New 138 kV Mill Creek Substation

August 2023

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1 Executive Summary

CenterPoint Energy Houston Electric, LLC ("CenterPoint Energy" or "CNP") is proposing to build a new 138 kV transmission line needed to provide service to a new 138/35 kV Mill Creek distribution substation in the Magnolia area in Montgomery County, TX. The new Mill Creek substation will include two 138/35 kV, 100 MVA distribution transformers serving a forecasted load of 70 MW by 2025. A new Mill Creek distribution substation is proposed to support load currently served by existing Pinehurst, Tomball, and Stone Lake substations as well as future load growth. Two 138 kV options were evaluated as follows:

- Option 1:
  - Construction of a new 138/35 kV Mill Creek substation
  - Loop 138 kV Pinehurst to Tomball ckt 81 into Mill Creek substation, with an approximately 4.5 mi double circuit line.

- Option 2:
  - Construction of a new 138/35 kV Mill Creek substation
  - Loop 138 kV Pinehurst to Kluge ckt 81 into Mill Creek substation, with an approximately 4.5 mi double circuit line.

Option 1 requires the installation of an 80 MVAR transmission cap bank to Kluge substation tapped off 138 kV Kluge to Pinehurst Ckt 81 and converting Pinehurst to a unity power factor (PF) station. Option 2 does not meet CenterPoint Planning Event criteria.

Option 1 is the most cost-effective solution to interconnect the new substation which will serve load currently served by existing Pinehurst, Tomball, and Stone Lake substations. This project also provides capacity for future area load growth. Option 1 is estimated to cost $61.34-$86.959M. This project is considered a "Neutral Project" by the Electric Reliability Council of Texas, Inc. (ERCOT), per ERCOT Protocols Section 3.11.4.3(1)(f), as it is a project to connect new load and will not create a new transmission circuit connection between two substations. Therefore, this project will follow the same process as ERCOT Tier 4 projects and does not require submittal to the Regional Planning Group for review. The project may require a Certificate of Convenience and Necessity (CCN), as several of the options could involve the construction of more than a 3-mile-long double circuit line to connect the new Mill Creek substation. The study evaluated summer peak conditions for both 2025 and 2027 based on the original load forecast which showed Mill Creek load being added in summer 2025. The most recent schedule now shows Mill Creek expected to be completed by August 2026. Since the study evaluated both 2025 and 2027 summer peak conditions, Transmission Planning assesses that the conclusions from the study would not change based on the new August 2026 completion date, thus inclusion of a summer peak 2026 study is not necessary. The August 2026 completion date takes into consideration typical lead times necessary to implement the proposed project, including the Public Utility Commission of Texas (PUCT) CCN process review and approval, materials, and construction lead times.

2 Background

CenterPoint Energy Distribution Planning has determined that a new load-serving substation Mill Creek is needed near the town of Magnolia in Montgomery County to support load currently served by existing Pinehurst, Tomball, and Stone Lake substations as well as future load growth.

CenterPoint Energy has identified three substation locations, 2-4.5 miles east of the 138 kV circuit 81 transmission right-of-way ("ROW"), as the future location for this new substation. All of the potential locations are electrically similar, with similar performance, thus only one representative location was used for this analysis. The 138 kV Tomball to Pinehurst to Kluge ckt 81 transmission line is the only 138 kV line close to the proposed substation site located in the most northern portion of the CenterPoint Energy service area; therefore, no other 138 kV transmission line interconnection options are feasible. Only 138 kV Tomball to Pinehurst to Kluge ckt 81 line segments were considered in this study.

Mill Creek substation will be a 138/35 kV distribution substation with 2-100 MVA transformers, 4-35 kV feeders, configured as a 138 kV loop substation to serve the forecasted 2025 load. The 6-year history and 10-year load forecast for Mill Creek substation is shown in Table 2-1. A study was performed to determine the thermal and voltage impacts of adding Mill Creek substation to the CenterPoint Energy transmission system. The substation is expected to be energized by August 2026.

Table 2-1: 6-year history and 10-year load forecast for Mill Creek substation

SUBSTATION NAME	Sub ID	KV	Z	S/C	HISTORICAL (MW)						FORECAST (MW)									
					2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
MILL CREEK	MLC	35	N	CYP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	70.80	70.89	70.97	71.06	71.15	71.24	71.32	71.41
PINEHURST	PI	35	N	CYP	169.80	176.36	168.79	186.22	183.77	210.30	237.94	252.75	207.46	207.71	207.97	208.22	208.48	208.73	208.99	209.25
TOMBALL 12KV	TB	12	N	CYP	16.25	15.66	15.76	15.91	15.69	15.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOMBALL 35KV	TB	35	N	CYP	152.48	156.18	161.36	169.02	169.31	186.20	172.13	178.70	163.95	164.15	164.35	164.55	164.75	164.95	165.16	165.36
STONE LAKE	STL	35	N	CYP	0.00	0.00	0.00	0.00	0.00	0.00	112.95	115.91	118.95	112.07	115.01	118.03	121.12	124.30	127.56	127.72
TOTAL (MW)					338.53	348.20	345.91	371.15	368.77	412.41	523.02	547.36	561.16	554.82	558.31	561.86	565.50	569.22	573.03	573.74

3 Study Assumptions, Base Cases Used & Study Cases

This study is based on the load forecast, generation pattern, and network topology (including the best estimate of any planned transmission line maintenance outages) projected for 2025 summer peak, 2027 summer peak, and the 2026 minimum load conditions contained in the ERCOT Steady-State Working Group ("SSWG") base cases posted on June 29, 2022. The base cases used for this study were built from the ERCOT SSWG cases and contain the changes listed in Appendix A. The base cases used for this study are collectively referred to as the Internal CNP Base Cases and were completed on October 07, 2022. The following internal base cases were used to perform this study.

- CNP_2025_SUM1_06292022_20221007.sav
- CNP_2027_SUM1_06292022_20221007.sav
- CNP_2026_MIN_06292022_20221007.sav

Distribution Planning provided the load forecast for the Study Case, detailed in Table 2-1. The provided load forecasts associated with the estimated 138/35 kV transformer losses are incorporated into the Study Cases, as summarized in Appendix B for 2025, 2027 summer peak cases and for 2026 minimum cases, respectively.

4 Transmission Options

CenterPoint Energy evaluated two interconnection options to connect the new 138/35 kV Mill Creek distribution substation. The Study Cases include the addition of Mill Creek substation and the resulting load forecast updates for the Pinehurst, Tomball, and Stone Lake substations as shown in Table 2-1. The expected transmission system configuration near Mill Creek substation in 2025 is shown in Figure 4-1.

- Option 1: Loop 138 kV Pinehurst to Tomball ckt 81 into Mill Creek substation, with an approximately 4.5 mi double circuit line. The one line-diagram for Option 1 configuration is shown in Figure 4-2.

- Option 2: Loop 138 kV Pinehurst to Kluge ckt 81 into Mill Creek substation, with an approximately 4.5 mi double circuit line. The one line-diagram for Option 2 configuration is shown in Figure 4-3.

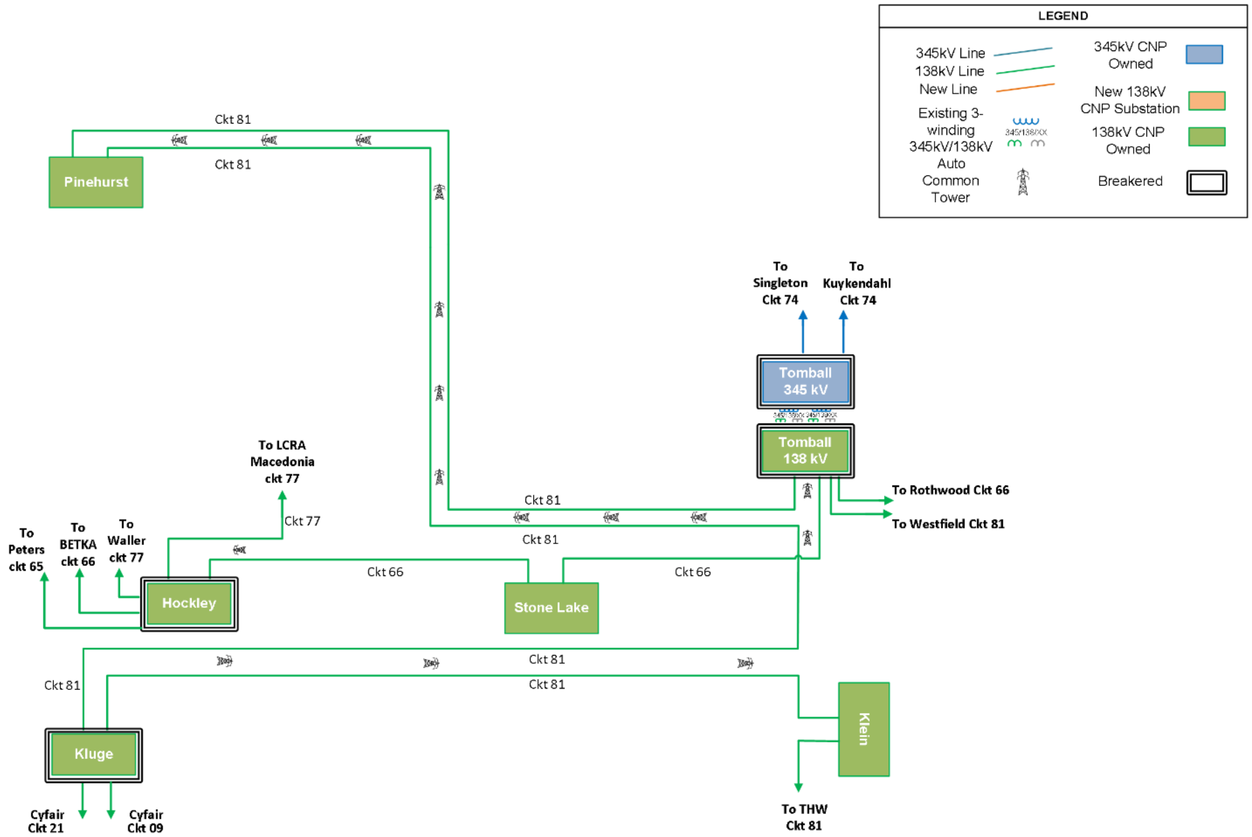

Figure 4-1: Expected Configuration in the Magnolia Area (2025 Summer Peak Base Case)

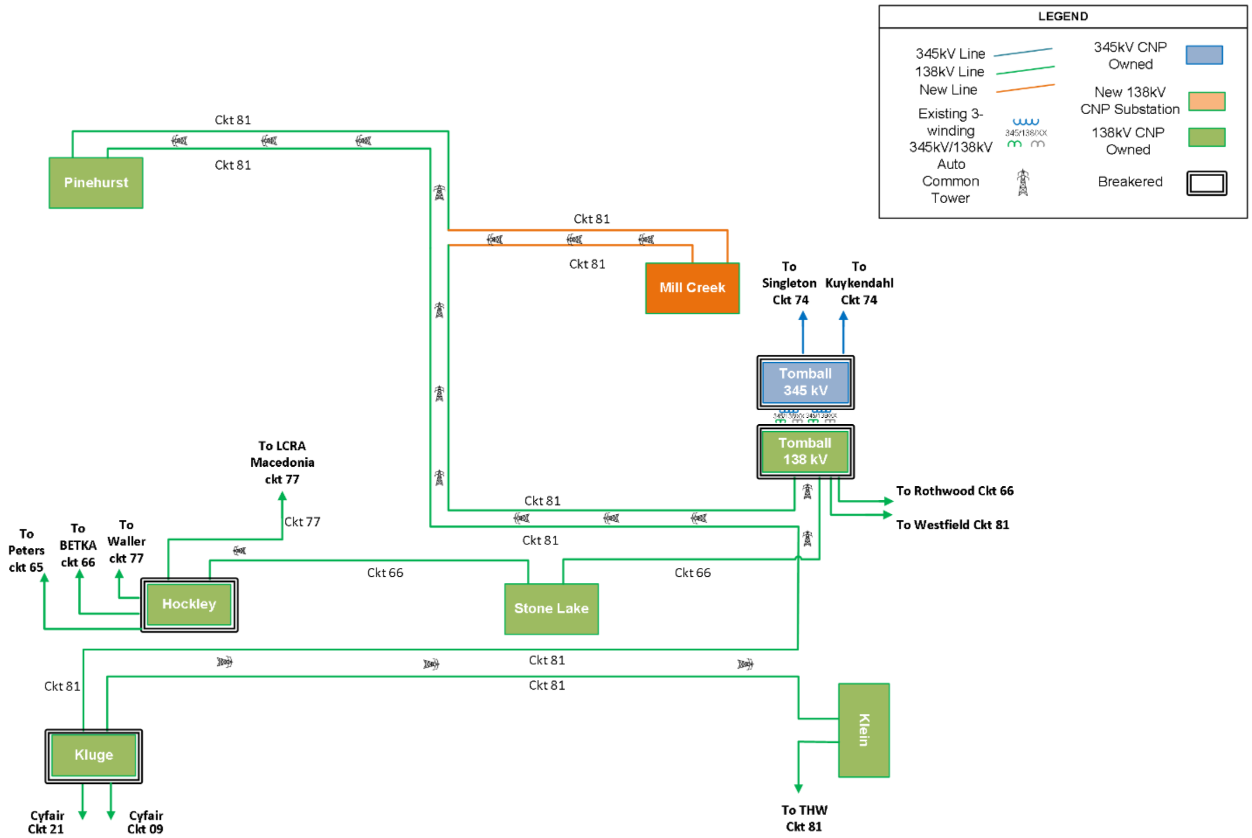

Figure 4-2: 138 kV Transmission System Configuration Near Mill Creek Substation proposed for Option 1

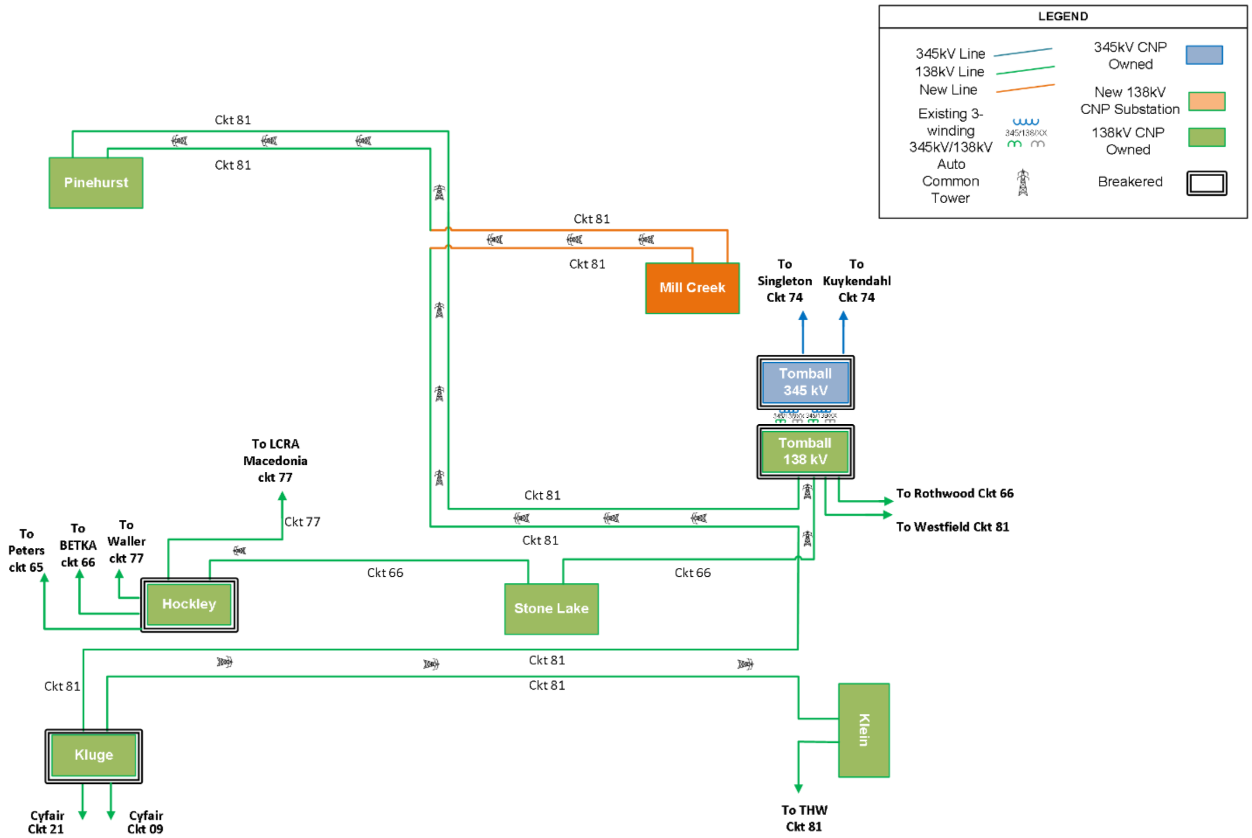

Figure 4-3: 138 kV Transmission System Configuration Near Mill Creek Substation proposed for Option 2

5 Steady-State Power Flow Analysis

CenterPoint Energy performed steady-state power flow analysis using the base cases and study cases described above. Designs were tested against the applicable North American Electric Reliability Corporation (NERC) Reliability Standard TPL- 001- 5.1, ERCOT Transmission Planning Criteria, and CenterPoint Energy Transmission System Design Criteria. CenterPoint Energy has developed planning events based on this reliability standard and performance criteria. The CenterPoint Energy Planning Events are defined as follows:

- CNP Planning Event P0 (no contingency) which is equivalent to NERC Category P0.
- CNP Planning Event P1 (consists of normal initial conditions followed by loss of one transmission element (generator, transmission circuit, transformer, or shunt device)) which is equivalent to NERC Category P1.
- CNP Planning Event P2 (consists of normal initial conditions followed by outage of two or more circuits due to failure of a breaker to operate under fault conditions or due to a bus section fault) which is equivalent to NERC Category P2.
- CNP Planning Event P3 (consists of normal initial conditions followed by loss of a generator and an additional outage of any of the following: (single circuit, single (A-1) autotransformer outage, or a single (G-1) generator outage)) which is equivalent to NERC Category P3, but also includes ERCOT-specific Reliability Performance Criteria Event 2 (consists of any single generating unit unavailable, followed by manual system adjustment, followed by a common tower outage, which includes outage of two circuits sharing a common tower for more than half a mile).
- NERC Category P4 Events are equivalent to NERC Category P2 Events for CenterPoint Energy's system; therefore, no specific P4 events are included in CenterPoint Energy's analysis.
- CNP Planning Event P5 (consists of normal initial conditions followed by delayed fault clearing due to the failure of a non-redundant component of a protection system protecting the faulted element to operate as designed, for one of the following: (generator, transmission circuit, transformer, shunt device, or bus section)) which is equivalent to NERC Category P5.
- CNP Planning Event P6 (consists of the outage of a 345/138 kV autotransformer (A-1) followed by an outage of any of the following: single circuit, single (A-1) autotransformer, or a single (G-1) generator) which is equivalent to NERC Category P6-2, but also includes ERCOT-specific Reliability Performance Criteria Event 3 (consist of unavailability of a 345/138 kV transformer, followed by manual system adjustments, followed by the common tower outage for circuits sharing a common tower for more than half a mile).
- CNP Planning Event P7 (consists of normal initial conditions followed by the outage of circuits sharing a common tower for more than a mile) which is equivalent to NERC

Category P7, but also includes ERCOT–specific Reliability Performance Criteria Event 1 (consist of the outage of circuits sharing a common tower for more than half a mile).

Studies were conducted in accordance with CenterPoint Energy Transmission System Design Criteria, which includes monitoring Rate A (normal rating) for CNP Planning Events P0 and P1 and Rate B (emergency rating) for CNP Planning Events P2 through P7. Bus voltages should remain within the 0.95 p.u. to 1.05 p.u. range for CNP Planning Events P0 and P1 and the 0.92 p.u. to 1.05 p.u. range for CNP Planning Events P2 through P7.

Detailed thermal loading and voltage results for all CNP Planning Events for the study cases are attached in Appendix C,D, and E: Steady-State Analysis Contingency Results.

The following legend applies for all tables:

- CNV – Contingency Not Valid.
- BNV – Branch/Bus Not Valid.
- FCNV – First Contingency Not Valid.
- SCNV – Second Contingency Not Valid.
- * - the overload occurs due to a different contingency that is shown; and
- ! – loading with a new rating of the line segment(s) with the rebuild/reconductor completed.

5.1 Contingency Analysis - Results

CenterPoint Energy performed contingency analysis to evaluate the impact of the new Mill Creek substation and corresponding Tomball, Pinehurst, and Stone Lake substation load changes for the two interconnection options in the years 2025 through 2027. A summary of the results for the summer peak cases of 2025 and 2027 and for the 2026 minimum case are shown in the following sections, the complete set of results for the two interconnection options are included in Appendix C.

5.1.1 CNP Planning Event P0

Under normal operating conditions, there were no base case thermal loading or voltage concerns identified for the CenterPoint Energy transmission system for either option.

5.1.2 CNP Planning Event P1

Under the CNP Planning Event P1, no new thermal loading concerns were identified. Voltage concerns were identified under CNP Planning Event P1 for Option 1 and 2. Refer to Table 5-1 and Appendix C for details.

Table 5-1: Voltage Results (per unit) under CNP Planning Event P1

Bus	Nominal_Voltage	Contingency	2025 Summer Peak Case			2027 Summer Peak Case			2026 Minimum Case		
			Base Case	Option 1	Option 2	Base Case	Option 1	Option 2	Base Case	Option 1	Option 2
46240 PINHUR_S81_8	138	SING OPN LIN 432 46240-46510(&1): 46240-46510 <CKT &1> PINHUR_S81_8 TO TOMBAL__B138	0.9704	CNV	0.913	0.9675	CNV	0.9094	1.0173	CNV	1.0042
99999 MILL CREEK	138		BNV	CNV	0.9306	BNV	CNV	0.9271	BNV	CNV	1.0086
46240 PINHUR_S81_8	138	SING OPN LIN 432 46240-46510(&1): 46240-46510 <CKT &1> MILL CREEK TO TOMBAL__B138	1.0135	0.942	CNV	1.0128	0.9388	CNV	1.0267	1.0096	CNV
99999 MILL CREEK	138		BNV	0.9357	CNV	BNV	0.9325	CNV	BNV	1.0079	CNV

5.1.3 CNP Planning Event P2

Under the CNP Planning Event P2, no new thermal loading concerns were identified. Voltage concerns were identified under CNP Planning Event P2 for Option 2. Refer to Table 5-2 and Appendix C for details.

Table 5-2: Voltage Results (per unit) under CNP Planning Event P2

Bus	Nominal_ Voltage	Contingency	2025 Summer Peak Case			2027 Summer Peak Case			2026 Minimum Case		
			Base Case	Option 1	Option 2	Base Case	Option 1	Option 2	Base Case	Option 1	Option 2
46240 PINHUR_S81_8	138	P2-3_TB-N110: 46510-46240 <CKT &1> TOMBAL__B138 TO PINHUR_S81_8 & 46510-46500-49076 <A1> TOMBAL AUTOTRANSFORMER A1	0.9703	CNV	0.9129	0.9675	CNV	0.9093	1.0172	CNV	1.0041

5.1.4 CNP Planning Event P3

Under the CNP Planning Event P3, no new thermal loading concerns were identified. Voltage concerns were identified under CNP Planning Event P3 for Option 2. Refer Table 5-3 and Appendix C for details.

Table 5-3: Voltage Results (per unit) under CNP Planning Event P3

Bus	Nominal _Voltage	Contingency	2025 Summer Peak Case			2027 Summer Peak Case			2026 Minimum Case		
			Base Case	Option 1	Option 2	Base Case	Option 1	Option 2	Base Case	Option 1	Option 2
46240 PINHUR_S81_8	138	P1-1_GEN_WAP_L6_110016: 110016 WAP_WAP_G6 <L6> AND SING OPN LIN 432 46240-46510(&1): 46240-46510 <CKT &1> PINHUR_S81_8 TO TOMBAL__B138	0.9692	SCNV	0.9114	0.9664	SCNV	0.908	FCNV	FCNV SCNV	FCNV

5.1.5 CNP Planning Event P5

Under the CNP Planning Event P5, there were no new thermal loading concerns or potential voltage concerns identified in the study area for the CenterPoint Energy transmission system. Refer Appendix C for detailed results.

5.1.6 CNP Planning Event P6

Under the CNP Planning Event P6, potential voltage concerns were identified for Option 2. A thermal loading concern was identified under CNP Planning Event P6 for Options 1 and 2. Refer Tables 5-4 and 5-5 and Appendix C for details.

Table 5-4: Thermal loading (%) under CNP Planning Event P6

Branch_Loading	Rating_Used_EMGY	Contingency	2025 Summer Peak Case			2027 Summer Peak Case			2026 Minimum Case		
			Base Case	Option 1	Option 2	Base Case	Option 1	Option 2	Base Case	Option 1	Option 2
44840-45886 <CKT 66> STONEL_B138 TO HOCKLY66T6_8	280	BUS 49076: 49076-46500-46510 <A1> TOMBAL AUTOTRANSFORMER A1 AND P7-1_E1>>T6681C_A2RADIAL: 46510-46570 <CKT &1> TOMBAL__B138 TO WESFLD__B138 & 46510-46295 <CKT &1> TOMBAL__B138 TO RTHWOD__A138 & 46510-46500-49067 <A2> TOMBAL AUTOTRANSFORMER A2	82.22 %	100.57 %	108.62 %	81.81 %	99.39 %	107.51 %	28.22 %	30.89 %	32.92 %

Table 5-5: Voltage Results (per unit) under CNP Planning Event P6

Bus	Nominal_Voltage	Contingency	2025 Summer Peak Case			2027 Summer Peak Case			2026 Minimum Case		
			Base Case	Option 1	Option 2	Base Case	Option 1	Option 2	Base Case	Option 1	Option 2
46520 TOMBAL_C81_8	138	BUS 49076: 49076-46500-46510 <A1> TOMBAL AUTOTRANSFORMER A1 AND P7-1_E1>>T6681C_A2RADIAL: 46510-46570 <CKT &1> TOMBAL__B138 TO WESFLD__B138 & 46510-46295 <CKT &1> TOMBAL__B138 TO RTHWOD__A138 & 46510-46500-49067 <A2> TOMBAL AUTOTRANSFORMER A2	0.9698	0.9316	0.9142	0.9655	0.9275	0.9098	1.0069	0.9962	0.9938
46510 TOMBAL__B138	138		0.9698	0.9316	0.9142	0.9655	0.9275	0.9098	1.0069	0.9962	0.9938
46240 PINHUR_S81_8	138	BUS 49039: 49039-45500-45510 <A1> THW AUTOTRANSFORMER A1 AND SING OPN LIN 509 46240-46510(&1): 46240-46510 <CKT &1> PINHUR_S81_8 TO TOMBAL__B138	0.9628	SCNV	0.9037	0.9625	SCNV	0.9028	1.0145	SCNV	1.0012

5.1.7 CNP Planning Event P7

Under the CNP Planning Event P7, there were no thermal loading or voltage concerns identified for the CenterPoint Energy transmission system for either option. See Appendix C for detailed results.

5.2 Kluge Split Bus Scenario Contingency Analysis – Results

The Kluge substation is connected in a 4-breaker ring bus with two sets of double circuit lines coming into the substation. For a double circuit outage (CNP Planning Event P7), the two remaining Kluge circuits are isolated, creating radial circuits feeding the Kluge load; therefore, there are three different scenarios to evaluate. CenterPoint Energy performed CNP Planning Events P3, P6, and P7 to assess the impact of the new Mill Creek substation on these load scenarios.

Scenario 1 (T0921B): Under this contingency the 138 kV Kluge – Zenith ckt 09 and Kluge – CAMRON ckt 21 are outaged leaving 138 kV Kluge – Pinehurst ckt 81 and Kluge – Klein ckt 81 radially energized, but isolated from each other. The distribution transformers tapped off the outaged circuits, TR2 and TR4, are assumed to roll to the remaining energized transformer, TR3, which is directly connected to 138 kV Kluge – Pinehurst.

Scenario 2 (T8181G Load 1): Under this contingency the 138 kV Kluge – Pinehurst ckt 81 and Kluge – Klein ckt 81 are outaged leaving 138 kV Kluge – Zenith ckt 09 and Kluge – CAMRON ckt 21 radially energized, but isolated from each other. The distribution transformer tapped off outaged ckt 81 to Pinehurst, TR3, is assumed to roll to energized transformer, TR2, which is directly connected to 138 kV Kluge – Zenith ckt 09.

Scenario 3 (T8181G Load 2): Under this contingency the 138 kV Kluge – Pinehurst ckt 81 and Kluge – Klein ckt 81 are outaged leaving 138 kV Kluge – Zenith ckt 09 and Kluge – CAMRON ckt 21 radially energized, but isolated from each other. The distribution transformer tapped off outaged ckt 81 to Pinehurst, TR3, is assumed to roll to energized transformer, TR4, which is directly connected to 138 kV Kluge – CAMRON ckt 21.

A summary of the results for the summer peak cases of 2025 and 2027 and the 2026 minimum cases are shown in the following sections. The complete sets of results for the two interconnection options are included in Appendix D.

5.2.1 CNP Planning Event P3 for the Kluge Split Bus Scenario

Under the CNP Planning Event P3, no new thermal loading concerns were identified for any of the Kluge Split Bus Load Scenarios. Voltage concerns were identified for Option 1 and

Option 2 under the Scenario 1. The Scenario 2 and Scenario 3 did not report potential thermal loading or voltage concerns. Refer to Table 5-6 and Appendix D for details.

Table 5-6: Voltage Results (per unit) under CNP Planning Event P3 (Kluge Split Bus)

Bus	Nominal _Voltage	Contingency	KLUGE SPLIT BUS								
			2025 Summer Peak Case			2027 Summer Peak Case			2026 Minimum Case		
			Base Case	Option 1	Option 2	Base Case	Option 1	Option 2	Base Case	Option 1	Option 2
			T0921B_P3	T0921B_P3	T0921B_P3	T0921B_P3	T0921B_P3	T0921B_P3	T0921B_P3	T0921B_P3	T0921B_P3
45952 KLUGE___81B8	138	P1-1_CVC_2_COMBINED-CYCLE: 110824 CVC_CVC_G5 <C0> & 110822 CVC_CVC_G2 <C2> AND >T0921B_CMD_SPLIT_BUS: 45952-45712 <CKT 21> KLUGE___81B8 TO CYFAIR21T1_8 & 45712-45700 <CKT 21> CYFAIR21T1_8 TO CAMRON_X21B8 & 45712-745712 <CKT 1> CYFAIR21T1_8 TO SODG_45712 & 45954-45711 <CKT 09> KLUGE_SPLIT TO CYFAIR_T09_8 & 45711-45801 <CKT 09> CYFAIR_T09_8 TO GERTIE09T3_8 & 45711-745711 <CKT 1> CYFAIR_T09_8 TO SODG_45711 & 45801-45812 <CKT 09> GERTIE09T3_8 TO FRYRD_09T2_8 & 45801-745801 <CKT 1> GERTIE09T3_8 TO SODG_45801 & 45812-44910 <CKT 09> FRYRD_09T2_8 TO ZENITH__B138 & 45812-745812 <CKT 1> FRYRD_09T2_8 TO SODG_45812 & 45952-45954 <CKT 1> KLUGE___81B8 TO KLUGE_SPLIT & 45953 KLUGE__C81_8 <C1>	0.9598	0.8841	0.9089	0.9589	0.8829	0.9079	1.0103	0.9965	0.9999
46240 PINHUR_S81_8	138		0.9857	0.9131	0.9624	0.9849	0.912	0.9616	1.017	1.0033	1.0118

5.2.2 CNP Planning Event P6 for the Kluge Split Bus Scenarios

Under the CNP Planning Event P6, no new thermal loading concerns were identified for any Kluge Split Bus Load Scenarios. Voltage concerns were identified for Option 1 and Option 2 under the Scenario 1. The Scenario 2 and Scenario 3 did not report potential thermal loading or voltage concerns. Refer to Table 5-7 and Appendix D for details.

Table 5-7: Voltage Results (per unit) under CNP Planning Event P6 (Kluge Split Bus)

Bus	Nominal_Voltage	Contingency	KLUGE SPLIT BUS								
			2025 Summer Peak Case			2027 Summer Peak Case			2026 Minimum Case		
			Base Case	Option 1	Option 2	Base Case	Option 1	Option 2	Base Case	Option 1	Option 2
			T0921B_P6	T0921B_P6	T0921B_P6	T0921B_P6	T0921B_P6	T0921B_P6	T0921B_P6	T0921B_P6	T0921B_P6
45952 KLUGE___81B8	138	P1-3_TB-A2_AUTO&SHUNT: 46510-46500-49067 <A2> TOMBAL AUTOTRANSFORMER A2 AND >T0921B_CMD_SPLIT_BUS: 45952-45712 <CKT 21> KLUGE___81B8 TO CYFAIR21T1_8 & 45712-45700 <CKT 21> CYFAIR21T1_8 TO CAMRON_X21B8 & 45712-745712 <CKT 1> CYFAIR21T1_8 TO SODG_45712 & 45954-45711 <CKT 09> KLUGE_SPLIT TO CYFAIR_T09_8 & 45711-45801 <CKT 09> CYFAIR_T09_8 TO GERTIE09T3_8 & 45711-745711 <CKT 1> CYFAIR_T09_8 TO SODG_45711 & 45801-45812 <CKT 09> GERTIE09T3_8 TO FRYRD_09T2_8 & 45801-745801 <CKT 1> GERTIE09T3_8 TO SODG_45801 & 45812-44910 <CKT 09> FRYRD_09T2_8 TO ZENITH__B138 & 45812-745812 <CKT 1> FRYRD_09T2_8 TO SODG_45812 & 45952-45954 <CKT 1> KLUGE___81B8 TO KLUGE_SPLIT & 45953 KLUGE__C81_8 <C1>	0.9557	0.8743	0.9029	0.9544	0.8728	0.9015	1.0136	0.9994	1.0028
46240 PINHUR_S81_8	138		0.9817	0.9037	0.9569	0.9806	0.9025	0.9558	1.0203	1.0062	1.0147

5.2.3 CNP Planning Event P7 for the Kluge Split Bus Scenarios

Under the CNP Planning Event P7, no new thermal loading concerns were identified for any Kluge Split Bus Load Scenarios. Voltage concerns were identified for Option 1 and Option 2 under the Scenario 1. The Scenario 2 and Scenario 3 did not report potential thermal loading or voltage concerns. Refer to Table 5-8 and Appendix D for details.

Table 5-8: Voltage Results (per unit) under CNP Planning Event P7 (Kluge Split Bus)

Bus	Nominal_Voltage	Contingency	KLUGE SPLIT BUS								
			2025 Summer Peak Case			2027 Summer Peak Case			2026 Minimum Case		
			Base Case	Option 1	Option 2	Base Case	Option 1	Option 2	Base Case	Option 1	Option 2
			T0921B_P7	T0921B_P7	T0921B_P7	T0921B_P7	T0921B_P7	T0921B_P7	T0921B_P7	T0921B_P7	T0921B_P7
45952 KLUGE___81B8	138	>T0921B_CMD_SPLIT_BUS: 45952-45712 <CKT 21> KLUGE___81B8 TO CYFAIR21T1_8 & 45712-45700 <CKT 21> CYFAIR21T1_8 TO CAMRON_X21B8 & 45712-745712 <CKT 1> CYFAIR21T1_8 TO SODG_45712 & 45954-45711 <CKT 09> KLUGE_SPLIT TO CYFAIR_T09_8 & 45711-45801 <CKT 09> CYFAIR_T09_8 TO GERTIE09T3_8 & 45711-745711 <CKT 1> CYFAIR_T09_8 TO SODG_45711 & 45801-45812 <CKT 09> GERTIE09T3_8 TO FRYRD_09T2_8 & 45801-745801 <CKT 1> GERTIE09T3_8 TO SODG_45801 & 45812-44910 <CKT 09> FRYRD_09T2_8 TO ZENITH__B138 & 45812-745812 <CKT 1> FRYRD_09T2_8 TO SODG_45812 & 45952-45954 <CKT 1> KLUGE___81B8 TO KLUGE_SPLIT & 45953 KLUGE__C81_8 <C1>	0.9616	0.8858	0.9114	0.9605	0.8844	0.9102	1.0157	1.0019	1.0053
46240 PINHUR_S81_8	138		0.9874	0.9147	0.9646	0.9865	0.9135	0.9637	1.0087	1.0087	1.0171

5.3 Steady State Analysis Conclusion

Contingency analysis indicates that:

- For Options 1 and 2 there was a potential thermal loading concern under CNP Planning Event P6.
- For Options 1 and 2, potential new low voltages were reported for CNP Planning Events P1, P3, P6, and P7.
- For Option 2 potential new low voltages were reported under the CNP Planning Event P2.

6. Implemented Upgrades: 80 MVAR capacitor bank.

To address the potential voltage concerns mentioned in Section 5, one of the possible solutions that can be implemented is to relocate the connection of the 80 MVAR capacitor bank installed at the Kluge substation tapped on138 kV Klein to Kluge ckt 81 to 138 kV Kluge to Pinehurst/Mill Creek ckt 81.

6.1 Contingency Analysis – Results

CenterPoint Energy performed contingency analysis to evaluate the impact of relocating the connection of the 80 MVAR capacitor bank installed at the Kluge substation in the two interconnection options in the years 2025 through 2027. A summary of the results for the summer peak cases of 2025 and 2027 are shown in the following sections, the complete sets of results for the two interconnection options are included in Appendix C. The 2026 minimum case was not evaluated as the 80 MVAR cap bank was off-line in the minimum case, thus the results would be exactly the same. Refer to Appendix C for the switching study of the 80 MVAR capacitor bank.

6.1.1 CNP Planning Event P0

Under normal operating conditions, no potential thermal loading or voltage concerns were identified.

6.1.2 CNP Planning Event P1

Under the CNP Planning Event P1, no new thermal loading concerns were identified under CNP Planning Event P1. Potential voltage concerns were identified for Option 1 and Option 2. Refer Table 6-1 and Appendix C for details.

Table 6 1: Voltage Results (per unit) under CNP Planning Event P1 Summer Peak Case

Bus	Nominal_Voltage	Contingency	2025 Summer Peak Case					2027 Summer Peak Case				
			Base Case	Option 1	Option 2	Option 1 UPG	Option 2 UPG	Base Case	Option 1	Option 2	Option 1 UPG	Option 2 UPG
46240 PINHUR_S81_8	138	SING OPN LIN 432 46240-46510(&1): 46240-46510 <CKT &1> PINHUR_S81_8 TO TOMBAL__B138	0.9704	CNV	0.913	CNV	0.913	0.9675	CNV	0.9094	CNV	0.9094
99999 MILL CREEK	138		BNV	CNV	0.9306	CNV	0.9306	BNV	CNV	0.9271	CNV	0.9271
46240 PINHUR_S81_8	138	SING OPN LIN 432 46240-46510(&1): 46240-46510 <CKT &1> MILL CREEK TO TOMBAL__B138	1.0135	0.942	CNV	0.942	CNV	1.0128	0.9388	CNV	0.9388	CNV
99999 MILL CREEK	138		BNV	0.9357	CNV	0.9357	CNV	BNV	0.9325	CNV	0.9325	CNV

6.1.3 CNP Planning Event P2

Under the CNP Planning Event P2, no new thermal loading concerns were identified under CNP Planning Event P2. Potential voltage concerns were identified for Option 2. Refer Table 6-2 and Appendix C for details.

Table 6-2: Voltage Results (per unit) under CNP Planning Event P1 Summer Peak Case

Bus	Nominal_ Voltage	Contingency	2025 Summer Peak Case					2027 Summer Peak Case				
			Base Case	Option 1	Option 2	Option 1 UPG	Option 2 UPG	Base Case	Option 1	Option 2	Option 1 UPG	Option 2 UPG
46240 PINHUR_S81_8	138	P2-3_TB-N110: 46510-46240 <CKT &1> TOMBAL__B138 TO PINHUR_S81_8 & 46510-46500-49076 <A1> TOMBAL AUTOTRANSFORMER A1	0.9703	CNV	0.9129	CNV	0.913	0.9675	CNV	0.9093	CNV	0.9093

6.1.4 CNP Planning Event P3

Under the CNP Planning Event P3, no new thermal loading concerns. Potential voltage concerns were identified for Option 2 under CNP Planning Event P3. Refer Table 6-3 and Appendix C for details.

Table 6- 3: Voltage Results (per unit) under CNP Planning Event P3 Summer Peak Case

Bus	Nominal Voltage	Contingency	2025 Summer Peak Case					2027 Summer Peak Case				
			Base Case	Option 1	Option 2	Option 1 UPG	Option 2 UPG	Base Case	Option 1	Option 2	Option 1 UPG	Option 2 UPG
46240 PINHUR_S81_8	138	P1-1_GEN_WAP_L6_110016: 110016 WAP_WAP_G6 <L6> AND SING OPN LIN 432 46240-46510(&1): 46240-46510 <CKT &1> PINHUR_S81_8 TO TOMBAL__B138	0.9692	SCNV	0.9114	SCNV	0.9114	0.9664	SCNV	0.908	SCNV	0.908

6.1.5 CNP Planning Event P5

Under the CNP Planning Event P5, no new thermal loading or potential voltage concerns were identified under CNP Planning Event P5. Refer Appendix C for details.

6.1.6 CNP Planning Event P6

Under the CNP Planning Event P6, potential voltage concerns were identified under CNP Planning Event P6 for Option 2. New thermal loading concerns were identified for Option 1 and Option 2. Refer Table 6-4, Table 6-5, and Appendix C for details.

Table 6-4: Thermal Loading Results (%) under CNP Planning Event P6 Summer Peak Case

Branch_Loading	Rating_Used_EMGY	Contingency	2025 Summer Peak Case					2027 Summer Peak Case				
			Base Case	Option 1	Option 2	Option 1 UPG	Option 2 UPG	Base Case	Option 1	Option 2	Option 1 UPG	Option 2 UPG
44840-45886 <CKT 66> STONEL_B138 TO HOCKLY66T6_8	280	BUS 49076: 49076-46500-46510 <A1> TOMBAL AUTOTRANSFORMER A1 AND P7-1_E1>>T6681C_A2RADIAL: 46510-46570 <CKT &1> TOMBAL__B138 TO WESFLD__B138 & 46510-46295 <CKT &1> TOMBAL__B138 TO RTHWOD__A138 & 46510-46500-49067 <A2> TOMBAL AUTOTRANSFORMER A2	82.22 %	100.57 %	108.62 %	100.57 %	108.62 %	81.81 %	99.39 %	107.51 %	99.39 %	107.51 %

Table 6-5: Voltage Results (per unit) under CNP Planning Event P6 Summer Peak Case

Bus	Nominal_Voltage	Contingency	2025 Summer Peak Case					2027 Summer Peak Case				
			Base Case	Option 1	Option 2	Option 1 UPG	Option 2 UPG	Base Case	Option 1	Option 2	Option 1 UPG	Option 2 UPG
46240 PINHUR_S81_8	138	BUS 49039: 49039-45500-45510 <A1> THW AUTOTRANSFORMER A1 AND SING OPN LIN 509 46240-46510(&1): 46240-46510 <CKT &1> PINHUR_S81_8 TO TOMBAL__B138	0.9628	SCNV	0.9037	SCNV	0.9037	0.9625	SCNV	0.9028	SCNV	0.9028
46520 TOMBAL_C81_8	138	BUS 49076: 49076-46500-46510 <A1> TOMBAL AUTOTRANSFORMER A1 AND P7-1_E1>>T6681C_A2RADIAL: 46510-46570 <CKT &1> TOMBAL__B138 TO WESFLD__B138 & 46510-46295 <CKT &1> TOMBAL__B138 TO RTHWOD__A138 & 46510-46500-49067 <A2> TOMBAL AUTOTRANSFORMER A2	0.9698	0.9316	0.9142	0.9316	0.9142	0.9655	0.9275	0.9098	0.9275	0.9098
46510 TOMBAL__B138	138		0.9698	0.9316	0.9142	0.9316	0.9142	0.9655	0.9275	0.9098	0.9275	0.9098

6.1.7 CNP Planning Event P7

No new thermal loading concerns or potential low voltages were reported under CNP Planning Event P7. See Appendix C for detailed results.

6.2 Kluge Split Bus Scenario Contingency Analysis – Results

CenterPoint Energy performed CNP Planning Event P3, P6, and P7 to evaluate the impact of the new Mill Creek substation under the three split bus load scenarios of the Kluge substation. A summary of the results for the summer peak cases of 2025 and 2027 and the 2026 minimum cases are shown in the following sections.

6.2.1 CNP Planning Event P3

Under the CNP Planning Event P3, no new thermal loading concerns or low voltage concerns were identified for any Kluge Split Bus Upgrade Load Scenarios. The Scenario 2 and Scenario 3 did not report potential thermal loading or voltage concerns. Refer to Table 6-6 and Appendix D for details.

Table 6- 6: Voltage Results (per unit) under CNP Planning Event P3 Summer Peak and Minimum Case (Kluge Split Bus)

<table>
<tr><th rowspan="4">Bus</th><th rowspan="4">Nominal _Voltage</th><th rowspan="4">Contingency</th><th colspan="6">KLUGE SPLIT BUS UPGRADE</th></tr>
<tr><th colspan="3">2025 Summer Peak Case</th><th colspan="3">2027 Summer Peak Case</th></tr>
<tr><th>Base Case</th><th>Option 1</th><th>Option 2</th><th>Base Case</th><th>Option 1</th><th>Option 2</th></tr>
<tr><th>T0921B_P3</th><th>T0921B_P3</th><th>T0921B_P3</th><th>T0921B_P3</th><th>T0921B_P3</th><th>T0921B_P3</th></tr>
<tr><td>45952 KLUGE___81B8</td><td>138</td><td rowspan="2">P1-1_CVC_2_COMBINED-CYCLE:
110824 CVC_CVC_G5 <C0>
&
110822 CVC_CVC_G2 <C2>
AND
>T0921B_CMD_SPLIT_BUS:
45952-45712 <CKT 21>
KLUGE___81B8 TO CYFAIR21T1_8
&
45712-45700 <CKT 21>
CYFAIR21T1_8 TO CAMRON_X21B8
&
45712-745712 <CKT 1>
CYFAIR21T1_8 TO SODG_45712
&
45954-45711 <CKT 09>
KLUGE_SPLIT TO CYFAIR_T09_8
&
45711-45801 <CKT 09>
CYFAIR_T09_8 TO GERTIE09T3_8
&
45711-745711 <CKT 1>
CYFAIR_T09_8 TO SODG_45711
&
45801-45812 <CKT 09>
GERTIE09T3_8 TO FRYRD_09T2_8
&
45801-745801 <CKT 1>
GERTIE09T3_8 TO SODG_45801
&
45812-44910 <CKT 09>
FRYRD_09T2_8 TO ZENITH__B138
&
45812-745812 <CKT 1>
FRYRD_09T2_8 TO SODG_45812
&
45952-45954 <CKT 1>
KLUGE___81B8 TO KLUGE_SPLIT
&
45953 KLUGE__C81_8 <C1></td><td>0.9598</td><td>0.9725</td><td>0.9982</td><td>0.9589</td><td>0.9713</td><td>0.9972</td></tr>
<tr><td>46240 PINHUR_S81_8</td><td>138</td><td>0.9857</td><td>0.9644</td><td>0.9916</td><td>0.9849</td><td>0.9634</td><td>0.9909</td></tr>
</table>

6.2.2 CNP Planning Event P6

Under the CNP Planning Event P6 no new thermal loading or voltage concerns were identified for any Kluge Split Bus Upgrade Load Scenarios. The Scenario 2 and Scenario 3 did not report potential thermal loading or voltage concerns. Refer to Table 6-7 and Appendix D for details.

Table 6-7: Voltage Results (per unit) under CNP Planning Event P6 Summer Peak and Minimum Case (Kluge Split Bus)

Bus	Nominal_Voltage	Contingency	KLUGE SPLIT BUS UPGRADE					
			2025 Summer Peak Case			2027 Summer Peak Case		
			Base Case	Option 1	Option 2	Base Case	Option 1	Option 2
			T0921B_P6	T0921B_P6	T0921B_P6	T0921B_P6	T0921B_P6	T0921B_P6
45952 KLUGE___81B8	138	P1-3_TB-A2_AUTO&SHUNT: 46510-46500-49067 <A2> TOMBAL AUTOTRANSFORMER A2 AND >T0921B_CMD_SPLIT_BUS: 45952-45712 <CKT 21> KLUGE___81B8 TO CYFAIR21T1_8 & 45712-45700 <CKT 21> CYFAIR21T1_8 TO CAMRON_X21B8 & 45712-745712 <CKT 1> CYFAIR21T1_8 TO SODG_45712 & 45954-45711 <CKT 09> KLUGE_SPLIT TO CYFAIR_T09_8 & 45711-45801 <CKT 09> CYFAIR_T09_8 TO GERTIE09T3_8 & 45711-745711 <CKT 1> CYFAIR_T09_8 TO SODG_45711 & 45801-45812 <CKT 09> GERTIE09T3_8 TO FRYRD_09T2_8 & 45801-745801 <CKT 1> GERTIE09T3_8 TO SODG_45801 & 45812-44910 <CKT 09> FRYRD_09T2_8 TO ZENITH__B138 & 45812-745812 <CKT 1> FRYRD_09T2_8 TO SODG_45812 & 45952-45954 <CKT 1> KLUGE___81B8 TO KLUGE_SPLIT & 45953 KLUGE__C81_8 <C1>	0.9557	0.9663	0.9932	0.9544	0.9647	0.9917
46240 PINHUR_S81_8	138		0.9817	0.9587	0.9871	0.9806	0.9573	0.986

6.2.3 CNP Planning Event P7

Under the CNP Planning Event P7, no new thermal loading or voltage concerns were identified for any Kluge Split Bus Upgrade Load Scenarios. The Scenario 2 and Scenario 3 did not report potential thermal loading or voltage concerns. Refer to Table 6-8 and Appendix D for details.

Table 6- 8: Voltage Results (per unit) under CNP Planning Event P7 Summer Peak and Minimum Case (Kluge Split Bus)

Bus	Nominal_Voltage	Contingency	KLUGE SPLIT BUS UPGRADE					
			2025 Summer Peak Case			2027 Summer Peak Case		
			Base Case	Option 1	Option 2	Base Case	Option 1	Option 2
			T0921B_P7	T0921B_P7	T0921B_P7	T0921B_P7	T0921B_P7	T0921B_P7
45952 KLUGE___81B8	138	>T0921B_CMD_SPLIT_BUS: 45952-45712 <CKT 21> KLUGE___81B8 TO CYFAIR21T1_8 & 45712-45700 <CKT 21> CYFAIR21T1_8 TO CAMRON_X21B8 & 45712-745712 <CKT 1> CYFAIR21T1_8 TO SODG_45712 & 45954-45711 <CKT 09> KLUGE_SPLIT TO CYFAIR_T09_8 & 45711-45801 <CKT 09> CYFAIR_T09_8 TO GERTIE09T3_8 & 45711-745711 <CKT 1> CYFAIR_T09_8 TO SODG_45711 & 45801-45812 <CKT 09> GERTIE09T3_8 TO FRYRD_09T2_8 & 45801-745801 <CKT 1> GERTIE09T3_8 TO SODG_45801 & 45812-44910 <CKT 09> FRYRD_09T2_8 TO ZENITH__B138 & 45812-745812 <CKT 1> FRYRD_09T2_8 TO SODG_45812 & 45952-45954 <CKT 1> KLUGE___81B8 TO KLUGE_SPLIT & 45953 KLUGE__C81_8 <C1>	0.9616	0.975	1.0005	0.9605	0.9736	0.9991
46240 PINHUR_S81_8	138		0.9874	0.9668	0.9935	0.9865	0.9656	0.9926

6.3 Steady State Analysis Conclusion

- Thermal loading concerns were still observed for Options 1 and 2 under CNP Planning Event P6.
- Low voltages in the Kluge bus split Scenario 1 in Section 5.1 were mitigated by moving Kluge 80 MVAR transmission cap bank CB1 tapping off 138 kV Pinehurst/Mill Creek ckt 81 for Options 1 and 2.
- The low voltages reported for Options 1 and 2 under CNP Planning Event P1 were not mitigated.
- Potential remaining low voltages under CNP Planning Events P2, P3, and P6 for Options 2 were not mitigated.

7. Steady-State Power Flow Analysis for Operational Scenario A.

Additional reactive support is required based on the concerns outlined in Section 6. Rather than adding more transmission capacitor banks, an alternative is to request that Distribution Planning change their usual substation design from 0.99 PF at the low side of the transformers to unity PF. Pinehurst substation[1] is the chosen substation to be in unity PF. To assess the effectiveness of this solution, we conducted an operational analysis to determine if the Pinehurst substation, designed to unity PF, could help alleviate the low voltages and meet the CenterPoint Energy Transmission Design Criteria.

Two new study Options were studied by combining the Pinehurst unity substation with the two interconnection options and their upgrades:

- Option 1A: Option 1 with the Kluge 80 MVAR cap bank moved to Pinehurst ckt 81 and Pinehurst substation at unity PF.
- Option 2A: Option 2 with the Kluge 80 MVAR cap bank moved to Mill Creek ckt 81 and Pinehurst substation at unity PF.

A summary of the results for the summer peak cases of 2025 and 2027 are shown in the following sections, the complete sets of results for the two interconnection options are included in Appendix D.

7.1 Contingency Analysis – Results

7.1.1 CNP Planning Event P0

Under normal operating conditions, no potential thermal loading or voltage concerns were identified.

7.1.2 CNP Planning Event P1

Under the CNP Planning Event P1, no new thermal loading concerns were identified under CNP Planning Event P1. Potential low voltage concerns were identified for Option 2. Refer to Table 7-1 and Appendix E for details.

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[1] Based on a preliminary operational study considering different combinations of Pinehurst, Tomball, Mill Creek, and Stone Lake with a unity power factor, Pinehurst was found to be the most effective performer when operating at a unity power factor.

Table 7- 1: Voltage Results (per unit) under CNP Planning Event P1 Summer Peak and Minimum Case

Bus	Nominal_Voltage	Contingency	2025 Summer Peak Case					2027 Summer Peak Case				
			Base Case	Option 1 UPG	Option 2 UPG	Option 1 UPGA	Option 2 UPGA	Base Case	Option 1 UPG	Option 2 UPG	Option 1 UPGA	Option 2 UPGA
46240 PINHUR_S81_8	138	SING OPN LIN 432 46240-46510(&1): 46240-46510 <CKT &1> PINHUR_S81_8 TO TOMBAL__B138	0.9704	CNV	0.913	CNV	0.9427	0.9675	CNV	0.9094	CNV	0.9395
99999 MILL CREEK	138		BNV	CNV	0.9306	CNV	0.9528	BNV	CNV	0.9271	CNV	0.9496
46240 PINHUR_S81_8	138	SING OPN LIN 432 46240-46510(&1): 46240-46510 <CKT &1> MILL CREEK TO TOMBAL__B138	1.0135	0.942	CNV	0.9619	CNV	1.0128	0.9388	CNV	0.9589	CNV
99999 MILL CREEK	138		BNV	0.9357	CNV	0.9557	CNV	BNV	0.9325	CNV	0.9527	CNV

7.1.3 CNP Planning Event P2

Under the CNP Planning Event P2, there were no new thermal loading concerns under CNP Planning Event P2. No new potential voltage concerns were identified for Option 2. Refer to Table 7-2 and Appendix E for detailed results.

Table 7- 2: Voltage Results (per unit) under CNP Planning Event P2 Summer Peak and Minimum Case

Bus	Nominal_ Voltage	Contingency	2025 Summer Peak Case					2027 Summer Peak Case				
			Base Case	Option 1 UPG	Option 2 UPG	Option 1 UPGA	Option 2 UPGA	Base Case	Option 1 UPG	Option 2 UPG	Option 1 UPGA	Option 2 UPGA
46240 PINHUR_S81_8	138	P2-3_TB-N110: 46510-46240 <CKT &1> TOMBAL__B138 TO PINHUR_S81_8 & 46510-46500-49076 <A1> TOMBAL AUTOTRANSFORMER A1	0.9703	CNV	0.913	CNV	0.9426	0.9675	CNV	0.9093	CNV	0.9395

7.1.4 CNP Planning Event P3

Under the CNP Planning Event P3, no potential thermal loading concern was reported. No new potential voltage concerns were identified for Option 2. Refer Appendix E for details.

Table 7- 3: Voltage Results (per unit) under CNP Planning Event P3 Summer Peak and Minimum Case

Bus	Nominal Voltage	Contingency	2025 Summer Peak Case					2027 Summer Peak Case				
			Base Case	Option 1 UPG	Option 2 UPG	Option 1 UPGA	Option 2 UPGA	Base Case	Option 1 UPG	Option 2 UPG	Option 1 UPGA	Option 2 UPGA
46240 PINHUR_S81_8	138	P1-1_GEN_WAP_L6_110016: 110016 WAP_WAP_G6 <L6> AND SING OPN LIN 432 46240-46510(&1): 46240-46510 <CKT &1> PINHUR_S81_8 TO TOMBAL__B138	0.9692	SCNV	0.9114	SCNV	0.9413	0.9664	SCNV	0.908	SCNV	0.9382

7.1.5 CNP Planning Event P5

Under the CNP Planning Event P5, no potential thermal loading or voltage concerns were identified. Refer Appendix E for details.

7.1.6 CNP Planning Event P6

Under the CNP Planning Event P6, no new potential thermal loading or new voltage concerns were identified. Refer Appendix E for details.

Table 7-4: Thermal Loading Results (%) under CNP Planning Event P6 Summer Peak Case

Branch_Loading	Rating_Used_EMGY	Contingency	2025 Summer Peak Case					2027 Summer Peak Case				
			Base Case	Option 1 UPG	Option 2 UPG	Option 1 UPGA	Option 2 UPGA	Base Case	Option 1 UPG	Option 2 UPG	Option 1 UPGA	Option 2 UPGA
44840-45886 <CKT 66> STONEL_B138 TO HOCKLY66T6_8	280	BUS 49076: 49076-46500-46510 <A1> TOMBAL AUTOTRANSFORMER A1 AND P7-1_E1>>T6681C_A2RADIAL: 46510-46570 <CKT &1> TOMBAL__B138 TO WESFLD__B138 & 46510-46295 <CKT &1> TOMBAL__B138 TO RTHWOD__A138 & 46510-46500-49067 <A2> TOMBAL AUTOTRANSFORMER A2	82.22 %	100.57 %	108.62 %	99.9%	107.67 %	81.81 %	99.39 %	107.51 %	98.77 %	106.50%

Table 7- 5: Voltage Results (per unit) under CNP Planning Event P6 Summer Peak and Minimum Case

Bus	Nominal_ Voltage	Contingency	2025 Summer Peak Case					2027 Summer Peak Case				
			Base Case	Option 1 UPG	Option 2 UPG	Option 1 UPGA	Option 2 UPGA	Base Case	Option 1 UPG	Option 2 UPG	Option 1 UPGA	Option 2 UPGA
46240 PINHUR_S81_8	138	BUS 49039: 49039-45500-45510 <A1> THW AUTOTRANSFORMER A1 AND SING OPN LIN 509 46240-46510(&1): 46240-46510 <CKT &1> PINHUR_S81_8 TO TOMBAL__B138	0.9628	SCNV	0.9037	SCNV	0.9426	0.9625	SCNV	0.9028	SCNV	0.9395
46520 TOMBAL_C81_8	138	BUS 49076: 49076-46500-46510 <A1> TOMBAL AUTOTRANSFORMER A1 AND P7-1_E1>>T6681C_A2RADIAL: 46510-46570 <CKT &1> TOMBAL__B138 TO WESFLD__B138 & 46510-46295 <CKT &1> TOMBAL__B138 TO RTHWOD__A138 & 46510-46500-49067 <A2> TOMBAL AUTOTRANSFORMER A2	0.9698	0.9316	0.9142	0.9436	0.9318	0.9655	0.9275	0.9098	0.9397	0.9276
46510 TOMBAL__B138	138		0.9698	0.9316	0.9142	0.9433	0.9318	0.9655	0.9275	0.9098	0.9394	0.9276

7.1.7 CNP Planning Event P7

Under the CNP Planning Event P7, there were no thermal loading or potential voltage concerns identified in the study area for the CenterPoint Energy transmission system. Refer Appendix E for detailed results.

7.2 Split Kluge Bus Contingency Analysis – Results

7.2.1 CNP Planning Event P3

No thermal loading concerns or potential low voltages were reported. Refer Appendix D for detailed results.

Table 7- 6: Voltage Results (per unit) under CNP Planning Event P3 Summer Peak and Minimum Case (Kluge Split Bus)

<table>
<tr><th rowspan="4">Bus</th><th rowspan="4">Nominal _Voltage</th><th rowspan="4">Contingency</th><th colspan="6">KLUGE SPLIT BUS UPGRADE+ PINEHURST UNITY</th></tr>
<tr><th colspan="3">2025 Summer Peak Case</th><th colspan="3">2027 Summer Peak Case</th></tr>
<tr><th>Base Case</th><th>Option 1</th><th>Option 2</th><th>Base Case</th><th>Option 1</th><th>Option 2</th></tr>
<tr><th>T0921B_P3</th><th>T0921B_P3</th><th>T0921B_P3</th><th>T0921B_P3</th><th>T0921B_P3</th><th>T0921B_P3</th></tr>
<tr><td>45952 KLUGE___81B8</td><td>138</td><td rowspan="2">P1-1_CVC_2_COMBINED-CYCLE:
110824 CVC_CVC_G5 <C0>
&
110822 CVC_CVC_G2 <C2>
AND
>T0921B_CMD_SPLIT_BUS:
45952-45712 <CKT 21>
KLUGE___81B8 TO CYFAIR21T1_8
&
45712-45700 <CKT 21>
CYFAIR21T1_8 TO CAMRON_X21B8
&
45712-745712 <CKT 1>
CYFAIR21T1_8 TO SODG_45712
&
45954-45711 <CKT 09>
KLUGE_SPLIT TO CYFAIR_T09_8
&
45711-45801 <CKT 09>
CYFAIR_T09_8 TO GERTIE09T3_8
&
45711-745711 <CKT 1>
CYFAIR_T09_8 TO SODG_45711
&
45801-45812 <CKT 09>
GERTIE09T3_8 TO FRYRD_09T2_8
&
45801-745801 <CKT 1>
GERTIE09T3_8 TO SODG_45801
&
45812-44910 <CKT 09>
FRYRD_09T2_8 TO ZENITH__B138
&
45812-745812 <CKT 1>
FRYRD_09T2_8 TO SODG_45812
&
45952-45954 <CKT 1>
KLUGE___81B8 TO KLUGE_SPLIT
&
45953 KLUGE__C81_8 <C1></td><td>0.9598</td><td>1.0156</td><td>1.0103</td><td>0.9589</td><td>0.9936</td><td>1.0093</td></tr>
<tr><td>46240 PINHUR_S81_8</td><td>138</td><td>0.9857</td><td>1.0016</td><td>1.0021</td><td>0.9849</td><td>0.9842</td><td>1.0015</td></tr>
</table>

7.2.2 CNP Planning Event P6

No thermal loading concerns or potential low voltages were reported. Refer Appendix D for detailed results.

Table 7- 7: Voltage Results (per unit) under CNP Planning Event P6 Summer Peak and Minimum Case (Kluge Split Bus)

Bus	Nominal_Voltage	Contingency	KLUGE SPLIT BUS UPGRADE+ PINEHURST UNITY					
			2025 Summer Peak Case			2027 Summer Peak Case		
			Base Case	Option 1	Option 2	Base Case	Option 1	Option 2
			T0921B_P6	T0921B_P6	T0921B_P6	T0921B_P6	T0921B_P6	T0921B_P6
45952 KLUGE___81B8	138	P1-3_TB-A2_AUTO&SHUNT: 46510-46500-49067 <A2> TOMBAL AUTOTRANSFORMER A2 AND >T0921B_CMD_SPLIT_BUS: 45952-45712 <CKT 21> KLUGE___81B8 TO CYFAIR21T1_8 & 45712-45700 <CKT 21> CYFAIR21T1_8 TO CAMRON_X21B8 & 45712-745712 <CKT 1> CYFAIR21T1_8 TO SODG_45712 & 45954-45711 <CKT 09> KLUGE_SPLIT TO CYFAIR_T09_8 & 45711-45801 <CKT 09> CYFAIR_T09_8 TO GERTIE09T3_8 & 45711-745711 <CKT 1> CYFAIR_T09_8 TO SODG_45711 & 45801-45812 <CKT 09> GERTIE09T3_8 TO FRYRD_09T2_8 & 45801-745801 <CKT 1> GERTIE09T3_8 TO SODG_45801 & 45812-44910 <CKT 09> FRYRD_09T2_8 TO ZENITH__B138 & 45812-745812 <CKT 1> FRYRD_09T2_8 TO SODG_45812 & 45952-45954 <CKT 1> KLUGE___81B8 TO KLUGE_SPLIT & 45953 KLUGE__C81_8 <C1>	0.9616	0.9895	1.0061	0.9605	0.988	0.9917
46240 PINHUR_S81_8	138		0.9874	0.9802	0.9985	0.9865	0.979	0.986

7.2.3 CNP Planning Event P7

No new thermal loading concerns or potential low voltages were reported. Refer Appendix D for detailed results.

Table 7- 8: Voltage Results (per unit) under CNP Planning Event P7 Summer Peak and Minimum Case (Kluge Split Bus)

Bus	Nominal_Voltage	Contingency	KLUGE SPLIT BUS UPGRADE+ PINEHURST UNITY					
			2025 Summer Peak Case			2027 Summer Peak Case		
			Base Case	Option 1	Option 2	Base Case	Option 1	Option 2
			T0921B_P7	T0921B_P7	T0921B_P7	T0921B_P7	T0921B_P7	T0921B_P7
45952 KLUGE___81B8	138	>T0921B_CMD_SPLIT_BUS: 45952-45712 <CKT 21> KLUGE___81B8 TO CYFAIR21T1_8 & 45712-45700 <CKT 21> CYFAIR21T1_8 TO CAMRON_X21B8 & 45712-745712 <CKT 1> CYFAIR21T1_8 TO SODG_45712 & 45954-45711 <CKT 09> KLUGE_SPLIT TO CYFAIR_T09_8 & 45711-45801 <CKT 09> CYFAIR_T09_8 TO GERTIE09T3_8 & 45711-745711 <CKT 1> CYFAIR_T09_8 TO SODG_45711 & 45801-45812 <CKT 09> GERTIE09T3_8 TO FRYRD_09T2_8 & 45801-745801 <CKT 1> GERTIE09T3_8 TO SODG_45801 & 45812-44910 <CKT 09> FRYRD_09T2_8 TO ZENITH__B138 & 45812-745812 <CKT 1> FRYRD_09T2_8 TO SODG_45812 & 45952-45954 <CKT 1> KLUGE___81B8 TO KLUGE_SPLIT & 45953 KLUGE__C81_8 <C1>	0.9616	0.9969	1.0124	0.9605	0.9956	1.0111
46240 PINHUR_S81_8	138		0.9874	0.9871	1.0039	0.9865	0.9861	1.003

7.3 Steady State Analysis Conclusion

- Option 2 reported low voltages concerns under CNP Planning Events P1, P2, P3, and P6.
- Option 1 did not report low voltages or thermal loading concerns under any of the CNP Planning Events.
- Thermal loading concerns were reported for Option 2 under CNP Planning Event P6.
- Option 2 does not meet CenterPoint Energy Transmission Design Criteria.
- Option 1 meets CenterPoint Energy Transmission Design Criteria.

8 Short Circuit Analysis

Short circuit analysis is performed to determine fault duty performance for the proposed project. The 2025 Base Case, 2025 Option 1, and 2025 Option 2 were used to perform the analysis and include applicable zero sequence and mutual coupling data. CenterPoint Energy performed an ANSI short circuit analysis as an initial screening. In accordance with CNP Design Criteria, available three-phase or single-phase-to-ground fault current should not exceed 99% of any transmission facility short circuit rating with all generation connected to the CenterPoint Energy transmission system modeled in service. Fault current calculations for determining the circuit breaker interrupting capability for faults that they are expected to interrupt is calculated by following the latest IEEE Standard C37.04 and IEEE Standard C37.010. The three-phase and single-phase short circuit current and the apparent X/R ratio for the base case and study case are shown below in Table 8-1. The new addition of the New Mill Creek substation did not result in any fault duty concerns for CenterPoint Energy equipment.

Table 8-1: Fault Duty Results

BUS NUMBER	BUS NAME	BUS (kV)	Rating (kA)	2025 BASE CASE				Max Breaker Loading	2025 OPTION 1				Max Breaker Loading	2025 OPTION 2				Max Breaker Loading
				Three - Phase Fault		Single - Phase Fault			Three - Phase Fault		Single - Phase Fault			Three - Phase Fault		Single - Phase Fault		
				kA	X/R	kA	X/R	%	kA	X/R	kA	X/R	%	kA	X/R	kA	X/R	%
99999	Mill Creek	138	N/A	N/A	N/A	N/A	N/A	N/A	17.70	11.91	10.47	7.35	N/A	17.641	10.75	11.56	6.91	N/A
46510	Tombal	138	50	45.75	18.0	39.96	19.78	91	44.90	18.22	39.03	20.17	90	45.58	18.12	39.64	19.99	91
45952	Kluge	138	63	30.50	10.8	18.00	7.2	48	29.33	10.92	16.82	7.13	47	30.23	10.97	17.48	7.16	48
46240	Pinhur	138	N/A	20.27	10.8	12.75	9.23	N/A	14.70	10.60	8.16	7.14	N/A	19.82	11.20	12.45	9.23	N/A

9 Planning Estimates

Planning cost estimates are shown in the Table 9-1. Estimated project timeline to complete these projects is August 2026.

Table 9-1: Planning Estimate

Option	Description	Substation Cost ($)	Transmission Cost ($)	Total Cost ($)
1	Mill Creek: Build new 138/35 kV distribution substation	$14,100,000 - $18,900,000	-	$14,100,000 - $18,900,000
	Pinehurst: Upgrade Pinehurst Sectionalizing Scheme	$144,000	-	$144,000
	Kluge: Reconnect 80 MVAR cap bank CB1 from Klein ckt 81 to Pinehurst ckt 81	$950,000	$700,000	$1,650,000
	Loop 138 kV Tomball to Pinehurst into Mill Creek sub	-	$40,646,000 - $69,968,000	$40,646,000 - $69,968,000
Total		$15,194,000 - $19,994,000	$41,346,000 - $70,668,000	$61,340,000 - $86,959,000

The following considerations were made for the new substation estimates shown in Table 9-1:

1. Mill Creek substation will not require fiber optic cable
2. Mill Creek substation will include one 138 kV sectionalizing device to bring the total on the circuit between Tomball and Kluge to three sectionalizing devices. If additional load growth in the area were to require an additional transformer addition, it would require the addition of a new 138 kV breaker station with transmission relaying.

Estimated project completion timeframes are based on typical timeframes to complete engineering, material acquisition, and construction. The timeframes begin when the project has achieved a “GO” status and end when the project is construction complete. The estimated timeframes do not account for additional time that may be necessary for property acquisition, permitting, outage restrictions, and coordination with other projects in the area.

10 Conclusions

Transmission Planning studied the impacts of adding the new Mill Creek distribution substation to the CenterPoint Energy transmission system. The new Mill Creek substation consists of two distribution transformers serving a forecasted load of 70 MW by August 2026.

To determine the preferred interconnection option, steady-state and short-circuit analyses were performed for the two options below:

- Option 1: Loop Pinehurst to Tomball ckt 81 into the new Mill Creek substation
- Option 2: Loop Pinehurst to Kluge ckt 81 into the new Mill Creek substation

The studies were performed for CNP Planning Events P1, P2, P3, P5, P6, and P7 using the 2025 summer peak, 2027 summer peak, and 2026 minimum load conditions. A potential thermal loading concern was observed under CNP Planning Event P6 for Options 1 and 2. Potential new low voltage concerns were seen for Options 1 and 2 under CNP Planning Events P1, P3, P6, and P7.

To mitigate the potential voltage concerns reported in Option 1 and 2, relocation the existing Kluge 80 MVAR cap bank from Kluge to Klein ckt 81 to Kluge to Pinehurst ckt 81 and the conversion of Pinehurst to a unity substation was implemented. Based on the results, Option 1 adequately resolved all the potential low voltage and thermal loading concerns. However, Option 2 reported some remaining loading and voltage concerns.

Based on Sections 5, 6, and 7, Option 1 is the best option to interconnect the new Mill Creek substation. Option 1 loops the Mill Creek substation between Pinehurst and Tomball ckt 81, with Pinehurst converted to a unity power factor substation and the relocation of the Kluge 80 MVAR capacitor bank from 138 kV Klein to Kluge transmission line ckt 81 to 138 kV Kluge to Pinehurst ckt 81.

The new Mill Creek substation is estimated to cost between $61.3M and $87M. The study evaluated summer peak conditions for both 2025 and 2027 based on the original load forecast which showed Mill Creek load being added in summer 2025. The most recent schedule now shows Mill Creek expected to be completed by August 2026. Since the study evaluated both 2025 and 2027 summer peak conditions, Transmission Planning assesses that the conclusions from the study would not change based on the new August 2026 completion date, thus inclusion of a summer peak 2026 study is not necessary. The August 2026 completion date takes into consideration typical lead times necessary to implement the proposed project, including the Public Utility Commission of Texas (PUCT) CCN process review and approval, materials, and construction lead times.

8 Appendix A

22SSWG_Jul_Base_Case_Changes_to_Cre

9 Appendix B

TransformerDataMill Creek_2023 and Lo

10 Appendix C

ACCC_Results_P1_20230627_2248.xlsx

ACCC_Results_P2_20230628_0635.xlsx

ACCC_Results_P3_20230628_1246.xlsx

ACCC_Results_P5_20230628_0637.xlsx

ACCC_Results_P6X_20230628_1032.xlsx

ACCC_Results_P7_20230628_0638.xlsx

11 Appendix D

6_ACCC_Results_P3_20230508_1847_Ap

7_ACCC_Results_P6X_20230508_1844_A

8_ACCC_Results_P7_20230508_1841_Ap

12 Appendix E

ACCC_Results_P1_20230628_1818.xlsx

ACCC_Results_P2_20230628_1820.xlsx

ACCC_Results_P3_20230630_0630.xlsx

ACCC_Results_P5_20230628_1821.xlsx

ACCC_Results_P6X_20230628_2040.xlsx

ACCC_Results_P7_20230628_1822.xlsx

13 Appendix F

Switching studies were performed at Kluge substation to determine that switching the respective capacitor bank does not cause a momentary voltage rise greater than 2% specified in CenterPoint's Transmission Design Criteria. Switching studies were performed on the 2023 MIN cases and 2025 SUM cases with the strongest line out of service. Switching results show that the proposed 80 MVAR cap bank does not violate the 2% transmission switching criteria as shown in Tables below.

Cap Bank at Kluge Substation 138 kV Voltage-Option 1					
Option 1 MIN CASE	Cap Bank (Mvar)	Out of Service	Initial Voltage	New Voltage	Voltage Rise (%)
	80	45711 CYFAIR to 45952 KLUGE	1.0232	1.0421	1.85
Option 1 SUM PEAK	Cap Bank (Mvar)	Out of Service	Initial Voltage	New Voltage	Voltage Rise (%)
	80	45711 CYFAIR to 45952 KLUGE	1.0001	1.0168	1.67

Cap Bank at Kluge Substation 138 kV Voltage-Option 2					
Option 2 MIN CASE	Cap Bank (Mvar)	Out of Service	Initial Voltage	New Voltage	Voltage Rise (%)
	80	45711 CYFAIR to 45952 KLUGE	1.0238	1.0428	1.86
Option 2 SUM PEAK	Cap Bank (Mvar)	Out of Service	Initial Voltage	New Voltage	Voltage Rise (%)
	80	45711 CYFAIR to 45952 KLUGE	1.0000	1.0168	1.68