

DISIS-2020-002

Cluster Interconnection Facilities

Study Phase 4 Report

5/10/2022



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1.0 Introduction

PSCo has completed the Interconnection Facilities Studies for the Definitive Interconnection System Impact Study (DISIS) Cluster DISIS-2020-002. The results of the Interconnection Facilities Study for each interconnection will be provided through two reports, the Cluster Interconnection Facilities Study Phase 4 Report and the Individual Interconnection Facilities Study Phase 4 Report.

This Cluster Interconnection Facilities Study Phase 4 Report contains the results of the non-binding cost estimates, the electrical switching configuration of the connection equipment, and an estimate of the time required to complete the construction and installation to implement the conclusions of the final Phase 2 Report of all shared facilities in the DISIS-2020-002. The Individual Interconnection Facility Study Phase 4 Report for each DISIS-2020-002 Generator Interconnection Request (GIR) provides the information specific to each GIR to physically and electrically connect the Interconnection Facilities to the Transmission System.

The DISIS-2020-002 Definitive Interconnection Study Cluster includes five (5) GIRs: GI-2020-12, GI-2020-13, GI-2020-14, GI-2020-15, and GI-2020-16.

- GI-2020-12 is a 400 MWac net rated wind Generating Facility requesting Energy Resource Interconnection Service (ERIS). The requested Point of Interconnection (POI) is a tap on the Waterton–Midway 345 kV line.
- GI-2020-13 is a 374 MWac net rated AC-Coupled solar Photovoltaic (PV) plus Battery Energy Storage (BES) Generating Facility requesting ERIS. The requested POI is a tap on the Boone–Midway 230 kV line.
- GI-2020-14 is a 700 MWac net rated wind Generating Facility requesting ERIS. The requested POI is a tap on the Waterton–Midway 345 kV line.
- GI-2020-15 is a 250 MWac net rated wind Generating Facility requesting ERIS. The requested POI is a tap on the Fort Lupton–Pawnee 230 kV line.
- GI-2020-16 is a 199.5 MWac net rated solar PV Generating Facility requesting Network Resource Interconnection Service (NRIS). The requested POI is the Barr Lake 230 kV Substation.

The Interconnection Facilities Studies are based on the [DISIS-2020-002 Phase 2 Study Report](#) dated 8/26/2021 and [DISIS-2020-002 Phase 2 Study Report – Addendum](#) dated 9/14/2021.

There were no impacts to any Affected Systems under this DISIS-2020-002 Definitive Interconnection Study Cluster.

The scope of the Interconnection Facilities Studies, which is Phase 4 of the Definitive Interconnection Study process, includes non-binding cost estimates and construction schedules of the Interconnection Facilities and Network Upgrades.



This Cluster Interconnection Facilities Study Report provides the following information:

1. Cost estimates and assumptions applicable to all GIRs in DISIS-2020-002
2. Station Network Upgrades per Section 4.2.4.a of Attachment N Revised Standard Large Generator Interconnection Procedures (LGIP) applicable to GIRs sharing common facilities and associated one-line diagrams
3. Network Upgrades per Section 4.2.4.b of Attachment N Revised LGIP only applicable to GIRs sharing common facilities
4. Contingent Facilities applicable to all GIRs in DISIS-2020-002

2.0 Cost Estimates and Assumptions

The cost estimates provided in this Cluster Interconnection Facilities Study Report and the Individual Interconnection Facility Study Reports are based on the following assumptions:

- The cost estimates are in 2022 dollars with an escalation percentage and contingencies applied to the cost estimates.
- The cost estimates do not include an Allowance for Funds Used During Construction (AFUDC).
- The estimated costs include all applicable labor and overheads associated with the siting, engineering, design, and construction of the PSCo facilities to facilitate interconnection.
- The estimated costs do not include the cost for any Customer owned equipment and associated design and engineering.
- Labor is estimated at straight time only, no overtime work is included.
- Lead times for materials were considered for the schedule.
- No costs for retail load metering are included in these estimates.
- PSCo (or its Contractor) will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- A Certificate of Public Convenience and Necessity (CPCN) may be required for the construction of the Interconnection Facilities and Station Network Upgrades. The expected time to obtain a CPCN approval is 18 months.
- The estimated time to permit, design, procure and construct the interconnection facilities is approximately 18 months after authorization to proceed (post CPCN) has been obtained.
- Customer will install two (2) redundant fiber optic circuits into the Transmission Provider's substation as part of its interconnection facilities construction scope.
- Power Quality Metering (PQM) will be required on the Customer's generation tie-line terminating into the POI.
- The Customer will be required to design, procure, install, own, operate and maintain a Load Frequency/Automated Generation Control (LF/AGC) RTU at their Customer substation. PSCo will be provided with indications, readings and data from the LF/AGC RTU.

3.0 Station Network Upgrade Costs

The Station Network Upgrade costs are allocated per-capita based on the number of Generation Facilities interconnecting at an individual station in accordance with Section 4.2.4.a of Attachment N Revised LGIP. If no allocation table is provided, then the GIR is allocated all of the Station Network Upgrade costs associated with the POI.

Table 3.1 – Total Cost of Station Network Upgrades by POI

POI	Total Cost (million)	GIRs Sharing the POI
GI-2020-12/GI-2020-14 345 kV Switching Station	\$41.853	GI-2020-12 and GI-2020-14
GI-2020-13 230 kV Switching Station	\$19.319	GI-2020-13
GI-2020-15 230 kV Switching Station	\$21.129	GI-2020-15
Barr Lake 230 kV Substation	\$7.617	GI-2020-16

3.1 GI-2020-12/GI-2020-14 345 kV Switching Station

The estimated total cost and details of the Station Network Upgrades required at the GI-2020-12/GI-2020-14 345 kV Switching Station, tapping the Midway–Waterton 345 kV line and the Daniels Park–Comanche 345 kV line, are shown in Table 3.1.1. These Station Network Upgrade costs are shared by GI-2020-12 and GI-2020-14 on a per-capita basis in accordance with Section 4.2.4.a. of Attachment N Revised LGIP, as shown in Table 3.1.2. Figure 3.1.1 provides the preliminary one-line diagram of the GI-2020-12/GI-2020-14 345 kV Switching Station showing POIs of GI-2020-12 and GI-2020-14.

Table 3.1.1 – Station Network Upgrades – GI-2020-12 /GI-2020-14 345 kV Switching Station

Element	Description	Cost Est. (million)
PSCo's GI-2020-12/GI-2020-14 345 kV Switching Station	Install a new 345 kV Switching Station tapping the Waterton–Midway 345 kV line 7017 and the Daniels Park–Comanche 345 kV line 7051. The new equipment includes: <ul style="list-style-type: none"> • (4) 345 kV deadend structures • (10) 345 kV 3,000 A circuit breakers • (20) 345 kV 3,000 A disconnect switches • (12) 345 kV CCVTs • (2) 345 kV SSVTs • (12) 345 kV surge arresters • (1) Electrical Equipment Enclosure (EEE) • (4) Wave traps • Station controls and wiring • Associated foundations and structures 	\$25.591
PSCo's GI-2020-12/GI-2020-14 345 kV Switching Station	Install required communication in the EEE at the GI-2020-12/14 345 kV Switching Station	\$0.552
PSCo's GI-2020-12/GI-2020-14 345 kV Switching Station	Tap lines 7017 and 7051 and route into GI-2020-12/GI-2020-14 345 kV Switching Station. Reconfiguration of lines to accommodate tap and routing lines 7017 and 7051 into the switching station includes raising line 7015 and moving line 5119 further west out of the alignment. Deadend structures added for lines 7017 and 7051 to cross under line 7015 entering the GI-2020-12/GI-2020-14 345 kV Switching Station	\$8.948
PSCo's Midway 345 kV Substation	Remote end upgrade for 7051 at Midway 345 kV Substation	\$1.545
PSCo's Comanche 345 kV Substation	Remote end upgrade for 7017 at Comanche 345 kV Substation	\$1.543
PSCo's Daniels Park 345 kV Substation	Remote end upgrade for 7017 at Daniels Park 345 kV Substation.	\$1.586
	Siting and Land Rights support for substation construction	\$2.088
Total Cost Estimate for PSCo-Funded, PSCo-Owned Interconnection Facilities		\$41.853
Time Frame	Site, design, procure and construct	36 Months*

*Construction of the GI-2020-12/GI-2020-14 345 kV Switching Station requires a CPCN from the Colorado Public Utilities Commission. The total time to obtain a CPCN, site, design, procure and construct the GI-2020-12/GI-2020-14 345 kV Station is expected to take up to 36 months.

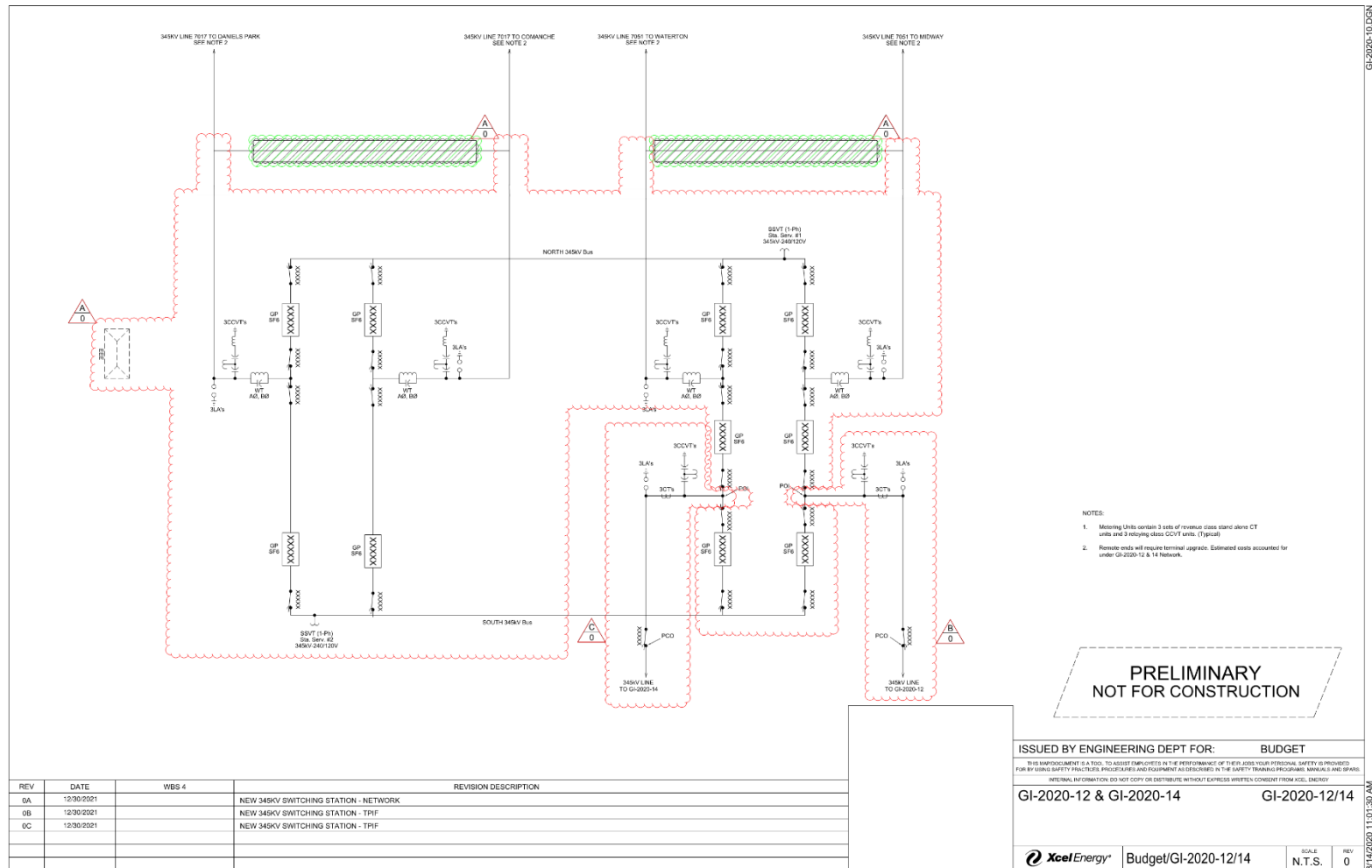
The following change was made to the cost allocation from the DISIS-2020-002 Phase 2 Report:

- The cost for the allocation of GI-2020-12/GI-2020-14 345 kV Switching Station between GI-2020-12 and GI-2020-14 has been allocated at 50 percent to each, GI-2020-12 and GI-2020-14. Per Section 4.2.4.a of Attachment N Revised LGIP, “Station equipment Network Upgrades, including all switching stations, shall be allocated based on the number of GIRs interconnecting at an individual station on a per capita basis (i.e. on a per Interconnection Request basis).” This cost was inadvertently allocated incorrectly in the DISIS-2020-002 Phase 2 Report based upon the generating capacity of each GIR.

Table 3.1.2 – Allocation of GI-2020-12/GI-2020-14 345 kV Switching Station Cost by GIR

GIR	GIR MW	% Share	Costs allocated to GIR (million)
GI-2020-12	400	50%	\$20.926
GI-2020-14	700	50%	\$20.926

Figure 3.1.1 – Preliminary One-line of the GI-2020-12/GI-2020-14 345 kV Switching Station showing POIs of GI-2020-12 and GI-2020-14



3.2 GI-2020-13 230 kV Switching Station

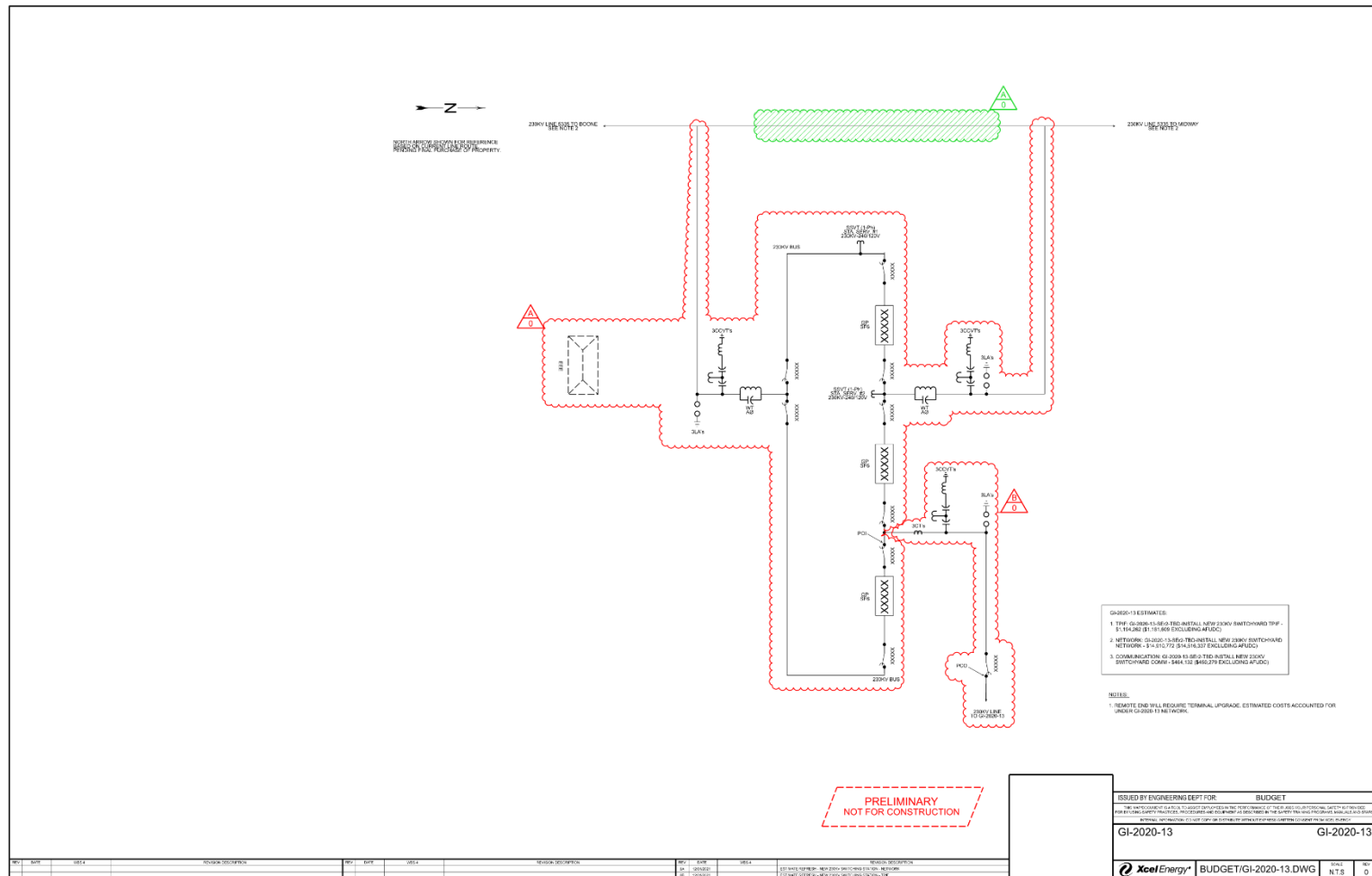
The estimated total cost and details of the Station Network Upgrades required at the GI-2020-13 230 kV Switching Station tapping the Boone–Midway 230 kV line are shown in Table 3.2.1. These Station Network Upgrade costs are 100% assigned to GI-2020-13 in accordance with Section 4.2.4.a. of Attachment N Revised LGIP. Figure 3.2.1 provides the preliminary one-line diagram of the GI-2020-13 230 kV Switching Station showing POI of GI-2020-13.

Table 3.2.1 – Station Network Upgrades – GI-2020-13 230 kV Switching Station

Element	Description	Cost Est. (million)
PSCo's GI-2020-13 230 kV Switching Station	Install a new 230 kV Switching Station tapping the Boone – Midway 230 kV line. The new equipment includes: <ul style="list-style-type: none"> • (9) 230 kV deadend structures • (3) 230 kV 3,000 A circuit breakers • (8) 230 kV 3,000 A disconnect switches • (6) 230 kV CCVTs • (2) 230 kV SSVTs • (6) 230 kV surge arresters • (1) Electrical Equipment Enclosure (EEE) • (2) Wave traps • Station controls and wiring • Associated foundations and structures 	\$14.516
PSCo's GI-2020-13 230 kV Switching Station	Install required communication in the EEE at the GI-2020-13 230 kV Switching Station	\$0.450
PSCo's GI-2020-13 230 kV Switching Station	Tap line 5335 and route into GI-2020-13 230 kV Switching Station	\$1.476
PSCo's Boone 230kV Substation	Remote end upgrade for 5335 at Boone 230 kV Substation	\$1.003
PSCo's Midway 230 kV Substation	Remote end upgrade for 5335 at Midway 230 kV Substation	\$1.003
	Siting and Land Rights support for substation construction	\$0.871
Total Cost Estimate for PSCo-Funded, PSCo-Owned Interconnection Facilities		\$19.319
Time Frame	Site, design, procure and construct	36 Months*

*Construction of the GI-2020-13 230 kV Switching Station requires a CPCN from the Colorado Public Utilities Commission. The total time to obtain a CPCN, site, design, procure and construct the GI-2020-13 230 kV Switching Station is expected to take up to 36 months.

Figure 3.2.1 – Preliminary One-line of the GI-2020-13 230 kV Switching Station showing GI-2020-13 POI



3.3 GI-2020-15 230 kV Switching Station

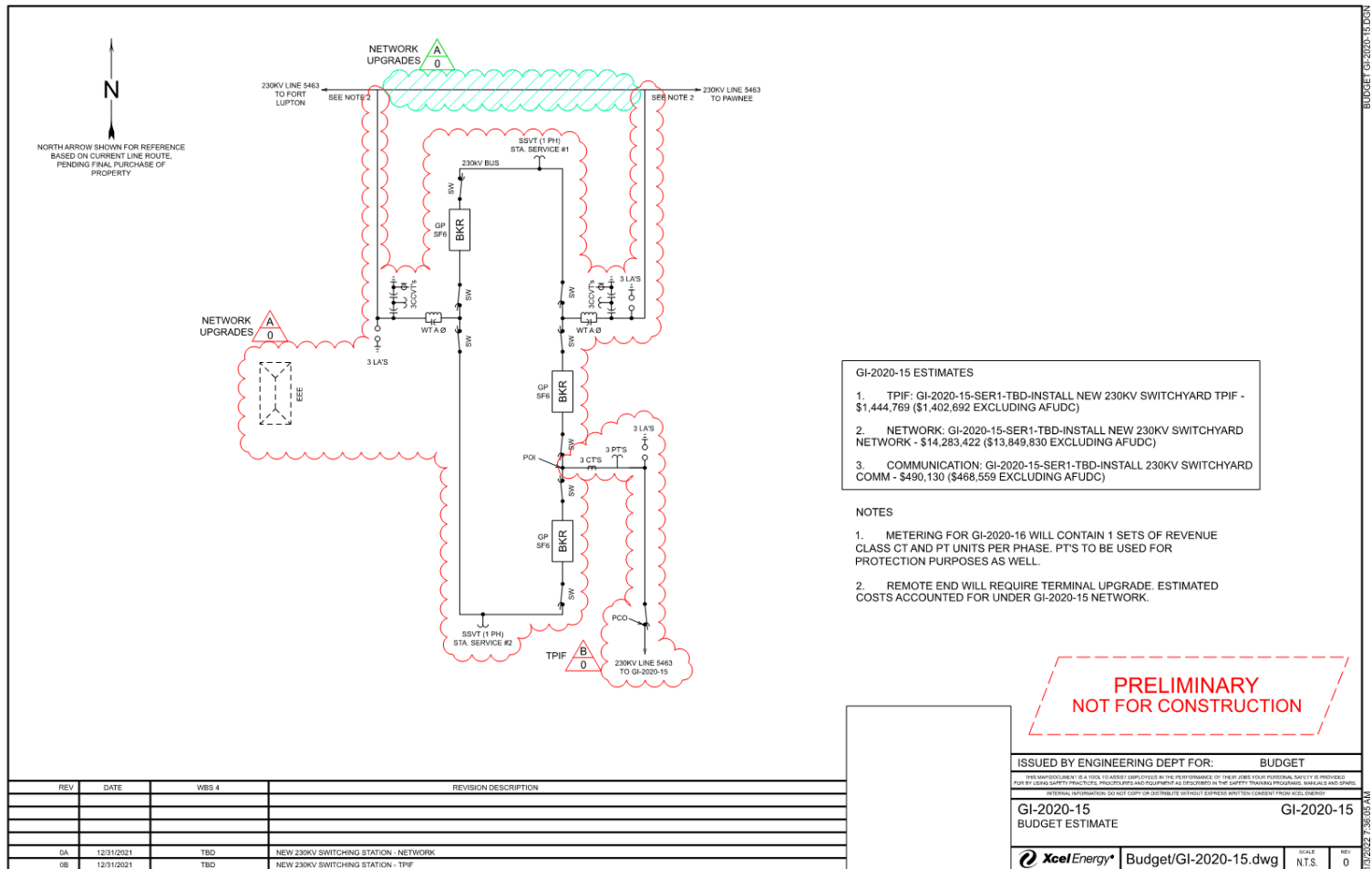
The estimated total cost and details of the Station Network Upgrades required at the GI-2020-15 230 kV Switching Station tapping the Fort Lupton–Pawnee 230 kV line are shown in Table 3.3.1. These Station Network Upgrade costs are 100% assigned to GI-2020-15 in accordance with Section 4.2.4.a. of Attachment N Revised LGIP. Figure 3.3.1 provides the preliminary one-line diagram of the GI-2020-15 230 kV Switching Station showing POI of GI-2020-15.

Table 3.3.1 – Station Network Upgrades – GI-2020-15 230 kV Switching Station

Element	Description	Cost Est. (million)
PSCo's GI-2020-15 New 230 kV Switching Station	Install a new 230 kV Switching Station tapping the Fort Lupton–Pawnee 230 kV line. The new equipment includes: <ul style="list-style-type: none"> • (8) 230 kV deadend structures • (3) 230 kV 3,000 A circuit breakers • (8) 230 kV 3,000 A disconnect switches • (6) 230 kV CCVTs • (2) 230 kV SSVTs • (6) 230 kV Surge Arresters • (1) Electrical Equipment Enclosure (EEE) • (2) Wave traps • Station controls and wiring • Associated foundations and structures 	\$13.850
PSCo's GI-2020-15 New 230 kV Switching Station	Install required communication in the EEE at the GI-2020-15 230 kV Switching Station	\$0.469
PSCo's GI-2020-15 New 230 kV Switching Station	Tap line 5463 and route into GI-2020-15 230 kV Switching Station	\$2.630
PSCo's Fort Lupton 230 kV Substation	Remote end upgrade for 5463 at Fort Lupton 230 kV Substation	\$1.303
PSCo's Pawnee 230 kV Substation	Remote end upgrade for 5463 at Pawnee 230 kV Substation	\$1.289
	Siting and Land Rights support for substation construction	\$1.588
Total Cost Estimate for PSCo-Funded, PSCo-Owned Interconnection Facilities		\$21.129
Time Frame	Site, design, procure and construct	36 Months*

*Construction of the GI-2020-15 230 kV Switching Station requires a CPCN from the Colorado Public Utilities Commission. The total time to obtain a CPCN, site, design, procure and construct the GI-2020-15 230 kV Switching Station is expected to take up to 36 months.

Figure 3.3.1 – Preliminary One-line of the GI-2020-15 230 kV Switching Station showing GI-2020-15 POI



3.4 Barr Lake 230 kV Substation Upgrade

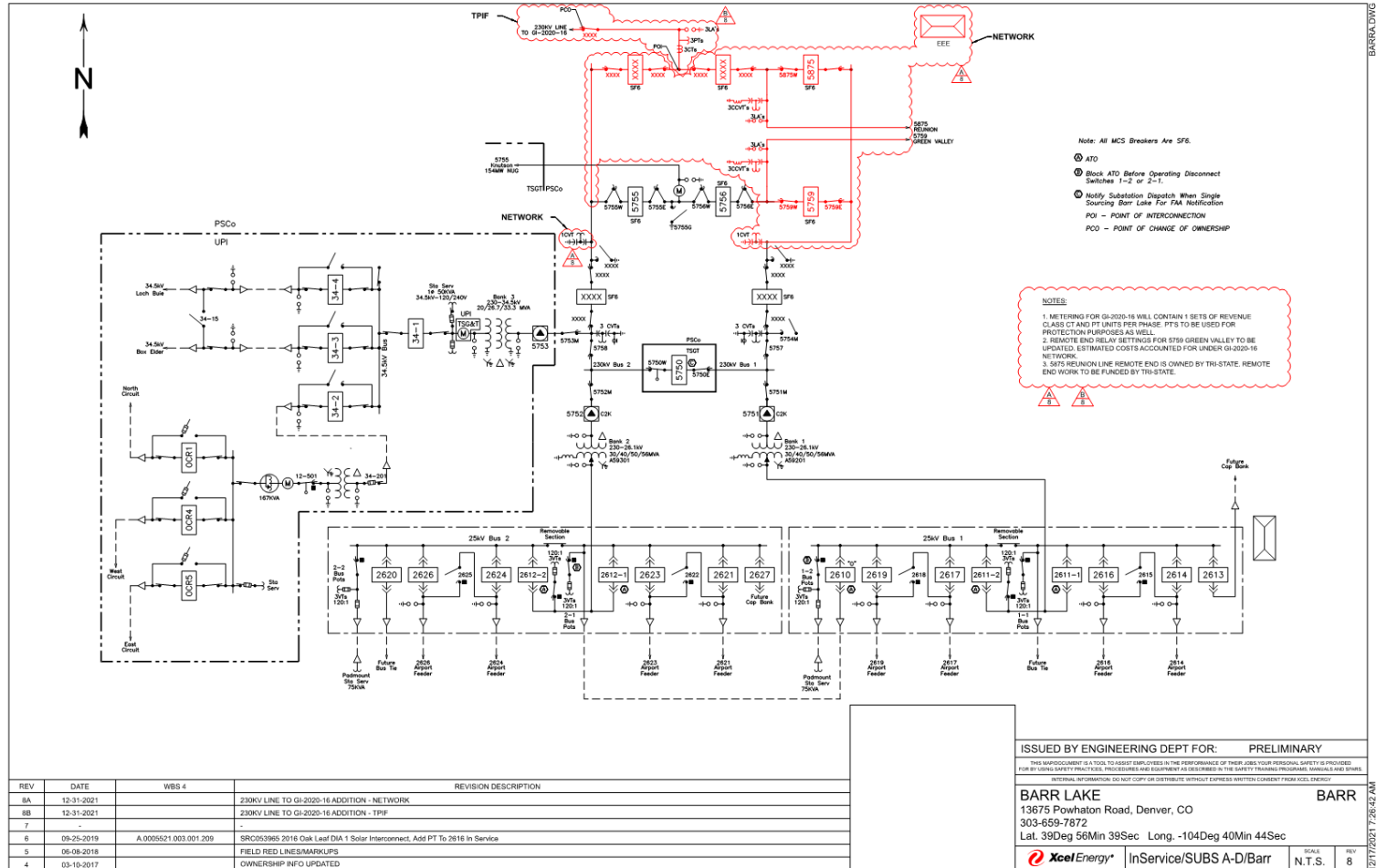
The estimated total cost and details of the Station Network Upgrades required at the Barr Lake 230 kV Substation are shown in Table 3.4.1. These Station Network Upgrade costs are 100% assigned to GI-2020-16 in accordance with Section 4.2.4.a. of Attachment N Revised LGIP. Figure 3.4.1 provides the preliminary one-line diagram of the Barr Lake 230 kV Substation showing POI of GI-2020-16.

Table 3.4.1 – Station Network Upgrades – Barr Lake 230 kV Substation

Element	Description	Cost Est. (million)
PSCo's Barr Lake 230 kV Substation	Expand Barr Lake 230 kV Substation to accommodate GI-2020-16. The new equipment includes: <ul style="list-style-type: none"> • (3) 230 kV deadend structures • (4) 230 kV 3,000 A circuit breakers • (8) 230 kV 3,000 A disconnect switches • (6) 230 kV CCVTs • (2) 230 kV CVTs • (6) 230 kV surge arresters • (1) Electrical Equipment Enclosure (EEE) • Station controls and wiring • Associated foundations and structures 	\$4.833
PSCo's Barr Lake 230 kV Substation	Upgrade required communication in the EEE at the Barr Lake 230 kV Substation	\$0.433
PSCo's Barr Lake 230 kV Substation	Line reconfiguration to accommodate Interconnection Customer	\$0.949
PSCo's Green Valley Substation	Remote end upgrade for 5759 at Green Valley 230 kV Substation	\$1.157
Tri-State G&T's Reunion Substation	Reunion 5875 Line Terminal Upgrade	\$0.100
	Siting and Land Rights support for substation construction	\$0.145
Total Cost Estimate for PSCo-Funded, PSCo-Owned Interconnection Facilities		\$7.617
Time Frame	Site, design, procure and construct	36 Months*

* Since the Barr Lake Substation will be expanded to interconnect GI-2020-16, it is expected that the expansion work may require a CPCN from the Colorado Public Utilities Commission. The total time to obtain a CPCN, site, design, procure and construct the Barr Lake Substation expansion is expected to take up to 36 months.

Figure 3.4.1 – Preliminary One-line of the GI-2020-16 at the Barr Lake 230 kV Substation showing GI-2020-16 POI



4.0 System Network Upgrades

The estimated total cost and details of the System Network Upgrades and GIRs sharing the cost are shown in Tables 4.1 and 4.2. The total cost of system network upgrades by GIR are shown in Table 4.3. The System Network Upgrade costs are allocated based on the proportional impact of each individual Generation Facility in the Cluster Study in accordance with Section 4.2.4.b of Attachment N Revised LGIP. The total time to site, design, procure and construct the upgrades is expected to take up to 36 months.

The following change was made to the cost allocations from the DISIS-2020-002 Phase 2 Report:

- The cost for “Terminal Upgrades at Comanche and Daniels Park Substations to allow looping of the Comanche–Daniels Park 345 kV line into GI-2020-12/GI-2020-14 345 kV Switching Station” have been included as Station Network Upgrades for the GI-2020-12/GI-2020-14 345 kV Switching Station and allocated to GI-2020-12 and GI-2020-14 in accordance with Section 4.2.4.a of Attachment N Revised LGIP. This cost was inadvertently included in the DISIS-2020-002 Phase 2 Report as an Other Network Upgrade and allocated between GI-2020-12, GI-2020-13, and GI-2020-14 in accordance with Section 4.2.4.b. of Attachment N Revised LGIP.

Table 4.1 – Total Cost of System Network Upgrades

Element	Description	Cost Est. (million)	GI-2020-12 Impact	GI-2020-13 Impact	GI-2020-14 Impact	GI-2020-15 Impact	GI-2020-16 Impact
PSCo's Waterton Substation	Add second Waterton 345/230 kV, 560 MVA xfmr	\$18.174	32.0%	16.8%	51.2%	0	0
Boone–GI-2020-13 230 kV Line	Uprate Boone–GI-2020-13 230 kV line to 394 MVA	\$0.171	0	100%	0	0	0
Cherokee 230 kV Breakers	Replace the four 230 kV Circuit Breakers identified as overstressed due to DISIS-2020-002 addition	\$3.520	20.7%	0%	24.4%	13.9%	41.0%
Arapahoe 230 kV Breakers	Replace the one 230 kV Circuit Breakers identified as overstressed due to DISIS-2020-002 addition	\$0.880	28.9%	0.8%	33.9%	8.8%	27.7%
Midway 230 kV Breakers	Replace the two 230 kV Circuit Breakers identified as overstressed due to DISIS-2020-002 addition	\$1.760	20.4%	53.8%	24.1%	0.6%	1.1%
Smoky Hill 230 kV Breakers	Replace the nine 230 kV Circuit Breakers identified as overstressed due to DISIS-2020-002 addition	\$7.920	30.8%	1.4%	36.2%	10.9%	20.7%
Barr Lake 230 kV Breakers	Replace the two 230 kV Circuit Breakers identified as overstressed due to DISIS-2020-002 addition	\$1.760	0.5%	0%	0.6%	0.5%	98.4%
Lookout 115 kV Breakers	Replace the three 115 kV Circuit Breakers identified as overstressed due to DISIS-2020-002 addition	\$2.310	28.7%	0%	33.9%	8.6%	28.7%

Table 4.2 – Allocation of Cost of System Network Upgrades

System Network Upgrade	GIR	% Share	Costs Allocated to GIR (million)
Add second Waterton 345/230 kV, 560 MVA xfmr	GI-2020-12	32.0%	\$5.816
	GI-2020-13	16.8%	\$3.053
	GI-2020-14	51.2%	\$9.305
Uprate Boone—GI-2020-13 230 kV line to 394 MVA	GI-2020-13	100%	\$0.171
Cherokee 230 kV breakers	GI-2020-12	20.7%	\$0.729
	GI-2020-14	24.4%	\$0.859
	GI-2020-15	13.9%	\$0.489
	GI-2020-16	41.0%	\$1.443
Arapahoe 230 kV breakers	GI-2020-12	28.9%	\$0.254
	GI-2020-13	0.8%	\$0.007
	GI-2020-14	33.9%	\$0.298
	GI-2020-15	8.8%	\$0.077
	GI-2020-16	27.7%	\$0.244
Midway 230 kV breakers	GI-2020-12	20.4%	\$0.359
	GI-2020-13	53.8%	\$0.947
	GI-2020-14	24.1%	\$0.424
	GI-2020-15	0.6%	\$0.011
	GI-2020-16	1.1%	\$0.019
Smoky Hill 230 kV breakers	GI-2020-12	30.8%	\$2.439
	GI-2020-13	1.4%	\$0.111
	GI-2020-14	36.2%	\$2.867
	GI-2020-15	10.9%	\$0.863
	GI-2020-16	20.7%	\$1.639
Barr Lake 230 kV breakers	GI-2020-12	0.5%	\$0.009
	GI-2020-14	0.6%	\$0.011
	GI-2020-15	0.5%	\$0.009
	GI-2020-16	98.4%	\$1.732
Lookout 115 kV breakers	GI-2020-12	28.7%	\$0.663
	GI-2020-14	33.9%	\$0.783
	GI-2020-15	8.6%	\$0.199
	GI-2020-16	28.7%	\$0.663

Table 4.3 – Total Cost of System Network Upgrades by GIR

GIR	Costs allocated to GIR (million)
GI-2020-12	\$10.269
GI-2020-13	\$4.289
GI-2020-14	\$14.547
GI-2020-15	\$1.648
GI-2020-16	\$5.740

5.0 Contingent Facilities

The following is the list of the unbuilt Interconnection Facilities and Network Upgrades upon which the costs, timing, and study findings of DISIS-2020-002 is dependent, and if delayed or not built, could cause a need for re-studies of the Interconnection Request or a reassessment of the Interconnection Facilities and/or Network Upgrades and/or costs and timing.

GI-2020-15 and GI-2020-16: There are no unbuilt facilities modeled in the Northern Colorado Study Pocket. The Contingent Facilities identified for GI-2020-15 and GI-2020-16 include the Interconnection Facilities, Station Upgrades and Network Upgrades identified for the respective GIR in this report.

GI-2020-12, GI-2020-13 and GI-2020-14: The Contingent Facilities identified for these GIRs are:

1. The following unbuilt transmission projects modeled in the study were identified as Contingent Facilities for GI-2020-12, GI-2020-13 and GI-2020-14 (in-service dates are estimated based on requests and subject to change):
 - Monument–Flying Horse 115 kV Series Reactor—ISD 2024
 - Greenwood–Arapahoe – Denver Terminal 230 kV line—ISD 2022
 - Upgrade Allison–Soda Lakes 115 kV line to 318 MVA—ISD 2022
 - Upgrade Daniels Park–Priarie1 230 kV line to 756 MVA—ISD 2023
 - Upgrade Greenwood–Priarie1 230 kV line to 576 MVA—ISD 2023
 - Upgrade Daniels Park–Priarie3 230 kV line to 576 MVA—ISD 2023
 - Upgrade Greenwood–Priarie3 230 kV line to 576 MVA—ISD 2023
 - Upgrade Midway 230 kV bus tie to 576 MVA—ISD 2023
 - Fuller 230/115 kV, 100 MVA #2 transformer—ISD 2023
 - The Cottonwood – Tesla 34.5 kV line is modeled open and Kettle Creek–Tesla 34.5 kV line is modeled closed on the CSU system—ISD 2023
 - Briargate S 115/230 kV transformer project tapping the Cottonwood–Fuller 230 kV line—ISD 2023
2. Station Network Upgrades identified for the respective GIRs in this report.
3. Other Network Upgrades identified for the respective GIRs in this report.