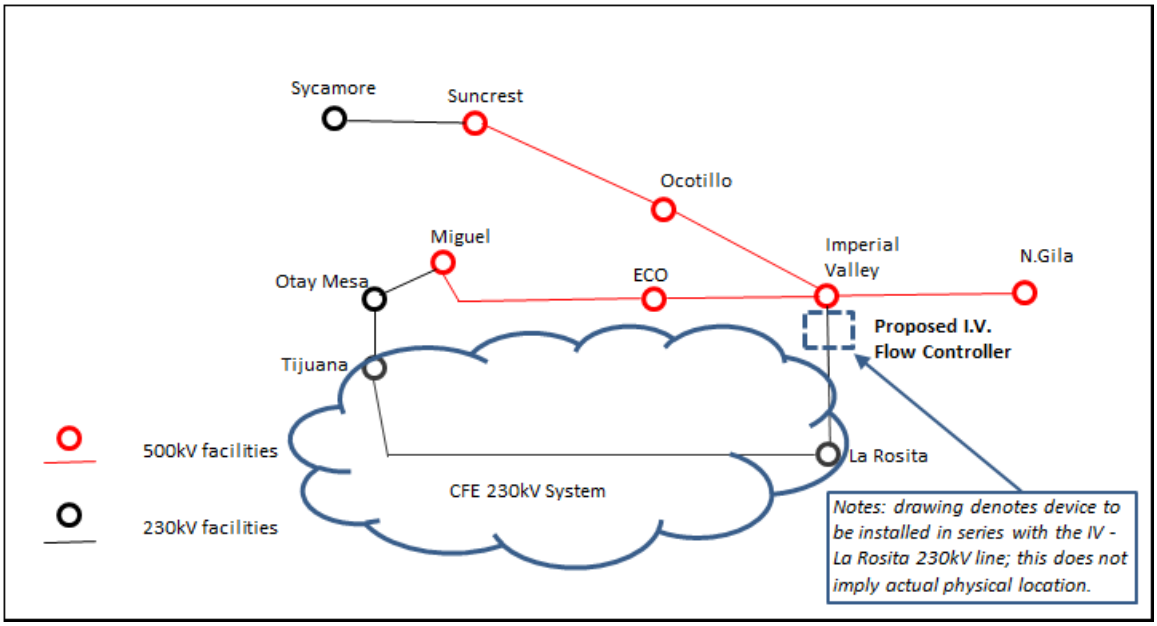
APPENDIX F: Description and Functional Specifications for Transmission Facilities Eligible for Competitive Solicitation

F1 Description and Functional Specifications of Proposed Reliability-Driven Imperial Valley 230 kV 800 MVA Phase Shifting Transformer Power Flow Controller Project

F1.1 Description

In the 2013-2014 Transmission Plan, the ISO has identified a reliability-driven need for an 800 MVA flow controller device to regulate power flow on the Imperial Valley – La Rosita 230kV line under critical Category B (N-1) or Category C.3 (N-1-1) contingencies. It is depicted in the single line diagram below:



The ISO identified two options for the Imperial Valley flow controller: back-to-back DC (B2BDC) or phase-shifting transformers. The final decision on which technology to procure and install will be forthcoming after further discussions with the Comision Federal de la Electricidad (CFE) of Mexico as the proposed flow controller device will affect power flow on the CFE 230kV transmission system. For this functional specification, it will be for the Imperial Valley Phase Shifting Transformer power flow controller. There is a separate functional specification for the Imperial Valley B2BDC power flow controller. The ISO estimates that the installed cost of the proposed phase shifting transformer power flow controller will cost a total of approximately $55 to $68 million.

F1.2 Functional Specifications

Phase Shifting Transformer Power Flow Controller Functional Specification

Location: at or near vicinity of Imperial Valley Substation

Continuous rating: 800 MVA

Emergency Rating: 115% of the continuous rating (4 hour);

Emergency Rating: 135% of the continuous rating (30 minutes)

Nominal line-to-line AC voltage: 230/230kV

ISO-modeled phase-shifting transformer impedance based on 230/230kV voltage and 100 MVA base:

- R= 0.000155 per unit
- X= 0.0101800 per unit

Through-fault and short-circuit capability: to be coordinated and provided by the utilities (i.e., SDG&E) for this information

Transmission line flow to be regulated: Imperial Valley – La Rosita 230kV line

Latest in-service date: May 1, 2017

System operating frequency: 60 Hz

Connecting terminals:

- Incoming: 230kV line terminal from Imperial Valley Substation;
- Outgoing: 230kV line to La Rosita Substation

Phase-shifting transformer:

- Total phase angle shift: 90 degrees;
- ISO-studied range: 0 to -90 degrees range (for flow from Imperial Valley Substation to La Rosita Substation); the specific starting angle and ending angle of the 90 degrees shift range could be updated and refined further after discussions with CFE;
- Equipped with 230kV bypass switch for clearance;
- Noise level limit: applicable local municipal code requirements
- Telemetry to be provided for remote control of the device

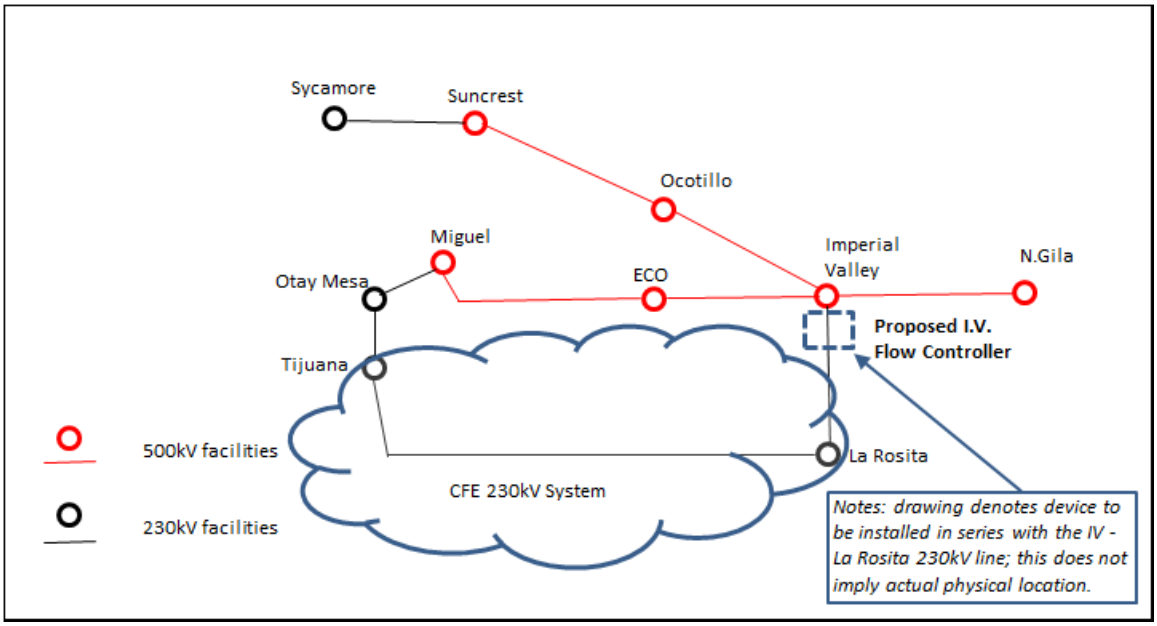
Notes:

Immediately following contingencies of critical (N-1 or N-1-1) of 500kV lines the phase shifting transformer flow should be able to withstand instantaneous flow increases from 0 MVA to 800 MVA. Further discussion with CFE is required for refinement and approval of the operation of the phase-shifting transformer power flow controller.

F2 Description and Functional Specifications of Proposed Reliability-Driven Imperial Valley 230 kV 800 MW Back-to-Back Direct Current (B2BDC) Power Flow Controller Project

F2.1 Description

In the 2013-2014 Transmission Plan, the ISO has identified a reliability-driven need for an 800 MVA flow controller device to regulate power flow on the Imperial Valley – La Rosita 230kV line under critical Category B (N-1) or Category C.3 (N-1-1) contingencies. It is depicted in the single line diagram below:



The ISO identified two options for the Imperial Valley flow controller: back-to-back DC (B2BDC) or phase-shifting transformers. The final decision on which technology to procure and install will be forthcoming after further discussions with the Comision Federal de la Electricidad (CFE) of Mexico as the proposed flow controller device will affect power flow on the CFE 230kV transmission system. For this functional specification, it will be for the Imperial Valley Back-to-Back DC flow controller. There is a separate functional specification for the Imperial Valley phase-shifting transformer(s). The ISO estimates that the installed cost of the proposed B2BDC flow controller, and new switchyard if needed, will cost a total of approximately $240 to $300 million.

F2.2 Functional Specifications

Back-to-Back DC Power Flow Controller Functional Specification

Location: at or near vicinity of the Imperial Valley Substation

Maximum rated power: 800 MW

Minimum Flow Level while energized: 0 MW

Nominal line-to-line AC voltage: 230kV

Transmission line flow to be regulated: Imperial Valley – La Rosita 230kV line

Latest in-service date: May 1, 2017

System operating frequency: 60 Hz

Connecting terminals:

- Incoming: 230kV line terminal from Imperial Valley Substation;
- Outgoing: 230kV line to La Rosita Substation

Back-to-back DC system

- Point-to-point DC system
- Control active power on the 230kV line
- To be located in the same building at Imperial Valley Substation or new adjacent switchyard if required;
- DC voltage for the B2BDC equipment is to be provided by the vendor as the optimal DC voltage level may vary between vendors' designs;
- Selection of the classical HVDC or voltage sourced converter technology is to be provided by the vendors that will result in the most economical design for the overall installed system (*i.e., cost savings associated with classical DC technology but potentially requiring larger footprint will need to be compared with higher cost but smaller foot print for the voltage-sourced converter technology)*.
- Response time: Tens of milliseconds
- Noise level limit: applicable local municipal code requirements
- Reactive power compensation at terminals as required (note: this is typically applicable to conventional HVDC technology)
- Equipped with 230kV bypass switch for clearance;

New Special Protection System

- To be installed for automatic control of the B2BDC system under critical N-1 or N-1-1 of 500kV lines. Should be capability of ramping from 0 MW to 800 MW within five seconds in response to SPS signal triggered by parallel 500 kV line contingencies. The SPS would be installed by SDG&E and would not be part of the scope of the B2BDC project. Further discussion with CFE is required for refinement and approval of the operation of the SPS and the B2BDC power flow controller.

F3 Description and Functional Specifications of Proposed Reliability-Driven Estrella Substation Project

F3.1 Description

In the 2013-2014 Transmission Planning Cycle, the ISO approved the construction of a reliability-driven *Estrella Substation Project* in the Los Padres Division of the PG&E service territory. The project will provide Paso Robles Substation with more reinforced 70 kV sources from Templeton and Estrella. A simplified single-line diagram of the proposed project is shown below in Figure G2-1.

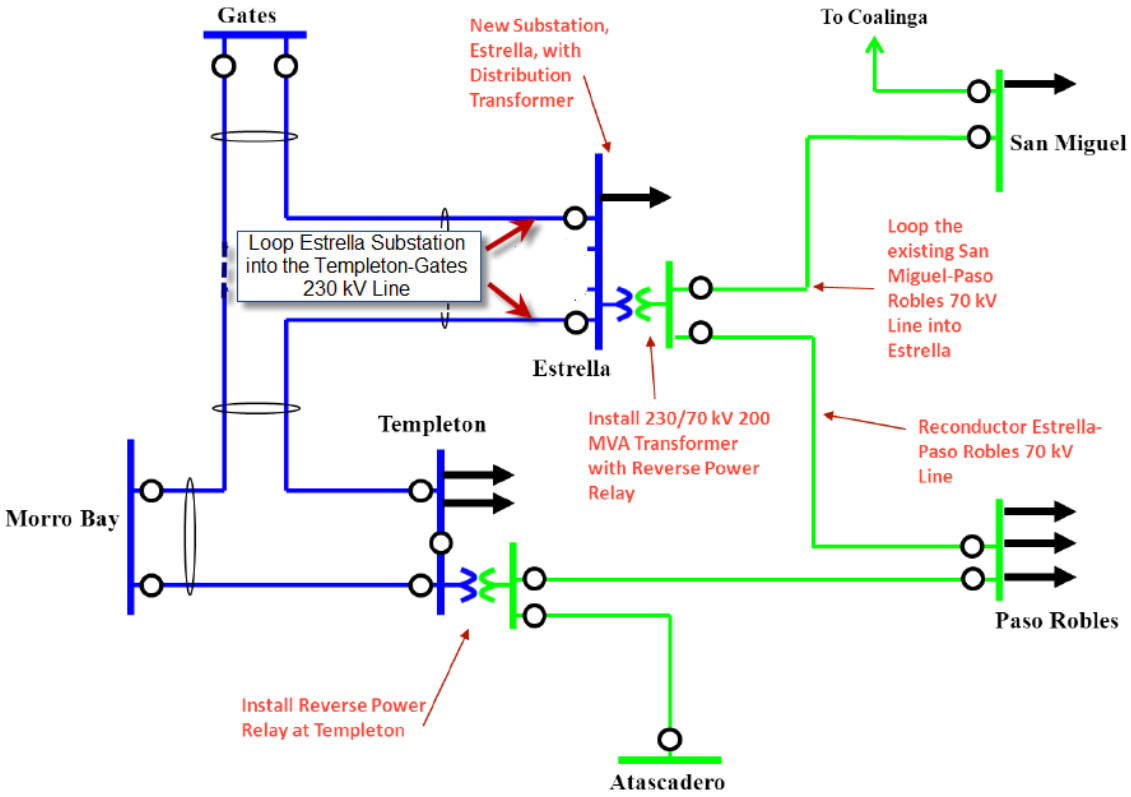


Figure G2-1: Proposed single-line diagram of the Estrella Substation Project

The scope of this project is to construct a new 230/70 kV substation, Estrella, approximately 5 miles east of the existing Paso Robles Substation. The Estrella substation will also be located relatively close to the Morro Bay-Gates No.2 and Templeton-Gates 230 kV transmission corridor. The Estrella 230 kV bus will be looped into the Templeton-Gates 230 kV line. A new 230/70 kV transformer will be installed at the Estrella substation. In addition, a 45 MVA distribution transformer will be installed on the Estrella 230 kV bus. The Estrella 70 kV bus will be looped into the existing San Miguel-Paso Robles 70 kV line. A reverse power relay will be installed on the Estrella 230/70 kV and the existing Templeton 230/70 kV #1 transformer banks to prevent the 70 kV system from feeding the 230 kV system. The Paso Robles-Estrella 70 kV

line will be reconductored sufficiently enough to prevent thermal overloads and it will operate at, a minimum, summer normal and summer emergency ratings of 825 and 975 amps, respectively.

The project will mitigate the thermal overloads and voltage concerns identified in the Los Padres 70 kV system specifically, in the San Miguel, Paso Robles, Templeton, Atascadero, Cayucos and San Luis Obispo areas following a Category B contingency due to loss of either the Templeton 230/70 kV #1 Bank or the Paso Robles-Templeton 70 kV Line. These two Category B contingencies put approximately 60-70 MW of load at Paso Robles at risk by activating the existing Paso Robles UVLS during summer peak conditions to alleviate the thermal and low voltage concerns. Also, a Category C3 contingency condition involving loss of Morro Bay-Templeton and Templeton-Gates 230 kV lines results in thermal overloads and low voltages in the underlying 70 kV system. With the additional source from the Gates 230 kV system, the *Estrella Substation Project* will provide robust system reinforcement to the Paso Robles and Templeton 70 kV system operations.

The ISO estimates that the proposed *Estrella Substation Project* will cost less than $35 million to $45 million in 2014 dollars. The proposed in-service date of the project is May 2019.

The facilities in the Estrella substation project that are considered eligible for competitive solicitation are the 230 kV buswork and termination equipment, and the 230/70 kV transformers. The 70 kV buswork and termination equipment and modifications to existing facilities are not eligible for competitive solicitation.

F3.2 Functional Specifications

Switching Station

Nominal Phase to Phase Voltage: 230 kV

Initial Bus Configuration (DBDB, BAAH, SBSB, etc.): Breaker and a half (BAAH)

Ultimate Bus Configuration (DBDB, BAAH, SBSB, etc.): BAAH

Initial Number of Lines: 2

Ultimate Number of Lines: 4 (To accommodate potential looping into the Morro Bay-Gates 230 kV Line)

Initial Number of 230 kV CBs: 6

Ultimate Number of 230 kV CBs: 12

Initial Minimum Bus Ampacity: TBD Ultimate Bus Ampacity: TBD

Minimum CB Ampacity: TBD Minimum CB Interrupting Capability: TBD

Transfer Bus Required (SBSB only): N/A

Station Minimum BIL?

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: May 2019

Low Profile Required: Subject to local permitting requirements

Gas Insulation Required: No

Initial Number of Transformers: 2

Ultimate Number of Transformers: 4

Transformer Nominal Low Winding Phase to Phase Voltage: TBD

Tertiary Winding Required? TBD Nominal Voltage Rating? TBD

Primary Voltage Winding (wye, grounded wye, delta, etc) TBD

Secondary Voltage Winding TBD Tertiary Voltage Winding TBD

Maximum Transformer % IZ TBD Minimum Transformer %IZ TBD

Minimum Transformer OA Rating TBD

Maximum Transformer Load TBD LTC Required? TBD

No Load Taps Required: TBD

F4 Description and Functional Specifications of Proposed Reliability-Driven Wheeler Ridge Jct Substation Project

F4.1 Description

In the 2013-2014 Transmission Planning Cycle, the ISO approved the construction of a reliability-driven *Wheeler Ridge Jct Substation Project* in the Kern Division of the PG&E service territory. The project will provide Wheeler Ridge Substation, as well as CDWR pumps, with a more reinforced 230 kV source from Kern PP. A simplified single-line diagram of the existing and proposed project is shown below in Figures G2-1 and G2-2.

Figure F4-1: Existing single-line diagram of the Wheeler Ridge Jct Substation Project

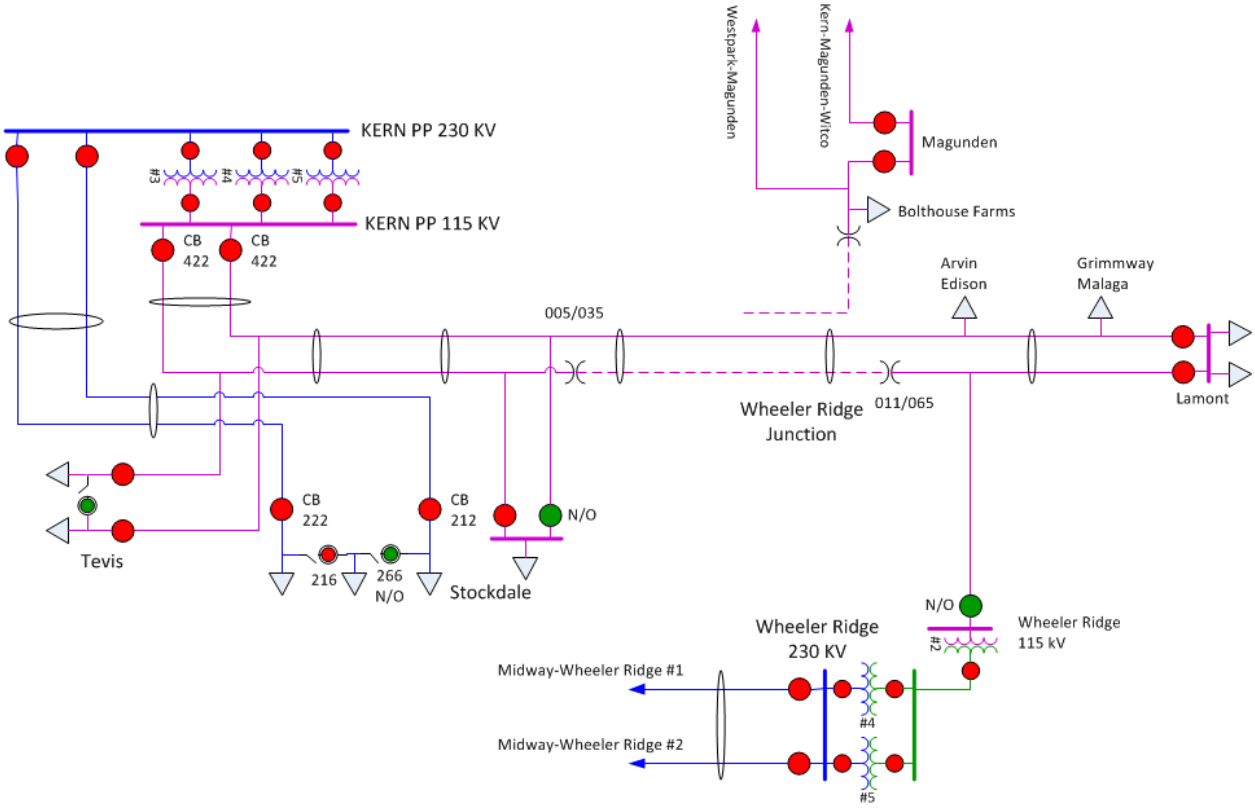
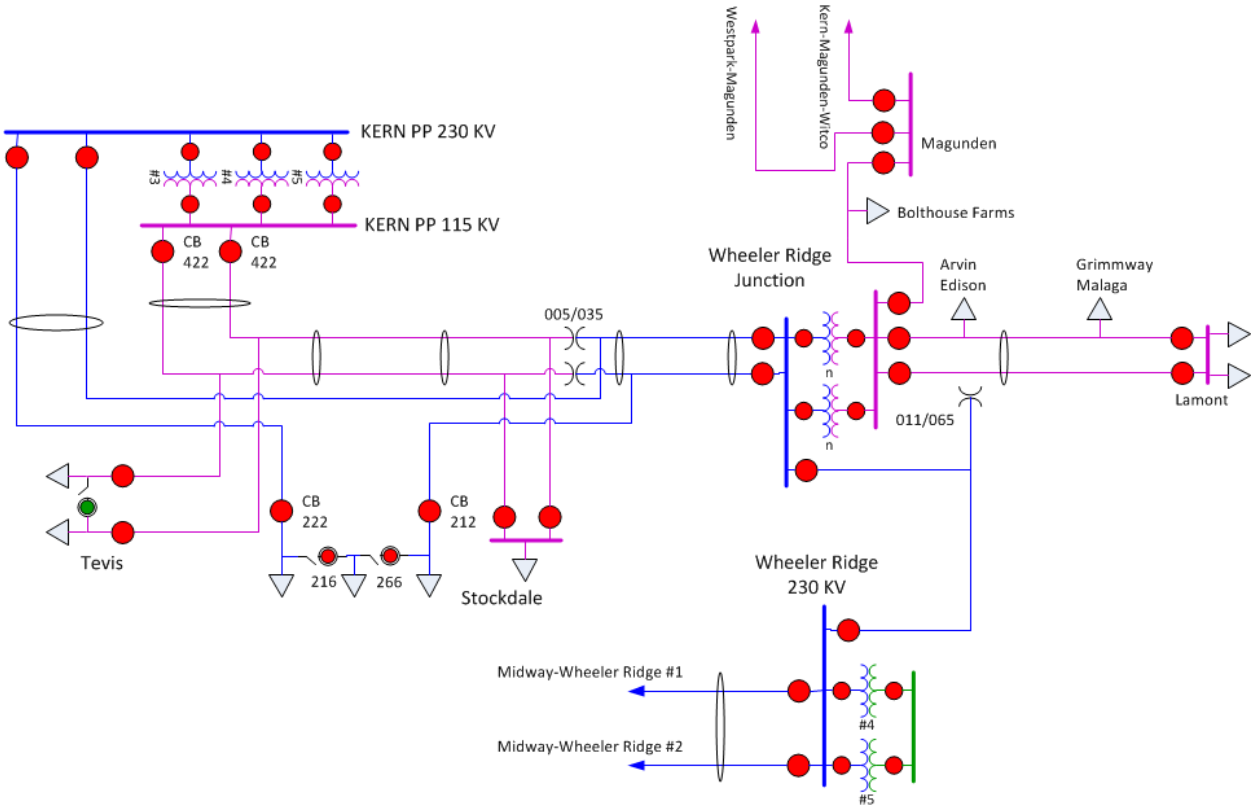


Figure F4-2: Proposed single-line diagram of the Wheeler Ridge Jct Substation Project



The scope of this project includes:

- Build new 230/115 kV transmission substation at Wheeler Ridge Junction (WRJ)
  - 3 – 230 kV line terminations (ultimate 6)
  - 3 – 115 kV line terminations (ultimate 8)
  - 2 – 230/115 kV 420 MVA transformers
- Convert 15.5 miles of the Wheeler Ridge-Lamont 115 kV line from Wheeler Ridge to tower 011/065 to 230 kV operation. Terminate at Wheeler Ridge and WRJ stations.
- Open end Kern-Tevis-Stockdale-Lamont 115 kV line at tower 005/035 and loop Stockdale 115 kV substation.
- Convert/Re-conductor 5 miles of the Kern-Tevis-Stockdale-Lamont 115 kV Line section from Towers 005/035 to 011/065 to 230 kV operation on both sides of double circuit tower line (other side is idle circuit). Terminate both circuits at the WRJ station. Terminate both remaining 115 kV lines to Lamont at WRJ station.
- Remove Stockdale #2 230 kV Tap from Stockdale substation, and terminate the first newly converted 230 kV circuit. Bypassing Stockdale substation.

- Terminate second newly converted 230 kV circuit at Stockdale substation, for a loop arrangement.
- Reconductor and upgrade 6 miles of the idle line from Wheeler Ridge Junction towards Magunden substation. Upgrade for 115 kV operation, and terminate at Magunden and WRJ stations.

The project will mitigate the thermal overloads and voltage concerns identified in the Wheeler Ridge 230 kV system, specifically in the area of the CDWR pumps, following a Category C1 or C2 contingency due to loss of either the Midway 230kV Bus 1D or Midway 230kV CB642 fault. This project will also mitigate several 115kV concerns on the Kern PP 115kV area.

This project is dependent on the Midway #2 230kV Line project that was submitted through the 2013 Request Window and approved during the 2013-2014 CAISO TPP.

The ISO estimates that the proposed *Wheeler Ridge Jct Project* will cost between $90 million and $140 million in 2014 dollars. The proposed in-service date of the project is May 2020.

The facilities in the Wheeler Ridge Junction substation project that are considered eligible for competitive solicitation are the 230 kV buswork and termination equipment, and the 230/70 kV transformers. The 115 kV buswork and termination equipment and the reconfiguration of existing facilities are not eligible for competitive solicitation.

F4.2 Functional Specifications

Substation

Nominal Phase to Phase Voltage: 230/115kV

Initial Bus Configuration (DBDB, BAAH, SBSB, etc.): Breaker and a half (BAAH)

Ultimate Bus Configuration (DBDB, BAAH, SBSB, etc.): BAAH

Initial Number of 230 kV Lines: 3

Ultimate Number of 230 kV Lines: TBD

Initial Number of 230 kV CBs: 8

Ultimate Number of 230 kV CBs: 12

Initial Minimum Bus Ampacity: TBD Ultimate Bus Ampacity: TBD

Minimum CB Ampacity: TBD Minimum CB Interrupting Capability: TBD

Transfer Bus Required (SBSB only): N/A

Station Minimum BIL?

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: May 2020

Low Profile Required: Subject to local permitting requirements

Gas Insulation Required: No

Initial Number of Transformers: 2

Ultimate Number of Transformers: 2

Transformer Nominal Low Winding Phase to Phase Voltage: 115

Tertiary Winding Required? TBD Nominal Voltage Rating? TBD

Primary Voltage Winding (wye, grounded wye, delta, etc) TBD

Secondary Voltage Winding 115 kV Tertiary Voltage Winding TBD

Maximum Transformer % IZ TBD Minimum Transformer %IZ TBD

Minimum Transformer OA Rating TBD

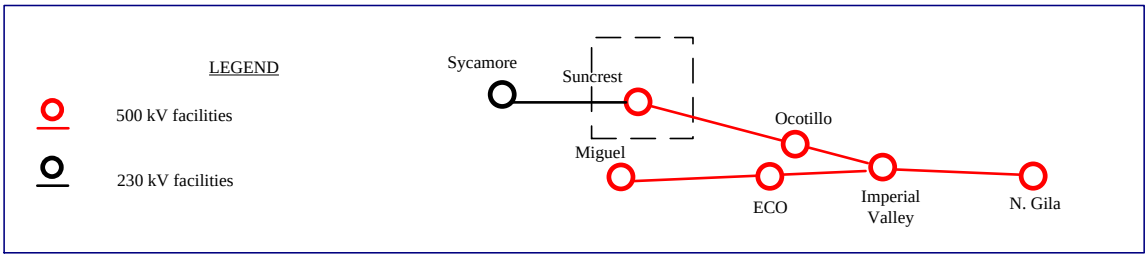
Maximum Transformer Load TBD LTC Required? TBD

No Load Taps Required: TBD

F5 Description and Functional Specifications of Proposed Policy-Driven Suncrest 230 kV 300 MVAr Dynamic Reactive Power Support

F5.1 Description

In the 2013-2014 Transmission Plan, the ISO has identified a policy-driven need for a 300 MVAr dynamic reactive power support connecting to the Suncrest 230 kV bus as depicted below:



The dynamic reactive power support is required to provide continuous or quasi-continuous reactive power response following system disturbances. It needs to be one of the following types of devices: SVC (Static VAR Compensator), STATCOM (Static Synchronous Compensator), or Synchronous Condenser. The ISO estimates that the cost of the proposed dynamic reactive power support will approximately cost $50 to 75 million.

F5.2 Functional Specifications

Dynamic Reactive Power Support Functional Specification:

Point of Interconnection: Suncrest 230 kV bus

Rated Real Power Output: 0 MW

Rated MVAR: +300/-100 at the Suncrest 230 kV bus

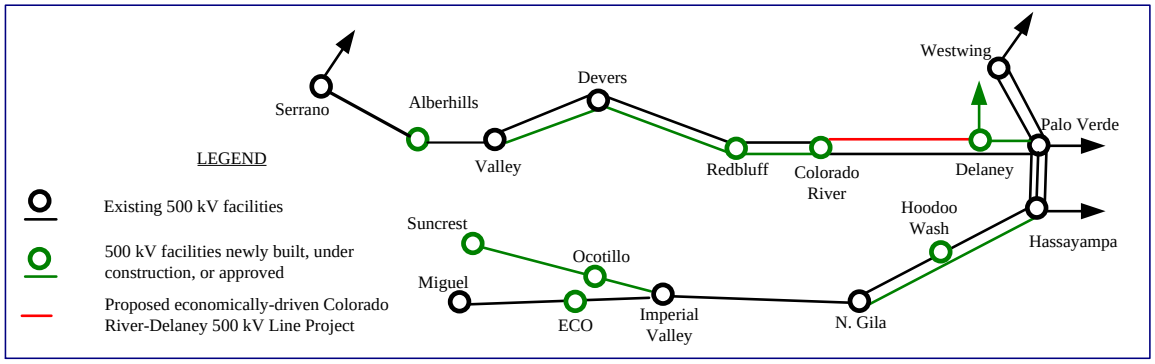
Nominal Terminal Voltage: 230 kV

Latest in Service Date: June 1, 2017

F6 Description and Functional Specifications of Proposed Economically Driven Colorado River – Delaney 500 kV Line Project

F6.1 Description

In the 2013-2014 Transmission Plan, the ISO has identified an economically-driven need for a 500 kV transmission line between SCE owned Colorado River 500 kV substation and APS owned Delaney 500 kV substation, as depicted below[1]:



The estimated cost of the proposed 500 kV line is $338 million in 2014 dollars. This estimated cost includes facilities necessary at the Delaney and Colorado River substations that will be installed by the owners of those substations. Once this project is approved by the ISO Board, the ISO will request cost estimates from APS and SCE for the facilities needed in these substations to connect the new Delaney-Colorado River line.

[1] The existing Paloverde-Colorado River 500 kV line may need to be looped into Delaney substation to ensure scheduling capability is aligned with maximum utilization of the new Delaney-Colorado River 500 kV line.

F6.2 Functional Specifications

Transmission Line Functional Specifications

Overhead Line Construction

Line Terminus 1: Colorado River Substation 500 kV Bus

Line Terminus 2: Delaney Substation 500 kV Bus

Nominal Phase to Phase Voltage: 500 kV

Minimum Line Continuous Ampacity - Summer: 3,800 Amps

Minimum Line Continuous Ampacity – Winter: 3,800 Amps

Minimum Line 4 Hour Emergency Ampacity – Summer: 5,200 Amps

Minimum Line 4 Hour Emergency Ampacity – Winter: 5,200 Amps

Minimum Line 30 Minute Emergency Ampacity – Summer: 5,600 Amps

Minimum Line 30 Minute Emergency Ampacity – Winter: 5,600 Amps

Approximate Line Impedance: (0.0012 to 0.0015) + j(0.027 to 0.033) pu (100 MVA base)

Maximum Line Resistance: 0.0015 pu (100 MVA base)

Approximate Line Length: 115-140 miles

Approximate Switched Shunt Line Reactor Capacity: 75 MVAR switched shunt reactor connected to the line at Colorado River terminal, 75 MVAR switched shunt reactor connected to the line at Delaney terminal

Approximate Series Compensation Level: 35%

Location of Series Compensation: Approximately in the middle of the Colorado River-Delaney 500 kV line or equivalent compensation at line termination stations

Minimum Series Capacitor Continuous Ampacity - Summer: 2,700 Amps

Minimum Series Capacitor Continuous Ampacity – Winter: 2,700 Amps

Minimum Series Capacitor 4 Hour Emergency Ampacity – Summer: 2,700 Amps

Minimum Series Capacitor 4 Hour Emergency Ampacity – Winter: 2,700 Amps

Minimum Series Capacitor 30 Minute Emergency Ampacity – Summer: 3,645 Amps

Minimum Series Capacitor 30 Minute Emergency Ampacity – Winter: 3,645 Amps

Latest In Service Date: 2020

Support Structures: Single 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

Route Requirement: The route should meet the applicable NERC/WECC standard so that Part 1.1.1 of Section E. Regional Differences of Standard FAC 010-2.1 related to the common mode contingency does not apply to the Colorado River-Palo Verde and Colorado River-Delaney 500 kV lines.

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