several independent N-2 contingencies that would require prior outage generation limitations of the proposed generation interconnection projects. These prior outage limitations would be developed through an operational study and/or operational guides if the projects continue to be developed. The limiting prior outages are listed below:

Limiting Prior Outage Facilities

1. Neligh East – Hoskins 345 kV
2. Neligh East 345/115 kV Transformer
3. Bloomfield – Gavins Point 115 kV
4. Creighton – Neligh East 115 kV
5. Hartington – Gavins Point 115 kV
6. Hoskins – Norfolk South 345 kV
7. Hoskins 345/115 kV Transformer
8. Meadow Grove – Norfolk South 230 kV
9. Gavins Point – Yankton Junction 115 kV
10. Gavins Point – Spirit Mound 115 kV

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 N-1 transmission facility overloads discovered in the Phase 4 screening that were associated with west-east and north-south transfer limitations in Nebraska. The loading on the line south of the GEN-2010-056 wind project interconnection on the Cooper – St. Joe 345 kV line was discovered for loss of the Cooper – Fairport 345 kV line. If the GEN-2010-056 wind project is developed, then the COOPER_S interface definition may need to be modified to address congestion at this new interconnection substation. The Nebraska City – Maryville – Sibley 345 kV line projects are expected to help relieve flowgate congestion through the transmission corridor south of Cooper.

The Short Circuit Analysis was performed to evaluate the fault interrupting capability of existing devices in the area and protection coordination issues following the generation interconnection projects and network upgrades. The results of this analysis showed that

there was one protective device that would be subject to replacement with a breaker due to the proposed interconnection projects.

Overall, the *NPPD DISIS-2013-002b Facility Study* documents the performance of the network following the addition of the generation interconnection project and network upgrades. The Facility Study has documented the transmission plan required for interconnection to the NPPD transmission system and the details of this plan are listed on the following pages.

**DISIS-2013-002b Interconnection Plan**

*Interconnection Facilities*

- GEN-2013-032 Interconnection Facilities – Expansion of the planned Neligh East (Antelope) 345/115 kV substation to accommodate a new 115 kV interconnection to the GEN-2013-032 wind project.

**$2.5 Million**

*Required ITP-NT Upgrades*

- Broken Bow Wind – Ord 115 kV project – This previously-identified 2014 ITP-NT project is required to provide generation interconnection capability for GEN-2013-032 due to N-1 issues identified on the Petersburg North – Petersburg – Albion 115 kV line in the facility study.

*Previously-identified Required Transmission Upgrades*

- Meadow Grove – Norfolk South 230 kV project – This previously-allocated DISIS-2013-001 project is required to provide generation interconnection capability for GEN-2013-032.
- Meadow Grove 230/115 kV & Meadow Grove – Petersburg North 115 kV – This previously-allocated DISIS-2013-001 project is required to provide generation interconnection capability for GEN-2013-032.
- Hoskins – Neligh East 345 kV project – This previously-allocated ITP10 project is required to provide generation interconnection capability for GEN-2013-032.

*Third-Party Required Transmission Upgrades*

- Gavins Point – Yankton Junction 115 kV upgrade – This WAPA project was identified by SPP as a necessary third party upgrade for the interconnection of GEN-2013-032. SPP, WAPA and the developer will need to coordinate to complete this upgrade.

# 1.0 Introduction

In April 2014, NPPD was notified that several generation interconnection requests in the SPP generation interconnection queue had advanced to the facility study stage. These generation interconnection requests were evaluated by SPP in the Definitive Interconnection System Impact Study (DISIS-2013-002). The generation interconnection requests are listed below:

| Project | MW | Type | Point-of-Interconnection |
|---|---|---|---|
| GEN-2013-021 | 229.5 | Wind | Ogallala 230 kV Substation |
| GEN-2013-032 | 204.0 | Wind | Neligh East 115 kV Substation (Antelope) |
| | 433.5 | | |

SPP entered into a facility study agreement with each of the generation interconnection customers and subsequently requested that NPPD perform the Facility Study for each request. SPP also requested the NPPD facility study address the impacts of GEN-2013-021 on the GGS flowgate. In response to the SPP request, NPPD has performed a Facility Study for each of the generation interconnection requests. Separate facility studies were performed for each request due to the complex nature of GEN-2013-021 which impacts the GGS flowgate and associated special protection system (SPS).

This facility study (DISIS-2013-002b) will focus solely on **GEN-2013-032 (Neligh East/Antelope)** and includes a detailed loadflow and short circuit 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 this generation interconnection project is below:

- GEN-2013-032 Interconnection Facilities – Expansion of Neligh East 115 kV Substation (Antelope)
- Gavins Point – Yankton Junction 115 kV upgrade – This WAPA project was identified by SPP as a necessary third party upgrade for the interconnection of GEN-2013-032. SPP and WAPA will need to coordinate to complete this upgrade.
- Meadow Grove – Norfolk South 230 kV project – This previously-allocated DISIS-2013-001 project is required to provide generation interconnection capability for GEN-2013-032.
- Meadow Grove 230/115 kV & Meadow Grove – Petersburg North 115 kV – This previously-allocated DISIS-2013-001 project is required to provide generation interconnection capability for GEN-2013-032.
- Hoskins – Neligh East 345 kV project – This previously-allocated ITP10 project is required to provide generation interconnection capability for GEN-2013-032.

# 2.0 Study Scope

## 2.1 Overview

This Facility Study will evaluate the impact of the requested generation 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-2013-002, and progressed to the facilities study stage. The GI projects on the NPPD transmission system included in the DISIS-2013-002 study are as follows:

| Project | MW | Type | Point-of-Interconnection |
|---|---|---|---|
| GEN-2013-021 | 229.5 | Wind | Ogallala 230 kV Substation |
| GEN-2013-032 | 204.0 | Wind | Neligh East 115 kV Substation (Antelope) |
| | 433.5 | | |

NPPD will perform a Facility Study for each of the generation interconnection requests. Separate facility studies will be performed for each request due to the complex nature of GEN-2013-021 which impacts the GGS flowgate and associated special protection system (SPS).

This facility study (DISIS-2013-002b) will focus on **GEN-2013-032 (Neligh East/Antelope)** and includes a detailed loadflow and short circuit 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 this generation interconnection project is below:

- GEN-2013-032 Interconnection Facilities – Expansion of Neligh East 345-115 kV Substation (Antelope) for 115 kV terminal for GEN-2013-032 interconnection.
- Gavins Point – Yankton Junction 115 kV upgrade – This WAPA project was identified by SPP as a necessary third party upgrade for the interconnection of GEN-2013-032. SPP and WAPA will need to coordinate to complete this upgrade.
- Meadow Grove – Norfolk South 230 kV project – This previously-allocated DISIS-2013-001 project is required to provide generation interconnection capability for GEN-2013-032.
- Meadow Grove 230/115 kV & Meadow Grove – Petersburg North 115 kV – This previously-allocated DISIS-2013-001 project is required to provide generation interconnection capability for GEN-2013-032.
- Hoskins – Neligh East 345 kV project – This previously-allocated ITP10 project is required to provide generation interconnection capability for GEN-2013-032.

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-2013-002 facility study will be required. The previously queued GI projects and network upgrades in the Nebraska area are as follows:

| **Request** | MW | Area | Point-Of-Interconnection | Status |
|---|---|---|---|---|
| GEN-2006-037N1 | 75 | NPPD | Broken Bow 115kV | Under Development |
| GEN-2008-086N02 | 200 | NPPD | Tap Ft Randall - Kelly 230kV (Meadow Grove) | Under Development |
| GEN-2008-123N | 89.7 | NPPD | Tap Guide Rock - Pauline 115kV | Under Development |
| GEN-2010-051 | 200 | NPPD | Tap Twin Church - Hoskins 230kV | Under Development |
| GEN-2011-027 | 120 | NPPD | Tap Twin Church - Hoskins 230kV | Under Development |
| GEN-2013-002 | 50.6 | LES | Tap Sheldon - Folsom 115kV CKT 1 | Facility Study |
| GEN-2010-041 | 10.5 | OPPD | S 1399 161kV | IA Pending |
| GEN-2011-055 | 52.8 | OPPD | South Sterling 69kV | IA Pending |
| GEN-2010-056 | 151 | MIPU | Tap Cooper - St. Joe 345kV | Under Development |
| GEN-2012-005 | 81 | NPPD | New 230 kV Sub on Ft. Randall – Meadow Grove 230 kV line | Facility Study |
| GEN-2013-004 | 6.5 | NPPD | Prairie Breeze 230 kV Collector Substation | Facility Study |
| GEN-2013-005 | 73.5 | NPPD | Prairie Breeze 230 kV Collector Substation | Facility Study |
| GEN-2013-006 | 50.6 | NPPD | Meadow Grove 230 kV Substation | Facility Study |
| GEN-2013-008 | 1.2 | NPPD | Steele Flats 115 kV Collector Substation | IA Pending |
| GEN-2013-014 | 25.5 | NPPD | Rosemont 115 kV Substation | IA Pending |
| GEN-2013-015 | 125.8 | NPPD | New 115 kV Sub on Pauline – Hildreth 115 kV line | IA Pending |
| GEN-2013-019 | 73.6 | LES | Sheldon - Folsom & Pleasant Hill 115kV CKT 2 | Facility Study |

Previously allocated interconnection facilities & network upgrades

- Meadow Grove 230 kV substation (for GEN-2008-086N02)
- Upgrade Ft.Randall-MeadowGrove-Kelly 230kV line
- Rosemont 115 kV substation (for GEN-2008-123N)
- Dixon County 230 kV substation (for GEN-2010-051)
- Upgrade Twin Church-DixonCounty-Hoskins 230kV line
- Cooper-St. Joseph 345 kV substation (for GEN-2010-056)
- Knox County 230 kV substation (for GEN-2012-005)
- Bladen 115 kV substation (for GEN-2013-015)
- Norfolk South 345/230 kV substation
- Meadow Grove – Norfolk South 230 kV line
- Meadow Grove – Petersburg North 115 kV line
- Neligh 115 kV over-dutied breaker

This facility study will assess the new system state with the generation interconnection request. 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 generation interconnections and network upgrades. The Facility Study will include the following study phases:

1. Loadflow Analysis
2. Short Circuit Analysis

The loadflow analysis will be an assessment of the transmission system following the addition of the generation interconnection project and network upgrades. 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 generation interconnection project and network upgrades on existing fault currents in the area and determine if the capability of existing fault interrupting devices are adequate.

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 uprate and will 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 generation interconnection project and network upgrades. The powerflow models used for the loadflow analysis will be 2013 Series SPP MDWG models. These models will represent expected near-term system conditions with the generation interconnection projects and will adequately represent a variety of worst-case seasonal conditions. The powerflow models utilized for the analysis will be:

2014 Spring Peak Case
2014 Summer 100% Peak Load Case
2014 Winter 100% Peak Load Case

The base SPP MDWG powerflow models will be updated with planned transmission facility additions in the area of the generation interconnection request. Specifically, the cases will be updated to include the Hoskins – Neligh East 345 kV project as the point-of-interconnection is dependent on this project.

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, and LES areas plus ties 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 generation interconnection projects. The 2013 Series 2014 Winter Peak Load case will be utilized to show the impacts of the worst case local area contingencies. All of the local area generation included in the study will be redispatched off-system. The purpose of this Phase will be to document sufficient generator outlet transmission capacity for the generation interconnection requests 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 Winter Peak Load case is approximately 70%

of summer peak for the Nebraska region. To stress the generation outlet capacity, the maximum accredited generation is modeled in Nebraska and exported into the surrounding MAPP & SPP regions. The following maximum accredited net generation levels will be modeled in this phase:

| | | |
|---|---|---|
| GEN-2013-032 (Neligh East) | = | 204.0 MW |
| GEN-2012-005 (Knox Co) | = | 81.0 MW |
| GEN-2013-004 (Prairie Breeze) | = | 6.5 MW |
| GEN-2013-005 (Prairie Breeze) | = | 73.5 MW |
| GEN-2013-006 (Meadow Grove) | = | 50.6 MW |
| GEN-2013-008 (Steele City) | = | 1.2 MW |
| GEN-2013-014 (Rosemont) | = | 25.5 MW |
| GEN-2013-015 (Bladen) | = | 125.8 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 |
| Nebraska City #1 | = | 652.0 MW |
| Nebraska City #2 | = | 682.0 MW |
| Cass County #1 | = | 161.5 MW |
| Cass County #2 | = | 161.5 MW |
| Flat Water Wind | = | 60.0 MW |
| Atchison County Wind | = | 144.0 MW |
| Laredo Ridge Wind | = | 80.0 MW |
| TPW Petersburg Wind | = | 40.5 MW |
| Broken Bow Wind | = | 80.0 MW |
| Bloomfield Crofton Hills Wind | = | 42.0 MW |
| Bloomfield Elkhorn Ridge Wind | = | 81.0 MW |
| Steele Flats Wind | = | 73.6 MW |
| Ainsworth Wind | = | 75.0 MW |
| Columbus Hydro #1-3 | = | 45.0 MW |
| Columbus ADM Co-Gen #1 | = | 75.0 MW |
| Gavins Point #1-3 | = | 92.0 MW |
| Ft. Randall #1-6 | = | 347.0 MW |
| GEN-2006-037N1 (BrokenBow) | = | 75.0 MW |
| GEN-2008-086N02 (MeadowGrove) | = | 200.0 MW |
| GEN-2008-123N (Rosemont) | = | 89.7 MW |
| GEN-2010-051 (DixonCo) | = | 200.0 MW |
| GEN-2011-027 (DixonCo) | = | 120.0 MW |

| | | |
|---|---|---|
| GEN-2013-002 (HallamN) | = | 50.6 MW |
| GEN-2010-041 (Flat Water exp.) | = | 10.5 MW |
| GEN-2011-055 (Johnson County) | = | 52.8 MW |
| GEN-2013-019 (HallamN2) | = | 73.6 MW |
| GEN-2010-056 (Cooper-StJoe) | = | 151.0 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 Nebraska area under emergency conditions.

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 west-to-east and north-to-south transfer conditions. Transfer cases will be established to evaluate the system with the new generation interconnection projects. Every single element rated from 115 kV – 345 kV in the NPPD, OPPD, and LES areas plus ties 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 impacts of the proposed generation interconnection projects on the existing substation equipment fault duty ratings in the area. The substations to be evaluated are those electrically close to the interconnection points of the generation interconnection projects.

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

## 2.4 Detailed Cost Estimates & Project Schedule

NPPD Engineering, Asset Management, and Project Management departments will review the transmission upgrades identified in the SPP DISIS-2013-002 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

Overview

This study was conducted using Rev 32.2.1 of Power Technology Inc.'s (PTI's) Power System Simulator (PSS/E) software package and the following SPP 2013 Series MDWG powerflow models:

2014 Spring Peak Load Case
2014 Winter Peak Load Case
2014 Summer 100% Peak Load Case

The powerflow models were updated to include the generation interconnection projects and network upgrades as well as the latest transmission upgrades documented in the latest regional transmission plans. Specifically, the cases will be updated to include the Hoskins – Neligh East 345 kV project as the point-of-interconnection is dependent on this project.

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:

| | | |
|---|---|---|
| GEN-2012-005 (Knox Co) | = | 81.0 MW |
| GEN-2013-004 (Prairie Breeze) | = | 6.5 MW |
| GEN-2013-005 (Prairie Breeze) | = | 73.5 MW |
| GEN-2013-006 (Meadow Grove) | = | 50.6 MW |
| GEN-2013-008 (Steele City) | = | 1.2 MW |
| GEN-2013-014 (Rosemont) | = | 25.5 MW |
| GEN-2013-015 (Bladen) | = | 125.8 MW |
| Sheldon #1 | = | 105.0 MW |
| Sheldon #2 | = | 120.0 MW |
| Nebraska City #1 | = | 652.0 MW |
| Nebraska City #2 | = | 682.0 MW |
| Flat Water Wind | = | 60.0 MW |
| Atchison County Wind | = | 144.0 MW |
| Laredo Ridge Wind | = | 80.0 MW |
| TPW Petersburg Wind | = | 40.5 MW |
| Broken Bow Wind | = | 80.0 MW |
| Bloomfield Crofton Hills Wind | = | 42.0 MW |
| Bloomfield Elkhorn Ridge Wind | = | 81.0 MW |
| Steele Flats Wind | = | 73.6 MW |
| Ainsworth Wind | = | 75.0 MW |
| Columbus Hydro #1-3 | = | 45.0 MW |
| Columbus ADM Co-Gen #1 | = | 75.0 MW |
| Gavins Point #1-3 | = | 92.0 MW |

| | | |
|---|---|---|
| Ft. Randall #1-6 | = | 347.0 MW |
| GEN-2006-037N1 (BrokenBow) | = | 75.0 MW |
| GEN-2008-086N02 (MeadowGrove) | = | 200.0 MW |
| GEN-2008-123N (Rosemont) | = | 89.7 MW |
| GEN-2010-051 (DixonCo) | = | 200.0 MW |
| GEN-2011-027 (DixonCo) | = | 120.0 MW |
| GEN-2013-002 (HallamN) | = | 50.6 MW |
| GEN-2010-041 (Flat Water exp.) | = | 10.5 MW |
| GEN-2011-055 (Johnson County) | = | 52.8 MW |
| GEN-2013-018 (S974-HydroTap) | = | 51.0 MW |
| GEN-2010-056 (Cooper-StJoe) | = | 151.0 MW |

The in-service 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 proposed future generation interconnection projects were dispatched off-system to other BA's in the SPP footprint. The new generation interconnection projects listed below were then added to the models and dispatched at 100%. The total output (204 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-2013-032 (Neligh East) | = | 204.0 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 facility study.

# 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, and LES areas out of service. Transmission facilities in the NPPD, OPPD, and LES 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 generation interconnection projects and proposed new network upgrades 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, and LES areas for the full AC solution contingency runs. Activity VCHK produced a listing of those buses whose voltage magnitude was greater than 1.05 PU, followed by a listing of buses whose voltage was less than 0.95 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 – 2014 Spring</u>

*System Intact Results (TPL-001):*

There were no impacted transmission facility overloads or bus voltages outside of limits under system intact or base case conditions for the 2014 Spring model.

*N-1 Contingency Results (TPL-002):*

There were no impacted transmission facility overloads or bus voltages discovered outside of limits under N-1 conditions for the 2014 Spring model.

Phase 1 – 2014 Summer Peak

*System Intact Results (TPL-001):*

There were no impacted transmission facility overloads or bus voltages outside of limits under system intact or base case conditions for the 2014 Summer Peak model.

*N-1 Contingency Results (TPL-002):*

The Petersburg North – Petersburg 115 kV line was found to overload for loss of the Loup City – North Loup 115 kV line (106.5%) or the Meadow Grove – Kelly 230 kV line (100.2%). The Petersburg – Albion 115 kV line was found to overload for loss of the Loup City – North Loup 115 kV line (102.9%). For both contingencies and overloads, the 2014 ITP-NT project of the Broken Bow Wind – Ord 115 kV line was found to mitigate the overloads to below 100%.

There were no impacted bus voltages discovered outside of limits under N-1 conditions for the 2014 Summer Peak model.

Phase 1 – 2014 Winter Peak

*System Intact Results (TPL-001):*

There were no impacted transmission facility overloads or bus voltages outside of limits under system intact or base case conditions for the 2014 Winter Peak model.

*N-1 Contingency Results (TPL-002):*

There were no impacted transmission facility overloads or bus voltages discovered outside of limits under N-1 conditions for the 2014 Winter Peak model.

**Phase 1 Results Summary**

The Phase 1 screening identified the Petersburg North – Petersburg – Albion 115 kV line as limiting for two N-1 contingencies in the 2014 Summer Peak case. The 2014 ITP-NT project of the Broken Bow Wind – Ord 115 kV line was found to mitigate the loading issue to below 100%. As such, the Broken Bow Wind – Ord 115 kV line project would need to be in-service prior to the interconnection of the GEN-2013-032 project to mitigate the issue. The Phase 1 screening did not discover any impacted bus voltages outside of limits for system intact or N-1 conditions.

## 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, and LES 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 generation interconnection projects and proposed new network upgrades according to TPL-003 and TPL-004 standards.

Phase 2 – 2014 Spring

*Category C Results (TPL-003):*

The Neligh East – County Line – Battle Creek 115 kV line was found to overload to 111.9% and 111.2%, respectively, for a stuck breaker outage in the Hoskins 345 kV substation (Hoskins – Neligh East 345 kV & Hoskins – Norfolk South 345 kV). No pre-contingency mitigation would be required for this contingency; however, post-contingency mitigation would be required of the generation interconnection to address this overload condition.

There were no impacted bus voltages discovered outside of limits under Category C contingency conditions for the 2014 Spring model.

*Category D Results (TPL-004):*

The Neligh East – County Line – Battle Creek 115 kV line was found to overload to 106.0% and 105.3%, respectively, for the loss of the Hoskins 345 kV substation. No pre-contingency mitigation would be required for this contingency; however, post-contingency mitigation would be required of the generation interconnection to address this overload condition.

There were no impacted bus voltages discovered outside of limits under Category D contingency conditions for the 2014 Spring model.

Phase 2 – 2014 Summer Peak

*Category C Results (TPL-003):*

The Petersburg North – Petersburg 115 kV line was found to overload (103.0%) for loss of the Kelly 230 kV bus or stuck breaker outage at Kelly 230 kV. No pre-contingency mitigation would be required for this contingency; however, post-contingency mitigation would be required of the generation interconnection to address this overload condition.

There were no impacted bus voltages discovered outside of limits under Category C contingency conditions for the 2014 Summer Peak model.

*Category D Results (TPL-004):*

The Petersburg North – Petersburg 115 kV line was found to overload (103.0%) for loss of the Kelly 230 kV substation. No pre-contingency mitigation would be required for this contingency; however, post-contingency mitigation would be required of the generation interconnection to address this overload condition.

There were no impacted bus voltages discovered outside of limits under Category D contingency conditions for the 2014 Summer Peak model.

Phase 2 – 2014 Winter Peak

*Category C Results (TPL-003):*

The Neligh East – County Line – Battle Creek 115 kV line was found to overload to 106.1% and 105.6%, respectively, for a stuck breaker outage in the Hoskins 345 kV substation (Hoskins – Neligh East 345 kV & Hoskins – Norfolk South 345 kV). No pre-contingency mitigation would be required for this contingency; however, post-contingency mitigation would be required of the generation interconnection to address this overload condition.

There were no impacted bus voltages discovered outside of limits under Category C contingency conditions for the 2014 Winter Peak model.

*Category D Results (TPL-004):*

The Neligh East – County Line – Battle Creek 115 kV line was found to overload to 107.9% and 107.3%, respectively, for the loss of the Hoskins 345 kV substation. No pre-contingency mitigation would be required for this contingency; however, post-

contingency mitigation would be required of the generation interconnection to address this overload condition.

There were no impacted bus voltages discovered outside of limits under Category D contingency conditions for the 2014 Winter Peak model.

**Phase 2 Results Summary**

The Neligh East – County Line – Battle Creek 115 kV line and Petersburg North – Petersburg 115 kV lines were found to overload for a number of Category C and Category D contingencies in the Phase 2 screening. No pre-contingency mitigation would be required for these contingencies; however, post-contingency mitigation would be required of the generation interconnection to address these overload conditions.

There were no impacted bus voltages outside of limits 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. ACCC was utilized to analyze the system by sequentially taking contingencies in the NPPD, LES, and OPPD area out-of-service and monitoring facilities in the NPPD, LES, and OPPD area for violations of loading or bus voltage criteria.

Phase 3 – 2014 Winter Peak – Maximum Generation (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 2014 Winter Peak – Maximum Generation model.

*N-1 Contingency Results (TPL-002):*

There were no impacted transmission facility overloads or bus voltages discovered outside of limits under N-1 conditions for the 2014 Winter Peak – Maximum Generation model.

### 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 Nebraska area. PSS/E activity ACCC was used as a screening tool on the maximum generation base case 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 Nebraska area and monitoring facilities in the NPPD, OPPD, and LES 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.

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-Harbine 115 kV
Stuck PCB at Hoskins 230 kV
Stuck PCB 3322 at Hoskins 345 kV
Stuck PCB 3308 at Hoskins 345 kV
Stuck PCB 3310 at Hoskins 345 kV
Stuck PCB 3312 at Hoskins 345 kV
Stuck PCB at Hoskins 115 kV north bus
Stuck PCB at Hoskins 115 kV south bus
Stuck PCB at Twin Church 230 kV north bus
Stuck PCB at Twin Church 230 kV south bus
Stuck PCB at Twin Church 115 kV
Stuck PCB at Twin Church 115 kV
Stuck PCB at Meadow Grove 230 kV
Stuck PCB at Meadow Grove 230 kV
Stuck PCB at Norfolk South 230 kV
Stuck PCB at Kelly 230 kV
Stuck PCB at Neligh East 115 kV (Neligh East 345/115, Neligh East – Creighton 115kV)
Stuck PCB at Neligh East 115 kV (Neligh East–County Line 115kV, Neligh East – Neligh 115kV)

Phase 3 – 2014 Winter Peak – Maximum Generation (Stuck PCB / Double Circuit)

The Neligh East – County Line – Battle Creek 115 kV line was found to overload to 110.4% and 109.8%, respectively, for a stuck breaker outage in the Hoskins 345 kV substation (Hoskins – Neligh East 345 kV & Hoskins – Norfolk South 345 kV).

The Neligh East – County Line – Battle Creek 115 kV line was found to overload to 105.5% and 104.9%, respectively, for a stuck breaker outage in the Neligh East 115 kV substation (Neligh East 345/115 kV transformer & Neligh East – Creighton 115 kV).

No pre-contingency mitigation would be required for these contingencies; however, post-contingency mitigation would be required of the generation interconnection to address these overload conditions.

There were no bus voltages outside of limits for the multiple element contingencies evaluated using the 2014 Winter Peak – 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 local area of the generation interconnection projects. PSS/E activity ACCC was used as a screening tool on the 2014 Winter Peak Maximum Generation powerflow model with the generation interconnection projects to identify those contingencies which deserve closer study. ACCC analyzed the system by sequentially taking out all independent N-2 contingencies in the local area and monitoring facilities in the NPPD, OPPD, and LES areas for violations of loading or bus voltage criteria. A total of 2055 independent N-2 contingencies were included in this contingency analysis.

Phase 3 – 2014 Winter Peak – Maximum Generation (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 2014 Winter Peak Maximum Generation case with the generation interconnection addition. The worst-case facility overloads identified in the ACCC analysis are summarized 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 generation interconnection 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 if all the projects are developed. 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. Neligh East – Hoskins 345 kV
2. Neligh East 345/115 kV Transformer
3. Bloomfield – Gavins Point 115 kV
4. Creighton – Neligh East 115 kV
5. Hartington – Gavins Point 115 kV
6. Hoskins – Norfolk South 345 kV
7. Hoskins 345/115 kV Transformer
8. Meadow Grove – Norfolk South 230 kV
9. Gavins Point – Yankton Junction 115 kV
10. Gavins Point – Spirit Mound 115 kV

## Phase 3 Results Summary

Overall, there were no impacted transmission facility overloads or bus voltages outside of limits discovered in the Phase 3 screening for NERC category A, B, and C contingencies. There were several independent N-2 contingencies that resulted in overloads and would require prior-outage generation limitations to mitigate the identified issues if all the proposed projects are developed.

## 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 generation interconnection projects according to TPL-001 and TPL-002 standards. This phase utilized the 2014 Winter 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. 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, and LES areas out of service. Transmission facilities in the NPPD, OPPD, and LES 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 2014 Winter Peak case with transfers.

*N-1 Contingency Results (TPL-002):*

Multiple overloaded transmission facilities were discovered in the monitored study areas in the N-1 ACCC analysis of the 2014 Winter Peak case with transfers and the generation interconnection projects. These facility overloads are listed below:

| Facility | Contingency | Rating | Loading |
|---|---|---|---|
| N.Platte–Stockville 115kV | GGS–Red Willow 345kV | 137 MVA | 105.5% |
| GEN-2010-056 Wind-St.Joe 345kV | Cooper – Fairport 345kV | 1195 MVA | 101.0% |
| Pauline-Rosemont 115kV | Guide Rock-Rosemont 115kV | 120 MVA | 101.4%[A] |
| Ogallala-Sidney 230kV | Sidney-Keystone 345kV | 320 MVA | 117.7%[B] |
| Victory Hill 230/115kV | Stegall-Wayside 230kV | 187 MVA | 105.7%[C] |

*A – Generator Outlet Issue at Rosemont 115 kV*
*B - Loading mitigated through implementation of Sidney DC RAS*
*C – Loading mitigated with future Stegall-Scottsbluff 115 kV project*

The loading on the line south of the GEN-2010-056 wind project interconnection on the Cooper – St. Joe 345 kV line was discovered for loss of the Cooper – Fairport 345 kV line. If the GEN-2010-056 wind project is developed, then the COOPER_S interface definition may need to be modified to address congestion at this new interconnection substation. The Nebraska City – Maryville – Sibley 345 kV line projects are expected to help relieve flowgate congestion through the transmission corridor south of Cooper.

The North Platte – Stockville 115 kV line was overloaded for loss of the GGS – Red Willow 345 kV line. This is a known limitation associated with the WNE_WKS flowgate. It is expected to be relieved by the future GGS – Thedford – Holt County 345 kV project in 2018.

**Phase 4 Results Summary**

Overall, there were multiple transmission facility overloads discovered in the Phase 4 screening that was associated with west-east and north-south transfer limitations in Nebraska. The north-south transfer limitations are expected to be relieved with the future addition of the Nebraska City – Maryville – Sibley 345 kV line in 2017. The west-east transfer limitations are expected to be relieved with the future addition of the GGS – Thedford – Holt County 345 kV line in 2018.

# 6.0 Short Circuit Analysis

## 6.1 Model Development

### Computer Programs

The Aspen OneLiner software program was utilized to perform short circuit simulations and studies on the transmission system. Standard procedures that the transmission system protection department uses for short-circuit studies were used for short-circuit calculations for this study. Where elements were added to the short-circuit model, best estimates for impedance parameters were used based on available data and typical modeling practices.

### Base System Model Additions ("Base Case")

The base system model used by the transmission system protection department as of November 7, 2013 was used as the starting point for the short-circuit model used for this study. The base system model included all projects that were in-service at the time the model was copied. For the study base case, planned system upgrades in the area of the studied projects and prior-queued large generator interconnections expected to be in-service prior to the projects being studied were added to the base case model. The following table lists the prior-queued large generator interconnections that were added to the base model for this study.

**Prior Queued Large Generator Interconnections**

| Queue Designation | Proposed POI | Capacity (MW) |
|---|---|---|
| GEN-2006-037N1 | Broken Bow 115 kV | 75 |
| GEN-2008-123N | Rosemont 115 kV (New substation) | 89.7 |
| GEN-2010-051 | Wakefield 230 kV (New substation) | 200 |
| GEN-2011-027 | Wakefield 230 kV (New substation) | 120 |
| GEN-2012-005 | Knox County 230 kV (New substation) | 81 |
| GEN-2013-004 | Prairie Breeze 230 kV (Add to existing 34.5 kV collector bus) | 6.5 |
| GEN-2013-005 | Prairie Breeze 230 kV | 73.5 |
| GEN-2013-006 | Meadow Grove 230 kV | 50.6 |
| GEN-2013-008 | Steele City 115 kV (Add to existing 34.5 kV collector bus) | 1.2 |
| GEN-2013-014 | Rosemont 230 kV | 25.5 |
| GEN-2013-015 | Bladen 115 kV (New substation) | 125.8 |

Along with the prior-queued large generator interconnections, system upgrades previously identified to accommodate the prior-queued projects were added to the study model. The upgrades previously identified included the following additions:

- New “Norfolk South” Substation tapping the Hoskins – Shell Creek 345 kV line
- New 345 kV – 230 kV autotransformer at the Norfolk South Substation
- New 230 kV transmission line from Norfolk South to Meadow Grove
- New 230 kV – 115 kV autotransformer at the Meadow Grove Substation
- New 115 kV transmission line from Meadow Grove to Petersburg North

In addition to the prior-queued large generator interconnections, planned system upgrades in the area of the studied projects were added to the base model. For this study, the upgrades associated with the Antelope 115 kV – 345 kV substation were included in the model, including the four re-routed 115 kV lines into the new Antelope Substation, the one new 345 kV line from Hoskins to Antelope, and a new 345 kV – 115 kV auto transformer at the new Antelope Substation. The planned 345 kV line from GGS – Cherry County – Holt County was also included with a 345 – 115 kV tie at Thedford 115 kV.

**Model Additions for Projects Being Studied (“Study Case”)**

The base-case study model was modified to include the new generation interconnections being considered in this study as well as the system upgrades identified to accommodate this additional generation. The following table lists the large generator interconnections that were added to the study-case model for this study.

**Large Generator Interconnections Added to Study Case**

| Queue Designation | Proposed POI | Capacity (MW) |
|---|---|---|
| GEN-2013-021 | Ogallala 230 kV (Expand existing substation) | 229.5 |
| GEN-2013-032 | Antelope 115 kV (Expand new substation) | 204 |

No network upgrades associated with the generator interconnections being studied were included with this study.

## 6.2 Study Methodology

The portion of the system potentially impacted by the projects being considered in this study was determined by identifying buses at which the available fault current increased by more than 5% between the base case and the study case. For buses identified as potentially impacted by these projects, the equipment connected at those buses was examined to determine if the additional fault current exceed the interrupting or short circuit current capability of the equipment.

To allow for modeling errors, all protective devices within 90% of their interrupting

rating or short-circuit capability will be identified. It is recommended that all breakers/fuses within 95% of the nameplate interrupting rating or short-circuit capacity be replaced unless otherwise noted.

## 6.3 Results

The device shown in the table below was recommended for replacement in NPPD's facility study for DISIS-2013-001, so the cost for the replacement should already be allocated to the previously considered projects.

| Substation | Device Number | Circuit | % of Rating | Δ |
|---|---|---|---|---|
| Neligh | CS1114-D2 Fuse | Cap Bank #1 Primary Fuse | 111% | 14% |

No additional devices were found to be above 95% of their interrupting rating or short-circuit capability due to the addition of the projects considered in this study.

# 7.0 Detailed Cost Estimates & Project Schedule

NPPD's Engineering, Asset Management, and Project Management groups have reviewed the list of interconnection facility upgrades that are required for GEN-2013-032 project. Detailed cost estimates have been prepared for the new facility upgrades that were identified in the SPP DISIS-2013-002 system impact study for the GEN-2013-032 request. 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:

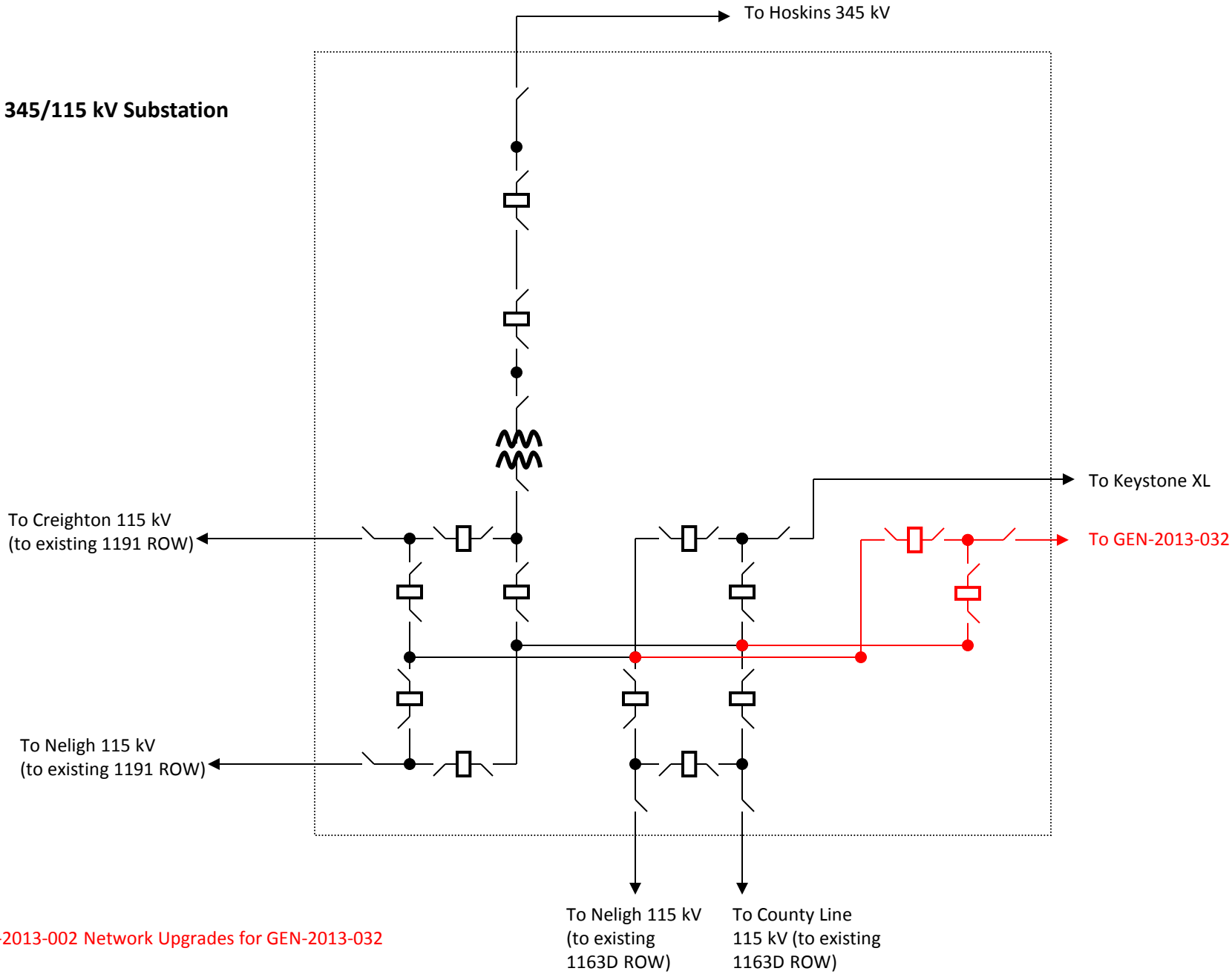
- GEN-2013-032 Interconnection Facilities – Expansion of the planned Neligh East (Antelope) 345/115 kV substation to accommodate a new 115 kV interconnection to the GEN-2013-032 wind project.

**$2.5 Million**

The substation one-line diagram highlighting the interconnection facility upgrades are on the following pages. NPPD will work with the generation interconnection projects to develop project schedules for the interconnection facilities and network upgrade projects listed above during the development of the generation interconnection agreement. Typical implementation schedules for new transmission lines (≥ 115 kV) are roughly 4 years 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 also be noted that the interconnection plan for the DISIS-2013-002b generation projects are dependent on the transmission upgrades/additions that are required as part of the previous Definitive Interconnection Studies and SPP ITP Studies. If there are any modifications to these previous studies and related upgrades, then the interconnection plan for the DISIS-2013-002b projects could be affected.

**Neligh East 345/115 kV Substation (Antelope)**




● DISIS-2013-002 Network Upgrades for GEN-2013-032