Southwest Power Pool

Facility Study
Generator Interconnection Request

GEN-2012-005
GEN-2013-004
GEN-2013-005
GEN-2013-006
GEN-2013-008
GEN-2013-014
GEN-2013-015

SPP Generator Interconnection Studies

January 2014

Revision History

Date	Author	Change Description
01/15/2014	SPP	Facility Study Report Issued

Summary

Nebraska Public Power District (NPPD) performed the following Facility Study at the request of the Southwest Power Pool for Generation Interconnection Requests GEN-2012-005, GEN-2013-004, GEN-2013-005, GEN-2013-006, GEN-2013-008, GEN-2013-014, and GEN-2013-015. The requests for interconnection were placed with SPP in accordance with SPP's Open Access Transmission Tariff, which covers new generator interconnections on SPP's transmission system. Table 1 includes the summary of the Generation Interconnection Requests.

Table 1: Generation Interconnection Requests Summary

G.I. Requests	Fuel Source	Capacity (MW)
GEN-2012-005	Wind	81.0
GEN-2013-004	Wind	6.5
GEN-2013-005	Wind	73.5
GEN 2013-006	Wind	50.6
GEN 2013-008	Wind	1.2
GEN-2013-014	Wind	25.5
GEN-2013-015	Wind	125.8

Interconnection Customer Interconnection Facilities

The Interconnection Customers will be responsible for all of the transmission facilities connecting the customers owned substation to the Point of Interconnection (POI). The Point of Interconnection (POI) for each Generation Interconnection request is listed in Table 2. The Interconnection Customer will also be responsible for any equipment located at the Interconnection Customer's substation necessary to maintain a power factor of 0.95 lagging to 0.95 leading at the POI.

Table 2: Generation Interconnection Requests' Point of Interconnection (POI)

G.I. Requests	Point of Interconnection (POI)
GEN-2012-005	Tap Fort Randall – Meadow Grove 230kV
GEN-2013-004	Meadow Grove 230kV (GEN-2008-082N02 Sub)
GEN-2013-005	Meadow Grove 230kV (GEN-2008-082N02 Sub)
GEN 2013-006	Meadow Grove 230kV
GEN 2013-008	Steele City 115kV (GEN-2011-018 Sub)
GEN-2013-014	Tap Guide Rock – Pauline 115kV (Rosemont)
GEN-2013-015	Tap Pauline – Hildreth 115kV

Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades

To allow interconnection for GEN-2012-005 the Transmission Owner will need to build a new 230kV substation along with any associated equipment for acceptance of the Interconnection Customer's Interconnection Facilities. To allow interconnection for GEN-2013-006 the Transmission Owner will need to expand the Meadow Grove Substation and construct any associated equipment for acceptance of the Interconnection Customer's Interconnection Facilities. To allow interconnection for GEN-2013-014 the Transmission Owner will need to expand the Rosemont Substation and construct any associated equipment for acceptance of the Interconnection Customer's Interconnection Facilities. To allow interconnection for GEN-2013-015 the Transmission Owner will need build a new 115kV Substation (Bladen) on Pauline – Hildreth 115kV transmission line along with any

associated equipment for acceptance of the Interconnection Customer's Interconnection Facilities. GEN-2013-004, GEN-2013-005, and GEN-2013-008 do not require Transmission Owner Interconnection Facilities Upgrades since these requests do not propose Transmission Owned Facilities as the direct Point of Interconnection (POI). The direct Point of Interconnection (POI) is proposed on Interconnection Customers' Owned Substations. Table 3 lists the Transmission Owner Interconnection Facilities and Non-Shared Network Upgrade Descriptions and current cost responsibilities for each Interconnection Customer.

Table 3: Transmission Owner Interconnection Facilities and Non-Shared Network Upgrades Description and Costs

G.I. Requests	Transmission Owner Interconnection Facilities and Non-Shared Network Upgrade Description	Transmission Owner Interconnection Facilities and Non-Shared Network Upgrade Costs
GEN-2012-005	Interconnection Facilities – Build new 230kV Interconnection Substation (Knox County) on Fort Randall – Meadow Grove 230kV transmission line	$9,100,000.00
GEN-2013-004	Interconnection Facilities – Expansion of GEN-2008-086N02 Customer owned Substation	$0.00*
GEN-2013-005	Interconnection Facilities – Expansion of GEN-2008-086N02 Customer owned Substation	$0.00*
GEN 2013-006	Interconnection Facilities – Expansion of Meadow Grove 230kV Substation	$1,400,000.00
GEN 2013-008	Interconnection Facilities – Expansion of GEN-2011-018 Customer owned Substation	$0.00*
GEN-2013-014	Interconnection Facilities – Expansion of Rosemont 115kV	$1,800,000.00
GEN-2013-015	Interconnection Facilities – Build new 115kV Interconnection Substation (Bladen) on Pauline – Hildreth 115kV transmission line. Also, include breaker additions at Hildreth 115kV Substation for protection related requirements	$6,300,000.00

*No Transmission Owner Interconnection Facilities required or proposed as Point of Interconnection (POI). Point of Interconnection (POI) is proposed on Interconnection Customer Owned Substation.

Shared Network Upgrades

The Interconnection Customers were studied within the DISIS-2013-001 Impact Study. At this time, the Interconnection Customer GEN-2012-005 is allocated $11,085,260.70 for Shared Network Upgrades. Interconnection Customer GEN-2013-004 is allocated $2,675,484.23 for Shared Network Upgrades. Interconnection Customer GEN-2013-005 is allocated $32,997,639.01 for Shared Network Upgrades. Interconnection Customer GEN-2013-006 is allocated $22,741,616.06. Interconnection Customer GEN-2013-008 is allocated $0.00 for Shared Network Upgrades. Interconnection Customer GEN-2013-014 is allocated $0.00 for Shared Network Upgrades. Interconnection Customer GEN-2013-015 is allocated $0.00 for Shared Network Upgrades. Table 4 consists of the detail Shared Network Upgrades for the Interconnection Customers.

Table 4: Shared Network Upgrades Descriptions and Costs Allocations

Network Upgrade	Allocated Cost By Customer				Total Upgrade Cost
	GEN-2012-005	GEN-2013-004	GEN-2013-005	GEN 2013-006	
Norfolk South 345/230 kV Substation – New 345/230 kV substation interconnecting to the existing Hoskins – Shell Creek 345 kV line somewhere south of Norfolk. Includes the addition of a 345/230 kV Transformer to connect to a new 230 kV line terminal.	$2,978,755.53	$651,354.71	$8,033,374.74	$5,536,515.02	$17,200,000.00
Meadow Grove – Norfolk South 230 kV line – A new 27-Mile 230 kV transmission line from Norfolk South Sub to the Meadow Grove 230 kV Substation	$4,329,586.53	$946,736.49	$11,676,416.77	$8,047,260.21	$25,000,000.00
Expand Meadow Grove 230 kV Substation – This substation expansion includes the addition of a new terminal for the addition of a 230/115 kV Transformer and the new 230 kV line to Norfolk South.	$1,656,151.51	$427,962.52	$5,278,204.50	$3,637,681.47	$11,000,000.00
Meadow Grove – Petersburg North 115 kV line – A new 27-Mile 115 kV transmission line from Meadow Grove Sub to the Petersburg North 115 kV Substation	$1,925,604.51	$589,666.97	$7,272,559.29	$5,012,169.23	$14,800,000.00
Expand Petersburg North 115 kV Substation – This substation expansion includes the addition of a new line terminal to accommodate the new 115 kV line to Meadow Grove.	$130,108.41	$39,842.36	$491,389.14	$338,660.08	$1,000,000.00
Neligh 115 kV Substation – Replace equipment at the Neligh 115 kV substation with a new breaker as identified during Short Circuit Analysis.	$65,054.21	$19,921.18	$245,694.57	$169,330.04	$500,000.00
Total Cost:	**$11,085,260.70**	**$2,675,484.23**	**$32,997,639.01**	**$22,741,616.06**	**$69,500,000.00**

If higher queued interconnection customers withdraw from the queue, suspend or terminate their GIA, restudies will have to be conducted to determine the Interconnection Customers' allocation of Shared Network Upgrades. All studies have been conducted on the basis of higher queued interconnection requests and the upgrades associated with those higher queued interconnection requests being placed in-service.

Other Network Upgrades
Certain Other Network Upgrades are not the cost responsibility of the Interconnection Customers, but may be required for full Interconnection Service. Below is each Interconnection Customers Other Network Upgrades:

The Other Network Upgrades for GEN-2012-005 include:

1. Fort Randall – Meadow Grove – Columbus 230kV circuit #1 conductor clearance increase, assigned to DISIS-2009-001 Customer
2. Dixon County – Twin Church 230kV circuit #1 conductor clearance increase (320MVA), assigned to DISIS-2010-002 Customer
3. Hoskins – Dixon County – Twin Church 230kV circuit #1 conductor clearance increase, assigned to DISIS-2011-001 Customer

The Other Network Upgrades for GEN-2013-004 include:

1. Fort Randall – Meadow Grove – Columbus 230kV circuit #1 conductor clearance increase, assigned to DISIS-2009-001 Customer
2. Dixon County – Rasmussen 230kV circuit #1 build, assigned to DISIS-2012-002 Customer
3. Dixon County – Twin Church 230kV circuit #1 conductor clearance increase (320MVA), assigned to DISIS-2010-002 Customer
4. Hoskins – Dixon County – Twin Church 230kV circuit #1 conductor clearance increase, assigned to DISIS-2011-001 Customer

The Other Network Upgrades for GEN-2013-005 include:

5. Fort Randall – Meadow Grove – Columbus 230kV circuit #1 conductor clearance increase, assigned to DISIS-2009-001 Customer
6. Dixon County – Rasmussen 230kV circuit #1 build, assigned to DISIS-2012-002 Customer
7. Dixon County – Twin Church 230kV circuit #1 conductor clearance increase (320MVA), assigned to DISIS-2010-002 Customer
8. Hoskins – Dixon County – Twin Church 230kV circuit #1 conductor clearance increase, assigned to DISIS-2011-001 Customer

The Other Network Upgrades for GEN-2013-006 include:

1. Fort Randall – Meadow Grove – Columbus 230kV circuit #1 conductor clearance increase, assigned to DISIS-2009-001 Customer
2. Dixon County – Rasmussen 230kV circuit #1 build, assigned to DISIS-2012-002 Customer
3. Dixon County – Twin Church 230kV circuit #1 conductor clearance increase (320MVA), assigned to DISIS-2010-002 Customer

4. Hoskins – Dixon County – Twin Church 230kV circuit #1 conductor clearance increase, assigned to DISIS-2011-001 Customer

The Other Network Upgrades for GEN-2013-008 include:

1. Dixon County – Rasmussen 230kV circuit #1 build, assigned to DISIS-2012-002 Customer

Other Network Upgrades for GEN-2013-014 include:

1. At this time, no Other Network Upgrades are assigned

Other Network Upgrades for GEN-2013-015 include:

1. At this time, no Other Network Upgrades are assigned

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

Affected System Facilities
There were possible Western Area Power Administration (WAPA) and MidAmerican Energy Company (MEC) Affected System Facilities were identified in the Phase 1 through Phase 4 Load flow Analysis of the Facility Study.

Conclusion

Interconnection Service for Interconnection Customers will be delayed until the Transmission Owner Interconnection Facilities, Non-Shared Network Upgrades, and Shared Network Upgrades assigned to each Interconnection Customer are constructed. Table 5 summarizes the Interconnection Facilities and Non-Shared Network Upgrades costs along with Shared Network Upgrades costs for each Interconnection Customer.

Table 5: Interconnection Customer Total Costs Allocations

Upgrade Type	Costs by Upgrade Type		Total Interconnection Customer Cost
	Interconnection Facilities & Non-Shared Network Upgrades	Shared Network Upgrades	
GEN-2012-005	$9,100,000.00	$11,085,260.70	**$20,185,260.70**
GEN-2013-004	$0.00*	$2,675,484.23	**$2,675,484.23**
GEN-2013-005	$0.00*	$32,997,639.01	**$32,997,639.01**
GEN 2013-006	$1,400,000.00	$22,741,616.06	**$24,141,616.06**
GEN-2013-008	$0.00*	$0.00	**$0.00**
GEN-2013-014	$1,800,000.00	$0.00	**$1,800,000.00**
GEN-2013-015	$6,300,000.00	$0.00	**$6,300,000.00**

*No Transmission Owner Interconnection Facilities required or proposed as Point of Interconnection (POI). Point of Interconnection (POI) is proposed on Interconnection Customer Owned Substation.

At this time, the total allocation of costs of Interconnection Service for GEN-2012-005 is estimated at $20,185,260.70. The total allocation of costs of Interconnection Service for

GEN-2013-004 is estimated at $2,675,484.23. The total allocation of costs of Interconnection Service for GEN-2013-005 is estimated at $32,997,639.01. The total allocation of costs of Interconnection Service for GEN-2013-006 is estimated at $24,141,616.06. The total allocation of costs of Interconnection Service for GEN-2013-008 is estimated at $0.00. The total allocation of costs of Interconnection Service for GEN-2013-014 is estimated at $1,800,000.00. The total allocation of costs of Interconnection Service for GEN-2013-015 is estimated at $6,300,000.00.

This study was performed in response to the Interconnection Customer under GIP 4.4.2 to evaluate the modification of its request. In accordance with GIP 4.4.2, the Interconnection Customer may choose to withdraw this request for modification.

DISIS-2013-001
GENERATION INTERCONNECTION
FACILITY STUDY

SPP GEN-2012-005	**81.0 MW at new 230 kV Sub on Ft. Randall–Meadow Grove 230 kV**
SPP GEN-2013-004	**6.5 MW at Prairie Breeze 230 kV Collector Substation**
SPP GEN-2013-005	**73.5 MW at Prairie Breeze 230 kV Collector Substation**
SPP GEN-2013-006	**50.6 MW at Meadow Grove 230 kV Substation**
SPP GEN-2013-008	**1.2 MW at Steele Flats 115 kV Collector Substation**
SPP GEN-2013-014	**25.5 MW at Rosemont 115 kV Substation**
SPP GEN-2013-015	**125.8 MW at new 115 kV Sub on Pauline – Hildreth 115 kV line**

JANUARY 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
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Executive Summary

The *NPPD DISIS-2013-001 Facility Study* was performed to document the reliability impacts of several 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-2012-005	81.0	Wind	New 230 kV Sub on Ft. Randall – Meadow Grove 230 kV line
GEN-2013-004	6.5	Wind	Prairie Breeze 230 kV Collector Substation
GEN-2013-005	73.5	Wind	Prairie Breeze 230 kV Collector Substation
GEN-2013-006	50.6	Wind	Meadow Grove 230 kV Substation
GEN-2013-008	1.2	Wind	Steele Flats 115 kV Collector Substation
GEN-2013-014	25.5	Wind	Rosemont 115 kV Substation
GEN-2013-015	125.8	Wind	New 115 kV Sub on Pauline – Hildreth 115 kV line
	364.1		

SPP entered into a Facility Study agreement with the generation interconnection customers and subsequently requested that NPPD perform the Facility Study for the GI requests. In response to the SPP request, NPPD has performed a Facility Study for the generation interconnection requests 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-2013-001 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 results of the Phase 1 portion of the loadflow analysis revealed no additional facility overloads or voltage violations that would require mitigation due to TPL-001 and TPL-002 contingencies.

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

Phase 3 of the loadflow analysis evaluated the local area transmission capacity with respect to delivering the fully accredited generating capability out of the area at 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 projects. 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.

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 was one N-1 transmission facility overloads discovered in the Phase 4 screening that were associated with north-south transfer limitations in eastern Nebraska. 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-2013-001 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 pages.

DISIS-2013-001 Interconnection Plan

- GEN-2012-005 Interconnection Facilities – New 230 kV Interconnection Substation (Knox County) on Ft. Randall – Meadow Grove 230 kV line

$9.1 Million

- GEN-2013-004 Interconnection Facilities – Expansion of Prairie Breeze 230 kV Collector Substation

$0*

- GEN-2013-005 Interconnection Facilities – Expansion of Prairie Breeze 230 kV Collector Substation

$0*

- GEN-2013-006 Interconnection Facilities – Expansion of Meadow Grove 230 kV Substation

$1.4 Million

- GEN-2013-008 Interconnection Facilities – Expansion of Steele Flats 115 kV Collector Substation

$0*

- GEN-2013-014 Interconnection Facilities – Expansion of Rosemont 115 kV Substation

$1.8 Million

- GEN-2013-015 Interconnection Facilities – New 115 kV Interconnection Substation (Bladen) on Pauline – Hildreth 115 kV line. Also includes breaker additions at the Hildreth 115 kV substation to meet protection-related interconnection requirements.

$6.3 Million

- Norfolk South 345/230 kV Substation – New 345/230 kV substation interconnecting to the existing Hoskins – Shell Creek 345 kV line somewhere south of Norfolk. Includes the addition of a 345/230 kV Transformer to connect to a new 230 kV line terminal.

$17.2 Million

- Meadow Grove – Norfolk South 230 kV line – A new 27-Mile 230 kV transmission line from Norfolk South Sub to the Meadow Grove 230 kV Substation

$25.0 Million

** No transmission interconnection facilities required or proposed point-of-interconnection is located in an existing wind developer's substation.*

- Expand Meadow Grove 230 kV Substation – This substation expansion includes the addition of a new terminal for the addition of a 230/115 kV Transformer and the new 230 kV line to Norfolk South.

$11.0 Million

- Meadow Grove – Petersburg North 115 kV line – A new 27-Mile 115 kV transmission line from Meadow Grove Sub to the Petersburg North 115 kV Substation

$14.8 Million

- Expand Petersburg North 115 kV Substation – This substation expansion includes the addition of a new line terminal to accommodate the new 115 kV line to Meadow Grove.

$1.0 Million

- Neligh 115 kV Substation – Replace overdutied equipment at the Neligh 115 kV substation with a new breaker as identified during Short Circuit Analysis.

$0.5 Million

Total Interconnection & Network Upgrades: $88.1 Million

1.0 Introduction

In October 2013, 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-2013-001). The generation interconnection requests are listed below:

Project	MW	Type	Point-of-Interconnection
GEN-2012-005	81.0	Wind	New 230 kV Sub on Ft. Randall – Meadow Grove 230 kV line
GEN-2013-004	6.5	Wind	Prairie Breeze 230 kV Collector Substation
GEN-2013-005	73.5	Wind	Prairie Breeze 230 kV Collector Substation
GEN-2013-006	50.6	Wind	Meadow Grove 230 kV Substation
GEN-2013-008	1.2	Wind	Steele Flats 115 kV Collector Substation
GEN-2013-014	25.5	Wind	Rosemont 115 kV Substation
GEN-2013-015	125.8	Wind	New 115 kV Sub on Pauline – Hildreth 115 kV line
	364.1		

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 all of the generation interconnection requests 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 Study and Facility Study. A list of interconnection and network upgrades identified in the System Impact Study as required for these generation interconnection projects is below:

- GEN-2012-005 Interconnection Facilities – New 230 kV Interconnection Substation (Knox County) on Ft. Randall – Meadow Grove 230 kV line
- GEN-2013-005 Interconnection Facilities – Expansion of Prairie Breeze 230 kV Collector Substation
- GEN-2013-006 Interconnection Facilities – Expansion of Meadow Grove 230 kV Substation
- GEN-2013-014 Interconnection Facilities – Expansion of Rosemont 115 kV Substation
- GEN-2013-015 Interconnection Facilities – New 115 kV Interconnection Substation (Bladen) on Pauline – Hildreth 115 kV line
- Norfolk South 345/230 kV Substation – New 345/230 kV substation interconnecting to the existing Hoskins – Shell Creek 345 kV line somewhere

south of Norfolk. Includes the addition of a 345/230 kV Transformer to connect to a new 230 kV line terminal.

- Meadow Grove – Norfolk South 230 kV line – A new 25-Mile 230 kV transmission line from Norfolk South Sub to the Meadow Grove 230 kV Substation

- Expand Meadow Grove 230 kV Substation – This substation expansion includes the addition of a new terminal for the addition of a 230/115 kV Transformer and the new 230 kV line to Norfolk South.

- Meadow Grove – Petersburg North 115 kV line – A new 25-Mile 115 kV transmission line from Meadow Grove Sub to the Petersburg North 115 kV Substation

- Expand Petersburg North 115 kV Substation – This substation expansion includes the addition of a new line terminal to accommodate the new 115 kV line to Meadow Grove.

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 the generator interconnection requests in the SPP Generator Interconnection Queue which were studied in the SPP Definitive Interconnection System Impact Study, SPP DISIS-2013-001, and progressed to the facilities study stage. The GI projects on the NPPD transmission system included in the DISIS-2013-001 study are as follows:

Project	MW	Type	Point-of-Interconnection
GEN-2012-005	81.0	Wind	New 230 kV Sub on Ft. Randall – Meadow Grove 230 kV line
GEN-2013-004	6.5	Wind	Prairie Breeze 230 kV Collector Substation
GEN-2013-005	73.5	Wind	Prairie Breeze 230 kV Collector Substation
GEN-2013-006	50.6	Wind	Meadow Grove 230 kV Substation
GEN-2013-008	1.2	Wind	Steele Flats 115 kV Collector Substation
GEN-2013-014	25.5	Wind	Rosemont 115 kV Substation
GEN-2013-015	125.8	Wind	New 115 kV Sub on Pauline – Hildreth 115 kV line
	364.1		

This Facility Study will focus on the generation interconnection projects requesting interconnection to the NPPD transmission system. The SPP DISIS-2013-001 system impact study identified several network transmission upgrades due to the proposed generation interconnections. These generation interconnection upgrades are listed below:

- GEN-2012-005 Interconnection Facilities – New 230 kV Interconnection Substation (Knox County) on Ft. Randall – Meadow Grove 230 kV line

- GEN-2013-005 Interconnection Facilities – Expansion of Prairie Breeze 230 kV Collector Substation

- GEN-2013-006 Interconnection Facilities – Expansion of Meadow Grove 230 kV Substation

- GEN-2013-014 Interconnection Facilities – Expansion of Rosemont 115 kV Substation

- GEN-2013-015 Interconnection Facilities – New 115 kV Interconnection Substation (Bladen) on Pauline – Hildreth 115 kV line

- Norfolk South 345/230 kV Substation – New 345/230 kV substation interconnecting to the existing Hoskins – Shell Creek 345 kV line somewhere south of Norfolk. Includes the addition of a 345/230 kV Transformer to connect to a new 230 kV line terminal.

- Meadow Grove – Norfolk South 230 kV line – A new 25-Mile 230 kV transmission line from Norfolk South Sub to the Meadow Grove 230 kV Substation

- Expand Meadow Grove 230 kV Substation – This substation expansion includes the addition of a new terminal for the addition of a 230/115 kV Transformer and the new 230 kV line to Norfolk South.

- Meadow Grove – Petersburg North 115 kV line – A new 25-Mile 115 kV transmission line from Meadow Grove Sub to the Petersburg North 115 kV Substation

- Expand Petersburg North 115 kV Substation – This substation expansion includes the addition of a new line terminal

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-2013-001 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	IA Pending
GEN-2013-002	50.6	LES	Tap Sheldon - Folsom 115kV CKT 1	Facility Study
GEN-2010-041	10.5	OPPD	S 1399 161kV	Under Development
GEN-2011-055	52.8	OPPD	South Sterling 69kV	Facility Study
GEN-2013-018	51	OPPD	Tap S974 - Hydrocarbon Tap 69kV	Facility Study
GEN-2010-056	151	MIPU	Tap Cooper - St. Joe 345kV	On Suspension

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)

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 projects 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 projects 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 facilities and associated transmission and validate adherence to system reliability criteria. This study will be performed in accordance with NERC Reliability Standards and the criteria set forth under those standards. This facility study will document the required transmission facility interconnection plan for the 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 projects 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 2014 timeframe and other system changes consistent with the latest SPP Integrated Transmission Plan.

The loadflow study will be split into four phases:

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

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

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

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

PHASE 1: This Phase is considered a comprehensive single contingency analysis of the entire Nebraska subregion. Every single element rated from 115 kV – 345 kV in the NPPD, OPPD, 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-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-2013-018 (S974-HydroTap)	=	51.0 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-2013-001 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.

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:

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 (364 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-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

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.

Network Upgrades

The SPP definitive generation interconnection study (DISIS-2013-001) identified several significant transmission additions that were required to accommodate the interconnection of the generation interconnection projects on the NPPD system. These transmission upgrade projects were modeled as base transmission upgrades in this facility study.

- Norfolk South 345/230 kV Substation
- Meadow Grove – Norfolk South 230 kV line
- Meadow Grove – Petersburg North 115 kV line

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):

There were no impacted transmission facility overloads or 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 did not discover any impacted transmission facility overloads or 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):

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

Category D Results (TPL-004):

There were no impacted transmission facility overloads or 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):

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

Category D Results (TPL-004):

There were no impacted transmission facility overloads or 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):

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

Category D Results (TPL-004):

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

Phase 2 Results Summary

Overall, there were no impacted transmission facility overloads or 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 3302 at Hoskins 345 kV
Stuck PCB 3308 at Hoskins 345 kV
Stuck PCB 3310 at Hoskins 345 kV
Stuck PCB 3312 at Hoskins 345 kV
Stuck PCB at Hoskins 115 kV north bus
Stuck PCB at Hoskins 115 kV south bus
Stuck PCB at Twin Church 230 kV north bus
Stuck PCB at Twin Church 230 kV south bus
Stuck PCB at Twin Church 115 kV
Stuck PCB at Twin Church 115 kV
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

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

There were no transmission facility overloads or 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 1449 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 additions. 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. Steele City – Knob Hill 115 kV
2. North Hebron – Carleton Junction 115 kV
3. Harbine – Fairbury 115 kV
4. North Hebron – Fairbury 115 kV
5. Pauline – Rosemont 115 kV
6. North Hastings – Bypass 115 kV
7. Pauline 345/115 kV Transformer

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):

A single overloaded transmission facility was 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.

The GEN-2010-056 Wind – St. Joe 345 kV line was overloaded above the 1073 MVA rating for loss of the Cooper – Fairport 345 kV line. This line was loaded to 106.8% of the 1073 MVA rating. The GEN-2010-056 Wind is a possible new substation on the Cooper – St. Joe 345 kV line to interconnect the GEN-2010-056 wind project that is currently under suspension. If this wind project is developed, the COOPER_S interface definition may need to be modified to address the potential constraint south of this new substation. The Axtell – Post Rock 345 kV and Nebraska City – Maryville – Sibley 345 kV line projects are expected to help relieve flowgate congestion through the transmission corridor south of Cooper.

Phase 4 Results Summary

Overall, there was a single transmission facility overload discovered in the Phase 4 screening that was associated with north-south transfer limitations in eastern Nebraska. The north-south transfer limitations in this area are expected to be relieved with the future addition of the Nebraska City – Maryville – Sibley 345 kV line. Transfer limitations in

this area will continue to be monitored if new substations are interconnected to existing lines which could impact the existing COOPER_S interface definition.

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. Table 1 lists the prior-queued large generator interconnections that were added to the base model for this study.

Table 1: 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

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 added to 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.

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. Table 2 lists the large generator interconnections that were added to the study-case model for this study.

Table 2: Large Generator Interconnections Added to Study Case

Queue Designation	Proposed POI	Capacity (MW)
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

In addition to the large generator interconnections being studied, system upgrades identified to accommodate the studied projects were added to the study model. For this study, the upgrades 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

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

There was one device that was found to be above 95% of its interrupting rating or short-circuit capability due to the addition of the projects considered in this study. The device is recommended for replacement with a breaker and is listed in the table below.

Substation	Device Number	Circuit	% of Rating	Δ
Neligh	CS1114-D2 Fuse	Cap Bank #1 Primary Fuse	97%	5%

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 the DISIS-2013-001 generation interconnection projects. Detailed cost estimates have been prepared for each of the facility upgrades that were identified in the SPP DISIS-2013-001 system impact study and this facility study. 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-2012-005 Interconnection Facilities – New 230 kV Interconnection Substation (Knox County) on Ft. Randall – Meadow Grove 230 kV line

  $9.1 Million

- GEN-2013-004 Interconnection Facilities – Expansion of Prairie Breeze 230 kV Collector Substation

  $0*

- GEN-2013-005 Interconnection Facilities – Expansion of Prairie Breeze 230 kV Collector Substation

  $0*

- GEN-2013-006 Interconnection Facilities – Expansion of Meadow Grove 230 kV Substation

  $1.4 Million

- GEN-2013-008 Interconnection Facilities – Expansion of Steele Flats 115 kV Collector Substation

  $0*

- GEN-2013-014 Interconnection Facilities – Expansion of Rosemont 115 kV Substation

  $1.8 Million

- GEN-2013-015 Interconnection Facilities – New 115 kV Interconnection Substation (Bladen) on Pauline – Hildreth 115 kV line. Also includes breaker additions at the Hildreth 115 kV substation to meet protection-related interconnection requirements.

  $6.3 Million

** No transmission interconnection facilities required or proposed point-of-interconnection is located in an existing wind developer's substation.*

- Norfolk South 345/230 kV Substation – New 345/230 kV substation interconnecting to the existing Hoskins – Shell Creek 345 kV line somewhere south of Norfolk. Includes the addition of a 345/230 kV Transformer to connect to a new 230 kV line terminal.

  $17.2 Million

- Meadow Grove – Norfolk South 230 kV line – A new 27-Mile 230 kV transmission line from Norfolk South Sub to the Meadow Grove 230 kV Substation

  $25.0 Million

- Expand Meadow Grove 230 kV Substation – This substation expansion includes the addition of a new terminal for the addition of a 230/115 kV Transformer and the new 230 kV line to Norfolk South.

  $11.0 Million

- Meadow Grove – Petersburg North 115 kV line – A new 27-Mile 115 kV transmission line from Meadow Grove Sub to the Petersburg North 115 kV Substation

  $14.8 Million

- Expand Petersburg North 115 kV Substation – This substation expansion includes the addition of a new line terminal to accommodate the new 115 kV line to Meadow Grove.

  $1.0 Million

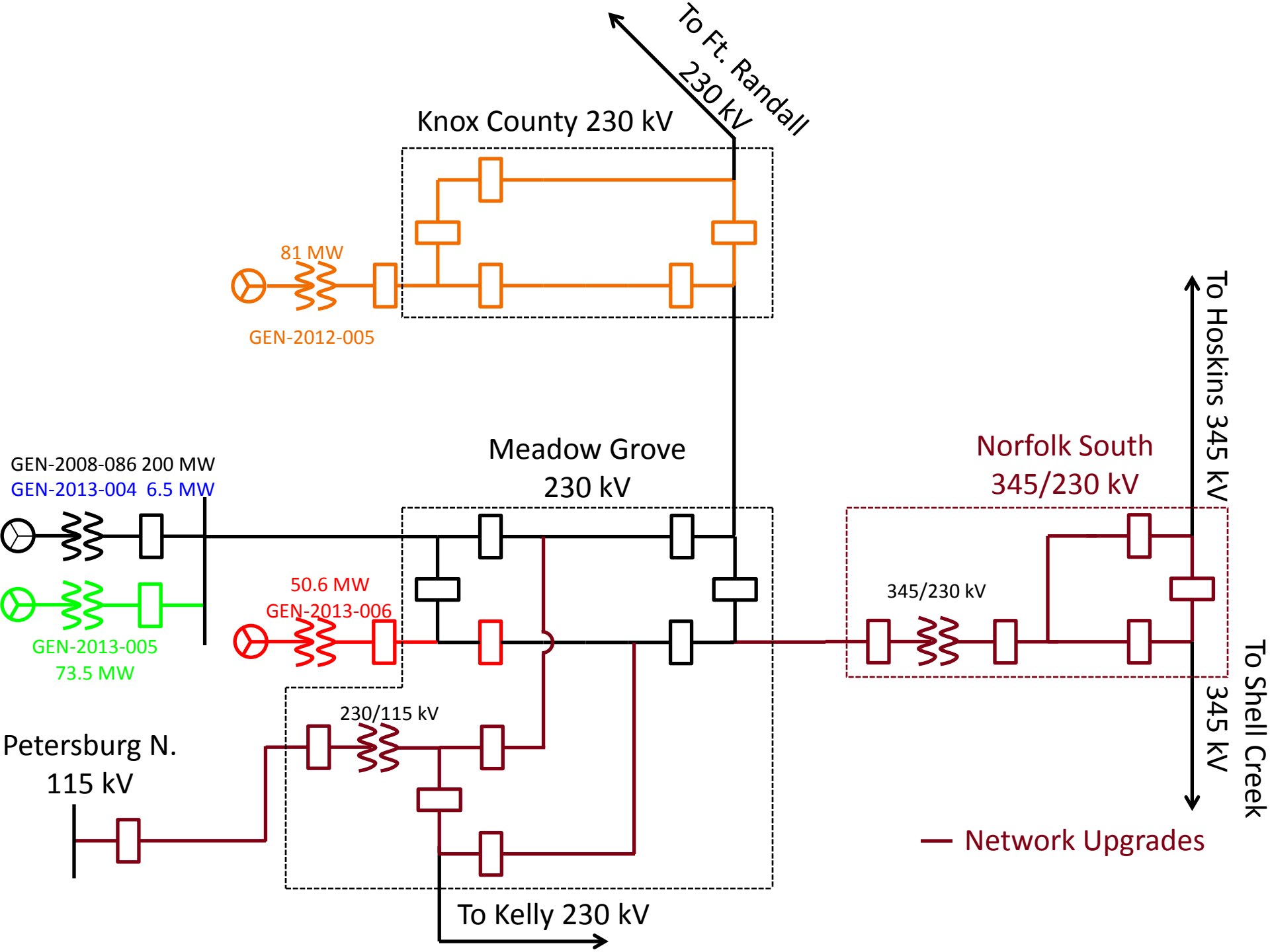
- Neligh 115 kV Substation – Replace overdutied equipment at the Neligh 115 kV substation with a new breaker as identified during Short Circuit Analysis.

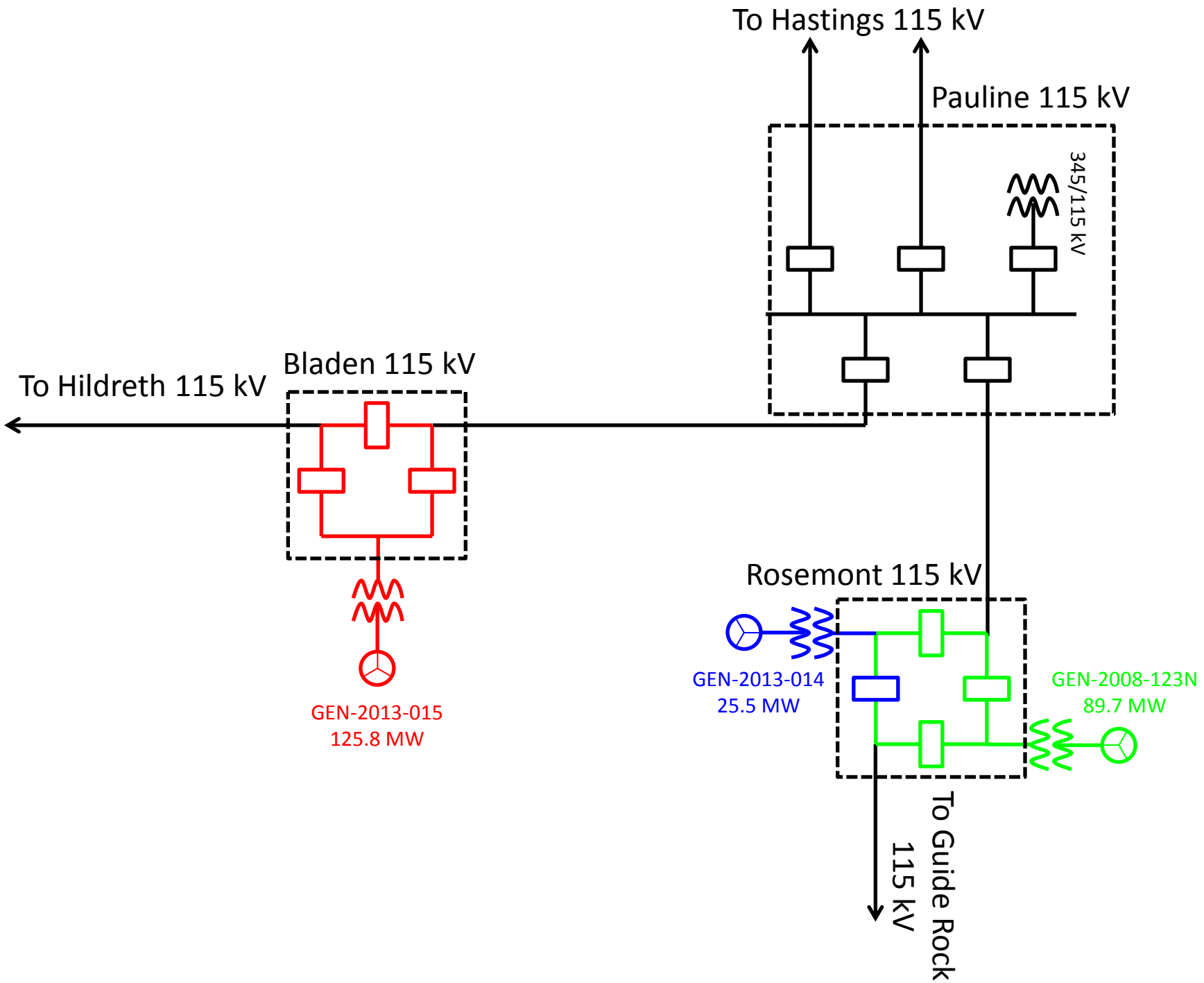
  $0.5 Million

Total Interconnection & Network Upgrades: $88.1 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-2013-001 generation projects are dependent on the transmission upgrades/additions that are required as part of the previous Definitive Interconnection Studies. If there are any modifications to these previous studies and related upgrades, then the interconnection plan for the DISIS-2013-001 projects could be affected.


To Ft. Randall
230 kV
Knox County 230 kV
81 MW
GEN-2012-005
GEN-2008-086 200 MW
GEN-2013-004 6.5 MW
Meadow Grove
230 kV
50.6 MW
GEN-2013-006
GEN-2013-005
73.5 MW
230/115 kV
Petersburg N.
115 kV
To Kelly 230 kV
Norfolk South
345/230 kV
345/230 kV
To Hoskins 345 kV
345 kV
To Shell Creek
Network Upgrades


To Hastings 115 kV
Pauline 115 kV
345/115 kV
To Hildreth 115 kV
Bladen 115 kV
GEN-2013-015
125.8 MW
Rosemont 115 kV
GEN-2013-014
25.5 MW
GEN-2008-123N
89.7 MW
To Guide Rock
115 kV