Provisional Interconnection Study Report for PI-2023-5

4/15/2024

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1.0 Executive Summary

The PI-2023-5 project is a Provisional Interconnection request for a 200 MW Wind Generating Facility with a Point of Interconnection (POI) at the May Valley 345 kV substation. PI-2023-5 is the Provisional Interconnection request later submitted as Generation Interconnection Request 3RSC-2023-3 in the 3RSC cluster..

The total cost of the transmission system improvements required for PI-2023-5 to qualify for Provisional Interconnection Service is estimated to be $5.152 million (Table 10 and Table 11).

The initial maximum permissible output of PI-2023-5 Generating Facility is 200 MW. The maximum permissible output of the Generating Facility in the PLGIA[1] would be reviewed quarterly and updated, if there are changes to the system conditions assumed in this analysis, to determine the maximum permissible output.

Security: PI-2023-5 is a request for NRIS. For NRIS requests, security shall estimate the risk associated with the Network Upgrades and the Interconnection Facilities and is assumed to be a minimum of $25 million.

In addition, the Interconnection Customer would assume all risk and liabilities with respect to changes between the PLGIA and the LGIA[2], including changes in output limits and Interconnection Facilities, Network Upgrades, Distribution Upgrades, and/or System Protection Facilities cost responsibility.

Note that Provisional Interconnection Service in and of itself does not convey transmission service.

[1] Provisional Large Generator Interconnection Agreement (PLGIA): Shall mean the interconnection agreement for Provisional Interconnection Service established between Transmission Provider and/or the Transmission Owner and the Interconnection Customer. The pro forma agreement is provided in Appendix 8 and takes the form of the Large Generator Interconnection Agreement, modified for provisional purposes.

[2] Large Generator Interconnection Agreement (LGIA): Shall mean the form of interconnection agreement applicable to an Interconnection Request pertaining to a Large Generating Facility that is included in the Transmission Provider's Tariff.

2.0 Introduction

PI-2023-5 is the Provisional Interconnection Service[3] request for a 200 MW Wind Generating Facility located in Kiowa County, Colorado.

- The POI of this project the new May Valley 345 kV substation. The May Valley 345 kV substation is part of the Colorado Power Pathway project.
- The Commercial Operation Date (COD) to be studied for PI-2023-3 as noted on the Provisional request form is 12/31/2025.

The geographical location of the transmission system near the POI is shown in Figure 1. Note an approximation was used to overlay the new Colorado Power Pathway onto the current one-line diagram.

[3] **Provisional Interconnection Service** shall mean an Interconnection Service provided by Transmission Provider associated with interconnecting the Interconnection Customer's Generating Facility to Transmission Provider's Transmission System and enabling that Transmission System to receive electric energy and capacity from the Generating Facility at the Point of Interconnection, pursuant to the terms of the Provisional Large Generator Interconnection Agreement and, if applicable, the Tariff.

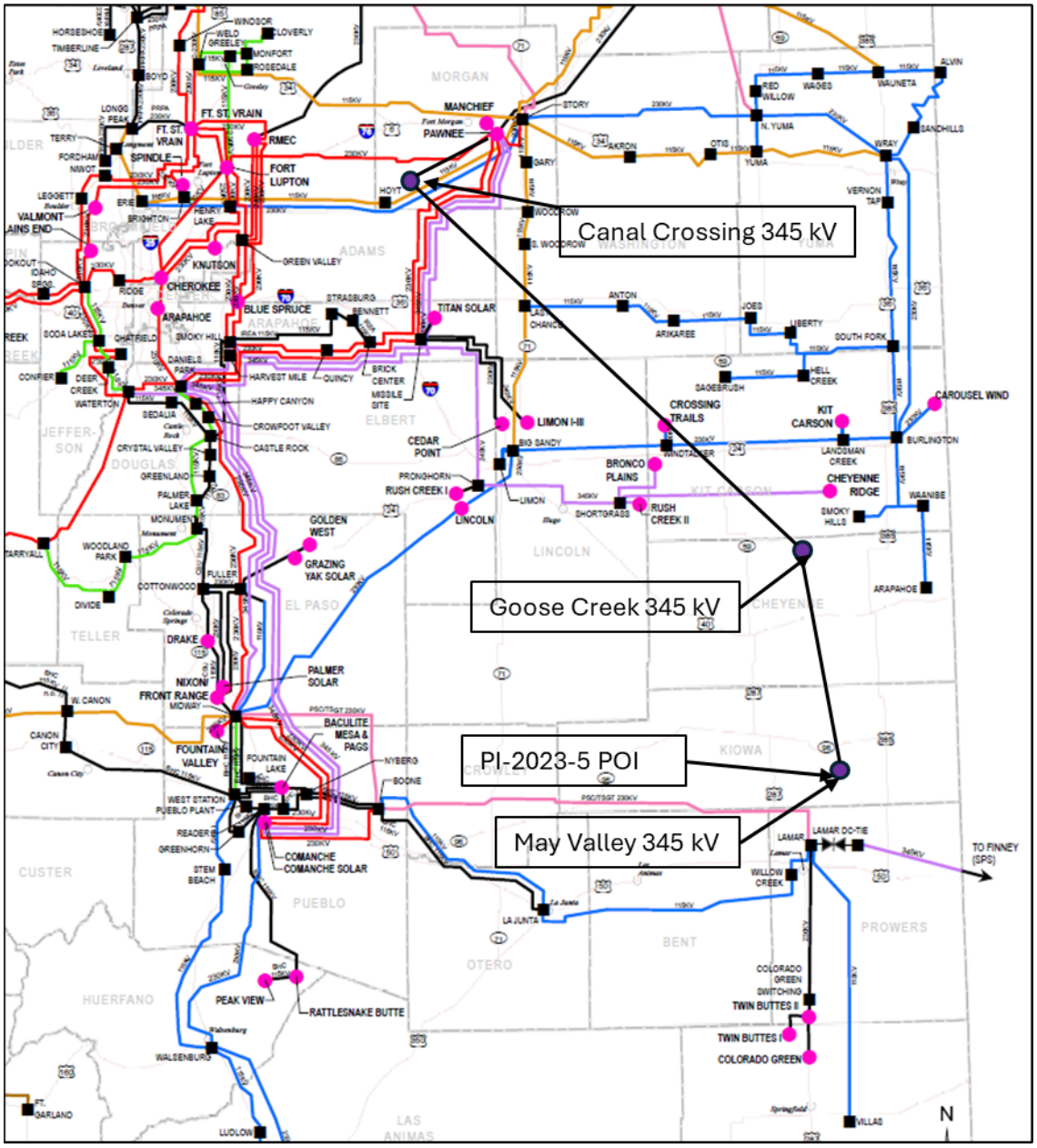

Figure 1: Point of Interconnection of PI-2023-5

3.0 Study Scope

The purpose of this study is to determine the impacts to the PSCo system and the Affected Systems from interconnecting PI-2023-5 for Provisional Service. Consistent with the assumption in the study agreement, PI-2023-5 selected Network Resource Interconnection Service (NRIS)[4].

The scope of this report includes voltage and reactive capability evaluation, steady state (thermal and voltage) analysis, transient stability analysis, short-circuit analysis, and cost estimates for Interconnection Facilities and Station Network Upgrades. The study also identifies the estimated Security[5] and Contingent Facilities associated with the Provisional Service.

3.1 Steady State Criteria

The following Criteria are used for the reliability analysis of the PSCo system and Affected Systems:

P0—System Intact conditions:

Thermal Loading: <=100% of the normal facility rating

Voltage range: 0.95 to 1.05 per unit

P1 & P2-1—Single Contingencies:

Thermal Loading: <=100% Normal facility rating

Voltage range: 0.90 to 1.10 per unit

Voltage deviation: <=8% of pre-contingency voltage

P2 (except P2-1), P4, P5 & P7—Multiple Contingencies:

Thermal Loading: <=100% Emergency facility rating

Voltage range: 0.90 to 1.10 per unit

Voltage deviation: <=8% of pre-contingency voltage

[4] **Network Resource Interconnection Service** shall mean an Interconnection Service that allows the Interconnection Customer to integrate its Large Generating Facility with the Transmission Provider's Transmission system (1) in a manner comparable to that in which the Transmission Provider integrates its generating facilities to serve native load customers; or (2) in an RTO or ISO with market-based congestion management, in the same manner as all other Network Resources. Network Resource Interconnection Service in and of itself does not convey transmission service.

[5] **Security** estimates the risk associated with the Network Upgrades and Interconnection Facilities that could be identified in the corresponding LGIA.

3.2 Transient Stability Criteria

The transient voltage stability criteria are as follows:

a. Following fault clearing, the voltage shall recover to 80% of the pre-contingency voltage within 20 seconds of the initiating event for all P1 through P7 events for each applicable Bulk Electric System (BES) bus serving load.
b. 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 events.
c. For Contingencies without a fault (P2.1 category event), 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.

The transient angular stability criteria are as follows:

a. P1—No generating unit shall pull out of synchronism. A generator being disconnected from the system by fault clearing action or by a special Protection System is not considered an angular instability.
b. P2–P7—One or more generators may pull out of synchronism, provided the resulting apparent impedance swings shall not result in the tripping of any other generation facilities.
c. P1–P7—The relative rotor angle (power) oscillations are characterized by positive damping (i.e., amplitude reduction of successive peaks) > 5% within 30 seconds.

3.3 Breaker Duty Analysis Criteria

Fault Current after PI addition should not exceed 100% of the Breaker Duty rating. PSCo can only perform breaker duty analysis on the PSCo system. Before the PI goes in-service the Affected Systems may choose to perform a breaker duty analysis to identify breaker duty violations on their system.

3.4 Study Methodology

For PSCo and non-PSCo facilities, thermal violations attributed to the request include all new facility overloads with a thermal loading >100% and increased by 1% or more from the benchmark case overload post the Generator Interconnection Request (GIR) addition.

The voltage violations assigned to the request include new voltage violations which resulted in a further variation of 0.01 per unit.

Since the request is for Provisional Service, if thermal or voltage violations are seen, the maximum permissible Provisional Interconnection before violations is identified. For voltage violations caused by reactive power deficiency at the POI, voltage upgrades are identified.

The Provisional Interconnection request should meet the transient stability criteria stated in Section 3.1. If the addition of the GIR causes any violations, the maximum permissible Provisional Interconnection Service before violations is identified.

3.5 Contingency Analysis

The transmission system on which steady state contingency analysis is run includes the WECC designated areas 70 and 73.

The transient stability analysis is performed for the following worst-case contingencies shown in Table 1.

Table 1 – Transient Stability Contingencies

Ref. No.	Fault Location	Fault Category	Outage(s)	Clearing Time (Cycles)
1	Goose Creek 345 kV	P1	Goose Creek - Canal Crossing 345 kV ckt 1	4
2	Goose Creek 345 kV	P1	Goose Creek - Cheyenne Ridge 345 kV ckt 1 Cheyenne Ridge Wind Generation	4
3	Goose Creek 345 kV	P1	Goose Creek - Shortgrass 345 kV ckt 1	4
4	May Valley 345 kV	P1	May Valley - Goose Creek 345 kV ckt 1	4
5	May Valley 345 kV	P1	PI-2023-5 Generation	4
6	Daniels Park 345 kV	P4	Daniels Park - Missile Site 345 kV ckt 1 Daniels Pak 345 kV Cap Bank	12

Ref. No.	Fault Location	Fault Category	Outage(s)	Clearing Time (Cycles)
7	Pronghorn 345 kV	P4	Pronghorn - Rush Creek 345 kV ckt Rush Creek Wind Generation Daniels Park 345 kV Cap Bank	12
8	Canal Crossing 345 kV	P4	Goose Creek - Canal Crossing 345 kV ckt 1 Goose Creek - Canal Crossing 345 kV ckt 2 Canal Crossing 345 kV Cap Bank	12

3.6 Study Area

The Eastern Colorado study area includes WECC designated zones 706. The Affected Systems included in the analysis include the Western Area Power Administration (WAPA) and Tri-State Generation and Transmission (TSGT) systems in the study area.

4.0 Base Case Modeling Assumptions

The study was performed using the 2024HS3 WECC base case that has been modified to represent a 2026 heavy summer loading conditions. The following planned transmission projects are modeled in the Base Case:

- Canal Crossing 345 kV substation
- Fort Saint Vrain 345 kV substation
- Goose Creek 345 kV substation
- May Valley 345 kV substation
- Sand 230 kV substation
- Kestrel 230 kV substation
- Coyote 230 kV substation
- Poder 115 kV substation
- Metro Water 115 kV substation
- Pintail 115 kV substation
- DCPL Tap 115 kV substation
- Carl Tap 69 kV substation

The following additional changes were made to the Intermountain Regional Electric Co-Op (CORE) model in the Base Case:

- Citadel 115 kV substation
- Spring Valley 115 kV substation
- Deer Trail 115 kV substation

The Base Case model includes higher-queued and existing PSCo and Affected System generation resources.

4.1 Benchmark Case Modeling

The Benchmark Case was created from the Base Case described in Section 4.0 by changing the study pocket generation dispatch to reflect heavy generation in the Eastern Colorado study pocket. This was accomplished by adopting the stressed generation dispatch given in Table 2.

Table 2 – Generation Dispatch Used to Create the Eastern Colorado Benchmark Case (MW is Gross Capacity)

Bus No.	Bus Name	Base kV	ID	Status	Pgen (MW)	Pmax (MW)
70310	PAWNEE	22	C1	1	523.60	526.00
70314	MANCHEF1	16	G1	1	118.40	131.50
70315	MANCHEF2	16	G2	1	117.90	131.00
70721	SPRNGCAN1_W1	0.57	W1	1	51.80	64.80
70710	PTZLOGN1	34.5	W1	1	160.80	201.00

Bus No.	Bus Name	Base kV	ID	Status	Pgen (MW)	Pmax (MW)
70712	PTZLOGN2	34.5	W2	1	96.00	120.00
70713	PTZLOGN3	34.5	W3	1	63.60	79.50
70714	PTZLOGN4	34.5	W4	1	140.00	175.00
70715	SPRNGCAN2_W2	0.69	W2	1	50.20	62.70
70733	CHEYRGE_W1	0.69	W1	1	43.20	54.00
70736	CHEYRGE_W2	0.69	W2	1	88.00	110.00
70739	CHEYRGW_W1	0.69	W1	1	109.12	136.40
70742	CHEYRGW_W2	0.69	W2	1	105.60	132.00
70670	CEDARPT_W1	0.69	W1	1	99.36	124.20
70671	CEDARPT_W2	0.69	W2	1	100.80	126.00
70767	RUSHCK1_W1	0.69	W1	1	161.12	201.40
70770	RUSHCK1_W2	0.69	W2	1	130.32	162.90
70771	RUSHCK2_W3	0.69	W3	1	166.40	208.00
70635	LIMON1_W	34.5	W1	1	160.80	201.00
70636	LIMON2_W	34.5	W2	1	160.80	201.00
70637	LIMON3_W	34.5	W3	1	160.80	201.00
70753	BRONCO_W1	0.69	W1	1	117.28	146.64
70749	BRONCO_W2	0.69	W2	1	128.96	161.18
70443	ARRIBA_W1	0.69	W1	1	80.08	100.05
70442	ARRIBA_W2	0.69	W2	1	80.80	100.05
Total					3215.74	3857.32

4.2 Study Case Modeling

A Study Case was created from the Benchmark Case by turning on the PI-2023-5 generation. The additional 200 MW output from PI-2023-5 was balanced against PSCo generation outside of the Eastern Colorado study pocket.

4.3 Short-Circuit Modeling

This request is for the interconnection of a 200 MW Solar Generating Facility (PI-2023-5) to the May Valley 345 kV substation. The output will not exceed 200 MW at the POI.

This project assumes the use of sixty-one (61) GE 3.4-140 wind turbine generators (WTGs) rated at 3.778 MVA operating at +/-0.90 pf for PI-2023-5. Each of the WTGs is connected to a collector transformer, 0.69/34.5kV, rated at 3.811 MVA. Two 345/34.5/13.8kV main GSU transformers rated at 73.8/98/123 MVA step the voltage up from the collector transformer

voltage to the POI voltage. An ~8-mile-long generation tie line interconnects the project to the May Valley 345 kV substation.

All connected generating facilities were assumed capable of producing maximum fault current. As such, all generation was modeled at full capacity, whether NRIS or ERIS is requested. Generation is modeled as a separate generating resource in CAPE and included at full capacity in the short-circuit study, regardless of any limitations to the output that would be imposed otherwise.

5.0 Provisional Interconnection Service Analysis

5.1 Voltage and Reactive Power Capability Evaluation

The following voltage regulation and reactive power capability requirements are applicable to non-synchronous generators:

- Xcel Energy's OATT requires all non-synchronous generator Interconnection Customers to provide dynamic reactive power within the power factor range of 0.95 leading to 0.95 lagging at the high side of the generator substation. Furthermore, Xcel Energy requires every Generating Facility to have dynamic voltage control capability to assist in maintaining the POI voltage schedule specified by the Transmission Operator.
- It is the responsibility of the Interconnection Customer to determine the type (switched shunt capacitors and/or switched shunt reactors, etc.), the size (MVar), and the locations (on the Interconnection Customer's facility) of any additional static reactive power compensation needed within the generating plant in order to have adequate reactive capability to meet the +/- 0.95 power factor at the high side of the main step-up transformer.
- It is the responsibility of the Interconnection Customer to compensate their generation tie line to ensure minimal reactive power flow under no load conditions.

All proposed reactive devices in customer provided models are switched favourably to provide appropriate reactive compensation in each test, therefore identified deficiencies are in addition to any proposed reactive compensation.

All the summary tables representing the GIR's Voltage and Reactive Power Capability tests adhere to the following color formatting representing the different aspects of the tests:

- Values highlighted in red indicate a failed reactive power requirement.
- Voltages outside the range of 0.95 p.u. to 1.05 p.u. are highlighted in yellow to provide additional information.

The PI-2023-5 GIR is modeled as follows:

Wind Generator 1: Pmax = 104.50 MW, Pmin = 0 MW, Qmax = 51.05 MVar, Qmin= -51.05 MVar

Wind Generator 2: Pmax = 101.10 MW, Pmin = 0 MW, Qmax = 49.40 MVar, Qmin= -49.40 MVar

The summary for the Voltage and Reactive Power Capability Evaluation for PI-2023-5 is:

- The GIR is capable of meeting ±0.95 pf at the high side of the main step-up transformer while maintaining a normal operating voltage at the POI.
- The GIR is capable of meeting ±0.95 pf at its terminals while meeting the interconnection service request.
- The reactive power exchange and voltage change across the gen-tie are acceptable under no load conditions.

The Voltage and Reactive Power Capability tests performed for PI-2023-5 are summarized in Table 3.

Table 3 – Reactive Capability Evaluation for PI-2023-5

Reactive Power Capability - Project PI-2023-5 - MPT High Side PF Checks																	
Generator 1 Terminals					Generator 2 Terminals					High Side of Main Transformer				POI			
Pgen (MW)	Qgen (MVar)	Qmax (MVar)	Qmin (MVar)	V (p.u.)	Pgen (MW)	Qgen (MVar)	Qmax (MVar)	Qmin (MVar)	V (p.u.)	P (MW)	Q (MVar)	V (p.u.)	PF	P (MW)	Q (MVar)	V (p.u.)	PF
104.5	51.1	51.1	-51.1	1.07	101.1	49.4	49.4	-49.4	1.07	200.2	65.8	1.01	0.9500	199.9	69.1	1.00	0.9451
104.5	17.0	51.1	-51.1	0.95	101.1	17.0	49.4	-49.4	0.95	200.1	-70.5	1.00	-0.9432	199.8	-67.2	1.00	-0.9478
0.0	-3.3	51.1	-51.1	1.01	0.0	-3.1	49.4	-49.4	1.01	0.0	-2.9	1.01	0.0000	0.0	8.4	1.01	0.0000

5.2 Steady State Analysis

Contingency analysis was performed on the East study pocket Study Case.

The results of the system intact analysis showed no violations.

The results of the single contingency analysis on the Study Case are shown in Table 4.

The results of the multiple contingency analysis on the Study Case are shown in Table 5 and Table 6.

All the single contingency overloads identified in Table 4 are alleviated through generation redispatch. The System Network Upgrades Reference Nos. 1 and 2 shown in Table 7 are not attributable to the study GIR because of the overloads occurring in the Benchmark Case. They are included for informational purposes. Mitigation for these facility overloads will be determined at a later date. The System Network Upgrade Reference No. 3 shown in Table 7 is attributed to the study GIR, but it is located within an Affected System. The remaining System Network Upgrades shown in Table 7 (Reference No. 4 and 5) were resolved by the project listed in Reference No. 4.

Per TPL-001-5, multiple contingency overloads are mitigated using system adjustments, including generation redispatch (includes GIRs under study) and/or operator actions. None of the multiple contingency overloads are attributed to the study GIRs.

Single contingency analysis showed no voltage violations attributed to the study GIR.

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Table 4 – East Pocket - Single Contingency Overloads

Ref. No.	Monitored Facility	Contingency Name	kV	Areas	Owner	Normal Rating (MVA)	Benchmark Case Loading (%)	Study Case Loading (%)	Loading Difference (%)
1	Story (73192) - Pawnee (70311) 230 kV ckt 1	Smokey Hill - Missile Site #7081	230	73/70	TSGT	581.00	124.04	135.62	11.58
2	Fort Lupton (70192) - Pawnee (70311) 230 kV ckt 1	Smokey Hill - Missile Site #7081	230	70	PSCo	478.00	103.63	108.87	5.24
3	EFMORGTP (73305) - FMWEST (73379) 115 kV ckt 1	Smokey Hill - Missile Site #7081	115	73	WAPA	121.00	98.67	101.13	2.46
4	Smoky Hill 345/230 kV Transformer #5	Smokey Hill - Harvest Mile 230 kV	345/230	70	PSCo	560.00	99.60	100.81	1.21
5	Smoky Hill 345/230 kV Transformer #4	Smokey Hill - Harvest Mile 230 kV	345/230	70	PSCo	560.00	99.60	100.81	1.21

Table 5 – East Pocket - Multiple Contingency Overloads

Ref. No.	Monitored Facility	Contingency Name	kV	Areas	Owner	Emergency Rating (MVA)	Benchmark Case Loading (%)	Study Case Loading (%)	Loading Difference (%)
1	Buckley 2 (70046) - Smoky Hill (70396) 230 kV ckt 1	BF_064c: Greenwood Bus Tie	230	70	PSCo	478	148.87	150.23	1.36
2	Buckley 2 (70046) - Tollgate (70491) 230 kV ckt 1	BF_064c: Greenwood Bus Tie	230	70	PSCo	554	128.46	129.62	1.16
3	Jewell 2 (70239) - Leetsdale (70260) 230 kV ckt 1	BF_064c: Greenwood Bus Tie	230	70	PSCo	478	118.28	119.66	1.38
4	Story (73192) - Pawnee (70311) 230 kV ckt 1	BF_057b: Ft Lupton Breaker 5522	230	73/70	TSGT	589	106.04	114.92	8.88

Ref. No.	Monitored Facility	Contingency Name	kV	Areas	Owner	Emergency Rating (MVA)	Benchmark Case Loading (%)	Study Case Loading (%)	Loading Difference (%)
5	Jewell 2 (70239) - Tollgate (70491) 230 kV ckt 1	BF_064c: Greenwood Bus Tie	230	70	PSCo	555	111.51	112.69	1.18
6	Buckley 2 (70046) - Smoky Hill (70396) 230 kV ckt 1	P7_101: Lines 5705, 5167, 5717	230	70	PSCo	478	127.58	128.64	1.06
7	Clark (70112) - Jordan (70241) 230 kV ckt 1	P7_58: Lines 5707, 5111	230	70	PSCo	364	120.36	121.68	1.32
8	Smoky Hill (70599) - Missile Site (70624) 345 kV ckt 1	P7_61: Lines 5113, 7109	345	70	PSCo	1775	106.94	114.35	7.41
10	EFMORGTP (73305) - FMWEST (73379) 115 kV ckt 1	P7_136: Lines 5467, 7081	115	73	WAPA	133	98.73	102.58	3.85

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Table 6 – East Pocket - Multiple Contingency Voltage Violations

Ref. No.	Monitored Facility	Bus No.	Contingency Name	kV	Areas	Owner	Benchmark Case Bus Voltage (p.u.)	Study Case Bus Voltage (p.u.)	Voltage Difference (p.u.)
1	CASTLRCK_TP2	70020	P7_136: Lines 5467, 7081	115	70	PSCo	0.9220	0.8984	-0.0236
2	HAPPY_CNYN	70115	P7_136: Lines 5467, 7081	115	70	PSCo	0.9230	0.8994	-0.0236
3	CROWFT_VLY	70117	P7_136: Lines 5467, 7081	115	70	IREA	0.9220	0.8987	-0.0233
4	SULLIVAN_2	70365	P7_136: Lines 5467, 7081	230	70	PSCo	0.9220	0.8988	-0.0232
5	MONACO_12	70481	P7_136: Lines 5467, 7081	230	70	PSCo	0.9220	0.8995	-0.0225
6	SULPHUR	70524	P7_136: Lines 5467, 7081	230	70	PSCo	0.9210	0.8990	-0.0220
7	DANIEL_PK	70601	P7_136: Lines 5467, 7081	345	70	PSCo	0.9170	0.8952	-0.0218
8	CITADEL_CR	71502	P7_136: Lines 5467, 7081	115	70	IREA	0.9230	0.8987	-0.0243

Table 7 – East Pocket – Benchmark Case Mitigation

Ref. No.	Network Upgrade	Owner	Facility Type	Minimum Required Rating (MVA)
1	Upgrade Story (73192) - Pawnee (70311) 230 kV ckt 1	TSGT	Line	787.90
2	Upgrade Fort Lupton (70192) - Pawnee (70311) 230 kV ckt 1	PSCo	Line	520.40
3	Upgrade EFMORGTP (73305) - FMWEST (73379) 115 kV ckt 1	WAPA	Line	122.40
4	Quincy – Smoky Hill 230 kV Line Tap at Harvest Mile	PSCo	Line	-

5.3 Transient Stability Results

The following results were obtained for the disturbances analysed:

- ✓ No machines lost synchronism with the system.
- ✓ No transient voltage drop violations were observed.
- ✓ Machine rotor angles displayed positive damping.

The results of the contingency analysis are shown in Table 8. The transient stability plots are shown in Appendix A in Section 10.0 of this report.

Table 8 – Transient Stability Analysis Results

Ref. No.	Fault Location	Fault Category	Outage(s)	Clearing Time (Cycles)	Post-Fault Voltage Recovery	Angular Stability
1	Goose Creek 345 kV	P1	Goose Creek - Canal Crossing 345 kV ckt 1	4	Stable	Stable
2	Goose Creek 345 kV	P1	Goose Creek - Cheyenne Ridge 345 kV ckt 1 Cheyenne Ridge Wind Generation	4	Stable	Stable
3	Goose Creek 345 kV	P1	Goose Creek - Shortgrass 345 kV ckt 1	4	Stable	Stable
4	May Valley 345 kV	P1	May Valley - Goose Creek 345 kV ckt 1	4	Stable	Stable
5	May Valley 345 kV	P1	PI-2023-5 Generation	4	Stable	Stable
6	Daniels Park 345 kV	P4	Daniels Park - Missile Site 345 kV ckt 1 Daniels Pak 345 kV Cap Bank	12	Stable	Stable
7	Pronghorn 345 kV	P4	Pronghorn - Rush Creek 345 kV ckt Rush Creek Wind Generation Daniels Park 345 kV Cap Bank	12	Stable	Stable
8	Canal Crossing 345 kV	P4	Goose Creek - Canal Crossing 345 kV ckt 1 Goose Creek - Canal Crossing 345 kV ckt 2 Canal Crossing 345 kV Cap Bank	12	Stable	Stable

5.4 Short-Circuit and Breaker Duty Analysis Results

The fault currents at the POI for three-phase and phase-to-ground faults can be found in Table 9 below, along with the Thevenin impedance at the POI. Both the base case and the case with the GIR added are shown.

Table 9 – Short-Circuit Parameters at PI-2023-5 POI (May Valley 345 kV substation)

	Before the PI Addition	After the PI Addition
Three Phase		
Three Phase Current	5220 A	5640 A
Positive Sequence Impedance	2.94172 + j38.0808 ohms	2.94172 + j38.0808 ohms
Negative Sequence Impedance	2.96554 + j38.0763 ohms	2.96554 + j38.0763 ohms
Zero Sequence Impedance	21.6655 + j100.398 ohms	7.61802 + j55.4155 ohms
Phase-to-Ground		
Single Line to Ground Current	3350 A	4890 A
Positive Sequence Impedance	2.94172 + j38.0808 ohms	2.94172 + j38.0808 ohms
Negative Sequence Impedance	2.96554 + j38.0763 ohms	2.96554 + j38.0763 ohms
Zero Sequence Impedance	21.6655 + j100.398 ohms	7.61802 + j55.4155 ohms

A breaker duty study on the PSCo transmission system did not identify any circuit breakers that became over-dutied because of adding the wind generation PI-2023-5.

5.5 Affected Systems

WAPA and TSGT are identified as Affected Systems as a result of overloads on their facilities as listed in Table 4.

5.6 Summary of Provisional Interconnection Analysis

All single contingency thermal violations were alleviated through generation redispatch, therefore, the maximum allowable output of the GIR without requiring any additional System Network Upgrades is 200 MW. Since this project's affiliated request is for NRIS, the study also identified all the suitable mitigations necessary to alleviate the overloads caused by the study GIR.

6.0 Cost Estimates

The total cost of the required Upgrades for PI-2023-5 to interconnect for Provisional Interconnection Service at the May Valley 345 kV substation is estimated to be **$5.152 million**. Note that cost estimates for system Network Upgrades on Affected Systems would not be provided by Xcel PSCo.

- **Cost of Transmission Provider's Interconnection Facilities (TPIF) is $3.445 million** (Table 10)
- **Cost of Station Network Upgrades is $1.707 million** (Table 11)
- **Cost of System Network Upgrades is $0**

The list of improvements required to accommodate the Provisional Interconnection of PI-2023-5 are given in Table 10, and Table 11.

Since the POI is a new substation, a CPCN would be required to accommodate the interconnection.

Table 10 – Transmission Provider's Interconnection Facilities

Element	Description	Cost Est. (million)
PSCo's May Valley 345 kV switching station	Interconnection of PI-2023-5 at the May Valley 345 kV switching station. The new equipment includes: • (1) 345 kV dead end structure • (1) 345 kV 3-phase arrester • (1) 345 kV 3000 A line disconnect switch • (1) 345 kV 3-phase CT for metering • (1) 345 kV 3-phase 3-winding CCVT • Dual fiber communication equipment • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures • Associated transmission line communications, fiber, relaying and testing	$3.395
PSCo's May Valley 345 kV switching station	Transmission line tap into substation from customer's dead-end structure on gen-tie. Three spans, conductor, insulators, hardware, and labor.	$0.050
	Total Cost Estimate for Interconnection Customer-Funded, PSCo-Owned Interconnection Facilities	**$3.445**

Table 11 – Station Network Upgrades

Element	Description	Cost Est. (million)
PSCo's May Valley 345 kV switching station	Interconnection of PI-2023-5 at May Valley 345 kV switching station on an existing breaker-and-a-half bay. The new equipment includes: • (1) 345 kV dead end structure • (1) 345 kV 3000 A SF6 circuit breaker • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures	$1.707
	Total Cost Estimate for PSCo-Funded, PSCo-Owned Interconnection Facilities	**$1.707**

PSCo has developed cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades required for the interconnection of PI-2023-5 for Provisional Interconnection Service. The estimated costs provided in this report are based upon the following assumptions:

- The estimated costs are in 2024 dollars with escalation and contingencies applied.
- Allowances for Funds Used During Construction (AFUDC) is not included.
- The estimated costs include all applicable labor and overheads associated with the siting, engineering, design, and construction of these new PSCo facilities.
- The estimated costs do not include the cost for any Customer owned equipment and associated design and engineering.
- Labor is estimated for straight time only—no overtime included.
- PSCo (or its Contractor) will perform all construction, wiring, testing, and commissioning for PSCo owned and maintained facilities.

The customer requirements include:

- Customer will install two (2) redundant fiber optic circuits (one primary circuit with a redundant backup) into the Transmission Provider's substation as part of its interconnection facilities construction scope.

- Power Quality Metering (PQM) will be required on the Customer's generation tie-line terminating into the POI.
- The Customer will be required to design, procure, install, own, operate and maintain a Load Frequency/Automated Generation Control (LF/AGC) RTU at their Customer substation. PSCo will be provided with indications, readings and data from the LF/AGC RTU.
- The Interconnection Customer will comply with the Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater Than 20 MW, as amended from time to time, and available at: XEL-POL-Transmission Interconnection Guideline Greater 20MW

6.1 Schedule

This section provides proposed milestones for the interconnection of PI-2023-5 to the Transmission Provider's Transmission System. The customer requested a back-feed date (In-Service Date for Transmission Provider Interconnection Facilities and Station Network Upgrades required for interconnection) for the Provisional Interconnection of September 2025. This is not attainable by the Transmission Provider, based upon the current schedule developed for this interconnection request. The Transmission Provider proposes the milestones provided below in Table 12.

Table 12 – Proposed Milestones for PI-2023-5

Milestone	Responsible Party	Estimated Completion Date
LGIA Execution	Interconnection Customer and Transmission Provider	July 2024
In-Service Date for Transmission Provider Interconnection Facilities and Station Network Upgrades required for interconnection	Transmission Provider	Jul 31, 2027
In-Service Date & Energization of Interconnection Customer's Interconnection Facilities	Interconnection Customer	August 31, 2027
Initial Synchronization Date	Interconnection Customer	August 31, 2027
Begin trial operation & testing	Interconnection Customer and Transmission Provider	August 31, 2027
Commercial Operation Date	Interconnection Customer	October 31, 2027

Some schedule elements are outside of the Transmission Provider's control and could impact the overall schedule. The following schedule assumptions provide the basis for the schedule milestones:

- Construction permitting (if required) for new facilities will be completed within 12 months of LGIA execution.
- The Transmission Provider is currently experiencing continued increases to material lead times which could impact the schedule milestones. The schedule milestones are based upon material lead times known at this time.
- Availability of line outages to interconnect new facilities to the transmission system.

7.0 Summary of Provisional Interconnection Service Analysis

The total estimated cost of the PSCo transmission system improvements required for PI-2023-5 to qualify for Provisional Interconnection Service would be $5.152 million.

The initial maximum permissible output of PI-2023-5 Generating Facility is 200 MW. The maximum permissible output of the Generating Facility in the PLGIA would be reviewed quarterly and updated if there are changes to system conditions compared to the system conditions previously used to determine the maximum permissible output.

Security: PI-2023-5 is a request for NRIS. For NRIS requests, security shall estimate the risk associated with the Network Upgrades and the Interconnection Facilities and is assumed to be a minimum of $25 million.

Note that Provisional Interconnection Service in and of itself does not convey transmission service.

8.0 Contingent Facilities

The portions of Colorado Power Pathway outlined in Section 4.0 are assumed to be completed prior to this GIR COD. Any capacity or lack thereof is based on these segments being completed. In the event these facilities are delayed, not constructed, reconfigured, redesigned, or otherwise changed from the manner and timing currently modeled for this study, the ability to provide Provisional Interconnection Service would need to be re-evaluated.

Additional Contingent Facilities identified for PI-2023-5 include the TPIF and Station Network Upgrades identified in Table 10 and Table 11, respectively.

9.0 Conceptual One-Line Diagram of PI-2023-5

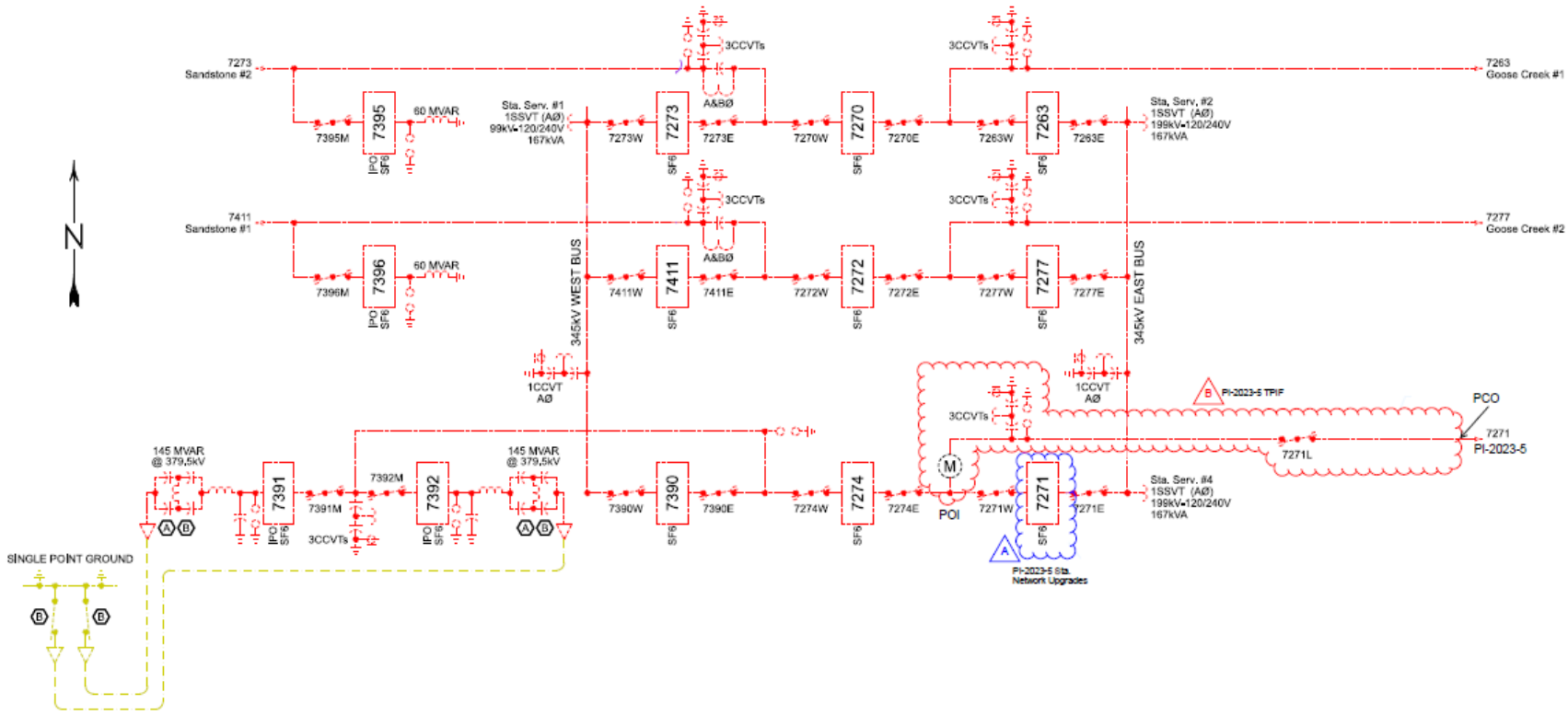

Figure 2 – Preliminary One-Line of PI-2023-5 at the May Valley 345 kV substation

10.0 Appendices

Appendix A: Transient Stability Plots	PI-2023-5_Transient Stability Plots.pdf