Xcel Energy Services, Inc.
Public Service Company of Colorado
Comanche Unit 2
(Repl-2024-001)
Retirement & Replacement Study Addendum

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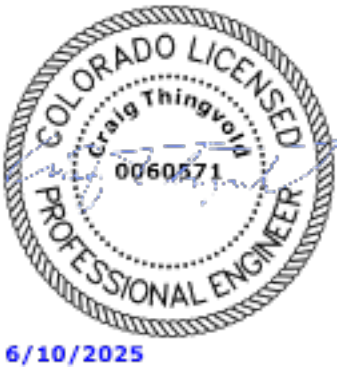
Disclaimer

The information contained in this report is subject to change based on assumptions. The best available information has been used to model the future transmission and generation facilities in this study. Should any of these assumptions change, the results and conclusions from the study are subject to reevaluation. This draft report is yet to be reviewed by the affected Transmission Owners and the results/conclusions of the study report could change based on the findings of the review process.

0 Certifications

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the Laws of the State of Colorado.



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1 Executive Summary

This report details the revised stability results of the generator replacement study performed for the replacement request Repl-2024-001 located at Comanche substation in Pueblo, CO. The new solar plant will replace the existing 335 MW Comanche unit 2. The existing Comanche Unit 2 will be retired effective December 31st, 2025 and the replacement generator will be in operation by August 17th, 2026.

This study was performed as an addendum to the generator replacement and reliability study report completed on April 14, 2025. The original study was performed based on the PSCo BPM Attachment N – Large Generator Interconnection Procedure Dated 10/15/2023 which follows the WECC criterion "TPL-001-WECC CRT-3.2" for transient stability analysis.

The original study identified transient stability performance concerns for multiple faults during the gap period between the proposed retirement date of the Existing Generating Facility and Commercial Operation Date of the Replacement Generating facility which indicated the need for reliability mitigation consisting of a synchronous condenser at Commanche during that period.

Comments were received from Xcel Energy PSCo regarding the criterion used and it was identified that the current BPM does not reflect the revised WECC transient stability criterion "TPL-001-WECC-CRT-4.0". This study includes stability analysis only and is based on the revised criterion. No reliability concerns remain based on the use of the revised WECC criterion.

PSCo is in the process of revising the BPM to reflect the current WECC transient stability criteria.

1.1 Project Overview

Replacement request Repl-2024-001 (Arroyo 2 solar) consists of 89 Sungrow SG4400UD-MV-US solar inverters interconnecting through three 94/125.3/156.7 MVA main power transformers to 230kV line. Repl-2024-001 connects to the Comanche 230kV substation through ~4.03 miles 230kV transmission line shared with Repl-2021-001.

The study involved analyzing the replacement of existing generators which included evaluating system reliability during the gap period between generator retirement and the commercial operation of the replacement generator.

All data necessary for the modeling of this generator was provided by the interconnection customer.

1.2 Stability Analysis

Stability analysis was performed to verify if the generator replacement meets reliability requirements.

No stability violations were identified due to the retirement of Comanche 2. Replacement of Comanche 2 with Repl-2024-001 has no adverse impact on the transmission system with or without the synchronous condenser at Comanche 230 kV Substation.

2 Study Assumptions and Methodology

2.1 Study Assumptions

The study is based on the analysis methods established by PSCo Attachment N LGIP to evaluate generator interconnection and retirement. The evaluation was performed by comparing the cases within each season due to multiple network changes in the area between study years. The case with the retiring unit on is the bench case. The case assumptions are given in Table 2.1-1.

Table 2.1-1 Case Assumptions

Model Name	Loads	Topology	Replacement Unit Repl-2024-001	Retiring Units Comanche 2	Comanche 2 Synchronous Condenser
2026 Bench	Summer Peak	2026	OFF	ON	N/A
2026 Study	Summer Peak	2026	OFF	OFF	N/A
2027 Bench	Summer Peak	2027	OFF	ON	OFF
2027 Study w/o SC	Summer Peak	2027	ON	OFF	OFF
2027 Study w SC	Summer Peak	2027	ON	OFF	ON

Stability analysis was performed using PSLF power flow program V23.

2.2 Criteria

The following stability criteria is used to assess the dynamic performance of the system during large disturbances. Anything outside the criteria below is considered a violation.

2.2.1 Stability assessment criteria

Transient voltage stability criteria require that all generating machines remain in synchronism and all power swings shall be well damped following a contingency event. Also, transient voltage performance shall meet the following WECC criterion "TPL-001-WECC-CRT-4.0:

1. Following fault clearing, the voltage shall recover to 80% of the pre-contingency voltage within 20 seconds for all contingencies for each BES bus serving load.
2. For all contingencies, following fault clearing and voltage recovery above 80%, voltage at each applicable BES bus serving load shall neither dip below 70% of pre-contingency voltage for more than 30 cycles nor remain below 80% of pre-contingency voltage for more than two seconds for all P1 through P7 Single-Line to Ground fault events.
3. For contingencies without a fault, voltage dips at each applicable BES bus serving load shall neither dip below 70% of pre-contingency voltage for more than 30 cycles nor remain below 80% of pre-contingency voltage for more than two seconds.

Transient angular stability criteria shall meet the following criteria:

1. P1 - No generating unit shall pull out of synchronism. A generator being disconnected from the system by fault clearing or by a special protection system is not considered an angular instability.
2. P2-P7 - One or more generators may pull out of synchronism, provided the resulting apparent impedance swings shall not result in the tripping of other generation facilities.
3. P1-P7 - The relative rotor angle oscillations are characterized by positive damping > 5% within 30 seconds.

Generators tripped due to LHVRT or LHFRT model settings are not considered stability issues.

2.3 Power Flow Model Updates

The cases used for this revision were the same as Repl-2021-001 Comanche U2 Reliability and Replacement Impact study. No additional updates were made to the study cases for this revision.

2.4 Stability Files

The stability files were received from PSCo for each case year. The dynamic models for the replacement generator were added to the base case to derive the study case. Dynamic model parameters for the replacement generator were received from the interconnection customer. Planned conversions of Comanche Unit 2 to synchronous condenser after retirement was also assessed with the replacement generator. Additional scenarios were simulated with and without synchronous condenser for the year 2027 case due to different in-service dates. Fault files were updated to simulate solid single line to ground faults for all P4 and P7 contingencies.

3 Stability Results

3.1 Stability Analysis for Comanche Unit 2 Retirement

Stability analysis was performed for the year 2026 case with and without Comanche Unit 2 to assess the stability of the system after the generator is retired and the replacement generator is not yet in service. The results show that all generating units within PSCo Transmission System remain in synchronism and have positive damping. The system voltages recover by the end of simulation to nominal levels. No transient voltage violations were identified which violate the WECC criterion TPL-001-WECC-CRT-4.0.

The Comanche 2 can be retired without any adverse impacts on the transmission system.

The summary of results for the faults simulated is given in Table 3.1-1. Appendix A contains the output stability plots for the simulated faults. Stability output detailed tables are available in Appendix B.

Table 3.1-1 Stability Analysis Results in Reliability Cases

Fault	Description	2026 Bench	2026 Study
F1	Three phase fault at bus 70654 Comanche 345 kV: Trip Comanche-Tundra 345	Stable	Stable
F2	Three phase fault at bus 70654 Comanche 345 kV: Trip Comanche 345 Gen3	Stable	Stable
F3	Three phase fault at bus 70654 Comanche 345 kV: Trip Comanche-TX4 345-230	Stable	Stable
F4	Three phase fault at bus 70031 Baculite 115 kV: Trip Baculite Mesa Gen1 GSU	Stable	Stable
F5	Three phase fault at bus 70107 Cherokee 230 kV: Trip Cherokee-Lacombe 230	Stable	Stable
F6	Three phase fault at bus 70122 Comanche 230 kV: Trip Comanche-Boone 230 ckt 1	Stable	Stable
F7	Three phase fault at bus 70601 Daniel 345 kV: Trip Daniel Park-Tundra 345 ckt 2	Stable	Stable
F8	Three phase fault at bus 70601 Daniel 345 kV: Trip Daniel Park-Missil Site 345	Stable	Stable
F9	Three phase fault at bus 70410 Ft St Vrain 230 kV: Trip Ft St Vrain-Isabelle 230	Stable	Stable
F10	Three phase fault at bus 70286 Midwy 230 kV: Trip Midwy-Milasol 230	Stable	Stable
F11	Three phase fault at bus 70464 Waterton 230 kV: Trip Waterton Tx 345-230	Stable	Stable
F12	Three phase fault at bus 70459 Walsenburg 230 kV: Trip Walsenburg-Valent 230	Stable	Stable

Fault	Description	2026 Bench	2026 Study
F13	Three phase fault at bus 70624 Missle Site 345 kV: Trip Missle Site-Smoky Hills 345	Stable	Stable
F14	Three phase fault at bus 70597 Harvest_MI 345 kV: Trip Daniels Park-Harvest_MI 345	Stable	Stable
F15	Solid single line to ground fault at bus 70654 Comanche 345 kV: Trip Comanche-Tundra 345 +7014-GSU3	Stable	Stable
F16	Solid single line to ground fault at bus 70601 Daniels Park 345 kV: Trip Daniels Park- Tundra 345 +7032-Tx4 345-230	Stable	Stable
F17	Solid single line to ground fault at bus 70139 Daniels Park 230 kV: Trip Daniels Park-Waterton 230 +5102-Daniels Park-Fuller230	Stable	Stable
F18	Solid single line to ground fault at bus 70286 Midway 115 kV: Trip Midway-Boone 230 +5128-Tx1 230-115	Stable	Stable
F19	Solid single line to ground fault at bus 70061 Boone 230 kV: Trip Boone-Comanche 230 (Comanche)+5337-Boone-Lamar 230	Stable	Stable
F20	Solid single line to ground fault at bus 70653 Tundra 2 kV: Trip Tundra-Daniel Park 345 1+2	Stable	Stable

3.2 Stability Analysis for Comanche Unit 2 Replacement

Stability analysis was performed for the year 2027 case with Comanche Unit 2 in service as bench case and the replacement generator with synchronous condenser as study case. The results show that all generating units within PSCo Transmission System remain in synchronism and have positive damping. The system voltages recover by the end of simulation to nominal levels. There were no transient violations for the faults simulated based on WECC criterion TPL-001-WECC-CRT-4.0.

Additional scenarios were simulated to identify if there are any stability violations due to replacement of Comanche Unit 2 with Repl-2024-001 prior to operation of Comanche 2 as synchronous condenser. The results show that the replacement of Comanche Unit 2 with Repl-2024-001 without the synchronous condenser has acceptable transient voltage and dynamic stability performance, meeting TPL-001-WECC-CRT-4.0 criterion. No material adverse impact is identified.

The replacement of Comanche 2 with Repl-2024-001 does not have any adverse impact on the system stability. There was no significant difference in results for study cases with and without synchronous condenser.

The summary of results for the faults simulated is given in Table 3.2-1. Appendix A contains the output stability plots for the simulated faults. Stability output detailed tables are available in Appendix B.

Table 3.2-1 Stability Analysis Results in Replacement Cases

Fault	Description	2027 Bench	2027 Study w/o SC	2027 Study with SC
F1	Three phase fault at bus 70654 Comanche 345 kV: Trip Comanche-Tundra 345	Stable	Stable	Stable
F2	Three phase fault at bus 70654 Comanche 345 kV: Trip Comanche 345 Gen3	Stable	Stable	Stable
F3	Three phase fault at bus 70654 Comanche 345 kV: Trip Comanche-TX4 345-230	Stable	Stable	Stable
F4	Three phase fault at bus 70031 Baculite 115 kV: Trip Baculite Mesa Gen1 GSU	Stable	Stable	Stable
F5	Three phase fault at bus 70107 Cherokee 230 kV: Trip Cherokee-Lacombe 230	Stable	Stable	Stable
F6	Three phase fault at bus 70122 Comanche 230 kV: Trip Comanche-Boone 230 ckt 1	Stable	Stable	Stable
F7	Three phase fault at bus 70601 Daniel 345 kV: Trip Daniel Park-Tundra 345 ckt 2	Stable	Stable	Stable
F8	Three phase fault at bus 70601 Daniel 345 kV: Trip Daniel Park-Missil Site 345	Stable	Stable	Stable
F9	Three phase fault at bus 70410 Ft St Vrain 230 kV: Trip Ft St Vrain-Isabelle 230	Stable	Stable	Stable
F10	Three phase fault at bus 70286 Midwy 230 kV: Trip Midwy-Milasol 230	Stable	Stable	Stable
F11	Three phase fault at bus 70464 Waterton 230 kV: Trip Waterton Tx 345-230	Stable	Stable	Stable
F12	Three phase fault at bus 70459 Walsenburg 230 kV: Trip Walsenburg-Valent 230	Stable	Stable	Stable
F13	Three phase fault at bus 70624 Missle Site 345 kV: Trip Missle Site-Smoky Hills 345	Stable	Stable	Stable
F14	Three phase fault at bus 70597 Harvest_MI 345 kV: Trip Daniels Park-Harvest_MI 345	Stable	Stable	Stable
F15	Solid single line to ground fault at bus 70654 Comanche 345 kV: Trip Comanche-Tundra 345 +7014-GSU3	Stable	Stable	Stable
F16	Solid single line to ground fault at bus 70601 Daniels Park 345 kV: Trip Daniels Park- Tundra 345 +7032-Tx4 345-230	Stable	Stable	Stable
F17	Solid single line to ground fault at bus 70139 Daniels Park 230 kV: Trip Daniels Park-Waterton 230 +5102-Daniels Park-Fuller230	Stable	Stable	Stable
F18	Solid single line to ground fault at bus 70286 Midway 115 kV: Trip Midway-Boone 230 +5128-Tx1 230-115	Stable	Stable	Stable
F19	Solid single line to ground fault at bus 70061 Boone 230 kV: Trip Boone-Comanche 230 (Comanche)+5337-Boone-Lamar 230	Stable	Stable	Stable
F20	Solid single line to ground fault at bus 70653 Tundra 2 kV: Trip Tundra-Daniel Park 345 1+2	Stable	Stable	Stable

4 Conclusion

There are no adverse impacts on the transmission system stability due to the retirement of Comanche 2 as per WECC criterion TPL-001-WECC-CRT-4.0.

The results of this study indicate Comanche Unit 2 can be replaced with Repl-2024-001 solar plant with no material adverse impact on the transmission system with or without synchronous condenser in service as per WECC criterion TPL-001-WECC-CRT-4.0.