APPENDIX G: Description and Functional Specifications for Transmission Facilities Eligible for Competitive Solicitation

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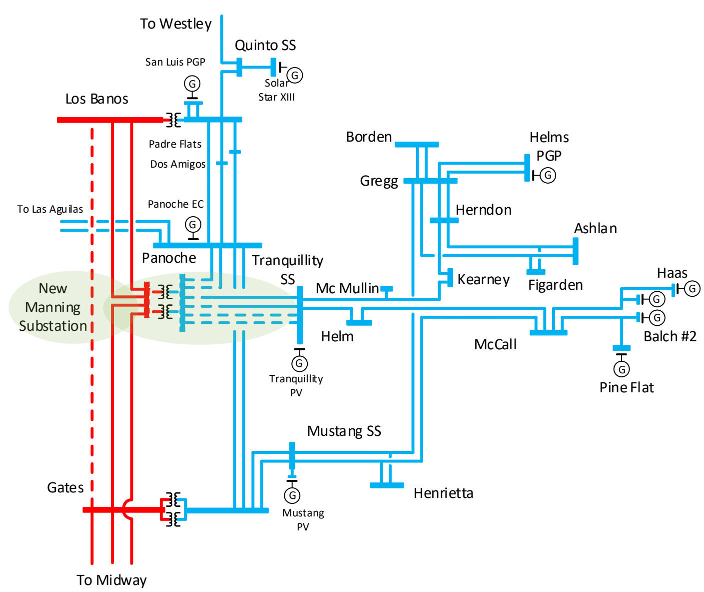
G1 Description and Functional Specifications of Proposed Policy-Driven Manning 500/230 kV Substation Project

G1.1 Description

In the 2021-2022 Transmission Plan, the ISO has identified a policy-driven need for the Manning 500/230 kV substation project to address overloads on the Borden-Storey 230 kV lines under normal and N-1 contingency conditions. The project also provides benefit in allowing for the advancement of renewable generation within the Westlands / San Joaquin area. Figure G1.1. provides a schematic diagram of the transmission system in the area. As shown in the figure, the project scope includes the followings:

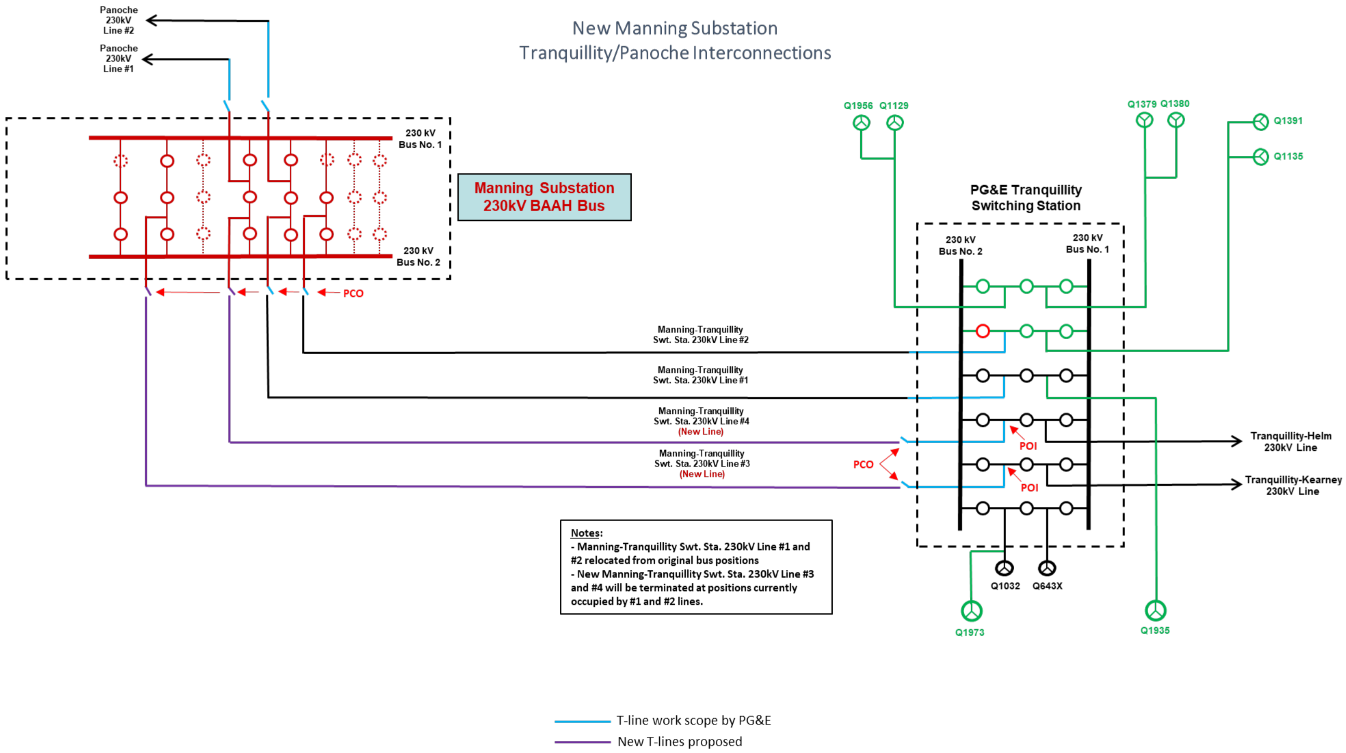
- A new Manning 500/230 kV substation
- Looping in the Los Banos – Midway #2 and the Los Banos – Gates #1 500 kV lines into Manning substation
- Add series capacitor to each of the Manning – Los Banos 500 kV lines. PG&E will adjust the existing series capacitors on the lines to keep the overall compensation constant.
- Two 500/230 kV Transformers
- A new double circuit 230 kV line between Manning and Tranquillity substations
- Looping in two existing Panoche – Tranquillity 230 kV line into Manning substation and reconductor the Manning – Tranquillity 230 kV lines. While this component is part of the overall scope of the project but since these are existing PG&E lines, this will be assigned to PG&E.

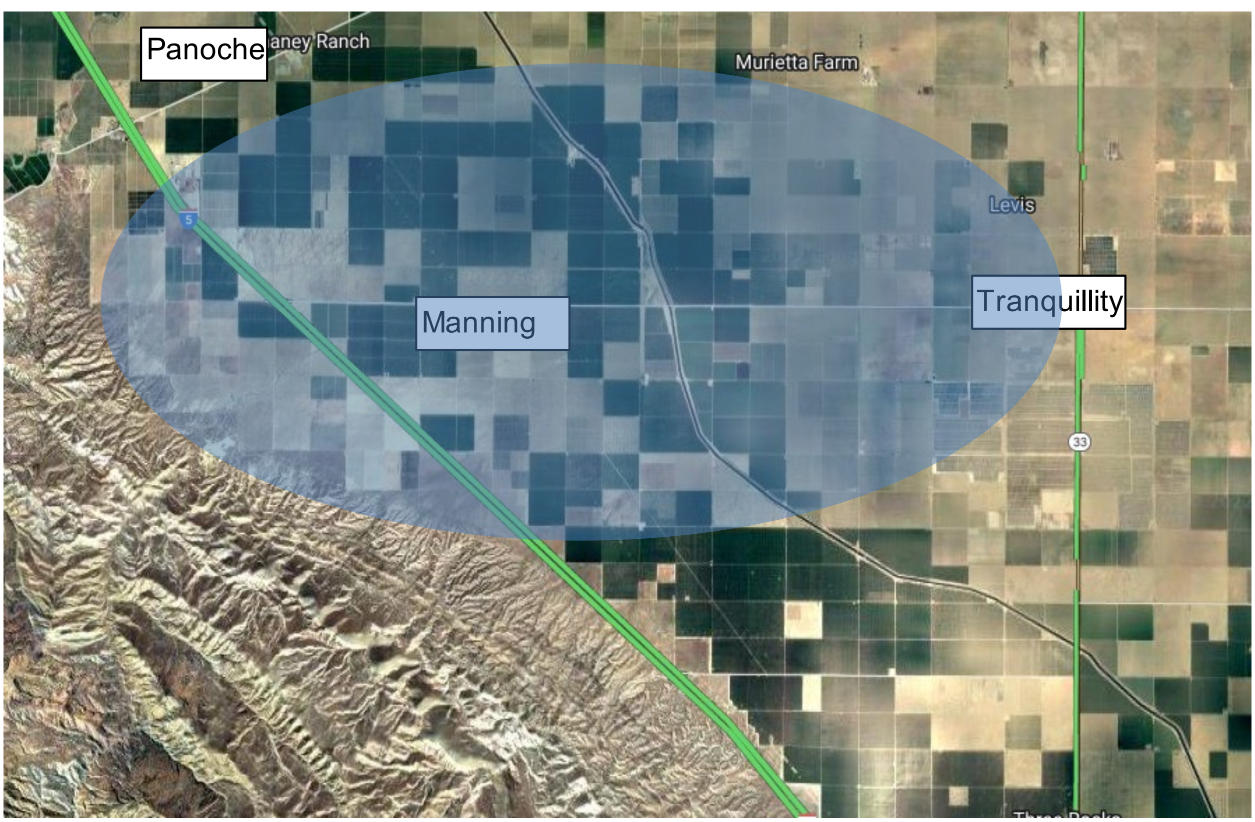
Figure G1-1: Location of Manning 500/230 kV Substation Project



The ISO estimates that the proposed project will approximately cost $325 to $485 million. The project is to be in-service no later than June of 2028. Figure G1-2 provides a schematic diagram of the interconnection to Tranquillity 230 kV substation and an approximate area for the location of the Manning substation.

Figure G1-2: Interconnection to Tranquillity 230 kV Substation and Approximate Area for the Location of Manning Substation





G1.2 Functional Specification for Manning 500/230 kV Substation Project

Manning Substation:

Nominal Phase to Phase Voltage: 500/230 kV

500 kV and 230 kV Initial Bus Configuration: Breaker and a half (BAAH)

500 kV and 230 kV Ultimate Bus Configuration: BAAH

Initial Number of 500 kV Lines: 4

Ultimate Number of 500 kV Lines: 8

Initial Number of 500 kV CBs: 10

Ultimate Number of 500 kV CBs: 18

Initial Number of 230 kV Lines: 6

Ultimate Number of 230 kV Lines: 10

Initial Number of 230 kV CBs: 13

Ultimate Number of 230 kV CBs: 24

Initial Minimum Bus Ampacity: ___3800A ___ Ultimate Bus Ampacity: ____3800A___

Minimum CB Ampacity: ____3000A ___ Minimum CB Interrupting Capability: ___63 kA__

Transfer Bus Required (SBSB only): N/A

Station Minimum BIL: 900 kV

Initial Reactive Power Requirements: None

Ultimate Reactive Power Requirements: To be determined

Telemetering Requirements: Install necessary equipment, including RTUs to monitor the typical bulk power elements such as MW, MVAr, and phase currents (Amps) at each line and also voltages (kV) at lines and buses and all circuit breaker (CB) status/control, protection relays statuses and alarms. The installed equipment must be capable of transmitting information to the appropriate Control Center.

Latest In Service Date: June 1, 2028

Low Profile Required: Subject to local permitting requirements

Gas Insulation Required: No, but if proposed shall be enclosed

Initial Number of Transformers: 3, including spare

Ultimate Number of Transformers: 3, including spare

Transformer Nominal Low Winding Phase to Phase Voltage: 230 kV

Tertiary Winding Required: ___No____ Nominal Voltage Rating: __N/A______

Primary Voltage Winding (wye, grounded wye, delta, etc): Grounded Wye

Secondary Voltage Winding: Grounded Wye Tertiary Voltage Winding: Corner Grounded Delta

Maximum Transformer % IZ: ____ 17% ______ Minimum Transformer %IZ: ___ 13% ___

Minimum Transformer Normal Rating: ___ 1100 MVA ____ Minimum Transformer 4-hour Emergency Rating: ___ 1300 MVA _____ LTC Required: ___ No ______

No Load Taps Required: 5 NLTs with two 2.5% taps above & below nominal voltage of 230 kV

CIP 14 requirement: The substation perimeter shall be fenced by a wall

Location of Series Compensation: Manning Substation. The cost of the series compensation is within the scope of this project and will be the responsibility of the approved project sponsor.

Minimum Series Capacitor Continuous Ampacity - Summer: 2700 A

Minimum Series Capacitor Continuous Ampacity – Winter: 2700 A

Minimum Series Capacitor 30 Minute Emergency Ampacity – Summer: 4000 A

Minimum Series Capacitor 30 Minute Emergency Ampacity – Winter: 4000 A

230 kV Transmission Line Functional Specifications - new Manning – Tranquillity lines

Overhead Line Construction

Line Terminus 1: Manning Substation 230 kV Bus

Line Terminus 2: Tranquillity Substation 230 kV Bus

Nominal Phase to Phase Voltage: 230 kV

Minimum Line Continuous Ampacity - Summer: 3000 Amps

Minimum Line Continuous Ampacity – Winter: 3000 Amps

Minimum Line 4 Hour Emergency Ampacity – 3000 Amps

Minimum Line 4 Hour Emergency Ampacity – 3000 Amps

Approximate Line Impedance: (0.00010 to 0.00014) + j(0.0009 to 0.0013) pu/mile (100 MVA base).

Approximate Line Length: TBD depending on the location of the Manning substatoin

Latest In Service Date: June 1, 2028

Support Structures: Single or double circuit structures

Shield Wire Required: Optical ground wire (minimum 6 pairs of fibers)

Failure Containment Loading Mitigation (anti-cascade structures, etc.): Per applicable codes

Shield Wire Ground Fault Withstand Ampacity: Coordinate with interconnecting entities

Aeolian Vibration Control (Conductor and Shield Wire): Vibration dampers must be installed on all conductors and overhead shield wires, with the exception of slack spans.

Transmission Line Minimum BIL: 1,800 kV with solidly grounded systems

Minimum ROW Width: Per applicable codes

Governing Design and Construction Standards: (GO 95, NESC Code, applicable municipal codes)

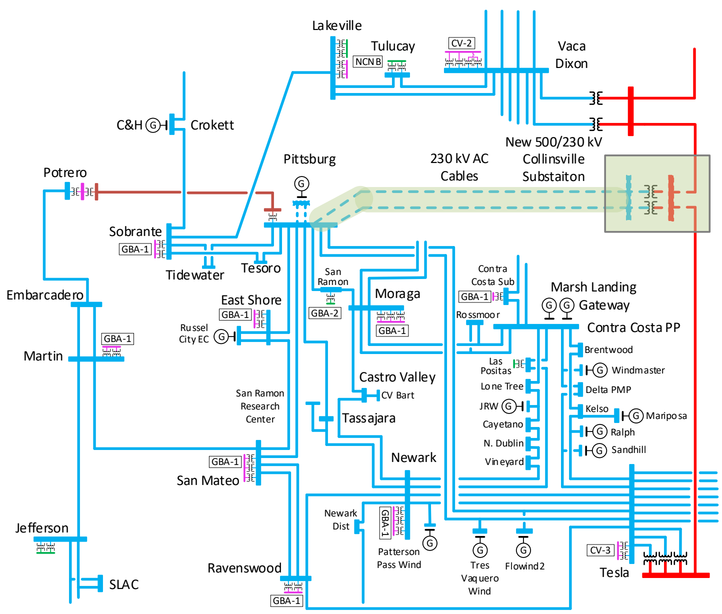
G2 Description and Functional Specifications of Proposed Policy-Driven Collinsville 500/230 kV Substation Project

G2.1 Description

In the 2021-2022 Transmission Plan, the ISO has identified a policy-driven need for the Collinsville 500/230 kV substation project to address multiple overloads on the 230 kV corridor between Contra Costa and Newark under normal, N-1, and N-2 contingency conditions. This project provides an additional supply from the 500 kV system into the northern Greater Bay Area to increase reliability to the area and advance additional renewable generation in the northern area. Figure G2.1. provides a schematic diagram of the transmission system in the area. As shown in the figure, the project scope includes the followings

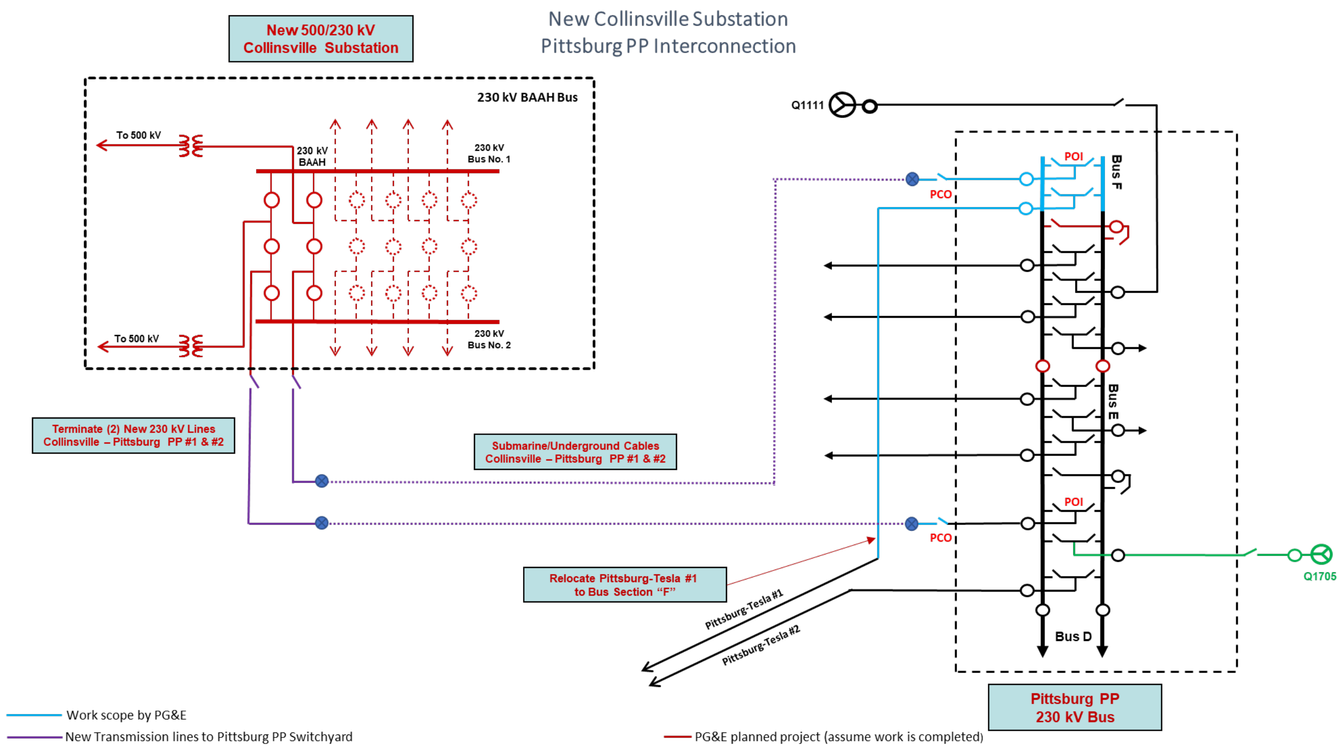
- A new Collinsville 500/230 kV substation
- Looping in the Vaca Dixon – Tesla 500 kV line into Collinsville substation
- Add a series capacitor to the Collinsville – Tesla 500 kV line
- Two 500/230 kV Transformers
- Two 230 kV cables from Collinsville to Pittsburg
- While not part of the scope of this project, considerations should be give for adding series reactor (around 20 ohms) to each cable in future.

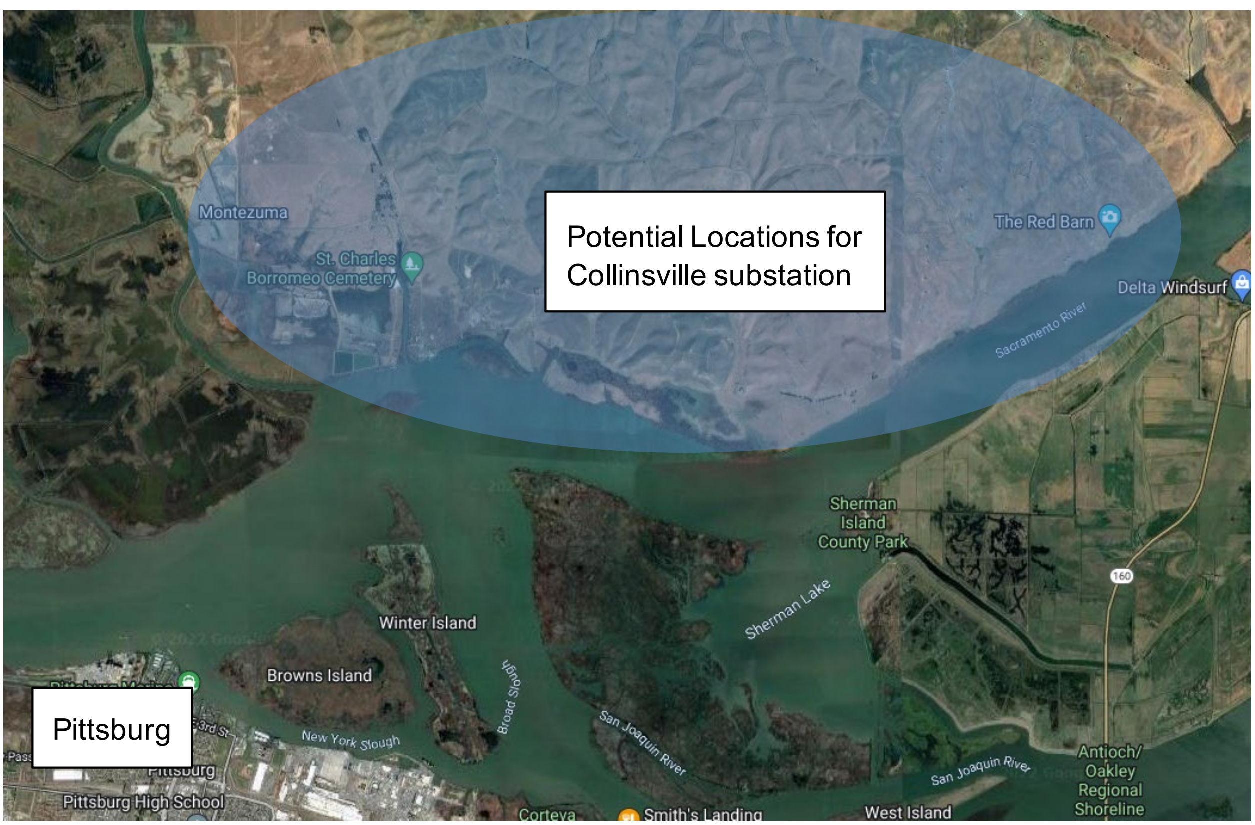
Figure G2-1: Location of Collinsville 500/230 kV Substation Project



The ISO estimates that the proposed project will approximately cost $475 to $675 million. The project is to be in-service no later than June of 2028. Figure G2-1 provides a schematic diagram of interconnection to the Pittsburg 230 kV substatoin.

Figure G2-2: Interconnection to Pittsburg 230 kV Substation





G2.2 Functional Specification for Collinsville 500/230 kV Substation Project

Collinsville Substation

Nominal Phase to Phase Voltage: 500/230 kV

500 kV and 230 kV Initial Bus Configuration: Breaker and a half (BAAH)

500 kV and 230 kV Ultimate Bus Configuration: BAAH

Initial Number of 500 kV Lines: 2

Ultimate Number of 500 kV Lines: 6

Initial Number of 500 kV CBs: 7

Ultimate Number of 500 kV CBs: 15

Initial Number of 230 kV Lines: 2

Ultimate Number of 230 kV Lines: 6

Initial Number of 230 kV CBs: 6

Ultimate Number of 230 kV CBs: 15

Initial Minimum Bus Ampacity: ___3000A___ Ultimate Bus Ampacity: ____3000A___

Minimum CB Ampacity: ____2000A ___ Minimum CB Interrupting Capability: ___63 kA__

Transfer Bus Required (SBSB only): N/A

Station Minimum BIL: 900 kV

Initial Reactive Power Requirements: None

Ultimate Reactive Power Requirements: To be determined

Telemetering Requirements: Install necessary equipment, including RTUs to monitor the typical bulk power elements such as MW, MVAr, and phase currents (Amps) at each line and also voltages (kV) at lines and buses and all circuit breaker (CB) status/control, protection relays statuses and alarms. The installed equipment must be capable of transmitting information to the appropriate Control Center.

Latest In Service Date: June 1, 2028

Low Profile Required: Subject to local permitting requirements

Gas Insulation Required: No, but if proposed shall be enclosed

Initial Number of Transformers: 3 including spare

Ultimate Number of Transformers: 3, including spare

Transformer Nominal Low Winding Phase to Phase Voltage: 230 kV

Tertiary Winding Required: ___No____ Nominal Voltage Rating: __N/A______

Primary Voltage Winding (wye, grounded wye, delta, etc): Grounded Wye

Secondary Voltage Winding: Grounded Wye Tertiary Voltage Winding: Corner Grounded Delta

Maximum Transformer % IZ: ____ 19% ______ Minimum Transformer %IZ: ___ 15% ___

Minimum Transformer Normal Rating: ___ 1500 MVA ____ Minimum Transformer 4-hour Emergency Rating: ___ 1800 MVA _____ LTC Required: ___ No ______

No Load Taps Required: 5 NLTs with two 2.5% taps above & below nominal voltage of 230 kV

CIP 14 requirement: The substation perimeter shall be fenced by a wall

Location of Series Compensation: Collinsville Substation. The cost of the series compensation is within the scope of this project and will be the responsibility of the approved project sponsor.

Minimum Series Capacitor Continuous Ampacity - Summer: 2700 A

Minimum Series Capacitor Continuous Ampacity – Winter: 2700 A

Minimum Series Capacitor 30 Minute Emergency Ampacity – Summer: 4000 A

Minimum Series Capacitor 30 Minute Emergency Ampacity – Winter: 4000 A

<u>230 kV Transmission Line Functional Specifications - Collinsville – Pittsburg lines</u>

Line Terminus 1: Collinsville 230 kV Bus

Line Terminus 2: Pittsburg Substation 230 kV Bus

Nominal Phase to Phase Voltage: 230 kV

Minimum Line Continuous Ampacity - Summer: 2100 Amps per circuit

Minimum Line Continuous Ampacity – Winter: 2100 Amps per circuit

Minimum Line 4 Hour Emergency Ampacity – Summer: 3500 Amps per circuit

Minimum Line 4 Hour Emergency Ampacity – Winter: 3500 Amps per circuit

Approximate Line Impedance: (0.000016 to 0.00002) + j(0.00026 to 0.00032) pu/mile (100 MVA base).

Approximate Line Length: TBD depending on the location of the Collinsville substation

Latest In Service Date: June 1, 2028

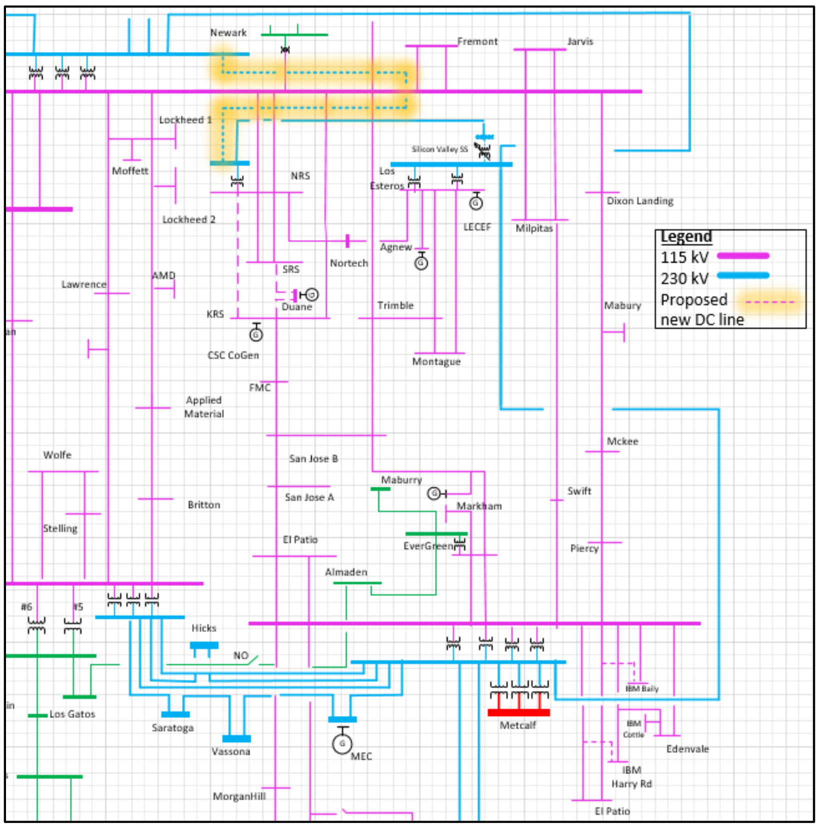
CIP 14 requirement: The substation perimeter shall be fenced by a wall

G3 Description and Functional Specifications of Proposed Reliability-Driven Newark – Northern Receiving Station HVDC Project

G3.1 Description

In the 2021-2022 Transmission Plan, the ISO has identified a reliability-driven need for a 500 MW VSC-HVDC project from Newark 230 kV to Northern Receiving Station (NRS) 230 kV substation to serve the load in the area. Figure G3.1. provides a schematic diagram of the transmission system in the area. The project consist of a VSC-HVDC link with converter stations close to Newark and Los Esteros 230 kV substations and 230 kV AC connection from the converter station at Los Esteros to NRS 230 kV substation.

Figure G3-1: Location of Newark to NRS HVDC Project



Due to space limitations it is not feasible to build a VSC-HVDC converter station adjacent to the NRS 230 kV substation, therefore the converter station should be built close to Los Estero 230 kV substation and be connected to the NRS 230 kV with a single 230 kV interconnection. The VSC-HVDC link should provide continuous flow on the complete range of the capability (unless the facility experienced a planned or forced outage). Subsynchronous Resonance (SSR) studies are required to be completed and any identified mitigation shall be implemented as part of this project. The ISO estimates that the proposed project will approximately cost $325 to $510 million. The project is to be in-service not later than June of 2028. Figure G3-2 provides a schematic diagram of the Interconnection of the project to Newark 230 kV and NRS 230 kV substations.

Figure G3-2: Interconnection to Newark 230 kV and NRS 230 kV Substations and Approximate Area for the Location of Converter Stations

Editorial Note: To be updated in the final plan

G3.2 Functional Specification for Newark – NRS HVDC Project

Rated Real Power: 500 MW measured at NRS 230 kV substation.

Rated Reactive Power: ±150 MVAR measured at Newark 230 kV and NRS 230 kV substations.

The entire inductive (absorption) range should be continuously available when the AC voltage is in the 230 kV – 242 kV range and the entire capacitive (injection) range should be available when the voltage is in the 207 kV – 238 kV range. To support voltage in the area, the reactive output range should be available independent of the real power flow on the VSC-HVDC. If the DC cable is out of service, the converters should be able to operate to support the voltage.

Response time: The time required for the output to go from 10% of the final value to 90% of the final value should be less than 150 ms.

Nominal Terminal AC Voltage: 230 kV

Latest in Service Date: June 1, 2028

Inverter Ride Through Capability: NERC PRC-024 requirements and NERC industry recommendation on momentary cessation [1]

Availability and Reliability requirements: The project shall be designed for high availability of at least 97%. All proposals shall provide a calculation identifying the designed annual availability of the system proposed.

Gas Insulation Required: No, but if proposed shall be enclosed

CIP 14 requirement: The substation perimeter shall be fenced by a wall

Run back capability: The HVDC controls should be able to receive signals for line statuses, and line loadings and implement a logic that will run HVDC back to preset power levels to address overloads.

Editorial Note: Additional specifications may be added in the final plan.

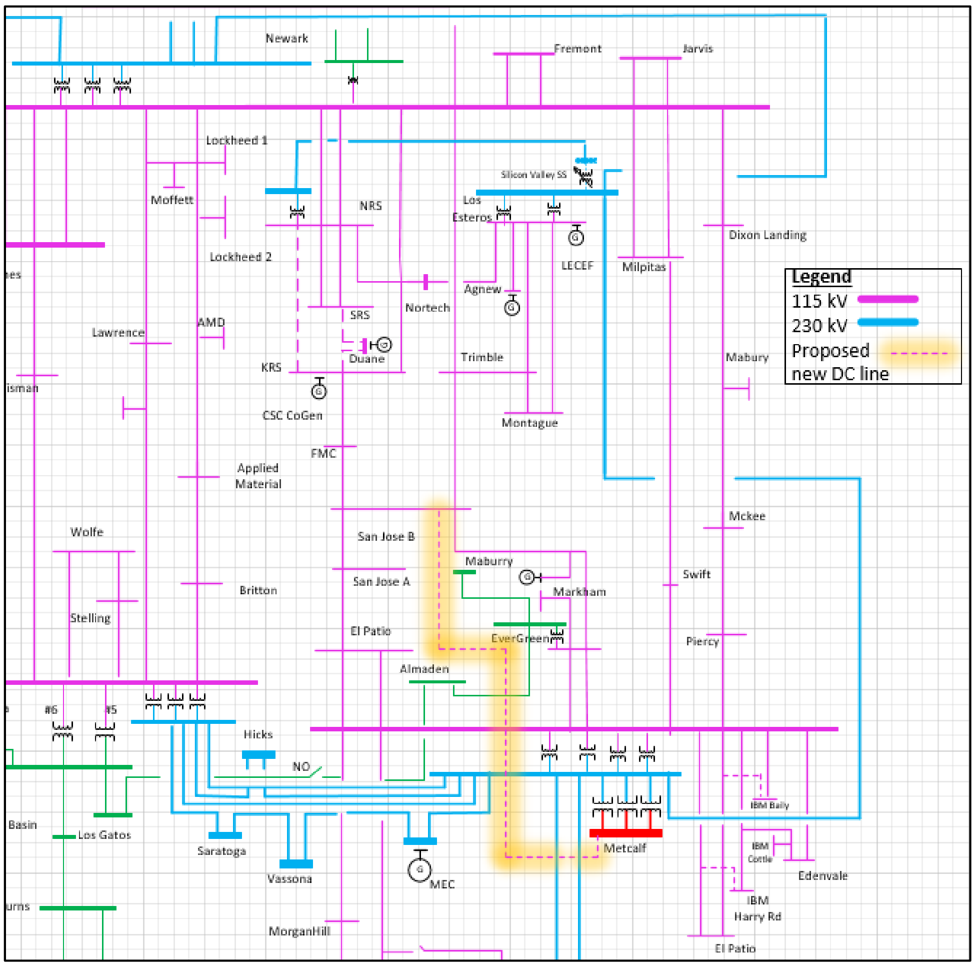
[1] https://www.nerc.com/pa/rrm/bpsa/Alerts%20DL/NERC_Alert_Loss_of_Solar_Resources_during_Transmission_Disturbance-II_2018.pdf

G4 Description and Functional Specifications of Proposed Reliability-Driven Metcalf – San Jose B HVDC Project

G4.1 Description

In the 2021-2022 Transmission Plan, the ISO has identified a reliability-driven need for a 500 MW VSC-HVDC project from Metcalf 500 kV to San Jose B 115 kV substation to serve the load in the area. Figure G4.1. provides a schematic diagram of the transmission system in the area.

Figure G4-2: Location of Metcalf 500 kV to San Jose B 115 kV HVDC Project



The VSC-HVDC link should provide continuous flow on the complete range of the capability (unless the facility experienced a planned or forced outage). Subsynchronous Resonance (SSR) studies are required to be completed and any identified mitigation shall be implemented as part of this project. The ISO estimates that the proposed project will approximately cost $525 to $615 million. The project is to be in-service not later than June of 2028. Figure G4-2 provides a schematic diagram of the Interconnection of the project to Metcalf 500 kV and San Jose 115 kV substations.

Figure G4-2: Metcalf 500 kV and San Jose B 115 kV Switchyard Layouts

Editorial Note: To be updated in the final plan

G4.2 Functional Specification for Metcalf – San Jose B HVDC Project

Rated Real Power: 500 MW measured at San Jose B 115 kV substation.

Rated Reactive Power: ±150 MVAR measured at Metcalf 500 kV and San Jose B 115 kV substations.

At Metcalf 500 kV end, the entire inductive (absorption) range should be continuously available when the AC voltage is in the 500 kV – 550 kV range and the entire capacitive (injection) range should be available when the voltage is in the 473 kV – 540 kV range.

At San Jose B 115 kV end, the entire inductive (absorption) range should be continuously available when the AC voltage is in the 115 kV – 126 kV range and the entire capacitive (injection) range should be available when the voltage is in the 104 kV – 121 kV range.

To support voltage in the area, the reactive output range should be available independent of the real power flow on the HVDC. If the DC cable is out of service, the converters should be able to operate to support the voltage.

Response time: The time required for the output to go from 10% of the final value to 90% of the final value should be less than 150 ms.

Nominal Terminal AC Voltage: 500 kV at Metcalf and 115 kV at San Jose B. Typically the bus voltage at Metcalf 500 kV bus is at 525 kV.

Latest in Service Date: June 1, 2028

Inverter Ride Through Capability: NERC PRC-024 requirements and NERC industry recommendation on momentary cessation [2]

Availability and Reliability requirements: The project shall be designed for high availability of at least 97%. All proposals shall provide a calculation identifying the designed annual availability of the system proposed.

Gas Insulation Required: No, but if proposed shall be enclosed

CIP 14 requirement: The substation perimeter should be fenced by a wall

Run back capability: The HVDC controls should be able to receive signals for line statuses, and line loadings and implement a logic that will run HVDC back to preset power levels to address overloads.

Editorial Note: Additional specifications may be added in the final plan.

[2] https://www.nerc.com/pa/rrm/bpsa/Alerts%20DL/NERC_Alert_Loss_of_Solar_Resources_during_Transmission_Disturbance-II_2018.pdf