PG&E's 2017 Request Window Proposals

CAISO 2017/2018 Transmission Planning Process

September 22, 2017

Transmission Projects Overview

Projects Seeking CAISO Approval:

Yosemite/Fresno

- Herndon-Bullard #1 & #2 115kV Reconductoring Project

Central Coast/Los Padres

- Oil Fields 60 kV Area Voltage Support

GBA

- Oakland Reliability Proposal

Load Interconnection Project Seeking CAISO Concurrence:

- California High Speed Rail (CHSR)

Herndon-Bullard #1 & #2 115kV Reconductoring Project

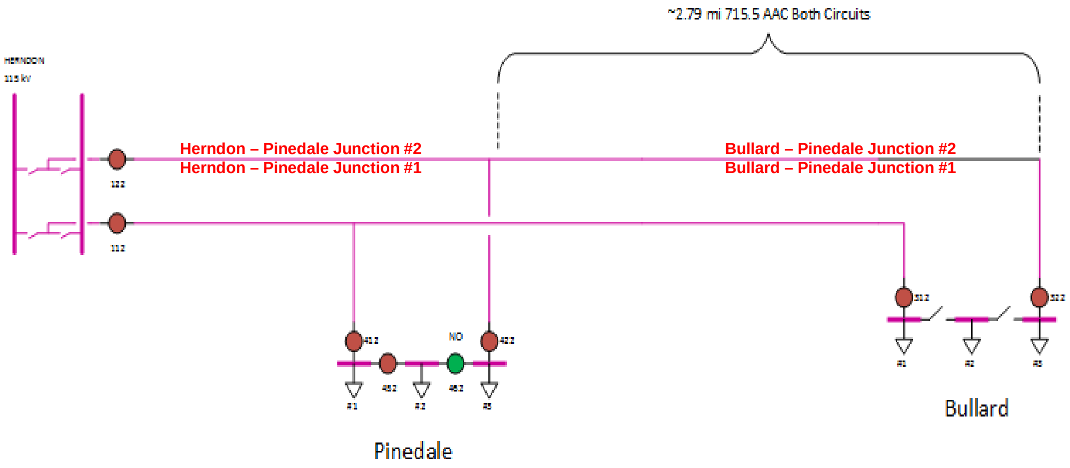
Herndon – Bullard 115 kV Reconductoring

Area Background

- Pinedale and Bullard 115kV substations are located in Northern Fresno and primary served by Herndon.
- Both Substations are radially served by two (2) 115kV sources which include the Herndon – Pinedale Junction # 1 and # 2 115kV lines.
- 35MW of DGs and AAEE are projected in this area by 2027.

Assessment (Base line cases with DGs and AAEE)

- P2-1 Contingency: Loss of either of the two parallel circuits from Herndon – Pinedale Junction.
  - Transmission Line Facility: Bullard – Pinedale Junction 2 115 kV Line is loaded to125% of its SE ratings in 2019
  - Transmission Line Facility: Bullard – Pinedale Junction 1 115 kV Line is loaded to103% of its SE ratings in 2019



Herndon – Bullard 115 kV Reconductoring

Sensitivity Assessment

- Sensitivity evaluated with all DGs and AAEEs out of service at Bullard and Pinedale Substations
- P2-1 Contingency: Loss of either of the two parallel circuits from Herndon – Pinedale Junction.
  - Transmission Line Facility: Bullard – Pinedale Junction 2 115 kV Line is loaded to135% of its SE ratings in 2019
  - Transmission Line Facility: Bullard – Pinedale Junction 1 115 kV Line is loaded to111% of its SE ratings in 2019

Sensitivity Assessment		Pre-Project			Post-Project			Contingency
Facility	Rating* (A)	2019	2022	2027	2019	2022	2027	
Bullard – Pinedale Junction #1 115 kV Line	740	111%	97%	105%	75%	66%	71%	P2-1: Herndon – Pinedale Junction #2
Bullard – Pinedale Junction #2 115 kV Line	740	135%	125%	132%	91%	84%	89%	P2-1: Herndon – Pinedale Junction #1

Regular Assessment		Pre-Project			Post-Project			Contingency
Facility	Rating* (A)	2019	2022	2027	2019	2022	2027	
Bullard – Pinedale Junction #1 115 kV Line	740	103%	87%	88%	70%	59%	60%	P2-1: Herndon – Pinedale Junction #2
Bullard – Pinedale Junction #2 115 kV Line	740	124%	111%	110%	84%	75%	74%	P2-1: Herndon – Pinedale Junction #1

*Summer Emergency

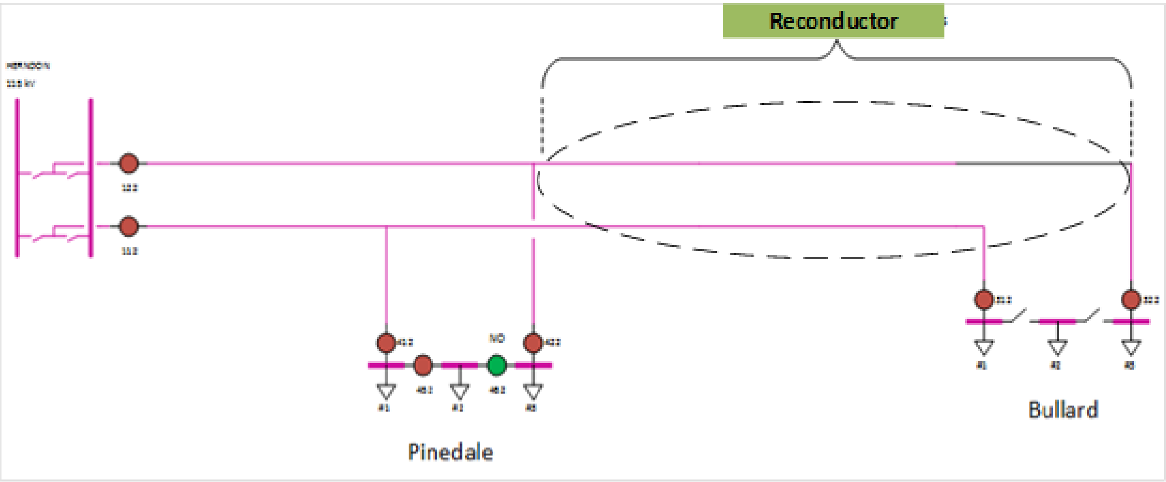
Herndon – Bullard 115 kV Reconductoring

Preferred Scope

- Reconductor ~6 circuit miles (3 miles of double circuit transmission lines) between Pinedale Jct and Bullard Substation on the Herndon-Bullard #1 and #2 115kV Lines.
- Reconductor the two circuits with larger conductor whose emergency rating is at least 1300 Amps.

Alternative Considered

- Curtailment of roughly 20 MW of load at Bullard and Pinedale substations. (TPL-001-4 not allow Non-Consequential Load Loss for P2-1)



Proposed In Service Date

- January 2021

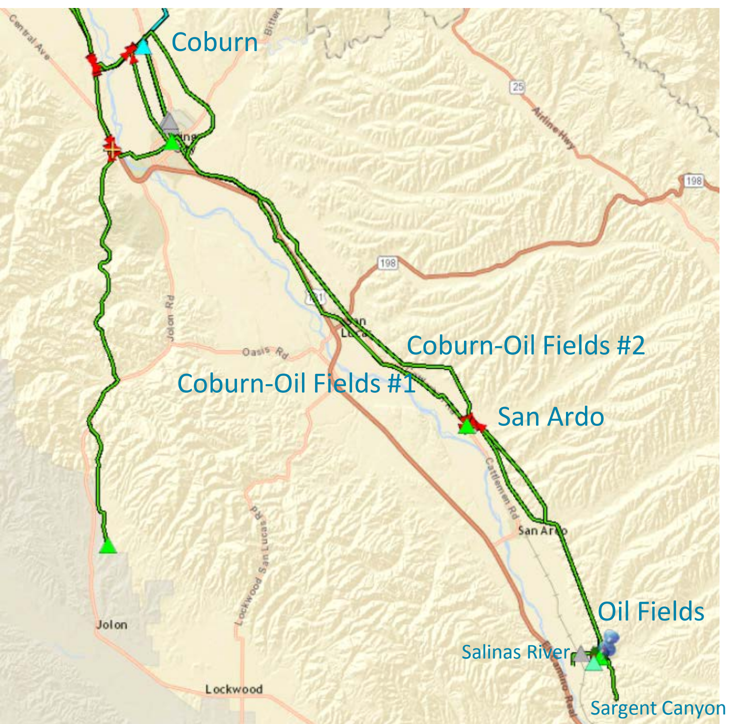
Estimated Cost

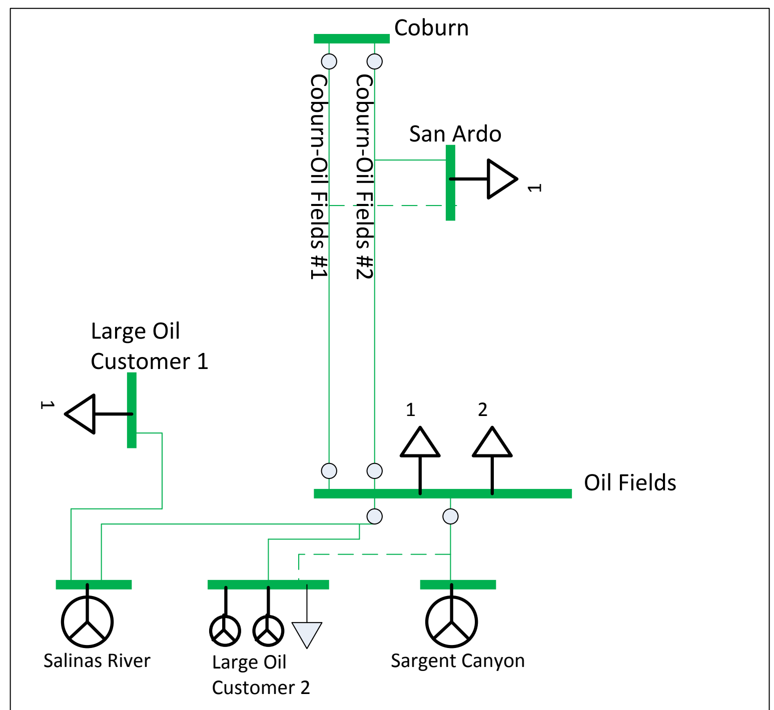
- $6M-$8M

Oil Fields 60 kV Area Voltage Support

Area Background

- Oil Fields area is located within Central Coast division
- Local 60 kV system is served mainly from 230 kV system at Coburn as well as by local generation
- Major generation sources in the area are Salinas River Cogen and Sargent Canyon (retired 2017).
- Over 2,700 distribution customers and two large oil production facilities are served
- Due to generators retirement and outages, this area import energy instead of export. When this area imports energy, the voltage is lower than before.

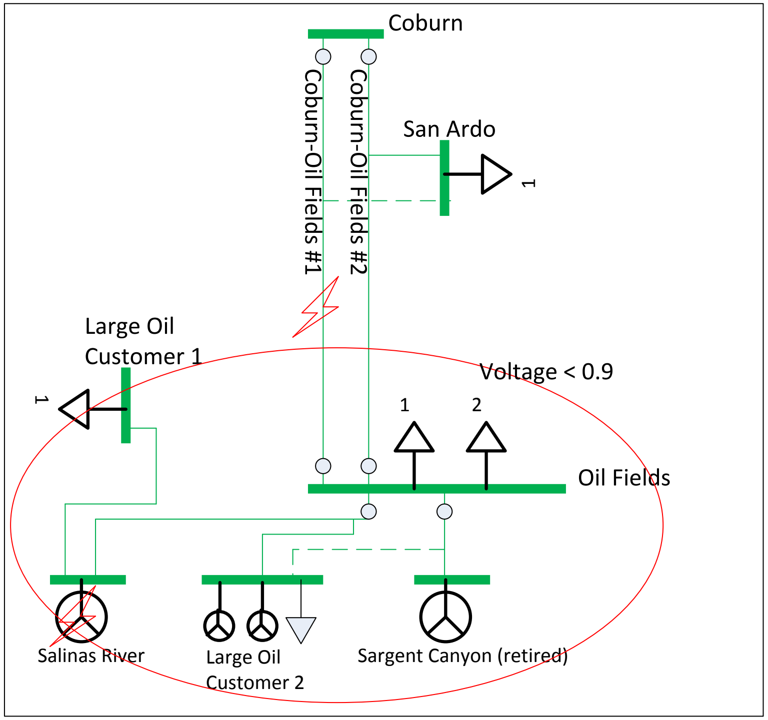




Assessment - Low Voltage Issues

Low voltages in the area

- Low voltages are observed both in the near-term (2019/2022) and long-term (2027) planning summer peak cases
  - Low voltages during Salinas River Cogen outage and Coburn-Oil Fields #1 outage (Category P3)
  - Low voltages ranging from 0.873 to 0.887



Proposed Project

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

- Voltage improved from 0.873-0.887 to 0.947-0.961 during P3 contingency after project

Preferred Location

- Oil Fields 60 kV Substation

Preferred Scope

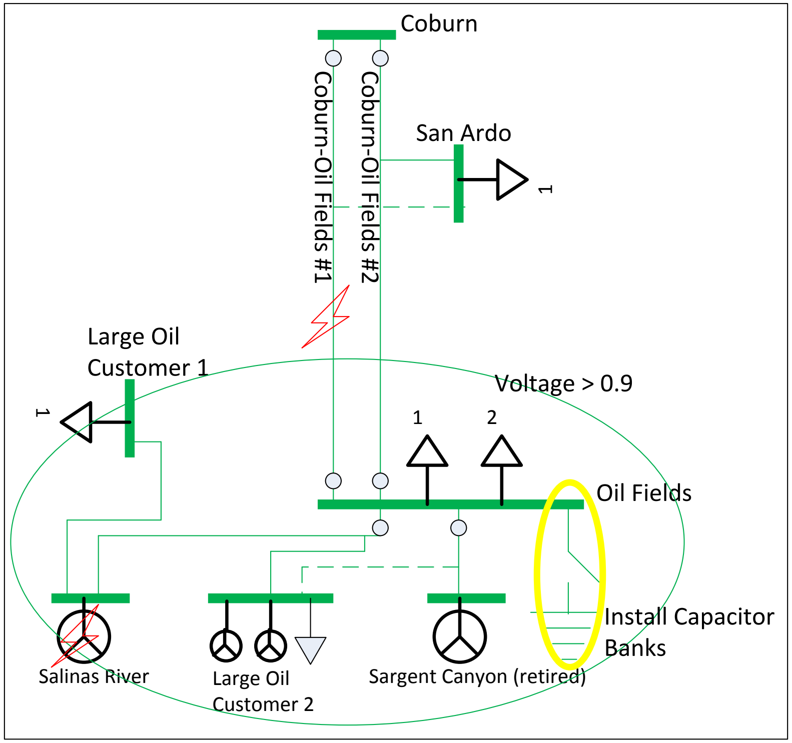
- Install 10 MVAR Shunt Capacitor
- Associated bus connection and bay work

Proposed In-Service Date

- May 2022 or earlier

Estimated Cost

- $7M - $10M



Other Alternatives Considered

- Status Quo
- Bring retired Sargent Canyon cogen back online

Thank you

Oakland Reliability Proposal
CAISO Stakeholder Meeting

CAISO 2017/2018 Transmission Planning Process

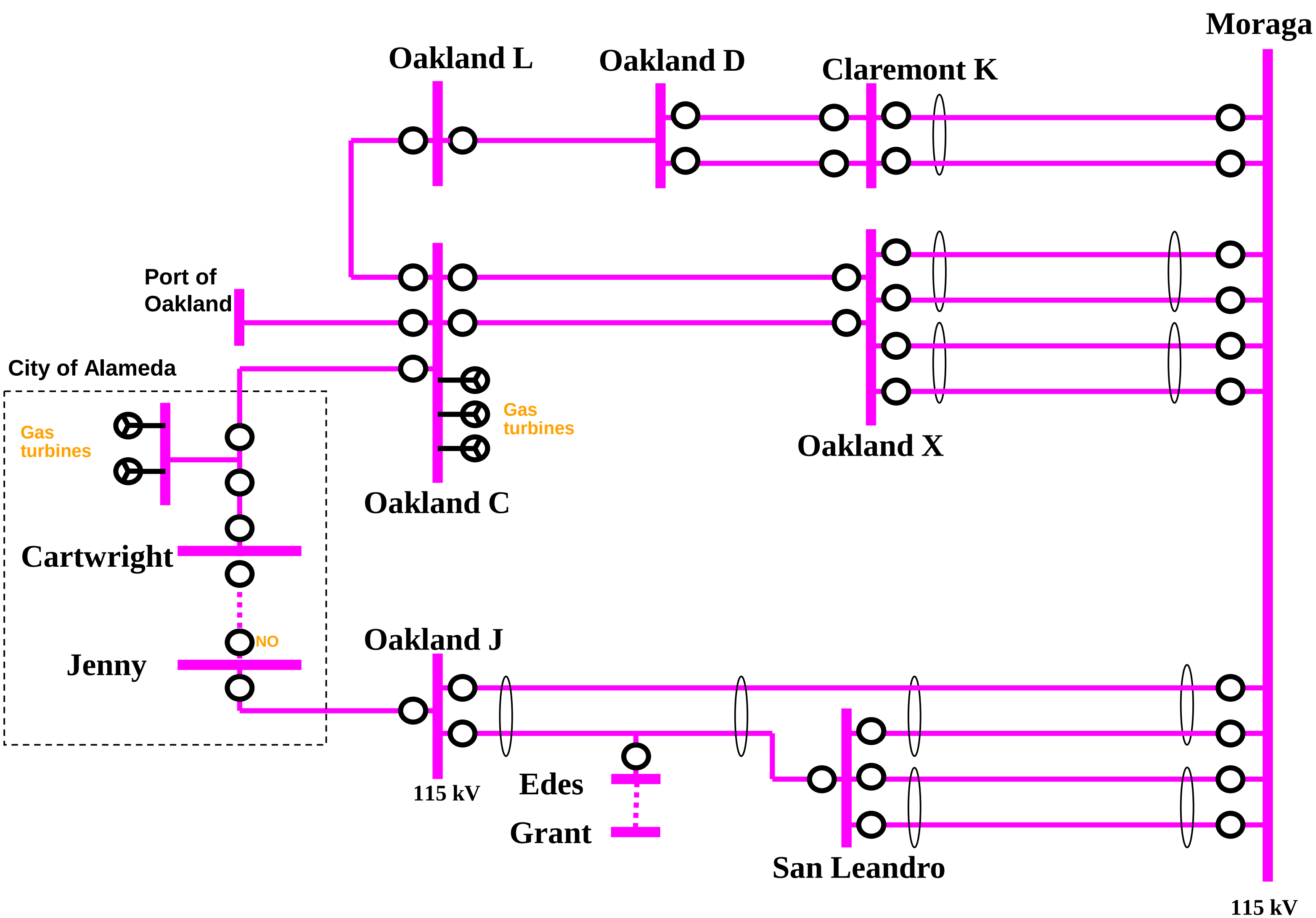
September 22, 2017

Background

Area Overview

- The Oakland area is served from Moraga Substation via several 115 kV overhead transmission lines and underground cables.
- The area consist of two separate load pockets: North and South Oakland. Port of Oakland receives PG&E wholesale contract service from the North, as does part of Alameda Municipal Power (under normal operations).
- Two Special Protection Schemes (SPS) are installed in the North Oakland pocket to protect underground cables from exceeding their thermal rating.
- Two generation facilities exist in the area, one facility is Oakland Power Plant (Capacity:165 MW) and the other is located within the City of Alameda (Capacity 49 MW).
- Oakland Power Plant began commercial operations in 1978, and currently operates under an annual Reliability Must Run (RMR) Contract.
- Alameda Generation began commercial operations in 1986, and operates under NCPA control.
- The C-X #3 underground cable was installed in 2010.

Existing Oakland 115 kV System



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CAISO’s Study in last 3 TPP Cycles

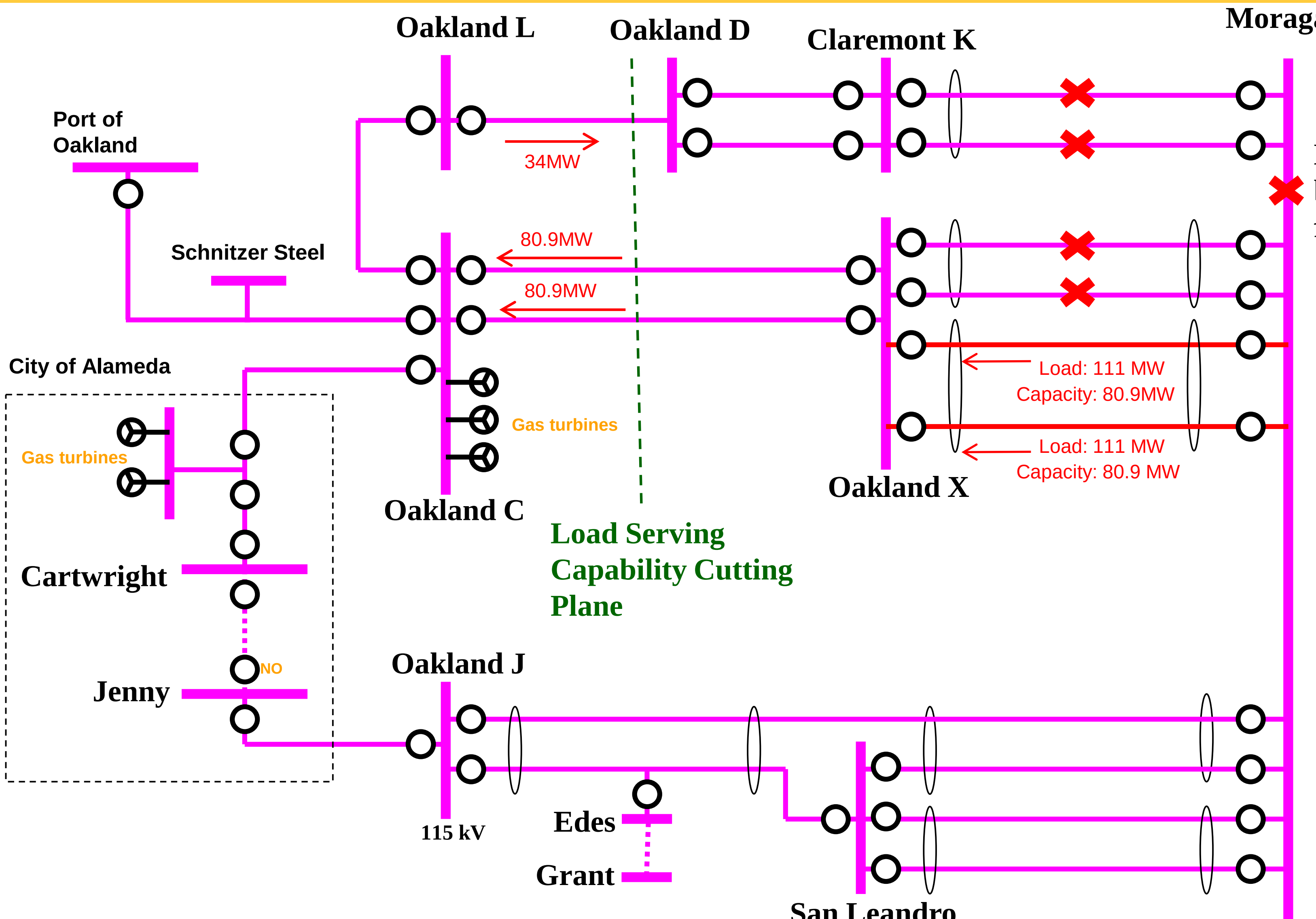
In the 2015-2016, 2016-2017, and 2017-2018 TPP Transmission Planning Cycles, the CAISO performed a study to determine the potential impact of Oakland Power Plant retirement.

The key takeaways from their studies:

- Existing SPSs in northern and southern part not triggered with all generation available.
- Ten 115 kV facilities overload for various P2 & P6 contingencies in North Oakland Pocket without generation available.
- The ISO will be considering transmission, generation or non-transmission solutions as they assess the needs of the area.
- The leading alternative at this time is a combination of transmission upgrades and preferred resources - a portfolio of demand response, energy efficiency, distributed generation and storage.
- Substation upgrades at Moraga 115 kV and Oakland X 115 kV for P2 and Alameda load transfer and preferred resource for P6
- In the near-term the area relies on SPS with a relatively small amount of load shedding as per the ISO Planning Standards; however the ISO will consider alternatives for the long-term horizon.

ASSESSMENT RESULTS: ASSUME OAKLAND GENERATION IS OFFLINE

Worst Single Event P2 Concern

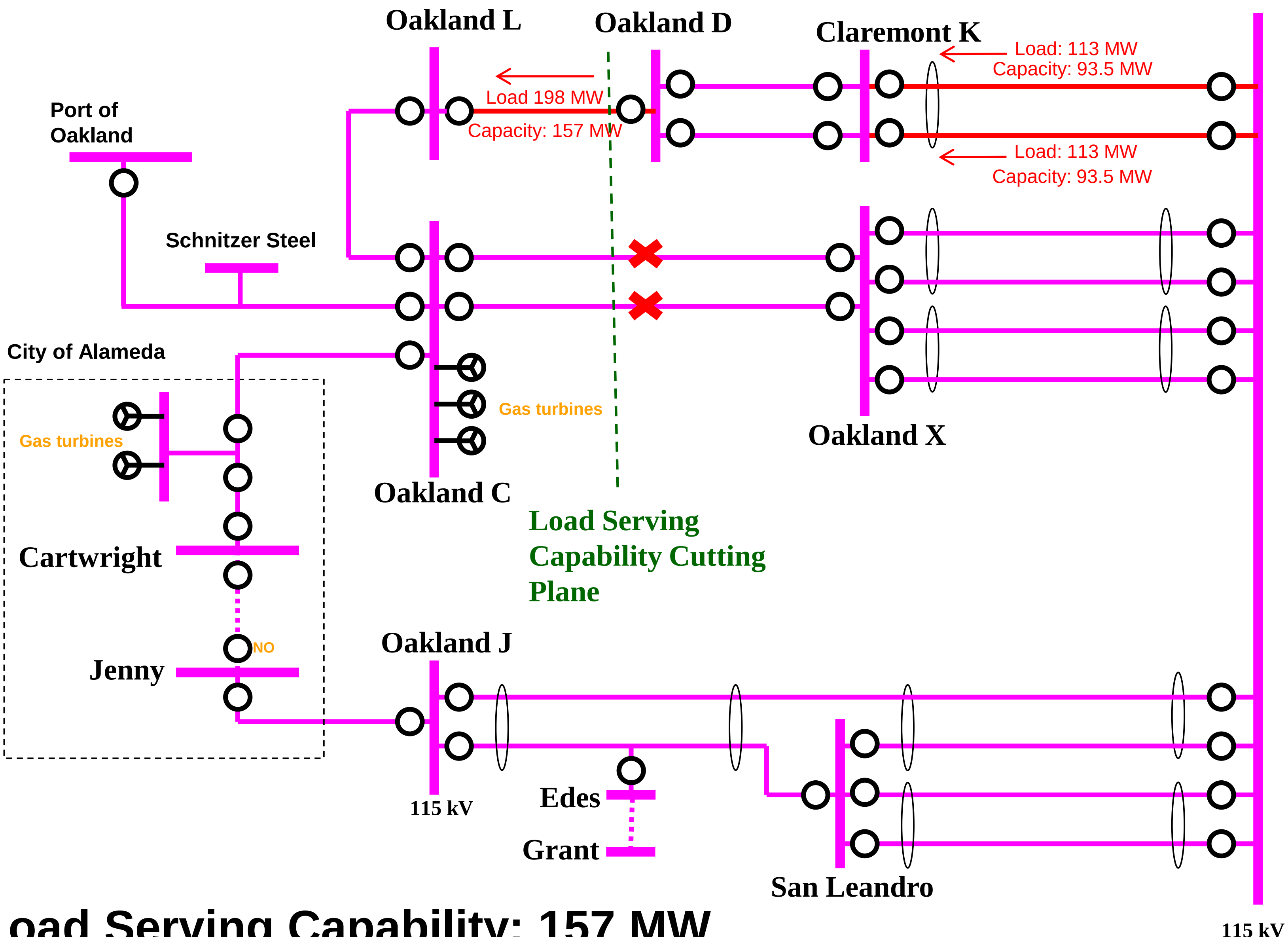


Load Serving Capability: 128 MW (81+81-34=128MW)

Single Event P2 Concerns

NERC	Facility Name	Contingency Name	Base
P2-4	C-X #2 [9962]	P2-4: CLARMNT 115kV - Section 2D & 1D	106%
P2-4	MORAGA-CLAREMONT #1 115kV [2700]	P2-4: MORAGA 115kV - Section 2E & 2D	104%
P2-2	MORAGA-CLAREMONT #1 115kV [2700]	P2-2: MORAGA 115kV Section 2D	104%
P2-4	MORAGA-CLAREMONT #2 115kV [2710]	P2-4: MORAGA 115kV - Section 1E & 1D	104%
P2-2	MORAGA 230/115 kV TRANSFORMER NO. 3	P2-2: MORAGA 230kV Section 2D	102%
P2-2	MORAGA 230/115 kV TRANSFORMER NO. 3	P2-2: MORAGA 230kV Section 2D	101%
P2-3	MORAGA 230/115 kV TRANSFORMER NO. 3	P2-3: MORAGA - 2D 230kV & CONTRA COSTA-MORAGA #2 line	102%
P2-4	MORAGA-OAKLAND #4 115kV [2750]	P2-4: MORAGA 115kV - Section 2D & 1D	132%
P2-4	MORAGA 230/115 kV TRANSFORMER NO. 3	P2-4: MORAGA 115kV - Section 2D & 1D	102%
P2-4	MORAGA-OAKLAND #3 115kV [2740]	P2-4: MORAGA 115kV - Section 2D & 1D	132%
P2-4	MORAGA-CLAREMONT #2 115kV [2710]	P2-4: STATIN X 115kV - Section 2D & 1D	118%
P2-4	D-L #1 [9963]		120%
P2-4	MORAGA-CLAREMONT #1 115kV [2700]		118%

Worst Multiple Event P6 Concern



Load Serving Capability: 157 MW

Multiple Event P6 Concerns:

NERC	Facility Name	Contingency Name	Base
P6	MORAGA-CLAREMONT #1 115kV [2700]	P6: MORAGA-CLAREMONT #2 115kV [2710] & SOBRANTE-MORAGA 115kV [3742]	108%
P6	MORAGA-CLAREMONT #2 115kV [2710]	P6: MORAGA-CLAREMONT #1 115kV [2700] & SOBRANTE-MORAGA 115kV [3742]	108%
P6	C-X #2 [9962]	P6: K-D #1 115kV [9966] & K-D #2 115kV [9967]	106%
P6	MORAGA 230/115 kV TRANSFORMER NO. 2	P6: MORAGA 230/115kV TB 3 & MORAGA 230/115kV TB 1	101%
P6	MORAGA 230/115kV TRANSFORMER NO. 2	P6: MORAGA 230/115kV TB 3 & MORAGA 230/115kV TB 1	103%
P6	MORAGA 230/115kV TRANSFORMER NO. 1	P6: MORAGA 230/115kV TB 3 & MORAGA 230/115kV TB 2	103%
P6	MORAGA 230/115kV TRANSFORMER NO. 1	P6: MORAGA 230/115kV TB 3 & MORAGA 230/115kV TB 2	101%
P6	MORAGA 230/115 kV TRANSFORMER NO. 3	P6: MORAGA 230/115kV TB 1 & MORAGA 230/115kV TB 2	114%
P6	MORAGA 230/115 kV TRANSFORMER NO. 3	P6: MORAGA 230/115kV TB 1 & MORAGA 230/115kV TB 2	114%
P6	MORAGA-CLAREMONT #2 115kV [2710]	P6: C-X #2 115kV [9962] & C-X #3 115kV [9925]	116%
P6	D-L #1 [9963]	P6: C-X #2 115kV [9962] & C-X #3 115kV [9925]	120%
P6	MORAGA-CLAREMONT #1 115kV [2700]	P6: C-X #2 115kV [9962] & C-X #3 115kV [9925]	116%
P6	C-X #2 [9962]	P6: D-L #1 115kV [9963] & C-X #3 115kV [9925]	121%
P6	MORAGA-CLAREMONT #2 115kV [2710]	P6: C-L #1 115kV [9961] & MORAGA-CLAREMONT #1 115kV [2700]	106%
P6	MORAGA-CLAREMONT #1 115kV [2700]	P6: C-L #1 115kV [9961] & MORAGA-CLAREMONT #2 115kV [2710]	106%

LOAD FORECAST

Load Forecasting Process

Description of Process

The method to derive the 24-hour peak day load forecast is described below:

Step 1: Derive current 24-hour peak day load shape

Multiplies peak from the TPP base case (208.53 MW in HE17) by hourly normalization factors derived through an average of the three highest loaded September days in 2016.

Step 2: Derive hourly gross load growth through 2022

Multiplies gross load growth through 2022 from the TPP base case (7.88 MW in HE17) by hourly normalization factors derived from PG&E's LoadSEER tool.

Step 3: Derive hourly generation of new solar through 2022

Multiplies nameplate quantity of new solar through 2022 from the TPP base case (16.1 MW) by hourly PV capacity factors provided by CAISO.

Step 4: Derive hourly load reduction of new EE through 2022

Multiplies quantity of new AAEE through 2022 from the TPP base case (15.9 MW) by hourly EE capacity factors provided by CAISO.

Step 5: Final 24-hour peak day load forecast in 2022

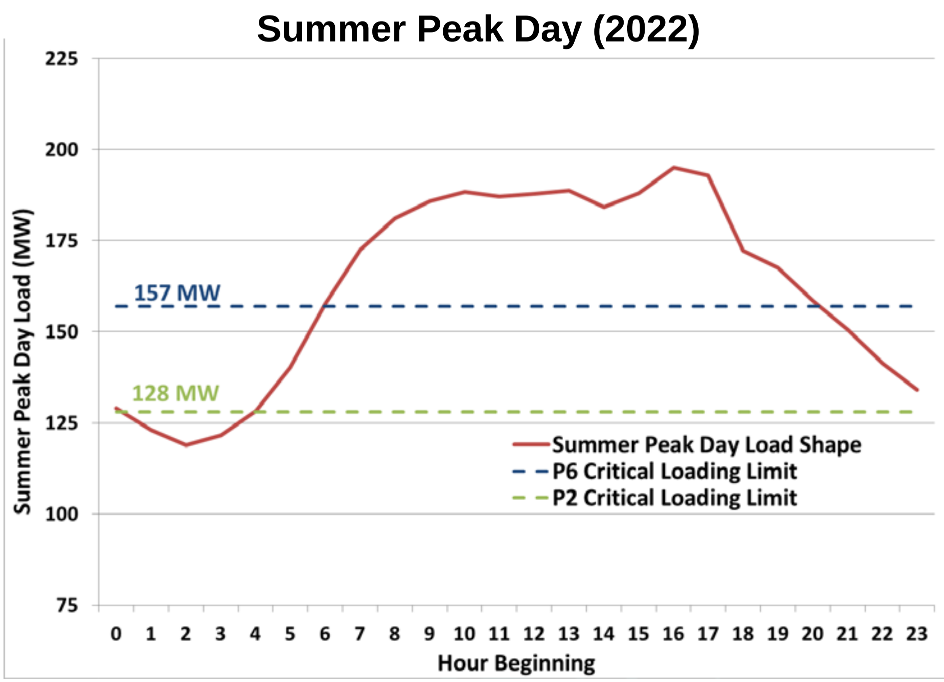
Sums Steps 1-4, as demonstrated in the table to the right.

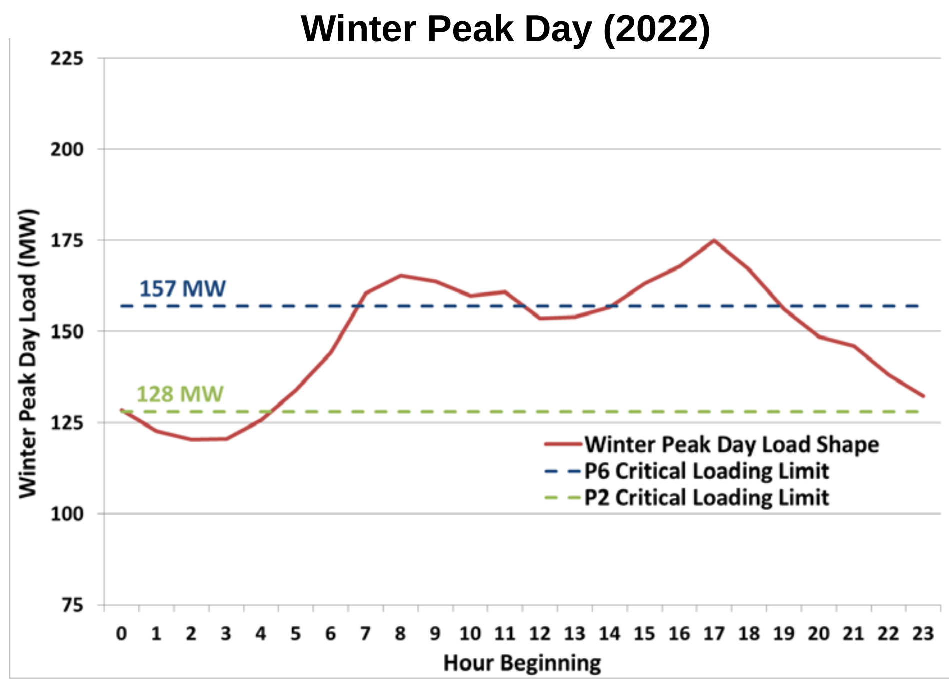
Derivation of the 2022 summer peak day load shape

Hour Beginning	Summer / September 2022				
	Step 1	Step 2	Step 3	Step 4	Final Load Forecast
	Current Peak Day Load Shape (MW)	Gross Load Growth (MW)	Additional PV Generation (MW)	Additional EE Load Reduction (MW)	2022 Peak Day Load Shape (MW)
0	127.69	5.99	0.00	-4.72	***128.97***
1	121.32	5.91	0.00	-4.23	***123.00***
2	117.01	5.81	0.00	-4.00	***118.82***
3	119.76	5.79	0.00	-3.95	***121.61***
4	126.46	6.03	0.00	-4.17	***128.32***
5	138.51	6.66	0.00	-4.87	***140.30***
6	157.28	7.21	-0.57	-6.35	***157.57***
7	176.06	7.49	-2.94	-8.23	***172.39***
8	189.99	7.56	-6.23	-10.13	***181.19***
9	199.14	7.67	-9.22	-11.80	***185.79***
10	204.62	7.84	-11.42	-12.63	***188.41***
11	205.00	7.87	-12.81	-12.97	***187.09***
12	206.59	7.95	-13.05	-13.71	***187.78***
13	207.69	8.00	-12.48	-14.55	***188.66***
14	202.69	7.98	-11.04	-15.40	***184.23***
15	204.33	8.01	-8.58	-15.86	***187.91***
16	208.53	7.88	-5.40	-15.90	***195.10***
17	202.24	7.47	-1.86	-15.03	***192.82***
18	177.61	7.85	-0.09	-13.18	***172.19***
19	171.33	7.90	0.00	-11.65	***167.58***
20	160.79	7.60	0.00	-9.98	***158.41***
21	152.26	7.10	0.00	-8.91	***150.46***
22	141.75	6.64	0.00	-7.13	***141.26***
23	133.57	6.33	0.00	-5.83	***134.06***

Note: The derivation of the Winter Peak Day load shape, which used an identical method, is omitted here for space.

Technical Need Definition





- **Single contingency event (P2)**
  - Cause: Loss of single element
  - To meet need: Resources must be instantaneously available.
- **Multiple contingency event (P6)**
  - Cause: Two overlapping single events (N-1-1), where operators have 30 minutes following the first outage to prepare the system for a second outage
  - To meet need: Resources must be instantaneously available or able to be dispatched within 30 minutes

Summary of Technical Need

	Summer P2	Summer P6	Winter P2	Winter P6
Peak	67.1 MW	38.1 MW	47.0 MW	18.0 MW
Duration	21 hrs.	15 hrs.	20 hrs.	9 hrs.
MWh	842 MWh	352 MWh	515 MWh	70 MWh

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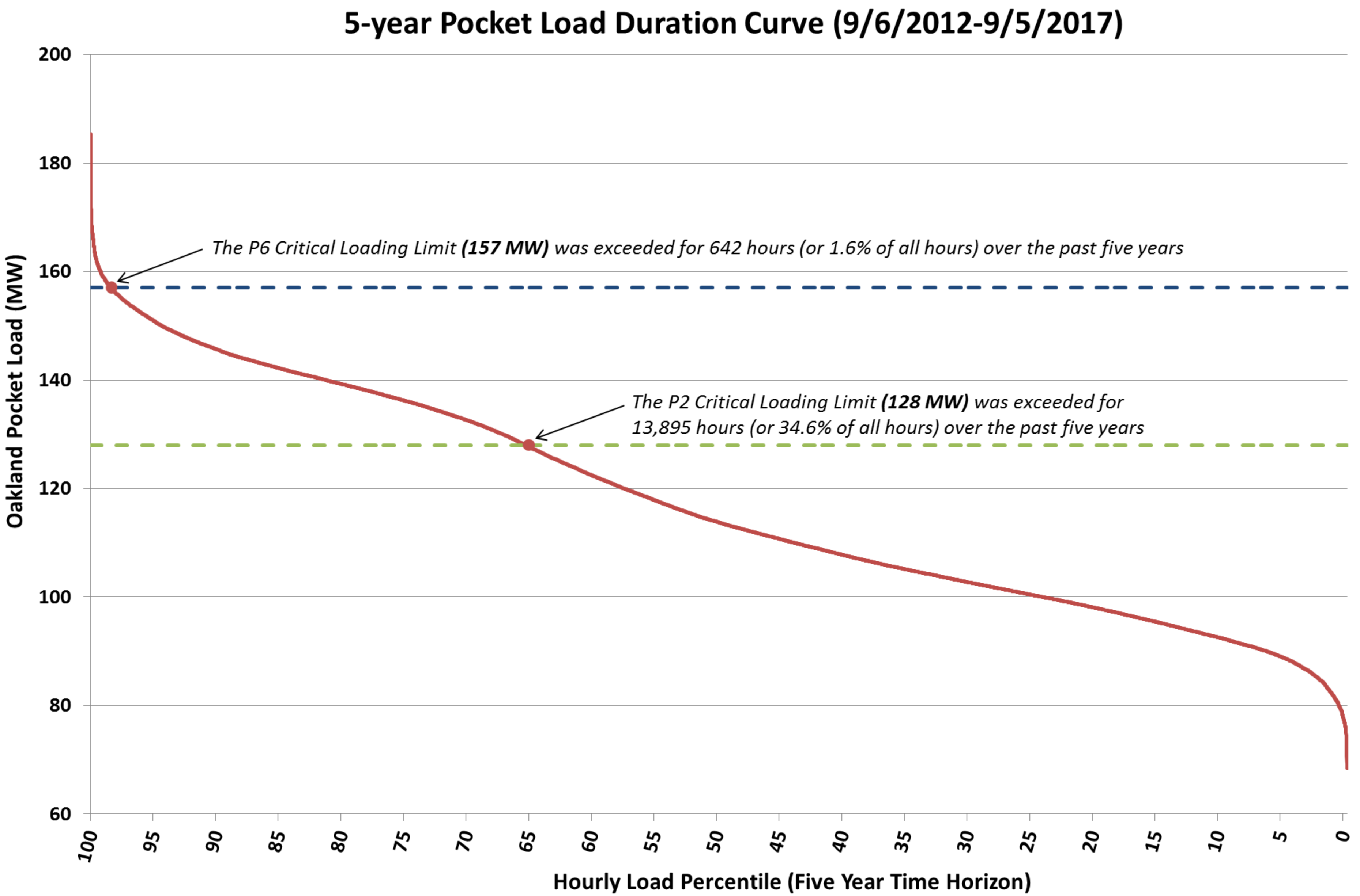
Historical Load Duration



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PROPOSED SUBSTATION UPGRADES

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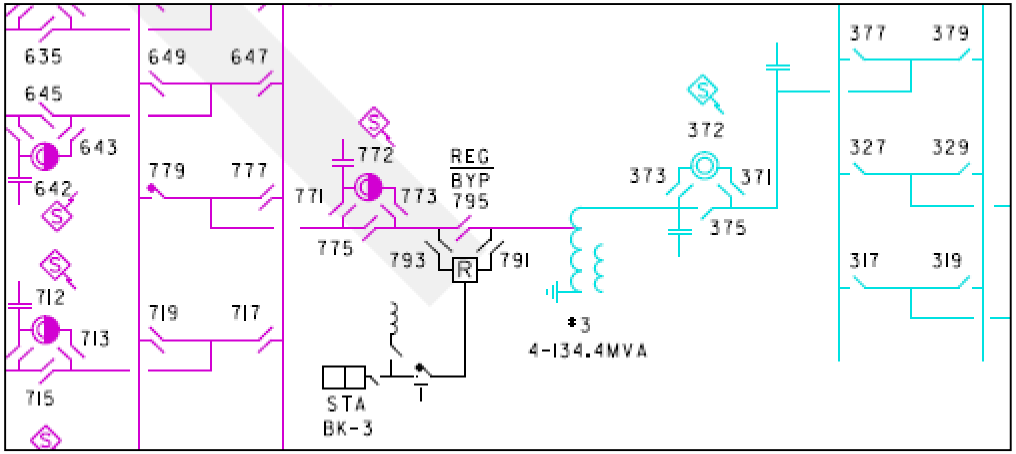
Proposed Substation Work Summary

Upgrades	Description	Capex Estimates ($M 2022)
Moraga 230/115 kV Bank 3 Upgrade	To increase the rating on Bank 3 by replacing six of the 2000-Amp 115 kV switches on the 230/115 kV Bank 3 connection to 3000-Amp switches.	$2M-$4M
Moraga 115 kV Bus Upgrades	To install two additional bus-sectionalizing breakers and a new bus-tie breaker.	$21M-$24M
Oakland X 115 kV Bus Upgrade	To replace the existing switch 363 with a new bus-sectionalizing breaker CB 362	$6M-$7M

Moraga 230/115 kV Bank 3



- On the 115 kV side, Bank 3 is connected to the bus through CB 772 and Switches 771, 773, 775, 777, 779 and Switches 791, 793 and 795 associated with the regulator.
- The rating of Bank 3 is limited to 398 MVA by the 115 kV switches.

- Contingency: Multiple P2 contingencies at Moraga 230kV Bus
- Overloaded Facilities:

  Moraga 230/115 kV Bank 3
- Mitigation: Increase the bank rating by replacing the six, 2000-Amp 115 kV switches (in red) with 3000-Amp switches.
- Cost Estimate: $2M-$4M
- Schedule: 2022

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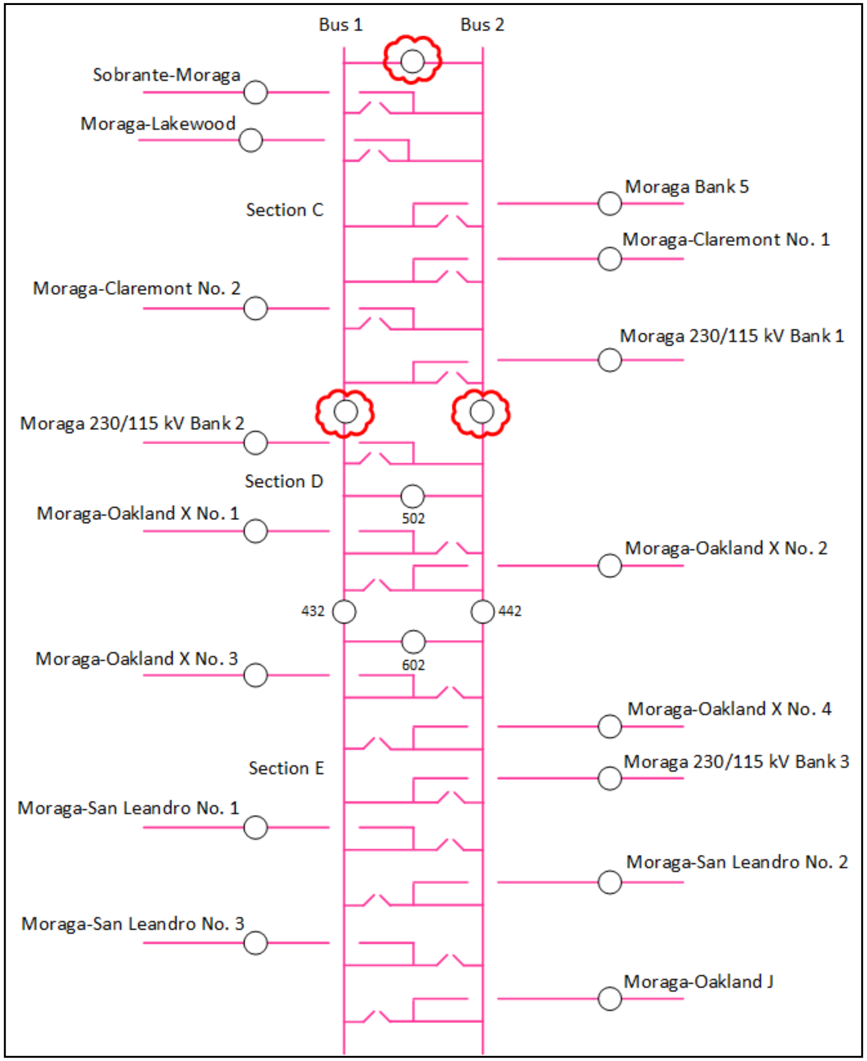
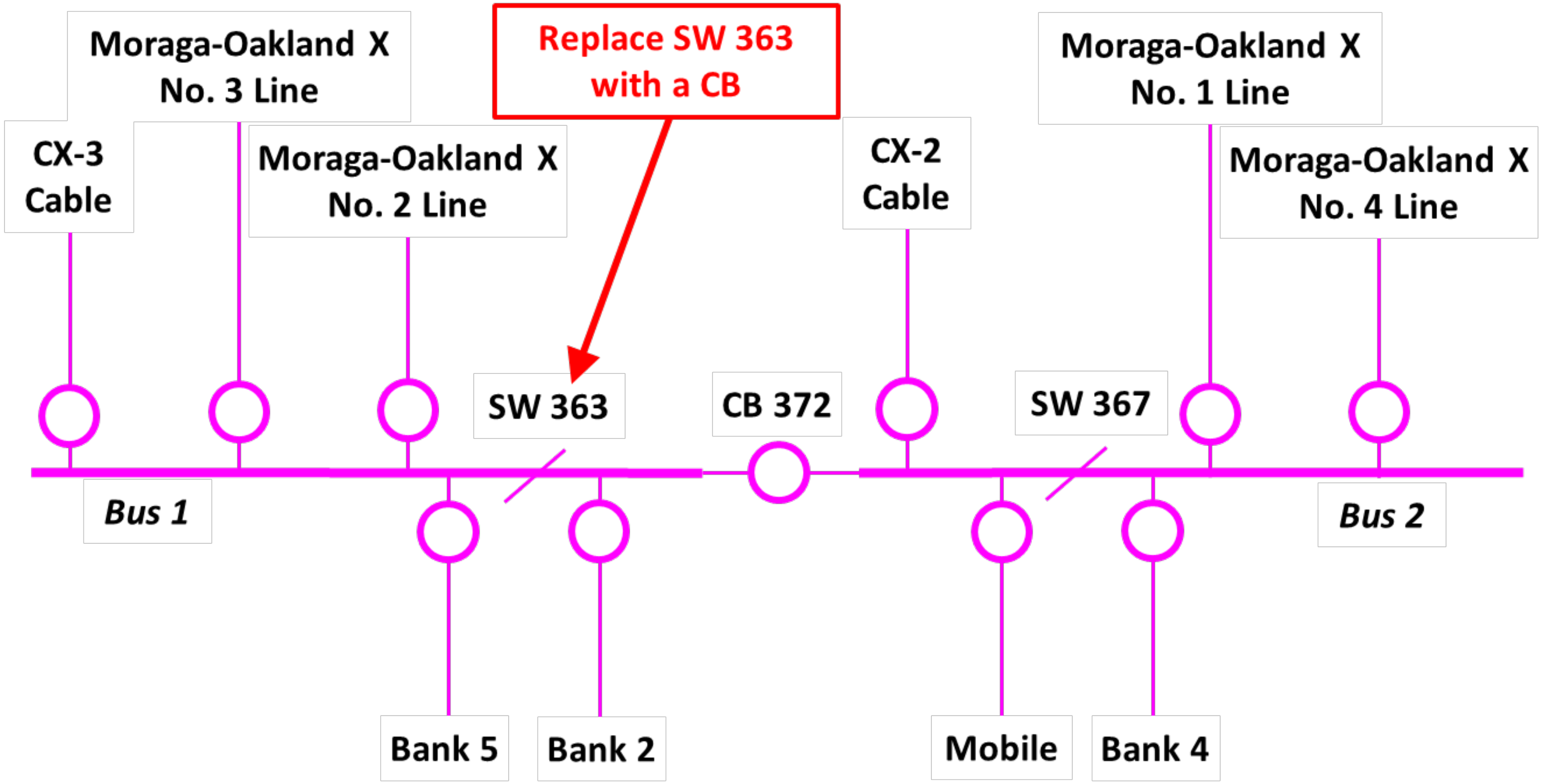
Moraga 115 kV Bus

- Contingencies: CB 502 or 432 or 442 Failure
- Overloaded Facilities:
  - Moraga-Claremont K No. 1
  - Moraga-Claremont K No. 2
  - Moraga-Oakland X No. 3
  - Moraga-Oakland X No. 4
  - Moraga 230/115 kV Bank 3
- Mitigation: To install two additional bus-sectionalizing breakers and a new bus-tie breaker.
- Cost Estimate: $21M-$24M
- Schedule:2022



Oakland X 115kB Bus Upgrade



- Contingency: CB 372 Failure
- Overloaded Facilities:

  Oakland D-L

  Moraga-Claremont No. 1

  Moraga-Claremont No. 2

- Mitigation: To install a new bus-sectionalizing breaker CB 362 using the space from removing SW 363
- Cost Estimate: \$6M-\$7M
- Schedule:2022

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Single Event P2 Concerns after Substation Upgrades

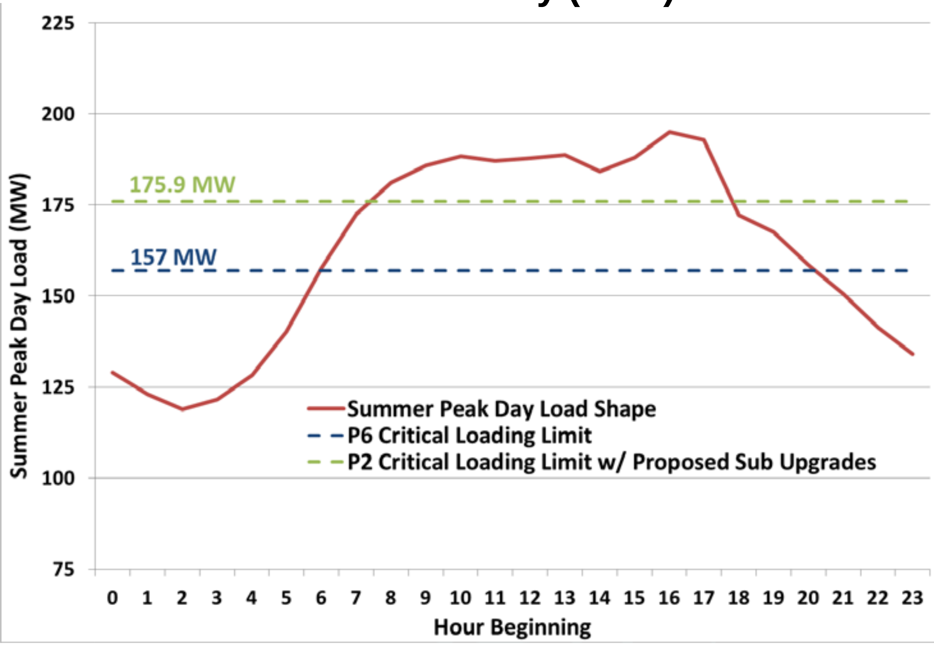
NERC	Facility Name	Contingency Name	Base	LM2022	Mitigation
P2-4	C-X #2 [9962]	P2-4: CLARMNT 115kV - Section 2D & 1D	106%	106%	
P2-4	MORAGA-CLAREMONT #1 115kV [2700]	P2-4: MORAGA 115kV - Section 2E & 2D	104%	<90%	Moraga Bus Upgrade
P2-2	MORAGA-CLAREMONT #1 115kV [2700]	P2-2: MORAGA 115kV Section 2D	104%	<90%	
P2-4	MORAGA-CLAREMONT #2 115kV [2710]	P2-4: MORAGA 115kV - Section 1E & 1D	104%	<90%	
P2-2	MORAGA 230/115 kV TRANSFORMER NO. 3	P2-2: MORAGA 230kV Section 2D	102%	88%	Moraga Transformer No. 3 Upgrade
P2-2	MORAGA 230/115 kV TRANSFORMER NO. 3	P2-2: MORAGA 230kV Section 2D	101%	88%	
P2-3	MORAGA 230/115 kV TRANSFORMER NO. 3	P2-3: MORAGA - 2D 230kV & CONTRA COSTA-MORAGA #2 line	102%	88%	
P2-4	MORAGA-OAKLAND #4 115kV [2750]	P2-4: MORAGA 115kV - Section 2D & 1D	132%	85%	Moraga Bus Upgrade
P2-4	MORAGA 230/115 kV TRANSFORMER NO. 3	P2-4: MORAGA 115kV - Section 2D & 1D	102%	<90%	Moraga Transformer No. 3 Upgrade
P2-4	MORAGA-OAKLAND #3 115kV [2740]	P2-4: MORAGA 115kV - Section 2D & 1D	132%	85%	Moraga Bus Upgrade
P2-4	MORAGA-CLAREMONT #2 115kV [2710]	P2-4: STATIN X 115kV - Section 2D & 1D	118%	<90%	Oakland X Bus Upgrade
P2-4	D-L #1 [9963]		120%	<90%	
P2-4	MORAGA-CLAREMONT #1 115kV [2700]		118%	<90%	

Multiple Event P6 Concerns after Substation Upgrades

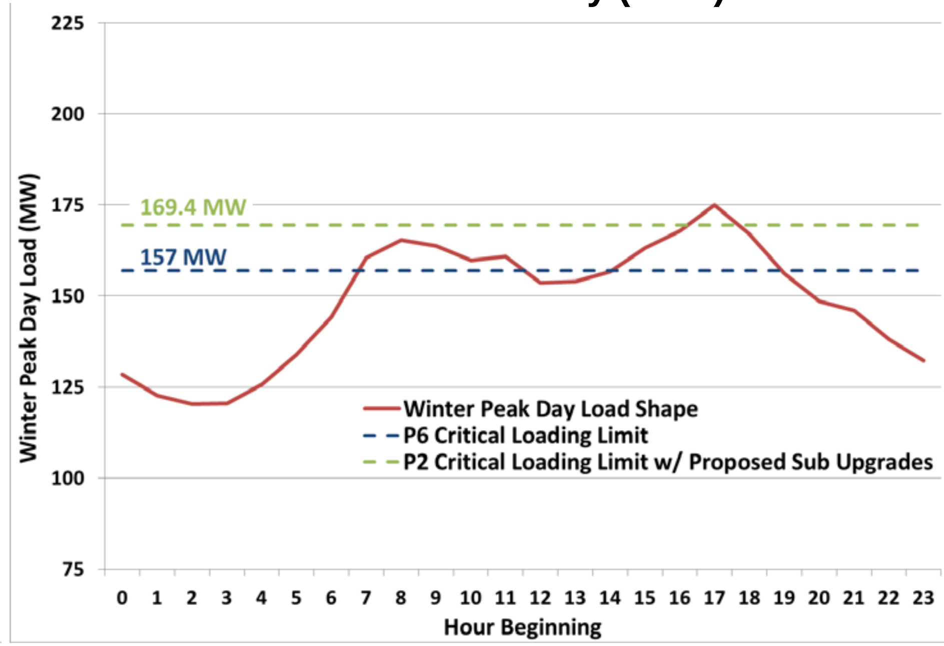
NERC	Facility Name	Contingency Name	Base	Full2022	Mitigation
P6	MORAGA-CLAREMONT #1 115kV [2700]	P6: MORAGA-CLAREMONT #2 115kV [2710] & SOBRANTE-MORAGA 115kV [3742]	108%	82%	Re-rate
P6	MORAGA-CLAREMONT #2 115kV [2710]	P6: MORAGA-CLAREMONT #1 115kV [2700] & SOBRANTE-MORAGA 115kV [3742]	108%	82%	Re-rate
P6	C-X #2 [9962]	P6: K-D #1 115kV [9966] & K-D #2 115kV [9967]	106%	106%	
P6	MORAGA 230/115 kV TRANSFORMER NO. 2	P6: MORAGA 230/115kV TB 3 & MORAGA 230/115kV TB 1	101%	101%	
P6	MORAGA 230/115kV TRANSFORMER NO. 2	P6: MORAGA 230/115kV TB 3 & MORAGA 230/115kV TB 1	103%	103%	
P6	MORAGA 230/115kV TRANSFORMER NO. 1	P6: MORAGA 230/115kV TB 3 & MORAGA 230/115kV TB 2	103%	103%	
P6	MORAGA 230/115kV TRANSFORMER NO. 1	P6: MORAGA 230/115kV TB 3 & MORAGA 230/115kV TB 2	101%	101%	
P6	MORAGA 230/115 kV TRANSFORMER NO. 3	P6: MORAGA 230/115kV TB 1 & MORAGA 230/115kV TB 2	114%	99%	Moraga Transformer No. 3 Upgrade + Portfolio
P6	MORAGA 230/115 kV TRANSFORMER NO. 3	P6: MORAGA 230/115kV TB 1 & MORAGA 230/115kV TB 2	114%	99%	
P6	MORAGA-CLAREMONT #2 115kV [2710]	P6: C-X #2 115kV [9962] & C-X #3 115kV [9925]	116%	86%	Re-rate
P6	D-L #1 [9963]	P6: C-X #2 115kV [9962] & C-X #3 115kV [9925]	120%	120%	
P6	MORAGA-CLAREMONT #1 115kV [2700]	P6: C-X #2 115kV [9962] & C-X #3 115kV [9925]	116%	86%	Re-rate
P6	C-X #2 [9962]	P6: D-L #1 115kV [9963] & C-X #3 115kV [9925]	121%	121%	
P6	MORAGA-CLAREMONT #2 115kV [2710]	P6: C-L #1 115kV [9961] & MORAGA-CLAREMONT #1 115kV [2700]	106%	88%	Re-rate
P6	MORAGA-CLAREMONT #1 115kV [2700]	P6: C-L #1 115kV [9961] & MORAGA-CLAREMONT #2 115kV [2710]	106%	88%	Re-rate

Technical Need Definition - Post Substation Upgrades

Summer Peak Day (2022)



Winter Peak Day (2022)

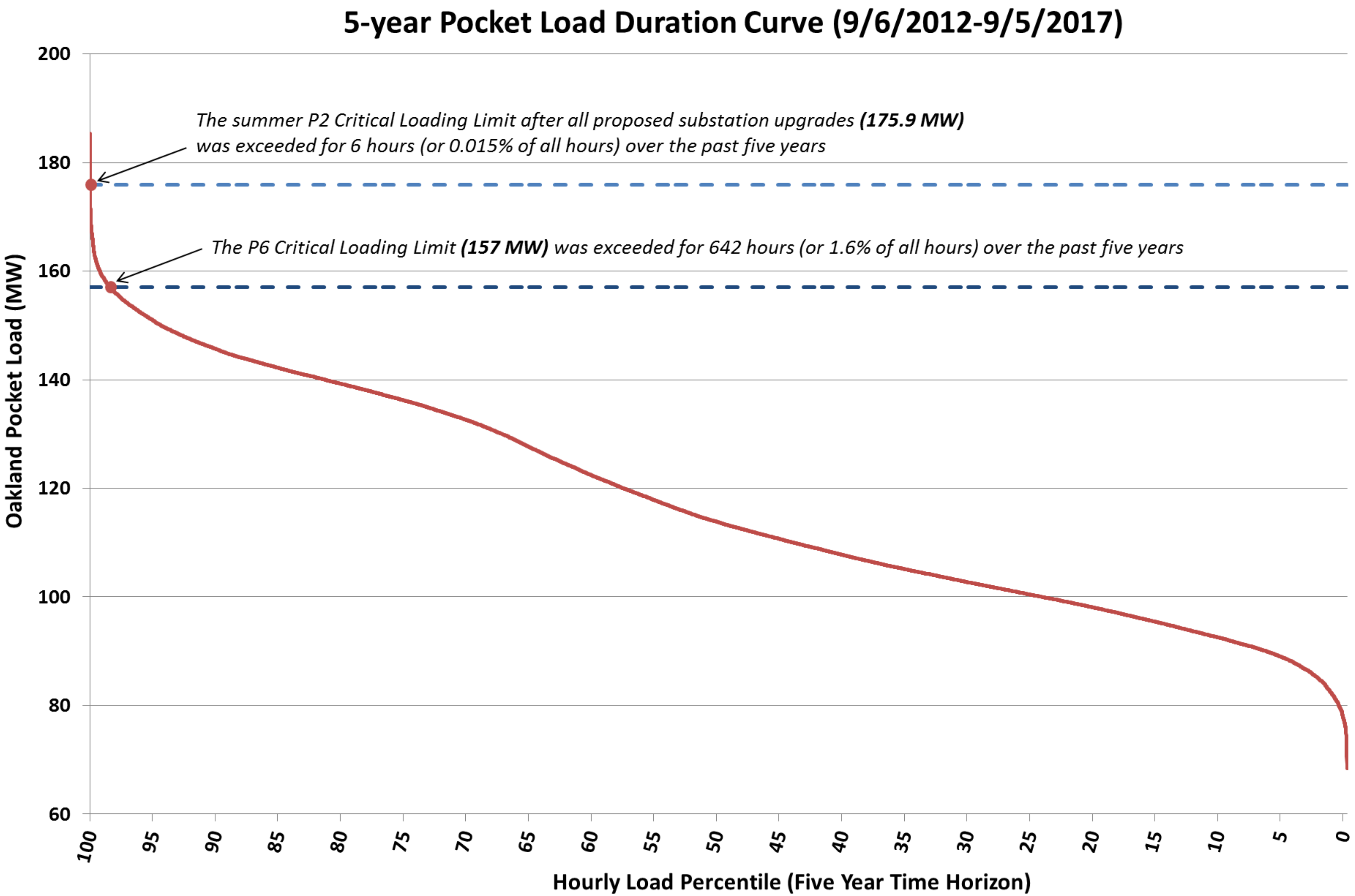


- **Single contingency event (P2)**
  - Cause: Loss of single element
  - To meet need: Resources must be instantaneously available.
- **Multiple contingency event (P6)**
  - Cause: Two overlapping single events (N-1-1), where operators have 30 minutes following the first outage to prepare the system for a second outage
  - To meet need: Resources must be instantaneously available or able to be dispatched within 30 minute

Summary of Technical Need

	Summer P2	Summer P6	Winter P2	Winter P6
Peak	19.2 MW	38.1 MW	5.6 MW	18.0 MW
Duration	10 hrs.	15 hrs.	1 hr.	9 hrs.
MWh	120 MWh	352 MWh	5.6 MWh	70 MWh

Historical Load Duration – Post Substation Upgrades



PROPOSED PREFERRED RESOURCE PORTFOLIO

Pacific Gas and Electric Company®

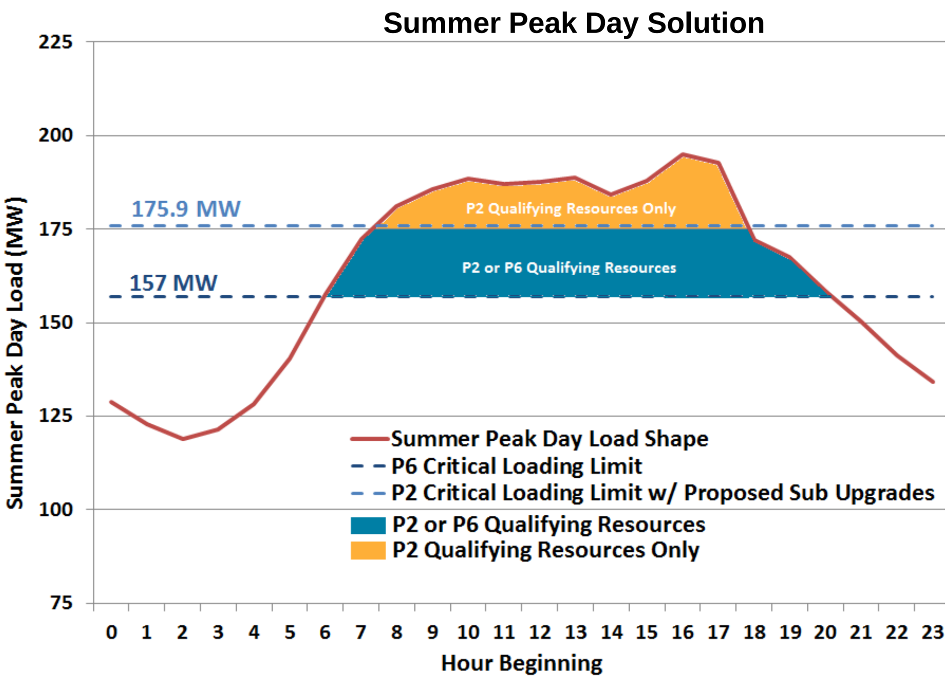
Preferred Resource Portfolio Summary

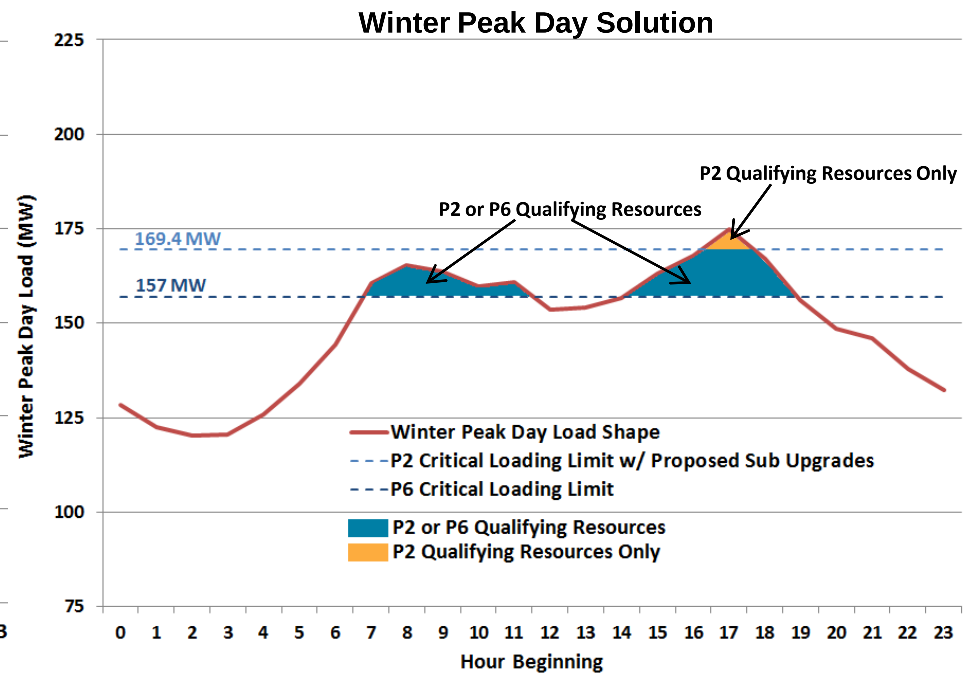
To mitigate the remaining need after all proposed substation upgrades, PG&E is proposing a combination of DERs, Energy Storage and Operational (Switching) Solutions, that will be assembled on a least-cost, best-fit basis

Summary of Preferred Resource Solution Candidates

Resource	Characteristics
Energy Efficiency	• Must be incremental to AAEE in TPP base case forecast. • Counts toward P2 and P6 needs.
Solar	• If BTM, must be incremental to DG in TPP base case forecast. • Counts toward P2 and P6 needs.
FTM Energy Storage	• It will count toward P2 need if dispatched automatically based on pocket load set-point.
Non-PV BTM Gen/Load Shift/Storage	• Includes resources such as permanent load shifting, BTM storage, and non-PV BTM generation. • May count toward P2 need if always present or dispatched automatically based on pocket load set-point.
DR/Other Market-Participating Resource	• BTM resources may participate where allowed by CAISO rules (PDR or RDRR). • May count toward P2 need if dispatched automatically based on pocket load set-point.
Operational (Load Transfers)	• Load transfer must be accomplished within 30 minutes. • May only count toward P6 need.

Solution Portfolio





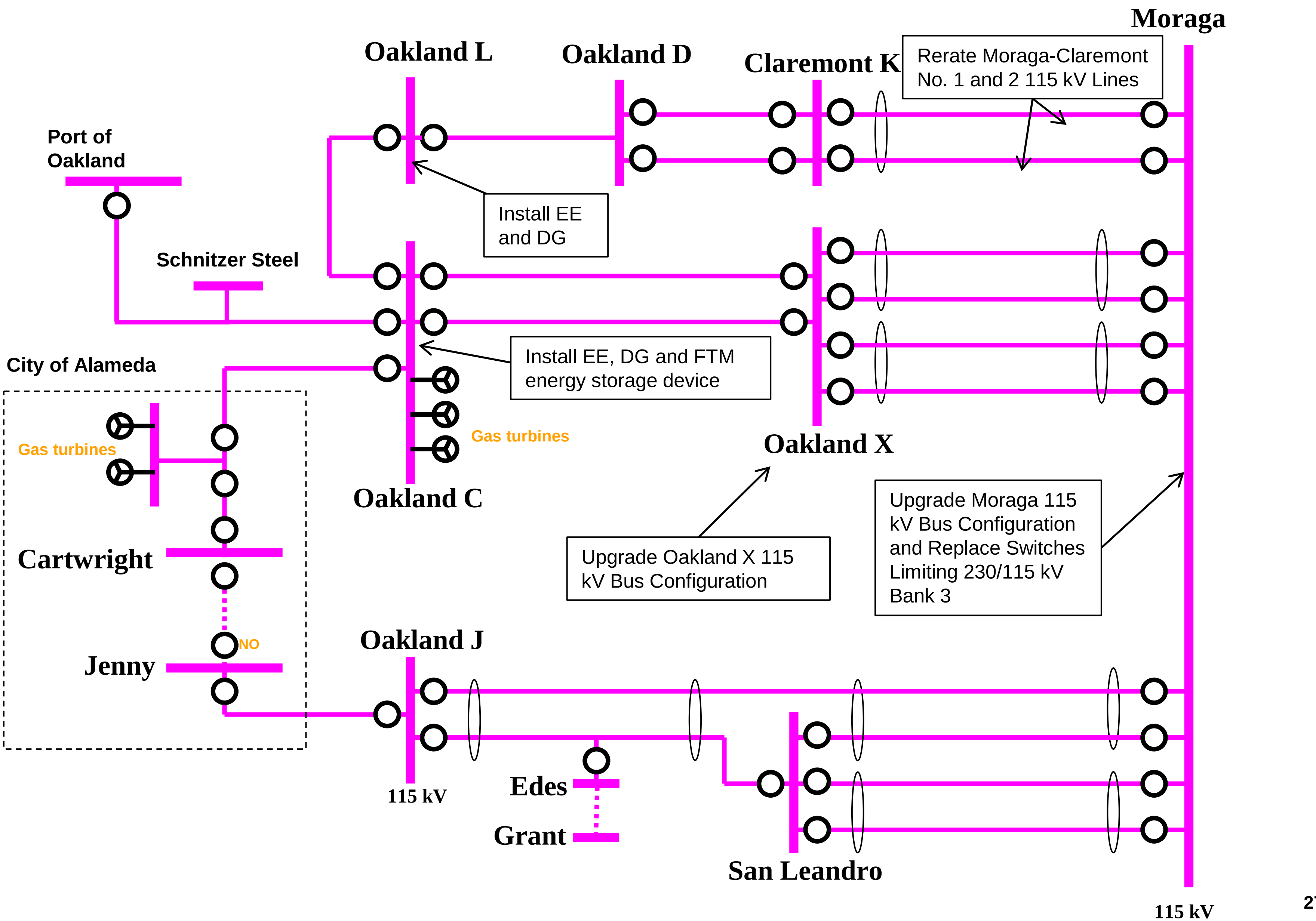
Resource	P2 Qualifying?	P6 Qualifying?
Energy Efficiency	X	X
Solar	X	X
FTM Energy Storage	X**	X
Non-PV BTM Gen/Load Shift/Storage	X**	X
DR/Other Market-Participating Resource	X**	X
Load Transfers		X

***If dispatched prior to contingency*

Pacific Gas and Electric Company®

SOLUTION SUMMARY

Future State Single Line Diagram



Pacific Gas and Electric Company

Single Event Concerns after Substation Upgrades

NERC	Facility Name	Contingency Name	Base	LM2022	Mitigation
P2-4	C-X #2 [9962]	P2-4: CLARMNT 115kV - Section 2D & 1D	106%	99%	Resources
P2-4	MORAGA-CLAREMONT #1 115kV [2700]	P2-4: MORAGA 115kV - Section 2E & 2D	104%	<90%	Moraga Bus Upgrade
P2-2	MORAGA-CLAREMONT #1 115kV [2700]	P2-2: MORAGA 115kV Section 2D	104%	<90%	Moraga Bus Upgrade
P2-4	MORAGA-CLAREMONT #2 115kV [2710]	P2-4: MORAGA 115kV - Section 1E & 1D	104%	<90%	Moraga Bus Upgrade
P2-2	MORAGA 230/115 kV TRANSFORMER NO. 3	P2-2: MORAGA 230kV Section 2D	102%	88%	Moraga Transformer No. 3 Upgrade
P2-2	MORAGA 230/115 kV TRANSFORMER NO. 3	P2-2: MORAGA 230kV Section 2D	101%	88%	Moraga Transformer No. 3 Upgrade
P2-3	MORAGA 230/115 kV TRANSFORMER NO. 3	P2-3: MORAGA - 2D 230kV & CONTRA COSTA-MORAGA #2 line	102%	88%	Moraga Transformer No. 3 Upgrade
P2-4	MORAGA-OAKLAND #4 115kV [2750]	P2-4: MORAGA 115kV - Section 2D & 1D	132%	85%	Moraga Bus Upgrade
P2-4	MORAGA 230/115 kV TRANSFORMER NO. 3	P2-4: MORAGA 115kV - Section 2D & 1D	102%	<90%	Moraga Transformer No. 3 Upgrade
P2-4	MORAGA-OAKLAND #3 115kV [2740]	P2-4: MORAGA 115kV - Section 2D & 1D	132%	85%	Moraga Bus Upgrade
P2-4	MORAGA-CLAREMONT #2 115kV [2710]	P2-4: STATIN X 115kV - Section 2D & 1D	118%	<90%	Oakland X Bus Upgrade
P2-4	D-L #1 [9963]	P2-4: STATIN X 115kV - Section 2D & 1D	120%	<90%	Oakland X Bus Upgrade
P2-4	MORAGA-CLAREMONT #1 115kV [2700]	P2-4: STATIN X 115kV - Section 2D & 1D	118%	<90%	Oakland X Bus Upgrade

Multiple Event Concerns after Substation Upgrades

NERC	Facility Name	Contingency Name	Base	Full2022	Mitigation
P6	MORAGA-CLAREMONT #1 115kV [2700]	P6: MORAGA-CLAREMONT #2 115kV [2710] & SOBRANTE-MORAGA 115kV [3742]	108%	82%	Re-rate
P6	MORAGA-CLAREMONT #2 115kV [2710]	P6: MORAGA-CLAREMONT #1 115kV [2700] & SOBRANTE-MORAGA 115kV [3742]	108%	82%	Re-rate
P6	C-X #2 [9962]	P6: K-D #1 115kV [9966] & K-D #2 115kV [9967]	106%	89%	Portfolio
P6	MORAGA 230/115 kV TRANSFORMER NO. 2	P6: MORAGA 230/115kV TB 3 & MORAGA 230/115kV TB 1	101%	99%	Portfolio
P6	MORAGA 230/115kV TRANSFORMER NO. 2	P6: MORAGA 230/115kV TB 3 & MORAGA 230/115kV TB 1	103%	99%	Portfolio
P6	MORAGA 230/115kV TRANSFORMER NO. 1	P6: MORAGA 230/115kV TB 3 & MORAGA 230/115kV TB 2	103%	99%	Portfolio
P6	MORAGA 230/115kV TRANSFORMER NO. 1	P6: MORAGA 230/115kV TB 3 & MORAGA 230/115kV TB 2	101%	99%	Portfolio
P6	MORAGA 230/115 kV TRANSFORMER NO. 3	P6: MORAGA 230/115kV TB 1 & MORAGA 230/115kV TB 2	114%	99%	Moraga Transformer No. 3 Upgrade + Portfolio
P6	MORAGA 230/115 kV TRANSFORMER NO. 3	P6: MORAGA 230/115kV TB 1 & MORAGA 230/115kV TB 2	114%	99%	
P6	MORAGA-CLAREMONT #2 115kV [2710]	P6: C-X #2 115kV [9962] & C-X #3 115kV [9925]	116%	86%	Re-rate
P6	D-L #1 [9963]	P6: C-X #2 115kV [9962] & C-X #3 115kV [9925]	120%	93%	Portfolio
P6	MORAGA-CLAREMONT #1 115kV [2700]	P6: C-X #2 115kV [9962] & C-X #3 115kV [9925]	116%	86%	Re-rate
P6	C-X #2 [9962]	P6: D-L #1 115kV [9963] & C-X #3 115kV [9925]	121%	93%	Portfolio
P6	MORAGA-CLAREMONT #2 115kV [2710]	P6: C-L #1 115kV [9961] & MORAGA-CLAREMONT #1 115kV [2700]	106%	88%	Re-rate
P6	MORAGA-CLAREMONT #1 115kV [2700]	P6: C-L #1 115kV [9961] & MORAGA-CLAREMONT #2 115kV [2710]	106%	88%	Re-rate

PG&E's Oakland Reliability Proposal

Operational Date: Summer 2022

Costs:

- Estimated $35M for Substation Upgrades
- Energy Storage & DER Portfolio, run a market solicitation
- Cost Effectiveness: Preliminary PG&E analysis shows the potential for $MM savings for customers (versus transmission or generation alternatives)

California High Speed Rail (CHSR)

Load Interconnection Request

September 22, 2017

PROJECT OVERVIEW

Background Information

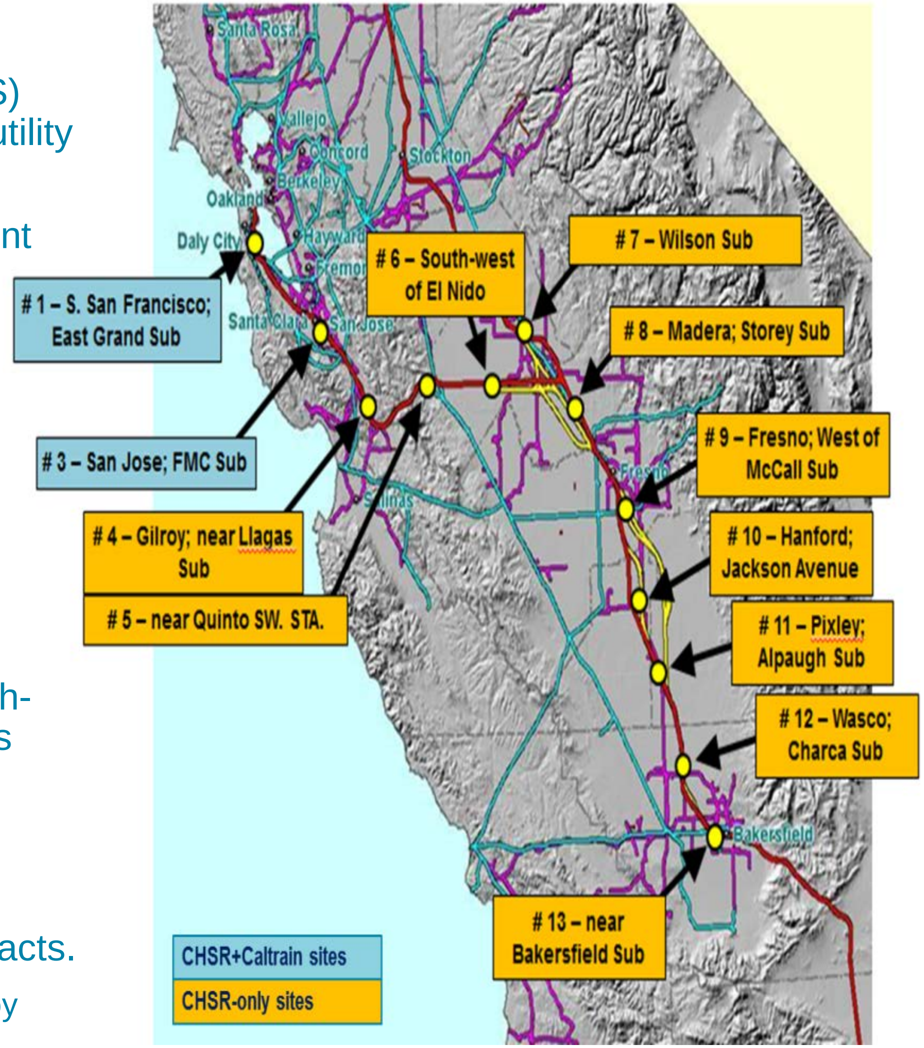
General:

- The California High-Speed Rail Authority (CHSRA) is undertaking a project to design and construct a high speed rail line to connect the major cities in California. The California High-Speed Rail Project (CHSTP) will have a nominal end-to-end length of 800 miles from San Francisco to San Diego, with trains travelling at speeds up to 220 mph.
- PG&E had been working with CHSRA on the 345-mile long portion of track from San Francisco to Bakersfield within PG&E territory, serving 12 traction power stations, which will be the initial operating segment.
- Site 1 and Site 3 had been studied together with Caltrain Electrification Project at San Francisco and South San Francisco.
- Today's presentation will cover Site 4 through Site 13, from Gilroy to Bakersfield.
- CHSRA has requested that the test track (sites 8 to 12) be electrified for testing by 2020, followed by Sites 4-7, to allow for initial train service operations to commence in the Silicon Valley to Central Valley section in 2025.

Study Objective

CHSR Technical Requirements:

- 50 kV AC Traction Electrification System (TES) served from two phases of 115 kV or 230 kV utility transmission system.
- Two dedicated feeds for each site from different sources.
- Approximately 30-mile intervals between the traction power substations - 12 traction power substations for the 345-mile portion of the line running in PG&E's service territory.



Study Scope:

- Preliminary scope and cost estimation for interconnection and network upgrades for High-Speed Rail Site 4 through Site 13 (ten stations total).
  - Interconnection Facility
  - Network Upgrade for Interconnection
- Mitigation plans to tackle adverse system impacts.
  - Based on the ultimate load forecast provided by CHSRA.
  - To be decided through annual Transmission Planning Process (TPP) with latest updates.

Load Forecast

Location	Study Load (MVA)	Latest Forecast - Dec 2016 (MVA)			
		Near Term		Long Term	
		2021 load	2023 load	Max 2025-2028 load	Max 2029-2087 load
Site 4	55	3	5	16	22
Site 5	20	1	2	6	8
Site 6	17	1	2	5	7
Site 7	35	2	4	7	14
Site 8	29	1	3	6	12
Site 9	67	3	7	13	27
Site 10	55	3	6	11	22
Site 11	8	0	1	2	3
Site 12	11	1	1	2	4
Site 13	64	3	6	13	26
Total (MVA)	**361**	**18**	**36**	**81**	**144**

- CHSRA is to provide updated load forecast, in-service/test dates annually for the 10-year planning horizon. This will be incorporated in the annual TPP.
- Mitigation plans or any other system upgrades will be identified as part of the annual TPP.

SITES 4 – 13
TRACTION POWER SUBSTATION INTERCONNECTIONS

Site 4: Near Llagas Substation

Project Scope – Interconnection (In-service Date 2020):

- Construct a new Switching Station with a 2-Bay Breaker-and-a-half (BAAH) configuration to loop in Spring – Llagas 115 kV Line.
- Extend 115 kV double-line from the new switching station to CHSR site 4.
- Substation work at Llagas substation.

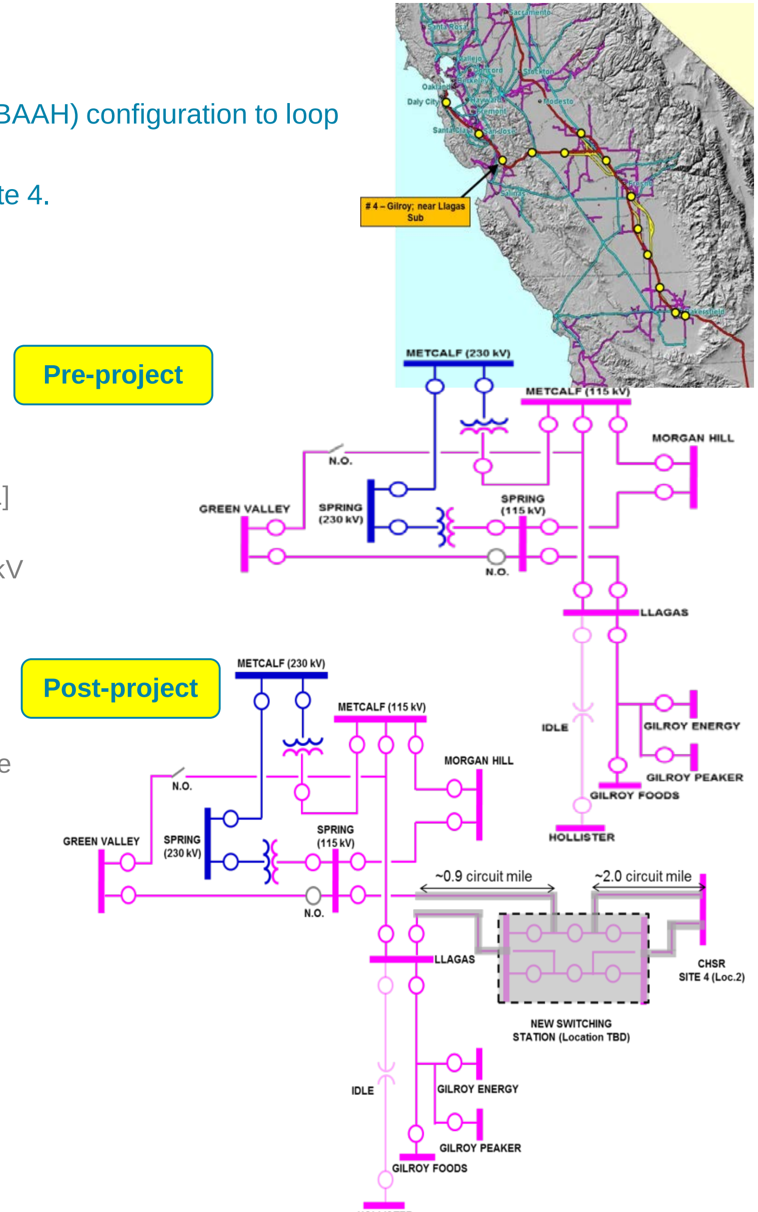
Assessment and Mitigations:

Unit: MVA	Study Load	2023 load	Max 2029-2087 load
Site 4	55	5	22

- **Trimble – San Jose B 115 kV Line**
  - Overloads increased by 1-4% under multiple [N-1], [G-1] and [N-1-1] contingencies.
  - Reconductor (re-rate being considered) Trimble – San Jose B 115 kV Line, addressed by Caltrain project.
- **Metcalf – Llagas 115 kV Line**
  - Overloaded to about 106% under the [N-1-1] contingency of losing Spring – CHSR04SS and Llagas – Gilroy Foods 115 kV Lines.
  - Reconductor Metcalf – Llagas 115 kV Line (Morgan J2 to Llagas line section, ~ 11 miles)
- **Spring – CHSR04SS 115 kV Line**
  - Overloaded to 104%~106% under [N-1-1] contingencies of losing Llagas-Gilroy Foods and Metcalf – Llagas 115 kV Lines.
  - Reconductor Spring – CHSR04SS 115 kV Line (Spring – Llagas section, ~11 miles)

Cost Estimation (in $Million):

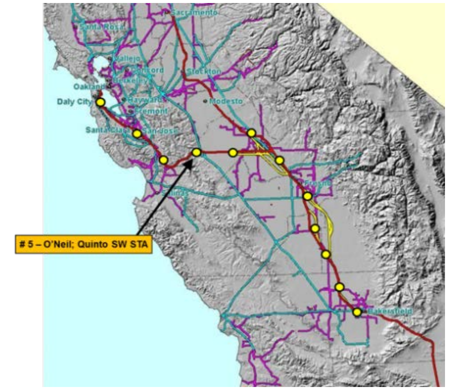
- **Interconnection Facility: $8**
- **Network Upgrade (Interconnection): $52**
- Network Upgrade (Mitigation): $40



Site 5: Near Quinto Switching Station

Project Scope – Interconnection (In-service Date 2020):

- Expand existing Quinto Switching Station with four (4) new circuit breakers to complete one partial bay and build a new partial bay.
- Build ~0.9 circuit mile of 230 kV double-line extension from CHSR Site 5 to Quinto SW STA
- Raise Tesla – Los Banos and Tracy Los Banos 500 kV Lines for the two CHSR lines to pass underneath.



Assessment and Mitigations:

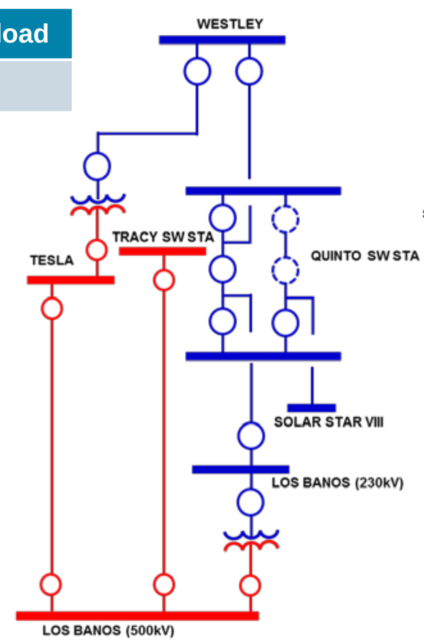
Unit: MVA	Study Load	2023 load	Max 2029-2087 load
Site 5	20	2	8

- **No New thermal or voltage issues**

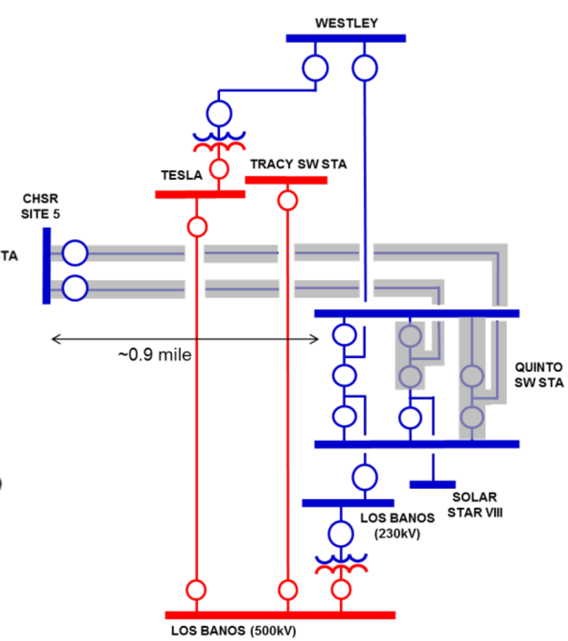
Cost Estimation (in $Million):

- **Interconnection Facility: $14**
- **Network Upgrade (Interconnection): $23**
- Network Upgrade (Mitigation): $0

Pre-project



Post-project

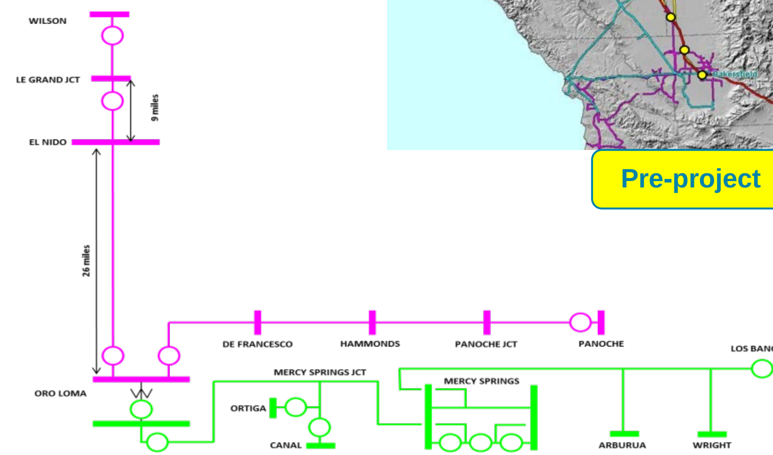


Site 6: Southwest of El Nido Substation

Project Scope – Interconnection (In-service Date 2020):

- Rebuild El Nido Substation with 3-bay BAAH configuration.
- Build ~6 circuit mile of double circuit 115kV T-line extensions from CHSR Site 6 to El Nido Substation.

Pre-project

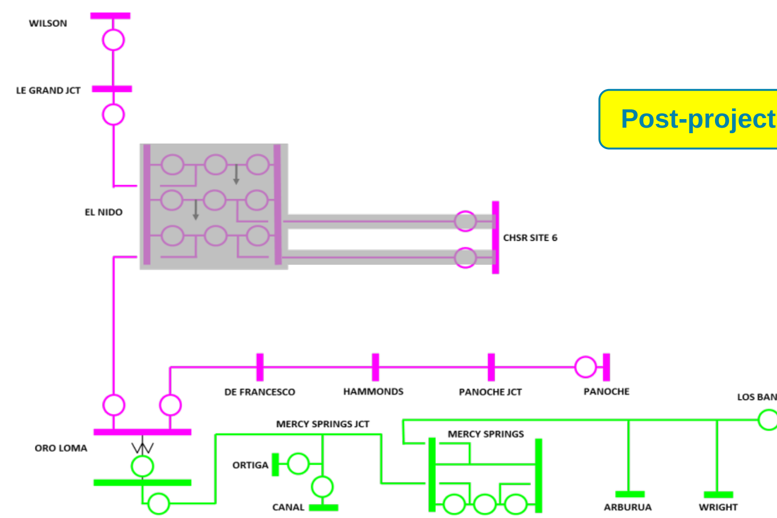


Assessment and Mitigations:

Unit: MVA	Study Load	2023 load	Max 2029-2087 load
Site 6	17	2	7

- **Panoche – Oro Loma 115 kV Line**
  - Overloads increased by 6-9% under multiple [N-1], [G-1] and [N-1-1] contingencies that involves Panoche – Mandota 115 kV Line.
  - Reconductor ~17 mile of Panoche – Oro Loma 115 kV Line from Panoche Jct to Oro Loma Substation, covered by TPP project.
- **Oro Loma 115/70 kV Transformer #2**
  - Existing overloads increased to about 113~116% under multiple [N-1] contingencies including circuit breaker failure at Panoche 115 kV Bus.
  - Upgrade limiting terminal and bus equipment at Oro Loma 70 kV bus to achieve full capacity of Oro Loma 115/70 kV Transformer #2.
- **Los Banos – Oro Loma – Canal 70 kV Line**
  - Overloaded by 3% for a [N-1-1] contingency of the Panoche-Mendota and Panoche-Oro Loma 115 kV lines and by 116% for a circuit breaker failure at Panoche 115 kV Bus.
  - Reconductor ~ 12. 5 mile of Los Banos - Oro Loma - Canal 70 kV Line from Mercy Springs Jct to Oro Loma Substation.

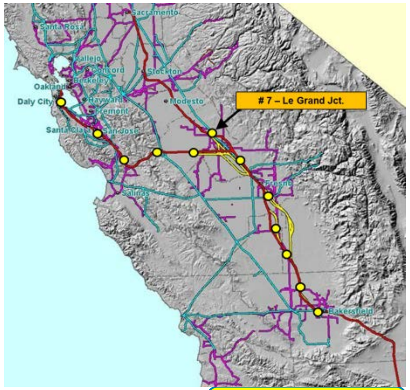
Post-project



Cost Estimation (in $Million):

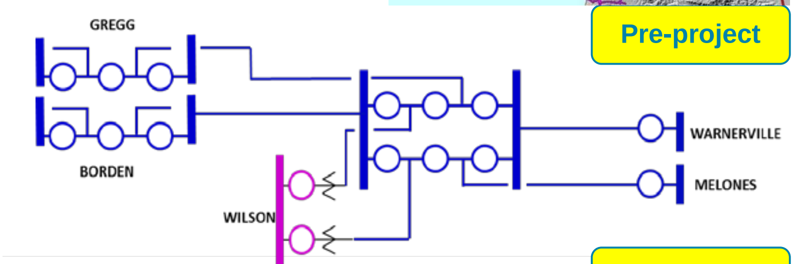
- **Interconnection Facility: $21**
- **Network Upgrade (Interconnection): $46**
- Network Upgrade (Mitigation for both Site 6 and 7): $25

Site 7: Southwest of Wilson Substation



Project Scope – Interconnection (In-service Date 2020):

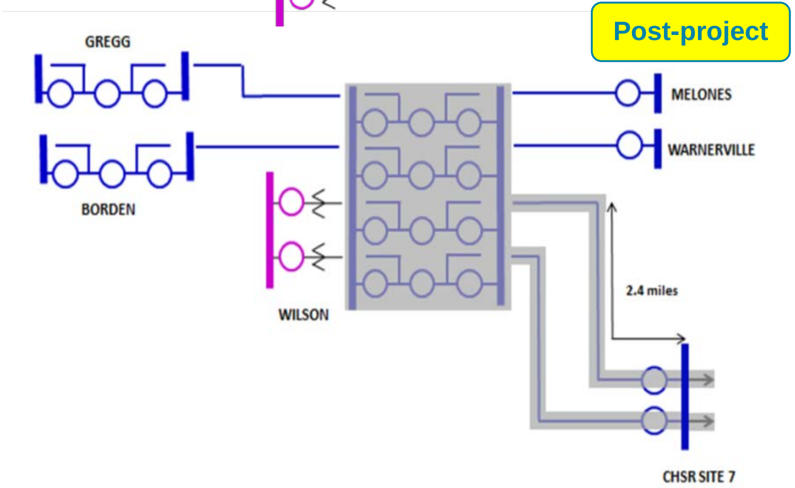
- Expand Wilson substation 230 kV bus to 4-Bay BAAH configuration and re-arrange existing lines and loads.
- Build ~2.4 circuit mile of double circuit 115 kV T-Line extension from Wilson substation to CHSR Site 7.



Assessment and Mitigations:

Unit: MVA	Study Load	2023 load	Max 2029-2087 load
Site 7	35	4	14

- **Mitigation combined with Site 6**



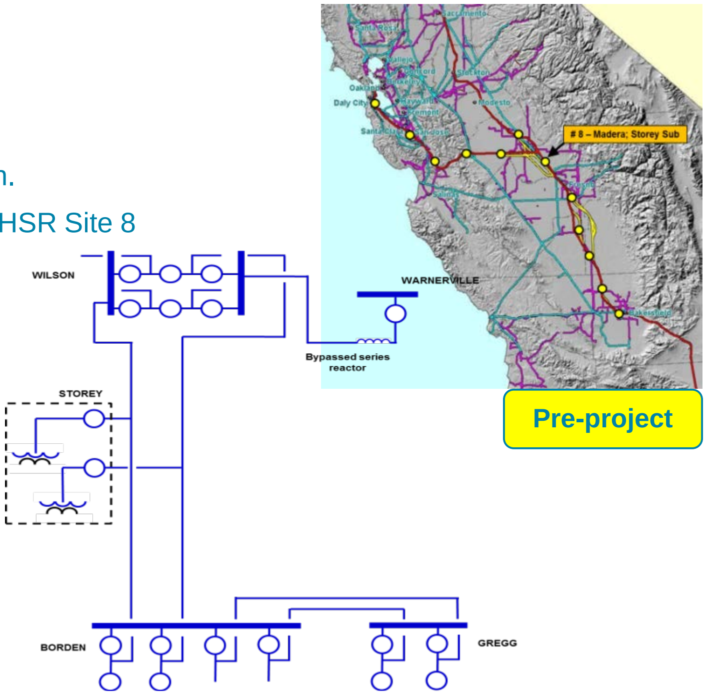
Cost Estimation (in $Million):

- **Interconnection Facility: $15**
- **Network Upgrade (Interconnection): $39**
- Network Upgrade (Mitigation combined with Site 6): $0

Site 8: East of Storey Substation

Project Scope – Interconnection (In-service Date 2020):

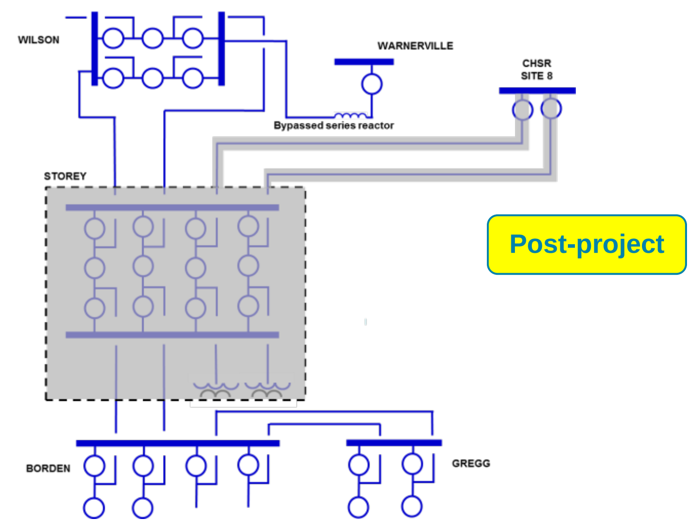
- Rebuild Storey Substation into a 4-Bay BAAH configuration.
- Loop both Wilson-Borden No.1 and No.2 230 kV Lines into Storey Substation.
- Construct double-circuit 230 kV T-line extension from Storey Substation to CHSR Site 8



Assessment and Mitigations:

Unit: MVA	Study Load	2023 load	Max 2029-2087 load
Site 8	29	3	12

- **Borden – Gregg No. 1 and No. 2 230 kV Lines**
  - Overloaded up to 111% under [N-1/G-1] contingencies and 136% under [N-1-1] contingencies that involve losing one of the Borden-Gregg Lines.
  - Reconductor Borden - Gregg No.1 and No.2 230kV Lines (~6 mile of double circuit)
- **Warnerville – Wilson 230 kV Line**
  - With the planned series reactor by-passed, existing small overloads increased by 10%~15% under double-line outages of Borden-Gregg lines or E1-Helms 230 kV Lines.
  - With the planned series reactor inserted, same contingencies cause overloads up to more than 130% on multiple 115 kV lines serving Wilson area.
  - Re-rate Warnerville - Wilson 230kV Line with 4fps summer emergency rating (~38 circuit mile). Series reactor bypassed in summer peak condition.
- **High Voltages in the Kearney Area**
  - In off-peak cases, 70 kV system near Kearney experience voltage 1.11~1.12 p.u. when losing Helms pump load and Kearney 230/70 kV Transformer.
  - To be addressed through annual assessment.



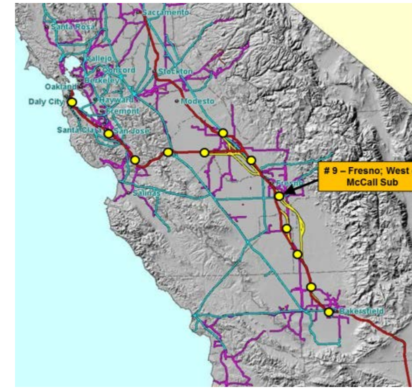
Cost Estimation (in $Million):

- **Interconnection Facility: $8**
- **Network Upgrade (Interconnection): $66**
- Network Upgrade (Mitigation for both Site 8 and 9): $21

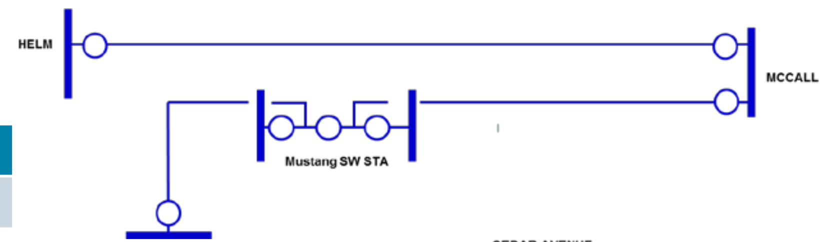
Site 9: West of McCall Substation

Project Scope – Interconnection (In-service Date 2020):

- Construct a new 230 kV 2-Bay BAAH Switching Station on Cedar Avenue.
- Loop Gates – McCall 230 kV Line (currently Mustang SW STA - McCall 230 kV Line) into the new switching station for CHSR Site 9.
- Construct double-circuit 230 kV T-line extension from the new Cedar Ave. SW STA to CHSR Site 9.



Pre-project

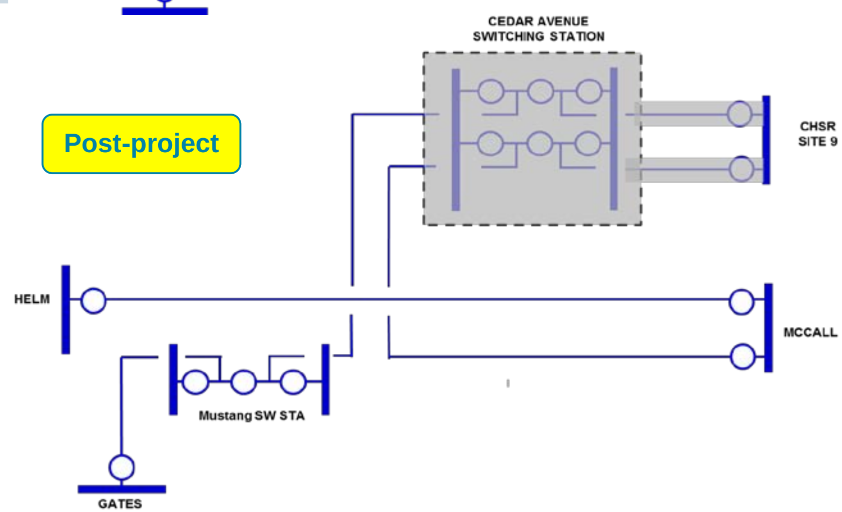


Assessment and Mitigations:

Unit: MVA	Study Load	2023 load	Max 2029-2087 load
Site 9	67	7	27

- **Mitigation combined with Site 8**

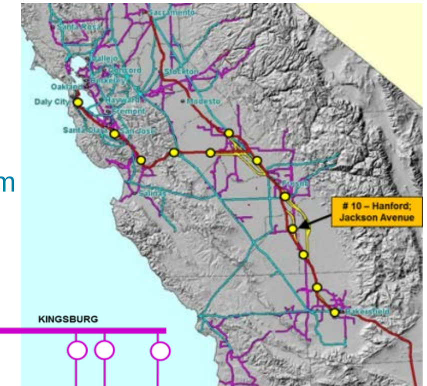
Post-project



Cost Estimation (in $Million):

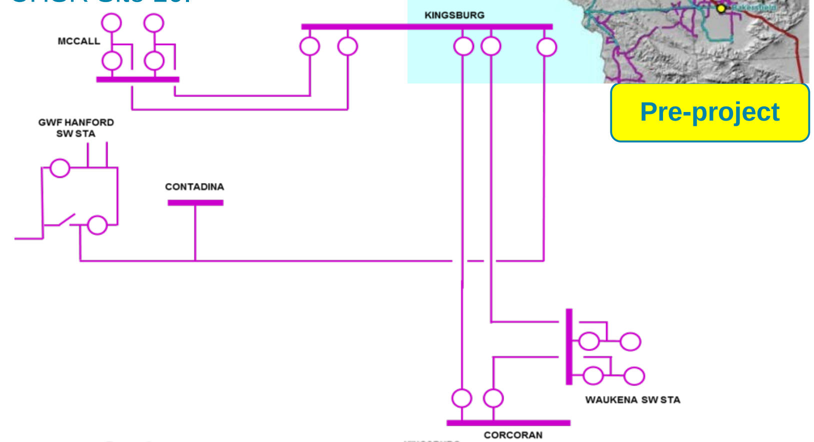
- **Interconnection Facility: $8**
- **Network Upgrade (Interconnection): $37**
- Network Upgrade (Mitigation combined with Site 8): $0

Site 10: Hanford, Jackson SW STA



Project Scope – Interconnection (In-service Date 2020):

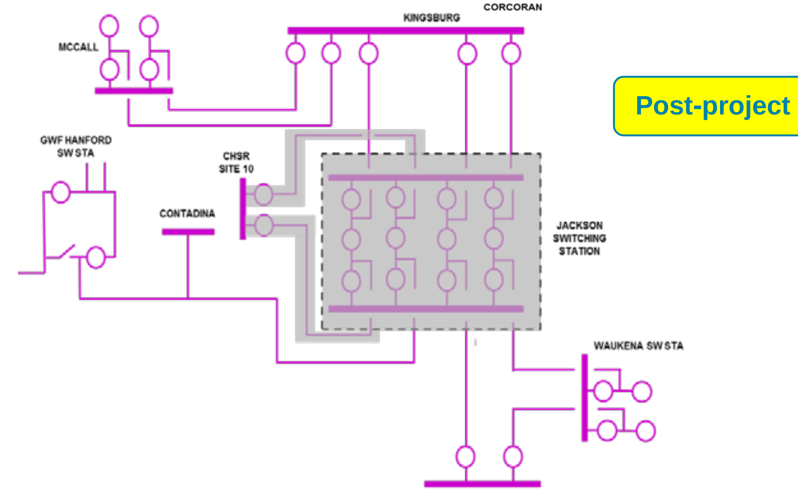
- Construct a new 115 kV 4-bay BAAH Switching Station (SW STA) named Jackson SW STA.
- Connect eight (8) 115 kV transmission lines into Jackson SW STA. Three (3) from Kingsburg, one (1) from Corcoran, one(1) from Waukena SW STA, one (1) from GWF Hanford SW STA and two (2) reserved for CHSR Site 10.
- Construct double-circuit 115 kV T-line extension from Jackson SW STA to CHSR Site 10.



Assessment and Mitigations:

Unit: MVA	Study Load	2023 load	Max 2029-2087 load
Site 10	55	6	22

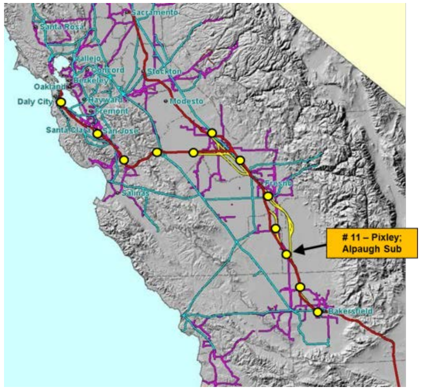
- **McCall – Kingsburg No. 1 and No. 2 115 kV Lines**
  - Overloaded up to 140% under [N-1-1] contingencies involving GWF – Kingsburg 115 kV line and one of the McCall – Kingsburg 115 kV lines.
  - Reconductor 11.6 circuit mile of McCall - Kingsburg No.1 and No. 2 115 kV Lines (double circuit)
- **GWF – Kingsburg 115 kV Line**
  - Overloaded to more than 133% under McCall – Kingsburg double line outage.
  - Reconductor 3.4 miles GWF – Contadina and Contadina – Jackson sections of the GWF – Jackson 115 kV Line



Cost Estimation (in $Million):

- **Interconnection Facility: $4**
- **Network Upgrade (Interconnection): $78**
- Network Upgrade (Mitigation for both Site 10 and 11): $51

Site 11: Pixley, Alpaugh Substation



Project Scope – Interconnection (In-service Date 2020):

- Rebuid Alpaugh Substation into 3-Bay BAAH configuration
- Construct double - circuit 115 kV T-lines from Alpaugh Substation to CHSR Site 11

Assessment and Mitigations:

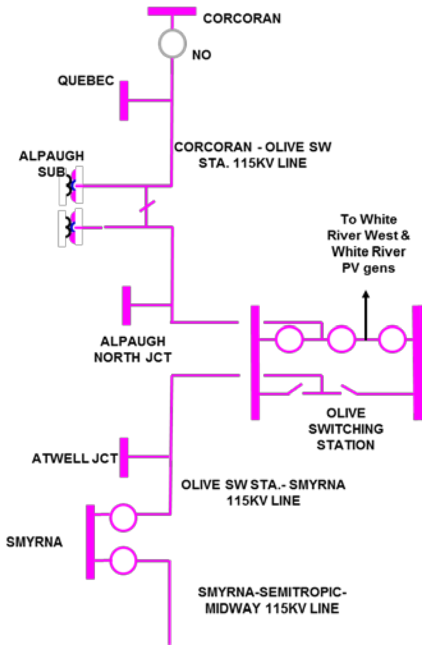
Unit: MVA	Study Load	2023 load	Max 2029-2087 load
Site 11	8	1	3

- **Mitigation combined with Site 10**

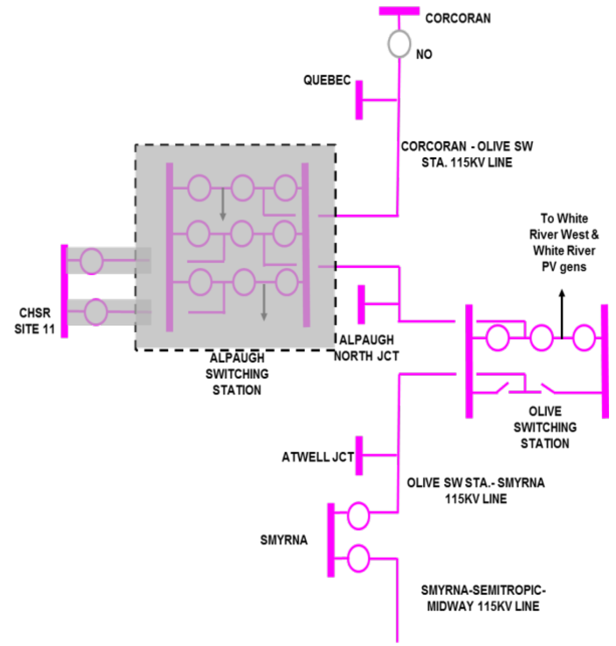
Cost Estimation (in $Million):

- **Interconnection Facility: $4**
- **Network Upgrade (Interconnection): $62**
- Network Upgrade (Mitigation combined with Site 10): $0

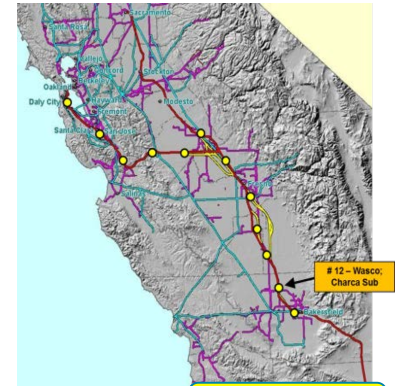
Pre-project



Post-project



Site 12: Northwest of Charca Substation



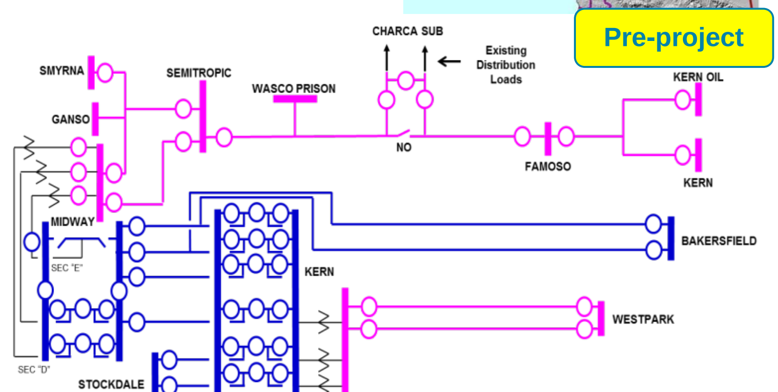
Project Scope – Interconnection (In-service Date 2020):

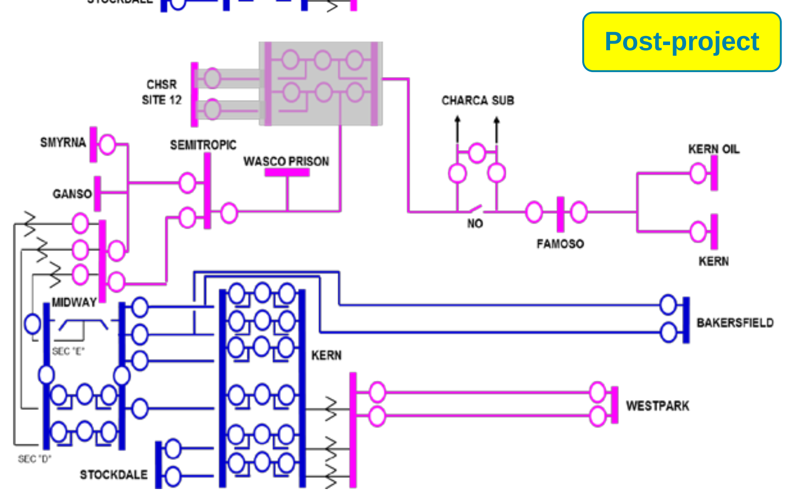
- Construct a new 115kV 2-bay BAAH switching station.
- Loop Semitropic - Charca 115kV transmission line into the new switching station.
- Build ~0.5 circuit mile of double circuit 115kV T-line extensions from CHSR Site 12 to the new switching station.

Assessment and Mitigations:

Unit: MVA	Study Load	2023 load	Max 2029-2087 load
Site 12	11	1	4

- **Midway – Kern No. 3 230 kV Line**
  - Overload increased from 103% to 108% under circuit breaker failure at Midway 230 kV Bus.
  - TPP project to convert Midway 230 kV Bus Section D into BAAH.
- **Midway 230/115kV Transformers**
  - In Outlying Kern Summer Peak Case, under [N-1-1] of two transformers, the remain one will be overloaded, less than 3%.
  - System adjustment.
- **Smyrna – Midway – Semitropic 115kV Line**
  - Semitropic Jct to Ganso and down to Midway: overloads under multiple [N-1/G-1] and [N-1-1] contingencies involving losing Lerdo – Famoso 115 kV Line.
  - Reconductor 6.89 mile from Ganso to Semitropic Jct and 6.84 mile from Ganso to Midway.
- ***Midway 115 kV CB Failure**
  - With NE Kern Conversion Project modeled in the case, Midway 115 kV CB 392 Failure can cause new overloads on line sections of Kern – Kern Oil – Famoso and Semitropic – Charca – Famoso 115 kV Lines.
  - Midway 115 kV Bus re-arrangement.





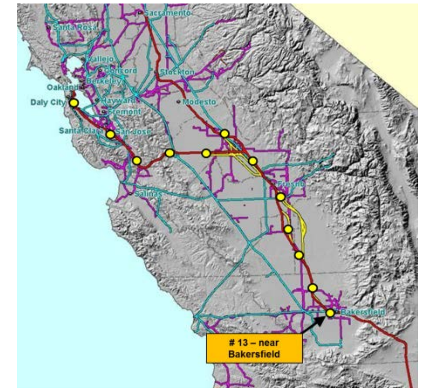
Cost Estimation (in $Million):

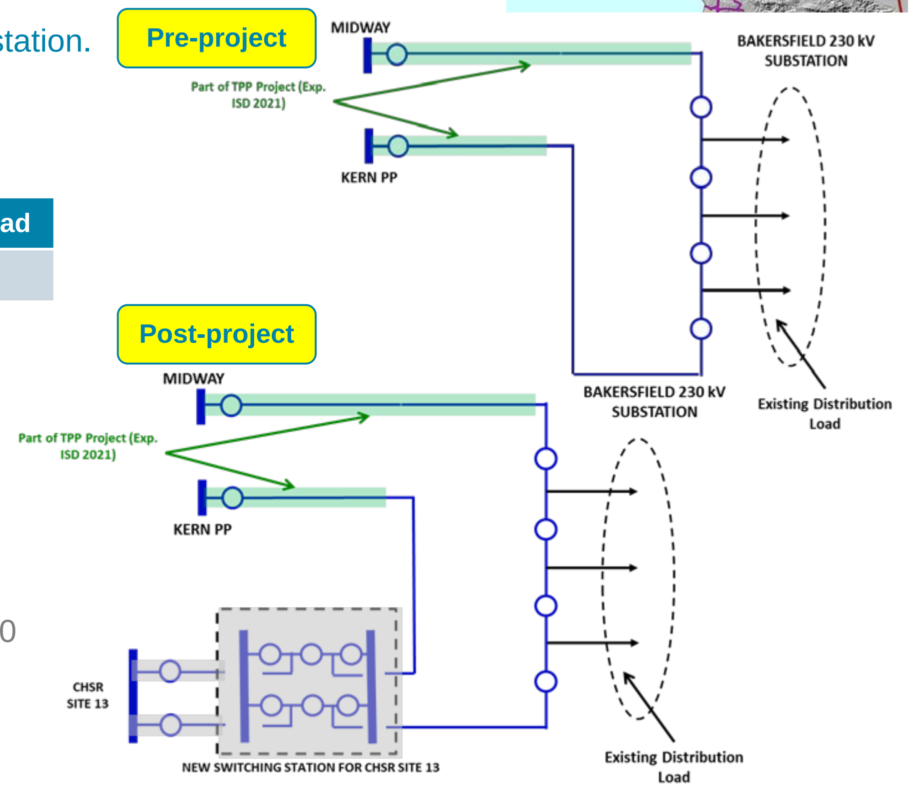
- **Interconnection Facility: $4**
- **Network Upgrade (Interconnection): $38**
- Network Upgrade (Mitigation for both Site 12 and 13): $28

Site 13: Bakersfield

Project Scope – Interconnection (In-service Date 2020):

- Construct a new 230kV 2-bay BAAH switching station ~0.2 mile from Bakersfield 230 kV Substation on strip of land to the West.
- Loop Kern PP - Bakersfield 230 kV line into the new switching station.
- Construct ~0.5 mile double-circuit 230kV T-line extension from the new switching station to CHSR Site 13.
- Implement Ground Grid coordination between the new 230 kV switching station and Bakersfield 230 kV Substation.
- Substation work at Bakersfield and the new switching station.





Assessment and Mitigations:

Unit: MVA	Study Load	2023 load	Max 2029-2087 load
Site 13	64	6	26

- **Mitigation combined with Site 12**

Cost Estimation (in $Million):

- **Interconnection Facility: $3**
- **Network Upgrade (Interconnection): $42**
- Network Upgrade (Mitigation combined with Site 12): $0

Project Costs Summary

Location	Interconnection Facility Cost ($M)	Network Upgrade – Interconnection Scope & Cost ($M)		Network Upgrade – Mitigation Cost ($M)
Site 4	$8	New 2 Bay 115 kV BAAH SW STA	$52	$40
Site 5	$14	Expand existing 230 kV SW STA with 1+1/2 Bay	$23	$0
Site 6	$21	Convert existing 115 kV sub to 3 Bay BAAH	$46	$25
Site 7	$15	Convert existing 230 kV sub to 4 Bay BAAH	$39	$0
Site 8	$8	Convert existing 230 kV sub to 4 Bay BAAH	$66	$21
Site 9	$8	New 2 Bay 230 kV BAAH SW STA	$37	$0
Site 10	$4	New 4 Bay 115 kV BAAH SW STA	$78	$51
Site 11	$4	Convert existing sub to 3 Bay 115 kV BAAH	$62	$0
Site 12	$4	New 2 Bay 115 kV BAAH SW STA	$38	$28
Site 13	$3	New 2 Bay 230 kV BAAH SW STA	$42	$0
Total ($M)	$89	$483		$165
	$737			

- The mitigations identified in the study were for the ultimate load of 361 MVA, which is not expected in the planning horizon.
- CHSRA is to provide updated load forecast annually. Mitigation in the post-2025 timeframe will need to be continuously monitored and evaluated through annual TPP.
- PG&E believes general principles of cost responsibility including, but not limited to, the following, are likely to be applicable:
  - Facilities that are requested by, or are necessary to serve, a customer and which only benefit that customer should have such costs, including all applicable labor, materials, or other necessary costs, borne solely by that customer until such time as other utility customers benefit from those facilities.
  - Should a customer have specific service requirements that exceed the customary or most economical means to serve the customers' expected load, that customer shall bear all costs for facilities, including all applicable labor, materials, or other necessary costs, in excess of those that would otherwise be required to provide the customary or most economical service.

*AACE Level 4 Cost Estimation with -30% to +50% range

Thank You