NPPD
DISIS-2023-001
FACILITY STUDY

GEN-2023-199 (Twin Church 230 kV)

FEBRUARY 2026

PREPARED FOR:
SOUTHWEST POWER POOL

PREPARED BY:
NEBRASKA PUBLIC POWER DISTRICT
ENERGY DELIVERY
TRANSMISSION ASSET PLANNING
ENGINEERING & ASSET MANAGEMENT

Nebraska Public Power District

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Introduction

The *NPPD DISIS-2023-001 Facility Study* was performed to document the interconnection facilities and network upgrades identified by SPP in Phase 2 Re-Study #1 of the SPP DISIS-2023-001 Study for the following requests:

GEN-2023-199 (Twin Church)

NPPD also reviewed the proposed interconnection facilities and network upgrades and associated generation interconnection request impacts on the Short Circuit capability of the NPPD system. The NPPD Facility Study includes detailed cost estimates and estimated project schedules for the upgrades identified in the SPP and NPPD studies.

The initial list of Interconnection / Network Upgrades from DISIS-2023-001 Phase 2 Re-Study #1 for the GEN-2023-199 GI requests is below:

- Twin Church 230 kV Substation

Loadflow Study

In order to ensure the proposed interconnection plan listed above can be implemented reliably, NPPD performed a loadflow study evaluating the proposed transmission interconnection plan for GEN-2023-199. This interconnection plan was evaluated using an out-year HVER study model associated with DISIS-2023-001 Phase 2 Re-study #1.

In addition, NPPD evaluated a different generation dispatch scenario for other HVER units in the local area. The SPP HVER models do not properly account for the output of all prior queued resources in the local area and severely restrict the output of prior queued HVER units which has a masking impact on transmission constraints in the area. It is important to ensure these resources are evaluated at full output levels to ensure interconnection reliability and to meet NERC FAC-001 requirements documented in NPPD's Facility Connection Requirements Document.

NPPD utilized PSS/E Activity ACCC to scan for local area transmission issues for system intact and single contingency event scenarios in the NPPD modeling area. The transmission options and dispatch scenarios evaluated in this loadflow study are listed in Tabel 1 below.

Table 1. Loadflow Study Parameters

SPP GI Study Models	
27SP	SPP HVER model: DIS231-TC02ALL-27SP0.sav, 2027 Summer Peak
27WP	SPP HVER model: DIS231-TC02ALL-27WP0.sav, 2027 Winter Peak

Dispatch Scenarios	
TC02ALL	Standard SPP HVER Dispatch
S10	HVER + Turtle Creek (Sholes, Haystack, Plum Creek) + Rattlesnake Creek Wind + Pierce County Solar at PMAX
S11	HVER + Turtle Creek (Sholes, Haystack, Plum Creek) + Rattlesnake Creek Wind + Pierce County Solar at PMAX + Holt County-Antelope 345 kV

Generator Bus #	Generator Bus Name	Generator Common Name	TC02ALL MW	S10 & S11 MW	△ MW
587153	[G16-021-GEN10.6900]	Haystack Wind	120	300	180
643253	[SHOLES.GEN.W0.6900]	Sholes Wind	21	160	139
643269	[RTLSNAK.GN1W12.000]	Rattlesnake Wind	48	120	72
643270	[RTLSNAK.GN2W12.000]	Rattlesnake Wind	80	200	120
643275	[PLUMBCR.GENW0.6900]	Plum Creek Wind	92	230	138
760791	[G17-201GEN1 0.6900]	Sholes II Wind	100	250	150
763442	[G18-131-GEN10.6600]	Pierce County Solar	89	221	133
763453	[G18-132-GEN10.6600]	Pierce County Solar	81	202	121
			630	1683	1053

Table 2. 2027 Summer Peak Loadflow Study Result Summary

Case	Dispatch Scenario	Thermal Issue
27SP	TC02ALL	None
27SP	S10	105.4% loading on Twin Church-Sioux City 230 kV SYSTEM INTACT
27SP	S10	135.7% loading on Twin Church-Sioux City 230 kV FLO Hoskins-Raun 345 kV
27SP	S10	112.0% loading on Twin Church-Emerson 115 kV FLO Twin Church-Sioux City 230 kV
27SP	S10	112.6% loading on Petersburg-PetersburgTap 115 kV FLO Hoskins-Pierce County 345 kV
27SP	S10	108.3% loading on Albion-PetersburgTap 115 kV FLO Hoskins-Pierce County 345 kV
27SP	S10	102.7% loading on Antelope-Creighton 115 kV FLO Hoskins-Pierce County 345 kV
27SP	S11	105.4% loading on Twin Church-Sioux City 230 kV SYSTEM INTACT
27SP	S11	130.2% loading on Twin Church-Sioux City 230 kV FLO Hoskins-Raun 345 kV
27SP	S11	111.2% loading on Twin Church-Emerson 115 kV FLO Twin Church-Sioux City 230 kV

Table 3. 2027 Winter Peak Loadflow Study Result Summary

Case	Dispatch Scenario	Thermal Issue
27WP	TC02ALL	None
27WP	S10	114.5% loading on Twin Church-Sioux City 230 kV SYSTEM INTACT
27WP	S10	153.0% loading on Twin Church-Sioux City 230 kV FLO Hoskins-Raun 345 kV
27WP	S10	115.8% loading on Twin Church-Emerson 115 kV FLO Twin Church-Sioux City 230 kV
27WP	S10	131.6% loading on Petersburg-PetersburgTap 115 kV FLO Hoskins-Pierce County 345 kV
27WP	S10	129.9% loading on Albion-PetersburgTap 115 kV FLO Hoskins-Pierce County 345 kV
27WP	S10	135.8% loading on Antelope-CountyLine 115 kV FLO Hoskins-Pierce County 345 kV
27WP	S10	132.0% loading on CountyLine-BattleCreek 115 kV FLO Hoskins-Pierce County 345 kV
27WP	S10	130.0% loading on BattleCreek-N.Norfolk 115 kV FLO Hoskins-Pierce County 345 kV
27WP	S11	114.3% loading on Twin Church-Sioux City 230 kV SYSTEM INTACT
27WP	S11	145.6% loading on Twin Church-Sioux City 230 kV FLO Hoskins-Raun 345 kV
27WP	S11	114.7% loading on Twin Church-Emerson 115 kV FLO Twin Church-Sioux City 230 kV

Loadflow Study Result Summary

The loadflow study results show there were several additional transmission constraints discovered in this analysis due to the dispatch of existing HVER resources in the northeast Nebraska area. The loadflow study results also show the Antelope – Holt County 345 kV line as a contingent upgrade for DISIS-2018/19 GI projects (Pierce County Solar) is needed to mitigate transmission constraints in the area. It is recommended that the additional constraints be addressed for the GEN-2023-199 GI requests to connect reliably. There were 2 transmission lines identified that would need to be rebuilt to address the local area transmission constraints in this study:

- Twin Church – Sioux City 230 kV (L2306)
- Twin Church – Emerson 115 kV (L1098)

Interconnection Facility and Network Upgrades

NPPD's Engineering, Asset Management, and Project Management groups have reviewed the interconnection facility upgrades that are required for SPP DISIS-2023-001 Generation Interconnection projects. Detailed cost estimates have been prepared for the facility upgrades that were identified in the system impact study for the requests. The prepared cost estimates are study level estimates (+20%/-20%) and assume implementation of standard NPPD construction and procurement practices. The cost estimates for the interconnection facilities are below:

Interconnection Facility Upgrades

- Twin Church 230 kV Substation
  - GEN-2023-199
    - 250 MW Solar
  - Expansion of Twin Church 230 kV Substation
  - 36 Month Lead Time

$ 2,000,000

Network Upgrades allocated to GI requests external to NPPD

- Build second Red Willow 345/115 kV transformer
  - Upgrade would require expansion of the Red Willow 345 kV substation to accommodate a second 345 / 115 kV transformer at this location. Upgrade would include terminal upgrades at both voltage levels and the addition of a second 345 / 115 kV transformer. Upgrade Bay 104/106 due to short circuit study results.
  - At least 336 MVA
  - 60 Month Lead Time

$ 38,600,000

Additional Network Upgrades identified in NPPD Loadflow Study

- Uprate Twin Church – Sioux City 230 kV (L2306)
  - Upgrade would require conductor uprates and terminal upgrades at both ends of L2306.
  - At least 500 MVA
  - 36 Month Lead Time

$ 17,300,000

- Uprate Twin Church – Emerson 115 kV (L1098)
  - Upgrade would require conductor uprates and terminal upgrades at both ends of L1098.
  - At least 175 MVA
  - 36 Month Lead Time

$ 1,300,000

Preliminary one-line diagrams each generation interconnection project are in Appendix 2.

Interconnection Facilities and Network Upgrade project schedule details will be further discussed in the development of the generator interconnection agreements (GIA) and the milestones associated with the generation interconnection projects.

Contingent Upgrades

The results of DISIS-2023-001 documented that several Generation Interconnection requests are contingent on the completion of the following previously allocated required network upgrades:

- Tobias – Elm Creek 345 kV transmission line (ITP24)
- Antelope – Holt County 345 kV transmission line (ITP24, DISIS-2018/19)

If the generation interconnection projects proceed to the generation interconnection agreement, then an operating study may need to be performed to fully assess and evaluate the operation of the generation facility and network upgrades in accordance with NERC Standards. The operating study requirement will be included in the generation interconnection agreement with NPPD. If any generation interconnection projects are identified to have significant impact on the GGS Stability Interface (Flowgate #6006) and LRS/DC stability limitations in western NE, then the operating study will need to take these issues into account. The operating study may also need to evaluate the reactive power control requirements and associated equipment necessary to meet operational voltage requirements at the requested point of interconnection.

Short Circuit Study

NPPD's Engineering group has reviewed the short circuit impacts of the SPP DISIS-2023-001 Generation Interconnection projects and updated list of network upgrades interconnected to the NPPD transmission system. The result of this study is documented in Appendix 1. The short circuit study identified several breakers that required mitigation. The details of these mitigations are listed below. These mitigation projects should be included in the appropriate Generation Interconnection agreements associated with the DISIS-2023-001 GI projects.

- The Olive Creek and Sheldon 115 kV breaker issues will be mitigated by implementing transmission option 1e below.

Transmission Option 1e

- Relocate Moore T1 transformer to Princeton Road Station and install new 115 kV line from Princeton Road to Sheldon using the existing Moore T1 115 kV tie line terminal at Sheldon Station.
- Relocate Olive Creek T2 transformer to Beatrice Power Station.
- Single 345 kV transmission line from Princeton Road Station to Olive Creek.
- Install additional grounding on generation interconnection request step-up transformers associated with all IBR's at Olive Creek 115 kV substation (GEN-2013-002, GEN-2013-019, GEN-2019-041, GEN-2021-027)

- The Beatrice 115 kV Bay 1110/1112/1120/1122 breakers will be mitigated through replacement with higher capacity units.

- The Red Willow 345 kV Bay 104/106 breakers will be mitigated through the 2nd Red Willow 345/115 kV transformer project.

Appendix 1

NPPD Short Circuit Study Report

DISIS-2023-001 Final Plans

Short Circuit Study

Model Development

Computer Programs

The Aspen OneLiner software program was utilized to perform short circuit simulations and studies on the transmission system. Where elements were added to the short-circuit model, best estimates for impedance parameters were used based on available data and typical modeling practices. Short-circuit calculation options used were as follows:

- Flat voltage profile with V(pu) = 1.0
- Generator Impedance = Subtransient
- Ignore loads, transmission line G+jB, and shunts with positive sequence values

OneLiner was used to calculate three-phase (3PH) and single-line-to-ground (SLG) system-intact bus fault currents for all system buses associated with interrupting devices being evaluated in this study. For devices that the full bus fault current approached or exceeded the device's interrupting rating, more detailed fault calculations were done, calculating the maximum phase current through the breaker for close-in faults, close-in faults with the remote end open, and bus faults with all other branches to the bus open. The maximum phase current of these faults was recorded.

Base System Model Additions ("Base Case")

The base system model used by the transmission system protection department as of October 27, 2025 was used as the starting point for the short-circuit model used for this study. The base system model included all projects that were in-service at the time the model was copied. All Nebraska-area generation in the short-circuit model was enabled in order to provide maximum short-circuit current. For the study base case, planned system upgrades in the area of the studied projects and prior-queued large generator interconnections expected to be in-service prior to the projects being studied were added to the base case model. The following table lists the prior-queued large generator interconnections that were added to the base model for this study.

Prior Queued Large Generator Interconnections

Queue Designation	Proposed POI	Capacity (MW)
GEN-2013-002	Hallam 115kV / Panama IBR to Olive Creek	50.6
GEN-2013-019	Hallam 115kV / Panama IBR to Olive Creek	73.6
GEN-2016-074	Sweetwater 345kV (Expand substation)	200
GEN-2017-144	Holt County 345kV Substation (Expand substation)	200
GEN-2017-181	Tobias 345kV Substation (Expand substation)	300
GEN-2017-182	Tobias 345kV Substation (Expand substation)	128
GEN-2017-201	Turtle Creek 345kV connect at Sholes WF	250
GEN-2017-234	Greeley 115kV Substation (New substation)	115
GEN-2018-060	Macon 345kV (Expand substation)	50
GEN-2018-125	Etna 345kV (New substation)	231
GEN-2018-131	Pierce County 345kV (New substation)	221.4
GEN-2018-132	Pierce County 345kV (New substation)	201.6
GEN-2019-039	Butler County 115kV (New substation)	174.5
GEN-2019-041	Olive Creek 115kV (Expand substation)	78
GEN-2020-011	Axtell 345kV Substation (Expand substation)	320
GEN-2020-013	Orleans 115kV Substation (Expand substation)	215
GEN-2020-069	Kilgore 115kV Substation (New substation)	52.85
GEN-2021-027	Olive Creek 115kV Substation (Expand substation)	102
GEN-2021-057	Antelope 345kV Substation (Expand substation)	300

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. These include:

- The planned 345kV line from GGS – Thedford – Holt County "RPLAN" was included with a 345kV/115kV tie transformer at Thedford 115 kV
- New 345kV line from Antelope to Holt County
- New Olive Creek sub addition near Mark Moore/Sheldon
- Upgrade of the Columbus East T3 to 336MVA
- Stanton North expansion for a new 100MVA load-serving transformer, future 115kV line Stanton North to Norfolk, Hoskins T1 replaced with a 336MVA
- Upgrade of Mark Moore T1 replacement with a 417MVA
- Rebuild of L1153B Columbus SE to new collector sub for G19-39-TAP (Butler County) to Rising City
- Rebuild of L1132 Holdrege-Orleans to new collector sub for G20-13 at/near Orleans
- Addition at Antelope of a 345kV/115kV transformer at 417MVA
- Addition at Axtell of a 345kV/115kV transformer at 417MVA
- Rebuild of L1067 Axtell-Kearney.

Model Additions for Projects Being Studied ("Study Case")

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

Large Generator Interconnections Added to Study Case

Queue Designation	Proposed POI	Capacity (MW)
GEN-2023-199	Twin Church 230kV Substation (Expand substation)	250
GEN-2023-222	NPPD BPS 345kV Substation (New substation)	478
GEN-2023-223	NPPD BPS 345kV Substation (New substation)	239
GEN-2023-224	NPPD Princeton Road 345kV Substation (New substation)	478
GEN-2023-225	NPPD Princeton Road 345kV Substation (New substation-115kV)	217

In addition to the DISIS-2021-001 generator interconnections, network system upgrades in the area of the studied projects were added to the base model. These include:

- New 345kV line Tobias 345kV substation to Elm Creek Kansas
- New substation Daykin 345kV ~10mi from Tobias on Tobias-ElmCreek
- New 345kV line BPS 345kV substation to Olive Creek
- New 345kV line Olive Creek 345kV substation to Princeton Road
- Addition at Red Willow of a 345kV/115kV transformer at 336MVA
- Rebuild of L1089 115kV Lowell to Minden

The short circuit study revealed extremely high fault currents on several 115kV buses. An additional short circuit was performed using some system modifications to limit the 115kV fault current to below 63kA. Mitigation changes to include:

- Move Mark Moore 345kV/115kV transformer at 417MVA to use at Princeton Road
- Move Olive Creek 345kV/115kV transformer #2 at 417MVA to use at BPS 345kV
- Existing L1180B Olive Creek-Firth rebuild to 137MVA
- Existing L1177A Beatrice-BPS 115kV rebuild to 250MVA
- Existing L1178A Beatrice-BPS 115kV rebuild to 250MVA
- Existing L1175C Beatrice-Harbine rebuild to 250MVA

Study Methodology

Circuit breaker, circuit switcher, and fuse ratings were identified by querying NPPD's SAP equipment database and extracting equipment data including short-circuit ratings. Breaker ratings given on an asymmetrical (total current) basis were converted to symmetrical current ratings using an assumed maximum system operating voltage of 1.00 per unit.

The calculated short-circuit current at the equipment bus was extracted from the short-circuit results from Aspen OneLiner and compared against the interrupting device interrupting rating. It is recommended that all equipment be replaced if it is found to be at or above 95% of its interrupting rating and seeing an increase of 1% or more in its interrupting duty as a result of the studied projects.

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 mitigation.

Location – Breaker	Manuf.	Model Number	Interrupting Rating	Max Expected Interrupting (A)	Relative Change (%)	Max Current (% of Rating)
All (21) OLIVE CREEK 115kV breakers	GENERAL ELECTRIC	Dt1-145-63-f1	63000	67096	19.5%	106.5%
All (15) SHELDON 115kV GE breakers	GENERAL ELECTRIC	DT1-145-63-F1	63000	66233	24.0%	105.1%
SHELDON 115-BAY 1126	SIEMENS	SPS2S-123-63-2	63000	69545	24.0%	110.4%
RED WILLOW 345-BAY 104	ABB	RMAG	25000	23741	7.1%	95.0%
RED WILLOW 345-BAY 106	ABB	RMAG	25000	23741	7.1%	95.0%

The mitigation changes studied would change the affected breakers to the list below:

Location – Breaker	Manuf.	Model Number	Interrupting Rating	Max Expected Interrupting (A)	Relative Change (%)	Max Current (% of Rating)
BEATRICE 115-BAY 1110	ALLIS CHALMERS	BZO-121-20-7	20000	19356.4	46.6%	96.8%
BEATRICE 115-BAY 1112	ALLIS CHALMERS	BZO-121-20-7	20000	19356.4	46.6%	96.8%
BEATRICE 115-BAY 1120	MCGRAW EDISON	AHF-48-121-20	20000	19356.4	46.6%	96.8%
BEATRICE 115-BAY 1122	MCGRAW EDISON	AHF-48-121-20	20000	19356.4	46.6%	96.8%
RED WILLOW 345-BAY 104	ABB	RMAG	25000	23741	7.1%	95.0%
RED WILLOW 345-BAY 106	ABB	RMAG	25000	23741	7.1%	95.0%

Mitigation Summary

The Olive Creek and Sheldon 115 kV breaker issues will be mitigated by implementing transmission option 1e below.

Transmission Option 1e

- Relocate Moore T1 transformer to Princeton Road Station and install new 115 kV line from Princeton Road to Sheldon using the existing Moore T1 115 kV tie line terminal at Sheldon Station.
- Relocate Olive Creek T2 transformer to Beatrice Power Station.
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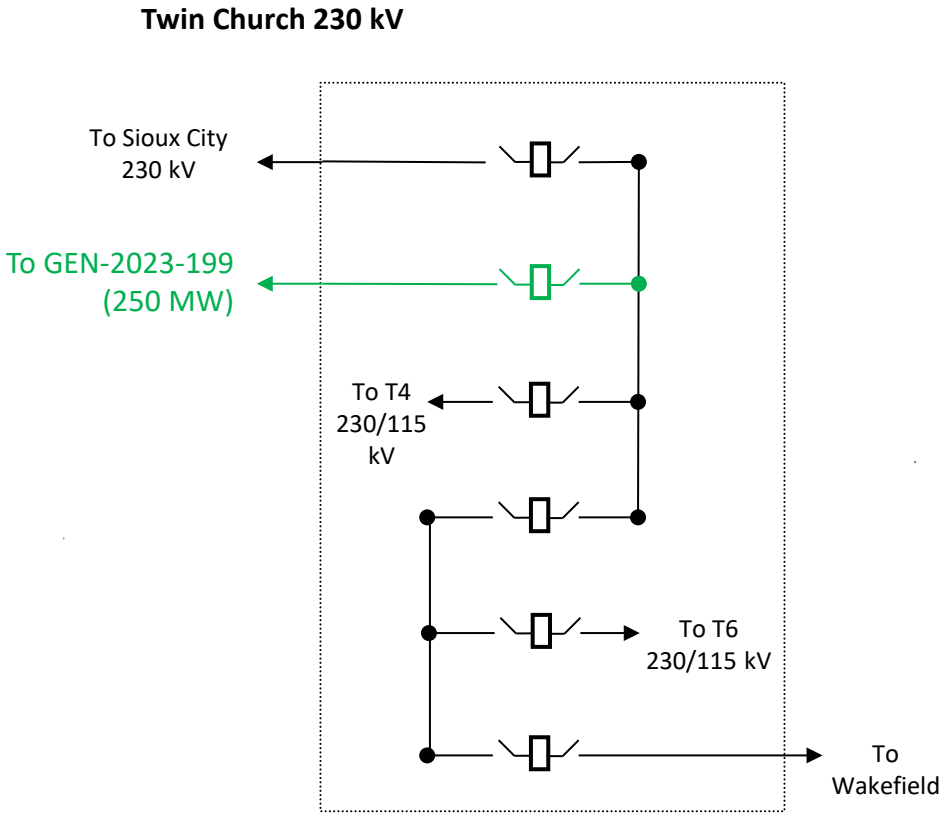
The Beatrice 115 kV Bay 1110/1112/1120/1122 breakers will be mitigated through replacement with higher capacity units.

The Red Willow 345 kV Bay 104/106 breakers will be mitigated through the 2nd Red Willow 345/115 kV transformer project.

After the mitigations, all devices were found to be below 95% of the interrupting ratings after the addition of the projects considered in this study.

Appendix 2

Generation Interconnection Facilities One-Line Diagrams



- DISIS-2023-001 Interconnection Facilities for GEN-2023-199 (including terminal/bay swap)