2020 Spring Resource Solicitation Cluster Study

Phase 1 Report

6/1/2020

Version History

Version	Reason for Update	Date
1.0	Draft before Customer Review	6/1/2020
1.1	Updated the ISD of Monument – Flying Horse project. Final report after Customer meeting	6/22/2020

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1.0 Executive Summary

The Spring 2020 Resource Solicitation Cluster (RSC) includes three (3) Generation Interconnection Request (GIR)s – RSC-2020-1, RSC-2020-2 and RSC-2020-4.

RSC-2020-1 is a 72MW$_{ac}$ net rated Solar Photovoltaic (PV) Generating Facility requesting Energy Resource Interconnection Service (ERIS). The Point of Interconnection (POI) is a tap on the Hartsel – Tarryall 230kV line.

The RSC-2020-2 is a 75MW$_{ac}$ increment in the output of GI-2018-24. The POI is same as GI-2018-24.

The RSC-2020-4 is a 53MW$_{ac}$ expansion of GI-2014-8. The RSC-2020-4 will use the same POI and gen-tie as GI-2014-8.

The RSC-2020-2 and RSC-2020-4 GIRs are studied under the Southern Colorado study pocket analysis. The studies are performed using the 2023HS Base Case and modeled heavy south to north flow on the Comanche – Midway – Jackson Fuller – Daniels Park transmission system.

The RSC-2020-1 is studied under the Western Slope study pocket analysis. The studies are performed using the 2023HS Base Case and modeled heavy TOT5 west-to-east flows.

Interconnection Service identified in this report in and of itself does not convey transmission service

1.1 RSC-2020-1

The total estimated cost of the transmission system improvements for RSC-2020-1 is $19.499 Million (Tables 15a and 15b)

Energy Resource Interconnection Service of RSC-2020-1 is: 72MW (after required transmission system improvements in Table 15a and 15b)

A Certificate of Public Convenience & Necessity (CPCN) is needed for the construction of the RSC-2020-1 230kV Switching Station. The estimated time frame for regulatory activities (CPCN) and to site, design, procure and construct the interconnection facilities is approximately 36 months after authorization to proceed has been obtained. Any delays in obtaining the CPCN may delay the COD of RSC-2020-1.

1.2 RSC-2020-2

The total estimated cost of the transmission system improvements for RSC-2020-2 is $0.05 Million (Tables 16a and 16b)

Energy Resource Interconnection Service of RSC-2020-2 is: 75MW (after required transmission system improvements in Table 16a and 16b)

The maximum combined output of GI-2018-24 and RSC-2020-2 at the POI shall not exceed 325MW at any time, which will be limited using the Plant Controller. The GIR output will also be monitored by PSCo operations. The construction of the Tundra 345kV Switching Station for GI-2018-24 will require a CPCN and the estimated time frame for regulatory activities (CPCN) and to site, design, procure and construct the interconnection facilities (entire Project) is approximately 36 months after authorization to proceed has been obtained. Any delays in obtaining the CPCN may delay the COD of RSC-2020-2

1.3 RSC-2020-4

The total estimated cost of the transmission system improvements for RSC-2020-4 is $0.05 Million (Tables 17a and 17b)

Energy Resource Interconnection Service of RSC-2020-2 is: 53MW (after required transmission system improvements in Table 17a and 17b).

The ERIS assumes GI-2014-12 LGIA is withdrawn if RSC-2020-4 moves forward. Also, the combination of GI-2014-8 and RSC-2020-4 at the Boone 230kV POI shall not exceed 113MW.

The interconnection of RSC-2020-2 is dependent on the construction of the construction of GI-2014-8 and associated Interconnection Facilities and Network Upgrades identified in the GI-2014-8 LGIA.

2.0 Introduction

Public Service Company of Colorado (PSCo) received four (4) GIRs in the Spring 2020 RSC out of which three (3) GIRs are considered valid and accepted. The total Interconnection Service requested in the RSC is 200MW. The GIRs are identified by their queue numbers – RSC-2020-1, RSC-2020-2 and RSC-2020-4. All the GIRs requested Energy Resource Interconnection Service (ERIS)[1]. A summary of the requests in the RSC is given in Table 1.

Table 1 – Summary of GIRs in the RSC

Resource Cluster Queue Number	Date RSC Request Received	Generation Type	Service Type	Location County/State	Interconnection Point Station or Line	Net Plant Max MW Sum | Win	In-Service Date	Comments/Status/Reason Not Completed
RSC-2020-1	01/15/2020	PV Solar	ERIS	Park County, CO	Hartsel-Tarryall 230 kV line	72 72	12/31/2022	-Affiliate Request. -Scoping Meeting Held 01/27/2020 -Resource Solicitation Cluster Study Underway
RSC-2020-2	01/15/2020	Battery	ERIS	Pueblo County, CO	Tundra Switchyard on the Comanche-Daniels Park 345 kV line	75 75	12/01/2022	-Affiliate Request. -Scoping Meeting Held 01/27/2020 -Resource Solicitation Cluster Study Underway
RSC-2020-4	01/15/2020	PV Solar	ERIS	Pueblo County, CO	Boone 230 kV Switchyard	53 53	12/31/2022	-Affiliate Request. -Scoping Meeting Held 01/27/2020 -Resource Solicitation Cluster Study Underway

3.0 Description of the GIRs

3.1 Description of RSC-2020-1

RSC-2020-1 is a 72MW$_{ac}$ net rated Solar Photovoltaic (PV) Generating Facility that will be located in Park County, Colorado. The Solar PV Generating Facility will consist of twenty-three (23) TMEIC 3.36MW, ±0.95PF inverters, each with its own 630V/34.5kV, 3.7MVA, Z=8% pad-mounted step-up transformer. The 34.5kV collector system will connect to one (1) 63/80/100MVA, 34.5/230/13.8kV wye-wye-delta, Z=10% main step-up transformer which will connect to the PSCo transmission system via 250 foot, 230kV transmission tie-line. The POI is a tap on PSCo's Hartsel – Tarryall 230kV line, at approximately mid length. The Generating Facility configuration also includes an 18Mvar capacitor bank on the 34.5kV bus.

[1] Energy Resource Interconnection Service shall mean an Interconnection Service that allows the Interconnection Customer to connect its Generating Facility to the Transmission Provider's Transmission System to be eligible to deliver the Generating Facility's electric output using the existing firm or non-firm capacity of the Transmission Provider's Transmission System on an as available basis. Energy Resource Interconnection Service in and of itself does not convey transmission service

The tap position on the Tarryall – Hartsel 230kV line will require building a new switching station referred to as "RSC-2020-1 230kV Switching Station" in this report.

The proposed Commercial Operation Date (COD) of RSC-2020-1 is December 31, 2022. For the study purpose, the back-feed date is assumed to be July 1, 2022, approximately six (6) months before the COD.

3.2 Description of RSC-2020-2

The RSC-2020-2 is a 75MW$_{ac}$ increment in the output of GI-2018-24 hybrid Generating Facility received in the Transitional Cluster. The combined output of RSC-2020-2 and GI-2018-24 at the POI will be 325MW$_{ac}$. The hybrid Generating Facility will have the same nameplate capacity as GI-2018-24 i.e., AC-coupled 250MW rated Solar PV generator and a 125MW rated Battery Energy Storage (BES) generator. The inverters, pad mount step-up transformer, 34.5kV collector system, gen-tie configuration and POI remain the same between RSC-2020-2 and GI-2018-24. But RSC-2020-2 changes the main step-up transformer configuration from one (1) 34.5/345/13.8kV, 255/340/425MVA Z=8.5% transformer to two (2) 34.5/345kV, 114/152/190MVA main step-up transformers.

The proposed COD of the RSC-2020-2 is same as GI-2018-24, December 31, 2022. The POI will be backfed for GI-2018-24, so a back-feed date is not applicable to RSC-2020-2.

The net output of GI-2018-24 and RSC-2020-2 will not exceed 325MW at any time, which will be limited using the Plant Power Controller. The PV and BES generating facilities will operated in back-feed voltage control mode.

3.3 Description of RSC-2020-4

The Interconnection Customer confirmed that RSC-2020-4 represents the same project as GI-2014-12 where the POI is changed to the Boone 230kV Substation. Also, the Interconnection Customer confirmed that RSC-2020-4 is to be considered as an expansion of the higher-queued GI-2014-8. Upon the execution of the RSC-2020-4 LGIA, the combination of GI-2014-12 and RSC-2020-4 will represent one 113MW Generating Facility at the Boone 230kV Substation.

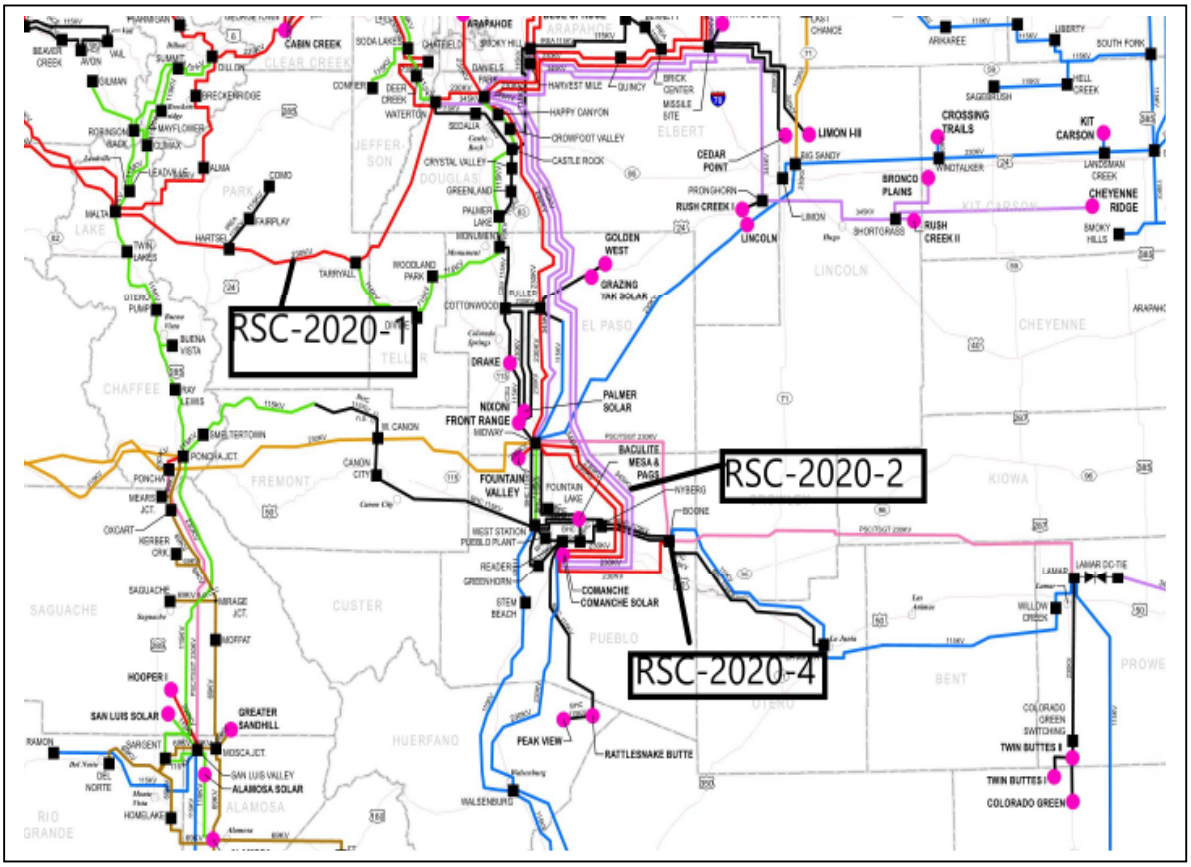
The RSC-2020-4 is a 53MW$_{ac}$ net expansion of GI-2014-8 which is a 60MW$_{ac}$ Solar PV Generating Facility that will be located in Pueblo County, Colorado. The RSC-2020-2 shares the same POI as GI-2014-8, which is PSCo's Boone 230kV Substation.

The total 113MW generating facility will consist of two sets of thirty-four (34) HEM FS3430M 3.37MW/3.55MVA, ±0.95PF inverters, each with its own 645V/34.5kV, 3.55MVA, Z=8.5% pad-mounted step-up transformer. The 34.5kV collector system will connect to one (1) 34.5/230/13.8kV, wye-wye-delta 133/174/218MVA, Z=8.0% main step-up transformer which will connect to PSCo's Boone 230kV Substation via 0.3 mile, 230kV transmission tie-line. The Generating Facility configuration also includes a 20Mvar capacitor bank on the 34.5kV bus.

The proposed COD of the RSC-2020-4 is December 31, 2022. The POI will be backfed for GI-2018-24, so a back-feed date is not applicable to RSC-2020-2.

The approximate locations of the three GIRs in the RSC and the surrounding transmission system are shown in Figure 1 below

Figure 1 – Approximate Locations of the POIs of the GIRs in the RSC



4.0 Study Scope

The purpose of the study is to determine the system impact of interconnecting all the three GIRs in the RSC for simultaneous Interconnection Service. The Interconnection Service requested by each GIR is given in Table 1.

The scope of the study includes steady state (thermal and voltage) analysis and Indicative Level cost estimates. The cost estimates provide total costs and each GIR cost responsibility for Transmission Provider Interconnection Facilities and Network Upgrade costs identified in the steady state analysis.

The steady state analysis identifies thermal and voltage violations in the PSCo system and the neighboring systems using the study criteria in Section 4.2 and study methodology in Section 4.3. For RSC-2020-2 and RSC-2020-4, the analysis only evaluated the impacts due to the 75MW and 53MW incremental capacities.

4.1 Study Pocket Determination

As shown in Figure 1, RSC-2020-1 is in Western Colorado region and falls under the “Western Colorado” study pocket. RSC-2020-2 and RSC-2020-4 are in the Southern Colorado region and fall under the “Southern Colorado” study pocket.

4.2 Study Criteria

PSCo adheres to applicable NERC Reliability Standards and WECC Reliability Criteria, as well as its internal transmission planning criteria for studies. The following Criteria is used for the reliability analysis of the PSCo system and neighboring utility systems for each study pocket analysis.

4.2.1 Steady-State Criteria

The steady state analysis criteria are as follows:

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

4.3 Study Methodology

The steady state assessment is performed using PSSE V33 and the ACCC tool.

4.3.1 Steady State Assessment methodology

The thermal and voltage violations are identified by running the same set of contingencies on the Benchmark Case and the Study Case and comparing the results. The violations identified in each study pocket analysis are attributed to the GIRs in that Study Pocket.

For PSCo facilities, thermal violations attributable to the Study Pocket GIRs include any facilities without a pre-existing thermal violation that (i) resulted in a thermal loading >100% post the Study Pocket GIR cluster addition and (ii) contributed to an incremental loading increase of 2% or more to the benchmark case loading. Pre-existing thermal violations on the PSCo system are attributed to the Study Pocket if the overloads increased by 1% or more. The Study Pocket thermal violations are then attributed to individual GIRs in the Study Pocket by calculating their individual contributions using DFAX criteria.

DFAX contribution criteria for identifying thermal overloads applicable to each GIR: ≥1%

For non-PSCo facilities, thermal violations attributed to the Study Pocket GIRs include all new facility overloads with a thermal loading of >100% and existing thermal overloads that increased by 1% or more from the benchmark case overload post the Study Pocket GIR Cluster addition. Any non-PSCo facility overloads are identified as Affected System violations in the study, except if the violation is attributable to an ERIS request.

The voltage violations assigned to the Study Pocket GIR Cluster include new voltage violations which resulted in a further variation of 0.1 per unit. The voltage violations are attributed to individual GIRs in the Study Pocket by calculating their individual contributions (0.005 per unit or higher) to the violations.

DFAX contribution criteria for identifying voltage violations applicable to each GIR: 0.005 p.u.

Any non-PSCo system voltage violations are identified as Affected System violations in the study, except if the violation is attributable to an ERIS request.

4.3.2 Contingency Analysis Area

For each study pocket analysis, the transmission system on which steady state contingency analysis is run includes the WECC designated areas 70 and 73, and WECC designated zone 121.

4.4 Study Area(s) considered for the RSC

The study area or monitored area is the electrical system consisting of PSCo's transmission system and the neighboring transmission systems that may be impacted by or that could impact interconnection of the Study Pocket GIR(s).

4.4.1 Southern Colorado Study Pocket Study Area

The study area for the Southern Colorado study pocket includes WECC designated zones 121, 700, 703, 704, 705, 709, 710, 712, 752 and 757. The neighboring utilities included in the analysis include Tri-State Generation and Transmission Inc. (TSGT), Black Hills Energy (BHE), Colorado Spring Utilities (CSU), Intermountain Rural Electric Association (IREA) and Western Area Power Administration (WAPA) systems in the study area.

4.4.2 Western Slope Study Area

The study area for the Western Slope study pocket includes WECC designates zones 700, 703, 704, 705, 708, 709, 790 and 791. The neighboring utilities included in the analysis include TSGT, IREA and WAPA systems in the study area.

5.0 Base Case Modeling Assumptions

The 2023HS case developed for the 2019 Colorado Coordinated Planning Group TPL1-4 studies is selected as the starting case. The case was reviewed by PSCo and neighboring utilities within the Colorado Coordinated Planning Group (CCPG) footprint and updates are incorporated. The base case year selected is consistent with the COD of all the GIRs in the RSC.

5.1 Base Case Modeling

The Base Case is created from the starting case by including the following un-built transmission projects. All transmission planned projects in PSCo's 10 year transmission plan that are expected to be in-service before July 2023, and have internal approval are modeled in the Base Case.

The PSCo planned projects are described at:
http://www.oasis.oati.com/woa/docs/PSCO/PSCOdocs/FERC_890_Q1_2020_Transmission_Plan_Presentation.pdf

The PSCo projects modeled in the Base Case include the following:

- Cloverly 115kV Substation – ISD 2021
- Graham Creek 115kV Substation – ISD 2022
- Husky 230/115kV Substation – ISD 2022
- Ault – Husky 230kV line – ISD 2022
- Husky – Graham Creek – Cloverly 115kV line – ISD 2022
- Monument – Flying Horse 115kV Series Reactor – ISD 2022
- Avery Substation – ISD 2021
- High Point Substation –ISD 2022
- Titan Substation – ISD 2022
- Gilman – Avon 115kV line – ISD 2022
- Upgrade Villa Grove – Poncha 69kV Line to 73MVA – ISD 2021
- Upgrade Poncha - Sargent - San Luis Valley 115kV line to 120MVA – ISD 2021

All transmission facilities are modeled at their expected ratings for 2023 Summer season. Also, the following facilities are modeled at their planned future ratings:

- Upgrade Allison – SodaLakes 115kV line to 318MVA – ISD 2021
- Upgrade Buckley34 – Smokyhill 230kV line to 506MVA – ISD 2021
- Upgrade Daniels Park – Priarie1 230kV line to 576MVA – ISD 2021
- Upgrade Greenwood – Priarie1 230kV line to 576MVA – ISD 2021
- Upgrade Daniels Park – Priarie3 230kV line to 576MVA – ISD 2021
- Upgrade Greenwood – Priarie3 230kV line to 576MVA – ISD 2021
- Upgrade Midway 230kV bus tie to 576MVA – ISD 2023
- Upgrade Waterton – Martin2 tap 115kV line to 189MVA – ISD 2021
- Upgrade Dainels Park 345/230kV # T4 to 560MVA – ISD 2021
- Upgrade Leetsdale – Monaco 230kV line to 560MVA – ISD 2021
- Upgrade Greenwood – Monaco 230kV line to 560MVA – ISD 2021
- Comanche – GI-2014-9 – MidwayPS 230kV line to 478MVA
- Upgrade Waterton – Martin1 tap 115kV line to 189MVA – ISD 2023

The Base Case model includes the existing PSCo generation resources. In addition, the following higher-queued generation which have an LGIA are modeled in the Base Case: GI-2009-8, GI-

2014-2, GI-2014-6, GI-2014-8, GI-2014-9, GI-2014-13, GI-2018-24 and GI-2019-6. While the higher-queued NRIS requests are dispatched at 100% nameplate, the higher-queued ERIS requests are modeled offline. Since RSC-2020-4 represents the same project as GI-2014-12 and the Interconnection Customer has committed to terminate the existing 2014-12 LGIA, GI-2014-12 is modeled offline in the Base Case.

5.1.1 Affected System Model

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

- 100MW TSGT_0809 solar facility tapping Gladstone – Walsenburg 230kV line – ISD 2023
- Fuller – Vollmer – Black Squirrel 115 kV line modeled at 173 MVA – ISD 2022
- Fuller 230/115kV, 100MVA #2 transformer – ISD 2023

The following additional changes were made to the Black Hills Energy (BHE) model in the Base Case per further review and comment from BHE:

- Fountain Valley – DesertCove 115kV line was modeled at 222MVA – ISD 1/2021
- Fountain Valley – MidwayBR 115kV line was modeled at 222MVA – ISD 1/2021
- Pueblo West Substation – ISD 1/2021
- Skyline Ranch Substation – ISD 10/2021
- West Station – Greenhorn 115kV line Rebuild – ISD 9/2022

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

- The Cottonwood – Tesla 34.5kV line is modeled open and Kettle Creek – Tesla 34.5kV line is modeled closed on the CSU system – ISD 2023
- Grazing Yak Solar – ISD 2020
- Briargate S 115/230kV transformer project tapping the Cottonwood – Fuller 230kV line – ISD 2023

6.0 Generation Interconnection Service Analysis

The RSC-2020-1 is the only GIR studied in the Western Colorado study pocket, the Interconnection Service for RSC-2020-1 is determined using the Western Colorado study pocket analysis. The RSC-2020-2 and the RSC-2020-4 are studied in the Southern Colorado study

pocket, so the Interconnection Service for RSC-2020-2 and RSC-2020-4 is determined using the Southern Colorado study pocket analysis.

6.1 Voltage and Reactive Power Capability Evaluation

All GIRs received in the RSC are non-Synchronous generators, accordingly, the following voltage regulation and reactive power capability requirements at the POI are applicable to each GIR:

- 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/POI. Finally, it is the responsibility of the Interconnection Customer to compensate their generation tie-line to ensure minimal reactive power flow under no load conditions.

The reactive power analysis looks for the capability of the GIR to maintain ±0.95pf at the high side of the main step-up transformer and maintain normal steady state operating voltage range (0.95-1.05 p.u.) at the POI. All GIRs are required to design their interconnection to meet the POI voltage control requirements that will be specified by PSCo's Transmission Operations group.

The Interconnection Customer is required to demonstrate to the satisfaction of PSCo's Transmission Operations group prior to the commercial in-service date of the generating plant that it can safely and reliably operate within the required power factor and the regulating voltage of the POI.

6.1.1 RSC-2020-1 reactive capability evaluation

The analysis indicates that RSC-2020-1 is capable of maintaining +/-0.95pf at the generator terminal and high side of the main step-up transformer, while staying within 0.95-1.05 p.u. voltage at the POI for 100%, 10% and 0% output levels.

Table 2 – Reactive capability evaluation of RSC-2020-1

Gen MW / Mvar	18 Mvar Cap bank Status	Gen Voltage (p.u.)	Main Step-up Transformer High Side				POI			
			Voltage (p.u.)	MW	Mvar	Power Factor	Voltage (p.u.)	MW	Mvar	Power Factor
73.1MW / 24.9Mvar	on	1.042	1.018	72	27.9	0.932 (lag)	1.018	72	27.9	0.932 (lag)
73.2MW / -24.9Mvar	off	0.975	0.986	71.9	-40.6	0.871 (lead)	0.986	71.9	-40.6	0.871 (lead)
7.3MW / 2.0Mvar	off	0.985	1.002	7.3	2.4	0.95 (lag)	1.002	7.3	2.4	0.950 (lag)
7.3MW / -2.9Mvar	off	1.001	1	7.3	-2.4	0.950 (lead)	1	7.3	-2.4	0.950 (lead)
0MW / -9.1Mvar	off	0.99	1	0	-1.1	N/A	1	72	-1.1	N/A

6.1.2 RSC-2020-2 reactive capability evaluation:

The analysis indicates that RSC-2020-2 is capable of maintaining ±0.95pf at the generator terminals and high side of the main step-up transformer, while staying within 0.95-1.05 p.u. voltage at the POI for 100%, 10% and 0% output levels. According to the Interconnection Customer, RSC-2020-2 hybrid generating facility will operate in back-feed voltage control mode, so PV and BES generator capabilities are not evaluated individually. Since the new combined output of RSC-2020-2 and GI-2018-24 will be 325MW, the reactive capability evaluation is performed for the net 325MW facility.

Table 3 – Reactive Capability Evaluation for RSC-2020-2

Gen MW (PV&BES) / Mvar PV&BES)	Gen Voltage (p.u.) (PV/BES)	Main Step-up Transformer High Side				POI			
		Voltage (p.u.)	MW	Mvar	Power Factor	Voltage (p.u.)	MW	Mvar	Power Factor
325MW / 176Mvar	1.121 / 1.126	1.037	320.2	121.6	0.935 (lag)	1.037	320.2	121.6	0.935 (lag)
325MW / -176Mvar	0.874 / 0.842	0.966	316.7	-271.7	0.759 (lead)	0.966	316.7	-271.7	0.759 (lead)
32.5MW / 9.2Mvar	1.024 / 1.026	1.018	32.5	10.7	0.950 (lag)	1.034	320.3	105	0.950 (lag)
32.5 MW / -12 Mvar	1.011 / 1.008	1.014	32.4	-10.6	0.950 (lead)	0.997	319.9	-104.9	0.950 (lead)
0 MW / -87 Mvar	0.958 / 0.935	1	-0.4	-89.9	N/A	1	-0.4	-89.9	N/A

6.1.3 RSC-2020-4 reactive capability evaluation

Since GI-2014-8 and RSC-2020-4 are the same Generating Facility, the reactive capability evaluation is performed for the net 113MW facility. The analysis indicates that the 113MW Generating Facility is capable of maintaining ±0.95pf at the generator terminals and high side of the main step-up transformer, while staying within 0.95-1.05 p.u. voltage at the POI for 100%, 10% and 0% output levels. The Generating Facility configuration includes a 20Mvar shunt capacitor bank in addition to the generator reactive output.

Table 4 – Reactive Capability Evaluation of RSC-2020-4

Gen MW / Mvar	20 Mvar Cap bank Status	Gen Voltage (p.u.)	Main Step-up Transformer High Side				POI			
			Voltage (p.u.)	MW	Mvar	Power Factor	Voltage (p.u.)	MW	Mvar	Power Factor
113MW / -42.4Mvar	on	0.98	1.031	111.5	-42.4	0.935 (lead)	1.031	111.5	-42.4	0.935 (lead)
113MW / 42.4Mvar	on	1.12	1.051	111.8	45	0.928 (lag)	1.05	111.8	45	0.928 (lag)
11.3MW / -3.3Mvar	off	1.032	1.037	11.3	-3.7	0.950 (lead)	1.037	11.3	-3.7	0.950 (lead)
11.3MW / 3.3Mvar	off	1.047	1.0385	11.3	3.7	0.950 (lag)	1.0385	11.3	3.7	0.950 (lag)
0MW / -42.4Mvar	off	0.964	1.028	-0.2	-44.6	N/A	1.028	-0.2	-44.6	N/A

6.2 Southern Colorado Study Pocket Analysis

6.2.1 Benchmark Case Modeling

The Benchmark Case for evaluating the Southern Colorado Study Pocket GIRs is developed from the Base Case described in Section 5.1 of this report by changing the Study Pocket generation dispatch to reflect a heavy south to north flow on the Comanche – Midway – Jackson Fuller – Daniels Park transmission system. This was accomplished by adopting the generation dispatch given in Table 5 for the Southern Colorado Study Pocket. The generation dispatch of the neighboring systems was provided by the neighboring utilities. Since RSC-2020-2 is an incremental output on top of the 250MW output of GI-2018-24, the Benchmark Case modeled GI-2018-24 at 250MW. Since RSC-2020-4 is an expansion of GI-2014-8, the Benchmark Case modeled GI-2014-8 at 60MW.

Table 5 – Generation Dispatch Used to Stress the Benchmark Case (MW is Gross Capacity)

Bus Name	ID	Status	PGen (MW)	PMax (MW)	Owner
APT_DSLS 4.16	G1	0	0	10	BHE
BAC_MSA GEN1 13.8	G1	1	59.4	90	BHE
BAC_MSA GEN2 13.8	G1	1	59.4	90	BHE
BAC_MSA GEN4 13.8	G1	1	26.4	40	BHE
BAC_MSA GEN4 13.8	G2	1	26.4	40	BHE
BAC_MSA GEN4 13.8	S1	1	16.4	24.8	BHE
BAC_MSA GEN5 13.8	G1	1	26.4	40	BHE
BAC_MSA GEN5 13.8	G2	1	26.4	40	BHE
BAC_MSA GEN5 13.8	S1	1	16.4	24.8	BHE
BAC_MSA GEN6 13.8	G1	1	26.4	40	BHE
BUSCHRNCH_LO 0.7	1	1	35.2	60	BHE
BUSCHRWTG1 0.7	G1	1	16.9	28.8	BHE
E_CANON 69	G1	0	0	8	BHE
PP_MINE 69	G1	0	0	3	BHE
PUB_DSLS 4.16	G1	0	0	10	BHE
R.F.DSLS 4.16	G1	0	0	10	BHE
RTLSNKWNDLO 0.7	G1	1	35.2	60	BHE
ALMSACT1 13.8	G1	0	0	17	PSCo
ALMSACT2 13.8	G2	0	0	14	PSCO
COGENTRIX_PV 34.5	S3	1	19.5	30	PSCO
COMAN_1 24	C1	1	360	360	PSCO
COMAN_2 24	C2	1	365	365	PSCO
COMAN_3 27	C3	1	788	788	PSCO
COMAN_PV 34.5	S1	1	102	120	PSCO
CO_GRN_E 34.5	W1	1	64.8	81	PSCo
CO_GRN_W 34.5	W2	1	64.8	81	PSCo
FTNVL1&2 13.8	G1	1	36	40	PSCO
FTNVL1&2 13.8	G2	1	36	40	PSCO
FTNVL3&4 13.8	G3	1	36	40	PSCO
FTNVL3&4 13.8	G4	1	36	40	PSCO
FTNVL5&6 13.8	G5	1	36	40	PSCO
FTNVL5&6 13.8	G6	1	36	40	PSCO

GSANDHIL_PV 34.5	S1	1	12.4	19	PSCO
JKFULGEN 0.69	W1	1	199.5	249.4	PSCO
LAMAR_DC 230	DC	0	0	210	PSCO
SOLAR_GE 34.5	S2	1	19.5	30	PSCO
SUNPOWER 34.5	S1	1	33.8	52	PSCO
TWNBUTTE 34.5	W1	1	60	75	PSCO
SI_GEN 0.6	1	1	24	30	TSGT
TBII_GEN 0.69	W	1	60	76	TSGT
TSGT_0809 0.62	PV	1	80	100	TSGT
GI-2009-8 34.5	S1	1	30	30	PSCo
GI-2014-2 34.5	S1	0	0	35	N/A
GI-2014-13 34.5	S1	0	53	53	N/A
GI-2014-6 34.5	S1	1	100	100	PSCo
GI-2014-8 34.5	S1	1	60	60	PSCo
GI-2014-9 34.5	WS	1	70	70	PSCo
GI-2014-12 34.5	S1	0	0	53	N/A
GI-2018-24 34.5	S1	1	250	250	N/A
GI-2019-6 34.5kV	S1	0	0	240	N/A

6.2.2 Study Case Modeling

The Study Case is created from the Benchmark Case by increasing the GI-2018-24 output to 325MW for RSC-2020-2 and modeling RSC-2020-4 at the Boone 230kV Substation using the GIR modeling data provided by the Interconnection Customer. The total 128MW output of the two GIRs is sunk to the PSCo Fort Saint Vrain Generation in the Northern Colorado.

6.2.3 Steady State Analysis

The results of the single contingency analysis (P1 and P2-1) are given in Table 6 below

Table 6 – Power Flow Analysis Results of Southern Colorado Study Pocket GIRs – Overloads identified in Single Contingency Analysis

Overloaded Facility	Type	Owner	Facility Normal Rating (MVA)	Facility Loading in Benchmark Case		Facility Loading in Study Case		% Change due to Study Pocket GIRs	Single Contingency Definition
				MVA Flow	% Line Loading	MVA Flow	% Line Loading		
Daniels Park – Prairie 1 230kV # 1	Line	PSCo	576	581.8	101.0%	603.1	104.7%	3.7%	Daniels Park – Prairie 3 230kV # 1
Daniels Park – Prairie 3 230kV # 1	Line	PSCo	576	576	100.0%	597.3	103.7%	3.7%	Daniels Park – Prairie 1 230kV # 1
MIDWAYPS 115/230 KV #1	Line	PSCo	100	123.6	123.6%	127.9	127.9%	4.3%	DANIELPK – TUNDRA 345 kV line 2
Palmer Lake – Monument 115kV #1	Line	CSU	108	120.3	111.4%	127.9	118.4%	7.0%	Daniels Park – Fuller 230kV Line # 1

For the stressed generation dispatch used in Table 5, the addition of Southern Pocket GIRs (RSC-2020-2 and RSC-2020-4) resulted in one new overload in the PSCo system and also increased the pre-existing overload on the CSU and PSCo lines.

Table 7 – Power Flow Analysis Results of Southern Colorado Study Pocket GIRs – Overloads identified in Multiple Contingencies

Overloaded Facility	Type	Owner	Facility Emergency Rating (MVA)	Facility Loading in Benchmark Case		Facility Loading in Study Case		% Change due to Study Pocket GIRs	Multiple Contingency Definition
				MVA Flow	% Line Loading	MVA Flow	% Line Loading		
Boone – Midway 230kV # 1	Line	PSCo	318.7	337.5	105.9%	368.1	115.5%	9.6%	P7: Comanche – Daniels Park 345kV Line # 2 & Tundra – Daniels Park 345kV Line # 1

Daniels Park – Fuller 230kV # 1	Line	PSCo	478	700.3	146.5%	736.6	154.1%	7.6%	P7: Comanche – Daniels Park 345kV Line # 2 & Tundra – Daniels Park 345kV Line # 1
Pueblo Plant – Reader 115kV # 1	Line	BHE	160	192.5	120.3%	200.6	125.4%	5.1%	P7: Comanche – Daniels Park 345kV Line # 2 & Tundra – Daniels Park 345kV Line # 1
HydePark – Pueblo Plant 115kV # 1	Line	BHE	160	174.7	109.2%	183.0	114.4%	5.2%	P7: Comanche – Daniels Park 345kV Line # 2 & Tundra – Daniels Park 345kV Line # 1
Midway 230/115kV # 1	Xfmr	PSCo	100	177.5	177.5%	186.2	186.2%	8.7%	P7: Comanche – Daniels Park 345kV Line # 2 & Tundra – Daniels Park 345kV Line # 1
Midway – Comanche 230kV # 1	Line	PSCo	478	462.7	96.8%	488.0	102.1%	5.3%	P7: Comanche – Daniels Park 345kV Line # 2 & Tundra – Daniels Park 345kV Line # 1
Midway – Fuller 230kV # 1	Line	PSCo	382.4	463.9	121.3%	483.6	126.6%	5.3%	P7: Comanche – Daniels Park 345kV Line # 2 & Tundra – Daniels Park 345kV Line # 1
Midway – GI-2014-9 230kV # 2	Line	PSCo	478	473.7	99.1%	500.0	104.6%	5.5%	P7: Comanche – Daniels Park 345kV Line # 2 & Tundra – Daniels Park 345kV Line # 1
Black Forest Tap – Black Squirrel 115kV # 1	Line	TSGT	173	183.7	106.2%	192.5	111.3%	5.1%	P7: Midway – Waterton 345kV Line #1 & Daniels Park – Fuller 230kV Line # 1
Fuller 230/115kV # 1	Xfmr	TSGT	100	99.5	99.5%	103.0	103.0%	3.5%	P7: Midway – Waterton 345kV Line #1 & Daniels Park – Fuller 230kV Line # 1
Fuller 230/115kV # 2	Xfmr	TSGT	100	99.5	99.5%	103.0	103.0%	3.5%	P7: Midway – Waterton 345kV Line #1 & Daniels Park – Fuller 230kV Line # 1
Gresham – Black Forest Tap 115kV # 1	Line	TSGT	173	178.4	103.1%	186.8	108.0%	4.9%	P7: Midway – Waterton 345kV Line #1 & Daniels Park – Fuller 230kV Line # 1
MidwayPS – MidwayBR 230kV # 2	Line	PSCo/ WAPA	576	644	111.8%	679.7	118.0%	6.2%	P7: Midway – Waterton 345kV Line #1 & Midway – Fuller 230kV Line # 1
Monument – Gresham 115kV # 1	Line	TSGT	145	174.1	120.1%	182.6	125.9%	5.8%	P7: Midway – Waterton 345kV Line #1 & Daniels Park – Fuller 230kV Line # 1

Palmer Lake – Monument 115kV # 1	Line	PSCo/ CSU	108	186.7	172.9%	197.6	183.0%	10.1%	P7: Midway – Waterton 345kV Line #1 & Daniels Park – Fuller 230kV Line # 1
Vollmer – Black Squirrel 115kV # 1	Line	TSGT	173	213.7	123.5%	222.5	128.6%	5.1%	P7: Midway – Waterton 345kV Line #1 & Daniels Park – Fuller 230kV Line # 1
Vollmer – Fuller 115kV # 1	Line	TSGT	173	214.5	124%	223.5	129.2%	5.2%	P7: Midway – Waterton 345kV Line #1 & Daniels Park – Fuller 230kV Line # 1
West Canyon – Hogback 115kV # 1	Line	BHE	120	127.1	105.9%	134.2	111.8%	5.9%	P4: Midway – Fuller 230kV Breaker Failure
West Canyon 230/115kV # 1	Line	BHE	100	103.5	103.5%	111.2	111.2%	7.7%	P4: Midway – Fuller 230kV Breaker Failure

The multiple contingency analysis shows several new overloads and increases to existing and Study Case overloads after the addition of the Southern Colorado Pocket Cluster GIRs. PSCo is in the process of identifying system mitigations which may include automatic generation adjustments schemes for the PSCo multiple contingencies studies in Table 7 above. These future mitigations will address the existing and new overloads, all GIRs in the Southern Colorado study pocket may become part of the mitigations and included in automatic generation adjustments.

The RSC-2020-2 and RSC-2020-4 are ERIS requests, the study determined the maximum allowable output of each GIR by calculating the DFAX contribution of each GIR to the worst system overload seen in Table 6 above.
Palmer Lake – Monument 115kV line is the worst overload in Table 6 above. For this worst case overload, RSC-2020-2 has a DFAX value of 4.96% and RSC-2020-4 has a DFAX value of 7.32%.

Based on the DFAX and the overloads above, it was determined that for the stressed generation dispatch used in Table 5,

- the maximum output of RSC-2020-2 before Network Upgrades are needed is 23MW
- the maximum output of RSC-2020-4 before Network Upgrades are needed is 0MW

However, for less stressed dispatch conditions when the generation south of Comanche Substation is lower, the maximum output of 75MW for RSC-2020-2 and 53MW for RSC-2020-4 may be possible, depending on the available firm and non-firm capacity of the transmission system.

6.2.4 Affected Systems

There are no Affected Systems identified in the Southern Colorado study pocket analysis.

6.2.5 Summary of Analysis

The maximum ERIS identified for RSC-2020-2 is 75MW
The maximum ERIS identified for RSC-2020-4 is 53MW

6.3 Western Slope Study Pocket Analysis

6.3.1 Benchmark Case Modeling

The Benchmark Case for evaluating the Western Slope Study Pocket GIRs is developed from the Base Case described in Section 5.1 by changing the generation dispatch in the Western part of Colorado to reflect a West to East flows across TOT5. The study modeled the TOT5 path at a maximum of 1,680MW by adopting the generation dispatch in Table 8 below.

Table 8 – Generation Dispatch Used to Stress the Western Slope Study Pocket Benchmark Case (MW is Gross Capacity)

benchmark case	Path flow MW
TOT5 path	
Terry Ranch – North Park 230 KV line	166.6

Craig – Ault 345 KV line	529.1
Hayden East – Gorepass 230 KV line	354.6
Gorepass – Hayden 138 KV line	82.3
Hopkins – Malta 230 KV line	200.2
Basalt – Malta 230 KV line	81
Poncha – N.Gunnison 115 KV line	45.6
Curecant – Ponchabr 230 KV line	220.8
Total TOT5 path flow	**1,680**
Generation	**Pgen MW**
Craig 1	470
Craig 2	470
Craig 3	478
Hayden 1	202
Hayden 2	285
Bonanza	490
MBPP-1	221
MBPP-2	150
cabincreek A	160
cabincreek B	160
Blue Mesa 1	40
Blue Mesa 2	40
Morrow 1	72
Morrow 2	72
Elbert-1	90
Elbert-2	90

6.3.2 Study Case Modeling

The Study Case is created from the Benchmark Case by modeling RSC-2020-1 on the Tarryall – Hartsel 230kV line using the GIR modeling data provided by the Interconnection Customer. The 72MW output of the GIR is sunk to the PSCo Pawnee Generation in the Northern Colorado.

6.3.3 Steady State Analysis

The results of the single contingency analysis (P1 and P2-1) are given in Table 9 below.

Table 9 – Power Flow Analysis Results of Western Slope Study Pocket GIRs – Overloads Identified in Single Contingency Analysis

Overloaded Facility	Type	Owner	Facility Normal Rating (MVA)	Facility Loading in Benchmark Case		Facility Loading in Study Case		% Change due to Study Pocket GIRs	Single Contingency Definition
				MVA Flow	% Line Loading	MVA Flow	% Line Loading		
Cabin Creek 230/115 # T1	Xfmr	PSCo	54	57.4	106.3%	58.2	107.9%	1.5%	Cabin Creek – Dillon 230kV Line # 1
Cabin Creek – Dillon 230kV # 1	Line	PSCo	462	529.2	114.5%	536.1	116.0%	1.5%	Ault – Craig 345kV Line # 1
Henderson – Portal 115kV # 1	Line	PSCo	120	127.0	105.8%	128.7	107.3%	1.4%	Cabin Creek – Dillon 230kV Line # 1
Cabin Creek – IdahoSprings 230kV # 1	Line	PSCo	473	607.0	128.3%	615.4	130.1%	1.8%	Cabin Creek – Lookout 230kV Line # 1
Cabin Creek – Lookout 230kV # 1	Line	PSCo	478	603.7	126.3%	612.1	128.0%	1.8%	Cabin Creek – IdahoSprings 230kV # 1
Idaho Springs – Lookout 230kV # 1	Line	PSCo	473	586.5	124.0%	594.9	125.8%	1.8%	Cabin Creek – Lookout 230kV Line # 1
Tarryall 230/115kV # T1	xfmr	PSCo	100	91.5	91.5%	105.7	105.7%	14.2%	Tarryall – Waterton 230kV Line # 1

The results of the single contingency analysis (P1 and P2-1) are given in Table 9. The addition of RSC-2020-1 caused several overloads on the PSCo system. The facility overloads impacted by the addition of RSC-2020-1 are as follows:

- Cabin Creek 230/115kV Transformer #T1 loading increased from 106.3% to 107.9% (PSCo facility)
- Cabin Creek - Dillon 230 KV line loading increased from 114.5% to 116.0% (PSCo facility)
- Henderps - Portal 115 KV line loading increased from 105.8% to 107.3% (PSCo facility)
- Cabin Creek - Idaho Springs 230 KV line loading increased from 128.3% to 130.1% (PSCo facility)
- Cabin Creek - Lookout 230 KV line loading increased from 126.3% to 128.0% (PSCo facility)
- Idaho Springs - Lookout 230 KV line loading increased from 124.0% to 125.8% (PSCo facility)
- Tarryall 230/115kV transformer loading increased from 91.5% to 105.7% (PSCo facility)

Table 10 describes the mitigation measures used to address contingency overloads in Table 9. The Cabin Creek – Georgetown 115kV line and Cabin Creek generation reduction are existing TOT5 operating practices that are used by the Path Manager, Western Area Power Administration, when it conducts TOT5 seasonal and planning studies to achieve 1680MW.

Table 10 – TOT5 Mitigation Measures to Address Criteria Violations

Monitored Facility (Line or Transformer)	NERC Single Contingency	Mitigation Measure
Cabin Creek 230/115kV Transformer #T1	Cabin Creek – Dillon 230kV Line	Open the Cabin Creek-Georgetown 115kV line (Existing TOT5 Operating Practice)
Cabin Creek – Dillon 230kV Line	Ault – Craig 345kV Line	Project under development
Henderson – Portal 115kV Line	Cabin Creek – Dillon 230kV Line	Open the Cabin Creek-Georgetown 115kV line (Existing TOT5 Operating Practice)
Cabin Creek – Idaho Springs 230kV Line	Cabin Creek – Lookout 230kV Line	Reduce Cabin Creek generation (Existing TOT5 Operating Practice)
Cabin Creek – Lookout 230kV Line	Cabin Creek – Idaho Springs 230kV Line	Reduce Cabin Creek generation (Existing TOT5 Operating Practice)
Idaho Springs – Lookout 230kV Line	Cabin Creek – Lookout 230kV Line	Reduce Cabin Creek generation (Existing TOT5 Operating Practice)

Tarryall 230/115kV Tansformer	Tarryall – Waterton 230kV Line	Re-Dispatch RSC-2020-1 to reduce the overload (Proposed TOT5 Operating Practice)

The Cabin Creek-Dillon 230kV contingency overload in Table 9 is based on a reduced transmission line rating that is anticipated to begin in 2020-2021 as a result of PSCo changing its line rating methodology. PSCo is in the process of developing a planned upgrade to increase the line rating before 2022. The new rating on this will line will be adequate to eliminate the Study Case overloads caused by RSC-2020-1. If this project is delayed, the RSC-2020-1 output will be limited based on the firm and non-firm capacity available on the system.

The Tarryall 230-115kV transformer contingency overload occurs due to the combination of (i) very high TOT5 west-to-east flows (ii) RSC-2020-1 project at its maximum output (iii) outage of the Tarryall-Waterton 230kV line.

Similar to the existing Operating Practices developed for high west-to-east TOT5, re-dispatching the RSC-2020-1 output will be proposed as a new TOT5 operating practice, and therefore this study assumes RSC-2020-1 may be curtailed for an outage of the Tarryall – Waterton 230kV line. The RSC-2020-1 output may also be limited based on existing firm and non-firm capacity available on the system.

As the Western Slope study analysis models very high TOT5 flow, running multiple contingency analysis on such a stressed case may result in unrealistic overloads. Hence, only single contingency analysis is performed.

6.3.4 Affected Systems

There are no Affected Systems identified in the Western Slope study pocket analysis.

6.3.5 Summary of Analysis

The maximum ERIS identified for RSC-2020-1 is 72MW

The output is dependent on the completion of the Cabin Creek – Dillon 230kV line uprate project currently under development. Also, the future TOT5 studies may identify re-dispatching RSC-2020-1 as an operating practice to reduce the Tarryall 230/115kV transformer overload.

7.0 Generation Interconnection Service Cost Estimates and Assumptions

There are three types of costs identified in the study

- Transmission Provider's Interconnection Facilities which are directly assigned to each GIR
- 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
- All other Network Upgrades which are allocated by the proportional impact per Section 4.2.4(b) of the LGIP.

The total costs of Network Upgrades assigned under Sections 4.2.4(a) and 4.2.4(b) are given below

7.1 Total Costs of Network Upgrades

The estimated total cost of the Network Upgrades for Interconnection, by each POI are shown in Table 11.

Table 11 – Total cost of Station Network Upgrades by POI

POI	Total Cost	GIRs Sharing the POI
RSC-2020-1 230kV Switching Station	$18,174,000	RSC-2020-1
Tundra Switching Station	0	RSC-2020-2
Boone 230kV Substation	0	RSC-2020-4

No other Network Upgrades were identified in this study.

7.2 Cost Estimates of Station and Other Network Upgrades by GIR

Table 12 – Allocation of RSC-2020-1 230kV Switching Station Costs to each GIR

GIR	GIR MW	% Share per Section 4.2.4(a) of Attachment N	Costs allocated to GIR (% share x total costs from Table 11)
RSC-2020-1	72MW	100%	$18,174,000

Table 13 – Allocation of Tundra Switching Station Costs to each GIR

GIR	GIR MW	% Share per Section 4.2.4(a) of Attachment N	Costs allocated to GIR (% share x total costs from Table 11)
RSC-2020-2	75MW	100%	0

Table 14 – Allocation of Comanche 230kV Substation POI costs to each GIR

GIR	GIR MW	% Share per Section 4.2.4(a) of Attachment N	Costs allocated to GIR (% share x total costs from Table 11)
RSC-2020-4	53MW	100%	0

7.2.1 Summary of Transmission Provider's Interconnection Facilities and Network Upgrades Costs allocated to RSC-2020-1

The total cost of the required Upgrades for RSC-2020-1 to interconnect at the RSC-2020-1 230kV Switching Station is **$19.499 Million.**

- **The cost of Transmission Provider's Interconnection Facilities is $1.325 Million**
- **The cost of Station Network Upgrades is $18.174 Million**

Figure 2 is a conceptual one-line of the RSC-2020-1 POI at the RSC-2020-1 230kV Switching Station.

The list of improvements required to accommodate the interconnection of RSC-2020-1, the Customer's 72MW Solar PV Generating Facility are given in Tables 15a and 15b. A CPCN will be required to build the RSC-2020-1 230kV Switching Station to accommodate the interconnection. The estimated time frame for regulatory activities (CPCN) and to site, design, procure and construct the interconnection facilities (entire Project) is approximately 36 months after authorization to proceed has been obtained.

System improvements are subject to revision as a more detailed and refined design is produced.

Table 15a – RSC-2020-1 Transmission Provider's Interconnection Facilities

Element	Description	Cost Est. (Millions)
RSC-2020-1 230kV Switching Station	Interconnect Customer to tap at the Hartsel-Tarryall switching station 230kV bus. The new equipment includes: • One 230kV dead end and one girder • Three 230kV arresters • One 230kV 2000A Switch • One set (of three) high side metering units • Fiber communication equipment • Station controls • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures	$1.250

	• Associated transmission line communications, fiber, relaying and testing.	
	Transmission line tap into substation:	$0.055
	Siting and Land Rights support for siting studies, land and ROW acquisition and construction	$0.020
	Total Cost Estimate for Transmission Providers Interconnection Facilities	**$1.325**
Time Frame	**Site, design, procure and construct**	**36 Months**

Table 15b – RSC-2020-1 Station Network Upgrades

Element	Description	Cost Est. (Millions)
RSC-2020-1 230kV Switching Station	Install a new three position ring bus switching station on the 230kV Hartsel - Tarryall line. The new equipment includes: • Three 230kV 3000A circuit breakers • Nine 230kV 2000A disconnect switches (assume all switch stands will be installed) • Six 230kV CCVTs • Two Line Traps • Six 230kV Surge Arresters • Four Deadends / 2 DE Girder • One Electrical Equipment Enclosure • Station controls and wiring • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures	$15.782
RSC-2020-1 230kV Switching Station	Install required communications in the EEE at the new switching station	$0.588
PSCo's Hartsel 230kV Bus	Update primary line relaying on line to RSC 2020-1	$0.331
PSCo's Tarryall 230kV Bus	Update primary and secondary line relaying and associated breaker fail on line to RSC 2020-1	$0.616
RSC-2020-1 230kV Switching Station	Terminate the transmission line into the new switching station	$0.637
	Siting and Land Rights support for substation site acquisition, permitting, and construction	$0.220
	Total Cost Estimate for Network Upgrades for Interconnection	**$18.174**
Time Frame	**Site, design, procure and construct**	**36 Months**

7.2.2 Summary of Interconnection Facilities and Network Upgrades Costs allocated to RSC-2020-2

The total cost of the required Upgrades for RSC-2020-2 to interconnect at the Tundra Switching Station is **$50,000.**

- **The cost of Transmission Provider's Interconnection Facilities is $50,000**
- **The cost of Station Network Upgrades is 0**

The list of improvements required to accommodate the interconnection of RSC-2020-2, the Customer's 75MW incremental output in GI-2018-24 hybrid Generating Facility output at the POI are given in Tables 16a and 16b. The work needed to interconnect RSC-2020-2 only includes testing of fibre, communication and relaying installed for GI-2018-24 to accommodate the incremental 75MW output. A CPCN will not be required to accommodate RSC-2020-2 interconnection, but a CPCN is required for the Tundra 345kV Switching Station construction as identified for GI-2018-24. The interconnection of RSC-2020-2 is dependent on the construction of the Tundra 345kV Switching Station.

System improvements are subject to revision as a more detailed and refined design is produced.

Table 16a – RSC-2020-2 Transmission Provider's Interconnection Facilities

Element	Description	Cost Est. (Millions)
GI-2018-24's Tundra 345kV Switching Station	Interconnect RSC-2020-2 Generating Facility. The new equipment includes: • testing of communications, relays	$0.05
	Transmission line tap into substation:	0
	Siting and Land Rights support for siting studies, land and ROW acquisition and construction	0
	Total Cost Estimate for Transmission Providers Interconnection Facilities	**$0.05**
Time Frame	**Site, design, procure and construct**	**12 Months**

Table 16b – RSC-2020-2 Station Network Upgrades

Element	Description	Cost Est. (Millions)
N/A	N/A	0

	Siting and Land Rights support for substation construction	0
	Total Cost Estimate for Network Upgrades for Interconnection	**0**
Time Frame	**Site, design, procure and construct**	**N/A**

7.2.3 Summary of Interconnection Facilities and Network Upgrades Costs allocated to RSC-2020-4

The total cost of the required Upgrades for RSC-2020-4 to interconnect at the PSCo's existing Boone 230kV Substation is **$0.05 Million.**

- **The cost of Transmission Provider's Interconnection Facilities is $0.05 Million**
- **The cost of Station Network Upgrades is 0**

The list of improvements required to accommodate the interconnection of RSC-2020-4, the Customer's 53MW expansion of GI-2014-8 are given in Tables 17a and 17b. The work needed to interconnect RSC-2020-4 only includes testing of fibre, communication and relaying installed for GI-2014-8 to accommodate the 53MW interconnection. A CPCN will not be required to accommodate RSC-2020-4 interconnection. The interconnection of RSC-2020-4 is dependent on the construction of the construction of GI-2014-8 and associated Interconnection Facilities and Network Upgrades identified in the GI-2014-8 LGIA.

System improvements are subject to revision as a more detailed and refined design is produced.

Table 17a – RSC-2020-4 Transmission Provider's Interconnection Facilities

Element	Description	Cost Est. (Millions)
GI-2014-8 Boone POI	Interconnect RSC-2020-4 Generating Facility. The new equipment includes: • testing of communications, relays	$0.05
	Transmission line tap into substation:	0
	Siting and Land Rights support for siting studies, land and ROW acquisition and construction	0
	Total Cost Estimate for Transmission Providers Interconnection Facilities	**$0.05**
Time Frame	**Site, design, procure and construct**	**12 Months**

Table 17b – RSC-2020-4 Network Upgrades for Interconnection (ERIS)

Element	Description	Cost Est. (Millions)
N/A	• N/A	0
	Siting and Land Rights support for substation construction	0
	Total Cost Estimate for Network Upgrades for Interconnection	**N/A**
Time Frame	**Site, design, procure and construct**	**N/A**

8.0 Summary of Generation Interconnection Service Results

This report is the Phase 1 study results and does not include short circuit or stability analysis. If there is a change in status of one or more higher-queued Interconnection Requests due to withdrawal from the queue, a restudy of the power flow analysis will be performed as needed during Phase 2 and study results and costs will be updated.

The Customer is required to design and build the Generating Facility to mitigate for any potential inverter interactions with the neighboring inverter based Generating Facility(ies) and/or the inverters of the hybrid Generating Facility.

Interconnection Service in and itself does not convey transmission service.

8.1 Cost Estimate Assumptions

The PSCo Engineering has developed Indicative Level cost estimates (IE) for Interconnection Facilities and Network/Infrastructure Upgrades required for the interconnection of the RSC GIRs simultaneously on the transmission system. The cost estimates are in 2020 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 Customer owned equipment and associated design and engineering.

- There is no accuracy for IE's.
- Labor is estimated for straight time only – no overtime included.
- Lead times for materials were considered for the schedule.

- The RSC-2020-1, RSC-2020-2 and RSC-2020-4 Generating Facilities are not in PSCo's retail service territory. Therefore, no costs for retail load metering are included in these estimates.
- PSCo (or it's Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- Customer will install two (2) redundant fiber optics circuits into the Transmission provider's substation as part of its interconnection facilities construction scope.
- Breaker duty study determined that no breaker replacements are needed in neighboring substations.
- Line outages will be necessary during the construction period. Outage availability could potentially be problematic and extend requested backfeed date.
- 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 / Xcel will need indications, readings and data from the LFAGC RTU.

8.2 RSC-2020-1:

The total estimated cost of the transmission system improvements for RSC-2020-1: $19.499 Million (Tables 15a and 15b)

Energy Resource Interconnection Service of RSC-2020-1 is: 72MW (after required transmission system improvements in Table 15a and 15b)

Note: A CPCN is needed for the construction of the RSC-2020-1 230kV Switching Station. The estimated time frame for regulatory activities (CPCN) and to site, design, procure and construct the interconnection facilities (entire Project) is approximately 36 months after authorization to proceed has been obtained. Any delays in obtaining the CPCN may delay the COD of RSC-2020-1.

8.3 RSC-2020-2:

The total estimated cost of the transmission system improvements for RSC-2020-2 are: $0.05 Million (Tables 16a and 16b)

Energy Resource Interconnection Service of RSC-2020-2 is: 75MW (after required transmission system improvements in Table 16a and 16b)

Note: the maximum combined output of GI-2018-24 and RSC-2020-2 shall not exceed 325MW at any time, which will be limited using the Plant Controller. The GIR output will also be monitored by PSCo operations. Additional monitoring and control requirements will be added to the LGIA to ensure the Interconnection Service amount is not exceeded. The construction of the Tundra 345kV Switching Station for GI-2018-24 will require a CPCN and the estimated time frame for regulatory activities (CPCN) and to site, design, procure and construct the interconnection facilities is approximately 36 months after authorization to proceed has been obtained. Any delays in obtaining the CPCN may delay the COD of RSC-2020-2.

PSCo is in the process of identifying system mitigations which may include automatic generation adjustment schemes for the PSCo's multiple contingencies evaluated in Table 6. RSC-2020-2 may become part of the mitigations and included in automatic generation adjustments.

8.4 RSC-2020-4:

The total estimated cost of the transmission system improvements for RSC-2020-4 are: $0.05 Million (Tables 17a and 17b)

Energy Resource Interconnection Service of RSC-2020-2 is: 53MW (after required transmission system improvements in Table 17a and 17b).

The ERIS assumes GI-2014-12 LGIA is withdrawn if RSC-2020-4 moves forward. Also, the combination of GI-2014-8 and RSC-2020-4 at the Boone 230kV POI shall not exceed 113MW.

The interconnection of RSC-2020-2 is dependent on the construction of the construction of GI-2014-8 and associated Interconnection Facilities and Network Upgrades identified in the GI-2014-8 LGIA.

PSCo is in the process of identifying system mitigations which may include automatic generation adjustment schemes for the PSCo's multiple contingencies evaluated in Table 6. RSC-2020-4 may become part of the mitigations and included in automatic generation adjustments.

Figure 2 – Preliminary One-line of the RSC-2020-1 POI at the RSC-2020-1 230kV Switching Station