Southwest Power Pool

Interconnection Facilities Studies For Generator Interconnection Requests GEN-2014-031/IFS-2014-002-08 GEN-2014-032/IFS-2014-002-09 GEN-2014-039/IFS-2014-002-13

SPP Generator Interconnection Studies

(#GEN-2014-031/IFS-2014-002-08)
(#GEN-2014-032/IFS-2014-002-09)
(#GEN-2014-039/IFS-2014-002-13)

October 2015

Revision History

Date	Author	Change Description
8/24/2015	SPP	Draft Interconnection Facilities Study Report Revision 0 Issued
10/2/2015	SPP	Final Interconnection Facilities Study Report posted

Summary

Nebraska Public Power District (NPPD) performed a detailed Interconnection Facilities Study at the request of Southwest Power Pool (SPP) for Generator Interconnection Request(s) (GIRs) listed in **Table 1**.

Table 1: IFS-2014-002 NPPD Interconnection Facilities Request(s)

Request Number	Location	Fuel Source	Amount (MW)	Original Customer Proposed In-Service Date
GEN-2014-031 IFS-2014-002-08	Antelope County, Nebraska	Wind	35.8	10/1/2015
GEN-2014-032 IFS-2014-002-09	Antelope County, Nebraska	Wind	10.2	10/1/2015
GEN-2014-039 IFS-2014-002-13	Saline County, Nebraska	Wind	73.4	12/1/2016

SPP has proposed that the full interconnection service in-service date will be after the assigned Interconnection Facilities and Non-Shared Network upgrades are completed.

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 Generator Interconnection Request(s) listed in **Table 1** were studied in the Interconnection Facilities Study for the proposed Point of Interconnection listed in **Table 2** for the NPPD transmission system.

Table 2: GI Requests Point of Interconnection

SPP G.I. Request Number	Point of Interconnection (POI)
GEN-2014-031 IFS-2014-002-08	Meadow Grove 230kV
GEN-2014-032 IFS-2014-002-09	Meadow Grove 230kV
GEN-2014-039 IFS-2014-002-13	Friend 115kV

GEN-2014-031/IFS-2014-002-08

The GEN-2014-031/IFS-2014-002-08 (GEN-2014-031) Interconnection Customer's generator facility consists of twenty (20) General Electric (G.E.) 1.79 MW wind turbines for a total generating nameplate rating of 35.8 MW. GEN-2014-031's 34.5kV collector system will connect to the GEN-2014-013/IFS-2014-001-07 (GEN-2014-013) 34.5kV bus and utilize the planned one (1) 230/34.5kV GEN-2014-013Interconnection Customer owned and maintained transformer(s) at the GEN-2014-013 Interconnection Customer owned substation. The short overhead 230kV transmission circuit planned for GEN-2014-013 will connect GEN-2014-031 and GEN-2014-013 to the GEN-2008-086N02 Interconnection

Customer 230kV facilities and utilize the GEN-2008-086N02 twenty-two (22) mile overhead 230kV generator lead to the Point of Interconnection (POI) at the existing NPPD owned 230kV bus at the Meadow Grove Substation. The Interconnection Customer, GEN-2014-031 will be responsible for all of the transmission facilities connecting the Interconnection Customer owned substation to the Point of Change of Ownership (PCO) with the Transmission Owner either through total or shared ownership with other Interconnection Customers. The Interconnection Customer, GEN-2014-031, will be responsible for any equipment located at the Customer substation necessary to maintain a power factor of 0.95 lagging and 0.95 leading at the POI, including approximately 4.1 Mvar[1] of reactors to compensate for injection of reactive power into the transmission system under reduced generating conditions. Also, the Interconnection Customer, GEN-2014-031 will need to coordinate with the Transmission Owner for relay, protection, control, and communication system configurations.

GEN-2014-032/IFS-2014-002-09

The GEN-2014-032/IFS-2014-002-09 (GEN-2014-032) Interconnection Customer Request consists of a 10.22 MW uprate to the GEN-2008-086N02 generator facility. GEN-2014-032 includes an uprate to the GEN-2008-086N02 one hundred – eighteen (118) General Electric (G.E.) 1.7 MW wind turbines to one hundred – eighteen (118) General Electric (G.E.) 1.79 MW turbines for a total generating nameplate rating of 211.22 for GEN-2008-086N02 and GEN-2014-032 combined. GEN-2014-032 will utilize the existing GEN-2008-086N02 facilities configuration to the Point of Interconnection on the 230kV bus at Meadow Grove. The Interconnection Customer, GEN-2014-032 will be responsible for all of the transmission facilities connecting the Interconnection Customer owned substation to the Point of Change of Ownership (PCO) with the Transmission Owner either through total or shared ownership with other Interconnection Customers. The Interconnection Customer, GEN-2014-032, will be responsible for any equipment located at the Customer substation necessary to maintain a power factor of 0.95 lagging and 0.95 leading, including reactors or equivalent means such as the WindFREE™ G.E. option to compensate for injection of reactive power into the transmission system under reduced generating conditions at the POI. Also, the Interconnection Customer, GEN-2014-032 will need to coordinate with the Transmission Owner for relay, protection, control, and communication system configurations.

GEN-2014-039/IFS-2014-002-13

The GEN-2014-039/IFS-2014-002-13 (GEN-2014-039) Interconnection Customer's generator facility consists of forty-one (41) General Electric (G.E.) 1.79 MW wind turbines for a total generating nameplate rating of 73.39 MW. GEN-2014-039 Interconnection Customer's 34.5kV collector system will connect to one (1) 115/34.5kV GEN-2014-039 Interconnection Customer owned and maintained transformer(s) at the GEN-2014-039 Interconnection Customer owned substation. The short (<1 mile) overhead 115kV transmission circuit will connect GEN-2014-039 to the Point of Interconnection (POI) at the

[1] This is an approximate minimum reactor amount needed for the configuration of the wind farm studied in DISIS-2014-002 Group 09 Reduced Wind Analysis Addendum. This approximate amount of reactors is subject to change based on results of modification study discussed above.

existing NPPD owned 115kV bus at the Friend Substation. The Interconnection Customer, GEN-2014-039 will be responsible for all of the transmission facilities connecting the Interconnection Customer owned substation to the Point of Change of Ownership (PCO) with the Transmission Owner. The Interconnection Customer, GEN-2014-039, will be responsible for any equipment located at the Customer substation necessary to maintain a power factor of 0.95 lagging and 0.95 leading at the POI. Also, the Interconnection Customer, GEN-2014-039 will need to coordinate with the Transmission Owner for relay, protection, control, and communication system configurations.

Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades

GEN-2014-031/IFS-2014-002-08

To facilitate the GEN-2014-031 interconnection, the Transmission Owner will need to review and update metering or relaying for acceptance of the GEN-2014-031 Interconnection Customer's Interconnection Facilities. Engineering and Construction (E&C) lead times for Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades will be developed during negotiations of the Generator Interconnection Agreement (GIA). **Table 3** displays the current estimated costs for GEN-2014-031 Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades.

Table 3: GEN-2014-031/IFS-2014-002-08 TOIF and Non-Shared Network Upgrades

Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades Description	Allocated Cost ($)	Allocated Percent (%)	Total Cost ($)
Meadow Grove Substation - Transmission Owner Interconnection Facilities 230kV Substation work for metering and/or relay work	$100,000	100%	$100,000
Meadow Grove Substation - Network Upgrades 230kV Substation work	$0	N/A	$0
Total	$100,000	100%	$100,000

At this time, GEN-2014-031 is responsible for $100,000 of Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades.

A Shared Facilities Usage Agreement for the shared facilities with GEN-2008-086N02 and GEN-2014-013 shall be required for Generator Interconnection Service. Shared Facilities Usage Agreement details will be determined during the negotiation phase of the GIA. If GEN-2014-013 withdraws or terminates it's Generator Interconnection Request (GIR), Transmission Owner Interconnection Facilities and Non-Shared Network Upgrade(s) and cost requirements for GEN-2014-013 shall be the cost allocation responsibility of GEN-2014-031.

GEN-2014-032/IFS-2014-002-09

To facilitate the GEN-2014-032 interconnection, the Transmission Owner will need to review and update metering or relaying for acceptance of the GEN-2014-032 Interconnection Customer's Interconnection Facilities. Currently, the cost of this work is assigned to GEN-2014-031. Engineering and Construction (E&C) lead times for Transmission Owner

Interconnection Facilities and Non-Shared Network Upgrades will be developed during negotiations of the Generator Interconnection Agreement (GIA). **Table 4** displays the current estimated costs for GEN-2014-032 Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades.

Table 4: GEN-2014-032/IFS-2014-002-09 TOIF and Non-Shared Network Upgrades

Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades Description	Allocated Cost ($)	Allocated Percent (%)	Total Cost ($)
Meadow Grove Substation - Transmission Owner Interconnection Facilities 230kV Substation work for metering and/or relay work	$0	N/A	$0
Meadow Grove Substation - Network Upgrades 230kV Substation work	$0	N/A	$0
Total	$0	N/A	$0

At this time, GEN-2014-032 is responsible for $0 of Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades.

If GEN-2014-031 withdraws or terminates it's Generator Interconnection Request (GIR), Transmission Owner Interconnection Facilities and Non-Shared Network Upgrade(s) and cost requirements for GEN-2014-031 shall be the cost allocation responsibility of GEN-2014-032.

GEN-2014-039/IFS-2014-002-13

To facilitate the GEN-2014-039 interconnection the Transmission Owner will need expand the existing NPPD Friend 115kV Substation to a ring configuration, install three (3) 115kV circuit breakers, associated disconnect switches, and other associated thermal equipment for acceptance of the GEN-2014-039Interconnection Customer's Interconnection Facilities. Engineering and Construction (E&C) lead times for Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades will be developed during negotiations of the Generator Interconnection Agreement (GIA). **Table 5** displays the current estimated costs for GEN-2014-039 Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades.

Table 5: GEN-2014-039/IFS-2014-002-13 TOIF and Non-Shared Network Upgrades

Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades Description	Allocated Cost ($)	Allocated Percent (%)	Total Cost ($)
Friend Substation - Transmission Owner Interconnection Facilities 115kV Substation work for installing 115kV line terminal, switch, and dead-end tower	$600,000	100%	$600,000
Friend Substation - Network Upgrades 230kV Substation work for installing three (3) 115kV breakers, switches, communication, metering, and associated terminal equipment	$4,300,000	100%	$4,300,000
Total	$4,900,000	N/A	$4,900,000

At this time, GEN-2014-039 is responsible for $4,900,000 of Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades.

Shared Network Upgrades

The Interconnection Customers, GEN-2014-031, GEN-2014-032, and GEN-2014-039 were studied within the DISIS-2014-002 Impact Study and the DISIS-2014-002-1 Impact Restudy as Energy Resource Interconnection Service (ERIS) and Network Resource Interconnection Service (NRIS) with updated cost allocations in DISIS-2014-002-2 Impact Restudy. At this time, the Interconnection Customers are 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 Upgrade(s). 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 Customers is allocated the following cost listed in **Table 5** for Shared Network Upgrade(s):

Table 6: GEN-2014-031/IFS-2014-002-08, GEN-2014-032/IFS-2014-002-09, and GEN-2014-039/IFS-2014-002-13 Shared Network Upgrades

Shared Network Upgrades Description	Allocated Cost ($)	Allocated Percent (%)	Total Cost ($)
Currently, GEN-2014-031/IFS-2014-002-08, GEN-2014-032/IFS-2014-002-09, and GEN-2014-039/IFS-2014-002-13 are not allocated any Shared Network Upgrades	$0	N/A	$0
Total	$0	N/A	$0

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 for GEN-2014-031/IFS-2014-002-08:

- Battle Creek – County Line – Neligh East 115kV circuit #1 rebuild assigned to DISIS-2013-002 Interconnection Customer
- Hoskins – Neligh 345/115kV Project build assigned in the SPP 2014 Integrated Transmission Plan- Near Term Assessment (2014 ITP NT) per SPP-200253 on schedule for 6/1/2016 in-service
- Hoskins – Dixon County – Twin Church 230kV circuit #1 conductor clearance increase assigned to DISIS-2010-002 and DISIS-2011-001 Interconnection Customers

Currently, the following Other Network Upgrades are required for GEN-2014-032/IFS-2014-002-09:

- Battle Creek – County Line – Neligh East 115kV circuit #1 rebuild assigned to DISIS-2013-002 Interconnection Customer

- Hoskins – Neligh 345/115kV Project build assigned in the SPP 2014 Integrated Transmission Plan- Near Term Assessment (2014 ITP NT) per SPP-200253 on schedule for 6/1/2016 in-service
- Hoskins – Dixon County – Twin Church 230kV circuit #1 conductor clearance increase assigned to DISIS-2010-002 and DISIS-2011-001 Interconnection Customers

Currently, the following Other Network Upgrades are required for GEN-2014-039/IFS-2014-002-13:

- Battle Creek – County Line – Neligh East 115kV circuit #1 rebuild assigned to DISIS-2013-002 Interconnection Customer
- Hoskins – Neligh 345/115kV Project build assigned in the SPP 2014 Integrated Transmission Plan- Near Term Assessment (2014 ITP NT) per SPP-200253 on schedule for 6/1/2016 in-service
- Hoskins – Dixon County – Twin Church 230kV circuit #1 conductor clearance increase assigned to DISIS-2010-002 and DISIS-2011-001 Interconnection Customers

Depending upon the status of higher or equally queued customers, the Interconnection Customers' 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-2014-031/IFS-2014-002-08, GEN-2014-032/IFS-2014-002-09, and GEN-2014-039/IFS-2014-002-13 will be delayed until the Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades are constructed.

The Interconnection Customer, GEN-2014-031/IFS-2014-002-08, is responsible for $100,000 of Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades. At this time, the Interconnection Customer, GEN-2014-031/IFS-2014-002-08, is allocated $0 for Shared Network Upgrades. After all Interconnection Facilities and Non-Shared Network Upgrades have been placed into service, Interconnection Service for 35.8 MW, as requested by, GEN-2014-031/IFS-2014-002-08, can be allowed. At this time the total allocation of costs assigned to, GEN-2014-031/IFS-2014-002-08, for interconnection Service are estimated at $100,000.

The Interconnection Customer, GEN-2014-032/IFS-2014-002-09, is responsible for $0 of Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades. If GEN-2014-031/IFS-2014-002-08 withdraws or terminates it's Generator Interconnection Request (GIR), Transmission Owner Interconnection Facilities and Non-Shared Network Upgrade(s) and cost requirements for GEN-2014-031/IFS-2014-002-08 shall be the cost allocation responsibility of GEN-2014-032/IFS-2014-002-09. At this time, the Interconnection Customer, GEN-2014-032/IFS-2014-002-09, is allocated $0 for Shared Network Upgrades. After all Interconnection Facilities and Non-Shared Network Upgrades have been placed into service, Interconnection Service for 10.22 MW, as requested by, GEN-2014-032/IFS-2014-002-09,, can be allowed. At this time the total allocation of costs assigned to, GEN-2014-032/IFS-2014-002-09, for interconnection Service are estimated at $0.

The Interconnection Customer, GEN-2014-039/IFS-2014-002-13, is responsible for $4,900,000 of Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades. At this time, the Interconnection Customer, GEN-2014-039/IFS-2014-002-13, is allocated $0 for Shared Network Upgrades. After all Interconnection Facilities and Non-Shared Network Upgrades have been placed into service, Interconnection Service for 73.4 MW, as requested by, GEN-2014-039/IFS-2014-002-13, can be allowed. At this time the total allocation of costs assigned to, GEN-2014-039/IFS-2014-002-13, for interconnection Service are estimated at $4,900,000.

DISIS-2014-002-1
GENERATION INTERCONNECTION FACILITY STUDY

SPP GEN-2014-031 35.8 MW at Prairie Breeze 230 kV Substation
SPP GEN-2014-032 10.2 MW at Prairie Breeze 230 kV Substation
SPP GEN-2014-039 73.4 MW at Friend 115 kV Substation

AUGUST 2015

PREPARED FOR:
SOUTHWEST POWER POOL

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

Nebraska Public Power District
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Executive Summary

The *NPPD DISIS-2014-002-1 Facility Study* was performed to document the reliability impacts of generation projects that are proposed to interconnect to the NPPD transmission system. These projects have developed through the SPP Definitive Interconnection System Impact Study process and have advanced to the facility study stage. SPP has requested that NPPD perform the Facility Study associated with the generation interconnection projects listed below:

Project	MW	Type	Point-of-Interconnection
GEN-2014-031	+35.8	Wind	Prairie Breeze 230 kV Substation
GEN-2014-032	+10.2	Wind	Prairie Breeze 230 kV Substation
GEN-2014-039	+73.4	Wind	Friend 115 kV Substation
	119.4		

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. This facility study focused on the impacts of the generation interconnection projects 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-2014-002-1 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 projects. 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 did not identify any significantly impacted facilities for system intact or N-1 conditions. The North Platte – Stockville 115 kV line was identified as an impacted constraint, however, the impact was less than the cutoff threshold for generation interconnection studies. The Phase 1 screening did not discover any impacted bus voltages outside of limits for system intact or N-1 conditions.

Phase 2 of the loadflow analysis involved a comprehensive multiple element contingency analysis of the Nebraska transmission system. The Phase 2 screening did not identify any significantly impacted facilities for Category C or Category D conditions. The North Platte – Stockville 115 kV line was identified as an impacted constraint, however, the impact was less than the cutoff threshold for generation interconnection studies. The Phase 2 screening did not discover any impacted bus voltages outside of limits for Category C or Category D conditions.

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. Bloomfield – Gavins Point 115 kV
2. Neligh East – Hoskins 345 kV
3. Neligh East 345/115 kV Transformer
4. Neligh East – County Line 115 kV
5. Gavins Point – Yankton Junction 115 kV
6. Gavins Point – Spirit Mound 115 kV
7. Knob Hill – Steele City 115 kV
8. GEN-2013-002/019 – Folsom & Pleasant Hill 115 kV
9. Geneva – Carleton Junction 115 kV
10. North Hebron – Carleton Junction 115 kV
11. Sheldon – Firth 115 kV
12. Moore 345/115 kV Transformer
13. Sheldon – SW 7th & Bennett 115 kV
14. Harbine – Fairbury 115 kV
15. North Hebron – Fairbury 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 limitations are expected to be marginally improved by the future transmission projects being developed in Nebraska (GGS-Thedford-Holt 345 kV, Nebraska City-Sibley 345 kV), however, these constraint relief benefits should be minimal and the issues documented in this phase of the study will persist if all the proposed generation interconnection projects move forward.

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 no protective devices that were subject to replacement due to the proposed interconnection projects.

Overall, the *NPPD DISIS-2014-002-1 Facility Study* documents the performance of the network following the addition of the generation interconnection projects 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 page. There is no generation interconnection capability available until the projects listed are completed as required.

DISIS-2014-002-1 Interconnection Plan

Interconnection Facilities

- GEN-2014-031 : Metering or Relay changes due to modifications at Prairie Breeze.
- GEN-2014-032 : Metering or Relay changes due to modifications at Prairie Breeze.

$0.1 Million

- GEN-2014-039 : Expansion of Friend 115 kV substation to ring configuration due to proposed generation interconnection and new 115 kV terminal.

$4.9 Million

Previously-identified Required Transmission Upgrades

- Rosemont 115 kV substation (for GEN-2008-123N)
- Dixon County 230 kV substation (for GEN-2010-051)
- Upgrade Twin Church-DixonCounty-Hoskins 230kV line
- Neligh East / Antelope 115 kV substation expansion (for GEN-2013-32)
- Neligh East – County Line – Battle Creek 115 kV upgrade

1.0 Introduction

In May 2015, 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 muliple Definitive Interconnection System Impact Studies (DISIS-2014-002, DISIS-2014-002-1, DISIS-2014-002-2). The generation interconnection requests are listed below:

Project	MW	Type	Point-of-Interconnection
GEN-2014-031	+35.8	Wind	Prairie Breeze 230 kV Substation
GEN-2014-032	+10.2	Wind	Prairie Breeze 230 kV Substation
GEN-2014-039	+73.4	Wind	Friend 115 kV Substation
	119.4		

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. In response to the SPP request, NPPD has performed a Facility Study for the generation interconnection requests.

This facility study (NPPD-DISIS-2014-002-1) 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. The System Impact Study did not identify any network upgrades required for interconnection of the new generation projects. The interconnection facilities and associated upgrades included in this study are listed below:

- GEN-2014-031 : Metering or Relay changes due to modifications at Prairie Breeze.
- GEN-2014-032 : Metering or Relay changes due to modifications at Prairie Breeze.
- GEN-2014-039 : Expansion of Friend 115 kV substation to ring configuration due to proposed generation interconnection and new 115 kV terminal.

2.0 Study Scope

2.1 Overview

This Facility Study will evaluate the impact of the requested generation interconnection projects on the NPPD transmission system. This study will evaluate generator interconnection requests in the SPP Generator Interconnection Queue studied in the SPP Definitive Interconnection System Impact Study, SPP DISIS-2014-002-1, and progressed to the facilities study stage. The GI projects on the NPPD transmission system included in the DISIS-2014-002-1 study are as follows:

Project	MW	Type	Point-of-Interconnection
GEN-2014-031	+35.8	Wind	Prairie Breeze 230 kV Substation
GEN-2014-032	+10.2	Wind	Prairie Breeze 230 kV Substation
GEN-2014-039	+73.4	Wind	Friend 115 kV Substation
	119.4		

NPPD will perform a Facility Study for these generation interconnection requests that 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. No network upgrades were identified in the System Impact Study as required for these generation interconnection projects.

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-2014-002-1 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-2008-123N	89.7	NPPD	Rosemont 115 kV Substation	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-2010-041	10.5	OPPD	S 1399 161kV	Under Development
GEN-2013-008	1.2	NPPD	Steele Flats 115 kV Collector Substation	In Service
GEN-2013-014	25.5	NPPD	Rosemont 115 kV Substation	On Suspension
GEN-2013-002	50.6	LES	Sheldon - Folsom & Pleasant Hill 115kV CKT 2	GIA Filed
GEN-2013-019	73.6	LES	Sheldon - Folsom & Pleasant Hill 115kV CKT 2	GIA Filed
GEN-2013-032	204	NPPD	Neligh East / Antelope 115 kV Substation	GIA Filed
GEN-2014-004	4	NPPD	Steele Flats 115 kV Collector Substation	In Service
GEN-2014-013	73.5	NPPD	Prairie Breeze 230 kV Collector Substation	Under Development

Previously allocated interconnection facilities & network upgrades

- Rosemont 115 kV substation (for GEN-2008-123N)
- Dixon County 230 kV substation (for GEN-2010-051)
- Upgrade Twin Church-DixonCounty-Hoskins 230kV line
- Neligh East / Antelope 115 kV substation expansion (for GEN-2013-32)
- Neligh East – County Line – Battle Creek 115 kV upgrade

This facility study assumes the previously allocated interconnection facilities and network upgrades have been completed. Any new generation interconnection request included in this study will require these same upgrades to be completed and no interconnection capacity is available until these upgrades have been completed. This facility study will assess the new system state with the generation interconnection requests. 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 2014 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:

2016 Spring Load Case
2016 Summer 100% Peak Load Case
2016 Winter 100% Peak Load Case
2020 Spring Load Case
2020 Summer 100% Peak Load Case
2020 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 requests.

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.

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.

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 2014 Series 2016 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. 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-2014-031 (Prairie Breeze)	=	35.8 MW
GEN-2014-032 (Prairie Breeze)	=	10.2 MW
GEN-2014-039 (Friend)	=	73.4 MW
GEN-2014-004 (Steele Flats)	=	3.96 MW
GEN-2014-013 (Prairie Breeze)	=	73.5 MW
GEN-2013-032 (Neligh East)	=	204.0 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-2013-019 (HallamN)	=	73.6 MW
GEN-2013-008 (Steele Flats)	=	1.2 MW
GEN-2013-014 (Rosemont)	=	25.5 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
Broken Bow Wind II	=	75.0 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
Prairie Breeze Wind	=	200.0 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

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.

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 any additional transmission upgrades identified in the SPP DISIS-2014-002-1 facility 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 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:

2016 Spring Load Case
2016 Summer 100% Peak Load Case
2016 Winter 100% Peak Load Case
2020 Spring Load Case
2020 Summer 100% Peak Load Case
2020 Winter 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.

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

GEN-2014-004 (Steele Flats)	=	3.96 MW
GEN-2014-013 (Prairie Breeze)	=	73.5 MW
GEN-2013-032 (Neligh East)	=	204.0 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-2013-019 (HallamN)	=	73.6 MW
GEN-2013-008 (Steele Flats)	=	1.2 MW
GEN-2013-014 (Rosemont)	=	25.5 MW

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 (119.4 MW) from the new generation interconnection projects was dispatched off-system to all other balancing authorities within the SPP footprint on a pro rata basis.

GEN-2014-031 (Prairie Breeze)	=	35.8 MW
GEN-2014-032 (Prairie Breeze)	=	10.2 MW
GEN-2014-039 (Friend)	=	73.4 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 match the power factor requirements identified in the system impact 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 – 2016 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 2016 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 2016 Spring model.

Phase 1 – 2016 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 2016 Summer Peak model.

N-1 Contingency Results (TPL-002):

The North Platte – Stockville 115 kV line was found to overload for loss of the GGS – Red Willow 345 kV line (114.6%). Without the new wind projects, this overload would be 112.9% so the impact to the constraint is less than the cutoff threshold. This residual impact should be noted as it does adversely impact the constraint and could be an issue in transmission service studies and/or real-time operations.

There were no impacted bus voltages discovered outside of limits under N-1 conditions for the 2016 Summer Peak model.

Phase 1 – 2016 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 2016 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 2016 Winter Peak model.

Phase 1 – 2020 Spring

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 2020 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 2020 Spring model.

Phase 1 – 2020 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 2020 Summer Peak model.

N-1 Contingency Results (TPL-002):

There were no impacted transmission facility overloads or bus voltages outside of limits under N-1 conditions for the 2020 Summer Peak model.

Phase 1 – 2020 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 2020 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 2020 Winter Peak model.

Phase 1 Results Summary

The Phase 1 screening did not identify any significantly impacted facilities for system intact or N-1 conditions. The North Platte – Stockville 115 kV line was identified as an impacted constraint, however, the impact was less than the cutoff threshold for generation interconnection studies. 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 – 2016 Spring

Category C Results (TPL-003):

There were no impacted facility overloads or bus voltages discovered outside of limits under Category C contingency conditions for the 2016 Spring model.

Category D Results (TPL-004):

The North Platte – Stockville 115 kV line was found to overload for loss of the GGS 345 kV substation (110.6%). Without the new wind projects, this overload would be 109.3% so the impact to the constraint is less than the cutoff threshold. This residual impact should be noted as it does adversely impact the constraint and could be an issue in transmission service studies and/or real-time operations.

There were no impacted bus voltages discovered outside of limits under Category D contingency conditions for the 2016 Spring model.

Phase 2 – 2016 Summer Peak

Category C Results (TPL-003):

The North Platte – Stockville 115 kV line was found to overload for loss of the GGS – Red Willow 345 kV and GGS – Sweetwater 345 kV #2 double circuit (122.7%). Without the new wind projects, this overload would be 121.3% so the impact to the constraint is less than the cutoff threshold. This residual impact should be noted as it does adversely impact the constraint and could be an issue in transmission service studies and/or real-time operations.

There were no impacted bus voltages discovered outside of limits under Category C contingency conditions for the 2016 Summer Peak model.

Category D Results (TPL-004):

There were no impacted facility overloads or bus voltages discovered outside of limits under Category D contingency conditions for the 2016 Summer Peak model.

Phase 2 – 2016 Winter Peak

Category C Results (TPL-003):

There were no impacted facility overloads or bus voltages discovered outside of limits under Category C contingency conditions for the 2016 Winter Peak model.

Category D Results (TPL-004):

There were no impacted facility overloads or bus voltages discovered outside of limits under Category D contingency conditions for the 2016 Winter Peak model.

Phase 2 – 2020 Spring

Category C Results (TPL-003):

There were no impacted facility overloads or bus voltages discovered outside of limits under Category C contingency conditions for the 2020 Spring model.

Category D Results (TPL-004):

There were no impacted facility overloads or bus voltages discovered outside of limits under Category D contingency conditions for the 2020 Spring model.

Phase 2 – 2020 Summer Peak

Category C Results (TPL-003):

There were no impacted facility overloads or bus voltages discovered outside of limits under Category C contingency conditions for the 2020 Summer Peak model.

Category D Results (TPL-004):

There were no impacted facility overloads or bus voltages discovered outside of limits under Category D contingency conditions for the 2020 Summer Peak model.

Phase 2 – 2020 Winter Peak

Category C Results (TPL-003):

There were no impacted facility overloads or bus voltages discovered outside of limits under Category C contingency conditions for the 2020 Winter Peak model.

Category D Results (TPL-004):

There were no impacted facility overloads or bus voltages discovered outside of limits under Category D contingency conditions for the 2020 Winter Peak model.

Phase 2 Results Summary

The Phase 2 screening did not identify any significantly impacted facilities for Category C or Category D conditions. The North Platte – Stockville 115 kV line was identified as an impacted constraint, however, the impact was less than the cutoff threshold for generation interconnection studies. The Phase 2 screening did not discover any impacted bus voltages outside of limits for Category C or Category D conditions.

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 – 2016 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 2016 Winter Peak – Maximum Generation model.

N-1 Contingency Results (TPL-002):

The North Platte – Stockville 115 kV line was found to overload for loss of the GGS – Red Willow 345 kV line (110.4%). Without the new wind projects, this overload would be 109.1% so the impact to the constraint is less than the cutoff threshold. This residual impact should be noted as it does adversely impact the constraint and could be an issue in transmission service studies and/or real-time operations.

There were no impacted bus voltages discovered outside of limits under N-1 conditions for the 2016 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.

Phase 3 – 2016 Winter Peak – Maximum Generation (Stuck PCB / Double Circuit / Extreme)

Category C Results (TPL-003):

There were no impacted transmission facility overloads or bus voltages outside of limits under the studied Category C conditions for the 2016 Winter Peak – Maximum Generation model.

Category D Results (TPL-004):

There were no impacted transmission facility overloads or bus voltages outside of limits under the studied Category D conditions for the 2016 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 2016 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 1806 independent N-2 contingencies were included in this contingency analysis.

Phase 3 – 2016 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 2016 Winter Peak Maximum Generation case with the generation interconnection addition. 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. Bloomfield – Gavins Point 115 kV
2. Neligh East – Hoskins 345 kV
3. Neligh East 345/115 kV Transformer
4. Neligh East – County Line 115 kV
5. Gavins Point – Yankton Junction 115 kV
6. Gavins Point – Spirit Mound 115 kV
7. Knob Hill – Steele City 115 kV
8. GEN-2013-002/019 – Folsom & Pleasant Hill 115 kV
9. Geneva – Carleton Junction 115 kV
10. North Hebron – Carleton Junction 115 kV
11. Sheldon – Firth 115 kV
12. Moore 345/115 kV Transformer
13. Sheldon – SW 7th & Bennett 115 kV
14. Harbine – Fairbury 115 kV
15. North Hebron – Fairbury 115 kV

Phase 3 Results Summary

Overall, there were no significantly impacted transmission facility overloads or bus voltages outside of limits discovered in the Phase 3 screening for NERC category A, B, C, and D contingencies. There were category B contingencies that resulted in facility overloads that were impacted; however, the impact was less than the cutoff threshold for generation interconnection studies. These facility overloads were documented in the facility study. 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 2016 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. 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):

The Red Willow – Mingo 345 kV line was overloaded to 104.5% of the 785 MVA facility rating and the bus voltages at Red Willow, Mingo and Post Rock 345 kV substation were 0.933, 0.926, and 0.935 per unit, respectively. This is a highly stressed north-south transfer case with the north-south ties in western Nebraska / western Kansas pushed to beyond its limits. The additional generation interconnected north of these constraints will only put more pressure on this area of the system in the future.

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 2016 Spring 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	140.4%
Stockville-RedWillow 115kV	GGS-Red Willow 345kV	137 MVA	123.8%
Beverly-Enders 115kV	GGS-Red Willow 345kV	160 MVA	105.2%
Grant-Enders 115kV	GGS-Red Willow 345kV	120 MVA	103.2%
Red Willow 345/115kV	GGS-Red Willow 345kV	336 MVA	116.2%
Red Willow-Mingo 345kV	Post Rock-Axtell 345kV	785 MVA	133.5%[A]
Ogallala-Sidney 230kV	Sidney-Keystone 345kV	320 MVA	133.4%[B]
GGS-Ogallala 230kV	GGS-Keystone 345kV	320 MVA	100.8%[B]

A – Only worst-case contingency listed in summary table
B – Loading mitigated through implementation of Sidney DC RAS

The bus voltages in western Nebraska are also severely stressed for worst-case contingencies listed above. Voltages on the 345 kV and 115 kV systems in the area are depressed to as low as 0.83-0.84 per unit for the GGS-Red Willow 345 kV and Post Rock-Axtell 345 kV contingencies.

The future ~220-mile GGS – Thedford – Holt 345 kV ITP10 project will help provide some marginal relief to these north-south constraints, however, it won't fully relieve the overloads or voltage issues highlighted in this section of the facility study. The GGS Thedford – Holt 345 kV provides a new west-to-east 345 kV path across Nebraska that helps relieve the flows on the existing west-to-east transmission system, but the prevailing north-to-south flows are marginally affected. The future Nebraska City – Sibley 345 kV line in eastern Nebraska will also provide some marginal relief to the north-south limitations in western Nebraska and western Kansas, but this relief should be minimal.

Phase 4 Results Summary

Overall, there were multiple transmission facility overloads and voltage issues discovered in the Phase 4 screening that were associated with west-east and north-south transfer limitations in Nebraska. The limitations are expected to be marginally improved by the future transmission projects being developed in Nebraska (GGS-Thedford-Holt 345 kV, Nebraska City-Sibley 345 kV), however, these constraint relief benefits should be minimal and the issues documented in this phase of the study will persist if all the proposed generation interconnection projects move forward.

6.0 Short Circuit Study

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 June 30, 2015 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. All Nebraska-area generation in the short-circuit model was enabled in order to provide maximum short-circuit current. 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-2008-123N GEN-2013-014	Rosemont 115 kV (New substation)	115.2
GEN-2010-051	Wakefield 230 kV (New substation)	200
GEN-2011-027	Wakefield 230 kV (New substation)	120
GEN-2014-013	Prairie Breeze 230 kV	73.5
GEN-2013-008	Steele City 115 kV (Add to existing 34.5 kV collector bus)	1.2
GEN-2013-032	Antelope 115 kV (Expand new substation)	204
GEN-2014-004	Steele Flats 115 KV (Add to existing 34.5 kV collector bus)	4
GEN-2013-002	New substation tapping L1197	50.6
GEN-2013-019	New substation tapping L1197	73.6

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:

- Antelope – Tilden – Battle Creek 115 kV line upgrade

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 – Thedford – Holt County was included with a 345 – 115 kV tie transformer at Thedford 115 kV. The planned 115 kV line from Ord to Broken Bow Wind/Muddy Creek substation was included.

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-2014-031	Prairie Breeze 230 kV (Add to existing 230 kV bus)	35.8
GEN-2014-032	Prairie Breeze 230 kV (Add to existing 34.5 kV collector bus)	10.2
GEN-2014-039	Friend 115 kV Substation	73.4

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

No 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 DISIS-2014-002-1 projects. Detailed cost estimates have been prepared for the facility upgrades that were identified in the system impact study for the requests. 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-2014-031 : Metering or Relay changes due to modifications at Prairie Breeze.
- GEN-2014-032 : Metering or Relay changes due to modifications at Prairie Breeze.

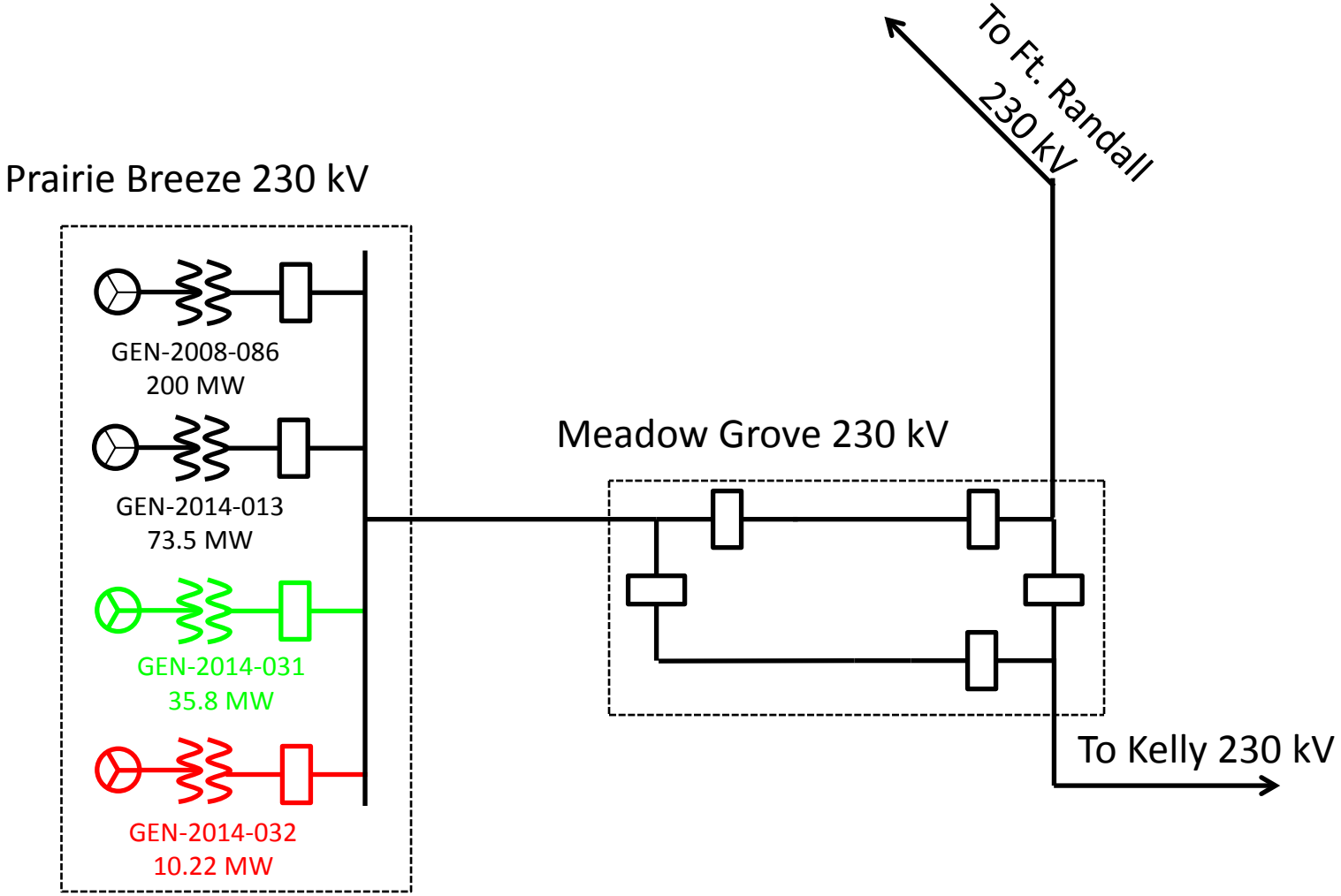
$0.1 Million

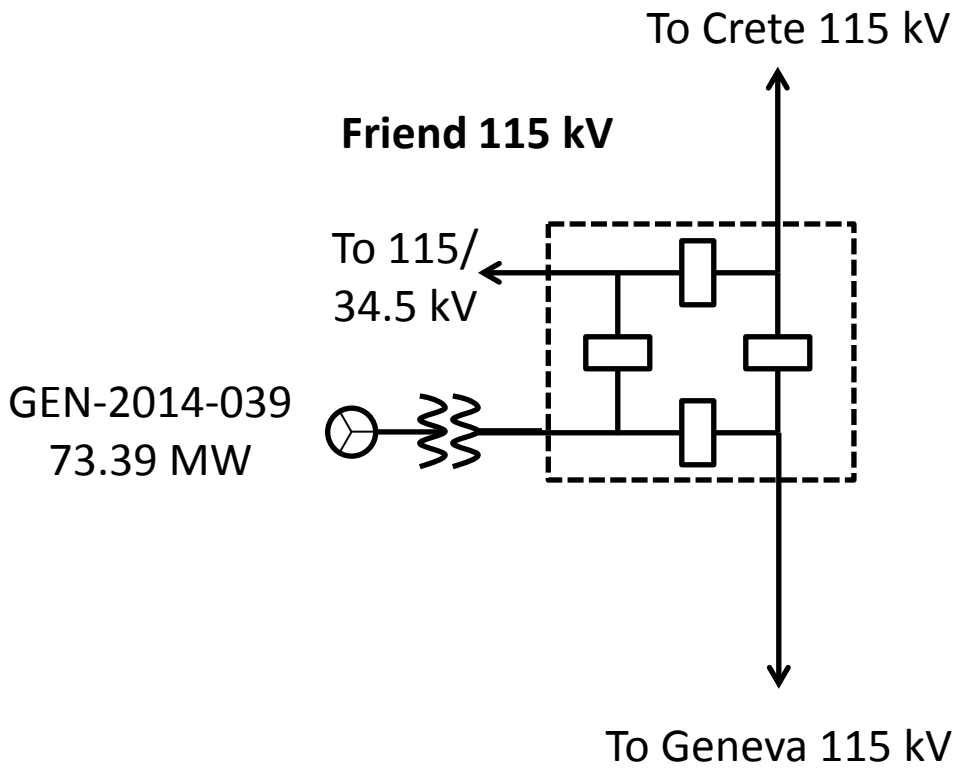
- GEN-2014-039 : Expansion of Friend 115 kV substation to ring configuration due to proposed generation interconnection and new 115 kV terminal.

$4.9 Million

The substation one-line diagram highlighting the 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-2014-002-1 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-2014-002-1 projects could be affected. There is no interconnection capacity for the DISIS-2014-002-1 projects without the previously identified upgrades.


To Ft. Randall
230 kV
Prairie Breeze 230 kV
GEN-2008-086
200 MW
GEN-2014-013
73.5 MW
GEN-2014-031
35.8 MW
GEN-2014-032
10.22 MW
Meadow Grove 230 kV
To Kelly 230 kV


To Crete 115 kV
Friend 115 kV
To 115/
34.5 kV
GEN-2014-039
73.39 MW
To Geneva 115 kV