INTERCONNECTION FACILITIES STUDY REPORT

GEN-2013-002

(IFS-2013-001-01)

&

GEN-2013-019

(IFS-2013-002-01)

Published March 2020

By SPP Generator Interconnections Dept.

REVISION HISTORY

DATE OR VERSION NUMBER	AUTHOR	CHANGE DESCRIPTION
08/08/2019	SPP	Initial draft report issued.
08/09/2019	SPP	Final report issued. Breakout interconnection costs to TOIF vs. Non-Shared Network Upgrade in Table 2 and 3. Updated Table 6 to reflect.
3/11/2020	SPP	Revised final report. Updated report with temporary and permanent interconnection cost estimates, NPPD and LES joint facility report attached.

CONTENTS

SUMMARY

INTRODUCTION

This Interconnection Facilities Study (IFS) for Interconnection Request GEN-2013-002/IFS-2013-001-01 (50.6 MW) and GEN-2013-019/IFS-2013-002-01(73.6 MW) for total of 124.20 MW generating facility located in Lancaster County, Nebraska. The Interconnection Requests were studied in the DISIS-2013-001 and DISIS-2013-002 Impact Study and Impact Restudies for Energy Resource Interconnection Service (ERIS) and Network Resource Interconnection Service (NRIS). Originally these projects were to interconnect to the Lincoln Electric System (LES) Sheldon – SW 7th & Bennet 115 kV line via a new 115kV ring substation. Interconnection Customer then requested change of Point of Interconnection (POI) from new substation with LES to Nebraska Public Power District (NPPD) Monolith (Olive Creek) 115 kV substation. Southwest Power Pool, Inc. completed Impact Restudy for POI and Generator Modification for the projects on February 2019.

The interconnecting Transmission Owner, Nebraska Public Power District (NPPD), performed a detailed IFS at the request of SPP in April 2019. After posting of IFS summary report in August 2019, the Interconnection Customer's requested in-service date is late 2021. At the request of SPP on Dec 2019, NPPD and LES jointly performed a facility study to review and provide a temporary interconnection that will meet the needs of the Interconnection Customer and facilitate the permanent interconnection at the new Monolith (Olive Creek) 115 kV substation. The full report is included in Appendix A. SPP has determined that full Interconnection Service will be available after the assigned Transmission Owner Interconnection Facilities (TOIF), Non-Shared Network Upgrades, Shared Network Upgrades, Contingent Network Upgrades, and Affected System Upgrades that are required for full interconnection service are completed.

The primary objective of the IFS is to identify necessary Transmission Owner Interconnection Facilities, Network Upgrades, other direct assigned upgrades, cost estimates, and associated upgrade lead times needed to grant the requested Interconnection Service.

PHASE(S) OF INTERCONNECTION SERVICE

It is not expected that Interconnection Service will occur in phases. However, full Interconnection Service will not be available until all Interconnection Facilities and Network Upgrade(s) can be placed in service.

CREDITS/COMPENSATION FOR AMOUNTS ADVANCED FOR NETWORK UPGRADE(S)

Interconnection Customer shall be entitled to compensation in accordance with Attachment Z2 of the SPP OATT for the cost of SPP creditable-type Network Upgrades, including any tax gross-up or any other tax-related payments associated with the Network Upgrades, that are not otherwise refunded to the Interconnection Customer. Compensation shall be in the form of either revenue credits or incremental Long Term Congestion Rights (iLTCR).

INTERCONNECTION CUSTOMER INTERCONNECTION FACILITIES

The Generating Facility is proposed to consist of fifty-four (54) 2.3 MW wind turbine generators (22 units for GEN-2013-002 and 23 units for GEN-2013-019) for a total generating nameplate capacity of 124.20 MW.

The Interconnection Customer's Interconnection Facilities to be designed, procured, constructed, installed, maintained, and owned by the Interconnection Customer at its sole expense include:

- 34.5 kV underground cable collection circuits;
- 34.5 kV to 115 kV transformation substation with associated 34.5 kV and 115 kV switchgear;
- One (1) 115/34.5 kV step-up transformer to be owned and maintained by the Interconnection Customer at the Interconnection Customer's substation;
- A 115 kV transmission line to connect the Interconnection Customer's substation to the Point of Interconnection ("POI") at the 115 kV bus at existing Transmission Owner substation ("Monolith (Olive Creek) 115 kV") that is owned and maintained by Transmission Owner;
- All transmission facilities required to connect the Interconnection Customer's substation to the POI;
- Equipment at the Interconnection Customer's substation necessary to maintain a composite power delivery at continuous rated power output at the point of interconnection at a power factor within the range of 95% lagging and 95% leading. Additionally approximately 6.5 MVAr[1] of reactors will be required to compensate for injection of reactive power into the transmission system under no/reduced generating conditions. The Interconnection Customer may use turbine manufacturing options for providing reactive power under no/reduced generation conditions. The Interconnection Customer will be required to provide documentation and design specifications demonstrating how the requirements are met; and,
- All necessary relay, protection, control and communication systems required to protect Interconnection Customer's Interconnection Facilities and Generating Facilities and coordinate with Transmission Owner's relay, protection, control and communication systems.

[1] This approximation minimum reactor amount is needed as studied in GEN-2013-002 & GEN-2013-019 Material Modification Impact Restudy on February 2019.

TRANSMISSION OWNER INTERCONNECTION FACILITIES AND NON-SHARED NETWORK UPGRADE(S)

To facilitate interconnection, the interconnecting Transmission Owner will perform work as shown below necessary for the acceptance of the Interconnection Customer's Interconnection Facilities.

Table 1 and **Table 2** lists the Interconnection Customer's estimated cost responsibility for Transmission Owner Interconnection Facilities (TOIF) and Non-Shared Network Upgrade(s) and provides an estimated lead time for completion of construction. The estimated lead time begins when the Generator Interconnection Agreement has been fully executed.

Table 1: Transmission Owner Interconnection Facilities (TOIF)

Transmission Owner Interconnection Facilities (TOIF)	Total Cost Estimate ($)	Allocated Percent (%)	Allocated Cost Estimate ($)	Estimated Lead Time
Phase 1: Temporary Interconnection Tap of the Sheldon – SW 7th & Bennet 115 kV line and re-route of the 115 kV line to the location of the temporary interconnection site.	$300,000	100%	$300,000	Late 2021
Phase 2: Permanent Interconnection **Transmission Owner Monolith 115 kV Substation**: Expand Monolith 115 kV substation to accommodate new 115 kV terminal for the interconnection of GEN-2013-002 and GEN-2013-019.	$300,000	100%	$300,000	2023/2024
Total	**$600,000**		**$600,000**	

Table 2: Non-Shared Network Upgrade(s)

Non-Shared Network Upgrades Description	Z2 Type[2]	Total Cost Estimate ($)	Allocated Percent (%)	Allocated Cost Estimate ($)	Estimated Lead Time
Phase 1: Temporary Interconnection Tap of the Sheldon – SW 7th & Bennet 115 kV line and re-route of the 115 kV line to the location of the temporary interconnection site.	non-creditable	$1,450,000	100%	$1,450,000	Late 2021

[2] Indicates the method used for calculating credit impacts under Attachment Z2 of the Tariff.

Non-Shared Network Upgrades Description	Z2 Type[2]	Total Cost Estimate ($)	Allocated Percent (%)	Allocated Cost Estimate ($)	Estimated Lead Time
Phase 2: Permanent Interconnection **Transmission Owner Monolith 115 kV Substation**: To be designed as traditional breaker and a half. This includes all switches on the rung, bus work, 2 breakers, CT's, PT's, panel, etc. and all other associated work and materials.	non-creditable	$1,950,000	100%	$1,950,000	2023/2024
Total		**$3,400,000**		**$3,400,000**	

SHARED NETWORK UPGRADE(S)

The Interconnection Customer's share of costs for Shared Network Upgrades is estimated in **Table 3** below.

Table 3: Interconnection Customer Shared Network Upgrade(s)

Shared Network Upgrades Description	Z2 Type	Total Cost Estimate ($)	Allocated Percent (%)	Allocated Cost Estimate ($)	Estimated Lead Time
None	N/A	$0	N/A	$0	N/A
Total		**$0**		**$0**	

All studies have been conducted assuming that higher-queued Interconnection Request(s) and the associated Network Upgrade(s) will be placed into service. If higher-queued Interconnection Request(s) withdraw from the queue, suspend or terminate service, the Interconnection Customer's share of costs may be revised. Restudies, conducted at the customer's expense, will determine the Interconnection Customer's revised allocation of Shared Network Upgrades.

CONTINGENT NETWORK UPGRADE(S)

Certain Contingent Network Upgrades are **currently not the cost responsibility** of the Interconnection Customer but will be required for full Interconnection Service.

Table 4: Interconnection Customer Contingent Network Upgrade(s)

Contingent Network Upgrade(s) Description	Current Cost Assignment	Estimated In-Service Date
None	$0	N/A

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

AFFECTED SYSTEM UPGRADE(S)

To facilitate interconnection, the Affected System Transmission Owner will be required to perform the facilities study work as shown below necessary for the acceptance of the Interconnection Customer's Interconnection Facilities. **Table 5** displays the current impact study costs as part of the Affected System Impact review. The Affected System facilities study could provide revised costs and will provide each Interconnection Customer's allocation responsibilities for the upgrades.

Table 5: Interconnection Customer Affected System Upgrade(s)

Affected System Upgrades Description	Total Cost Estimate ($)	Allocated Share (%)	Allocated Cost Estimate ($)
None	$0	N/A	$0
Total	**$0**		**$0**

CONCLUSION

After all Interconnection Facilities and Network Upgrades have been placed into service, Interconnection Service for 124.20 MW can be granted. Full Interconnection Service will be delayed until the TOIF, Non-Shared NU, Shared NU, Contingent NU and Affected System NU that are required are completed. The Interconnection Customer's estimated cost responsibility for TOIF and Network Upgrades that is required for full interconnection service are summarized in the table below.

Table 6: Cost Summary

Phase 1: Temporary Interconnection

Description	Allocated Cost Estimate
Transmission Owner Interconnection Facilities	$300,000
Network Upgrades	$1,450,000
Total	**$1,750,000**

Phase 2: Permanent Interconnection

Description	Allocated Cost Estimate
Transmission Owner Interconnection Facilities	$300,000
Network Upgrades	$1,950,000
Total	**$2,250,000**

APPENDICES

A: TRANSMISSION OWNER'S INTERCONNECTION FACILITIES STUDY REPORT AND NETWORK UPGRADES REPORT(S)

See next page for the Transmission Owner's Interconnection Facilities Study Report and Network Upgrades Report(s).

DISIS-2013-002-4
GENERATION INTERCONNECTION
JOINT FACILITY STUDY

GEN-2013-002 & GEN-2013-019   124.2 MW at Monolith 115 kV Substation

March 2020

PREPARED FOR:
SOUTHWEST POWER POOL

PREPARED BY:
NEBRASKA PUBLIC POWER DISTRICT
AND
LINCOLN ELECTRIC SYSTEM

Nebraska Public Power District
"Always there when you need us"

Lincoln Electric System

The *NPPD-LES DISIS-2013-002-4 Joint Facility Study* was performed to document the reliability impacts of a generation project that is proposed to interconnect to the NPPD/LES transmission system. This project has developed through the SPP Definitive Interconnection System Impact Study process and has advanced to the facility study stage. SPP has requested that NPPD and LES perform a joint Facility Study associated with the generation interconnection projects listed below:

Project	MW	Type	Point-of-Interconnection
GEN-2013-002 & GEN-2013-019	124.2	Wind	Monolith 115 kV Substation

NPPD and LES entered into a joint facility study agreement to evaluate the interconnection of the generation interconnection customer. NPPD and LES subsequently performed the joint Facility Study at the request of SPP for these generation interconnection requests.

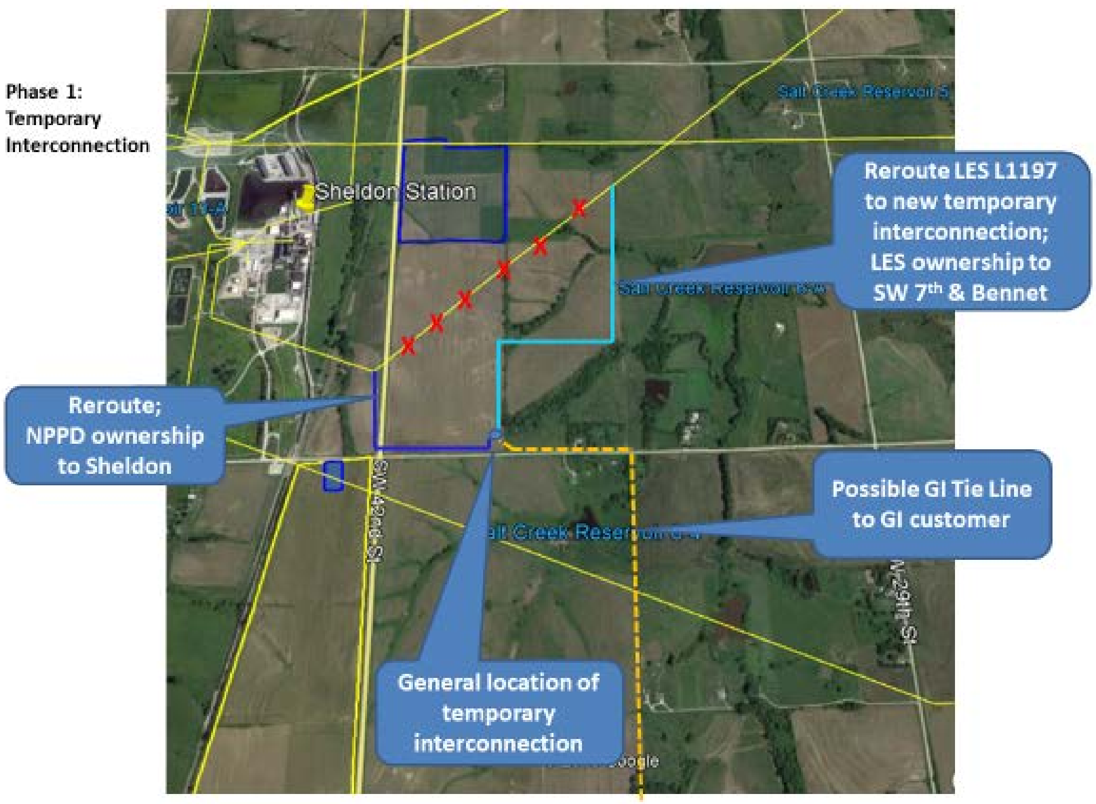
For background reference, the original facility studies were conducted by LES which focused on the impacts of GEN-2013-002 & GEN-2013-019 and included a detailed loadflow analysis and short circuit analysis. The stability analysis was performed by Mitsubishi Electric on behalf of SPP in the DISIS stage. Originally, these GI projects were planned to interconnect to the LES Sheldon – SW 7th & Bennet 115 kV line (or previously modeled as Sheldon – Folsom 115 kV) via a new 115 kV ring substation. Since the posting of the original LES Facility Studies in 2014 & 2015, GEN-2013-002 & GEN-2013-019 have merged to a common POI and the Sheldon – SW 7th & Bennet 115 kV line is planned to be re-routed into the new NPPD Monolith (Olive Creek) 115 kV substation adjacent to Sheldon Station. The original studies did not identify any additional network upgrades that were the sole responsibility of these GI projects. NPPD performed a facility study (NPPD DISIS-2013-002-3) in 2019 which included the GI projects interconnected to the new NPPD Monolith (Olive Creek) 115 KV substation.

The construction schedule for the new NPPD Monolith/Olive Creek substation project is currently in the 2023/2024 timeframe. The interconnection customer has requested interconnection service prior to 2023/2024 so NPPD and LES have been requested to perform an additional facility study evaluating a temporary interconnection that will meet the needs of the customer and facilitate the permanent interconnection at the new Monolith (Olive Creek) 115 kV substation. This joint facility study is being performed to review temporary interconnection facilities for GEN-2013-002 and GEN-2013-019 on the existing LES Sheldon – SW 7th & Bennet 115 kV line and the re-route of the line around the site of the future Monolith/Olive Creek 115 kV substation. NPPD and LES have also agreed to transfer ownership of the 115 kV line from the temporary POI back to Sheldon from LES to NPPD.

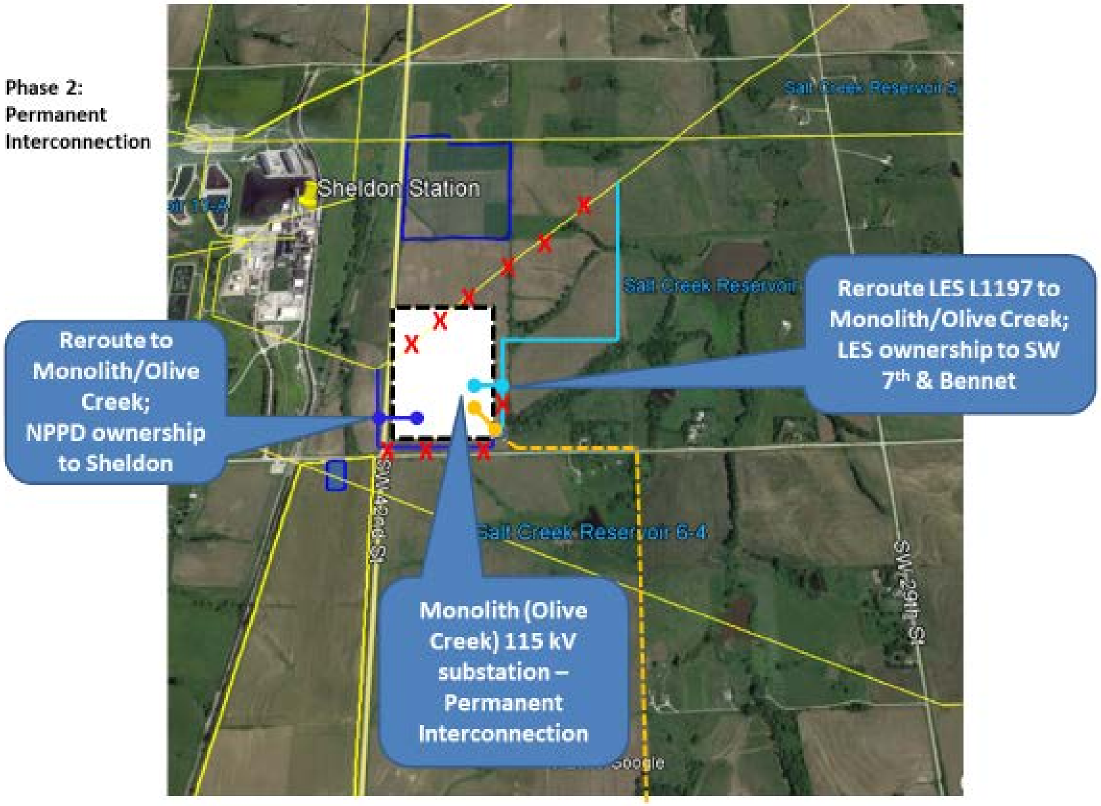
For this Joint Facility Study, LES has performed additional study work and analysis to review the impacts of the proposed GI projects on the transmission system. The LES documentation of this study work is included in *Addendum A* of this report. The LES study work did not identify any impacted facilities or network upgrades due to the proposed GI projects.

For this Joint Facility Study, NPPD has performed additional study work to evaluate the impact on the short circuit capabilities of the transmission system with the proposed temporary interconnection. The NPPD documentation of this study work is included in *Addendum B* of this report. The NPPD study work did not identify any new facilities that were impacted due to the proposed GI projects that weren't already scheduled for replacement.

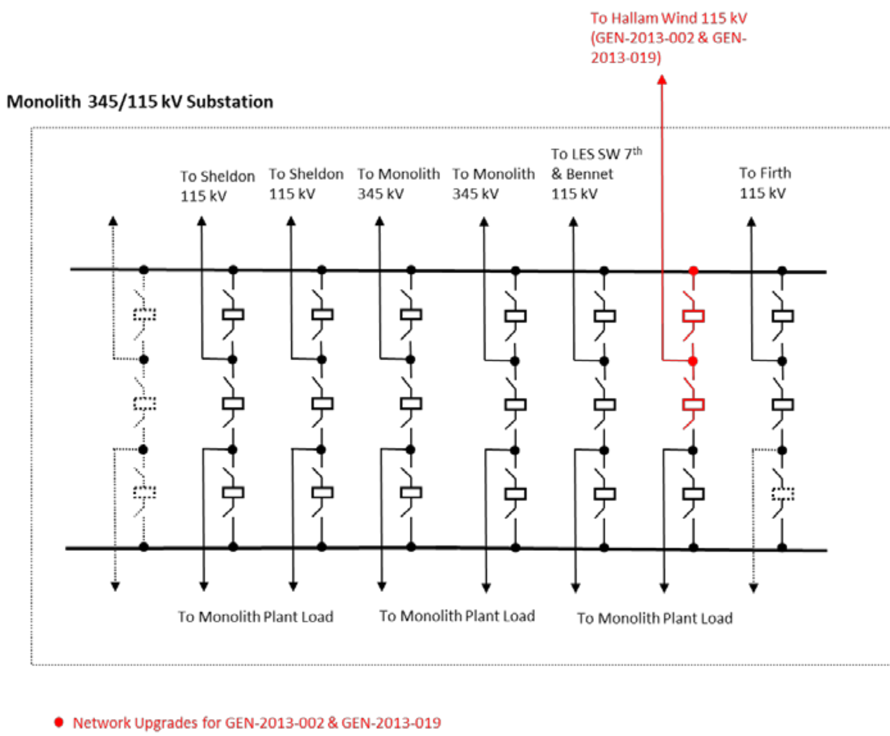
NPPD has developed new cost estimates for the proposed temporary and permanent interconnection of the GI projects. The temporary interconnection (Phase 1) will be a tap of the Sheldon – SW 7th & Bennet 115 kV line and re-route of the 115 kV line to the location of the temporary interconnection site. This is displayed in the high-level graphical representation below:



The permanent interconnection (Phase 2) will be expansion of the Monolith / Olive Creek 115 kV substation to include a terminal for the generation tie line for the generation interconnection projects. This is displayed in the high-level graphical representation below:



A conceptual one-line diagram of the proposed Monolith 115 kV substation with the wind project generation interconnection requests is below:



NPPD has prepared the following cost estimates for the interconnection facilities and network upgrades associated with the generation interconnection projects:

> **Phase 1 – Temporary Interconnection**: Re-route L-1197 to location of temporary interconnection of GEN-2013-002 and GEN-2013-019.
>
> **$ 1.75 Million**
>
> **Phase 2 – Permanent Interconnection in Monolith/Olive Creek 115 kV substation**: Expand Monolith/Olive Creek 115 kV substation to accommodate new 115 kV terminal for the interconnection of GEN-2013-002 and GEN-2013-019.
>
> **$ 2.25 Million**

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. Currently, the work for the temporary interconnection (Phase 1) can be accommodated in late 2021 and the work for the permanent interconnection (Phase 2) can be accommodated in 2023/2024. 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.

Addendum A – LES Facility Study document

INTERCONNECTION FACILITY STUDY (GEN-2013-002 & GEN-2013-019)

Steady State Analysis

Lincoln Electric System

Effective 2/3/2020

1.0 Executive Summary

This study investigated the impact of both a temporary and permanent interconnection of the proposed 124.2 MW Hallam (Blue Prairie) Wind Farm (known as GEN-2013-002 and GEN-2013-019) on Lincoln Electric System's transmission system. Feasibility was determined by investigating the reliability of the LES portion of the Bulk Electric System (BES) based on steady state analysis under various system conditions. This study demonstrated that the proposed temporary interconnection between the wind farm and NPPD will not require Lincoln Electric System to make any network upgrades. A future permanent interconnection between the wind farm and NPPD was also not required to upgrade the network of the LES transmission system.

2.0 Introduction

2.1 General Information

This study of the Hallam Wind Farm and Lincoln Electric System's transmission system was performed to ensure that the proposed temporary and permanent interconnection would not be a detriment to the reliability of the LES portion of the BES. The system reliability was assessed based on all applicable standards and criteria.

2.2 Scope

The purpose of this study was to determine if a temporary and permanent interconnection between the Hallam Wind Farm and NPPD adversely impacted the transmission system of LES. This was achieved by subjugating the transmission system to various disturbances as required by the NERC reliability standards and ensuring that both SPP and LES criteria were met.

3.0 Study Procedure

3.1 Methodology

The methodology used to study the temporary and permanent interconnection scenarios were based on simulating the following contingency categories taken from the TPL-001-4 Reliability Standard (Table 1):

- P1 – all single element contingencies in area 650 plus tie lines and selected other contingencies in the study area.
- P4 and P7 – all multiple element contingencies including stuck breaker contingencies and common structure outages.

- P6 – multiple element contingencies (N-1-1) involving independent outages of facilities within the study area.

The post-contingency loading on the monitored facilities were screened against 100% of the seasonal normal rating (Rate A). The monitored facilities covered Nebraska and included the areas of 640, 641, 642, 645, and 650. The post-contingency voltage levels were screened for voltages outside a range from 0.90 PU to 1.05 PU.

3.2 Steady State Model Development

The following power flow cases from the SPP 2019 Model Series were used for this study:

Year 2021
    Summer Peak and Spring Peak

Year 2024
    Summer Peak and Summer Shoulder

Year 2029
    Summer Peak

The 2021 and 2024 cases cover the near-term planning horizon and the 2029 summer case covers the long-term planning horizon. The LES spring peak is approximately 60% of the summer peak. The summer shoulder load is set at 70% of the summer peak.

Modifications to the SPP 2019 Model Series cases were needed to bring the models up to date. The system modifications are listed below:

- Onsite verification of bus conductors led to facility ratings for line L1015B (19&Alvo – NW 12th&Arbor) to be changed from 251 to 344 MVA (Summer Normal Rating)
- Facility ratings for Line L6775B (84th &Bluff – 84th & Fletcher) were changed from 319 to 359 MVA (Summer Normal Rating) due to relay setting changes.
- NPPD updated the conductor rating for line L1181B, which is a 115kV line from 70th & Bluff to Davey. from 112 to 140 MVA (Summer Normal Rating)
- Impedance changes were implemented relating to the tapped locations of new substations at 120th & Alvo, 40th & Bennet, and 76th & Rokeby.

3.3 Transmission Facilities

LES has no generation or transmission facilities out of service for planned maintenance during the study period. Load tap changing transformers are the only automatic devices and were included in the power flow cases. All local capacitors and reactors connected to the system are manually switched via SCADA.

4.0 Temporary Interconnection Analysis

The new Monolith 115kV substation will not be in service until 2023-2024, according to NPPD. Based on this date, a temporary interconnection was studied for the model years 2021 and 2024. To accommodate this temporary interconnection, the Point-of-Interconnection (POI) for the LES line L1197 is to be relocated from the Sheldon 115 kV substation to a new location nearby. This temporary interconnection will occur on NPPD's side of the new POI and will be under the ownership and responsibility of NPPD.

For detailed information on the individual case years, please refer to the next following subsections.

4.1 Year 2021 Power Flow Cases

The analysis for the temporary interconnection used 2021 summer peak and 2021 spring peak cases that were selected from the SPP 2019 series models. The power flow cases simulated the temporary interconnection accordingly in both system intact and post-contingency conditions after system modifications mentioned above. The 2021 summer peak load demand is 773 MW, and the LES spring peak load is approximately 60% of its summer peak load, which is about 446 MW.

4.2 Year 2024 Power Flow Cases

The 2024 cases used for the analysis of the temporary interconnection were 2024 summer peak and 2024 summer shoulder cases that were selected from the SPP 2019 series models. The power flow cases simulated the temporary interconnection accordingly in both system intact and post-contingency conditions after system modifications that included branch rating updates and branch impedance modification. The forecasted LES 2024 summer peak demand is 777 MW. The summer shoulder load is set to 70% of the summer peak load. Accordingly, the forecasted 2024 summer shoulder load demand is 544 MW.

4.3 Temporary Interconnection Study Results

The results of the system intact, single/multiple event contingency and N-1-1 contingency analyses were used to verify the impacts of this temporary interconnection on the LES transmission system.

The base cases were analyzed before and after the addition of the Hallam Wind Farm Temporary Interconnection. The following are the key findings from the power flow analysis:

- All LES transmission facilities were loaded within their appropriate seasonal normal ratings after the interconnection in all the cases.

- All LES bus voltages were maintained between 0.95 PU and 1.05 PU of normal system voltage in both year cases.

Single/multiple event contingency analysis included all the single element outages, multiple elements due to a fault and stuck breaker, and multiple contingency events for a loss of two or more circuits on common structure. All contingencies were monitored for percentage of flow rating greater than 100% RATE A and bus voltages that were not within 0.9 PU - 1.05 PU bandwidth. According to the study, no violations were flagged in this contingency analysis for the temporary interconnection of the Hallam Wind Farm in all the cases.

The N-1-1 analysis evaluated the impacts of independent contingency conditions for the study area. All possible combinations of N-1-1 contingencies in the area were simulated in this study. No violations on the LES transmission system were found in the N-1-1 contingency analysis for the temporary interconnection of the Hallam Wind Farm.

Based on the results of the above analyses, the temporary interconnection of the 124.2 MW Hallam Wind Farm will not cause any issues to the LES portion of the Bulk Electric System.

5.0 Permanent Interconnection Analyses

NPPD plans to construct a new Monolith substation and the expected in-service date is 2023-2024. The permanent interconnection needed to be studied and documented to make sure the impact of a permanent interconnection was minimal for the LES transmission system. To permanently connect to NPPD's transmission system, the POI for LES' line L1197 is to be re-terminated to the new Monolith 115 kV substation. Additionally, the wind farm requires a modified POI at the new Monolith substation. For detailed information on the individual case years, please refer to the next following subsections.

5.1 Year 2024 Power Flow Cases

The 2024 cases used for the analysis of the permanent interconnection were 2024 summer peak and 2024 summer shoulder cases that were selected from the SPP 2019 series models. The power flow cases simulated the permanent interconnection accordingly in both system intact and post-contingency conditions after system modifications mentioned in section 3.3.

The forecasted LES 2024 summer peak demand is 777 MW. The summer shoulder load is set to 70% of the summer peak load, which is 544 MW.

5.2 2029 Power Flow Case

The 2029 Summer Peak case was a case studied for long-term planning purposes regarding the permanent interconnection for the Hallam Wind Farm. The power flow case simulated the permanent interconnection accordingly in both system intact and post-contingency conditions after system modifications in the same way as the 2024 cases. The forecasted load used for the 2029 Summer peak was 783 MW.

5.3 Permanent Interconnection Study Results

The results of the system intact, single/multiple event contingency and N-1-1 contingency analyses were used to verify the impacts of this permanent interconnection on the LES transmission system.

The base cases were analyzed before and after the addition of the Hallam Wind Farm permanent interconnection. The following are the key findings from the power flow analysis:

- All LES transmission facilities were loaded within their appropriate seasonal normal ratings after the interconnection in all the cases.
- All LES bus voltages were maintained between 0.95 PU and 1.05 PU of normal system voltage in both year cases.

Single/multiple event contingency analysis included all the single element outages, multiple elements due to a fault and stuck breaker, and multiple contingency event for loss of two or more circuits on common structure. All contingencies were monitored for percentage of flow rating greater than 100% RATE A and bus voltages that were not within 0.95 PU - 1.05 PU bandwidth. No violations were flagged in this contingency analysis for the permanent interconnection of the wind farm both in the 2024 and 2029 cases.

The N-1-1 analysis evaluated the impacts of independent contingency conditions for the study area. All possible combinations of N-1-1 contingencies in the area were simulated in this study. No violations on the LES transmission system were found in the N-1-1 contingency analysis for the permanent interconnection of the Hallam Wind Farm.

Based on the results of the above analyses, the permanent interconnection of the 124.2 MW Hallam Wind Farm will not attribute any impacts to the LES portion of the Bulk Electric System.

6.0 Stability Analysis

A Stability Analysis, performed previously by SPP, determined that the machine rotor angle damping and transient voltages satisfied the “SPP Disturbance Performance Requirements” and the wind farm also satisfied the Low Voltage Ride Through (LVRT) requirements of FERC Order #661A. (Reference: “GEN-2013-002 & GEN-2013-019 Impact Restudy for Generator Modification, February 2019)

7.0 Short Circuit Fault Duty Evaluation

It is standard practice for LES to recommend replacing a circuit breaker when the current through the breaker for a fault exceeds 100% of its interrupting rating. For this generator interconnection, LES previously determined that no existing LES breakers were found to exceed their interrupting capability after addition of the Customer’s Phase I 50.6 MW and the Phase II 73.6 MW generation facilities. Therefore, there is no short circuit upgrade costs associated with the GEN-2013-002 and GEN-2013-019 interconnections. These results were consistent with the restudy that showed a maximum change in the fault current in the immediate area was 1.6kA.(Reference: “SPP Facility Study for Generator Interconnection Request GEN-2013-002”, March 2015 and “SPP Facility Study for Generator Interconnection Request GEN-2013-019”, March 2015)

8.0 Summary and Conclusion

The evaluation of the results of the steady state, single/multiple event contingency, and N-1-1 contingency analysis for both the temporary and permanent interconnection showed that the construction of the Hallam Wind Farm would have no adverse effect on the LES transmission system. In conclusion, there is no required network upgrades for the LES portion of the Bulk Electric System.

Addendum B – NPPD Short Circuit Analysis

NPPD Short Circuit Study

Model Development

Computer Programs

The Aspen One-liner software program (V14.7) was utilized to perform short circuit simulations and studies on the transmission system. The data files (transmission lines/transformer/generator constants) for the Aspen Oneliner are updated by NPPD numerous times per year as transmission system changes and additions occur across Nebraska. The short circuit data information (system equivalent impedances) for transmission system interconnections to non-Nebraska utilities are periodically updated with system changes or additions. The software program calculates the symmetrical (alternating current component) short circuit currents in physical amps or per unit values. If asymmetrical currents (alternating current component plus direct current component) are required, these values should be separately calculated and based on the X/R ratio at the fault location and the protective device operating time.

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

The Aspen Oneliner short circuit program does not have a specific generation module to model the wind generation transient short circuit current contributions for short circuits on the transmission system. A generation source at 50.6MVA(GEN-2013-002) and a 73.6MVA(GEN-2013-019) are modeled as a temporary three terminal line on L1197 from Sheldon to LES SW 7th and Bennet.

Base System Model Additions

The 2019 base short circuit data file was utilized to create a model for the Hallam Wind short circuit study. Below is the list of additions included in this short circuit study.

1. *Windfarm additions*: The addition of 124.2MW of wind generation modeled as a temporary three terminal line on NPPD L1197 from Sheldon to LES SW 7th and Bennet as 50.6MVA(GEN-2013-002) and a 73.6MVA(GEN-2013-019) generation sources.

The Aspen One-liner data file for this configuration is “WF 124.2MW tapped into L1197 NPPD 2019 DEC 17.OLR”. Other system additions necessary for the transmission of power due to the addition of this wind farm may be identified and have not been included in this short circuit study.

Study Methodology

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

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

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

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

Results

The following devices were found to be above 95% of their interrupting rating due to the addition of the projects considered in this study and are recommended for replacement.

Location – Circuit Switcher	Manuf.	Model Number	Interrupting Rating	Max Expected Interrupting (A)	Max Current (% of Rating)	Relative Change (%)
SHELDON 1134	WESTING HOUSE	1150-GM-10000	36511	35911	**98%**	7.1%
SHELDON 1136	WESTING HOUSE	1150-GM-10000	36511	35911	**98%**	7.1%

NOTE: All of the Sheldon 115kV breakers have been previously flagged for replacement with the Monolith Phase 2 buildout. If Monolith Phase 2 does not materialize in the future, then we may need to develop a permanent interconnection for this wind facility that would include these breaker replacements at Sheldon.