# INFO-2022-1

# Informational Study Report

# 2/1/2023

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## 1.0 Summary

This report is an informational evaluation of a 200 MW Solar Photovoltaic (PV) plus 100 MW Battery Energy Storage System (BESS) Hybrid Generating Facility requesting 200 MW of interconnection service with a Point of Interconnection (POI) tapping the Keenesburg – St. Vrain 230 kV line. The expected Commercial Operation Date (COD) of the Generating Facility is 2025. The following studies were performed in this informational study:

1. Generating Facility as a 200 MW of Network Resource Interconnection Service (NRIS)
2. Generating Facility as a 200 MW of Energy Resource Interconnection Service (ERIS)

This report is an informational evaluation and does not grant any Interconnection Service or Transmission Service. The results are based on the modeling assumptions and study scope specified by the Customer, which may or may not reflect the standard modeling assumptions followed for the LGIP studies.

### 1.1 INFO-2022-1 NRIS Results

The total cost of the upgrades required to interconnect INFO-2022-1 on the Keenesburg – St. Vrain 230 kV line for NRIS is $207.11 million (Table 11, Table 13, and Table 14)

### 1.2 INFO-2022-1 ERIS Results

The total cost of the upgrades required to interconnect INFO-2022-1 on the Keenesburg – St. Vrain 230 kV line for ERIS is $19.61 million (Table 11, and Table 13)

Maximum allowable output of INFO-2022-1 without requiring additional System Network Upgrades is 0 MW.

ERIS of INFO-2022-1 is 200 MW when using the existing firm or non-firm capacity of the Transmission System on an “as available” basis.

## 2.0 Introduction

This report is an informational evaluation of a 200 MW Solar (PV) plus 100 MW BESS Hybrid Generating Facility connecting on the Keenesburg – St. Vrain 230 kV line. Since this is an informational study, the study modeled a generic 200 MW Generating Facility that can maintain ±0.95 power factor at the POI.

A summary and description of the request for INFO-2022-1 as an NRIS are shown in Table 1.

**Table 1 – Summary of Request for INFO-2022-1 as an NRIS**

| INFO# | Resource Type | Service (MW) | Service Type | COD | POI | Location |
|---|---|---|---|---|---|---|
| INFO-2022-1 | PV + BESS | 200 | NRIS | 2025 | Keenesburg – St. Vrain 230 kV line | Weld County, CO |

A summary and description of the request for INFO-2022-1 as an ERIS are shown in Table 2.

**Table 2 – Summary of Request for INFO-2022-1 as an ERIS**

| INFO# | Resource Type | Service (MW) | Service Type | COD | POI | Location |
|---|---|---|---|---|---|---|
| INFO-2022-1 | PV + BESS | 200 | ERIS | 2025 | Keenesburg – St. Vrain 230 kV line | Weld County, CO |

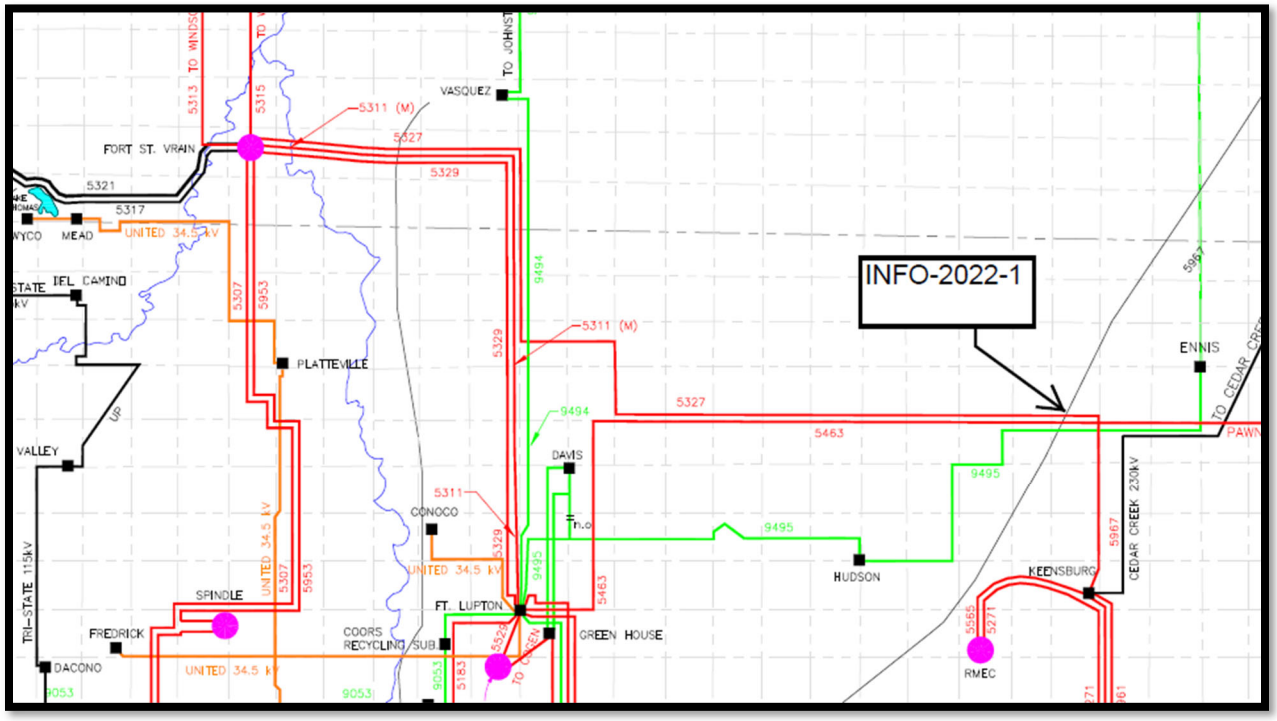


**Figure 1: Approximate Location of INFO-2022-1 POI**

## 3.0 Study Scope

The study was performed using the modeling assumptions specified by the Interconnection Customer (IC).

The scope of the study includes steady-state (thermal and voltage) analysis and cost estimates. The non-binding cost estimates provide total cost responsibility for Transmission Provider Interconnection Facilities (TPIF), Station Network Upgrades, and System Network Upgrades.

Per the Study Request, INFO-2022-1 was analyzed as both an ERIS and NRIS. Grid Charging capability for INFO-2022-1 was also analyzed.

## 3.1 Study Pockets

The POI of INFO-2022-1 is located within the Northern Colorado study pocket.

## 3.2 Study Areas

The study area for the Northern Colorado study pocket includes the WECC base case zones 700, 703 and 706. The Affected Systems included in the analysis is the Tri-State Generation and Transmission Inc. (TSGT) transmission system in the study area.

## 3.3 Study Criteria

The following steady-state analysis criteria is used to identify violations on the PSCo system and the 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

## 3.4 Study Methodology

The steady-state power flow assessment is performed using the PowerGEM TARA software. The generation redispatch for ERIS is identified using TARA's Security Constrained Redispatch (SCRD) tool.

Thermal violations are identified if a facility (i) resulted in a thermal loading >100% in the Study Case after the study pocket GIR cluster addition and (ii) contributed to an incremental loading increase of 1% or more to the benchmark case loading.

Voltage violations are identified if a bus (i) resulted in a bus voltage >1.1 p.u. (or <0.9 p.u.) in the Study Case after the study pocket GIR cluster addition and (ii) contributed to an adverse impact of +0.005 p.u. (or -0.005 p.u.) compared to the Benchmark Case voltage.

DFAX criteria for identifying contribution to thermal overloads is ≥1%. DFAX criteria for identifying contribution to the voltage violations is 0.005 p.u.

When the study pocket has a mix of NRIS and ERIS requests, it is studied by first modeling the NRIS GIRs at their full requested amount and modeling the ERIS GIRs offline. Network Upgrades required to mitigate the thermal and/or voltage violations are only allocated to NRIS requests because other GIR's output is modeled at zero.

The NRIS GIRs and their associated Network Upgrades are then modeled in the NRIS Study Case, and ERIS GIRs are dispatched at 100% to study the system impact. Violations are identified and the study evaluates if a generation redispatch combination eliminates the violation. If generation redispatch is unable to eliminate the violation, upgrades will be identified.

The resources included in the Security Constrained Redispatch (SCRD) are:

- All PSCo and Non-PSCo resources connected to the PSCo Transmission System
- Higher-queued NRIS generation in the PSCo queue
- Generation connected to an Affected System Transmission System if that generation is a designated network resource to serve load connected to PSCo
- All other generation connected to an Affected System Transmission System and Stressed in the Study Case may be dispatched to the Base Case level

Maximum allowable ERIS generation is calculated for each GIR using its distribution factor(s) (DFAX) for overloads identified at full output, such that all identified overloads are eliminated.

## 4.0 Base Case Modeling Assumptions

The 2026HS2a1 WECC case released on July 31, 2020, was selected as the starting case. The Base Case was created from the Starting Case by including the following modeling changes. The following approved transmission projects in PSCo's 10-year transmission plan, with an in-service date before summer 2026 were modeled: (http://www.oasis.oati.com/woa/docs/PSCO/PSCOdocs/FERC_890_Q1_2020_Transmission_Plan_Presentation.pdf)

- Cloverly 115 kV Substation – ISD 2021
- Graham Creek 115 kV Substation – ISD 2022
- Husky 230/115 kV Substation – ISD 2022
- Mirasol 230 kV Substation – ISD 2022
- Avery Substation – ISD 2021
- Barker Substation – Bank1 ISD: 2021, Bank 2 ISD: 2022
- High Point Substation – ISD 2022
- Titan Substation – ISD 2022
- Dove Valley Substation – ISD 2023
- Stock Show – ISD 2026
- Monument – Flying Horse 115 kV Series Reactor – ISD 2024
- Ault – Husky 230 kV line – ISD 2022
- Husky – Graham Creek – Cloverly 115 kV line – ISD 2022
- Gilman – Avon 115 kV line – ISD 2022
- Climax – Robinson Rack – Gilman 115 kV – ISD 2022
- Greenwood – Arapahoe – Denver Terminal 230 kV – ISD 2022
- Upgrade Villa Grove – Poncha 69 kV Line to 73 MVA – ISD 2021
- Upgrade Poncha – Sargent - San Luis Valley 115 kV line to 120 MVA – ISD 2021
- Upgrade Antonito – Romeo – Old40 Tap – Alamosa Terminal – Alamosa Switchyard 69 kV line to 143 MVA – ISD 2023
- Tundra Switching Station 345 kV – ISD 2022
- Upgrade Allison – SodaLakes 115 kV line to 318 MVA – ISD 2022

The following additional changes were made to the TSGT model in the Base Case per further review and comment from TSGT:

- Fuller – Vollmer 115 kV line modeled at 173 MVA – ISD 2022
- Black Squirrel – Vollmer 115 kV line modeled at 144 MVA – ISD 2022
- Black Squirrel – Black Forest Tap 115 kV line modeled at 144 MVA – ISD 2022
- Beaver Creek – Adena 115 kV line modeled at 114 MVA
- Fuller 230/115 kV, 150 MVA #2 transformer – ISD 2023
- Paddock – Shaw Ranch – Calhan Tap – Santa Fe Springs 115 kV Loop modeled open

The following additional changes were made to the CSU model in the Base Case per further review and comment from CSU:

- The Cottonwood – Tesla 34.5 kV line modeled open and Kettle Creek – Tesla 34.5 kV line modeled closed on the CSU system – ISD 2023
- Briargate South 115/230 kV transformer project tapping the Cottonwood – Fuller 230 kV line – ISD 2023

The Base Case model includes the existing PSCo generation resources and all Affected Systems' existing resources.

In addition, the following higher-queued generation from PSCo's queue were modeled offline in the Base Case along with any System Network Upgrades identified in their corresponding studies.

- Individual GIRs (GI-2014-5, GI-2014-6, GI-2014-7, GI-2014-9, GI-2014-13, GI-2014-14, GI-2016-4, and GI-2016-15)
- Transitional Cluster (GI-2018-24, and GI-2019-6)
- DISIS-2020-001 Cluster
- 2RSC-2020-05 Cluster
- DISIS-2020-002 Cluster
- DISIS-2021-003 Cluster
- DISIS-2021-004 Cluster
- DISIS-2022-005 Cluster

While the higher-queued NRIS requests in the study pocket were dispatched at 100% while performing each study pocket's analysis, the higher-queued ERIS requests were modeled offline.

# 5.0 Northern Colorado Study Pocket Analysis

## 5.1 Benchmark Cases Modeling

### 5.1.1 Generation Scenario

The Benchmark Case for Generation scenario was created from the Base Case by adopting the generation dispatch in Table 3 to reflect heavy generation in the Northern Colorado pocket.

**Table 3 – Generation Dispatch Used to Create the Northern Colorado Generation Benchmark Case (MW is Gross Capacity)**

| Bus Number | Bus name | ID | Status | Pgen (MW) | Pmax (MW) |
|---|---|---|---|---|---|
| 70188 | FTLUP1-2 | G1 | 1 | 45.00 | 50.00 |
| 70188 | FTLUP1-2 | G2 | 1 | 45.00 | 50.00 |
| 70406 | ST.VR_2 | G2 | 1 | 132.40 | 146.00 |
| 70407 | ST.VR_3 | G3 | 1 | 165.90 | 183.00 |
| 70408 | ST.VR_4 | G4 | 1 | 185.00 | 204.00 |
| 70409 | ST.VRAIN | ST | 1 | 290.10 | 320.00 |
| 70448 | VALMONT6 | G6 | 1 | 49.90 | 57.00 |
| 70498 | QF_BCP2T | G3 | 1 | 34.20 | 45.00 |
| 70498 | QF_BCP2T | ST | 1 | 34.50 | 45.40 |
| 70499 | QF_B4-4T | G4 | 1 | 32.60 | 37.20 |
| 70499 | QF_B4-4T | G5 | 1 | 32.60 | 37.20 |
| 70500 | QF_CPP1T | G1 | 1 | 18.30 | 20.30 |
| 70500 | QF_CPP1T | G2 | 1 | 22.50 | 25.00 |
| 70501 | QF_CPP3T | ST | 1 | 40.70 | 45.20 |
| 70556 | QF_B4D4T | ST | 1 | 68.80 | 78.60 |
| 70557 | VALMNT7 | G7 | 1 | 38.80 | 44.30 |
| 70558 | VALMNT8 | G8 | 1 | 38.80 | 44.30 |
| 70580 | PLNENDG1_1 | G8 | 1 | 4.70 | 5.40 |
| 70580 | PLNENDG1_1 | G0 | 1 | 4.70 | 5.40 |
| 70580 | PLNENDG1_1 | G1 | 1 | 4.70 | 5.40 |
| 70580 | PLNENDG1_1 | G2 | 1 | 4.70 | 5.40 |
| 70580 | PLNENDG1_1 | G3 | 1 | 4.70 | 5.40 |
| 70580 | PLNENDG1_1 | G4 | 1 | 4.70 | 5.40 |
| 70580 | PLNENDG1_1 | G5 | 1 | 4.70 | 5.40 |
| 70580 | PLNENDG1_1 | G6 | 1 | 4.70 | 5.40 |
| 70580 | PLNENDG1_1 | G7 | 1 | 4.70 | 5.40 |
| 70580 | PLNENDG1_1 | G9 | 1 | 10.60 | 12.20 |
| 70585 | PLNENDG2_1 | G2 | 1 | 7.00 | 8.10 |
| 70585 | PLNENDG2_1 | G3 | 1 | 7.00 | 8.10 |

| Bus Number | Bus name | ID | Status | Pgen (MW) | Pmax (MW) |
|---|---|---|---|---|---|
| 70585 | PLNENDG2_1 | G4 | 1 | 7.00 | 8.10 |
| 70585 | PLNENDG2_1 | G5 | 1 | 7.00 | 8.10 |
| 70585 | PLNENDG2_1 | G6 | 1 | 7.00 | 8.10 |
| 70585 | PLNENDG2_1 | G7 | 1 | 9.20 | 10.60 |
| 70585 | PLNENDG2_1 | G1 | 1 | 7.00 | 8.10 |
| 70586 | PLNENDG2_2 | G7 | 1 | 8.70 | 11.20 |
| 70586 | PLNENDG2_2 | G6 | 1 | 8.20 | 10.60 |
| 70586 | PLNENDG2_2 | G5 | 1 | 6.30 | 8.10 |
| 70586 | PLNENDG2_2 | G4 | 1 | 6.30 | 8.10 |
| 70586 | PLNENDG2_2 | G3 | 1 | 6.30 | 8.10 |
| 70586 | PLNENDG2_2 | G1 | 1 | 6.30 | 8.10 |
| 70586 | PLNENDG2_2 | G2 | 1 | 6.30 | 8.10 |
| 70587 | PLNENDG1_2 | G2 | 1 | 6.30 | 8.10 |
| 70587 | PLNENDG1_2 | G3 | 1 | 6.30 | 8.10 |
| 70587 | PLNENDG1_2 | G4 | 1 | 4.20 | 5.40 |
| 70587 | PLNENDG1_2 | G5 | 1 | 6.30 | 8.10 |
| 70587 | PLNENDG1_2 | G6 | 1 | 6.30 | 8.10 |
| 70587 | PLNENDG1_2 | G1 | 1 | 6.30 | 8.10 |
| 70587 | PLNENDG1_2 | G7 | 1 | 4.20 | 5.40 |
| 70587 | PLNENDG1_2 | G8 | 1 | 4.20 | 5.40 |
| 70587 | PLNENDG1_2 | G0 | 1 | 4.20 | 5.40 |
| 70587 | PLNENDG1_2 | G9 | 1 | 6.10 | 7.90 |
| 70588 | RMEC1 | G1 | 1 | 139.40 | 155.00 |
| 70589 | RMEC2 | G2 | 1 | 139.80 | 155.50 |
| 70591 | RMEC3 | ST | 1 | 291.40 | 324.00 |
| 70818 | MTNBRZ_W1 | W1 | 1 | 135.20 | 169.00 |
| 70823 | CEDARCK_1A | W1 | 1 | 180.00 | 225.00 |
| 70824 | CEDARCK_1B | W2 | 1 | 64.40 | 80.50 |
| 70825 | CEDAR2_W1 | W1 | 1 | 101.50 | 126.30 |
| 70826 | CEDAR2_W2 | W2 | 1 | 82.00 | 102.10 |
| 70827 | CEDAR2_W3 | W3 | 1 | 20.10 | 25.00 |
| 70950 | ST.VR_5 | G5 | 1 | 165.90 | 183.00 |
| 70951 | ST.VR_6 | G6 | 1 | 165.90 | 183.00 |
| 71974 | GI-2020-16-4 | 1 | 1 | 199.50 | 207.70 |
| 722032 | GI22-03_BS | 1 | 1 | 202.80 | 202.80 |
| 722043 | GI22-04_BS | 1 | 1 | 202.80 | 202.80 |
| 722084 | GI22-08_BE | 1 | 1 | 203.00 | 203.40 |
| Total | | | | **3775.70** | **4229.90** |

### 5.1.2 Grid Charging Scenario

The Benchmark Case for Grid Charging scenario was created from the Base Case by adopting the generation dispatch in Table 4.

**Table 4 – Generation Dispatch Used to Create the Northern Colorado Grid Charging Benchmark Case (MW is Gross Capacity)**

| Bus Number | Bus name | ID | Status | Pgen (MW) | Pmax (MW) |
|---|---|---|---|---|---|
| 70188 | FTLUP1-2 | G1 | 1 | 45.00 | 50.00 |
| 70188 | FTLUP1-2 | G2 | 1 | 45.00 | 50.00 |
| 70406 | ST.VR_2 | G2 | 1 | 132.40 | 146.00 |
| 70407 | ST.VR_3 | G3 | 1 | 165.90 | 183.00 |
| 70408 | ST.VR_4 | G4 | 1 | 185.00 | 204.00 |
| 70409 | ST.VRAIN | ST | 1 | 290.10 | 320.00 |
| 70448 | VALMONT6 | G6 | 1 | 49.90 | 57.00 |
| 70498 | QF_BCP2T | G3 | 1 | 34.20 | 45.00 |
| 70498 | QF_BCP2T | ST | 1 | 34.50 | 45.40 |
| 70499 | QF_B4-4T | G4 | 1 | 32.60 | 37.20 |
| 70499 | QF_B4-4T | G5 | 1 | 32.60 | 37.20 |
| 70500 | QF_CPP1T | G1 | 1 | 18.30 | 20.30 |
| 70500 | QF_CPP1T | G2 | 1 | 22.50 | 25.00 |
| 70501 | QF_CPP3T | ST | 1 | 40.70 | 45.20 |
| 70556 | QF_B4D4T | ST | 1 | 68.80 | 78.60 |
| 70557 | VALMNT7 | G7 | 1 | 38.80 | 44.30 |
| 70558 | VALMNT8 | G8 | 1 | 38.80 | 44.30 |
| 70580 | PLNENDG1_1 | G8 | 1 | 4.70 | 5.40 |
| 70580 | PLNENDG1_1 | G0 | 1 | 4.70 | 5.40 |
| 70580 | PLNENDG1_1 | G1 | 1 | 4.70 | 5.40 |
| 70580 | PLNENDG1_1 | G2 | 1 | 4.70 | 5.40 |
| 70580 | PLNENDG1_1 | G3 | 1 | 4.70 | 5.40 |
| 70580 | PLNENDG1_1 | G4 | 1 | 4.70 | 5.40 |
| 70580 | PLNENDG1_1 | G5 | 1 | 4.70 | 5.40 |
| 70580 | PLNENDG1_1 | G6 | 1 | 4.70 | 5.40 |
| 70580 | PLNENDG1_1 | G7 | 1 | 4.70 | 5.40 |
| 70580 | PLNENDG1_1 | G9 | 1 | 10.60 | 12.20 |
| 70585 | PLNENDG2_1 | G2 | 1 | 7.00 | 8.10 |
| 70585 | PLNENDG2_1 | G3 | 1 | 7.00 | 8.10 |
| 70585 | PLNENDG2_1 | G4 | 1 | 7.00 | 8.10 |
| 70585 | PLNENDG2_1 | G5 | 1 | 7.00 | 8.10 |
| 70585 | PLNENDG2_1 | G6 | 1 | 7.00 | 8.10 |
| 70585 | PLNENDG2_1 | G7 | 1 | 7.00 | 10.60 |

| Bus Number | Bus name | ID | Status | Pgen (MW) | Pmax (MW) |
|---|---|---|---|---|---|
| 70585 | PLNENDG2_1 | G1 | 1 | 9.20 | 8.10 |
| 70586 | PLNENDG2_2 | G7 | 1 | 6.30 | 11.20 |
| 70586 | PLNENDG2_2 | G6 | 1 | 6.30 | 10.60 |
| 70586 | PLNENDG2_2 | G5 | 1 | 6.30 | 8.10 |
| 70586 | PLNENDG2_2 | G4 | 1 | 6.30 | 8.10 |
| 70586 | PLNENDG2_2 | G3 | 1 | 6.30 | 8.10 |
| 70586 | PLNENDG2_2 | G1 | 1 | 8.20 | 8.10 |
| 70586 | PLNENDG2_2 | G2 | 1 | 8.70 | 8.10 |
| 70587 | PLNENDG1_2 | G2 | 1 | 4.20 | 8.10 |
| 70587 | PLNENDG1_2 | G3 | 1 | 6.30 | 8.10 |
| 70587 | PLNENDG1_2 | G4 | 1 | 6.30 | 5.40 |
| 70587 | PLNENDG1_2 | G5 | 1 | 6.30 | 8.10 |
| 70587 | PLNENDG1_2 | G6 | 1 | 4.20 | 8.10 |
| 70587 | PLNENDG1_2 | G1 | 1 | 6.30 | 8.10 |
| 70587 | PLNENDG1_2 | G7 | 1 | 6.30 | 5.40 |
| 70587 | PLNENDG1_2 | G8 | 1 | 4.20 | 5.40 |
| 70587 | PLNENDG1_2 | G0 | 1 | 4.20 | 5.40 |
| 70587 | PLNENDG1_2 | G9 | 1 | 6.10 | 7.90 |
| 70588 | RMEC1 | G1 | 1 | 139.40 | 155.00 |
| 70589 | RMEC2 | G2 | 1 | 139.80 | 155.50 |
| 70591 | RMEC3 | ST | 1 | 291.40 | 324.00 |
| 70818 | MTNBRZ_W1 | W1 | 1 | 35.50 | 169.00 |
| 70823 | CEDARCK_1A | W1 | 1 | 47.30 | 225.00 |
| 70824 | CEDARCK_1B | W2 | 1 | 16.90 | 80.50 |
| 70825 | CEDAR2_W1 | W1 | 1 | 26.60 | 126.30 |
| 70826 | CEDAR2_W2 | W2 | 1 | 21.50 | 102.10 |
| 70827 | CEDAR2_W3 | W3 | 1 | 5.30 | 25.00 |
| 70950 | ST.VR_5 | G5 | 1 | 165.90 | 183.00 |
| 70951 | ST.VR_6 | G6 | 1 | 165.90 | 183.00 |
| 71974 | GI-2020-16-4 | 1 | 1 | 199.50 | 207.70 |
| 722032 | GI22-03_BS | 1 | 1 | 202.80 | 202.80 |
| 722043 | GI22-04_BS | 1 | 1 | 202.80 | 202.80 |
| 722084 | GI22-08_BE | 1 | 1 | 203.00 | 203.40 |
| Total | | | | **3345.60** | **4229.90** |

## 5.2 INFO-2022-1 – NRIS

### 5.2.1 Study Cases Modeling

An NRIS Study Case was developed from the Generation scenario Benchmark Case by modeling INFO-2022-1 as a tap on the Keenesburg – St. Vrain 230 kV line. The 200 MW NRIS output of INFO-2022-1 is balanced against all PSCo generation connected to the PSCo Transmission System outside the study pocket on a pro-rata basis.

### 5.2.2 Steady-State Analysis

Contingency analysis was performed on the North pocket NRIS Study Case.

The results of the system intact and single contingency analysis on the NRIS Study Case are shown in Table 5 and Table 6.

Xcel PSCo identified that the system-intact and single contingency overloads tabulated in Table 5 and Table 6 are mitigated by the System Network Upgrades tabulated in Table 7.

The multiple contingency analysis on the NRIS Study Case did not show any thermal violations.

Single contingency and multiple contingency analysis showed no voltage violations attributed to the INFO-2022-1 as NRIS.

## Table 5 – Northern Colorado Study Pocket NRIS Results – System Intact Analysis

| Overloaded Facility | Type | Owner | Normal Rating (MVA) | Benchmark Case | | NRIS Study Case | | Loading % Change Due to Study GIR | Contingency Definition |
|---|---|---|---|---|---|---|---|---|---|
| | | | | MVA Flow | % Loading | MVA Flow | % Loading | | |
| VALMONT (70447) TO SPNDLE (70592) 230 kV CKT #1 | Line | PSCo | 478.0 | 479.43 | 100.3 | 495.45 | 103.7 | 3.4 | Base Case |

## Table 6 – Northern Colorado Study Pocket NRIS Results – Single Contingency Analysis

| Overloaded Facility | Type | Owner | Normal Rating (MVA) | Benchmark Case | | NRIS Study Case | | Loading % Change Due to Study GIR | Contingency Definition |
|---|---|---|---|---|---|---|---|---|---|
| | | | | MVA Flow | % Loading | MVA Flow | % Loading | | |
| VALMONT (70447) TO SPNDLE (70592) 230 kV CKT #1 | Line | PSCo | 478.0 | 549.22 | 114.9 | 568.7 | 119.0 | 4.1 | ST.VRAIN (70410) TO ISABELLE (70544) 230 kV CKT #1 |
| BANCROFT (70045) TO GRAY_ST. (70208) 115 kV CKT #1 | Line | PSCo | 159.0 | 186.32 | 117.2 | 188.1 | 118.3 | 1.1 | ALLISON (70023) TO SODALAKE (70400) 115 kV CKT #1 |
| GI-2021-6 TA (88883) TO SKYRANCH (70392) 230 kV CKT #1 | Line | PSCo | 484.0 | 507.86 | 104.9 | 540.6 | 111.7 | 6.8 | GREENVAL (70048) TO SPRUCE (70528) 230 kV CKT #1 |
| HENRYLAK (70606) TO HENRYLAK (70605) 230/115 kV CKT #T1 | Xfmr | TSGT | 100.0 | 108.39 | 108.4 | 110.7 | 110.7 | 2.3 | BARRLAKE (70047) TO REUNION (70610) 230 kV CKT #1 |
| FTLUPTON (70192) TO ST.VRAIN (70410) 230 kV CKT #1 | Line | PSCo | 478.0 | 495.35 | 103.6 | 527.5 | 110.4 | 6.7 | FTLUPTON (70192) TO ST.VRAIN (70410) 230 kV CKT #2 |
| CHEROKEE (70107) TO LACOMBE (70324) 230 kV CKT #1 | Line | PSCo | 435.0 | 440.87 | 101.4 | 475.4 | 109.3 | 7.9 | LOOKOUT (70266) TO WESTPS (70480) 230 kV CKT #1 |
| VALMONT (70444) TO VALMONT (70447) 230/115 kV CKT #T7 | Xfmr | PSCo | 280.0 | 300.30 | 107.3 | 304.9 | 108.9 | 1.6 | VALMONT (70444) TO VALMONT (70447) 230/115 kV CKT #T8 |
| VALMONT (70444) TO VALMONT (70447) 230/115 kV CKT #T8 | Xfmr | PSCo | 280.0 | 300.30 | 107.3 | 304.9 | 108.9 | 1.6 | VALMONT (70444) TO VALMONT (70447) 230/115 kV CKT #T7 |
| SKYRANCH (70392) TO SPRUCE (70528) 230 kV CKT #1 | Line | PSCo | 484.0 | 484.87 | 100.2 | 517.6 | 106.9 | 6.8 | GREENVAL (70048) TO SPRUCE (70528) 230 kV CKT #1 |
| BARRLAKE (70047) TO REUNION (70610) 230 kV CKT #1 | Line | PSCo | 478.0 | 488.61 | 102.2 | 504.8 | 105.6 | 3.4 | FTLUPTON (70192) TO JLGREEN (70529) 230 kV CKT #1 |
| FTLUPTON (70192) TO ST.VRAIN (70410) 230 kV CKT #2 | Line | PSCo | 509.0 | 495.46 | 97.3 | 527.6 | 103.7 | 6.3 | FTLUPTON (70192) TO ST.VRAIN (70410) 230 kV CKT #1 |
| FTLUPTON (70192) TO JLGREEN (70529) 230 kV CKT #1 | Line | PSCo | 487.0 | 471.12 | 96.7 | 489.1 | 100.4 | 3.7 | RIVERDAL (70362) TO HENRYLAK (70605) 230 kV CKT #1 |

**Table 7 – Northern Colorado Study Pocket NRIS – System Network Upgrades**

| Network Upgrade | Facility Type |
|---|---|
| UPGRADE VALMONT (70447) TO SPNDLE (70592) 230 kV CKT #1 | Line |
| UPGRADE BANCROFT (70045) TO GRAY_ST. (70208) 115 kV CKT #1 | Line |
| UPGRADE GI-2021-6 TA (88883) TO SKYRANCH (70392) 230 kV CKT #1 | Line |
| UPGRADE HENRYLAK (70606) TO HENRYLAK (70605) 230/115 kV CKT #T1 | Xfmr |
| UPGRADE FTLUPTON (70192) TO ST.VRAIN (70410) 230 kV CKT #1 | Line |
| UPGRADE CHEROKEE (70107) TO LACOMBE (70324) 230 kV CKT #1 | Line |
| UPGRADE VALMONT (70444) TO VALMONT (70447) 230/115 kV CKT #T7 | Xfmr |
| UPGRADE VALMONT (70444) TO VALMONT (70447) 230/115 kV CKT #T8 | Xfmr |
| UPGRADE SKYRANCH (70392) TO SPRUCE (70528) 230 kV CKT #1 | Line |
| UPGRADE BARRLAKE (70047) TO REUNION (70610) 230 kV CKT #1 | Line |
| UPGRADE FTLUPTON (70192) TO ST.VRAIN (70410) 230 kV CKT #2 | Line |
| UPGRADE FTLUPTON (70192) TO JLGREEN (70529) 230 kV CKT #1 | Line |

### 5.2.3 Affected Systems

TSGT was identified as an impacted Affected System as a result of NRIS study overloads on their facilities as listed in Table 5 and Table 6.

### 5.2.4 Summary

NRIS identified for INFO-2022-1 is 200 MW.

The NRIS study identified the overloads caused by the INFO-2022-1 as a NRIS GIR and identified suitable System Network Upgrades for the identified overloads.

## 5.3 INFO-2022-1 – ERIS

### 5.3.1 Study Cases Modeling

An ERIS Study Case was developed from the Generation scenario Benchmark Case by modeling INFO-2022-1 as a tap on the Keenesburg – St. Vrain 230 kV line. The 200 MW ERIS output of INFO-2022-1 is balanced against all PSCo generation connected to the PSCo Transmission System outside the study pocket on a pro-rata basis.

### 5.3.2 Steady-State Analysis

Contingency analysis was performed on the North pocket ERIS Study Case.

The results of the system intact and single contingency analysis on the ERIS Study Case are shown in Table 8Table 5 and Table 9.

All the identified system intact and single overloads can be alleviated/mitigated using SCRD redispatch as explained in Section 3.4, therefore there are no System Network Upgrades required for the ERIS GIRs. The analysis also showed no voltage violations attributed to the ERIS GIRs.

The multiple contingency analysis on the ERIS Study Case did not show any violations.

The maximum allowable ERIS generation is calculated using each GIR's distribution factor (DFAX) for each of the overloads, such that all the identified overloads in Table 8 and Table 9 are eliminated. The overloads identified in Table 8Table 5 and Table 9 show that ERIS GIR contribute to existing overloads in the Benchmark Case. Therefore, the maximum allowable ERIS generation for GIR INFO-2022-1 is 0 MW.

## Table 8 – Northern Colorado Study Pocket ERIS Results – System Intact Analysis

| Overloaded Facility | Type | Owner | Normal Rating (MVA) | Benchmark Case | | ERIS Study Case | | Loading % Change Due to Study GIR | Contingency Definition |
|---|---|---|---|---|---|---|---|---|---|
| | | | | MVA Flow | % Loading | MVA Flow | % Loading | | |
| VALMONT (70447) TO SPNDLE (70592) 230 kV CKT #1 | Line | PSCo | 478.0 | 479.43 | 100.3 | 495.45 | 103.7 | 3.4 | Base Case |

## Table 9 – Northern Colorado Study Pocket ERIS Results – Single Contingency Analysis

| Overloaded Facility | Type | Owner | Normal Rating (MVA) | Benchmark Case | | ERIS Study Case | | Loading % Change Due to Study GIR | Contingency Definition |
|---|---|---|---|---|---|---|---|---|---|
| | | | | MVA Flow | % Loading | MVA Flow | % Loading | | |
| VALMONT (70447) TO SPNDLE (70592) 230 kV CKT #1 | Line | PSCo | 478.0 | 549.22 | 114.9 | 568.7 | 119.0 | 4.1 | ST.VRAIN (70410) TO ISABELLE (70544) 230 kV CKT #1 |
| BANCROFT (70045) TO GRAY_ST. (70208) 115 kV CKT #1 | Line | PSCo | 159.0 | 186.32 | 117.2 | 188.1 | 118.3 | 1.1 | ALLISON (70023) TO SODALAKE (70400) 115 kV CKT #1 |
| GI-2021-6 TA (88883) TO SKYRANCH (70392) 230 kV CKT #1 | Line | PSCo | 484.0 | 507.86 | 104.9 | 540.6 | 111.7 | 6.8 | GREENVAL (70048) TO SPRUCE (70528) 230 kV CKT #1 |
| HENRYLAK (70606) TO HENRYLAK (70605) 230/115 kV CKT #T1 | Xfmr | TSGT | 100.0 | 108.39 | 108.4 | 110.7 | 110.7 | 2.3 | BARRLAKE (70047) TO REUNION (70610) 230 kV CKT #1 |
| FTLUPTON (70192) TO ST.VRAIN (70410) 230 kV CKT #1 | Line | PSCo | 478.0 | 495.35 | 103.6 | 527.5 | 110.4 | 6.7 | FTLUPTON (70192) TO ST.VRAIN (70410) 230 kV CKT #2 |
| CHEROKEE (70107) TO LACOMBE (70324) 230 kV CKT #1 | Line | PSCo | 435.0 | 440.87 | 101.4 | 475.4 | 109.3 | 7.9 | LOOKOUT (70266) TO WESTPS (70480) 230 kV CKT #1 |
| VALMONT (70444) TO VALMONT (70447) 230/115 kV CKT #T7 | Xfmr | PSCo | 280.0 | 300.30 | 107.3 | 304.9 | 108.9 | 1.6 | VALMONT (70444) TO VALMONT (70447) 230/115 kV CKT #T8 |
| VALMONT (70444) TO VALMONT (70447) 230/115 kV CKT #T8 | Xfmr | PSCo | 280.0 | 300.30 | 107.3 | 304.9 | 108.9 | 1.6 | VALMONT (70444) TO VALMONT (70447) 230/115 kV CKT #T7 |
| SKYRANCH (70392) TO SPRUCE (70528) 230 kV CKT #1 | Line | PSCo | 484.0 | 484.87 | 100.2 | 517.6 | 106.9 | 6.8 | GREENVAL (70048) TO SPRUCE (70528) 230 kV CKT #1 |
| BARRLAKE (70047) TO REUNION (70610) 230 kV CKT #1 | Line | PSCo | 478.0 | 488.61 | 102.2 | 504.8 | 105.6 | 3.4 | FTLUPTON (70192) TO JLGREEN (70529) 230 kV CKT #1 |
| FTLUPTON (70192) TO ST.VRAIN (70410) 230 kV CKT #2 | Line | PSCo | 509.0 | 495.46 | 97.3 | 527.6 | 103.7 | 6.3 | FTLUPTON (70192) TO ST.VRAIN (70410) 230 kV CKT #1 |
| FTLUPTON (70192) TO JLGREEN (70529) 230 kV CKT #1 | Line | PSCo | 487.0 | 471.12 | 96.7 | 489.1 | 100.4 | 3.7 | RIVERDAL (70362) TO HENRYLAK (70605) 230 kV CKT #1 |

### 5.3.3 Affected Systems

TSGT was identified as an impacted Affected System as a result of ERIS study overloads on their facilities as listed in Table 8Table 5 and Table 9.

### 5.3.4 Summary

The ERIS study showed system intact and single contingency overloads which were alleviated by performing OPF redispatch. Therefore, the study did not identify any required System Network Upgrades for INFO-2022-1 as an ERIS.

A DFAX analysis, with respect to thermal overloads, was performed to compute the maximum allowable output for INFO-2022-1 as an ERIS. The maximum allowable output for:

- INFO-2022-1 is 0 MW

ERIS, when using the existing firm or non-firm capacity of the Transmission System on an “as available” basis for:

- INFO-2022-1 is 200 MW

## 5.4 INFO-2022-1 – Grid Charging

### 5.4.1 Study Cases Modeling

A Grid Charging Study Case was developed from the Grid Charging scenario Benchmark Case by modeling INFO-2022-1 as a tap on the Keenesburg – St. Vrain 230 kV line. The 100 MW load of INFO-2022-1 while charging is balanced against all PSCo generation connected to the PSCo Transmission System outside the study pocket on a pro-rata basis.

### 5.4.2 Steady-State Analysis

Contingency analysis was performed on the North pocket Grid Charging Study Case.

The system intact, single contingency and multiple contingency analysis on the Grid Charging Study Case did not show any voltage violations or thermal overloads attributed to INFO-2022-1.

### 5.4.3 Affected Systems

There are no Affected Systems identified during Grid Charging scenario.

### 5.4.4 Summary

Grid Charging study was performed for INFO-2022-1. The study did not identify any voltage violations or thermal overloads attributed to INFO-2022-1. Grid Charging capability without any additional System Network Upgrades for:

- INFO-2022-1 is 100 MW

## 6.0 Cost Estimates and Assumptions

There are three types of costs identified in the study:

1. Transmission Provider's Interconnection Facilities (TPIF) which are directly assigned to each GIR
2. Station equipment Network Upgrades, which are allocated each GIR connecting to that station on a per-capita basis per Section 4.2.4(a) of the LGIP
3. All System Network Upgrades which are allocated by the proportional impact per Section 4.2.4(b) of the LGIP
    - System Network Upgrades allocated to INFO-2022-1 as an NRIS
    - System Network Upgrades allocated to INFO-2022-1 as an ERIS

## 6.1 Total Cost of Transmission Provider's Interconnecting Facilities

The total cost of Transmission Provider's Interconnection Facilities for each POI and INFO-2022-1's cost assignment is given in Table 10Table 10.

**Table 10 – Total Cost of Transmission Provider's Interconnection Facilities**

| GIR | POI | Total Cost (million) |
|---|---|---|
| INFO-2022-1 | Keenesburg – St. Vrain 230 kV line | $1.40 |

Table 11 specifies the INFO-2022-1 project's Transmission Provider's Interconnection Facilities and the corresponding costs.

**Table 11 – INFO-2022-1 Transmission Provider's Interconnection Facilities**

| Element | Description | Cost Est. (million) |
|---|---|---|
| New 230 kV Switching Station | Transmission Provider Interconnection Facilities for INFO-2022-1 generation at a new switching station on the Keenesburg - Fort St. Vrain 230 kV line 5327. | $1.40 |
| **Total Cost Estimate for Interconnection Customer-Funded, PSCo-Owned Interconnection Facilities** | | **$1.40** |

## 6.2 Total Cost of Station Network Upgrades

The total cost of Station Network Upgrades for INFO-2022-1 is given in Table 12Table 12.

**Table 12 – Total Cost of Station Network Upgrades by GIR**

| GIR | POI | Total Cost (million) |
|---|---|---|
| INFO-2022-1 | Keenesburg – St. Vrain 230 kV line | $18.21 |

The details of the Station Network Upgrades required at the Keenesburg – St. Vrain 230 kV line new POI Switching Station are shown in Table 13.

**Table 13 – Station Network Upgrades – INFO-2022-1 230 kV Switching Station**

| Element | Description | Cost Est. (million) |
|---|---|---|
| New 230 kV Switching Station | Install new Switching Station tapping the Keenesburg - Fort St. Vrain 230 kV line 5327. | $12.40 |
| New 230 kV Switching Station | Install required communication in the EEE at the new 230 kV Switching Station | $0.43 |
| Keenesburg 230 kV Substation | Remote end upgrade for line 5327 at Keenesburg 230 kV Substation | $0.51 |
| Fort St. Vrain 230 kV Substation | Remote end upgrade for line 5327 at Fort St. Vrain 230 kV Substation | $0.40 |
| Keenesburg - Fort St. Vrain 230 kV Line (5327) | Line tap North side of new 230 kV Switching Station | $0.87 |
| Keenesburg - Fort St. Vrain 230 kV Line (5327) | Line tap South side of new 230 kV Switching Station | $1.00 |
| Keenesburg - Cedar Creek 230 kV Line (5967) Foreign Owned by Cedar Creek | Relocate Line 5967 to accommodate Line tap of 5327 into new 230 kV Switching Station (work to be coordinated with Cedar Creek) | $0.60 |
| | Siting and Land Rights land acquisition | $2.00 |
| **Total Cost Estimate for PSCo-Funded, PSCo-Owned Interconnection Facilities** | | **$18.21** |

## 6.3 Total Cost of System Network Upgrades

### 6.3.1 INFO-2022-1 – NRIS

Steady-state analysis for INFO-2022-1 as an NRIS discovered System Network Upgrades in the Northern Colorado study pocket. The System Network Upgrade costs associated with INFO-2022-1 studied as an NRIS request are described in .

Table 14.

Table 14 – System Network Upgrades –Northern Colorado Study Pocket for NRIS

| Description | Facility Type | Current Rating (MVA) | Minimum Normal Rating (MVA) | Total Cost Est. (million) |
|---|---|---|---|---|
| UPGRADE VALMONT (70447) TO SPNDLE (70592) 230 kV CKT #1 | Line | 478 | 570 | $109.00 |
| UPGRADE BANCROFT (70045) TO GRAY_ST. (70208) 115 kV CKT #1 | Line | 159 | 189 | $18.30 |
| UPGRADE GI-2021-6 TO (88883) TO SKYRANCH (70392) 230 kV CKT #1 (Line 5275) | Line | 484 | 540 | $9.20 |
| UPGRADE HENRYLAK (70606) TO HENRYLAK (70605) 230/115 kV CKT #T1 | Xfmr | 100 | 110 | $9.00 |
| UPGRADE FTLUPTON (70192) TO ST.VRAIN (70410) 230 kV CKT #1 | Line | 478 | 528 | $4.00 |
| UPGRADE CHEROKEE (70107) TO LACOMBE (70324) 230 kV CKT #1 | Line | 435 | 475 | $4.00 |
| UPGRADE VALMONT (70444) TO VALMONT (70447) 230/115 kV CKT #T7 | Xfmr | 280 | 305 | $9.00 |
| UPGRADE VALMONT (70444) TO VALMONT (70447) 230/115 kV CKT #T8 | Xfmr | 280 | 305 | $9.00 |
| UPGRADE SKYRANCH (70392) TO SPRUCE (70528) 230 kV CKT #1 | Line | 484 | 518 | $4.00 |
| UPGRADE BARRLAKE (70047) TO REUNION (70610) 230 kV CKT #1 | Line | 478 | 505 | $4.00 |
| UPGRADE FTLUPTON (70192) TO ST.VRAIN (70410) 230 kV CKT #2 | Line | 509 | 528 | $4.00 |
| UPGRADE FTLUPTON (70192) TO JLGREEN (70529) 230 kV CKT #1 | Line | 487 | 490 | $4.00 |
| **Total Cost Estimate for PSCo-Funded, PSCo-Owned Interconnection Facilities** | | | | **$187.50** |
| **Estimated Timeline to Implement Upgrades after Customer Execution of Agreement with PSCo** | | | | **36 Months** |

### 6.3.2 INFO-2022-1 – ERIS

Steady-state analysis for INFO-2022-1 as an ERIS did not discover any System Network Upgrades in the Northern Colorado study pocket. There are no System Network Upgrade costs associated with INFO-2022-1 studied as an ERIS.

## 6.4 Summary of Costs assigned to INFO-2022-1 as NRIS

The total cost of the required upgrades for INFO-2022-1 to interconnect at a new INFO-2022-1 345 kV Switching Station on the Keenesburg – St. Vrain 230 kV line as NRIS is $207.11 million.

- **Cost of Transmission Provider's Interconnection Facilities is $1.40 million (Table 11)**
- **Cost of Station Network Upgrades is $18.21 million (Table 13)**
- **Cost of System Network Upgrades is $187.50 million (Table 14)**

The list of improvements required to accommodate the interconnection of INFO-2022-1 are given in Table 11, Table 13 and Table 14. System improvements are subject to revision as a more detailed and refined design is produced.

## 6.5 Summary of Costs assigned to INFO-2022-1 as ERIS

The total cost of the required upgrades for INFO-2022-1 to interconnect at a new INFO-2022-1 345 kV Switching Station on the Keenesburg – St. Vrain 230 kV line as ERIS is $19.61 million.

- **Cost of Transmission Provider's Interconnection Facilities is $1.40 million (Table 11)**
- **Cost of Station Network Upgrades is $18.21 million (Table 13)**
- **Cost of System Network Upgrades is $0 million**

The list of improvements required to accommodate the interconnection of INFO-2022-1 are given in Table 11 and Table 13. System improvements are subject to revision as a more detailed and refined design is produced.

## 6.6 Cost Estimate Assumptions

The cost estimates are in 2021 dollars with escalation and contingencies applied. Allowances for Funds Used During Construction (AFUDC) is not included. These estimated costs include all applicable labor and overheads associated with the siting, engineering, design, and construction of these new PSCo facilities. This estimate does not include the cost for any Interconnection Customer owned equipment and associated design and engineering. A level of accuracy is not specified for the estimates.

1. Labor is estimated for straight time only – no overtime included
2. Lead times for materials were considered for the schedule
3. The GIRs are not located in PSCo's retail service territory. Therefore, no costs for retail load metering are included in these estimates
4. PSCo (or it's Contractor) crews will perform all construction, wiring, testing, and commissioning for PSCo owned and maintained facilities
5. Customer will install two (2) redundant fiber optics circuits into the Transmission provider's substation as part of its interconnection facilities construction scope
6. Breaker duty study determined that no breaker replacements are needed in neighboring substations
7. Line outages will be necessary during the construction period. Outage availability could potentially be problematic and extend requested back-feed date
8. Power Quality Metering (PQM) will be required on the Customer's generation tie-line terminating into the POI
9. 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 / Xcel will need indications, readings, and data from the LFAGC RTU

## 7.0 Appendices

| | |
|---|---|
| Appendix A: Multiple Contingency Definitions |  Appendix A - Multiple Contingen |