PG&E's 2018 Request Window Proposals

CAISO 2018-2019 Transmission Planning Process

September 21, 2018

Transmission Project Proposals Overview

Seven Projects Seeking CAISO Approval:

Central Coast/Los Padres

- CHCSS-Salinas-Soledad #1 and #2 115kV Lines Reconductoring Project

Yosemite/Fresno

- Kingsburg-Lemoore 70 kV Reconductoring Project

Stockton

- Tesla 230 kV Bus Series Reactor Project

North Valley

- Tyler 60 kV Shunt Capacitor Project
- Cottonwood 115 kV Bus Sectionalizing Breakers Project

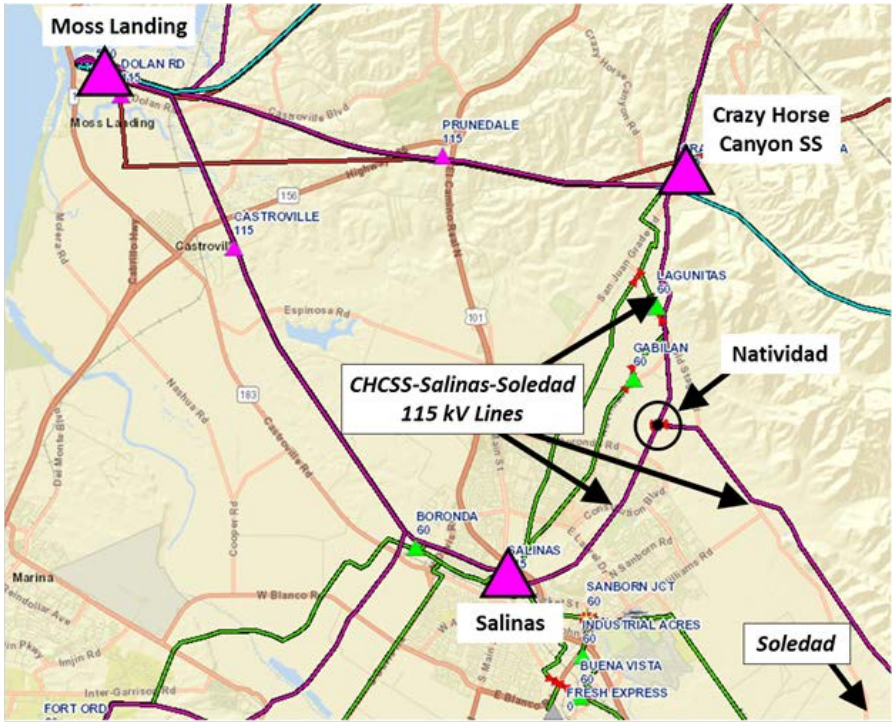
500 kV Bulk System

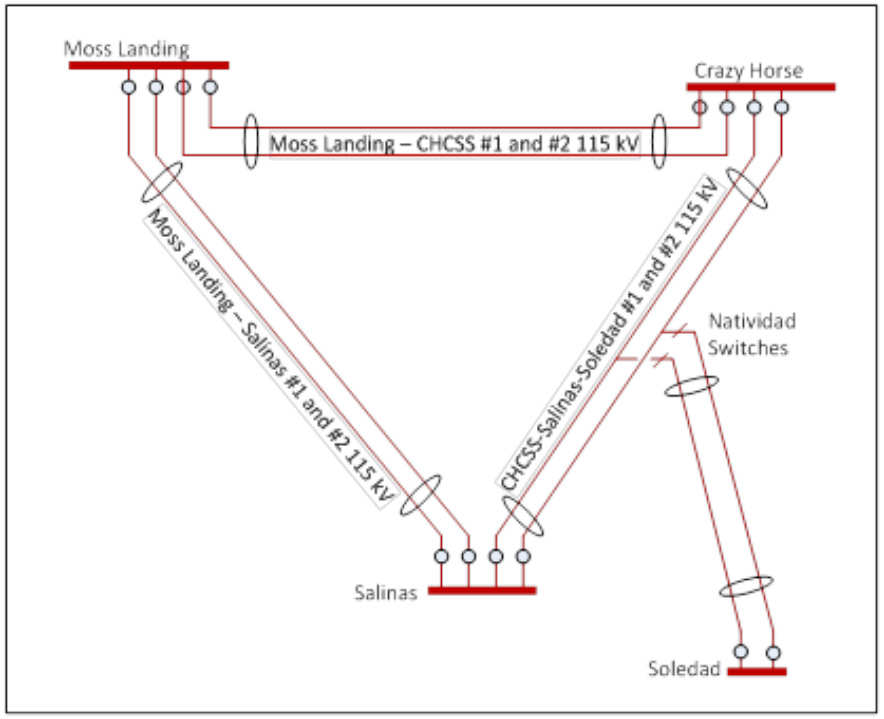
- Round Mountain 500 kV Voltage Support Project
- Gates 500 kV Voltage Support Project

CHCSS-Salinas-Soledad 115 kV #1 and #2 Reconductor Project

Area Background

- Crazy Horse Canyon Switch Station (CHCSS), Natividad Switching Station, and Salinas Substation are located within the Central Coast division
- Moss Landing-CHCSS #1 & #2 115 kV Lines, Moss landing-Salinas #1 & #2 115 kV Lines, and Crazy Horse Canyon-Salinas-Soledad #1 & #2 115 kV Lines serve the above substations with Moss Landing Substation being the main source
- The CHCSS-Salinas-Soledad #1 & #2 115 kV Lines are mostly comprised of copper conductor built more than 80 years ago

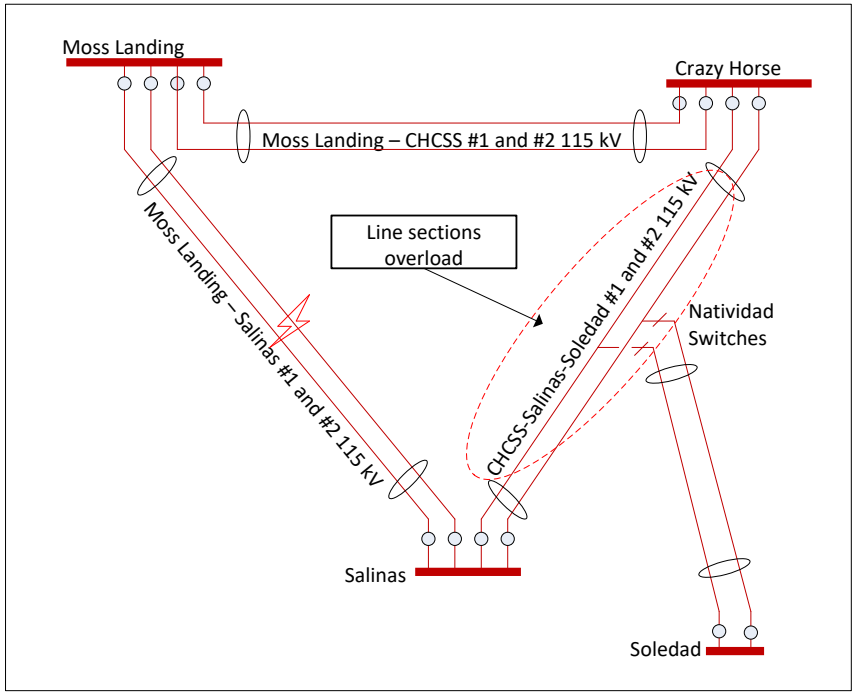




Assessment – Overloads Issues

Overloads on CHCSS-Salinas-Soledad #1 & #2 115 kV lines

- Overloads are observed both in the near-term (2020/2023) and long-term (2028) planning summer peak cases and winter peak cases
  - Overloads during Moss Landing-Salinas #1 & #2 outage (Category P6 and P7)
  - Overloads ranging up to 139%



			Pre Project			Contingency	
#	Facility	Facility Rating	2020	2023	2028	Category	Contingency Name
1	CHCSS-Natividad Section	115 kV	127.05	131	138.72	P6 P7	Moss Landing - Salinas #1 and #2 115 kV Lines
2	Natividad -Salinas Section	115 kV	113.2	116.04	121.05	P6 P7	Moss Landing - Salinas #1 and #2 115 kV Lines

Note: Facility Overload are percentage values.

Proposed Project

Power flow analysis was performed and it was determined that line reconductor is needed

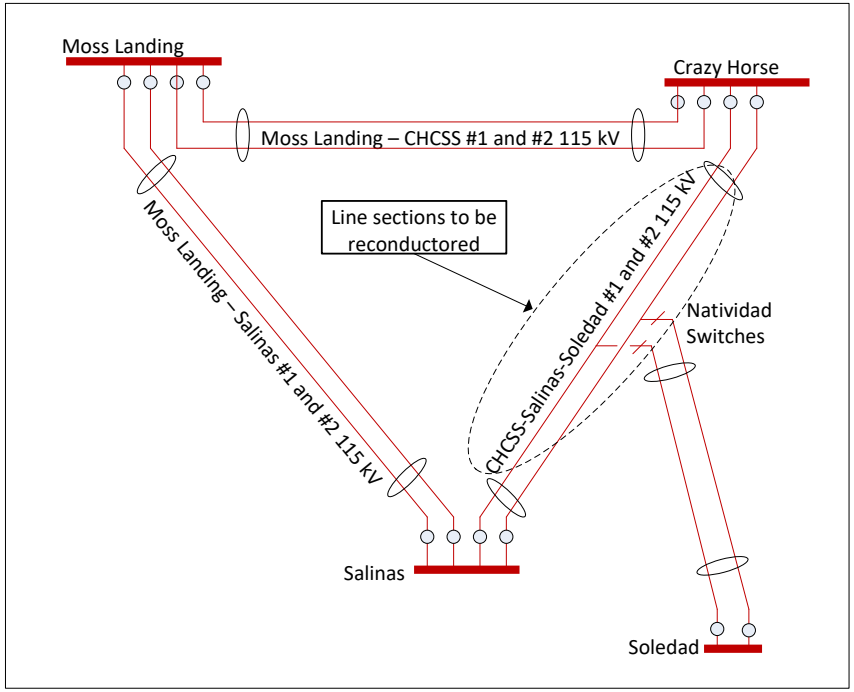
- Overloads mitigated during P6 and P7 contingencies after project

Preferred Location

- CHCSS-Salinas-Soledad #1 & #2 115 kV lines

Preferred Scope

- Reconductor both 115 kV lines from CHCSS, past Natividad, to Salinas Substation
- Associated bus connection and tower work



Other Alternatives Considered

- Status Quo
- SPS

Proposed In-Service Date

- Dec 2025 or earlier

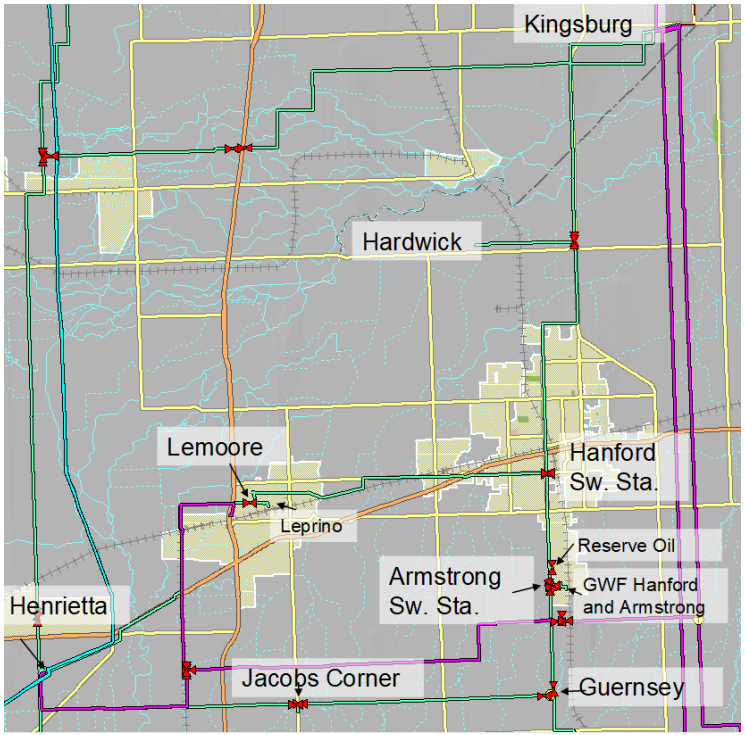
Estimated Cost

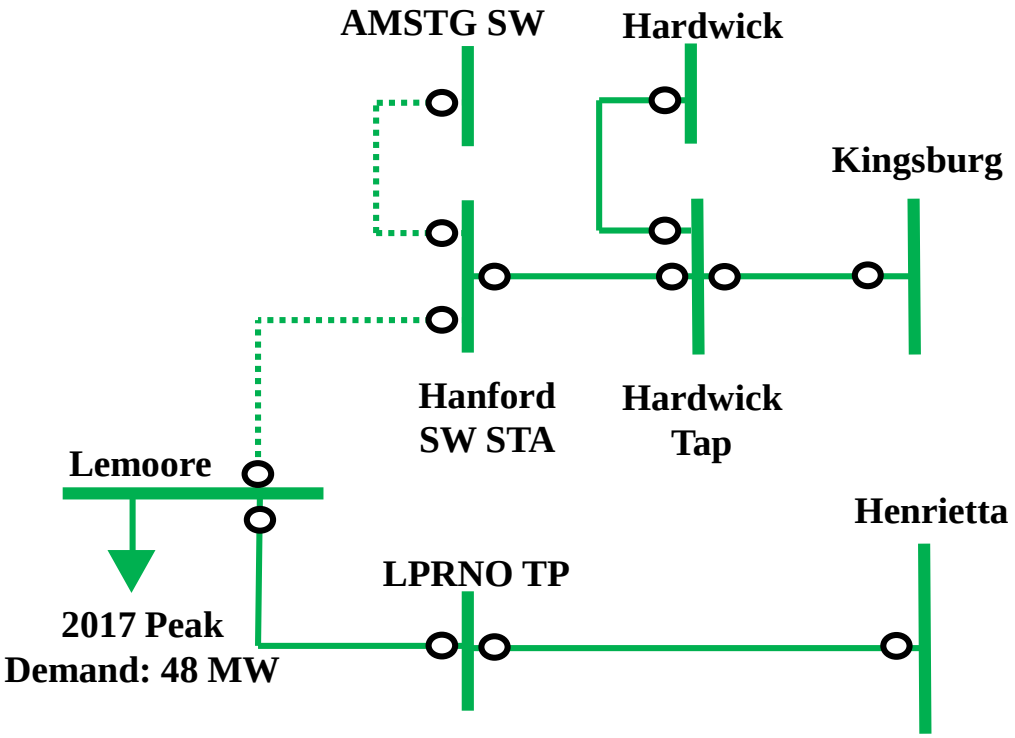
- $35M - $42M

Kingsburg – Lemoore 70 kV Line Reconductoring Project

Area Background

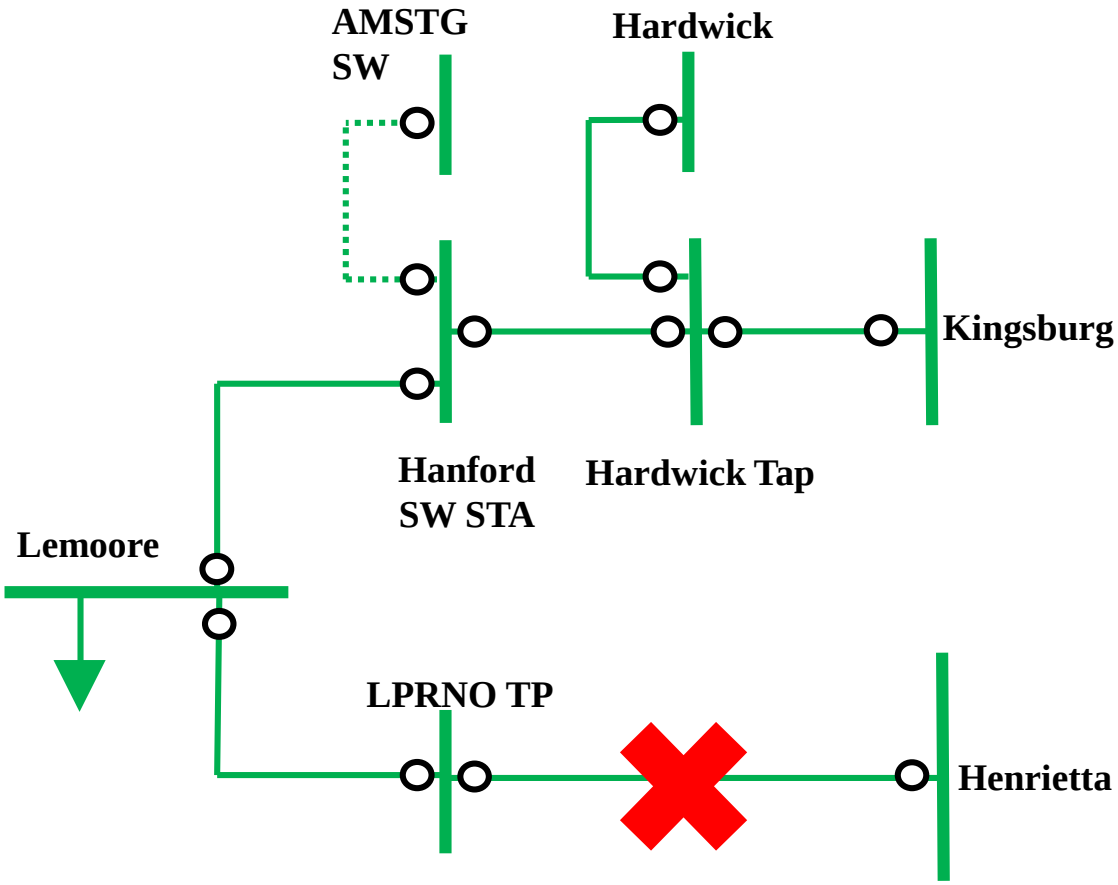
- Lemoore 70 kV system is normally served from Henrietta substation.
- Kingsburg is a back up source for the customers at Lemoore.
- The Kingsburg – Lemoore 70 kV Line is operated normally open due to capacity and reliability deficiencies.





Assessment – Customer Reliability Issue

- Currently, if there is an outage on the Henrietta – Lemoore line during the summer, Lemoore Substation cannot be restored until repairs are made to the main source.
- If we restore the load at Lemoore after this outage, the overloads on the Kingsburg-Lemoore 70 kV line could vary from 107%-160%.



Facility	Ratings* (A)	2019	2022	2027
Section between Hanford SW STA and Lemoore)	282	143%	156%	160%
Section between Hardwick Tap and Hanford SW STA)	377	107%	116%	120%
Section between Kingsburg and Hardwick Tap)	377	129%	141%	144%

Proposed Project

The line section with the smallest conductor size is between the Hanford Switching Station and Lemoore Substation.

Preferred Scope

- Reconductor 8.3 miles of the Hanford SW and Lemoore section to remove the most limiting conductors
- Upgrade terminal equipment as needed

Benefit Cost Ratio (BCR)

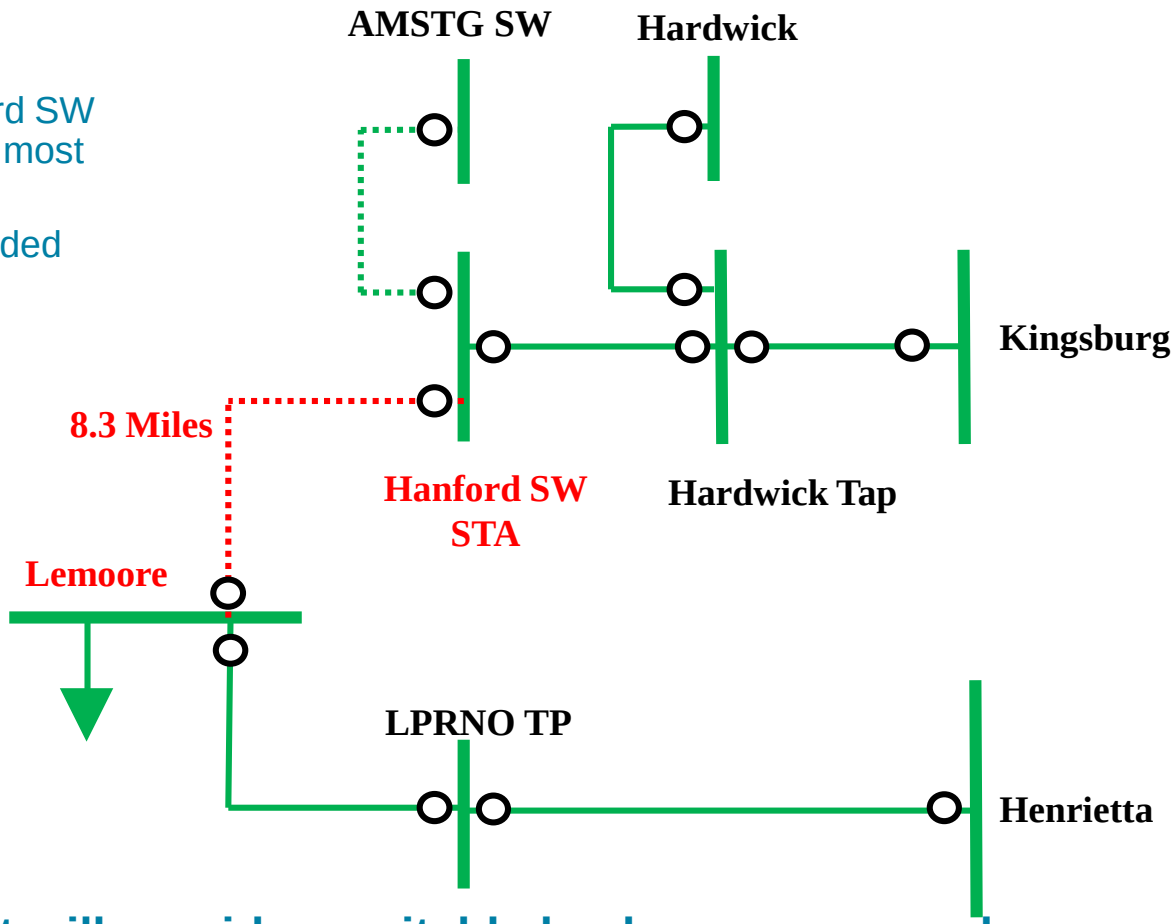
- BCR = 1.64

Proposed In-Service Date

- March 2021

Estimated Cost

- $12.2M - $14.6M

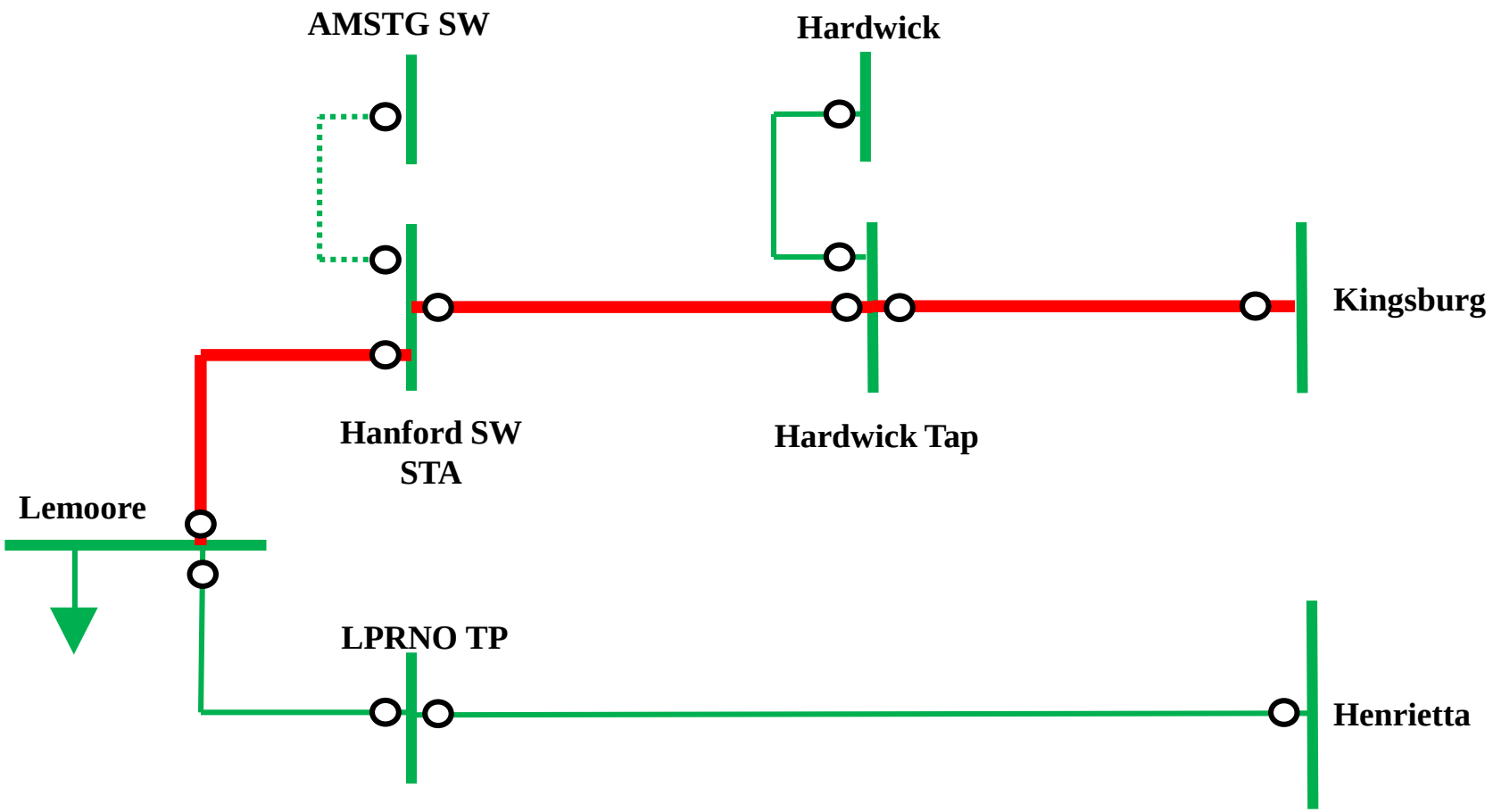


Upon completion, this project will provide a suitable back-up source and reduce the number and duration of sustained outages to approximately 65% of the customers served by the Lemoore Substation.

Proposed Projects

Other Alternatives Considered

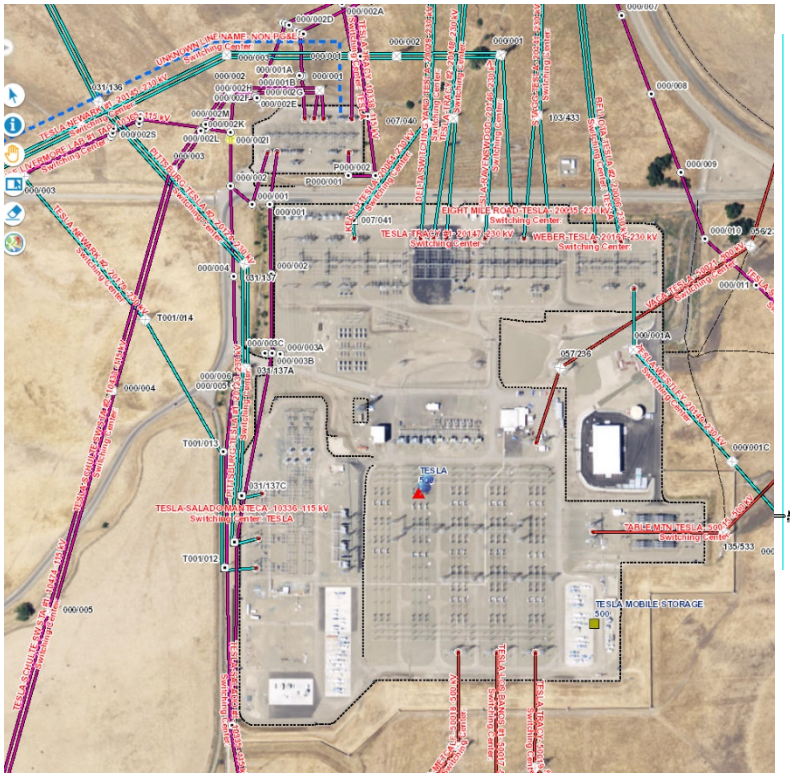
- Status Quo
- Reconductor the entire 27.4 miles of the Kingsburg – Lemoore 70 kV Line (NOT recommended due to higher cost and permitting uncertainties.)

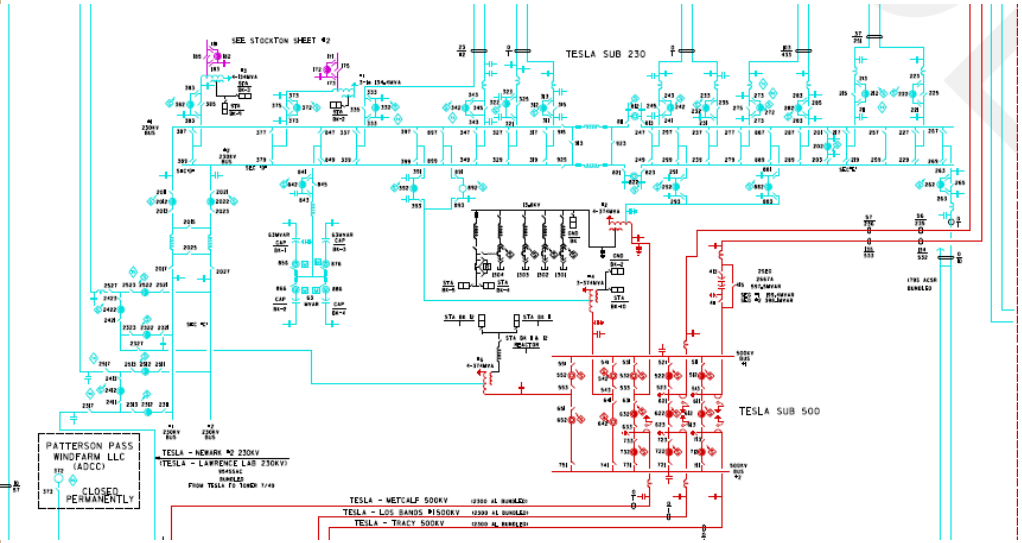


Tesla 230 kV Series Reactors Project

Area Background

- Tesla Substation is a critical source of power for both the Greater Bay Area and San Joaquin County
- The substation is connected to the bulk power system via five 500 kV lines, fourteen 230 kV Lines, three 500/230 kV and two 230/115 kV transformer banks
- Tesla 230 kV breakers are rated at the maximum PG&E system design limit of 63 kA
- Existing bus reactors between Tesla 230 kV bus sections C-D and D-E are 8 ohms and 4 ohms equivalent respectfully





Proposed Project

Short Circuit Duty study on Tesla 230 kV Bus shows overstressed Circuit Breakers

- This concern is significant since the level has exceeded the maximum PG&E system limit 63 kA.

Preferred Scope

- Project scope is to replace existing reactors between Tesla 230 kV bus sections C-D and D-E (8 ohms and 4 ohms equivalent respectfully) with 18 ohm equivalent.
- Re-arrange various 230 kV line connections on the Tesla 230 kV Bus
- Make protection system upgrades as required

Proposed In-Service date

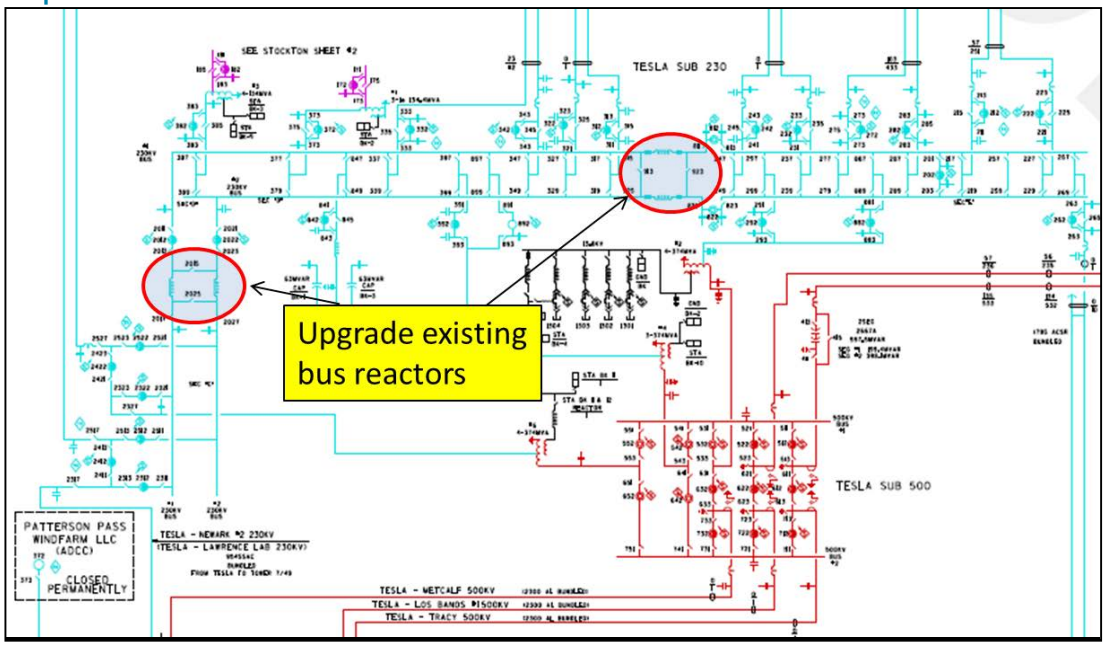
- May 2023

Estimated Cost

- $24M - $29M

Other Alternatives Considered

- Alternative 1: Status Quo
- Alternative 2: Replace 230 kV circuit breakers with 80 kA interrupting capacity breakers and reinforce the bus structure for higher fault stresses (This does not align with the PG&E's existing grounding practices and other company standards.)



Assessment-Short Circuit Duty Study

- The SCD study identified 11 breakers at Tesla 230 kV bus overstressed during certain fault condition

- Short Circuit level on Tesla 230 kV Bus need to be reduced to avoid Overstressed Circuit Breakers, This concern is more significant since the level has exceeded the maximum PG&E system design limit of 63 kA

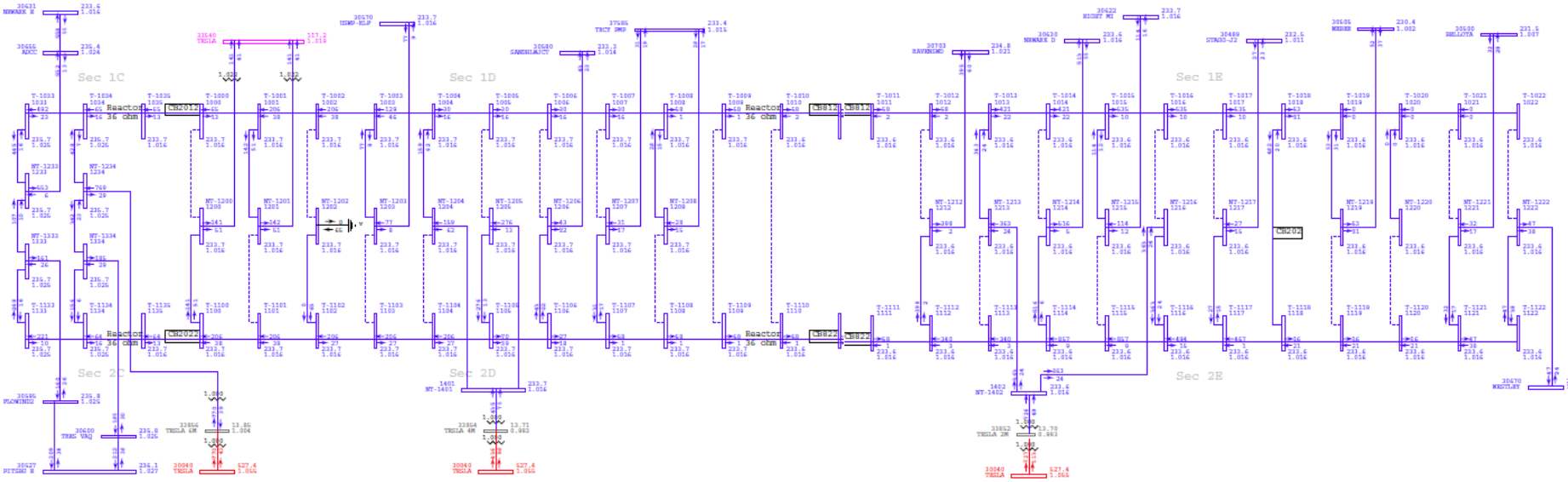
Current year	Pre-Project	Post-Project
Three Phase Fault	64740	55643
Single Line to Ground Fault	62626	53965
Double Line to Ground Fault	63815	54851

Year 2 Values	Pre-Project	Post-Project
Three Phase Fault	65,974	56,340
Single Line to Ground Fault	64,067	54,778
Double Line to Ground Fault	65,088	56,340

Year 5 Values	Pre-Project	Post-Project
Three Phase Fault	65925	56293
Single Line to Ground Fault	64001	54720
Double Line to Ground Fault	65032	55600

Assessment – Power Flow and Bus Flow Study

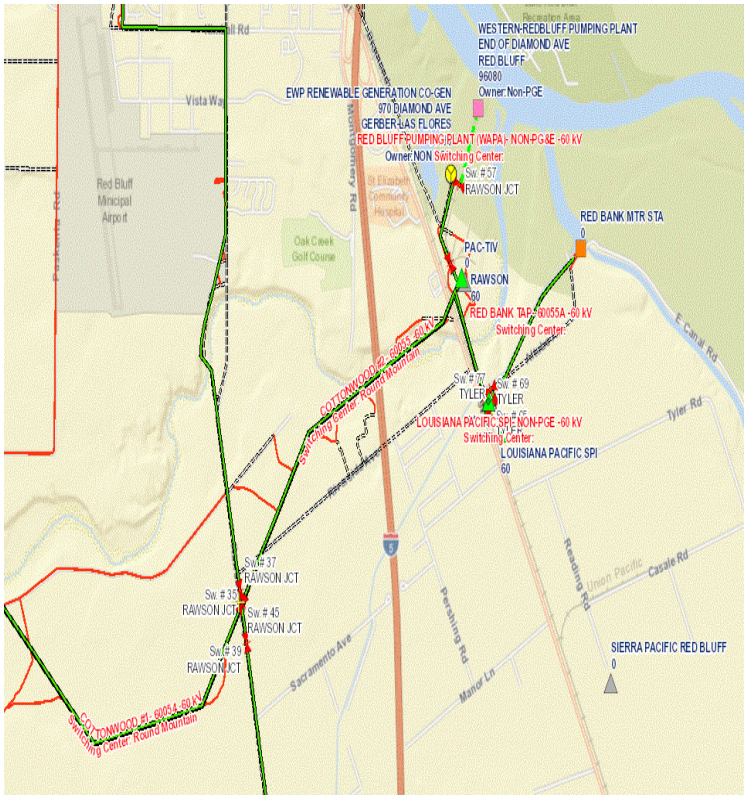
- Replacing existing reactors with higher impedance reactors change power flow on the Tesla 230 kV bus and transmission lines and transformers close to this substation.
- Power flow assessment results identified a few NERC Category P3 and P6 thermal issues.
- Reduce Contra Costa Area Generation or 230 kV Line rearrangement at Tesla 230 kV bus will solve this problem
- Bus flow study shows no issues by modeling the bus segments and switches in power flow cases

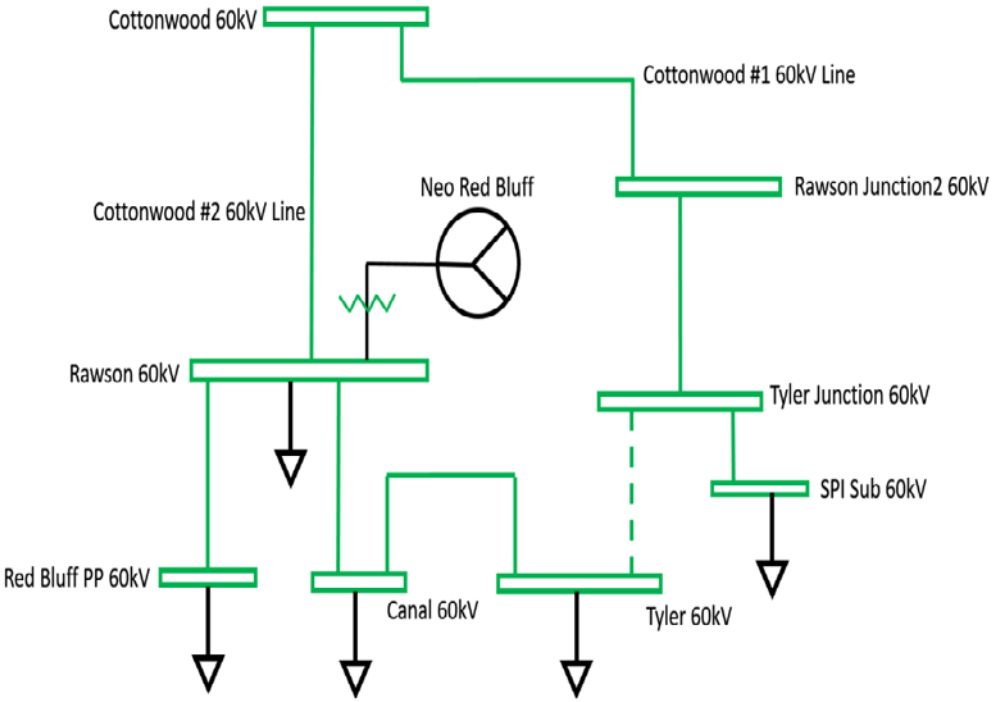


Tyler Substation
Reactive Support Project

Area Background

- Tyler 60 kV substation is located in North Valley area.
- Generation in this area is limited and supplies reactive power demand.
- Tyler 60kV load pocket is mainly served from cottonwood substation
- Due to projected demand in the local pocket low voltage violations are observed upon outage of the generation.

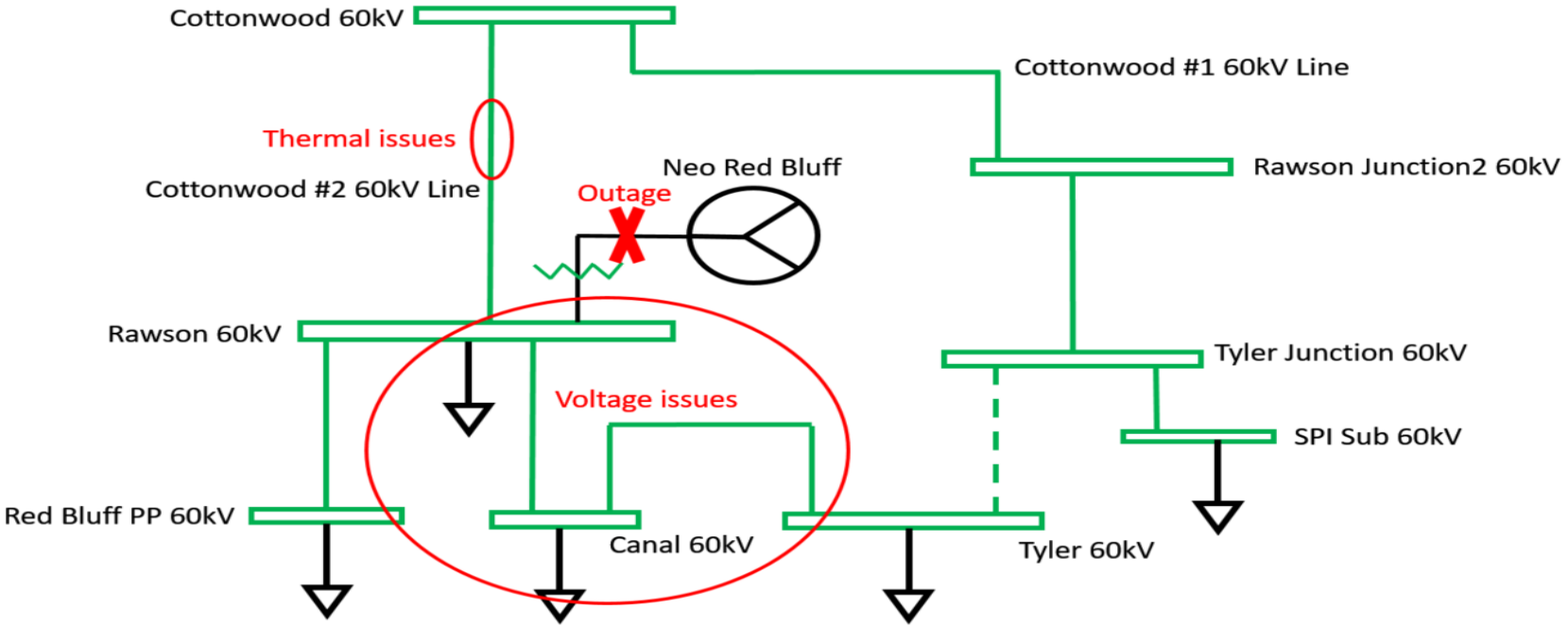




Assessment - Voltage and Thermal

Area Assessment Summer Peak		Pre-Project Voltage pu (% deviation)			Post-Project Voltage pu (% deviation)			Contingency
Facility	kV	2020	2023	2028	2020	2023	2028	
TYLER	60	0.92 (11.2%)	0.92 (11.4%)	0.86 (16%)	1.027 (0.8%)	1.026 (0.9%)	0.964 (5.5%)	P1-1: NEO RED BLUFF GEN UNIT 1
RASN JNT								
CR CANAL								
CANAL TP								
NEO REDT								

Area Assessment Summer Peak		Pre-Project (%)			Post-Project (%)			Contingency
Facility	Rating Amperes (Emergency)	2020	2023	2028	2020	2023	2028	
COTTONWOOD #2 60 kV (COTTONWOOD to RAWSON JNT)	513	88	90	107	84	86	93	P1-1: NEO RED BLUFF GEN UNIT 1



Proposed Project

Power flow analysis was performed and was determined that a voltage support device is needed in the area

- Voltage improved from 0.86 (16%) to 0.964 (5.5%) post contingency after project.

Preferred Location

- Tyler substation 60 kV

Preferred Scope

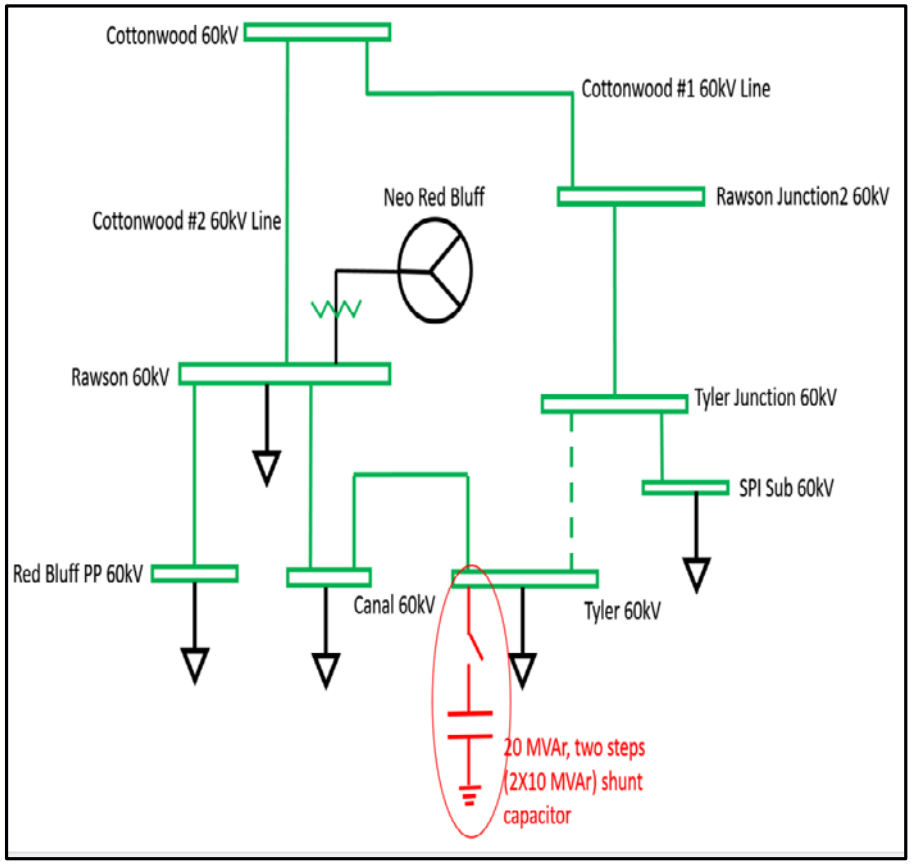
- Construct 20 MVAR, two steps (2*10 MVAR) shunt capacitor.
- Associated substation upgrades

Proposed In-Service Date

- May 2022

Estimated Cost

- $ 5.75 - $7M



Proposed Project

Other Alternatives Considered

Status Quo:

This alternative is not recommended because it does not mitigate the low voltages at Tyler 60 kV area**.**

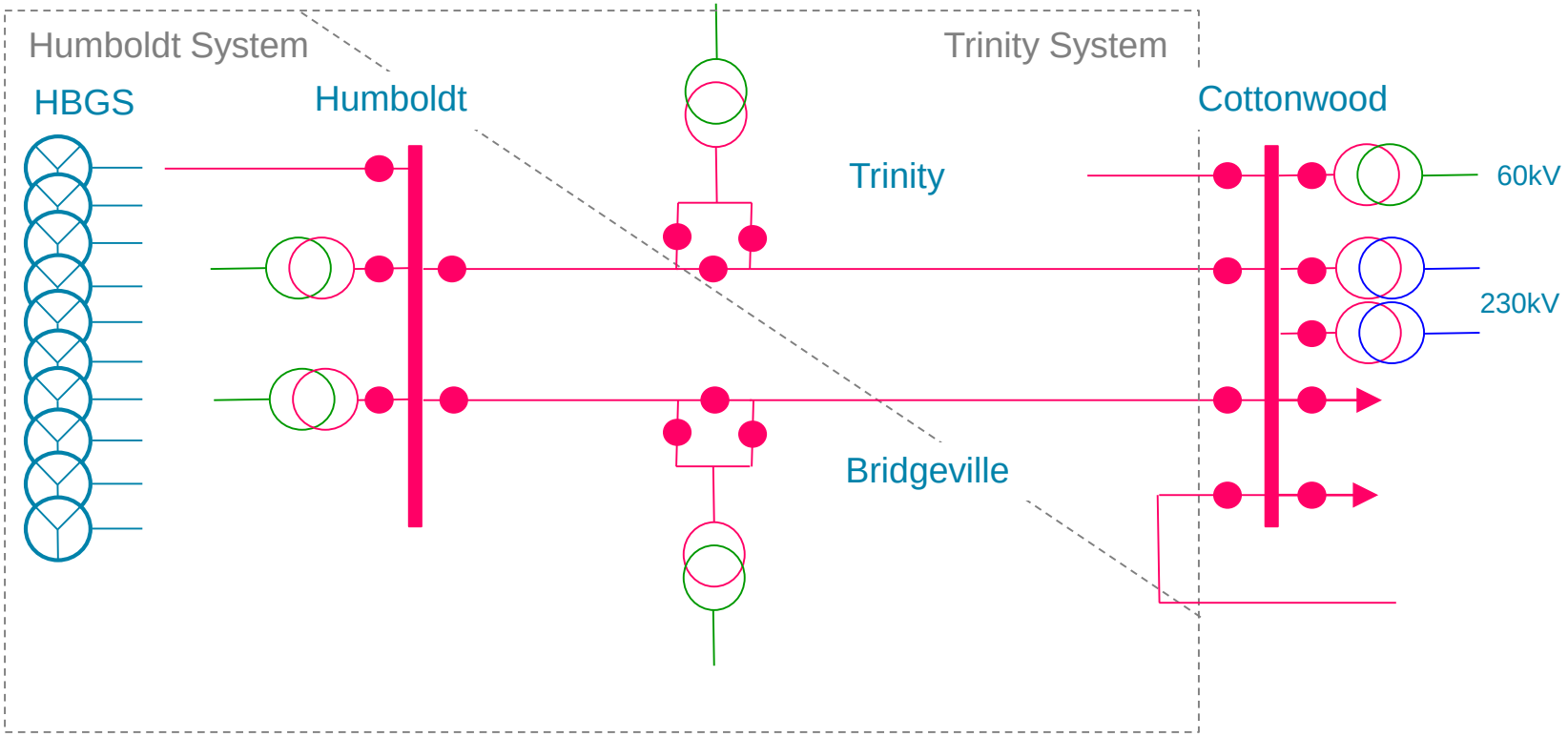
Reactive support at Rawson substation:

This alternative provides same benefits as the proposed project. Although, considering the fact that this substation has tap connection and Tyler substation is a flip-flop, Tyler substation has been selected for this reactive support.

Cottonwood 115kV Bus Sectionalizing Breakers Project

Area Background

- The Humboldt and Trinity systems are served by two 115 kV transmission lines from Cottonwood as well as a 60 kV network and local generation.
- The major generation resource in the area is the Humboldt Bay Generating Station (HBGS).
- Humboldt substation has an Under-Voltage Load Shedding (UVLS) scheme that is part of the PG&E UVLS Program designed to shed load in order to protect against voltage collapse.
- PG&E is required to study all UVLS Programs per PRC-010-2

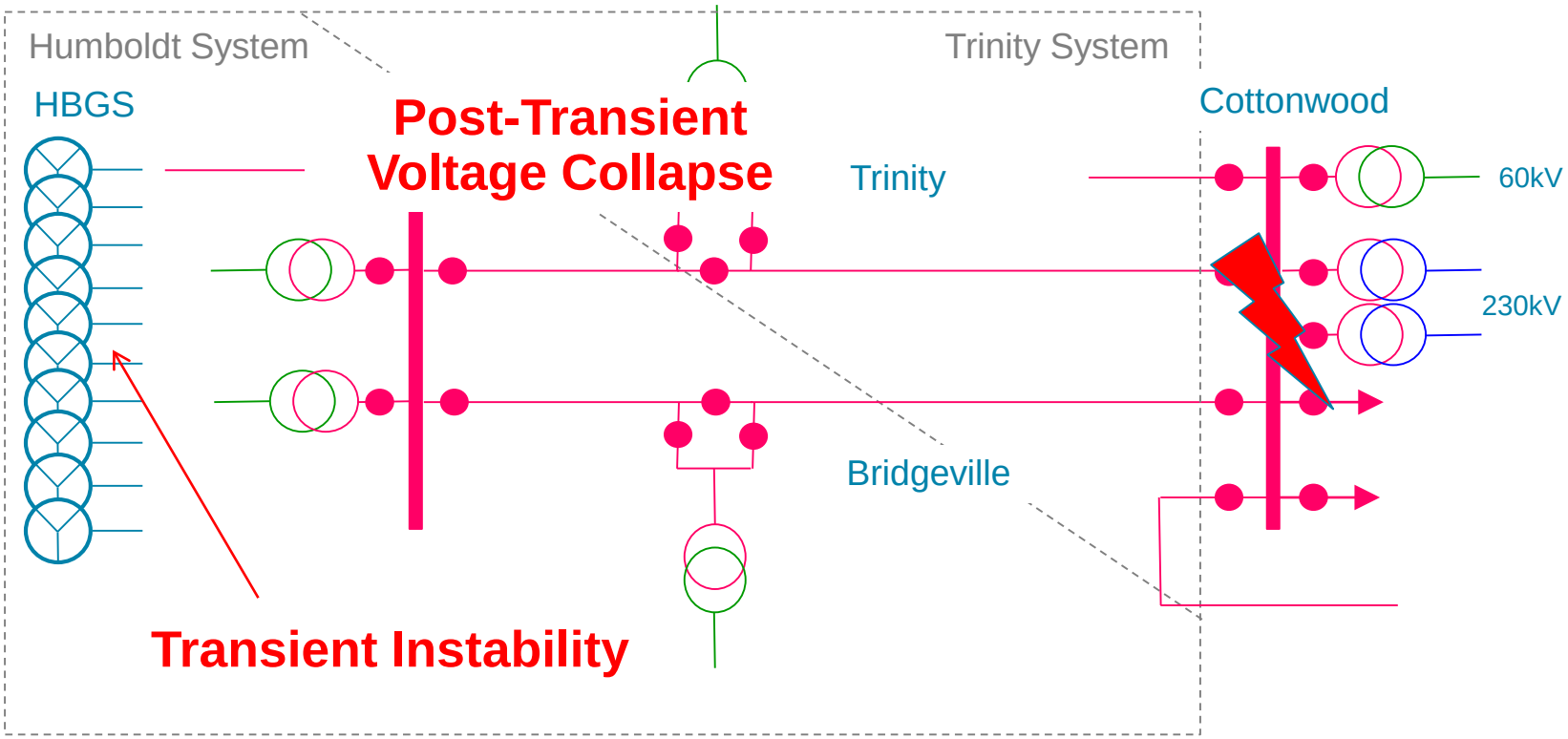


UVLS Assessment – Reliability Study

- **Assumptions for reliability studies to confirm UVLS adequacy**
  - The Humboldt system is winter peaking and unique to the rest of the system. As such, generalized assumptions do not apply.
  - Humboldt system assumptions:
    1. Set HBGS to minimum dispatch for 80 MW Humboldt Import.
    2. QFs such as Fairhaven, LP Samoa, and Pacific Lumber generation should be assumed offline. Only Blue Lake may be assumed online.
    3. Cascade Tie Imports should be zero.
    4. The P2 and P4 outages involving Cottonwood CB 102 should be studied for both power flow and transient stability without Humboldt UVLS action.

UVLS Assessment – Reliability Issues

- **Voltage collapse**: The 2017 Humboldt UVLS Program Validation study identified voltage collapse under present day operating conditions following loss of both Cottonwood 115 kV operating busses due to either the P2 Cottonwood CB 102 internal breaker fault or the P4 bus outage with CB 102 stuck.
- **Transient Stability**: The HBGS units are observed to trip in the dynamic simulation
- The current UVLS design does not detect the voltage collapse condition and will not protect the system for this outage



Proposed Project

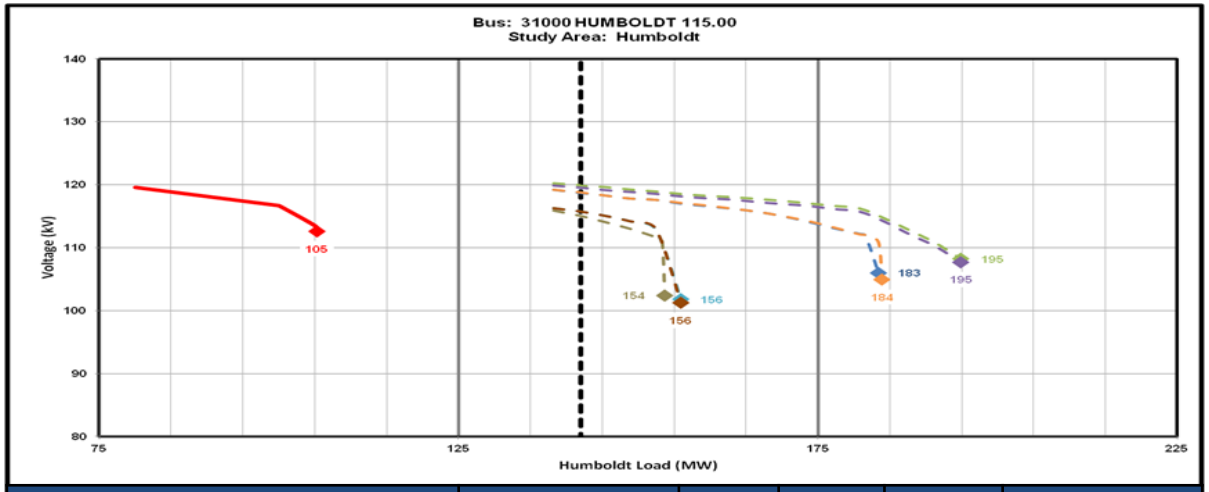
Sectionalizing the Cottonwood 115kV Bus Mitigates the Concern

- **Pre-Project vs Post-Project PV Plots**

  Post-transient voltage collapse load margin increases from -25.7 % to 8.4 %

- **Power Flow Results**

  The Jessup Tap-Cottonwood 115 kV Line section is currently limited to 400 Amps by Cottonwood CB 132



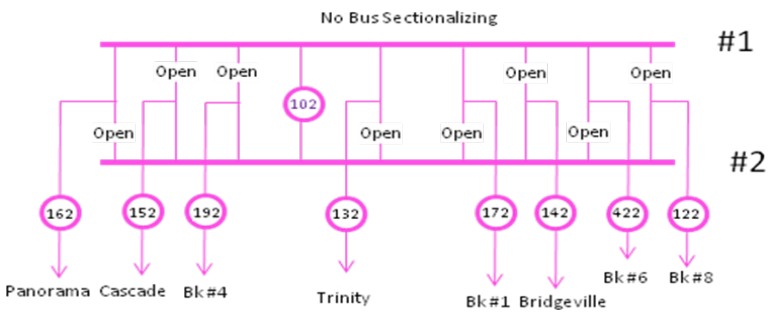
Contingency	Element	Rating	Pre-Project	Post-Project	Post-Project With limiting element upgrade
Cottonwood CB 102 • Loss of entire 115kV Station	N/A	N/A	DIV	N/A	N/A
Cottonwood 2D-2E Bus Tie CB • Bridgeville-Cottonwood 115kV • Cottonwood 230/115kV Bank 1 • Cottonwood-Cascade 115kV • Cottonwood-Panorama 115kV	JESSTAP - COTWD_1D 115 kV Line	400 A	N/A	109.9 %	82.6 %
Cottonwood 1E-2E Bus Tie CB • Bridgeville-Cottonwood 115kV • Cottonwood 230/115kV Bank 1 • Cottonwood Load Banks 6 & 8 • Sections 1D & 2D separated	JESSTAP - COTWD_1D 115 kV Line	400 A	N/A	101.7 %	76.5 %

Proposed Project

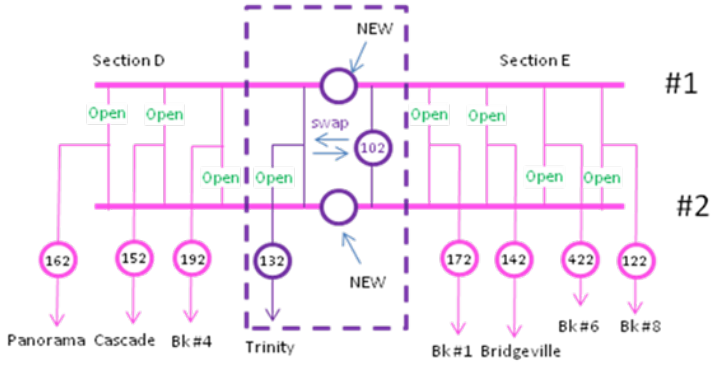
Preferred Scope

- Swap the CB 132 (Cottonwood-Trinity) and CB 102 positions in the bus
- Install sectionalizing breakers in the #1 and #2 operating busses between CB 102 and CB 132
- Adjust bus selector switches to new setup
- Upgrade CB 132 so that the Cottonwood-Jessup section of the Cottonwood-Trinity 115 kV Line is conductor-limited

Cottonwood 115kV Bus
Existing Setup



Cottonwood 115kV Bus
Sectionalize & Re-Arrange the Bus #1 & #2 connections
(includes Bus Selector Switches Changes)



NOTE: Trinity-Cottonwood 115kV line (CB 132) would swap locations with the existing Substitute Breaker (CB 102)

Proposed Project

Proposed In-Service Date

- May 2022 or earlier

Estimated Cost

- $8.5 - $10.5M

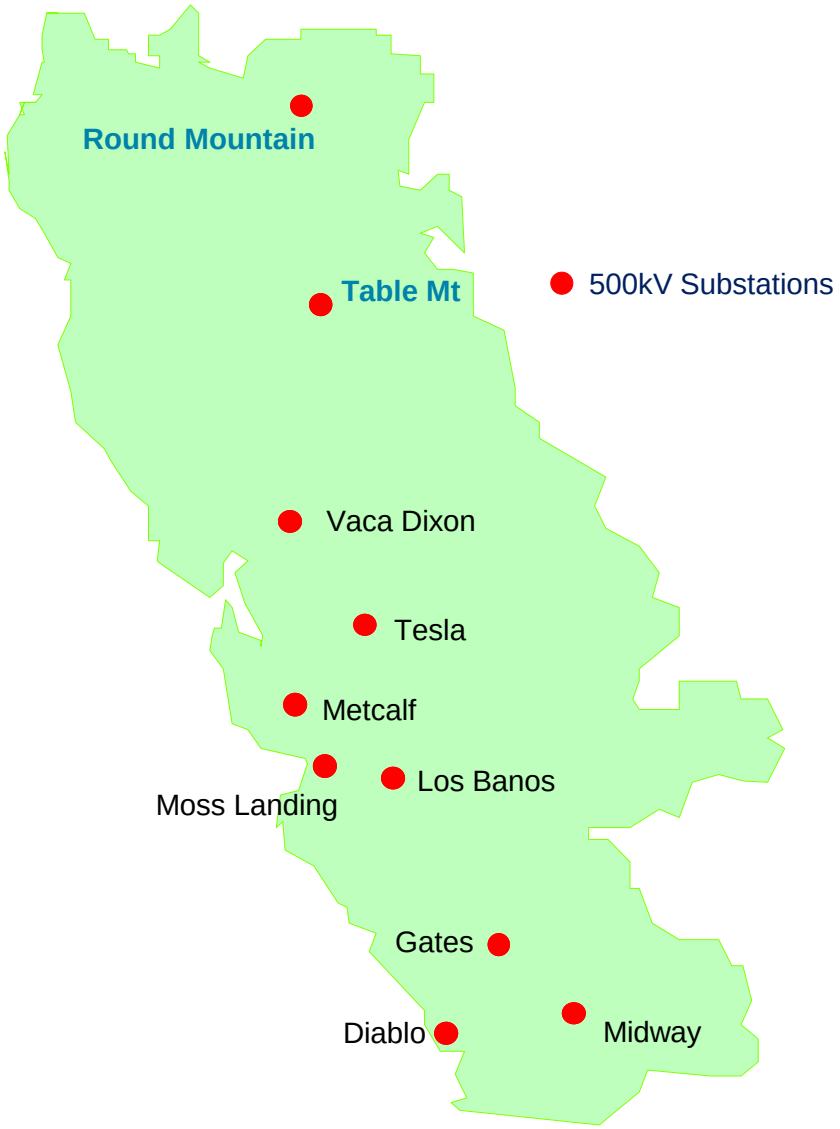
Other Alternatives Considered

- Augmentation of the Humboldt UVLS is not feasible due to microwave signal interruptions due to weather and terrain

Round Mountain 500 kV Voltage Support Project

Background

- Round Mountain Substation is part of the Pacific Intertie. The substation is vital to imports/exports between the Northwest and California
- Round Mountain substation has an abundant amount of hydro electric generation connected at the 230 kV Substation
- Real time operating voltage data for recent years have shown that voltages at Round Mountain and Table Mountain 500 kV Substations exceed high end thresholds for significant amount of the time



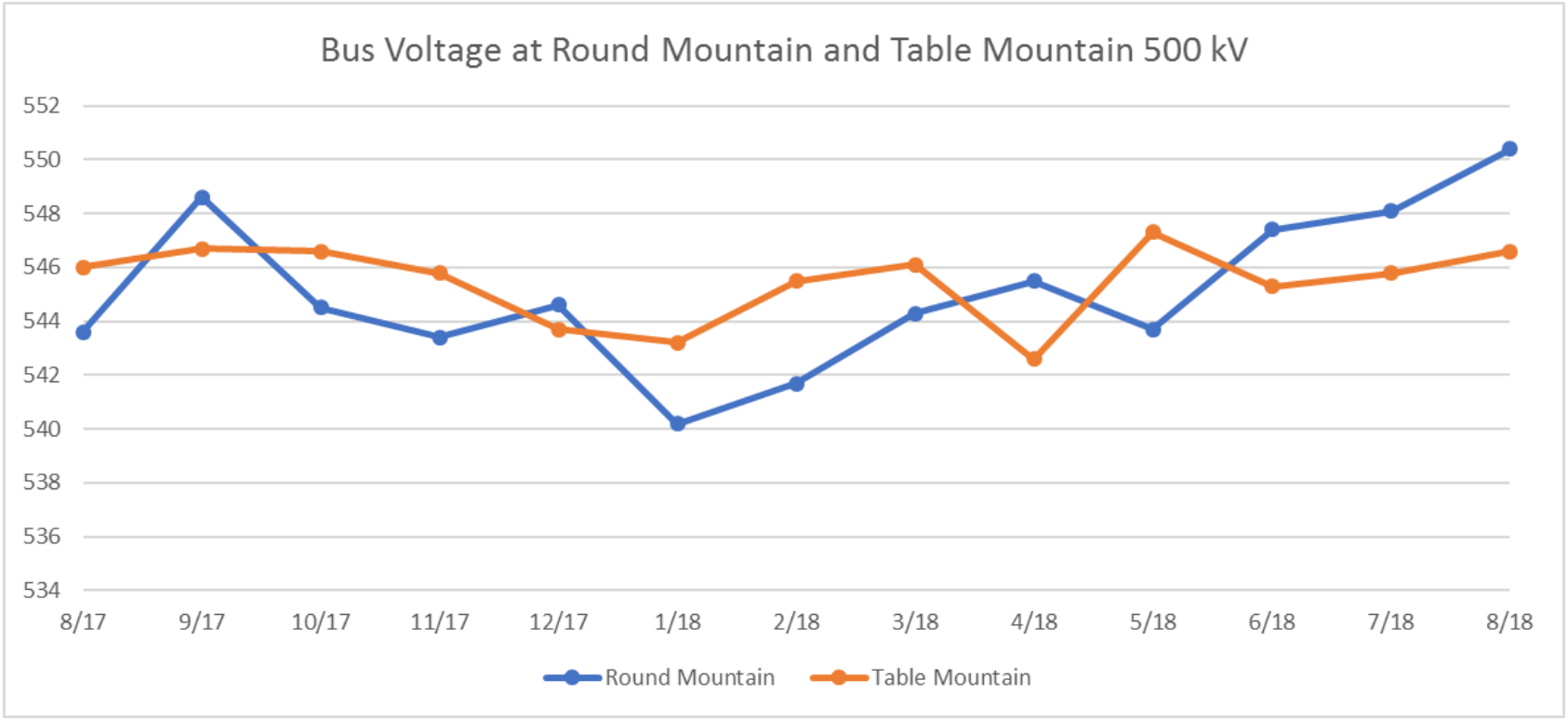
Overall Assessment

- The CAISO as part of its “Bulk and Regional Voltage Issues” presentation during the 2017 September Stakeholder meeting also identified similar high voltage exceedance concerns particularly when the COI flow is low.
- CAISO further identified that installing voltage support at Round Mountain 500 kV Substation could be a potential mitigation measure.
- This project will mitigate NERC TPL-001-4 Category P0 (normal system) high voltage issues identified in real time and previous years minimum load scenarios.
- This year a need is identified in the off-peak scenarios with reference to the CAISO Planning standards, PG&E Operating Standards and NERC TPL-001-4 standards for P6 contingencies.
- PG&E’s voltage operating limits per O-59 Operating Procedure are shown below

Nominal Voltage	Normal Operating Voltage Range (Pre-Contingency)				Emergency Operating Voltage Range (Post-Contingency)			
	Low End		High End		Low End		High End	
kV	kV	Pu	kV	pu	kV	pu	kV	pu
500	525	1.050	540	1.080	495	0.990	551	1.102
230	230	1.000	238	1.035	224	0.974	242	1.052
115	114	0.991	121	1.052	110	0.957	129	1.122

Real Time Voltage Assessment

- Real time voltage data for the past year have shown that voltages at Round Mountain and Table Mountain 500 kV Substations exceed high end thresholds of 540 kV for across the entire year



Planning Studies Assessment

- High voltages seen in Winter Off-peak Planning Study Scenario:

Facility Violation	Pre Project 2028 OfpkW	Contingency
TABLE MT	553.33	P6_1_1-0Round Mountain-Table Mountain #2 500kV Line & Malin-Round Mountain #1 500 kV Line
TRACY	554.35	
TABLE MT	551.5	P6_1_1-5Malin-Round Mountain #1 500 kV Line & ROUND MT 230/500kV Bank #1 & Round Mountain-Table Mountain #1 500kV Line
TRACY	554.19	
TABLE MT	553.33	P6_1_1-6Round Mountain-Table Mountain #2 500kV Line & Table Mountain-Tesla 500 kV Line
TRACY	554.35	
ROUND MT	553.67	P6_1_2-3Round Mountain-Table Mountain #2 500kV Line & Round Mountain-Table Mountain #1 500kV Line & Malin-Round Mountain #1 500 kV Line
TABLE MT	552.75	
TABLE MT	553.67	P6_1_1-2Round Mountain-Table Mountain #2 500kV Line & ROUND MT 230/500kV Bank #1
TRACY	554.96	
TRACY	551.2	P6_1_1-12Table Mountain-Tesla 500 kV Line & TRACY-TESLA #1 500kV Line

Round Mountain 500 kV Voltage Support

Scope

Reactive Support

Install a single +/- 500 MVAR STATCOM providing reactive support with continuous and controlled capability. The STATCOM can provide dynamic support to the grid.

System Upgrades

The STATCOM will require a single 500 kV connection to the 500 kV bus. The Round Mountain 500 kV bus is setup for BAAH, but currently connected and operated as a ring-bus. To allow for the connection of the STATCOM the 500 kV bus will be converted to three bays of BAAH.

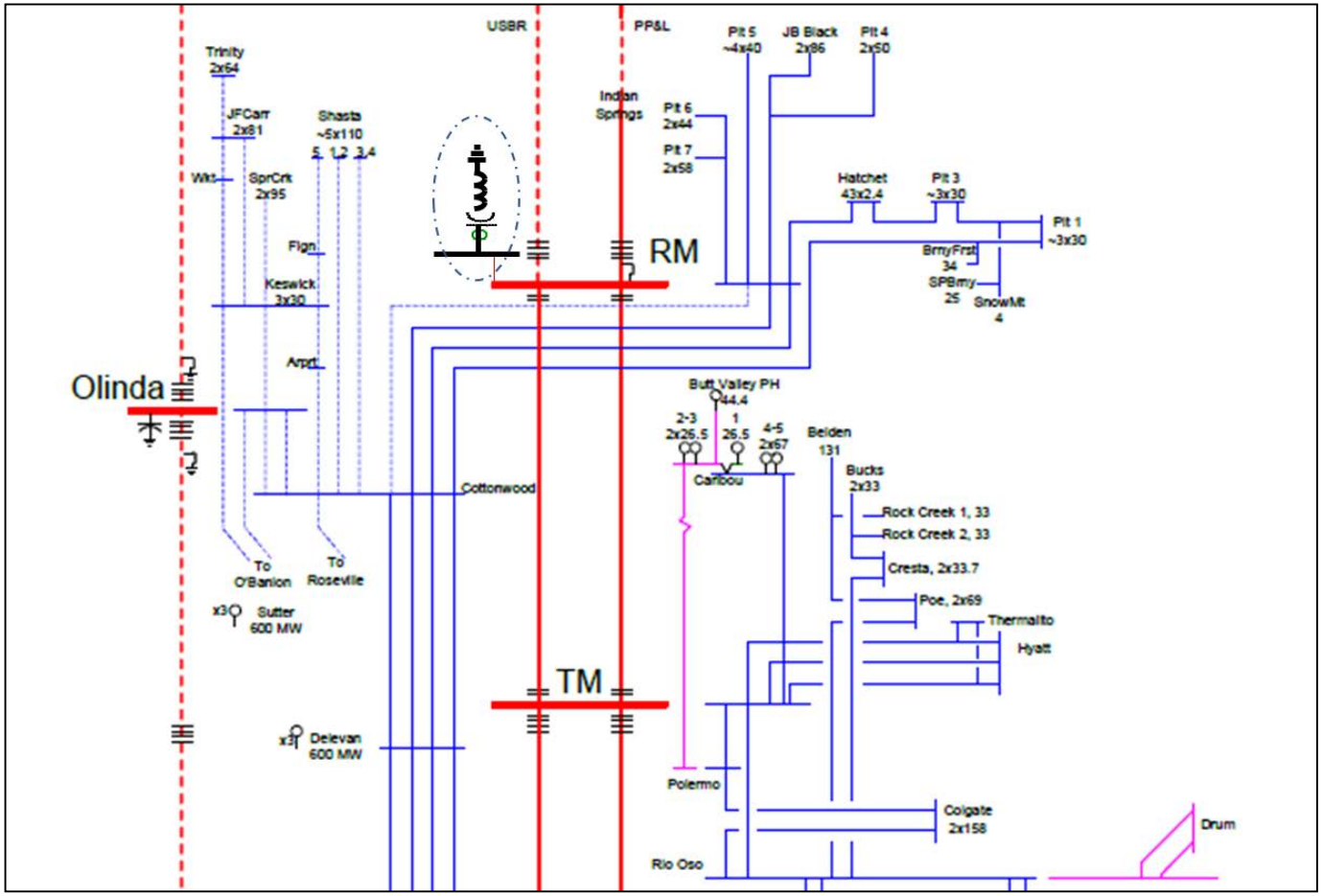
Cost

The expected costs for the project are:
Voltage support equipment procurement and install is approximately $105M
Upgrades to accommodate the installation is approximately $55M
Total Cost of $160M - $190M

In Service Date

- December 2024 or earlier

Round Mountain 500 kV Voltage Support

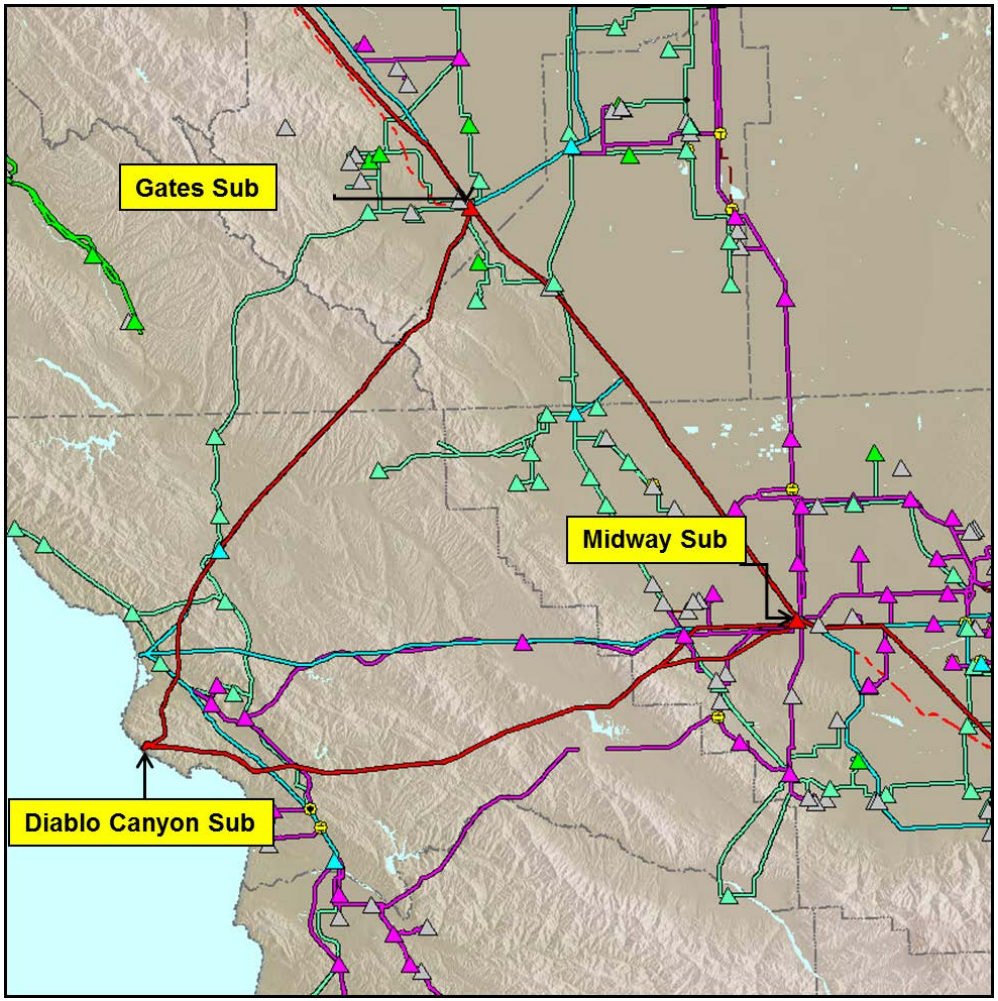


Future Single Line Diagram

Gates 500 kV Voltage Support Project

Background

- The power generated from Diablo Canyon Power Plant is exported to the north and the east through the 500 kV transmission lines.
- There are several transmission ties to the Fresno, Los Padres, and Kern systems, with the majority of these interconnections made at Gates and Midway substations.
- The Gates 500kV substation also supports a large amount of renewable generation.



Assessment

- This project mitigates expected high voltages incurred by NERC TPL-001-4 Category P0, P1, P6, P7 and extreme contingencies on the Bulk System upon the retirement of the Diablo Canyon Power Plant.
- The most severe of these contingencies (P0) may lead to facility voltages of up to 552 kV (normal) and a P1 Los Banos – Midway 500 kV line or Diablo – Midway No. 2 500 kV Line Shunt outage may lead to facility voltages of 555 kV (emergency).
- A significant amount of reactive support is needed to bring 500 kV voltages down to acceptable levels
- PG&E has developed three potential options that could be considered.

Gates 500 kV Voltage Support Project Proposed Scope

- Install voltage support devices at Gates Substation to mitigate system voltage concerns expected upon the retirement of Diablo Canyon Power Plant. Approximately, 1000 MVARs need to be absorbed at Gates 500 kV

All identified options include the following substation work:

The reactive support project at Gates will require two 500kV connections to the 500kV bus. The Gates 500kV bus is setup for five 500kV AIS BAAH. There is one available connection. The second connection will require building a partial bay.

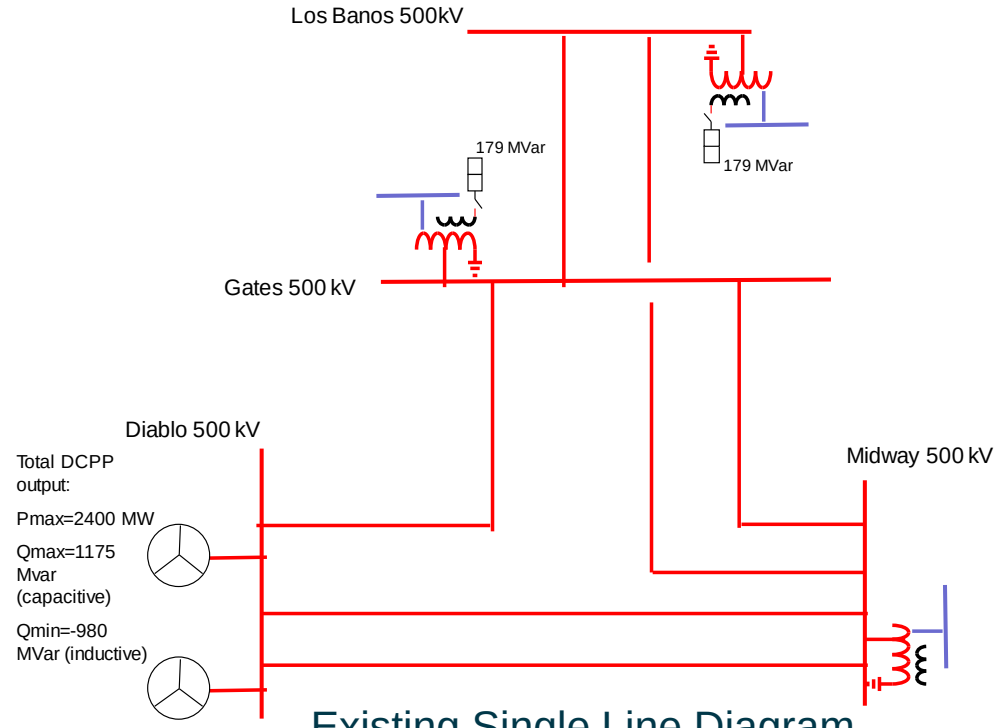
The high level project scope includes:

- Install one 500kV breaker and associated switches in Bay 2
- Build new partial bay (two breakers) with breakers and switches on the Westside of the bus
- Build low-profile or Iso-phase bus to connect the reactive support equipment
- Install breakers and reactive support equipment protection scheme in the existing 500kV control building

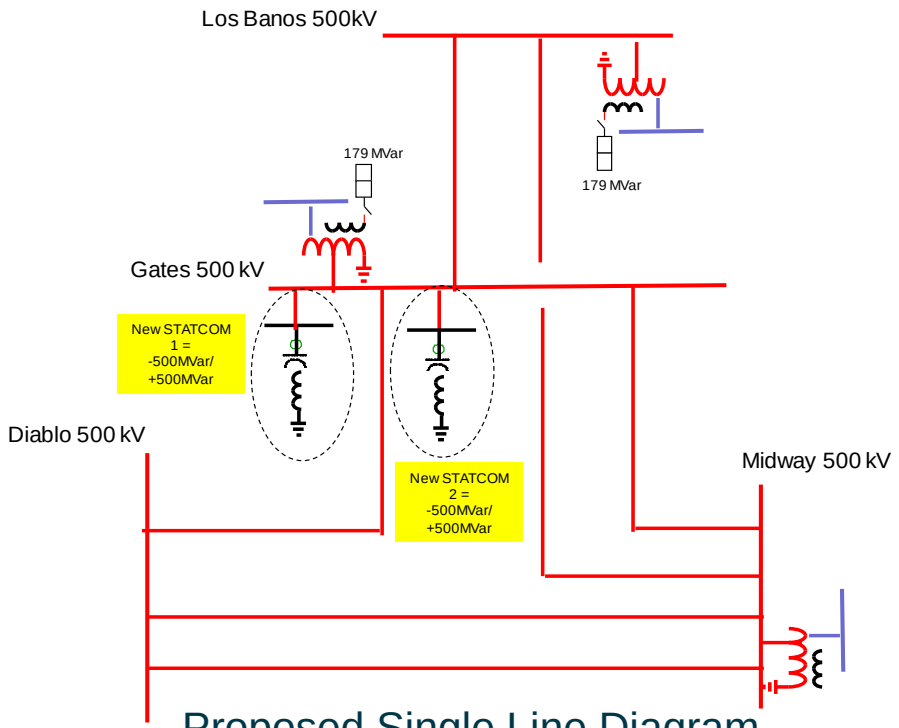
Gates 500 kV Voltage Support Project Option 1

Option 1

Install two +/- 500 MVAR STATCOM segments providing a total of 1000 MVARs capacitive and 1000 MVARs inductive reactive support with continuous and controlled capability. Both STATCOMS could operate independently, providing redundancy and provide dynamic support to the grid even when one is out of service.



Existing Single Line Diagram



Proposed Single Line Diagram

Cost

- $240M-$290M (total with substation work)

Gates 500 kV Voltage Support Project Option 2 and 3

Option 2

- Install one +500/-500 MVAR STATCOM and -500 MVAR shunt reactors at Gates Substation.
- The hybrid system will provide a good balance of inductive and capacitive dynamic reactive support in addition to discrete inductive capability controlled by the STATCOM.
- This hybrid system provides redundancy to protect against high system voltages

Option 3

- Install one +0/-1000 MVAR SVC and +350 MVAR shunt capacitor at Gates Substation.
- This option provides a good balance of continuous and controlled inductive dynamic reactive support in addition to discrete capacitive reactive capability
- One drawback is that the entire inductive reactive support is provided by the SVC

Cost

- Total cost for these option is to be determined and will depend upon the desired make up of the systems

Gates 500 kV Voltage Support Project

Other Alternatives Considered

- Status Quo
- Open Diablo – Midway 500kV line during normal conditions

In Service Date

- December 2024

Thank you