Agenda
Reliability Assessment and Study Updates

Kaitlin McGee
Sr. Stakeholder Engagement and Policy Specialist

2023-2024 Transmission Planning Process Stakeholder Meeting
November 16, 2023

Reminders

- Stakeholder calls and meetings related to Transmission Planning are not recorded.
  - Given the expectation that documentation from these calls will be referred to in subsequent regulatory proceedings, we address written questions through written comments, and enable more informal dialogue at the call itself.
  - Minutes are not generated from these calls, however, written responses are provided to all submitted comments.
- Calls are structured to stimulate an honest dialogue and engage different perspectives.
- Please keep comments professional and respectful.

Instructions for raising your hand to ask a question

- If you are connected to audio through your computer or used the “call me” option, select the raise hand icon located on the bottom of your screen.
  Note: #2 only works if you dialed into the meeting.
  - Please remember to state your name and affiliation before making your comment.

2023-2024 Transmission Planning Process Stakeholder Call – Agenda

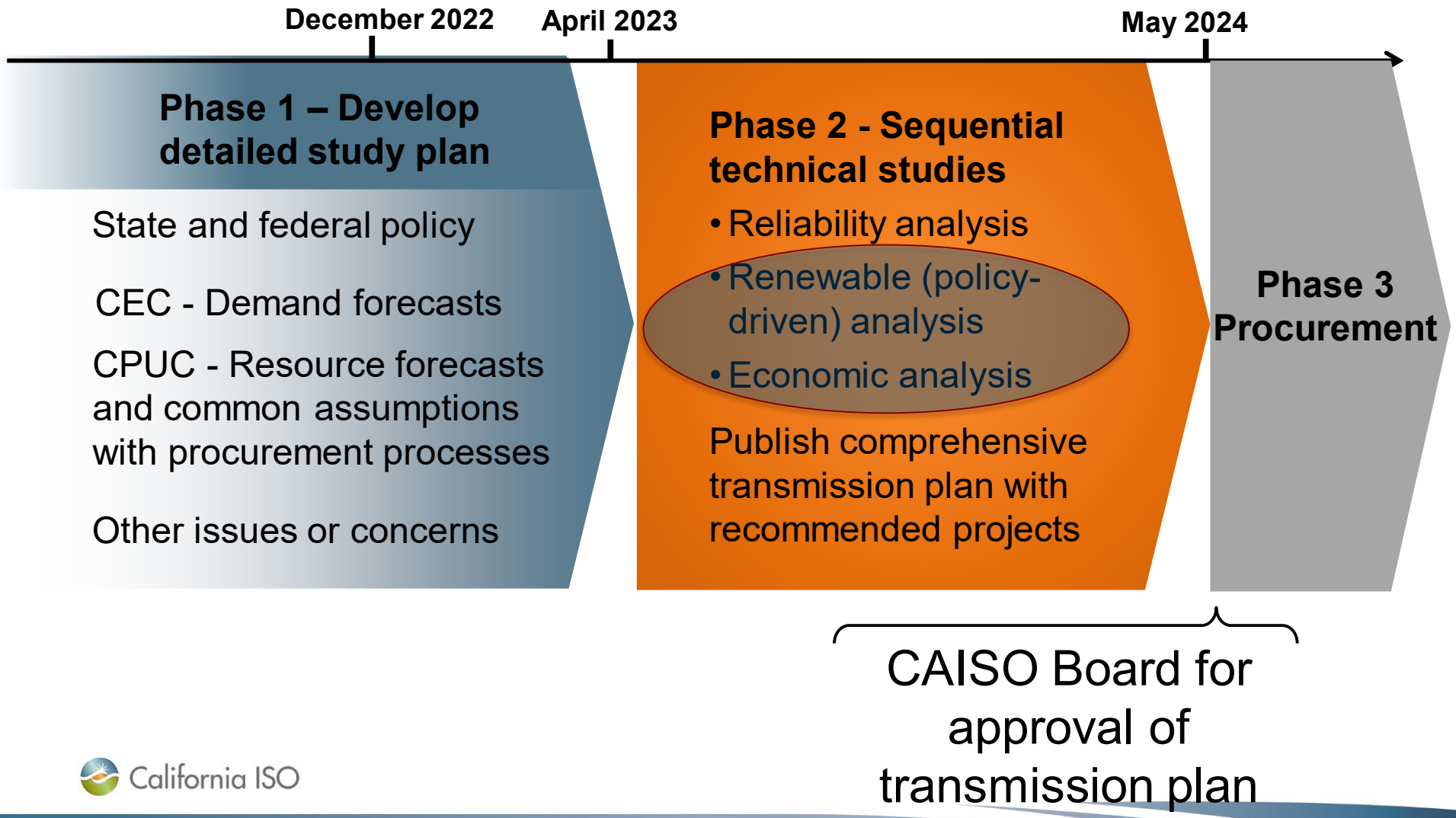
Topic	Presenter
Overview	Binaya Shrestha
Reliability <$50 Million Project Recommendation - North	Preethi Rondla
Reliability <$50 Million Project Recommendation - South	RTS Engineers
MIC Expansion Requests	Catalin Micsa
Preliminary Policy Assessment Introduction - Preliminary Results of SCE and GLW areas - Preliminary Results for SDG&E area - Preliminary Results for PG&E area	Nebiyu Yimer - RTS Engineers - Luba Kravchuk - Lindsey Thomas
Preliminary Results of Economic Analysis	Yi Zhang
Wrap-up	Kaitlin McGee

Introduction and Overview
Preliminary Reliability Assessment Results

Binaya Shrestha
Manager, Regional Transmission - North

2023-2024 Transmission Planning Process Stakeholder Meeting
November 16, 2023

2023-2024 Transmission Planning Process

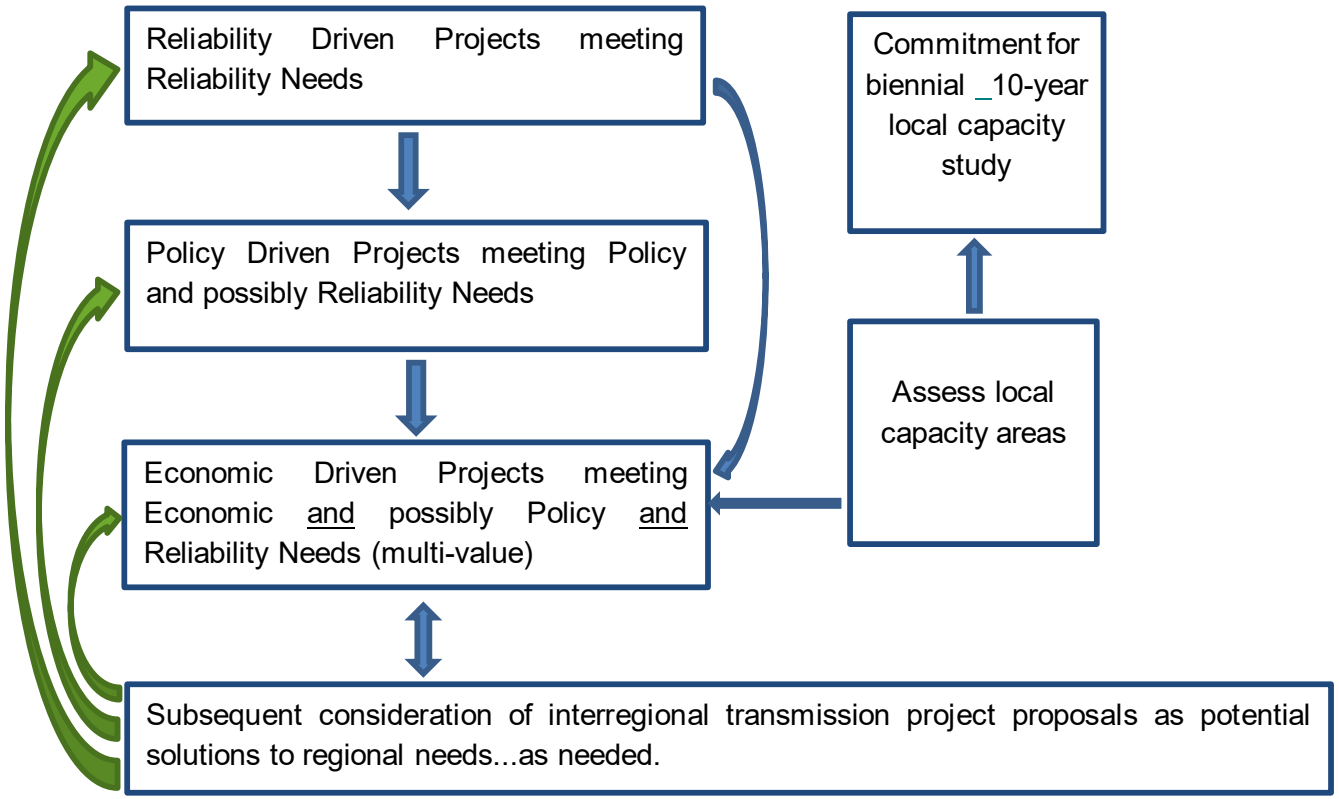


2023-2024 Transmission Plan Milestones

- Draft Study Plan posted on February 23
- Stakeholder meeting on Draft Study Plan on February 28
  - Comments submitted by March 14
- Final Study Plan posted on August 16
- Preliminary reliability study results posted on August 15
- Stakeholder meeting on September 26 and 27
  - Comments submitted by October 11
- Request window closed October 15
- Preliminary policy and economic study results on November 16
  - Comments to be submitted by December 4
- Draft transmission plan to be posted on March 31, 2024
- Stakeholder meeting in April
  - Comments to be submitted within two weeks after stakeholder meeting
- Revised draft for approval at May Board of Governor meeting

California ISO

Studies are coordinated as a part of the transmission planning process



2022-2023 Transmission Planning Process
Reliability Assessment - Update

- ISO recommended projects have two paths for approval:
  - For management approval, reliability projects less than $50 million can be presented at November stakeholder session
  - For Board of Governor approval of reliability projects over $50 million and projects not presented for management approval, are included in draft plan to be issued for stakeholder comments by March 31, 2024

2023 Request Window Submissions

Project Name	Submitter	Review of Submission
Atlantic High Voltage Mitigation (Rescope)	PG&E	May be considered for reliability alternative
Calistoga 60 kV Voltage Support	PG&E	May be considered for reliability alternative
Camden 70 kV Reinforcement	PG&E	May be considered for reliability alternative
Covelo 60 kV Voltage Support	PG&E	May be considered for reliability alternative
Crazy Horse Canyon-Salinas-Soledad #1 and #2 115 kV Line Reconductoring	PG&E	May be considered for reliability alternative
Diablo Canyon Area 230 kV High Voltage Mitigation	PG&E	May be considered for reliability alternative
French Camp Reinforcement (Conceptual)	PG&E	Does not meet a reliability need identified by the CAISO in this TPP cycle.
Gates 230/70 kV Transformer Addition	PG&E	May be considered for reliability alternative
Martin-Millbrae 60 kV Area Reinforcement	PG&E	May be considered for reliability alternative
Reedley 70 kV Capacity Increase	PG&E	May be considered for reliability alternative
Spence 60kV Area Reinforcement (Conceptual)	PG&E	Does not meet a reliability need identified by the CAISO in this TPP cycle.
Tejon Area Reinforcement (Conceptual)	PG&E	Does not meet a reliability need identified by the CAISO in this TPP cycle.
Vaca Dixon Area Reinforcement (Rescope)	PG&E	May be considered for reliability alternative

2023 Request Window Submissions

Project Name	Submitter	Review of Submission
Valley Center System Improvement	SDGE	May be considered for reliability alternative
New Penasquitos - Mira Sorrento Line	SDGE	May be considered for reliability alternative
TL600 Clairemont Loop-in	SDGE	May be considered for reliability alternative
Short Circuit Mitigation for Imperial Valley 230 kV Circuit Breakers	SDGE	May be considered for reliability alternative
Short Circuit Mitigation for Miguel 230 kV Circuit Breakers	SDGE	May be considered for reliability alternative
Trout Canyon - Lugo 500 kV	GLW	Does not meet a reliability need identified by the CAISO in this TPP cycle. However, it may be considered as a policy and economic solution.
Eldorado 500 kV Bus Short Circuit Duty (SCD) Mitigation	SCE	May be considered for reliability alternative
Mira Loma 500 kV Bus SCD Mitigation	SCE	May be considered for reliability alternative
Inyo 230 kV Shunt Reactor	SCE	May be considered for reliability alternative
Etiwanda 230 kV SCD Mitigation	SCE	May be considered for reliability alternative
Mendota RAS	MCE Clean Energy	Merchant transmission
Pacific Transmission Expansion Project	California Western Grid Development, LLC.	May be considered for reliability alternative

20-Year Transmission Outlook

- The ISO will be holding a separate stakeholder call on the preliminary analysis for the outlook

- The ISO has tentatively scheduled the call for January 4, 2024
  - A market notice will be sent out in advance for the stakeholder call

Comments

- Comments due by end of day December 4, 2023

- Submit comments through the ISO's commenting tool, using the template provided on the process webpage:
- https://stakeholdercenter.caiso.com/RecurringStakeholderProcesses/2023-2024-Transmission-planning-process

2023-2024 Transmission Planning Process
PG&E Area
Less than $50 Million Project Approvals and Project for Concurrence

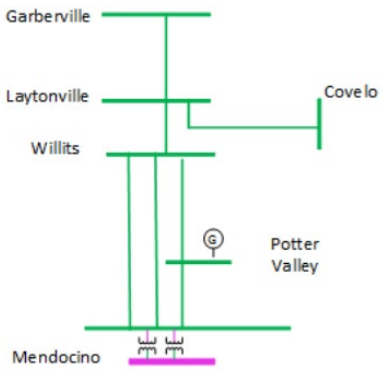
Preethi Rondla
Sr. Regional Transmission Engineer

2023-2024 Transmission Planning Process Stakeholder Meeting
November 16, 2023

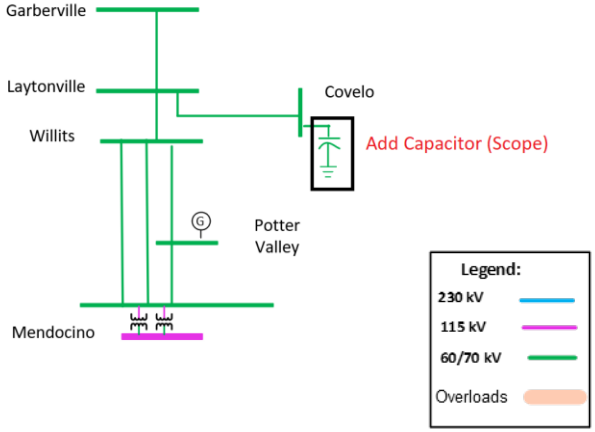
Covelo 60 kV Voltage Support (North Coast North Bay)

- Reliability Assessment Need
  - NERC Category P1 starting 2025.
  - Load increases
- Project Submitter
  - PG&E
- Project Scope
  - Install a 10 MVAR Shunt Capacitor at Covelo 60 kV
  - Substation
- Project Cost
  - $11M - $22M
- Alternatives Considered
  - Status Quo is not recommended because it does not mitigate the expected capacity constraints due to low voltage without having to rely on dropping customer load before/after a single contingency event.
- Estimated In-service Date
  - 2030 or earlier
- Recommendation
  - Approval

Existing

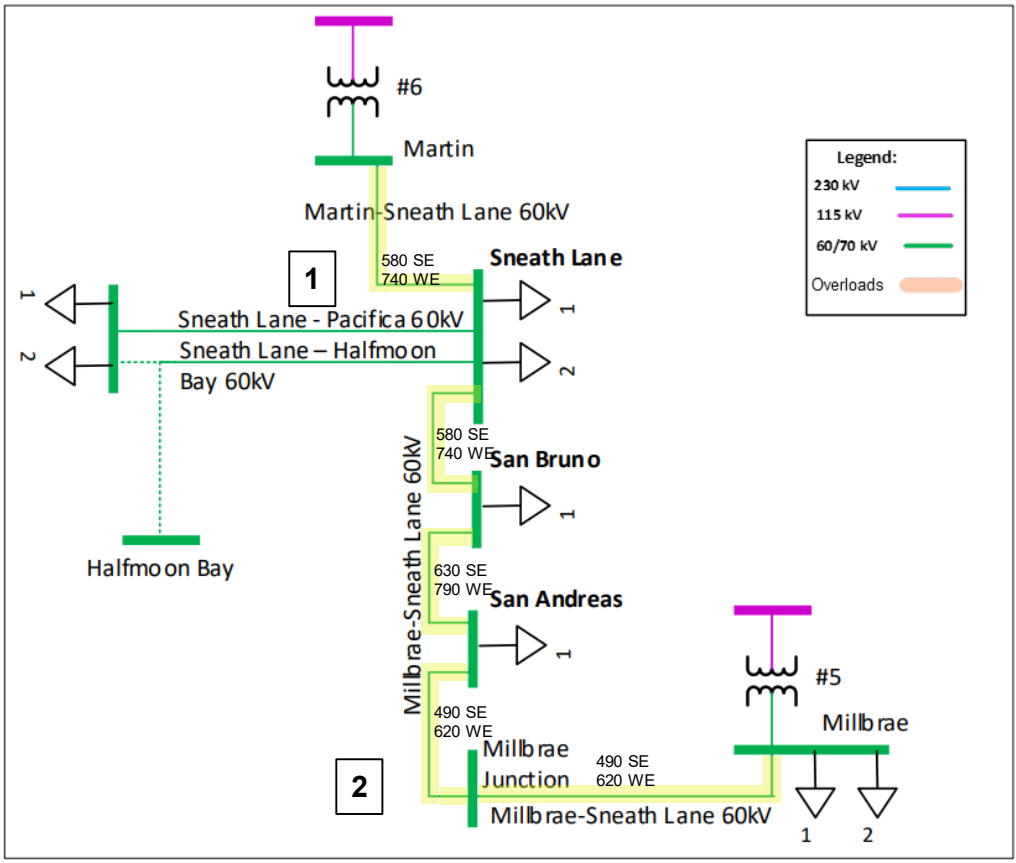


Proposed



Martin-Millbrae 60 kV Area Reinforcement project (Greater Bay Area)

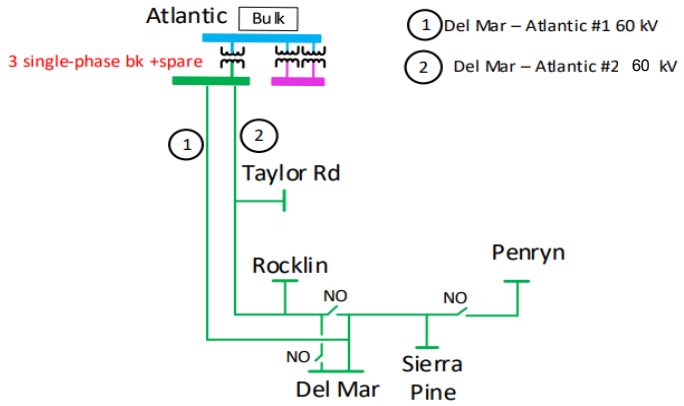
- Reliability Assessment Need
  - NERC Categories P1 and P2 starting 2025 winter peak.
  - Load growth
- Project Submitter
  - PG&E
- Project Scope
  1. Reconductor 7.2 miles on the Martin-Sneath Lane 60 kV line with a larger conductor to achieve 1100 Amps SE and 1200 Amps WE.
  2. Reconductor 2.5 miles on the Millbrae-Sneath Lane 60 kV line with a larger conductor to achieve 1100 Amps SE and 1200 Amps WE.
- Project Cost
  - $20.0M - $40.0M
- Alternatives Considered
  - Status quo. Not recommended due to potential criteria violations.
  - Energy Storage. Not recommended because of charging limitations.
- Estimated In-service Date
  - 2030 or earlier. In the interim, the operating solution to mitigate the overloads is transferring load to Halfmoon Bay.
- Recommendation
  - Approval



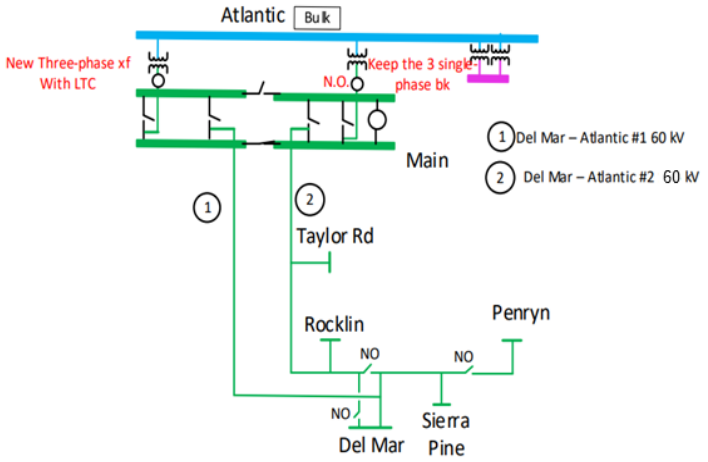
Atlantic High Voltage Mitigation (Re-scope)

- Current Scope from TPP 2021-22
  - Add Voltage regulator for HV mitigation starting Spring off-peak 2026
  - Initial Project Cost $5M - $10M
- Reliability Assessment Need
  - Failure of one 1-single phase bank
  - NERC Category P0 High Violations starting 2028.
  - Projected 125 MW of load growth in long term at Atlantic 60 kV load pocket
- Project Submitter
  - PG&E
- Project Scope
  - Install a 200 MVA 3-phase 230/60 kV transformer with LTC at Atlantic Substation
  - Associated bus work at Atlantic Substation to install the new transformer.
- Project Cost
  - $20M - $40M*
- Alternatives Considered
  - Alternative 1: Status Quo
    - Not Recommended due to not mitigating P0 High Voltage violations
  - Alternative 2: Install regulator and spare single-phase bank
    - Not Recommended due to missing wider score i.e. improved customer reliability, operational flexibility and providing a back-up source
- Estimated In-service Date
  - May 2029
- Recommendation
  - Approval

Existing



Proposed



2023-2024 Transmission Planning Process
SCE Metro Area
Less than $50 Million Projects Recommended for Approvals and Project for Concurrence

Frank Chen
Regional Transmission Engineer Lead

2023-2024 Transmission Planning Process Stakeholder Meeting
November 16, 2023

Mira Loma 500 kV Bus SCD Mitigation Project

- Project Submitter : SCE
- Reliability Assessment Need
  - two 500 kV circuit breakers at Mira Loma exceeds Short circuit duty (SCD) rating today after field verification, in addition to the four 500 kV circuit breakers already approved in the 2022-2023 TPP
  - The SCD is greater than 118.7% and 137.2% of the rated capability in the near-term and the longer-term planning horizons
  - New generation in the area will be limited due to safety concerns without the project
- Project Scope
  - Replace the two 500 kV circuit breakers with new 63 kA rated circuit breakers
- Alternative Considered:
  - Developing a complex operating procedure opening 500 kV transmission lines to manage the SCD overstress, which was dismissed because it could result in significant curtailment of renewable resources and other reliability concerns during peak hours
- Project Cost: $5M
- Expected In-Service Date: 6/30/2027
- Impact of Proposed Project:
  - Lowers SCD within allowable limits and increases margin significantly
  - Enables new generation and transmission interconnections in the area
- Recommendation: Approval

Mira Loma 500 kV Bus SCD Mitigation Project

One-Line Diagram

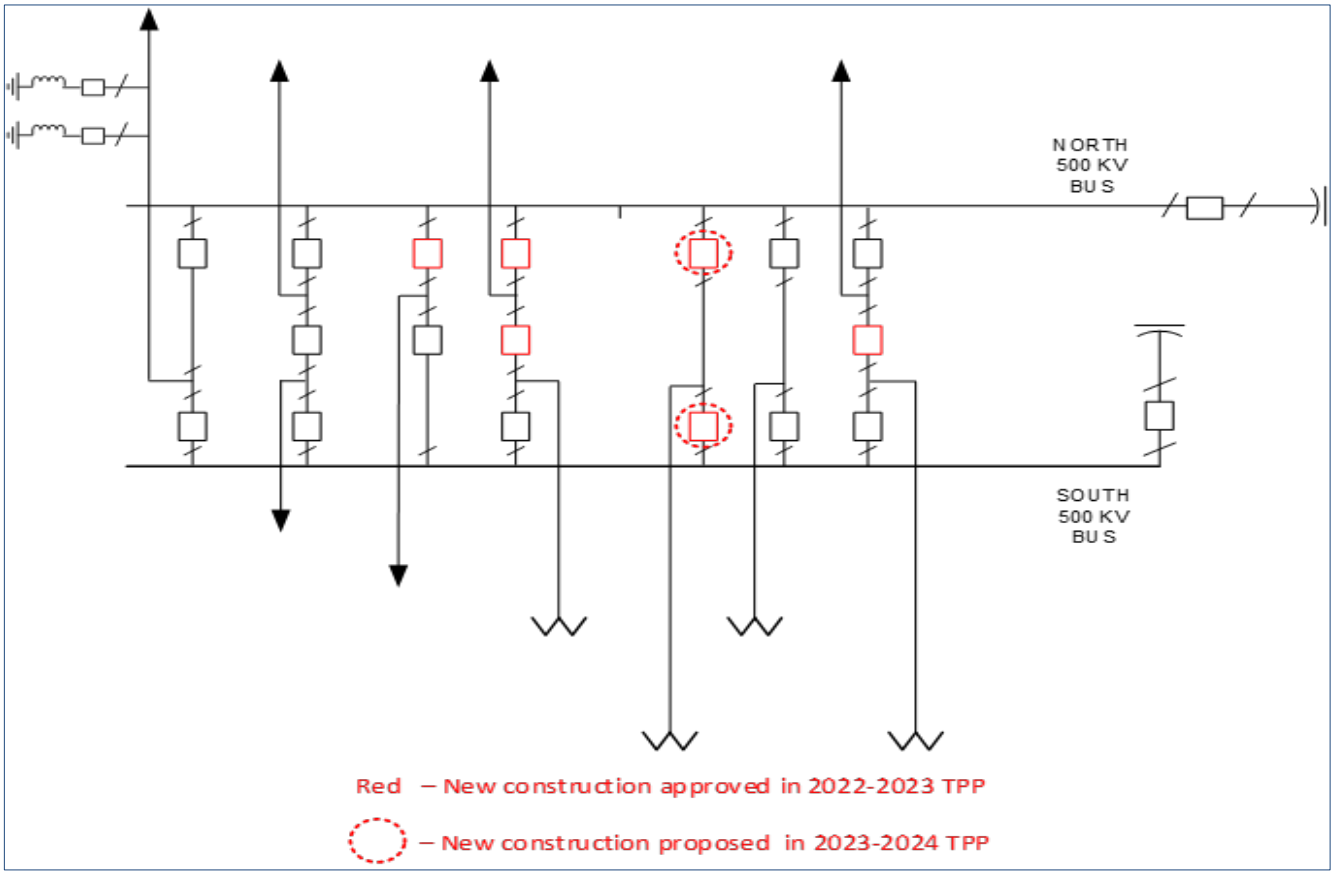


Diagram source: SCE 2021-2022 TPP RW submission

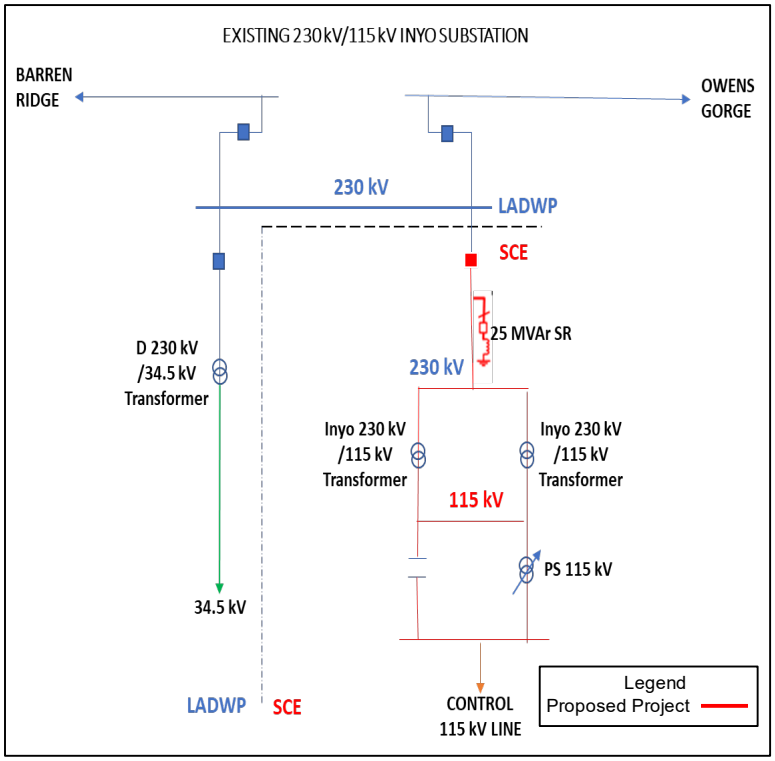
2023-2024 Transmission Planning Process
SCE North of Lugo Area
Less than $50 Million Projects Recommended for Approvals and Project for Concurrence

Meng Zhang
Regional Transmission Engineer Lead

2023-2024 Transmission Planning Process Stakeholder Meeting
November 16, 2023

Inyo 230 kV Shunt Reactor Project (North of Lugo Area)

- Reliability Assessment Need
  - NERC Category P5 high voltage starting 2025.
  - Real time high voltage issues at Inyo 230 kV bus
  - Actual bus voltages that are far beyond the voltage limits in the ISO Planning Standards.
- Project Submitter
  - SCE
- Project Scope
  - Install a new 25 MVAR shunt reactor at SCE side Inyo 230 kV substation
- Project Cost
  - $20M
- Alternatives Considered
  - Continue to utilize the system operating bulletins SOB 80 and SOB 17. This alternative has been ineffective
- Estimated In-service Date
  - 2027
- Recommendation
  - Approval
  - The project will supersede the Control 115 kV shunt reactor project approved in 2022-2023 TPP



2023-2024 Transmission Planning Process
SCE Eastern Area
Less than $50 Million Projects Recommended for Approvals and Project for Concurrence

Nikitas Zagoras
Sr. Regional Transmission Engineer

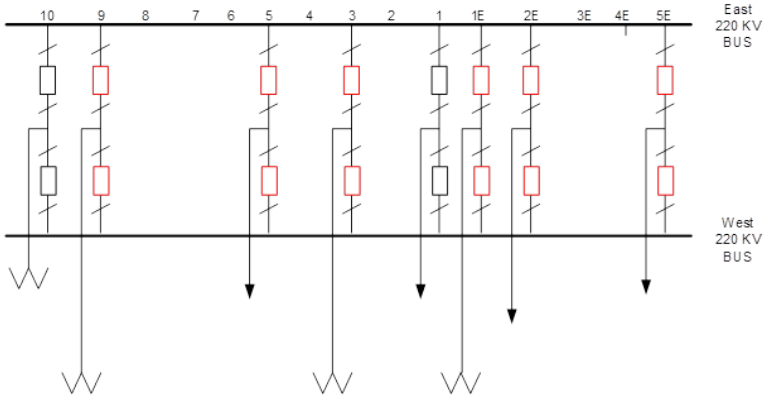
2023-2024 Transmission Planning Process Stakeholder Meeting
November 16, 2023

Etiwanda 230 kV Bus SCD Mitigation

- Reliability Assessment Need
  - Short-circuit duty (SCD) studies indicate that the twelve 230 kV circuit breakers are expected to be loaded to greater than 95% of their rated three-phase SCD capability in the near term (2025) and to 100% in the long term (2035).
- Project Submitter
  - SCE
- Project Scope
  - Replace twelve (12) 230 kV circuit breakers at Etiwanda currently rated 63 kA tested at X/R ratio of 17 with new 63 kA rated circuit breakers tested at X/R ratio of 35
- Project Cost
  - $40M (ISD 12/31/2027)
- Alternatives Considered
  - Develop operating procedure to open 230 kV transmission lines in real time
- Recommendation
  - Increases SCD margin at Etiwanda 230 kV
  - Enables renewable generation and transmission interconnections in the area

Approval

Single Line Diagram



Red – New construction proposed in 2023-2024 TPP

SCD Study Results

Scenario	Pre Etiwanda 230 kV Bus SCD Mitigation		Post Etiwanda 230 kV Bus SCD Mitigation	
	Eff 3PH SCD	% Loaded	Eff 3PH SCD	% Loaded
2025	60.6 kA	96.2%	56.6 kA	89.8%
2035	63.0 kA	100.0%	58.0 kA	92.1%

2023 MIC Expansion Requests

Catalin Micsa
Senior Advisor, Transmission Infrastructure Planning

2023-2024 Transmission Planning Process Stakeholder Meeting
November 16, 2023

2023 Valid MIC expansion requests

No.	Requestor Name	Intertie Name (Scheduling Point)	MW quantity	Resource type
1-2	Southern California Edison	BLYTHE_ITC (BLYTHE161)	23	Hydro
3	Marin Clean Energy	GONDIPPDC_ITC (GONIPP)	20	Geothermal
		MONAIPPDC_ITC (MDWP)		
4-6	California Community Power	GONDIPPDC_ITC (GONIPP)	38.5	Geothermal
		SILVERPK_ITC (SILVERPEAK55)		
		SUMMIT_ITC (SUMMIT120)		
		IID-SDGE_ITC (IVLY2)	40	
		GONDIPPDC_ITC (GONIPP)	13	
		SILVERPK_ITC (SILVERPEAK55)		
7	Fervo Energy Cal Choice Energy Authority Clean Energy Alliance Desert Energy Community	IPPDCADLN_ITC (IPP & IPPUTAH)	20	Geothermal
8	Fervo Energy Clean Power Alliance	IPPDCADLN_ITC (IPP & IPPUTAH)	33	Geothermal
9	Clean Power Alliance	MEAD_ITC (MEAD230)	119	Wind

Not all MIC expansion requests trigger an actual need for expansion

- First the CAISO checks is these resources were included in the base portfolio in order to avoid duplicate entries.
- Second the CAISO calculates if a MIC expansion is needed (see methodology in RR BPM section 6.1.3.5).
- If MIC expansion is needed, the increase in MIC needs to be modeled and tested through deliverability studies
  - NQC deliverability study (if applicable in year one)
  - TPP deliverability study
  - GIP deliverability study
- One or multiple of these studies can limit the deliverability and therefore the MIC expansion.

Assessment of valid 2023 MIC expansion requests

No	Requestor Name	Intertie Name (Scheduling Point)	MW quantity	Triggers expansion	Comments
1-2	Southern California Edison	BLYTHE_ITC (BLYTHE161)	23	Yes	Partial
3	Marin Clean Energy	GONDIPPDC_ITC (GONIPP)	20	In CPUC Portfolio	CPUC portfolio triggers MIC expansion.
		MONAIPPDC_ITC (MDWP)			
4-6	California Community Power	GONDIPPDC_ITC (GONIPP)	38.5	In CPUC Portfolio	CPUC portfolio triggers MIC expansion.
		SILVERPK_ITC (SILVERPEAK55)			Active as back-up location only.
		SUMMIT_ITC (SUMMIT120)			
		IID-SDGE_ITC (IVLY2)	40		No expansion needed.
		GONDIPPDC_ITC (GONIPP)	13		CPUC portfolio triggers MIC expansion.
		SILVERPK_ITC (SILVERPEAK55)			
7	Fervo Energy Cal Choice Energy Authority Clean Energy Alliance Desert Energy Community	IPPDCADLN_ITC (IPP & IPPUTAH)	20	Yes	Full
8	Fervo Energy Clean Power Alliance	IPPDCADLN_ITC (IPP & IPPUTAH)	33	Yes	Full
9	Clean Power Alliance	MEAD_ITC (MEAD230)	119	In CPUC Portfolio	CPUC portfolio triggers MIC expansion.

MIC expansion requests currently being assessed (not already part of the CPUC portfolio)

No.	Year	Requestor Name	Intertie Name (Scheduling Point)	MW quantity	Resource type
1-2	2022	San Diego Community Power	ELDORADO_ITC (WILLOWBEACH)	90	Wind
3-5		Valley Electric Association	MEAD_ITC (MEAD 230)	33	Hydro
6				90	Hybrid (Solar/Battery)
7-8	2023	Southern California Edison	BLYTHE_ITC (BLYTHE161)	7	Hydro
9		California Community Power	SUMMIT_ITC (SUMMIT120) *	39	Geothermal
			SILVERPK_BG (SILVERPEAK55) *		
10		Fervo Energy Cal Choice Energy Authority Clean Energy Alliance Desert Energy Community	IPPDCADLN_ITC (IPP & IPPUTAH)	20	Geothermal
11		Fervo Energy Clean Power Alliance	IPPDCADLN_ITC (IPP & IPPUTAH)	33	Geothermal

* = As back-up locations only – main delivery point included as GONDIPPDC_ITC (GONIPP) and part of the CPUC portfolio

NQC Deliverability Study (2024)

Intertie Name (Scheduling Point)	Status	Comments:
GONDIPPDC_ITC (GONIPP)	Failed	
BLYTHE_ITC (BLTHE161)	Failed	
ELDORADO_ITC (WILLOWBEACH)	Failed	Includes both CPUC portfolio and MIC expansion requests.
MEAD_ITC (MEAD 230)	Failed	Includes both CPUC portfolio and MIC expansion requests.
SILVERPK_ITC (SILVERPEAK55)	Pass	Included in the CPUC portfolio. Temporary expansion included in 2024 MIC.

- Only applicable to MIC expansion request for RA year 2024
- Permanent expansion depends on the TPP and GIP deliverability study results

TPP Deliverability Study

Intertie Name (Scheduling Point)	Status	Comments:
GONDIPPDC_ITC (GONIPP)	Partial Pass	Fully included in the CPUC portfolio. For potential increase see mitigation for Eldorado-McCullough constraint.
IPPDCADLN_ITC (IPP & IPPUTAH)	Failed	For potential increase see mitigation for Eldorado-McCullough constraint.
BLYTHE_ITC (BLYTHE161)	Failed	For potential increase see mitigation for Eldorado-McCullough constraint.
ELDORADO_ITC (WILLOWBEACH)	Failed	For potential increase see mitigation for Eldorado-McCullough and Sloan Canyon-Eldorado constraints.
MEAD_ITC (MEAD 230)	Failed	Part included in the CPUC portfolio. For potential increase see mitigation for Eldorado-McCullough and Sloan Canyon-Eldorado constraints.
SILVERPK_BG (SILVERPEAK55)	Failed	Main included in the CPUC portfolio. For potential increase see mitigation for Eldorado-McCullough, Sloan Canyon-Eldorado, Control-Inyokern Tap and Control-Silver Peak constraints.
SUMMIT_ITC (SUMMIT120)	Failed	Used as back-up only. For potential increase see Drum-Higgins and PG&E 500 kV constraints.
IID-SDGE_BG (IVLY2)	N/A	Included in the CPUC portfolio. No need for expansion.

Policy-driven Deliverability Assessment Preliminary Results

Transmission Infrastructure Planning

2023-2024 Transmission Planning Process Stakeholder Meeting
November 16, 2023

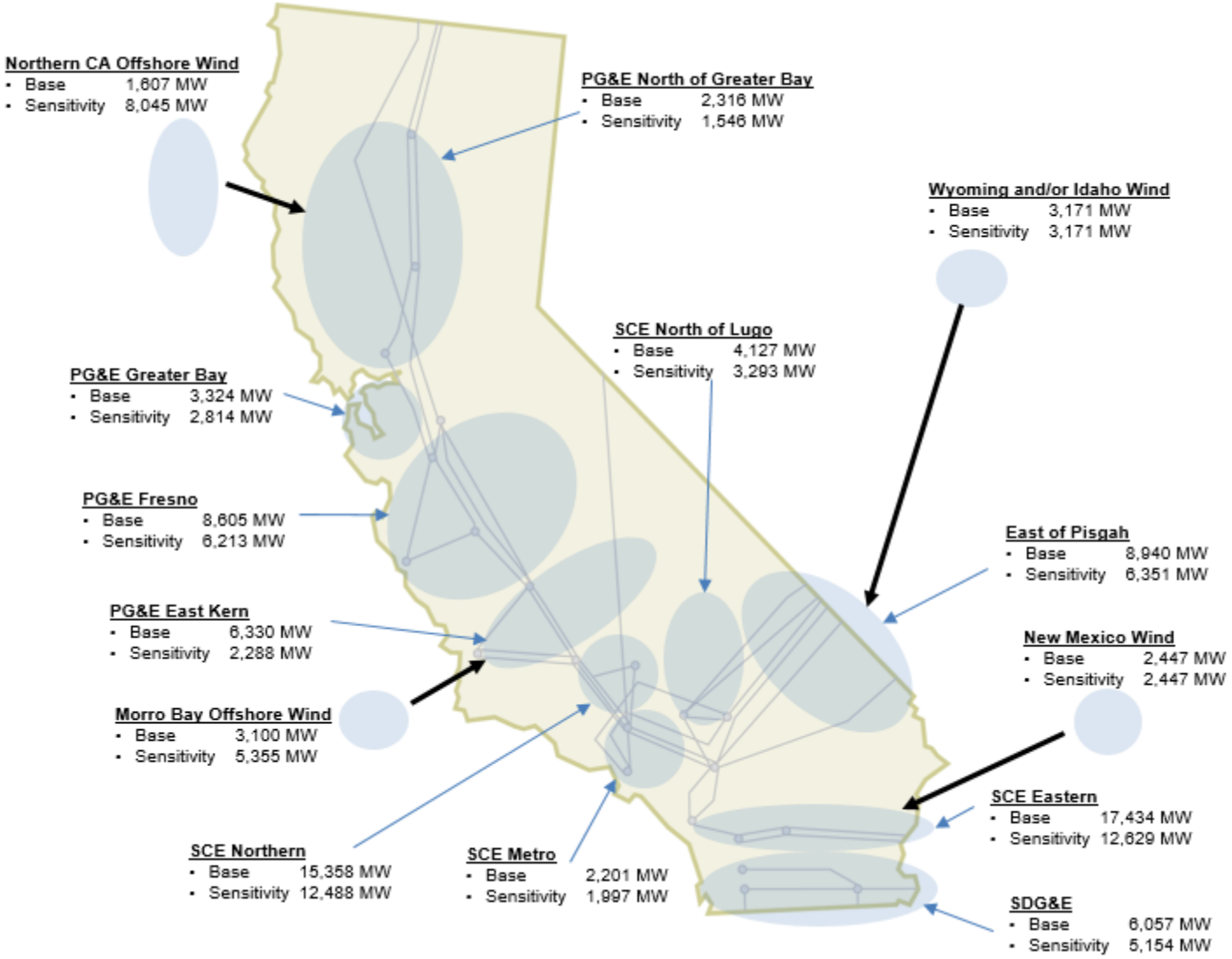
Introduction

- The 2023-2024 TPP policy-driven deliverability assessment is based on the base and OSW sensitivity portfolios transmitted by CPUC for year 2035
  - Base Portfolio is based on a 30 MMT by 2030 GHG target and the 2021 CEC demand forecast utilizing the additional transportation electrification (ATE) assumptions
  - Sensitivity Portfolio is based on the same GHG target and load forecast intended to test the transmission needs associated with 13.4 GW of offshore wind
- The PG&E area is the focus of the OSW sensitivity portfolio assessment
- MIC expansion requests are also assessed as part of the studies

Introduction – Cont'd

- The deliverability assessment consists of on-peak assessment (HSN and SSN) and Off-peak assessment
- Alternatives considered to address on-peak deliverability constraints
  - RAS or other operating solutions
  - Reducing generic battery-storage where applicable
  - Transmission upgrade alternatives
- Alternatives considered to address off-peak deliverability constraints if constraint is not addressed by reducing thermal generation output to zero, dispatching existing energy storage in charging mode and reducing imports
  - RAS or other operating solutions
  - Dispatch portfolio energy storage in charging mode
  - Transmission upgrade alternatives if they provide sufficient economic benefits

2023-2024 TPP Adopted Base and OSW Sensitivity Portfolios (2035)



Base and Sensitivity Portfolios by Resource Type

Resource Type	Base Portfolio			Sensitivity Portfolio		
	FCDS (MW)	EO (MW)	Total (MW)	FCDS (MW)	EO (MW)	Total (MW)
Solar	15,636	23,311	38,947	11,442	14,304	25,746
Wind – In State	2,511	564	3,074	2,511	564	3,074
Wind – Out-of-State (Existing TX)	690	100	790	690	100	790
Wind – Out-of-State (New TX)	4,828	0	4,828	4,828	0	4,828
Wind - Offshore	4,546	161	4,707	13,239	161	13,400
Li Battery	28,374	0	28,374	23,545	0	23,545
Geothermal	2,037	0	2,037	1,149	0	1,149
Long Duration Energy Storage (LDES)	2,000	0	2,000	1,000	0	1,000
Biomass/Biogass	134	0	134	134	0	134
Distributed Solar	125	0	125	125	0	125
Total	**60,880**	**24,135**	**85,015**	**58,663**	**15,129**	**73,791**

Portfolio adjustments based on CPUC guidance

- Unaccounted for TPD allocation modeled (MW)[1]

Transmission Area	Substation	Voltage	Resource Type	FCDS
SCE Eastern Study Area	Delaney	500	Storage	102.0
SDG&E Study Area	Hoodoo Wash	500	Storage	42.5
East of Pisgah Study Area	Ivanpah	230	Storage	200.0
East of Pisgah Study Area	Mohave	500	Storage	120.0
SCE Eastern Study Area	Redbluff	230	Storage	12.5
			Total	**477.0**

- Adjustments due to additional in-development resources (MW)[1]

				Adopted Base Portfolio Resources (2035)			Post Decision Adjustments			Updated Base Portfolio Resources (2035)		
Transmission Area	CAISO Substation	Voltage	Resource Type	FCDS (MW)	EODS (MW)	Total (MW)	FCDS (MW)	EODS (MW)	Total (MW)	FCDS (MW)	EODS (MW)	Total (MW)
SCE Northern Area	Windhub	500	Li_Battery	412	-	412	(412)	-	(412)	-	-	-
SCE Northern Area	Windhub	230	Li_Battery	1,255	-	1,255	412	-	412	1,667	-	1,667
SCE Northern Area	Windhub	500	Solar	780	-	780	-	-	-	780	-	780
SCE Northern Area	Windhub	230	Solar	846	1,068	1,914	-	-	-	846	1,068	1,914
				3,293	**1,068**	**4,361**	-	-	-	**3,293**	**1,068**	**4,361**

1 https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/busbardashboard2035_30mmt_hebase_vd2_08-11-23.xlsx

MIC expansion requests assessed

No.	Requestor Name	Intertie Name (Scheduling Point)	MW quantity	Resource type
1-2	San Diego Community Power	ELDORADO_ITC (WILLOWBEACH)	90	Wind
3-5	Valley Electric Association	MEAD_ITC (MEAD 230)	33	Hydro
6			90	Hybrid (Solar/Battery)
7-8	Southern California Edison	BLYTHE_ITC (BLYTHE161)	7	Hydro
9	Cal Choice Energy Authority Clean Energy Alliance Desert Energy Community	IPPDCADLN_ITC (IPP & IPPUTAH)	20	Geothermal
10	Clean Power Alliance	IPPDCADLN_ITC (IPP & IPPUTAH)	33	Geothermal
11	California Community Power	SUMMIT_ITC (SUMMIT120) *	39	Geothermal
		SILVERPK_BG (SILVERPEAK55) *		

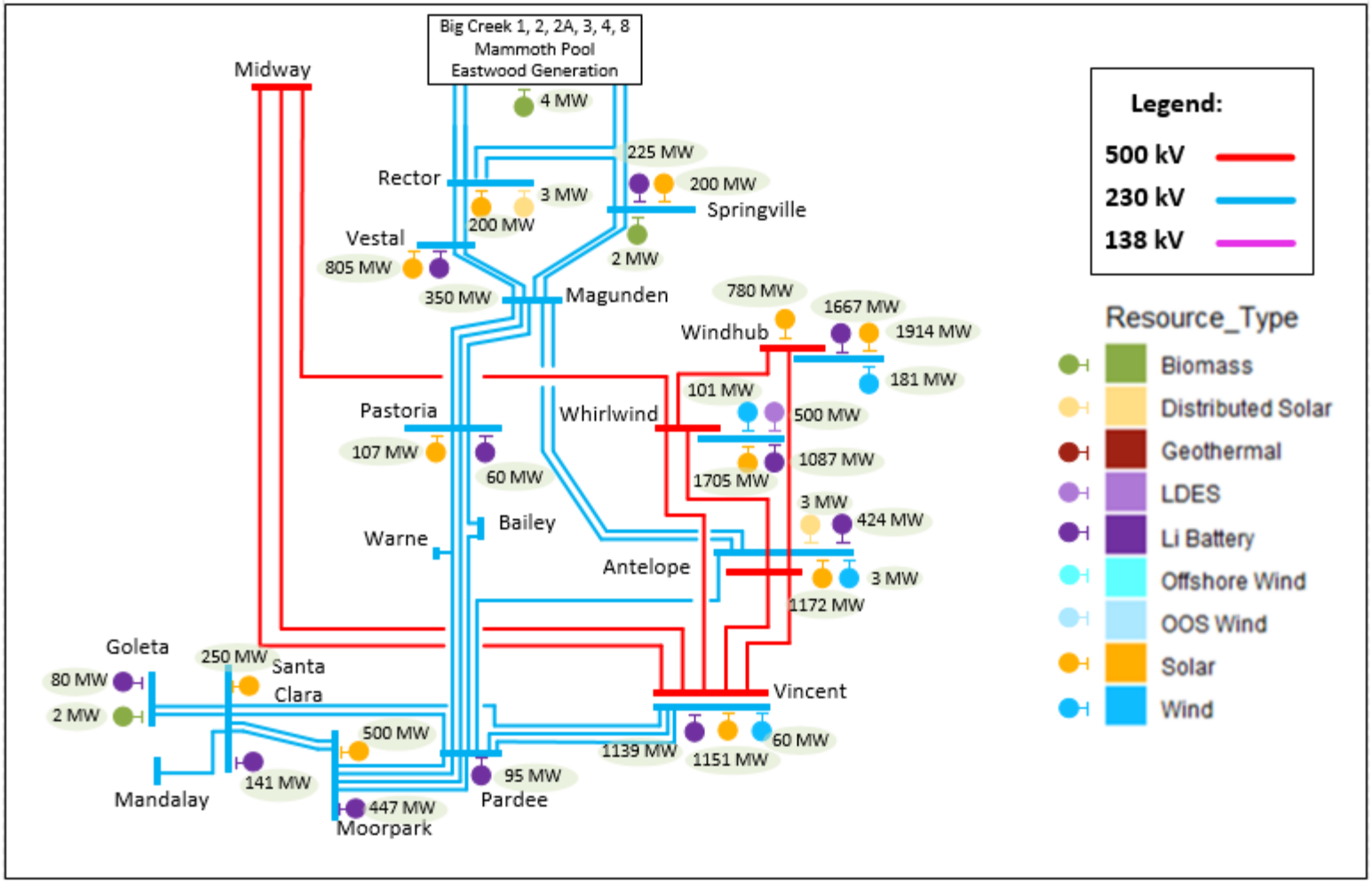
* = As back-up locations only – main delivery point included as GONDIPPDC_ITC (GONIPP) and part of the CPUC portfolio

SCE Northern Interconnection Area

SCE Northern Interconnection Area

Resource Type	Base Portfolio		
	FCDS (MW)	EO (MW)	Total (MW)
Solar	3,763	5,022	8,784
Wind – In State	345	0	345
Wind – Out-of-State (Existing TX)	0	0	0
Wind – Out-of-State (New TX)	0	0	0
Wind - Offshore	0	0	0
Li Battery	5,714	0	5,714
Geothermal	0	0	0
Long Duration Energy Storage (LDES)	500	0	500
Biomass/Biogass	8	0	8
Distributed Solar	6	0	6
Total	**10,336**	**5,022**	**15,358**

Base Portfolio: SCE Northern Area



FCDS
10,336
MW

Total
15,358
MW

On-peak SCE Northern area deliverability constraints

Overloaded Facility	Contingency	More Limiting Condition	Loading (%)	
			Base	Sensitivity
Windhub #1 or #2 500/230 kV transformer*	Windhub #1 or #2 500/230 kV transformer	HSN	140%	N/A
Windhub #3 or #4 500/230 kV transformer*	Windhub #3 or #4 500/230 kV transformer	HSN	115%	N/A
Big Creek 3 - Rector 230 kV Circuit 2	Big Creek 1 - Rector 230 kV Circuit 1 and Rector - Big Creek 3 230 kV Circuit 1	HSN	122%	N/A

* The loading on the transformers depends on which Windhub 230 kV bus, Bus A or Bus B, generic portfolio resources are mapped to.

On-peak Windhub #1 & #2 500/230 kV transformers constraint summary

Affected transmission zones		Tehachapi area – Windhub 230 kV Bus A	
		Base	**Sensitivity**
Portfolio MW behind constraint		1163 MW	N/A
Portfolio battery storage MW behind constraint		1033 MW	
Deliverable portfolio MW w/o mitigation		530 MW	
Total undeliverable baseline and portfolio MW		633 MW	
Mitigation Options	RAS	Planned Windhub CRAS	
	Reduce generic battery storage (MW)	Not needed	
	Transmission upgrade including cost	Not Needed	
Recommended Mitigation		Planned Windhub CRAS	

Affected interties	N/A	
	Base	**Sensitivity**
MIC expansion request MW behind constraint	N/A	N/A
Deliverable MIC expansion request MW		

On-peak Windhub #3 & #4 500/230 kV transformers constraint summary

Affected transmission zones		Tehachapi area – Windhub 230 kV Bus B	
		Base	**Sensitivity**
Portfolio MW behind the constraint		1603 MW	N/A
Portfolio battery storage MW behind the constraint		761 MW	
Deliverable portfolio MW w/o mitigation		1395 MW	
Total undeliverable baseline and portfolio MW		208 MW	
Mitigation Options	RAS	Planned Windhub CRAS	
	Re-locate portfolio battery storage (MW)	Not needed	
	Transmission upgrade including cost	Not Needed	
Recommended Mitigation		Planned Windhub CRAS	

Affected interties	N/A	
	Base	**Sensitivity**
MIC expansion request MW behind constraint	N/A	N/A
Deliverable MIC expansion request MW		

On-peak North of Magunden constraint summary

Affected transmission zones		North of Magunden area	
		Base	**Sensitivity**
Portfolio MW behind the constraint		289 MW	N/A
Portfolio battery storage MW behind the constraint		233 MW	
Deliverable portfolio MW w/o mitigation		0 MW	
Total undeliverable baseline and portfolio MW		443 MW	
Mitigation Options	RAS	Existing BCV/SJV RAS	
	Re-locate portfolio battery storage (MW)	Not needed	
	Transmission upgrade including cost	Not Needed	
Recommended Mitigation		Existing BCV/SJV RAS	

Affected interties	N/A	
	Base	**Sensitivity**
MIC expansion request MW behind constraint	N/A	N/A
Deliverable MIC expansion request MW		

On-peak Windhub area export constraint

- The deliverability of FC resources interconnecting at Windhub Substation is limited by the simultaneous or overlapping outage of Antelope – Windhub 500kV Line and Whirlwind – Windhub 500 kV Line without time for system adjustments, which results in islanding of the Windhub System and the consequential loss of 3000 to 6000 MW of generation.
- The loss of one Windhub 500 kV line results in exposing the entire ISO and surrounding areas to voltage collapse-driven cascading outages for loss of the second Windhub 500 kV line in the Cluster 13 and Cluster 14 studies. This results in the need to immediately curtail up to 5000 MW of generation, or cascading outages if the second contingency occurs before the generation can be curtailed.
- An area deliverability constraint has been enforced to address this voltage collapse and loss of resource issue.
- The constraint was exceeded in the base portfolio under the HSN condition.
- The ISO is currently re-evaluating the maximum generation amount that can be islanded at Windhub Substation before cascading occurs and based on that information identify if a policy-driven transmission mitigation is needed.

Off-peak SCE Northern area deliverability constraints

Overloaded Facility	Contingency	Loading (%)	
		Base	Sensitivity
Windhub #1 or #2 500/230 kV transformer*	Windhub #1 or #2 500/230 kV transformer	119%	N/A
Whirlwind #1 or #3 500/230 kV transformer	Whirlwind #1, #3 or #4 500/230 kV transformer	101%	N/A
Midway–Whirlwind 500 kV (PG&E)	Base Case	112%	N/A
Midway–Whirlwind 500 kV (SCE)	Vincent–Midway #1 and #2 500 kV lines**	128%	N/A

* Depending on which Windhub 230 kV bus, Bus A or Bus B, generic portfolio resources are mapped to, could overload Banks #3 and #4 500/230 kV transformers.

** Operational always credible common corridor N-2 that is under review.

Off-peak Windhub #1 & #2 500/230 kV transformers constraint summary

Affected renewable transmission zones		Tehachapi area – Windhub 230 kV Bus A	
		Base	**Sensitivity**
Portfolio solar and wind MW behind the constraint		1216 MW	N/A
Energy storage portfolio MW behind the constraint		1033 MW	
Renewable curtailment without mitigation (MW)		371 MW	
Mitigation Options:	Portfolio ES (in charging mode) (MW)*	305 MW	
	RAS	Planned Windhub CRAS	
	Transmission upgrades	Not needed	
Recommended Mitigation		Planned Windhub CRAS	

* The Portfolio energy storage (in charging mode) amount is the quantity needed to mitigate the constraint after baseline battery storage is fully utilized.

Off-peak Whirlwind 500/230 kV transformers constraint summary

Affected renewable transmission zones		Tehachapi area – Whirlwind 230 kV	
		Base	**Sensitivity**
Portfolio solar and wind MW behind the constraint		1579 MW	N/A
Energy storage portfolio MW behind the constraint		1635 MW	
Renewable curtailment without mitigation (MW)		103 MW	
Mitigation Options:	Portfolio ES (in charging mode) (MW)*	36 MW	
	RAS	Planned Whirlwind CRAS	
	Transmission upgrades	Not needed	
Recommended Mitigation		Planned Whirlwind CRAS	

* The Portfolio energy storage (in charging mode) amount is the quantity needed to mitigate the constraint after baseline battery storage is fully utilized.

Off-peak Midway–Whirlwind 500 kV line constraint summary

Affected renewable transmission zones		All of Southern California	
		Base	**Sensitivity**
Portfolio solar and wind MW behind the constraint		27047 MW	N/A
Energy storage portfolio MW behind the constraint		22582 MW	
Renewable curtailment without mitigation (MW)		1042 MW	
Mitigation Options:	Portfolio ES (in charging mode) (MW)*	Not needed	
	RAS	Not applicable for P0 overload	
	Transmission upgrades	Bypass the series capacitor of the Midway–Whirlwind 500 kV line and increase the rating on SCE's segment by eliminating the line ground clearance restriction	
Recommended Mitigation		Reduce thermal generation output and dispatch baseline storage in charging mode	

* The Portfolio energy storage (in charging mode) amount is the quantity needed to mitigate the constraint after baseline battery storage is fully utilized.

SCE Northern Area area results summary

- All portfolio resources in the SCE Northern area, except those interconnected at Windhub Substation, are deliverable with existing RAS or planned CRAS.

- The ISO is currently re-evaluating the maximum generation amount that can be islanded at Windhub Substation before cascading occurs and based on that information identify if a policy-driven transmission mitigation is needed.

- Renewable curtailment at Windhub and Whirlwind Substations in the Off-Peak Condition can be avoided by relying on planned CRAS.

- The thermal overload of Midway–Whirlwind 500 kV line can be avoided by reducing thermal generation output and dispatching baseline storage in charging mode.

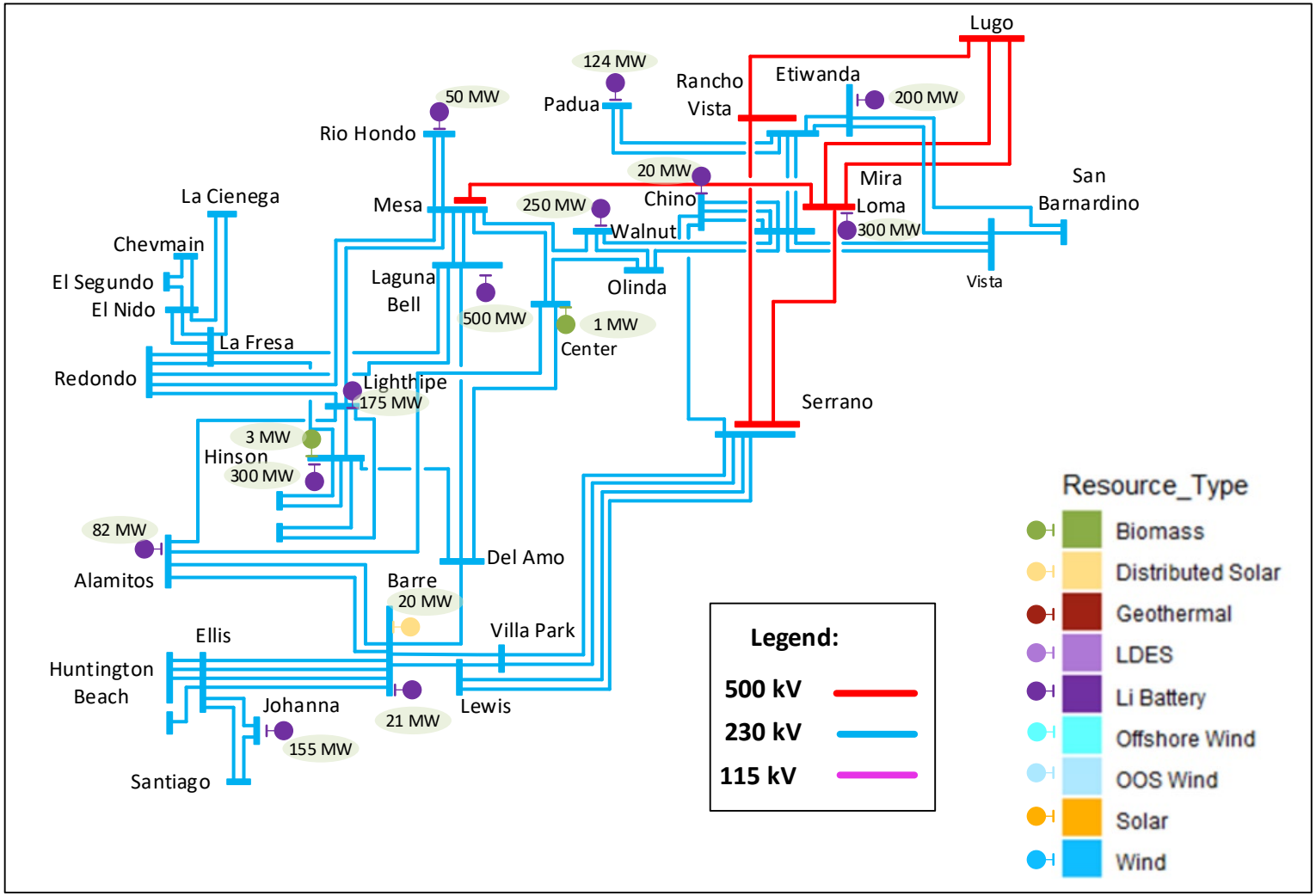
    - Transmission upgrades could also be considered as a mitigation option, but they would need to provide economic benefits.

SCE Metro Interconnection Area

SCE Metro Interconnection Area

Resource Type	Base Portfolio		
	FCDS (MW)	EO (MW)	Total (MW)
Solar	0	0	0
Wind – In State	0	0	0
Wind – Out-of-State (Existing TX)	0	0	0
Wind – Out-of-State (New TX)	0	0	0
Wind - Offshore	0	0	0
Li Battery	2,177	0	2,177
Geothermal	0	0	0
Long Duration Energy Storage (LDES)	0	0	0
Biomass/Biogass	4	0	4
Distributed Solar	20	0	20
Total	**2,201**	**0**	**2,201**

Base Portfolio: SCE Metro Area



FCDS
2,201
MW

Total
2,201
MW

SCE Metro Interconnection Area

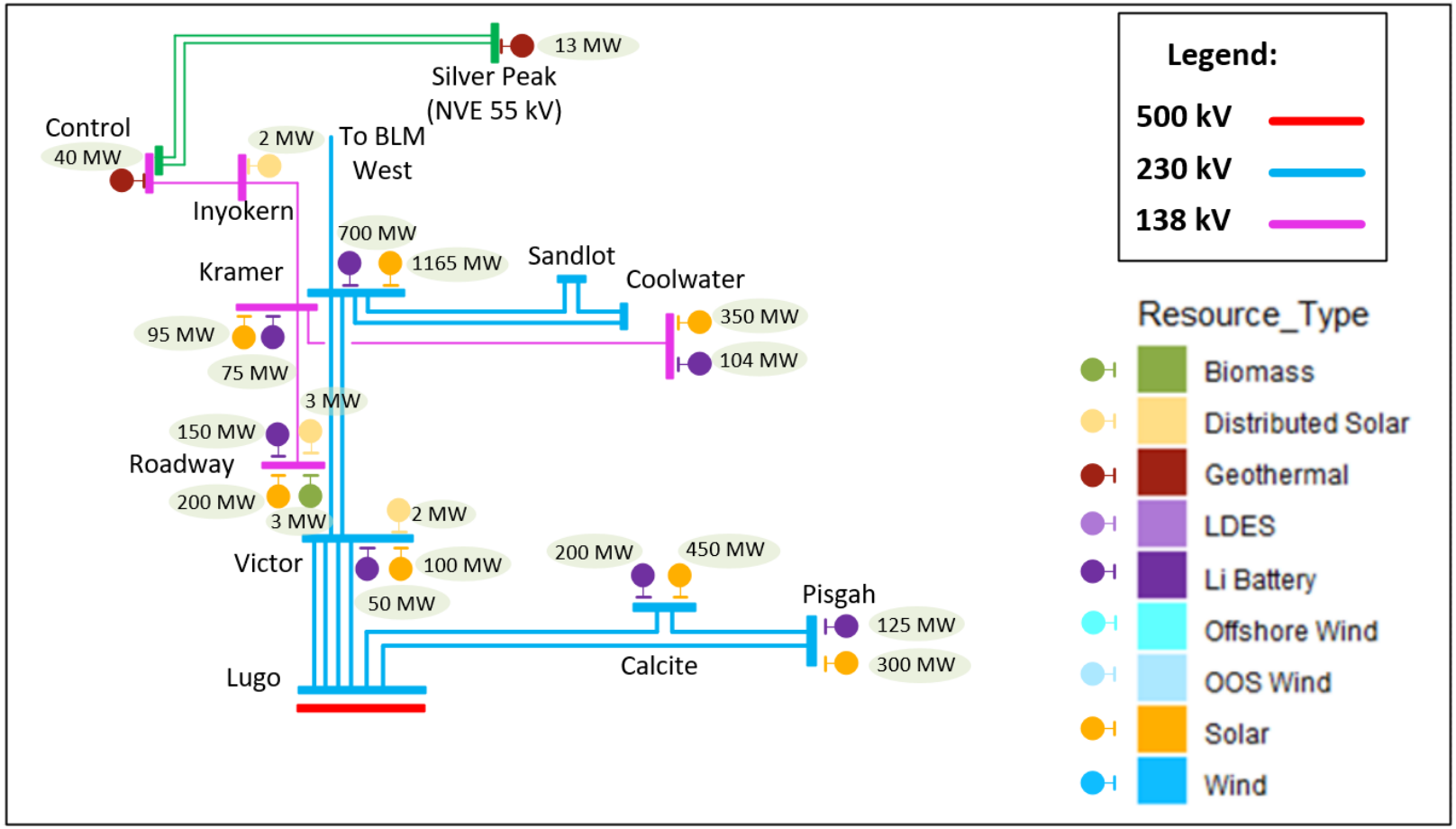
- No issues identified in the SCE Metro area

SCE North of Lugo (NOL) Interconnection Area

SCE North of Lugo Interconnection Area

Resource Type	Base Portfolio		
	FCDS (MW)	EO (MW)	Total (MW)
Solar	1,310	1,350	2,660
Wind – In State	0	0	0
Wind – Out-of-State (Existing TX)	0	0	0
Wind – Out-of-State (New TX)	0	0	0
Wind - Offshore	0	0	0
Li Battery	1,404	0	1,404
Geothermal	53	0	53
Long Duration Energy Storage (LDES)	0	0	0
Biomass/Biogass	3	0	3
Distributed Solar	7	0	7
Total	**2,777**	**1,350**	**4,127**

Base Portfolio: SCE North of Lugo Area



FCDS
2,777
MW

Total
4,127
MW

On-peak SCE North of Lugo (NOL) area constraints

Overloaded Facility	Contingency	Base Portfolio Overloading (%)	
		HSN	SSN
Coolwater 230/115 kV Tr.	Kramer–Coolwater & Kramer–Sandlot 230 kV lines	139.5%	162.4
	Kramer–Coolwater & Sandlot–Coolwater 230 kV lines	128.6%	120.3%
Tortilla–Coolwater 115 kV	Kramer–Coolwater & Kramer–Sandlot 230 kV lines	--	106.9%
Coolwater–Kramer 115 kV		--	106.9%
Control–Inyokern Tap 115 kV	Control–Coso–Inyokern 115 kV line	109.2%	106.7%
Control–Silver Peak C 55kV	Control–Silver Peak A 55kV line	140.6%	146.7%
Control–Silver Peak A 55kV	Control–Silver Peak C 55kV line	133.8%	138.7%
Silver Peak PST	Base Case	305.0%	305.0%
Calcite–Lugo 230 kV	Pisgah–Lugo 230 kV	117.3%	100.6%
	Lugo–Victorville 500 kV	105.4%	91.1%
	Eldorado–Lugo 500 kV	102.1%	--

On-peak Coolwater area 230/115 kV Tr. & 115 kV lines constraint summary

Affected transmission zones		NOL Area	
		Base (SSN)	**Sensitivity**
Portfolio MW behind constraint		1,186 MW	N/A
Portfolio battery storage MW behind constraint		376 MW	
Deliverable portfolio MW w/o mitigation		747 MW	
Total undeliverable baseline and portfolio MW		439 MW	
Mitigation Options	RAS	Expanded Mohave Desert RAS	
	Reduce generic battery storage (MW)	Not needed	
	Transmission upgrade including cost	Not needed	
Recommended Mitigation		Expanded Mohave Desert RAS	

Affected interties	N/A	
	Base	**Sensitivity**
MIC expansion request MW behind constraint	N/A	N/A
Deliverable MIC expansion request MW		

On-peak Control–Inyokern Tap 115 kV constraint summary

Affected transmission zones		NOL Control area	
		Base (HSN)	Sensitivity
Portfolio MW behind the constraint		54 MW	N/A
Portfolio battery storage MW behind the constraint		0 MW	
Deliverable portfolio MW w/o mitigation		54 MW	
Total undeliverable baseline, portfolio and MIC request MW		26 MW	
Mitigation Options	RAS	Bishop RAS	
	Re-locate portfolio battery storage (MW)	N/A	
	Transmission upgrade including cost	Not needed	
Recommended Mitigation		Bishop RAS	

Affected interties	SILVERPK_BG	
	Base	**Sensitivity**
MIC expansion request MW behind constraint	39 MW	N/A
Deliverable MIC expansion request MW (with mitigation)	39 MW	

Control–Silver Peak 55kV (Path 52, SILVERPK_BG) constraint summary

Affected transmission zones		Imports over Path 52 (SILVERPK_BG)*	
		Base (HSN/SSN)	Sensitivity
Portfolio MW behind the constraint		13 MW	N/A
Portfolio battery storage MW behind the constraint		0 MW	
Deliverable portfolio MW w/o mitigation		13 MW	
Total undeliverable baseline, portfolio and MIC request MW		35 MW	
Mitigation Options	RAS	N/A	
	Re-locate portfolio battery storage (MW)	N/A	
	Transmission upgrade including cost	Not needed	
Recommended Mitigation		Reduce requested MIC expansion to 4 MW	

Affected interties	SILVERPK_BG	
	Base	**Sensitivity**
MIC expansion request MW behind constraint	39 MW	N/A
Deliverable MIC expansion request MW	4 MW	

* The SILVERPK_BG intertie capacity is limited by the 17 MW rating of Path 52 and 17 MVA rating of Silver Peak PST

Calcite–Lugo 230 kV constraint summary

Affected transmission zones		Calcite and Pisgah Substations	
		Base (HSN)	Sensitivity
Portfolio MW behind the constraint		625 MW	N/A
Portfolio battery storage MW behind the constraint		325 MW	
Deliverable portfolio MW w/o mitigation		522 MW	
Total undeliverable baseline and portfolio MW		103 MW	
Mitigation Options	RAS	Planned Calcite RAS	
	Re-locate portfolio battery storage (MW)	N/A	
	Transmission upgrade including cost	Not needed	
Recommended Mitigation		Planned Calcite RAS	

Affected interties	None	
	Base	**Sensitivity**
MIC expansion request MW behind constraint	N/A	N/A
Deliverable MIC expansion request MW	N/A	

Off-peak SCE NOL area deliverability constraints

Overloaded Facility	Contingency	Loading (%)	
		Base	Sensitivity
Coolwater–Kramer 115 kV	Kramer–Coolwater & Kramer–Sandlot 230 kV (Loading results are based on DC solution as the AC solution diverged)*	152.9%	N/A
Coolwater 230/115 kV Tr.		183.3%	N/A
Tortilla–Coolwater 115 kV		137.8%	N/A
Kramer 230/115 kV #1 & #2 Tr.		129.6%	N/A
Tortilla–Kramer 115 kV		133.4%	N/A
Kramer–Sandlot 230 kV	Kramer–Coolwater 230 kV	120.7%	N/A
Kramer–Coolwater 230 kV	Kramer–Sandlot 230 kV	112.7%	N/A
Kramer–Victor #1 and #2 230 kV	New Kramer–Victor #3 and #4 230 kV	117.4%	N/A
Calcite–Lugo 230 kV	Pisgah–Lugo 230 kV	152.8%	N/A
	Eldorado–Lugo 500 kV	133.1%	N/A
	Base case	125.8%	N/A
Pisgah–Lugo 230 kV	Calcite–Lugo 230 kV	114.2%	N/A
Calcite–Pisgah 230 kV		121.2%	N/A

* The Kramer–Coolwater & Sandlot–Coolwater 230 kV line outage also causes loverloads on the same lines but is not reported because it is less limiting.

Off-peak Kramer–Coolwater area 230/115 kV lines and transformers constraint summary

Affected renewable transmission zones		Kramer – Coolwater Area	
		Base	**Sensitivity**
Portfolio solar and wind MW behind the constraint		987 MW	N/A
Energy storage portfolio MW behind the constraint		617 MW	
Renewable curtailment without mitigation (MW)		456 MW	
Mitigation Options:	Portfolio ES (in charging mode) (MW)*	376 MW	
	RAS	Expanded Mojave desert RAS	
	Transmission upgrades	Not needed	
Recommended Mitigation		Expanded Mojave desert RAS	

* The Portfolio energy storage (in charging mode) amount is the amount needed to mitigate the constraint after baseline battery storage is fully utilized.

Off-peak Kramer–Victor 230 kV constraint summary

Affected renewable transmission zones		North of Victor	
		Base	**Sensitivity**
Portfolio solar and wind MW behind the constraint		1,792 MW	N/A
Energy storage portfolio MW behind the constraint		1,242 MW	
Renewable curtailment without mitigation (MW)		377 MW	
Mitigation Options:	Portfolio ES (in charging mode) (MW)*	255 MW	
	RAS	Expanded Mojave Desert RAS	
	Transmission upgrades	Not needed	
Recommended Mitigation		Expanded Mojave desert RAS	

* The Portfolio energy storage (in charging mode) amount is the amount needed to mitigate the constraint after baseline battery storage is fully utilized.

Off-peak Lugo–Calcite–Pisgah 230 kV constraint summary

Affected renewable transmission zones		Calcite and Pisgah Substations	
		Base	**Sensitivity**
Portfolio solar and wind MW behind the constraint		750 MW	N/A
Energy storage portfolio MW behind the constraint		325 MW	
Renewable curtailment without mitigation (MW)		200 MW	
Mitigation Options:	Portfolio ES (in charging mode) (MW)*	200 MW	
	RAS	Planned Calcite RAS	
	Transmission upgrades	Not needed	
Recommended Mitigation		Planned Calcite RAS	

* The Portfolio energy storage (in charging mode) amount is the amount needed to mitigate the constraint after baseline battery storage is fully utilized.

NOL area results summary

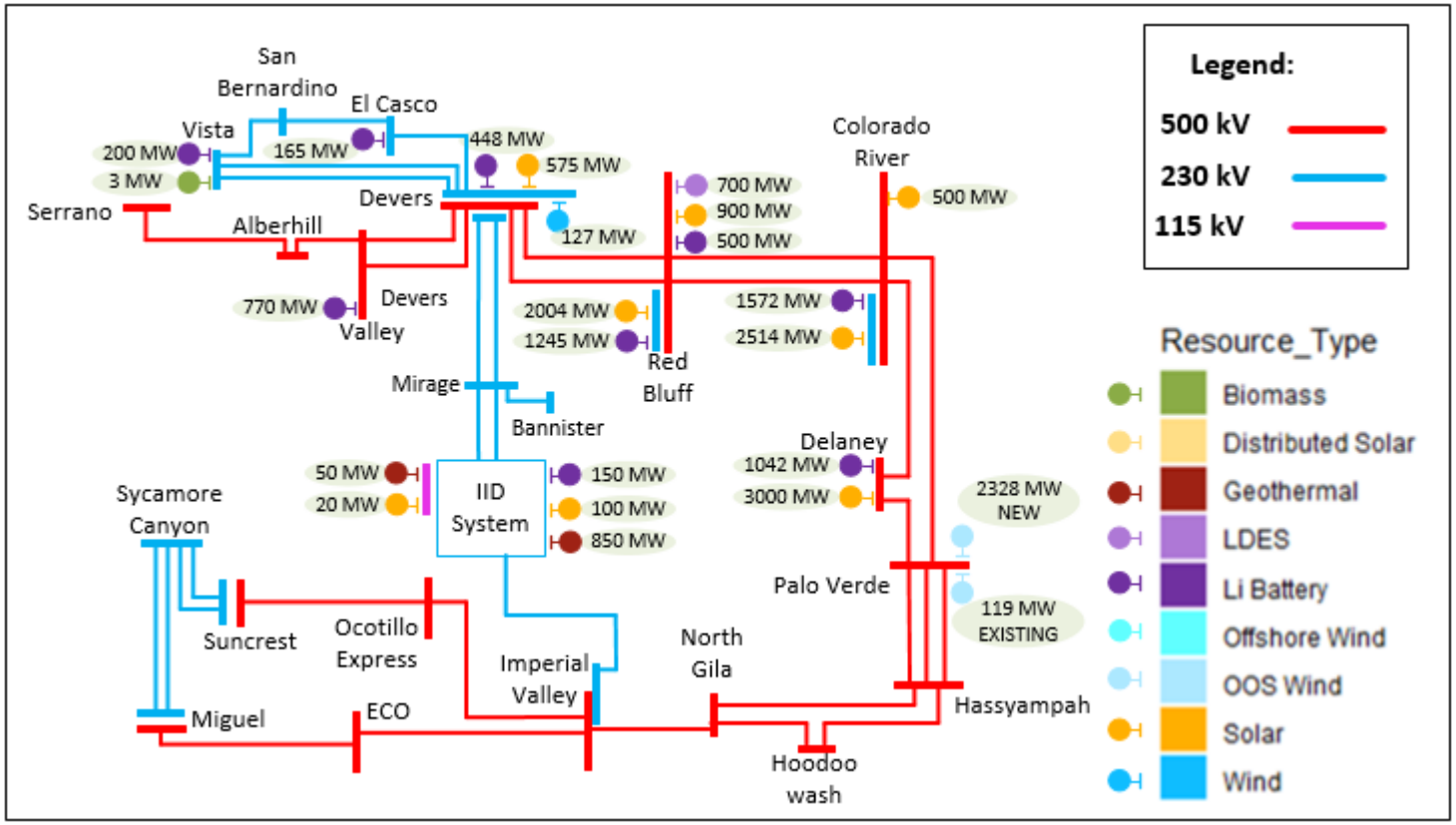
- All portfolio resources in the NOL area are deliverable with existing or expanded RAS
- Out of the 39 MW of California Community Power's SILVERPK_BG MIC expansion request, only about 4 MW is deliverable

SCE Eastern Interconnection Area

SCE Eastern Interconnection Area

Resource Type	Base Portfolio		
	FCDS (MW)	EO (MW)	Total (MW)
Solar	6,092	0	6,092
Wind – In State	107	20	127
Wind – Out-of-State (Existing TX)	119	0	119
Wind – Out-of-State (New TX)	2,328	0	2,328
Wind - Offshore	0	0	0
Li Battery	6,092	0	6,092
Geothermal	900	0	900
Long Duration Energy Storage (LDES)	700	0	700
Biomass/Biogass	3	0	3
Distributed Solar	0	0	0
Total	**13,198**	**6,684**	**19,881**

Base Portfolio: SCE Eastern Area



FCDS
13,198 MW

Total
19,881 MW

On-peak SCE Eastern area deliverability constraints

Overloaded Facility	Contingency	More Limiting Condition	Loading (%)	
			Base	Sensitivity
Colorado River 500/230 kV Transformer No.1	Colorado River 500/230 kV Transformer No.2	HSN	122	N/A
Colorado River 500/230 kV Transformer No.2	Colorado River 500/230 kV Transformer No.1	HSN	122	N/A

On-peak Colorado River 500/230 kV constraint summary

Affected transmission zones		Colorado River	
		Base	**Sensitivity**
Portfolio MW behind the constraint		2530 MW	N/A
Portfolio battery storage MW behind the constraint		1499 MW	
Deliverable portfolio MW w/o mitigation		2052 MW	
Total undeliverable baseline and portfolio MW		478 MW	
Mitigation Options	RAS	West of Colorado River CRAS	
	Re-locate portfolio battery storage (MW)	Not needed	
	Transmission upgrade including cost	Not needed	
Recommended Mitigation		West of Colorado River CRAS	

Affected interties	N/A	
	Base	**Sensitivity**
MIC expansion request* MW behind constraint	N/A	N/A
Deliverable MIC expansion request MW		

**The BLYTHE_ITC (BLYTHE161) MIC expansion request was not found to be behind any SCE Eastern area deliverability constraints with the 2035 Base Portfolio*

Off-peak SCE Eastern area deliverability constraints

Overloaded Facility	Contingency	Loading (%)	
		Base	Sensitivity
Colorado River 500/230 kV Transformer No.1	Colorado River 500/230 kV Transformer No.2	183	N/A
Colorado River 500/230 kV Transformer No.2	Colorado River 500/230 kV Transformer No.1	183	N/A
Red Bluff 500/230 kV Transformer No.1	Red Bluff 500/230 kV Transformer No.2	147	N/A
Red Bluff 500/230 kV Transformer No.2	Red Bluff 500/230 kV Transformer No.1	147	N/A
Colorado River 500/230 kV Transformer No.1	Base Case	109	N/A
Colorado River 500/230 kV Transformer No.2	Base Case	109	N/A

Off-peak Colorado River 500/230 kV constraint summary

Affected renewable transmission zones		Colorado River	
		Base	**Sensitivity**
Portfolio solar and wind MW behind the constraint		2262 MW	N/A
Energy storage portfolio MW behind the constraint		1563 MW	
Renewable curtailment without mitigation (MW)		1501 MW	
Mitigation Options:	Portfolio ES (in charging mode) (MW)*	1135 MW	
	RAS	West of Colorado River CRAS	
	Transmission upgrades	Not needed	
Recommended Mitigation		West of Colorado River CRAS and/or batteries in charging mode	

* The Portfolio energy storage (in charging mode) amount is the quantity needed to mitigate the constraint after baseline battery storage is fully utilized.

Off-peak Red Bluff 500/230 kV constraint summary

Affected renewable transmission zones		Red Bluff	
		Base	**Sensitivity**
Portfolio solar and wind MW behind the constraint		2168 MW	N/A
Energy storage portfolio MW behind the constraint		1280 MW	
Renewable curtailment without mitigation (MW)		906 MW	
Mitigation Options:	Portfolio ES (in charging mode) (MW)*	674 MW	
	RAS	West of Colorado River CRAS	
	Transmission upgrades	Not needed	
Recommended Mitigation		West of Colorado River CRAS and/or batteries in charging mode	

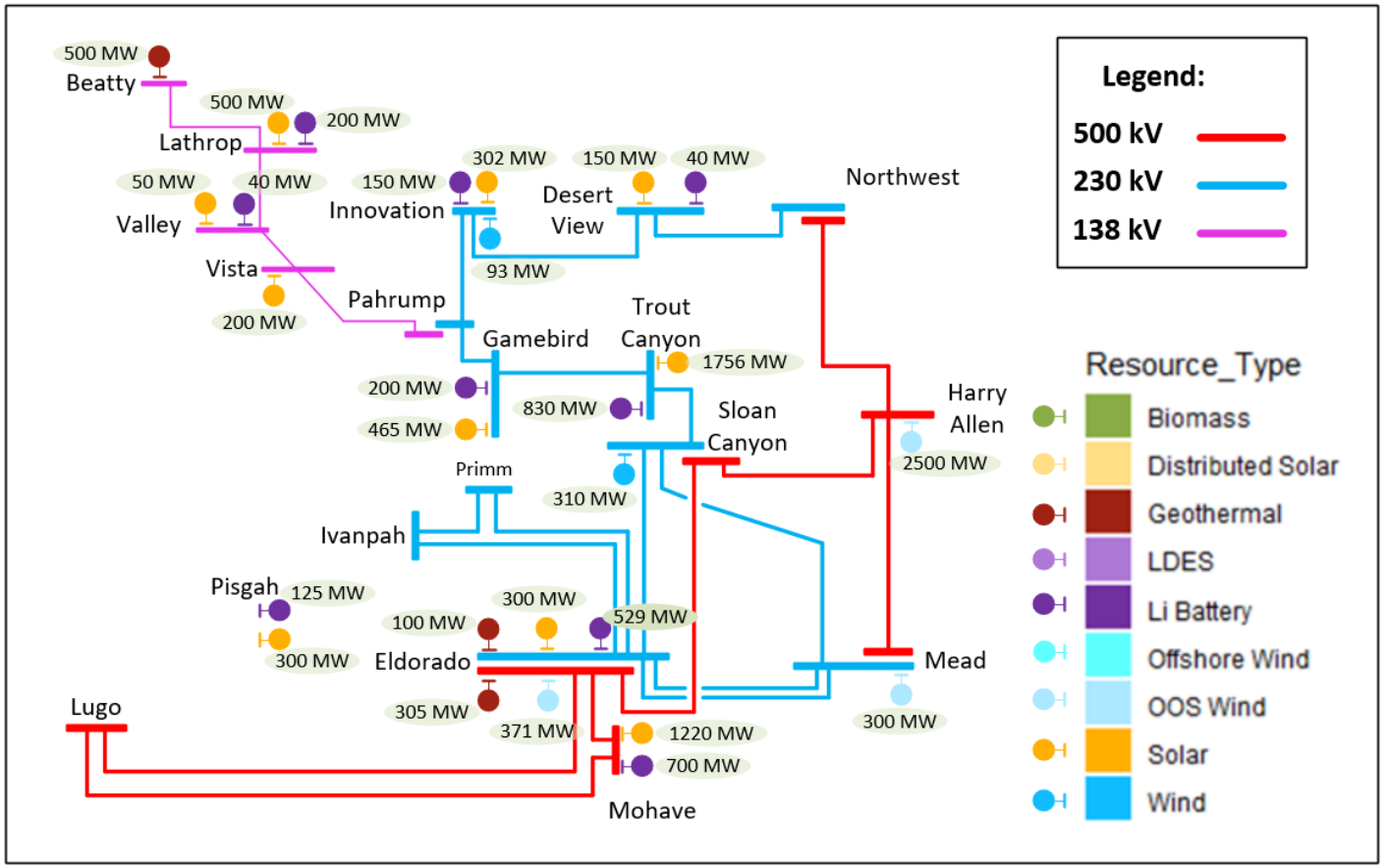
* The Portfolio energy storage (in charging mode) amount is the quantity needed to mitigate the constraint after baseline battery storage is fully utilized.

East of Pisgah Interconnection Area

East of Pisgah Interconnection Area

Resource Type	Base Portfolio		
	FCDS (MW)	EO (MW)	Total (MW)
Solar	2,157	2,786	4,943
Wind – In State	403	0	403
Wind – Out-of-State (Existing TX)	571	100	671
Wind – Out-of-State (New TX)	2,500	0	2,500
Wind - Offshore	0	0	0
Li Battery	2,689	0	2,689
Geothermal	905	0	905
Long Duration Energy Storage (LDES)	0	0	0
Biomass/Biogass	0	0	0
Distributed Solar	0	0	0
Total	**9,225**	**2,886**	**12,111**

Base Portfolio: East of Pisgah Area



FCDS
9,225
MW

Total
12,111
MW

On-peak East of Pisgah area deliverability constraints

Overloaded Facility	Contingency	More Limiting Condition	Loading (%)	
			Base	Sen.
Sloan Canyon-Eldorado 500kV Line	Base Case	HSN	100.4%	N/A
VEA PST-IS Tap 138kV Line	Trout Canyon – Sloan Canyon 500kV Nos. 1&2 lines	HSN	127.4%	
IS Tap – Northwest 138kV Line	Trout Canyon – Sloan Canyon 500kV Nos. 1&2 lines	HSN	118.7%	
Sandy – Amargosa 138kV Line	Trout Canyon – Sloan Canyon 500kV Nos. 1&2 lines	HSN	117.1%	
Gamebird – Sandy 138kV Line	Trout Canyon – Sloan Canyon 500kV Nos. 1&2 lines	HSN	102.3%	
Eldorado – McCullough 500kV Line	Eldorado – Lugo 500kV line	HSN	110.4%	

On-peak Sloan Canyon – Eldorado 500kV constraint summary

Affected transmission zones		East of Lugo area	
		Base	**Sensitivity**
Portfolio MW behind constraint		7,509 MW	N/A
Portfolio battery storage MW behind constraint		2,186 MW	
Deliverable portfolio MW w/o mitigation		7,509 MW	
Total undeliverable baseline and portfolio MW		0 MW	
Mitigation Options	RAS	N/A	
	Reduce generic battery storage (MW)	Not needed	
	Transmission upgrade including cost	Not Needed	
Recommended Mitigation		Curtail MIC expansion request	

Affected interties	ELDORADO_ITC, MEAD_ITC, SILVERPK_BG	
	Base	**Sensitivity**
MIC expansion request MW behind constraint	252	N/A
Deliverable MIC expansion request MW	53	

On-peak VEA-GLW constraint summary

Affected transmission zones		GLW and VEA area	
		Base	**Sensitivity**
Portfolio MW behind constraint		3,412 MW	N/A
Portfolio battery storage MW behind constraint		1,417 MW	
Deliverable portfolio MW w/o mitigation		3,115 MW	
Total undeliverable baseline and portfolio MW		297 MW	
Mitigation Options	RAS	New Trout Canyon RAS	
	Reduce generic battery storage (MW)	Not needed	
	Transmission upgrade including cost	Not Needed	
Recommended Mitigation		New Trout Canyon RAS	

Affected interties	N/A	
	Base	**Sensitivity**
MIC expansion request MW behind constraint	N/A	N/A
Deliverable MIC expansion request MW		

On-peak Eldorado – McCullough 500kV constraint summary

Affected transmission zones		East of Lugo area	
		Base	**Sensitivity**
Portfolio MW behind constraint		9,074 MW	N/A
Portfolio battery storage MW behind constraint		3,131 MW	
Deliverable portfolio MW w/o mitigation		8,038 MW	
Total undeliverable baseline and portfolio MW		1,036 MW	
Mitigation Options	RAS	Lugo – Victorville RAS	
	Reduce generic battery storage (MW)	Not needed	
	Transmission upgrade including cost	Not Needed	
Recommended Mitigation		Lugo – Victorville RAS	

Affected interties	ELDORADO_ITC, MEAD_ITC, BLYTHE_ITC, SILVERPK_BG, IPPDCADLN_ITC	
	Base	**Sensitivity**
MIC expansion request MW behind constraint	312	N/A
Deliverable MIC expansion request MW	0	

Off-peak East of Pisgah area deliverability constraints

Overloaded Facility	Contingency	Loading (%)	
		Base	Sen.
VEA PST-IS Tap 138kV Line	Trout Canyon – Sloan Canyon 500kV Nos. 1&2 lines	161.6%	N/A
	Northwest – Desert View 230kV Nos. 1&2 lines	129.3%	
	Innovation – Desert View 230kV Nos. 1&2 lines	115.9%	
IS Tap – Northwest 138kV Line	Trout Canyon – Sloan Canyon 500kV Nos. 1&2 lines	154.4%	
	Northwest – Desert View 230kV Nos. 1&2 lines	123.6%	
	Innovation – Desert View 230kV Nos. 1&2 lines	110.2%	
Sandy – Amargosa 138kV Line	Trout Canyon – Sloan Canyon 500kV Nos. 1&2 lines	159.7%	
Gamebird – Sandy 138kV Line	Trout Canyon – Sloan Canyon 500kV Nos. 1&2 lines	136.0%	
Amargosa 230/138kV Transformer	Trout Canyon – Sloan Canyon 500kV Nos. 1&2 lines	121.0%	
Innovation – VEA PST 138kV Line	Trout Canyon – Sloan Canyon 500kV Nos. 1&2 lines	108.1%	
Eldorado – McCullough 500kV Line	Eldorado – Lugo 500kV line	105.5%	

Off-peak VEA-GLW constraint summary

Affected renewable transmission zones		GLW and VEA area	
		Base	**Sensitivity**
Portfolio solar and wind MW behind the constraint		3,506 MW	N/A
Energy storage portfolio MW behind the constraint		1,466 MW	
Renewable curtailment without mitigation (MW)		1,240 MW	
Mitigation Options:	Portfolio ES (in charging mode) (MW)*	1,002 MW	
	RAS	New Trout Canyon RAS	
	Transmission upgrades	Not needed	
Recommended Mitigation		New Trout Canyon RAS and/or battery charging	

* The Portfolio energy storage (in charging mode) amount is the amount needed to mitigate the constraint after baseline battery storage is fully utilized.

Off-peak Eldorado - McCullough constraint summary

Affected renewable transmission zones		East of Pisgah area	
		Base	**Sensitivity**
Portfolio solar and wind MW behind the constraint		8,175 MW	N/A
Energy storage portfolio MW behind the constraint		2,695 MW	
Renewable curtailment without mitigation (MW)		500 MW	
Mitigation Options:	Portfolio ES (in charging mode) (MW)*	350 MW	
	RAS	Not needed	
	Transmission upgrades	Not needed	
Recommended Mitigation		Charge portfolio energy storage	

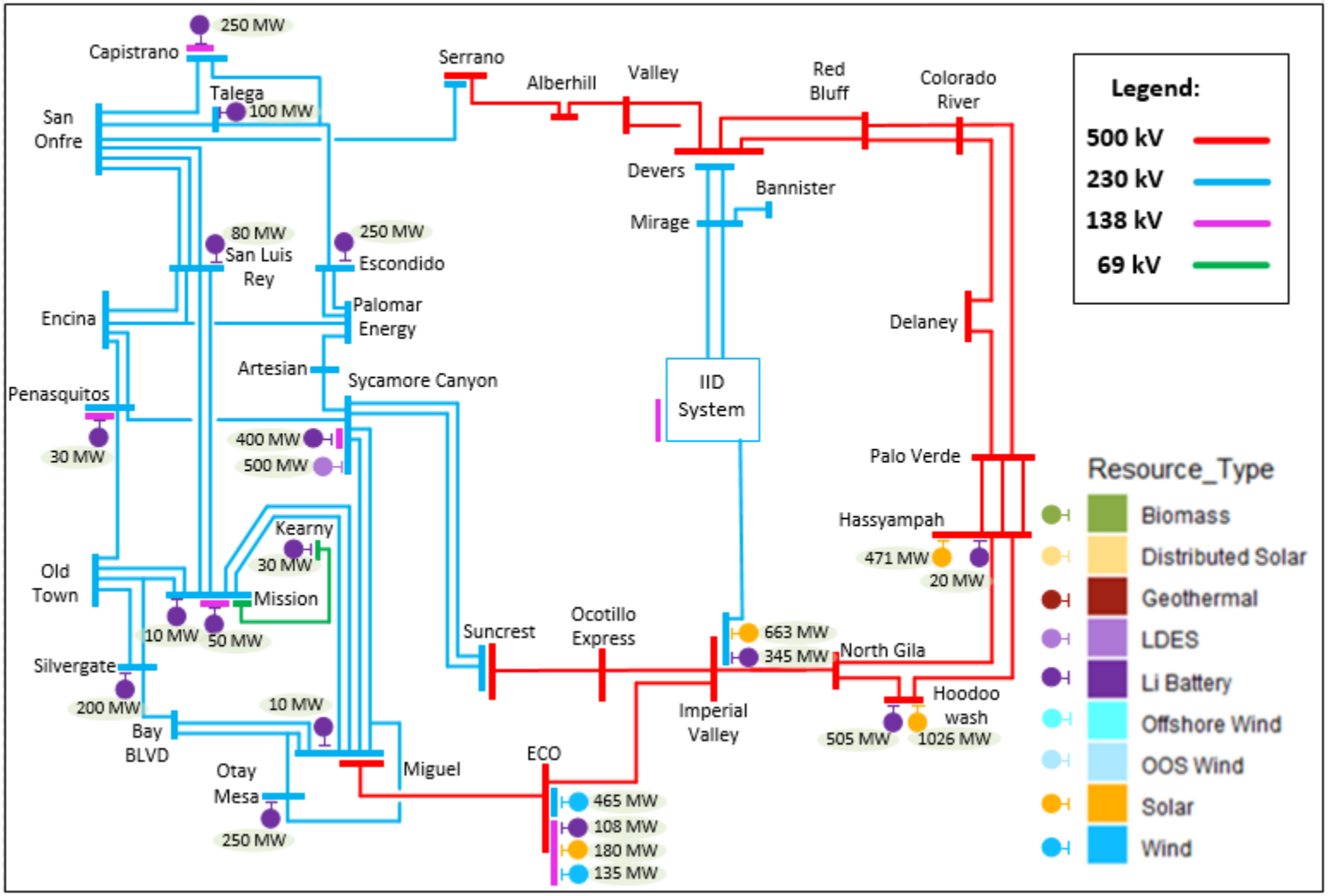
* The Portfolio energy storage (in charging mode) amount is the amount needed to mitigate the constraint after baseline battery storage is fully utilized.

SDG&E Interconnection Area

SDG&E Interconnection Area

Resource Type	Base Portfolio		
	FCDS (MW)	EO (MW)	Total (MW)
Solar	650	1,690	2,340
Wind – In State	240	360	600
Wind – Out-of-State (Existing TX)	0	0	0
Wind – Out-of-State (New TX)	0	0	0
Wind - Offshore	0	0	0
Li Battery	2,617	0	2,617
Geothermal	0	0	0
Long Duration Energy Storage (LDES)	500	0	500
Biomass/Biogass	0	0	0
Distributed Solar	0	0	0
Total	**4,007**	**2,050**	**6,057**

Base Portfolio: SDG&E Area



FCDS
4,007
MW

Total
6,057
MW

On-peak SDGE area deliverability constraints – Silvergate-Bay Boulevard

Overloaded Facility	Contingency	More Limiting Condition	Loading (%)	
			Base	Sensitivity
Silvergate-Bay Boulevard 230 kV	Miguel-Mission 230 kV #1 and #2	HSN	104%	N/A
	Imperial Valley-NSONGS 500 kV	HSN	106%	N/A

On-peak Silvergate-Bay Boulevard constraint summary

Affected transmission zones		ECO, Imperial Valley, Hoodoo Wash, SDGE Internal	
		Base	**Sensitivity**
Portfolio MW behind constraint		2133 MW	N/A
Portfolio battery storage MW behind constraint		695 MW	
Deliverable portfolio MW w/o mitigation		863 MW	
Total undeliverable baseline and portfolio MW		1270 MW	
Mitigation Options	RAS	None	
	Reduce generic battery storage (MW)	Not needed	
	Transmission upgrade including cost	Not needed	
Recommended Mitigation		Use 2 hour emergency rating	

Affected interties	N/A	
	Base	**Sensitivity**
MIC expansion request MW behind constraint	N/A	N/A
Deliverable MIC expansion request MW		

On-peak SDGE area deliverability constraints – Silvergate-Old Town

Overloaded Facility	Contingency	More Limiting Condition	Loading (%)	
			Base	Sen.
Silvergate-Old Town 230 kV	Silvergate-Mission-Old Town 230 kV	HSN	133%	N/A
	Imperial Valley-NSONGS 500 kV	HSN	105%	
	Old Town-Mission 230 kV and Silvergate-Mission-Old Town 230 kV	HSN	124%	
	Miguel-Mission 230 kV #1 and #2	HSN	105%	
Silvergate-Old Town Tap 230 kV	Silvergate-Old Town 230 kV	HSN	134%	
	Imperial Valley-NSONGS 500 kV	HSN	102%	
	Miguel-Mission 230 kV #1 and #2	HSN	102%	

On-peak Silvergate-Old Town constraint summary

Affected transmission zones		ECO, SDGE Internal	
		Base	**Sensitivity**
Portfolio MW behind constraint		1017 MW	N/A
Portfolio battery storage MW behind constraint		417 MW	
Deliverable portfolio MW w/o mitigation		586 MW	
Total undeliverable baseline and portfolio MW		431 MW	
Mitigation Options	RAS	None	
	Reduce generic battery storage (MW)	Not needed	
	Transmission upgrade including cost	Not needed	
Recommended Mitigation		Use 30 minute emergency rating	

Affected interties	N/A	
	Base	**Sensitivity**
MIC expansion request MW behind constraint	N/A	N/A
Deliverable MIC expansion request MW		

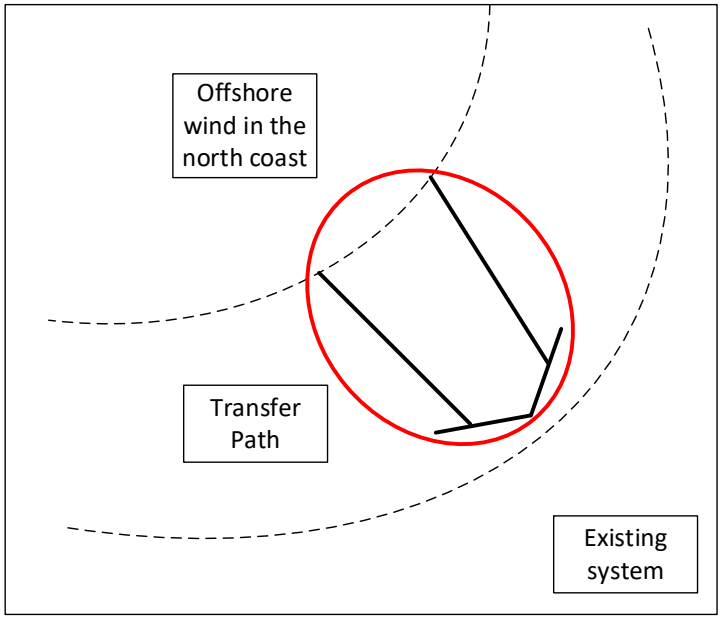
Off-peak SDG&E area deliverability constraints

- No off-peak constraints were identified for the SDG&E area

PG&E Humboldt Area Offshore Wind Interconnection Alternatives Related Results

Transmission Technology Assumptions for the Transfer Path to Interconnect OSW in the North Coast

Technology	Normal Rating Assumptions (MVA)	Emergency Rating Assumptions (MVA)
500 kV AC line to Fern Road	3,500	4,500
Onshore overhead VSC-HVDC to Collinsville Substation	3,000	3,500
Offshore sea cable VSC-HVDC to a Substation in the Bay Area	2,000	2,500

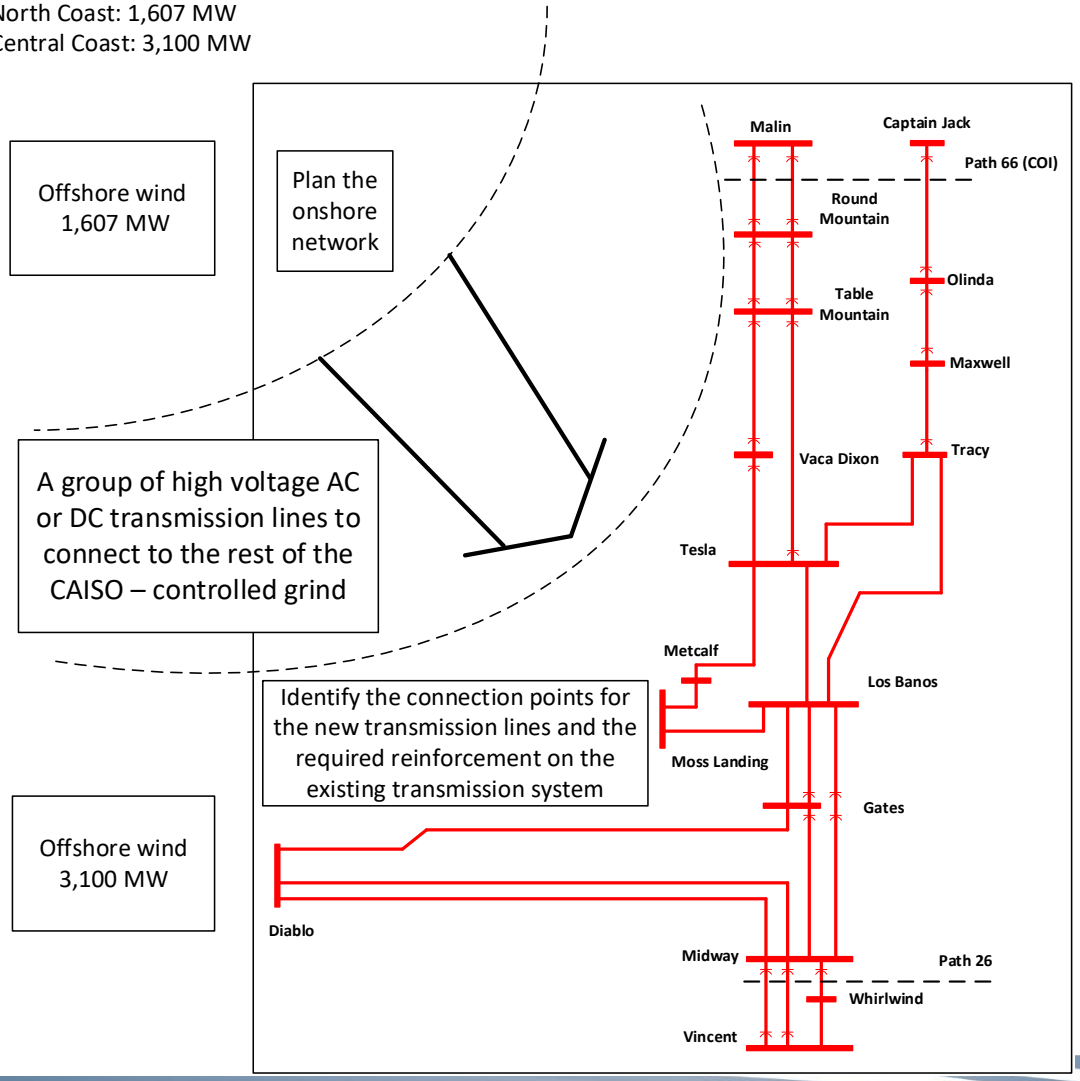


- Based on ISO Planning Standards
  - Maximum generation tripping under N-1 contingency is 1,150 MW
  - Maximum generation tripping under DCTL (N-2) is 1,400 MW

Offshore wind assumptions in the 2023-2024 Base Portfolio

Offshore Wind in the 2023-2024 TPP Base Portfolio (4,707MW):

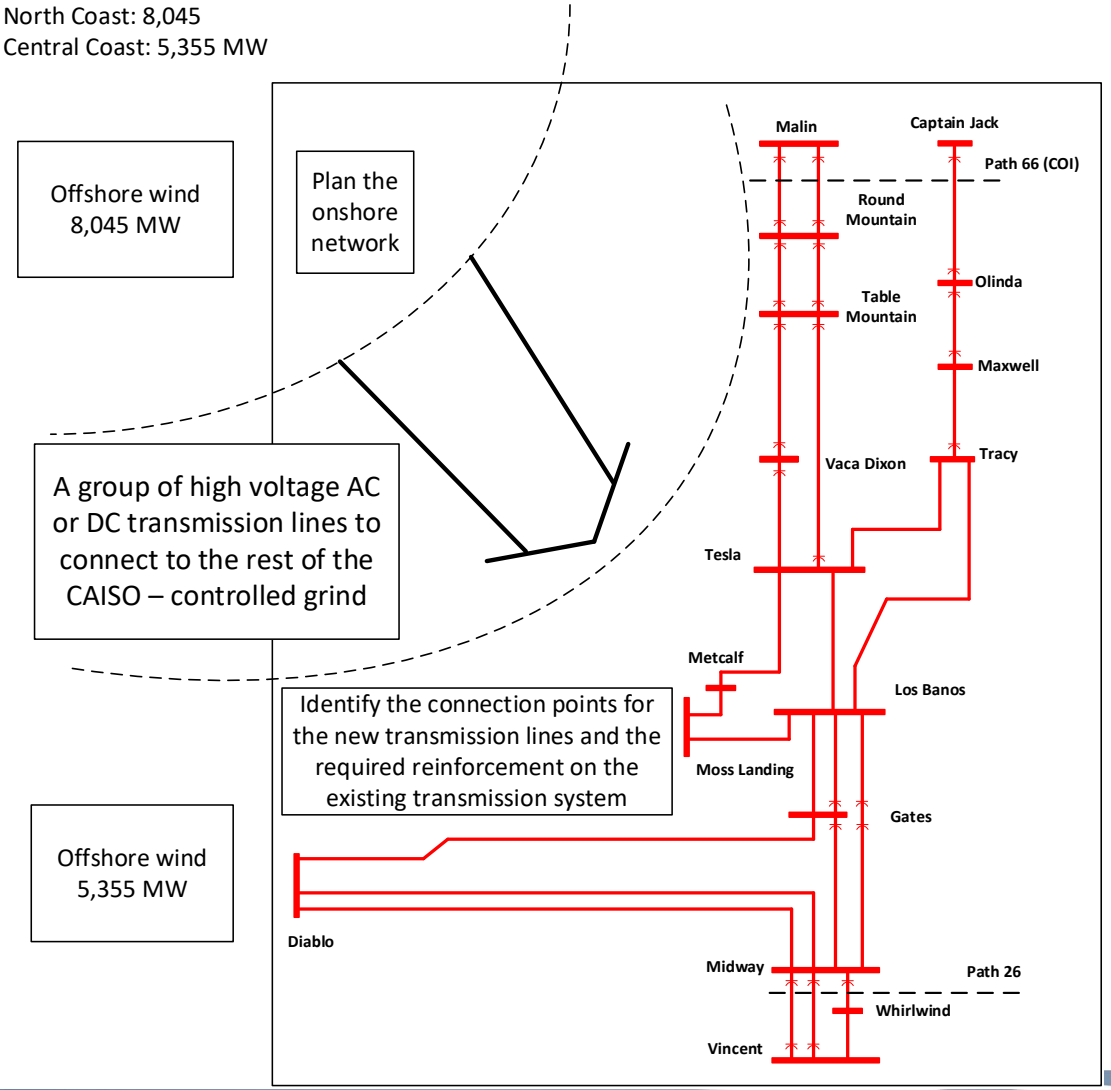
North Coast: 1,607 MW
Central Coast: 3,100 MW



Offshore wind assumptions in the 2023-2024 Sensitivity Portfolio

Offshore Wind in the 2023-2024 TPP Sensitivity Portfolio (13,400MW):

North Coast: 8,045
Central Coast: 5,355 MW



Interconnection alternatives considered

Baseline:

Concept/ Alternative	500 kV AC	Onshore HVDC	Offshore HVDC
Base_A	2 Fern RD	0	0
Base_B	0	1 Collinsville	0
Base_C	0	0	1 Moss Landing
Base_D	0	0	1 BayHub

Sensitivity:

Concept/Alternative	500 kV AC	Onshore HVDC	Offshore HVDC
Sen_A_1	1 Fern RD	1 Collinsville	1 Bayhub
Sen_A_2	1 Fern RD	1 Collinsville	1 Moss Landing
Sen_B	1 Fern RD	2 Collinsville	0
Sen_C	2 Fern RD	0	1 Bayhub

Note: For all Sensitivity cases a new 500 kV line from Fern Road to Tesla is assumed.

On-peak baseline Humboldt area offshore wind related constraints

Overloaded Facility	Contingency	Loading (%)			
		Base A	Base B	Base C	Base D
Table Mountain – Vaca Dixon 500kV line	Base Case	122%	<100%	103%	101%
	TABLE MTN-TESLA 500KV	129%	103%	106%	105%
Fern Rd – Table Mountain 500 kV line #1	Base Case	107%	<100%	<100%	<100%
	OLINDA-TRACY 500KV	106%	<100%	<100%	<100%
Fern Rd – Table Mountain 500 kV line #2	Base Case	107%	<100%	<100%	<100%
	OLINDA-TRACY 500KV	107%	<100%	<100%	<100%
Table Mountain – Tesla 500 kV line	TABLE MTN-VACA 500KV	114%	<100%	<100%	<100%
Vaca – Collinsville 500 kV line	TABLE MTN-TESLA 500KV	106%	<100%	<100%	<100%
Collinsville – PittsburgE 230kV line	Base Case	106%	112%	<100%	<100%
Collinsville – PittsburgF 230kV line	Base Case	<100%	110%	<100%	<100%
	COLLINSVILLE-PITTSBURG-E #1 230KV	124%	130%	<100%	106%

Note: For all constraints HSN was the most limiting scenario

On-peak baseline Humboldt area offshore wind related constraints

Overloaded Facility	Contingency	Loading (%)			
		Base A	Base B	Base C	Base D
North Dublin -Vineyard 230 kV	CONTRA COSTA-LAS POSITAS 230KV	<100%	103%	100%	<100%
Cayetano-Lone Tree (USWP-Cayetano) 230kV Line	TESLA-NEWARK #1 230KV & TESLA-RAVENSWOOD 230KV	100%	<100%	<100%	<100%
Tesla - Newark 230 kV Line No. 2	TESLA-NEWARK #1 230KV & TESLA-RAVENSWOOD 230KV	<100%	107%	104%	<100%
Henrietta-GWF 115 kV Line	HELM-MCCALL 230KV & HENTAP2-MUSTANGSS #1 230KV	<100%	<100%	<100%	103%
Eastshore 230/115kV Transformer #1	E. SHORE 230/115KV TB 2	<100%	<100%	<100%	107%
Eastshore 230/115kV Transformer #2	E. SHORE 230/115KV TB 1	<100%	<100%	<100%	108%
Cortina - Mendocino 115 kV Line (Indian Valley – Lucern)	EAGLE ROCK-CORTINA & EAGLE ROCK-REDBUD LINES (2)	<100%	<100%	101%	<100%
Eagle Rock - Cortina 115 kV (Cortina to Highland)	CORTINA-MENDOCINO #1 115KV	<100%	<100%	100%	<100%
Fulton - Hopland 60 kV (Geyser Jct to Fitch Mt. Tap)	GEYSERS #9-LAKEVILLE & EAGLE ROCK-FULTON-SILVERADO LINES	<100%	<100%	104%	100%

Note: For all constraints HSN was the most limiting scenario

On-peak baseline Table Mountain – Vaca Dixon 500kV line Constraint Summary

Affected transmission zones					
		Base A	Base B	Base C	Base D
Portfolio MW behind constraint		1817	401	371	371
Portfolio battery storage MW behind constraint		79	79	79	79
Deliverable portfolio MW w/o mitigation		0	0	0	316
Total undeliverable baseline and portfolio MW		2138	524	523	134
Mitigation Options	RAS	N/A	N/A	N/A	N/A
	Reduce generic battery storage (MW)	TBD	TBD	TBD	TBD
	Transmission upgrade including cost	New Fern Road- Tesla 500 kV Line	Reinstate 500 kV Line Rerates	Reinstate 500 kV Line Rerates	Reinstate 500 kV Line Rerates
Recommended Mitigation		TBD	TBD	TBD	TBD

On-peak baseline Fern Rd – Table Mountain 500 kV line #1 Constraint Summary

Affected transmission zones					
		Base A	Base B	Base C	Base D
Portfolio MW behind constraint		1780	N/A	N/A	N/A
Portfolio battery storage MW behind constraint		5			
Deliverable portfolio MW w/o mitigation		1270			
Total undeliverable baseline and portfolio MW		516			
Mitigation Options	RAS	N/A			
	Reduce generic battery storage (MW)	TBD			
	Transmission upgrade including cost	Reinstate 500 kV Line Rerates			
Recommended Mitigation		TBD			

On-peak baseline Fern Rd – Table Mountain 500 kV line #2 Constraint Summary

Affected transmission zones					
		Base A	Base B	Base C	Base D
Portfolio MW behind constraint		1780	N/A	N/A	N/A
Portfolio battery storage MW behind constraint		5			
Deliverable portfolio MW w/o mitigation		1209			
Total undeliverable baseline and portfolio MW		576			
Mitigation Options	RAS	N/A			
	Reduce generic battery storage (MW)	TBD			
	Transmission upgrade including cost	Reinstate 500 kV Line Rerates			
Recommended Mitigation		TBD			

On-peak baseline Table Mountain – Tesla 500 kV line Constraint Summary

Affected transmission zones					
		Base A	Base B	Base C	Base D
Portfolio MW behind constraint		1847	N/A	N/A	N/A
Portfolio battery storage MW behind constraint		79			
Deliverable portfolio MW w/o mitigation		798			
Total undeliverable baseline and portfolio MW		1128			
Mitigation Options	RAS	TBD			
	Reduce generic battery storage (MW)	TBD			
	Transmission upgrade including cost	Reinstate 500 kV Line Rerates			
Recommended Mitigation		TBD			

On-peak baseline Vaca – Collinsville 500 kV line Constraint Summary

Affected transmission zones					
		Base A	Base B	Base C	Base D
Portfolio MW behind constraint		2165	N/A	N/A	N/A
Portfolio battery storage MW behind constraint		478			
Deliverable portfolio MW w/o mitigation		2058			
Total undeliverable baseline and portfolio MW		584			
Mitigation Options	RAS	TBD			
	Reduce generic battery storage (MW)	TBD			
	Transmission upgrade including cost	Reinstate 500 kV Line Rerates			
Recommended Mitigation		TBD			

On-peak baseline Collinsville – PittsburgE 230kV line Constraint Summary

Affected transmission zones					
		Base A	Base B	Base C	Base D
Portfolio MW behind constraint		1446	1446	N/A	N/A
Portfolio battery storage MW behind constraint		0	0		
Deliverable portfolio MW w/o mitigation		0	0		
Total undeliverable baseline and portfolio MW		1446	1446		
Mitigation Options	RAS	N/A	N/A		
	Reduce generic battery storage (MW)	TBD	TBD		
	Transmission upgrade including cost	Collinsville 230 kV Reactor	Collinsville 230 kV Reactor		
Recommended Mitigation		TBD	TBD		

On-peak baseline Collinsville – PittsburgF 230kV line Constraint Summary

Affected transmission zones					
		Base A	Base B	Base C	Base D
Portfolio MW behind constraint		1682	1682	N/A	236
Portfolio battery storage MW behind constraint		0	0		0
Deliverable portfolio MW w/o mitigation		0	0		0
Total undeliverable baseline and portfolio MW		4294	4294		1172
Mitigation Options	RAS	N/A	N/A		N/A
	Reduce generic battery storage (MW)	TBD	TBD		TBD
	Transmission upgrade including cost	Collinsville 230 kV Reactor	Collinsville 230 kV Reactor		Collinsville 230 kV Reactor
Recommended Mitigation		TBD	TBD		TBD

On-peak baseline North Dublin -Vineyard 230 kV Constraint Summary

Affected transmission zones					
		Base A	Base B	Base C	Base D
Portfolio MW behind constraint		N/A	92	92	N/A
Portfolio battery storage MW behind constraint			0	0	
Deliverable portfolio MW w/o mitigation			0	18	
Total undeliverable baseline and portfolio MW			117	73	
Mitigation Options	RAS		TBD	TBD	
	Reduce generic battery storage (MW)		TBD	TBD	
	Transmission upgrade including cost		Reconducor	Reconducor	
Recommended Mitigation			TBD	TBD	

On-peak baseline Cayetano-Lone Tree (USWP-Cayetano) 230 kV Line Constraint Summary

Affected transmission zones					
		Base A	Base B	Base C	Base D
Portfolio MW behind constraint		91	N/A	N/A	N/A
Portfolio battery storage MW behind constraint		0			
Deliverable portfolio MW w/o mitigation		91			
Total undeliverable baseline and portfolio MW		186			
Mitigation Options	RAS	TBD			
	Reduce generic battery storage (MW)	TBD			
	Transmission upgrade including cost	Reconducor			
Recommended Mitigation		TBD			

On-peak baseline Tesla - Newark 230 kV Line No. 2 Constraint Summary

Affected transmission zones					
		Base A	Base B	Base C	Base D
Portfolio MW behind constraint		N/A	80	80	N/A
Portfolio battery storage MW behind constraint			0	0	
Deliverable portfolio MW w/o mitigation			0	0	
Total undeliverable baseline and portfolio MW			471	309	
Mitigation Options	RAS		TBD	TBD	
	Reduce generic battery storage (MW)		TBD	TBD	
	Transmission upgrade including cost		Reconducor	Reconducor	
Recommended Mitigation			TBD	TBD	

On-peak baseline Henrietta-GWF 115 kV Line Constraint Summary

Affected transmission zones					
		Base A	Base B	Base C	Base D
Portfolio MW behind constraint		N/A	N/A	N/A	25
Portfolio battery storage MW behind constraint					68
Deliverable portfolio MW w/o mitigation					9
Total undeliverable baseline and portfolio MW					85
Mitigation Options	RAS				TBD
	Reduce generic battery storage (MW)				TBD
	Transmission upgrade including cost				Reconducor
Recommended Mitigation					TBD

On-peak baseline Eastshore 230/115kV Transformer #1 Constraint Summary

Affected transmission zones					
		Base A	Base B	Base C	Base D
Portfolio MW behind constraint		N/A	N/A	N/A	1447
Portfolio battery storage MW behind constraint					250
Deliverable portfolio MW w/o mitigation					1055
Total undeliverable baseline and portfolio MW					642
Mitigation Options	RAS				TBD
	Reduce generic battery storage (MW)				TBD
	Transmission upgrade including cost				New 230/115 Bank #3
Recommended Mitigation					TBD

On-peak baseline Eastshore 230/115kV Transformer #2Constraint Summary

Affected transmission zones					
		Base A	Base B	Base C	Base D
Portfolio MW behind constraint		N/A	N/A	N/A	1447
Portfolio battery storage MW behind constraint					250
Deliverable portfolio MW w/o mitigation					1142
Total undeliverable baseline and portfolio MW					555
Mitigation Options	RAS				TBD
	Reduce generic battery storage (MW)				TBD
	Transmission upgrade including cost				New 230/115 Bank #3
Recommended Mitigation					TBD

On-peak baseline Cortina - Mendocino 115 kV Line (Indian Valley – Lucern) Constraint Summary

Affected transmission zones					
		Base A	Base B	Base C	Base D
Portfolio MW behind constraint		N/A	N/A	4	N/A
Portfolio battery storage MW behind constraint				150	
Deliverable portfolio MW w/o mitigation				121	
Total undeliverable baseline and portfolio MW				33	
Mitigation Options	RAS			Yes	
	Reduce generic battery storage (MW)			TBD	
	Transmission upgrade including cost			Reconductor	
Recommended Mitigation				TBD	

On-peak baseline Eagle Rock - Cortina 115 kV (Cortina to Highland) Constraint Summary

Affected transmission zones					
		Base A	Base B	Base C	Base D
Portfolio MW behind constraint		N/A	N/A	4	N/A
Portfolio battery storage MW behind constraint				150	
Deliverable portfolio MW w/o mitigation				140	
Total undeliverable baseline and portfolio MW				14	
Mitigation Options	RAS			Yes	
	Reduce generic battery storage (MW)			TBD	
	Transmission upgrade including cost			Reconductor	
Recommended Mitigation				TBD	

On-peak baseline Fulton - Hopland 60 kV (Geyser Jct to Fitch Mt. Tap) Constraint Summary

Affected transmission zones					
		Base A	Base B	Base C	Base D
Portfolio MW behind constraint		N/A	N/A	2	2
Portfolio battery storage MW behind constraint				150	150
Deliverable portfolio MW w/o mitigation				95	143
Total undeliverable baseline and portfolio MW				57	9
Mitigation Options	RAS			TBD	TBD
	Reduce generic battery storage (MW)			TBD	TBD
	Transmission upgrade including cost			Reconductor	Reconductor
Recommended Mitigation				TBD	TBD

On-peak baseline potentially load driven constraints

Overloaded Facility	Contingency	Loading (%)			
		Base A	Base B	Base C	Base D
Metcalf-Hicks 230 kV Line	Metcalf-Monta Vista No. 3 & Monta Vista-Coyote Sw. Sta. 230 kV Line	115%	<100%	104%	<100%
Table Mountain-Pease 60 kV Line (Tres Vias-Biggsjct)	Table Mountain(D)-Rio Oso 230 kV Line and Table Mountain(D)-Palermo 230 kV Line	110%	106%	105%	104%
Moraga-Oakland J 115kV Line	SAN LEANDRO-OAKLND J #1 115KV	107%	107%	<100%	<100%
San Jose B – Trimble 115 kV line	Los Esteros - Trimble & Los Esteros - Montague 115 kV	117%	116%	<100%	<100%
Saratoga-Vasona 230 kV Line	Metcalf-Monta Vista No. 3 & Monta Vista-Coyote Sw. Sta. 230 kV Line	<100%	<100%	103%	<100%
Eastshore-San Mateo 230kV Line	Newark-Ravenswood 230 kV and Tesla-Ravenswood 230 kV lines	113%	112%	<100%	<100%
Pittsburg-Eastshore 230kV Line	RUSCTYECST1 18.00KV & RUSCTYECCT2 15.00KV & RUSCTYECCT1 15.00KV GEN UNITS	104%	106%	<100%	<100%

Note: For all constraints HSN was the most limiting scenario

Potential mitigation matrix for Humboldt area offshore wind interconnection alternatives baseline issues

Potential Mitigation	Base A	Base B	Base C	Base D
North Dublin -Vineyard 230 kV Reconductor		x	x	
Cayetano-Lone Tree (USWP-Cayetano) 230kV Line Reconducor	x			
Tesla - Newark 230 kV Line No. 2 Reconductor		x	x	
Henrietta-GWF 115 kV Line Reconductor				x
New Fern Road- Tesla 500 kV Line	x			
Reinstate 500 kV Line Rerates		x	x	x
New Eastshore 230/115kV Transformer #3				x
Cortina - Mendocino 115 kV Line Reconductor or RAS			x	
Fulton - Hopland 60 kV (Geyser Jct to Fitch Mt. Tap) Reconductor			x	x
Eagle Rock - Cortina 115 kV (Cortina to Highland) Reconductor or RAS			x	
Collinsville 230 kV Reactor	x	x		x

On-peak sensitivity Humboldt area offshore wind related constraints

Overloaded Facility	Contingency	Loading (%)			
		Base A1	Base A2	Base B	Base C
Table Mountain – Vaca Dixon #1 500kV line	Base Case	<100%	<100%	<100%	122%
	TABLE MTN-TESLA 500KV	101%	101%	<100%	142%
Vaca Dixon – Telsa 500kV line	P1-2:A0:26:_COLLINSVILLE-TESLA 500KV [0]	104%	<100%	131%	139%
Table Mountain – Tesla 500 kV	Base Case	<100%	<100%	<100%	102%
	P1-2:A0:4:_TABLE MTN-VACA 500KV [6090]	<100%	<100%	<100%	116%
Table Mountain – Vaca Dixon #2 500kV line	Base Case	<100%	<100%	<100%	119%
Vaca Dixon – Collinsville #1 500kV line	Base Case	<100%	<100%	<100%	142%
	P7-2:A99:1:_HUMBOLDT OSW-Collinsville HVDC Line [0]	<100%	<100%	<100%	102%
Fern Road – Table Mountain #1 500 kV	Fern Road – Table Mountain #2 500 kV	<100%	<100%	<100%	164%
Fern Road – Table Mountain #2 500 kV	Fern Road – Table Mountain #1 500 kV	<100%	<100%	<100%	164%
Fern Road – Table Mountain #3 500 kV	Base Case	<100%	<100%	<100%	135%
Collinsville – Tesla 500kV line	Base Case	<100%	<100%	109%	<100%
	P1-2:A0:33:_HUMBOLDT OSW-FERN ROAD #1 500KV [6020]	<100%	<100%	139%	<100%
Collinsville 500/230 kV Transformer Bank #1	Collinsville 500/230 kV Transformer Bank #2	<100%	<100%	104%	<100%
Collinsville 500/230 kV Transformer Bank #2	Collinsville 500/230 kV Transformer Bank #1	<100%	<100%	104%	<100%

On-peak sensitivity Humboldt area offshore wind related constraints

Overloaded Facility	Contingency	Loading (%)			
		Base A1	Base A2	Base B	Base C
Collinsville – PittsburgF 230kV line	COLLINSVILLE-PITTSBURG-E #1 230KV	122%	142%	155%	120%
Eastshore 230/115kV Transformer #1	E. SHORE 230/115KV TB 2	111%	<100%	<100%	113%
Eastshore 230/115kV Transformer #2	E. SHORE 230/115KV TB 1	112%	<100%	<100%	112%
Martinez-Sobrante 115kV Line	OLEUM-MARTINEZ 115KV	<100%	<100%	101%	<100%
Pease - Marysville - Harter 60 kV Line	PALERMO-NICOLAUS 115KV	<100%	<100%	<100%	101%
Tesla - Newark 230 kV Line No. 2	TESLA-NEWARK #1 230KV & TESLA-RAVENSWOOD 230KV	<100%	107%	113%	<100%
Cayetano-Lone Tree (USWP-Cayetano) 230kV Line	CONTRA COSTA-LAS POSITAS 230KV	<100%	101%	111%	<100%
North Dublin -Vineyard 230 kV	CONTRA COSTA-LAS POSITAS 230KV	<100%	101%	113%	<100%
Fulton - Hopland 60 kV (Hopland Jct to Cloverdale Jct)	GEYSERS #9-LAKEVILLE & EAGLE ROCK-FULTON-SILVERADO LINES	103%	<100%	<100%	101%
Round MT- Cottonwood 230 kV line	CAPTJACK-OLINDA 500KV	<100%	<100%	<100%	115%

On-peak sensitivity potentially load driven constraints

Overloaded Facility	Contingency	Loading (%)			
		Base A1	Base A2	Base B	Base C
Moraga-Oakland J 115kV Line	SAN LEANDRO-OAKLND J #1 115KV	<100%	110%	116%	<100%
Las Positas-Newark 230kV Line	TESLA-NEWARK #1 230KV & TESLA-RAVENSWOOD 230KV	<100%	<100%	182%	<100%
San Leandro-Oakland J 115kV Line	MORAGA-OAKLAND J 115KV	<100%	<100%	107%	<100%
Embarcadero-Potrero 230kV Line	Bayhub-LosEsteros 230 kV Line	120%	<100%	<100%	116%
Morro Bay 230/115 Transformer No. 6	MIDWAY-TEMBLOR 115KV	104%	<100%	<100%	104%
Brighton - Davis 115 kV Line	Rio Oso-West Sacramento 115 kV Line & West Sacramento-Brighton 115 kV Line	103%	103%	103%	<100%
Temblor-San Luis Obispo 115 kV Line	TEMPLETON-GATES 230KV [5934] & GATES-CALFLATSSS #1 230KV	109%	<100%	<100%	108%
ESTRELLA-PSA RBLS 70 kV	MORRO BAY-CALFLATS SS AND TEMPLETON-GATES 230 KV LINES	112%	<100%	<100%	111%
Table Mountain-Pease 60 kV Line (Peachton-Gridley)	Table Mountain(D)-Rio Oso 230 kV Line and Table Mountain(D)-Palermo 230 kV Line	<100%	<100%	<100%	104%
East Shore – Pittsburg 230 kV Line	RUSCTYECST1 18.00KV & RUSCTYECCT2 15.00KV & RUSCTYECCT1 15.00KV GEN UNITS	<100%	110%	117%	<100%

Note: For all constraints HSN was the most limiting scenario

Potential mitigation matrix for Humboldt area offshore wind interconnection alternatives sensitivity issues

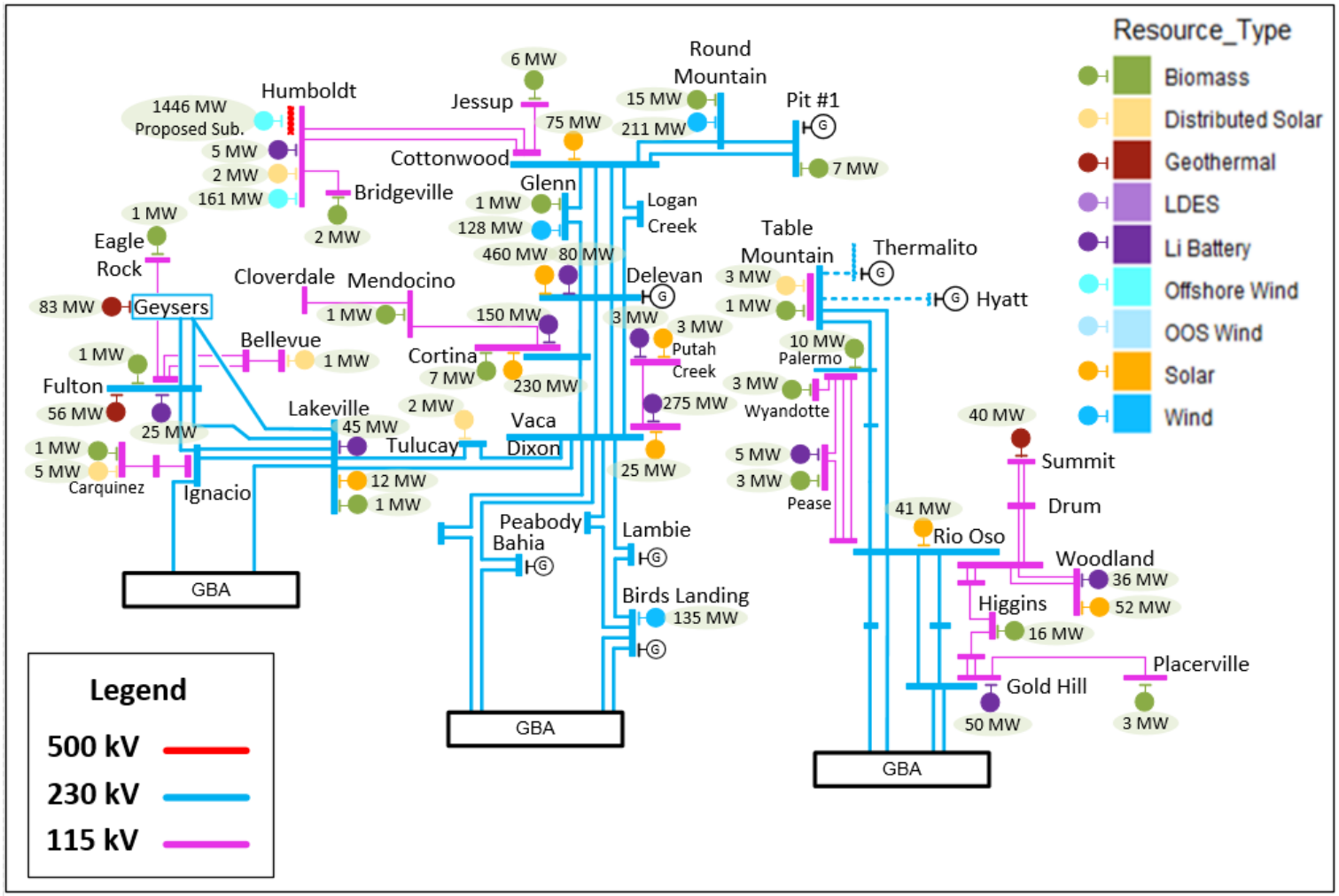
Potential Mitigation	Base A1	Base A2	Base B	Base C
New 500 kV Mitigation TBD	X	X	X	X
Reinstate 500 kV Line Rerates	X	X	X	X
North Dublin -Vineyard 230 kV Reconductor		X	X	
Cayetano-Lone Tree (USWP-Cayetano) 230kV Line Reconducor		X	X	
Tesla - Newark 230 kV Line No. 2 Reconductor		X		
New Eastshore 230/115kV Transformer #3	X			
Fulton - Hopland 60 kV (Hopland Jct to Cloverdale Jct) Reconductor	X			X
Round MT- Cottonwood 230 kV line #3 Reconductor				X
Martinez-Sobrante 115kV Line Reconductor			X	
Pease - Marysville - Harter 60 kV Line Reconductor				X
Collinsville 230 kV Reactor	X	X	X	X

PG&E North of Greater Bay Interconnection Area

PG&E North of Greater Bay Interconnection Area

Resource Type	Base Portfolio		
	FCDS (MW)	EO (MW)	Total (MW)
Solar	185	713	898
Wind – In State	320	154	474
Wind – Out-of-State (Existing TX)	0	0	0
Wind – Out-of-State (New TX)	0	0	0
Wind - Offshore	1,446	161	1,607
Li Battery	674	0	674
Geothermal	179	0	179
Long Duration Energy Storage (LDES)	0	0	0
Biomass/Biogass	79	0	79
Distributed Solar	13	0	13
Total	**2,895**	**1,027**	**3,923**

Base Portfolio: North of Greater Bay Area



FCDS
2,895
MW

Total
3,923
MW

North of Greater Bay Area Interconnection Area Constraints

Overloaded Facility	Contingency	Loading (%)	
		Base	Sensitivity
HOPLAND BANK 115/60.00 BANK NO.2	GEYSERS #9-LAKEVILLE & EAGLE ROCK-FULTON-SILVERADO LINES	115%	112%
Geyser56-MPE Tap 115 kV	EAGLE ROCK -REDBUD & CORTINA-MENDOCINO #1 LINES	105%	104%
Ukiah-Hopland-Cloverdale 115 kV (Ukiah sub 115kv to Hopland Jct 115kv)	EAGLE ROCK -REDBUD & CORTINA-MENDOCINO #1 LINES	107%	107%
Fulton - Hopland 60 kV (Hopland Jct 60 kV to Cloverdale Jct 60 kV to Geysers Jct 60 kV)	GEYSERS #9-LAKEVILLE & EAGLE ROCK-FULTON-SILVERADO LINES	117%	115%
Cascade-Deschutes 60 kV Line	Base Case	107%	109%
	COLEMAN-COTTONWOOD 60KV	100%	<100%

Note: For all constraints HSN was the most limiting scenario

On-peak Hopland Bank 115/60 kV #2 Constraint Summary

		Base	**Sensitivity**
Portfolio MW behind constraint		2	TBD
Portfolio battery storage MW behind constraint		0	TBD
Deliverable portfolio MW w/o mitigation		0	TBD
Total undeliverable baseline and portfolio MW		79	TBD
Mitigation Options	RAS	None	TBD
	Reduce generic battery storage (MW)	N/A	TBD
	Transmission upgrade including cost	Maintenance Project	TBD
Recommended Mitigation		Maintenance Project	TBD

On-peak Geyser56-MPE Tap 115 kV Constraint Summary

		Base	**Sensitivity**
Portfolio MW behind constraint		1	TBD
Portfolio battery storage MW behind constraint		0	TBD
Deliverable portfolio MW w/o mitigation		0	TBD
Total undeliverable baseline and portfolio MW		111	TBD
Mitigation Options	RAS	TBD	TBD
	Reduce generic battery storage (MW)	N/A	TBD
	Transmission upgrade including cost	Reconductor	TBD
Recommended Mitigation		TBD	TBD

On-peak Ukiah-Hopland-Cloverdale 115 kV (Ukiah sub 115kv to Hopland Jct 115kv) Constraint Summary

		Base	**Sensitivity**
Portfolio MW behind constraint		2	TBD
Portfolio battery storage MW behind constraint		150	TBD
Deliverable portfolio MW w/o mitigation		0	TBD
Total undeliverable baseline and portfolio MW		194	TBD
Mitigation Options	RAS	TBD	TBD
	Reduce generic battery storage (MW)	TBD	TBD
	Transmission upgrade including cost	Reconductor	TBD
Recommended Mitigation		TBD	TBD

On-peak Fulton – Hopland 60 kV Line (Hopland Jct. 60 kV to Cloverdale Jct. 60 kV) Constraint Summary

		Base	**Sensitivity**
Portfolio MW behind constraint		2	TBD
Portfolio battery storage MW behind constraint		150	TBD
Deliverable portfolio MW w/o mitigation		0	TBD
Total undeliverable baseline and portfolio MW		198	TBD
Mitigation Options	RAS	TBD	TBD
	Reduce generic battery storage (MW)	TBD	TBD
	Transmission upgrade including cost	Reconductor	TBD
Recommended Mitigation		TBD	TBD

On-peak Cascade – Deschutes 60 kV Line Constraint Summary

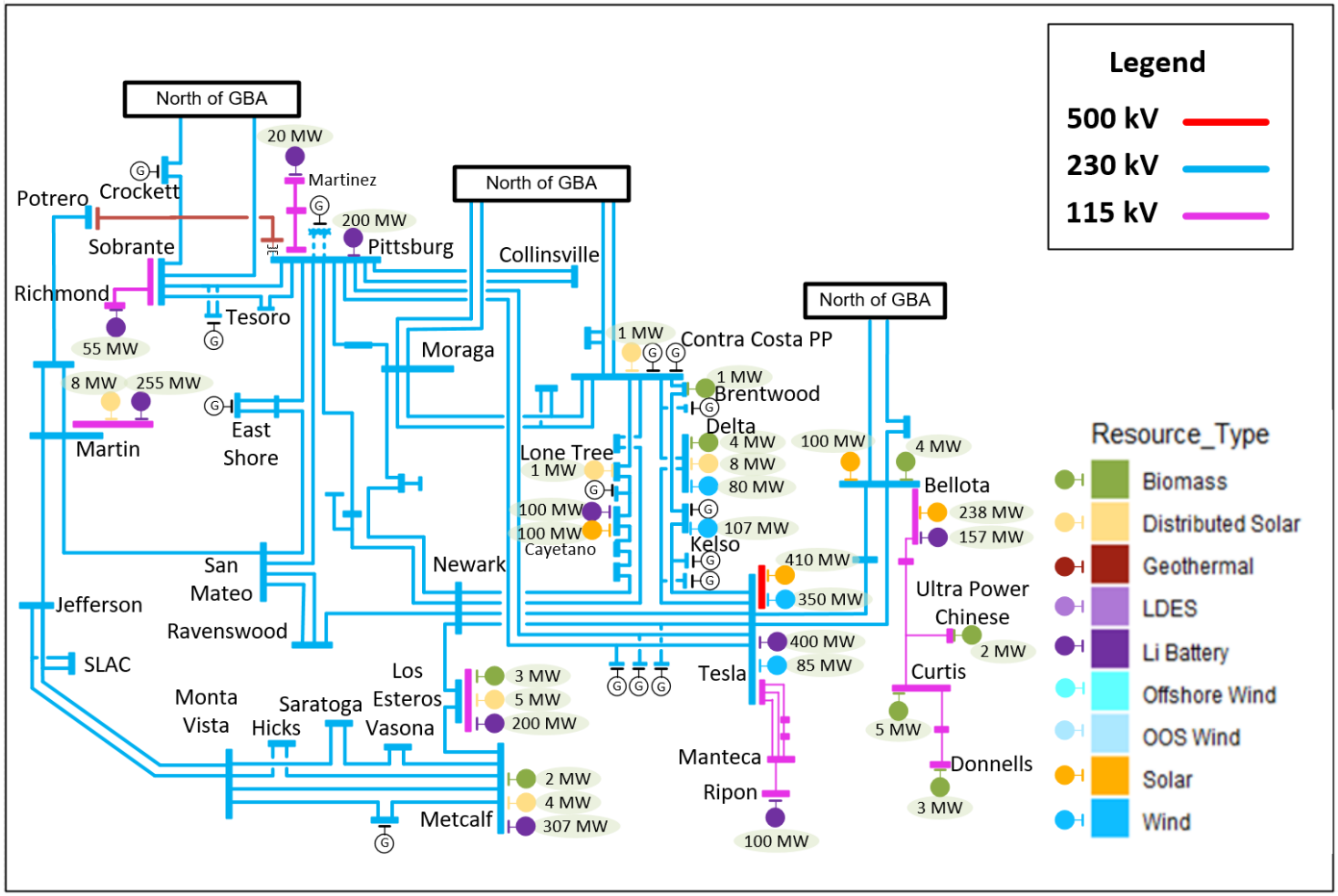
		Base	**Sensitivity**
Portfolio MW behind constraint		6	N/A
Portfolio battery storage MW behind constraint		5	
Deliverable portfolio MW w/o mitigation		0	
Total undeliverable baseline and portfolio MW		39	
Mitigation Options	RAS	N/A	
	Reduce generic battery storage (MW)	TBD	
	Transmission upgrade including cost	Reconductor	
Recommended Mitigation		TBD	

PG&E Greater Bay Interconnection Area

PG&E Greater Bay Interconnection Area

Resource Type	Base Portfolio		
	FCDS (MW)	EO (MW)	Total (MW)
Solar	500	348	848
Wind – In State	592	30	622
Wind – Out-of-State (Existing TX)	0	0	0
Wind – Out-of-State (New TX)	0	0	0
Wind - Offshore	0	0	0
Li Battery	1,803	0	1,803
Geothermal	0	0	0
Long Duration Energy Storage (LDES)	0	0	0
Biomass/Biogass	24	0	24
Distributed Solar	27	0	27
Total	**2,945**	**378**	**3,324**

Base Portfolio: Greater Bay Area



FCDS
2,945
MW

Total
3,324
MW

Greater Bay Area Interconnection Area Constraints

Overloaded Facility	Contingency	Loading (%)	
		Base	Sensitivity
Spring Gap-MI-WUK 115 kV Line	Base Case	101%	101%
Sobrante 230/115 kV Transformer Bank #1	SOBRANTE 230/115KV TB 2	112%	117%
Sobrante 230/115 kV Transformer Bank #2	SOBRANTE 230/115KV TB 1	112%	117%

Note: For all constraints HSN was the most limiting scenario

On-peak Spring Gap – MI-WUK 115 kV Line Constraint Summary

		Base	**Sensitivity**
Portfolio MW behind constraint		3	TBD
Portfolio battery storage MW behind constraint		0	TBD
Deliverable portfolio MW w/o mitigation		2	TBD
Total undeliverable baseline and portfolio MW		1	TBD
Mitigation Options	RAS	N/A	TBD
	Reduce generic battery storage (MW)	N/A	TBD
	Transmission upgrade including cost	Reconductor	TBD
Recommended Mitigation		Reconductor	TBD

On-peak Sobrante 230/115 kV Transformer Bank #1 Constraint Summary

		Base	**Sensitivity**
Portfolio MW behind constraint		142	TBD
Portfolio battery storage MW behind constraint		25	TBD
Deliverable portfolio MW w/o mitigation		0	TBD
Total undeliverable baseline and portfolio MW		406	TBD
Mitigation Options	RAS	TBD	TBD
	Reduce generic battery storage (MW)	TBD	TBD
	Transmission upgrade including cost	New 230/115 kV bank	TBD
Recommended Mitigation		TBD	TBD

On-peak Sobrante 230/115 kV Transformer Bank #2 Constraint Summary

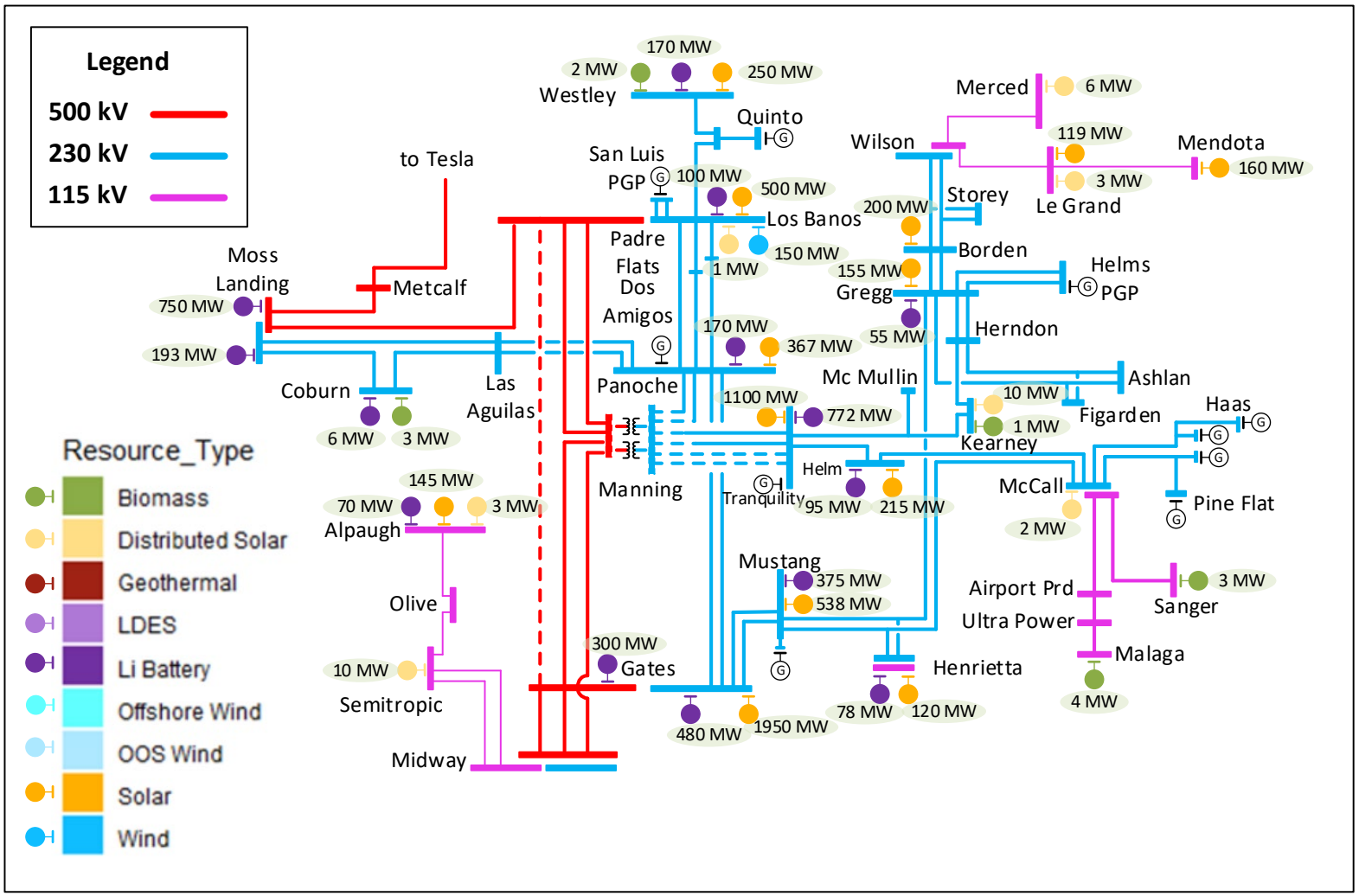
		Base	**Sensitivity**
Portfolio MW behind constraint		142	TBD
Portfolio battery storage MW behind constraint		25	TBD
Deliverable portfolio MW w/o mitigation		0	TBD
Total undeliverable baseline and portfolio MW		407	TBD
Mitigation Options	RAS	TBD	TBD
	Reduce generic battery storage (MW)	TBD	TBD
	Transmission upgrade including cost	New 230/115 kV bank	TBD
Recommended Mitigation		TBD	TBD

PG&E Greater Fresno Interconnection Area

PG&E Fresno Interconnection Area

Resource Type	Base Portfolio		
	FCDS (MW)	EO (MW)	Total (MW)
Solar	3,184	0	3,184
Wind – In State	249	0	249
Wind – Out-of-State (Existing TX)	0	0	0
Wind – Out-of-State (New TX)	0	0	0
Wind - Offshore	0	0	0
Li Battery	3,184	0	3,184
Geothermal	0	0	0
Long Duration Energy Storage (LDES)	0	0	0
Biomass/Biogass	12	0	12
Distributed Solar	35	0	35
Total	**6,241**	**2,364**	**8,605**

Base Portfolio: PG&E Fresno Area



FCDS
6,241
MW

Total
8,605
MW

Fresno Interconnection Area Constraints

Overloaded Facility	Contingency	Loading (%)	
		Base	Sensitivity
Mccall 230/115kV Bank 1	MC CALL 230/115KV TB 3	103%	<100%
Mccall 230/115kV Bank 3	MC CALL 230/115KV TB 1	101%	<100%
McCall-Sanger #2 115 kV Line	MCCALL-REEDLEY 115KV & MCCALL-SANGER #3 115KV	114%	112%
Herndon-Woodward 115 kV Line	HERNDON-BARTON 115KV & HERNDON-MANCHESTER 115KV	125%	<100%
Kingsburg D-Kingsburg E Bus tie 115kV	Base Case	107%	<100%
GWF-Kingsburg 115 kV Line	Base Case	106%	<100%
	HELM-MCCALL 230KV & HENTAP2-MUSTANGSS #1 230KV	170%	<100%

Note: For all constraints HSN was the most limiting scenario

On-peak McCall 230/115 kV Transformer #1 Constraint Summary

		Base	**Sensitivity**
Portfolio MW behind constraint		120	N/A
Portfolio battery storage MW behind constraint		95	
Deliverable portfolio MW w/o mitigation		0	
Total undeliverable baseline and portfolio MW		262	
Mitigation Options	RAS	TBD	
	Reduce generic battery storage (MW)	TBD	
	Transmission upgrade including cost	New 230/115 kV bank	
Recommended Mitigation		TBD	

On-peak McCall 230/115 kV Transformer #2 Constraint Summary

		Base	**Sensitivity**
Portfolio MW behind constraint		122	N/A
Portfolio battery storage MW behind constraint		95	
Deliverable portfolio MW w/o mitigation		143	
Total undeliverable baseline and portfolio MW		74	
Mitigation Options	RAS	TBD	
	Reduce generic battery storage (MW)	TBD	
	Transmission upgrade including cost	New 230/115 kV bank	
Recommended Mitigation		TBD	

On-peak McCall – Sanger #2 115 kV Line Constraint Summary

		Base	**Sensitivity**
Portfolio MW behind constraint		2	TBD
Portfolio battery storage MW behind constraint		0	TBD
Deliverable portfolio MW w/o mitigation		0	TBD
Total undeliverable baseline and portfolio MW		270	TBD
Mitigation Options	RAS	TBD	
	Reduce generic battery storage (MW)	N/A	
	Transmission upgrade including cost	Reconductor	
Recommended Mitigation		TBD	

On-peak Herndon – Woodward 115 kV Line Constraint Summary

		Base	**Sensitivity**
Portfolio MW behind constraint		150	N/A
Portfolio battery storage MW behind constraint		55	
Deliverable portfolio MW w/o mitigation		0	
Total undeliverable baseline and portfolio MW		368	
Mitigation Options	RAS	TBD	
	Reduce generic battery storage (MW)	TBD	
	Transmission upgrade including cost	Reconductor	
Recommended Mitigation		TBD	

On-peak Kingsburg D – Kingsburg E 115 kV Bus Tie Constraint Summary

		Base	**Sensitivity**
Portfolio MW behind constraint		25	N/A
Portfolio battery storage MW behind constraint		68	
Deliverable portfolio MW w/o mitigation		0	
Total undeliverable baseline and portfolio MW		134	
Mitigation Options	RAS	N/A	
	Reduce generic battery storage (MW)	TBD	
	Transmission upgrade including cost	Reconductor	
Recommended Mitigation		TBD	

On-peak GWF-Kingsburg 115 kV Line Constraint Summary

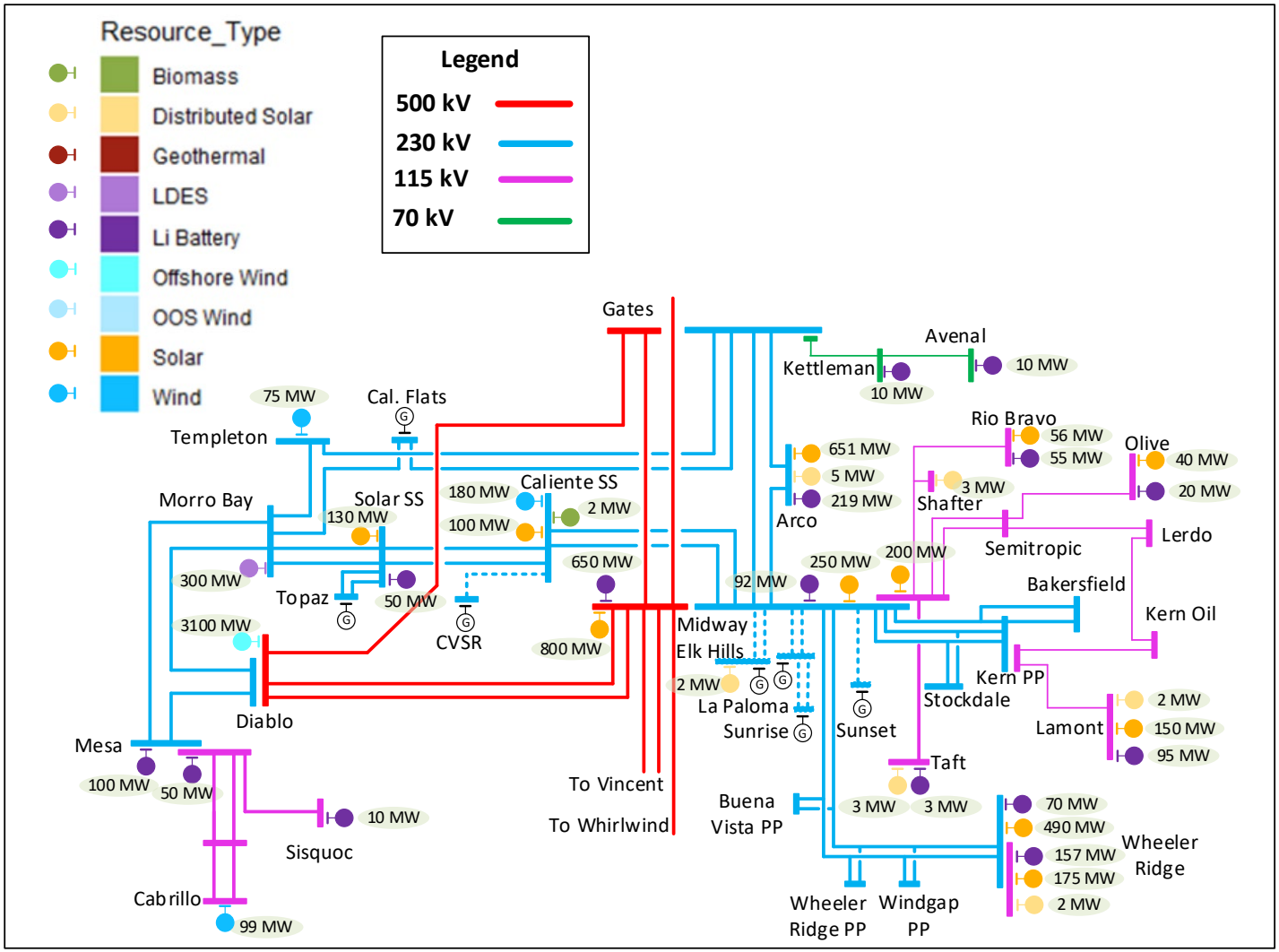
		Base	**Sensitivity**
Portfolio MW behind constraint		25	N/A
Portfolio battery storage MW behind constraint		68	
Deliverable portfolio MW w/o mitigation		0	
Total undeliverable baseline and portfolio MW		114	
Mitigation Options	RAS	N/A	
	Reduce generic battery storage (MW)	TBD	
	Transmission upgrade including cost	Reconductor	
Recommended Mitigation		TBD	

PG&E Kern Interconnection Area

PG&E Kern Interconnection Area

Resource Type	Base Portfolio		
	FCDS (MW)	EO (MW)	Total (MW)
Solar	1,361	2,374	3,735
Wind – In State	255	0	255
Wind – Out-of-State (Existing TX)	0	0	0
Wind – Out-of-State (New TX)	0	0	0
Wind - Offshore	3,100	0	3,100
Li Battery	2,021	0	2,021
Geothermal	0	0	0
Long Duration Energy Storage (LDES)	300	0	300
Biomass/Biogass	2	0	2
Distributed Solar	18	0	18
Total	**7,056**	**2,374**	**9,430**

Base Portfolio: PG&E Kern Area



FCDS
7,056
MW

Total
9,430
MW

Kern Interconnection Area Constraints

Overloaded Facility	Contingency	Loading (%)	
		Base	Sensitivity
Wheeler Ridge 115/70 kV Transformer #2	Base Case	155%	<100%
	WHEELER RIDGE-ADOBE SW STA 115KV	127%	<100%

Note: For all constraints HSN was the most limiting scenario

On-peak Wheeler Ridge 115/70 kV Transformer #2 Constraint Summary

		Base	**Sensitivity**
Portfolio MW behind constraint		2.4	N/A
Portfolio battery storage MW behind constraint		87	
Deliverable portfolio MW w/o mitigation		56	
Total undeliverable baseline and portfolio MW		34	
Mitigation Options	RAS	N/A	
	Reduce generic battery storage (MW)	TBD	
	Transmission upgrade including cost	Upgrade Transformer	
Recommended Mitigation		TBD	

Preliminary Economic Assessment Results

Yi Zhang
Sr. Advisor, Transmission Infrastructure Planning

2023-2024 Transmission Planning Process Stakeholder Meeting

November 16, 2023

Outline of the presentation

- PCM development update
- Base portfolio PCM preliminary results
- Sensitivity portfolio (30 MMT) PCM preliminary results
- Economic study requests and preliminary high priority study areas

Planning PCM development

Out of state wind and Offshore wind in the Base portfolio PCM

- Out-of-state wind
  - NW wind requiring new transmission were modeled at Pinal C 500 kV bus
  - The TransWest Express project was modeled for Wyoming wind
  - The SWIP North project was modeled for Idaho wind
- Offshore wind in the Base portfolio PCM
  - Humboldt Bay Offshore wind (161 MW) in the base portfolio PCM was modeled at Humboldt 115 kV
  - Incremental Humboldt Bay offshore wind (1446 MW) was modeled at Fern Road 500 kV bus
  - Morro Bay offshore wind (3100 MW) were modeled at the Diablo Canyon 500 kV bus

Offshore wind in the Sensitivity portfolio PCM

- Offshore wind in the Sensitivity portfolio PCM
  - Humboldt Bay offshore wind (161 MW) in the base portfolio PCM was modeled at Humboldt 115 kV
  - Incremental Humboldt Bay offshore wind (7884 MW) was modeled at a new 500 kV bus at Humboldt with transmission upgrades:
    - Humboldt - Fern Road 500 kV AC line
      - Also includes Fern Road – Vaca Dixon – Tesla 500 kV AC line
    - Humboldt – Collinsvile HVDC
    - Humboldt – Bayhub HVDC with Bayhub local 230 kV upgrades
  - Morro Bay offshore wind (5355 MW) were modeled at the Diablo Canyon 500 kV bus

Base portfolio preliminary PCM results

Base portfolio preliminary PCM – congestion

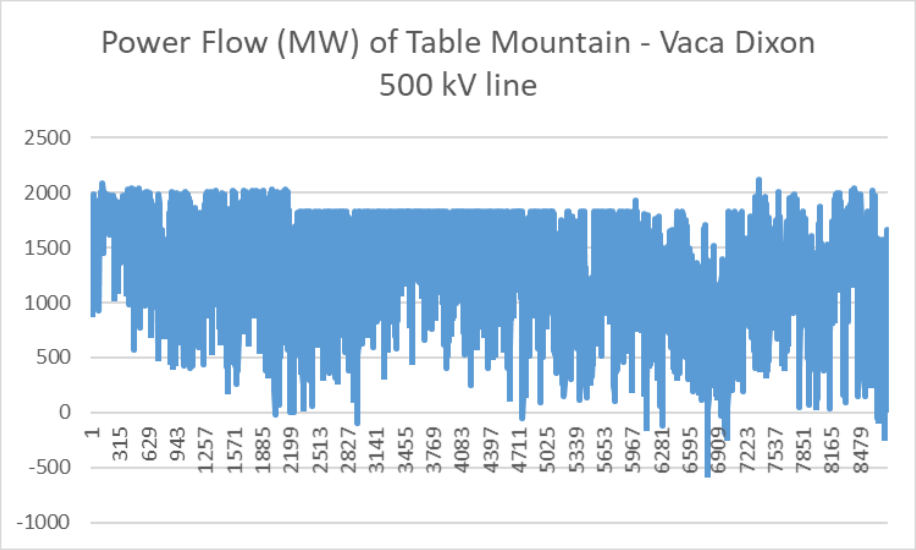
Area	Total Congestion Cost ($M)	Total Congestion Hours (Hrs)
PG&E Fresno Henrietta 115 kV	147.60	2,636
COI Corridor	132.43	1,677
Path 26 Corridor	72.07	3,474
PG&E Mosslanding-Las Aguilas 230 kV	35.47	1,198
Path 61 (Victorville-Lugo)	34.75	362
Path 46 WOR	30.39	31
PG&E Collinsville corridor	29.08	1,203
SCE East of Pisgah	22.75	2,340
Path 15 Corridor	19.68	988
SDGE/CFE	19.59	1,112
SCE North of Lugo	12.79	3,062
GridLiance/VEA	9.40	1,787
PG&E Kern 230kV	8.36	1,303
PG&E Panoche/Oro Loma area	5.89	1,705
PG&E Sierra	5.52	1,187
SDG&E Southern	3.00	204
SCE J.Hinds-Mirage	1.31	251
PG&E Fresno Los Banos 230 kV	1.23	163
PG&E Fresno 230 kV	1.17	201
SDG&E Northern	1.14	913
PG&E GBA	0.90	915
PG&E POE-RIO OSO 230 kV	0.87	153
SCE Eastern	0.57	141
SCE W.LA LCIENEGA-LA FRESA 230 kV	0.55	24
Path 49 EOR	0.54	2
Path 65 PDCI	0.51	105

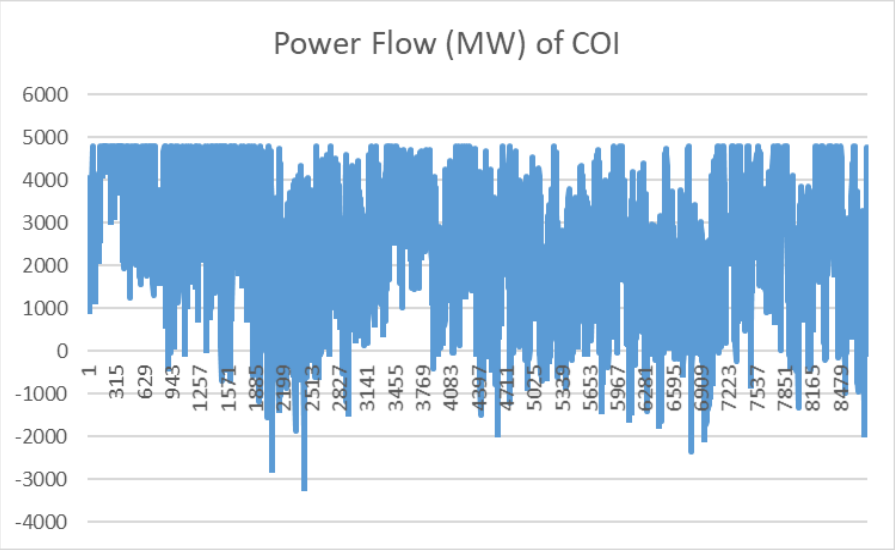
COI Corridor congestion

Constraints Name	Costs ($K)	Duration (Hrs)	From Bus Name	From Bus ID	To Bus Name	To Bus ID
TABLE MTN-TM_VD_11 500 kV line #1	43,090	524	TABLE MTN	30015	TM_VD_11	300151
TABLE MTN-TM_VD_11 500 kV line, subject to PG&E-BANC N-1 Maxwell-Tracy 500kV	41,179	408	TABLE MTN	30015	TM_VD_11	300151
P66 COI	26,831	417				
TM_VD_12-VACA-DIX 500 kV line #1	13,656	191	TM_VD_12	300152	VACA-DIX	30030
RM_TM_22-TABLE MTN 500 kV line #2	4,519	87	RM_TM_22	300054	TABLE MTN	30015
ROUND MT-RM_TM_11 500 kV line, subject to PG&E N-1 CapJack-Olinda 500 kV with Colusa SPS	1,698	15	ROUND MT	30005	RM_TM_11	300051
ROUND MT-RM_TM_21 500 kV line #2	996	17	ROUND MT	30005	RM_TM_21	300053
TABLE MTN-TM_TS_11 500 kV line #1	260	5	TABLE MTN	30015	TM_TS_11	300153
TABLE MTN-TM_TS_11 500 kV line, subject to PG&E-BANC N-1 Maxwell-Tracy 500kV	106	7	TABLE MTN	30015	TM_TS_11	300153
ROUND MT-RM_TM_11 500 kV line #1	81	2	ROUND MT	30005	RM_TM_11	300051
VD_CV_11-COLLINSVILLE 500 kV line #1	13	1	VD_CV_11	300301	COLLINSVILLE	30033
TM_TS_12-TESLA 500 kV line #1	4	1	TM_TS_12	300154	TESLA	30040
VACA-DIX-VD_CV_11 500 kV line #1	0	2	VACA-DIX	30030	VD_CV_11	300301

* Congestion occurs when the flow is from north to south

COI corridor flow and Humboldt Bay offshore wind generation





Humboldt Bay offshore wind Average Output (MW)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	431	508	556	539	540	522	523	546	530	490	532	565	528	597	659	680	688	681	684	651	581	553	555	564
Feb	691	661	646	620	603	619	620	624	646	634	684	686	710	723	698	680	695	642	705	739	763	788	758	718
Mar	690	720	748	779	781	829	837	850	872	835	775	765	743	733	734	753	748	745	750	728	749	757	798	741
Apr	438	428	416	418	404	434	459	484	447	509	522	507	551	572	580	568	513	482	495	445	401	385	374	394
May	672	705	720	733	690	733	750	728	728	696	696	737	745	765	751	685	681	722	722	719	713	722	739	718
Jun	596	661	671	674	661	664	663	694	718	732	771	817	812	784	749	683	669	668	658	622	614	580	581	590
Jul	816	868	911	928	950	966	961	961	986	922	927	919	905	876	875	868	867	869	866	851	833	833	845	875
Aug	718	769	765	758	759	751	740	731	704	696	688	667	685	707	734	714	692	694	679	661	628	654	641	684
Sep	567	562	536	520	538	516	488	487	475	477	484	464	483	520	516	515	512	518	509	506	499	535	558	548
Oct	427	387	380	352	381	383	364	368	361	386	388	410	414	419	383	412	431	446	488	448	455	422	431	446
Nov	525	500	531	545	548	502	561	559	590	559	571	572	602	593	597	560	550	547	544	587	587	590	586	539
Dec	645	637	672	709	703	625	649	714	666	768	783	802	776	772	773	761	777	723	706	646	599	631	618	600

PG&E Fresno Henrietta 115 kV Congestion under 230 kV N-2

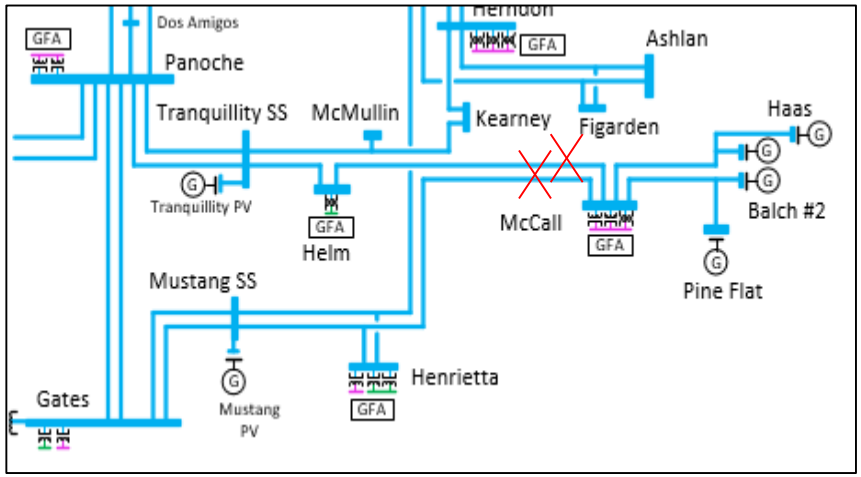
Constraints Name	Costs ($K)	Duration (Hrs)	From Bus Name	From Bus ID	To Bus Name	To Bus ID	CKT
GWFHANFORDSS-CONTADNA 115 kV line, subject to PG&E N-2 HELM-MCCALL and HENTAP2-MUSTANGSS #1 230kV with RAS	92,005	1,828	GWFHANFORDSS	34429	CONTADNA	34428	1
LPRNJCTSS-GWFHANFORDSS 115 kV line, subject to PG&E N-2 HELM-MCCALL and HENTAP2-MUSTANGSS #1 230kV with RAS	55,594	808	LPRNJCTSS	34519	GWFHANFORDSS	34429	1

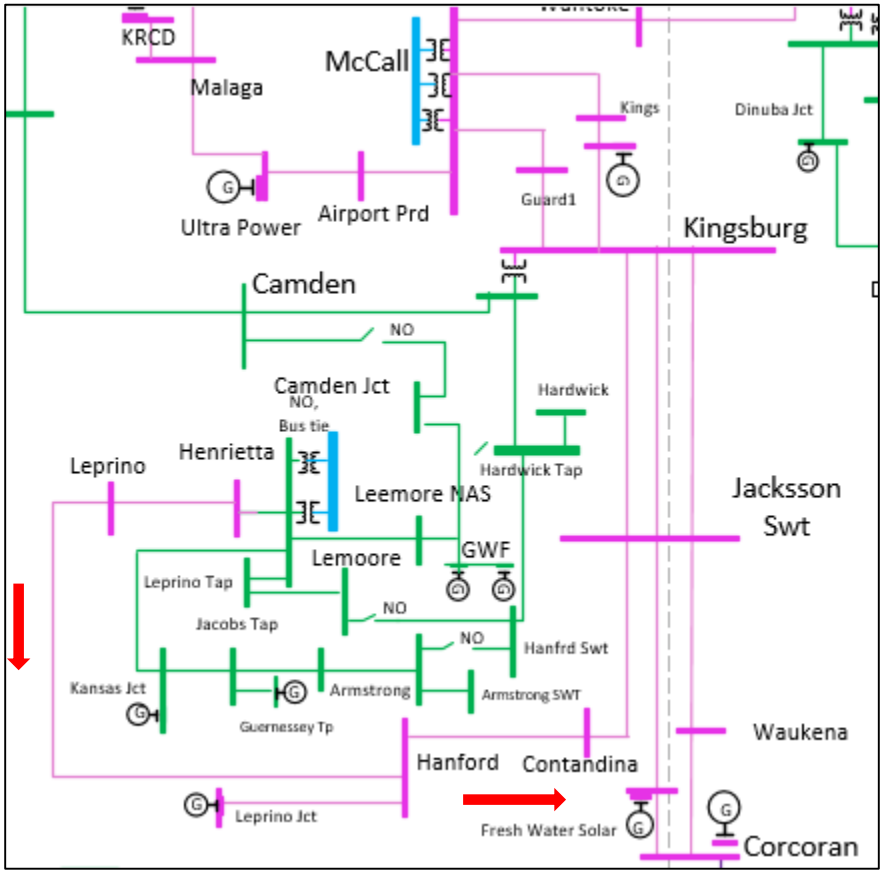
- SPS of tripping solar generators in the Henrietta 115 kV system was modeled

GWF Hanford – Contadina 115 kV congestion occurrences

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	1	2	3	2	3	2	1	5	20	16	16	10	11	10	8	8	2	3	12	18	12	10	7	7
Feb	5	5	3	1	1	0	1	12	17	11	4	4	2	1	3	2	5	0	4	14	15	19	9	8
Mar	3	2	1	0	0	0	0	11	10	7	5	4	3	2	4	3	3	1	4	9	7	6	8	7
Apr	10	5	1	0	0	1	23	14	12	10	5	4	4	2	4	5	2	1	0	2	4	9	6	7
May	3	4	1	1	1	6	12	5	7	1	2	1	2	1	2	3	5	6	1	1	4	3	4	1
Jun	5	4	2	2	2	1	2	2	2	1	1	1	0	1	3	8	11	11	6	16	13	12	15	12
Jul	4	5	2	0	1	1	11	6	4	2	3	3	2	11	13	21	19	18	18	19	23	22	21	13
Aug	0	2	1	0	0	0	8	18	10	5	4	0	2	2	9	15	17	6	12	16	20	18	18	11
Sep	8	6	3	4	1	0	6	19	14	9	13	5	2	7	6	13	11	8	16	19	20	20	15	15
Oct	4	5	3	2	1	0	1	19	21	17	14	9	6	4	4	3	2	3	13	18	22	20	15	11
Nov	0	0	0	0	0	0	0	0	15	11	6	4	6	4	4	0	0	1	4	10	6	2	2	0
Dec	0	1	0	0	0	0	0	2	14	16	10	6	2	5	2	0	0	0	8	7	3	4	2	2

PG&E Fresno Henrietta 115 kV Congestion under 230 kV N-2

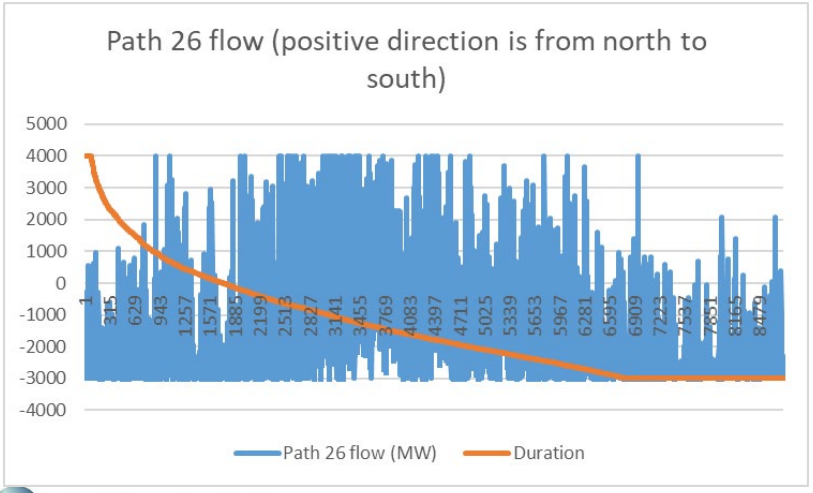


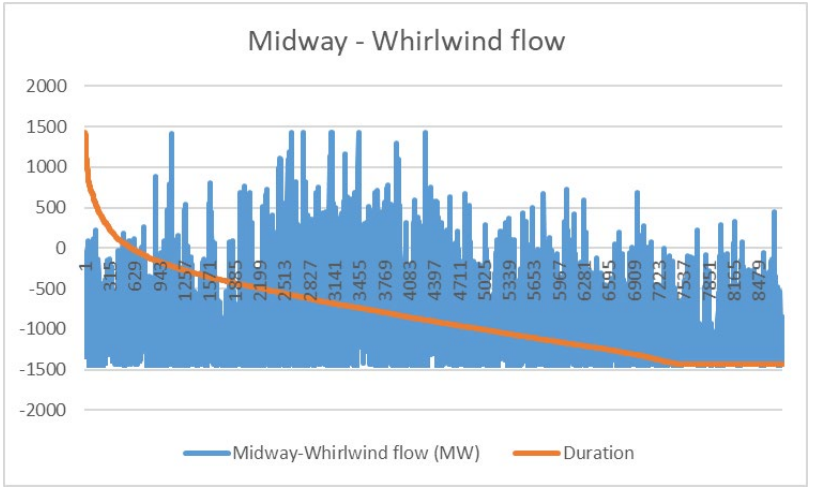


- Potential mitigations can be:
  - Open the Henrietta 115 kV system following the N-2 contingency
  - Reconfigure the 230 kV system to eliminate the P7 contingency
- Reliability impact of these mitigation alternatives needs to be assessed

Path 26 Corridor congestion

Constraints Name	North to South flow		South to North flow	
	Cost ($K)	Duration (Hrs)	Cost ($K)	Duration (Hrs)
P26 Northern-Southern California	57	96	47,976	1,979
MW_WRLWND_31-MW_WRLWND_32 500 kV line #3	2	9	23,996	1,339
MW_WRLWND_32-WIRLWIND 500 kV line, subject to SCE N-1 Midway-Vincent #2 500kV	11	26	2	4
MW_VINCNT_12-VINCENT 500 kV line #1	11	3	0	0
MW_VINCNT_22-VINCENT 500 kV line #2	9	6	0	0
MW_VINCNT_11-MW_VINCNT_12 500 kV line, subject to SCE N-1 Midway-Vincent #2 500kV	4	12	0	0





Path 26 corridor congestion patterns

Path 26 congestion occurrences

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	1	5	9	7	6	3	1	17	29	26	23	21	21	21	20	17	12	12	15	18	16	13	13	14
Feb	3	4	4	6	4	2	5	16	10	6	6	7	8	10	6	8	5	9	12	12	8	4	5	8
Mar	6	6	5	3	3	2	10	13	13	10	7	7	7	6	8	5	7	2	16	15	13	9	9	11
Apr	2	1	0	0	1	1	9	7	9	4	6	3	2	2	2	1	2	0	3	3	3	2	2	1
May	4	1	0	0	1	0	1	2	0	1	1	1	0	0	0	0	1	0	0	1	0	0	0	0
Jun	2	2	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	3	2	1	1	1
Jul	0	0	2	0	0	4	7	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1	2	2
Aug	0	0	5	5	5	5	6	2	0	0	0	0	0	0	0	0	0	0	0	7	4	0	1	1
Sep	2	4	10	9	7	8	22	7	3	2	3	2	1	1	0	1	0	6	7	7	4	3	4	5
Oct	4	7	11	10	6	6	17	24	6	5	4	3	3	3	3	5	2	11	13	10	8	8	8	14
Nov	8	13	14	11	10	9	6	25	24	22	23	21	22	21	19	15	18	21	21	19	19	19	20	23
Dec	4	6	9	9	7	7	5	22	29	26	25	23	18	19	18	14	15	18	23	21	19	16	16	19

Midway – Whirlwind congestion occurrences

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	0	0	0	0	0	0	0	0	2	3	6	3	4	3	4	3	5	4	3	3	4	5	4	4
Feb	3	3	2	2	2	2	2	2	10	14	9	8	7	4	8	5	5	4	5	10	11	11	8	12
Mar	3	3	3	2	3	3	3	11	15	15	16	13	12	12	9	6	7	3	4	5	8	8	5	9
Apr	11	9	7	7	6	6	4	11	16	11	8	7	7	3	3	5	2	0	0	4	3	0	1	3
May	4	4	2	1	1	0	2	2	5	4	0	0	0	0	1	0	5	0	0	4	0	1	0	0
Jun	1	2	1	1	1	1	2	1	1	1	0	0	1	2	2	3	3	2	3	9	12	11	14	17
Jul	0	0	0	0	0	0	3	7	2	1	0	0	0	0	0	1	8	2	7	13	17	16	19	16
Aug	0	0	0	0	0	0	4	13	7	6	5	4	3	2	4	6	5	1	4	8	11	9	12	10
Sep	0	0	0	0	0	0	1	16	11	10	5	4	3	3	3	6	3	1	2	8	13	10	9	12
Oct	0	0	0	0	0	0	0	7	14	15	11	5	2	2	3	4	2	2	4	9	9	10	10	10
Nov	0	0	0	0	0	0	1	4	10	9	15	12	9	10	12	10	6	5	9	7	8	7	7	6
Dec	0	0	0	0	0	0	0	0	1	6	8	7	8	7	8	4	1	3	4	5	5	4	4	4

- S. CA renewable contributes to the Path 26 corridor congestion when flow is from south to north
- S. CA battery discharging in evening contributes to night time congestion
  - S. CA wind also contributes to night time congestion
- Midway-Whirlwind 500 kV line summer rating remains low to get higher emergency rating
- PG&E solar and offshore wind generation provides push-back flow

Generation patterns of SCE Wind, SCE Battery, and Northern CA offshore wind

SCE Wind Average Output (MW)

SCE Wind	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	2,266	2,368	2,510	2,518	2,569	2,528	2,587	2,531	2,369	2,297	2,207	2,197	2,179	2,170	2,170	2,148	2,195	2,199	2,251	2,288	2,265	2,358	2,356	2,366
Feb	2,989	2,896	2,982	2,875	2,870	2,782	2,660	2,412	2,189	2,178	2,183	2,148	2,154	2,185	2,221	2,166	2,461	2,679	2,703	2,628	2,676	2,893	2,994	2,980
Mar	2,426	2,330	2,457	2,482	2,481	2,485	2,357	2,054	1,861	1,912	1,909	1,872	1,892	1,846	1,918	1,962	2,065	2,554	2,566	2,585	2,579	2,694	2,681	2,527
Apr	2,804	2,701	2,623	2,630	2,461	2,266	2,143	1,910	1,790	1,690	1,584	1,504	1,565	1,605	1,720	1,853	1,838	2,773	2,929	3,110	3,092	2,998	2,914	2,845
May	2,082	1,894	1,770	1,791	1,664	1,593	1,327	1,225	1,056	918	797	759	820	875	1,086	1,393	1,541	2,103	2,465	2,699	2,758	2,717	2,656	2,323
Jun	2,265	1,952	1,813	1,775	1,566	1,354	857	693	679	665	655	560	679	842	942	1,144	1,499	2,198	2,757	2,882	2,948	2,919	2,848	2,585
Jul	2,171	1,882	1,645	1,400	1,164	869	461	370	303	362	389	404	476	651	894	1,289	1,724	2,328	2,636	2,744	2,914	2,935	2,819	2,497
Aug	1,993	1,875	1,860	1,749	1,612	1,313	1,046	755	649	673	610	633	708	751	968	1,237	1,593	2,145	2,263	2,440	2,473	2,392	2,455	2,295
Sep	1,699	1,606	1,483	1,467	1,398	1,234	1,027	923	923	982	1,080	1,342	1,431	1,623	1,704	1,838	2,084	1,998	1,967	2,033	2,139	2,238	2,240	2,090
Oct	1,756	1,775	1,816	1,805	1,807	1,756	1,576	1,460	1,403	1,388	1,383	1,338	1,372	1,390	1,471	1,503	1,530	1,620	1,775	1,855	1,860	1,916	1,870	1,833
Nov	2,281	2,328	2,334	2,254	2,288	2,289	2,386	2,404	2,427	2,494	2,529	2,534	2,501	2,553	2,633	2,552	2,369	2,234	2,259	2,251	2,191	2,199	2,200	2,252
Dec	2,453	2,349	2,374	2,481	2,504	2,463	2,374	2,410	2,361	2,341	2,365	2,274	2,280	2,319	2,315	2,247	2,244	2,475	2,476	2,463	2,315	2,376	2,381	2,412

SCE Battery Average Output (MW)

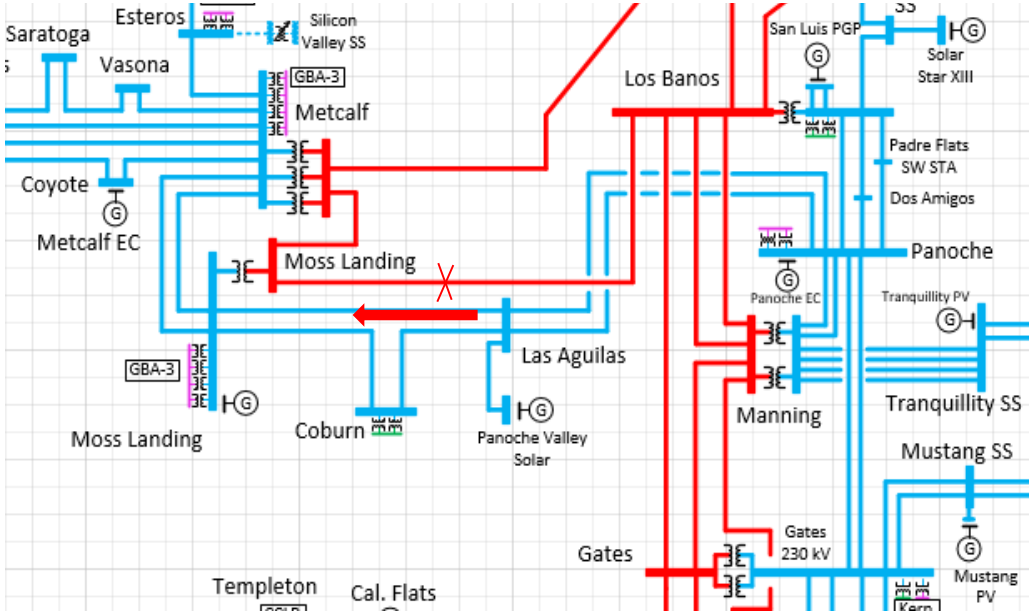
SCE Battery	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	-12,711	-965	0	0	0	0	0	374	-6,709	-16,953	-18,248	-13,622	-14,960	-16,281	-12,010	-8,155	14,724	30,095	19,585	13,137	9,460	5,591	6,099	3,455
Feb	-3,314	-300	-465	-255	0	0	446	850	-35,500	-46,946	-41,263	-38,923	-42,737	-45,194	-54,159	-45,243	-2,780	38,983	47,121	52,641	52,643	37,009	37,464	36,328
Mar	-2,256	-2,617	-113	0	0	0	142	-2,029	-33,287	-46,590	-45,466	-50,997	-48,423	-48,579	-41,364	-35,684	-9,613	29,994	55,748	57,677	65,438	44,622	29,223	29,081
Apr	0	0	0	0	0	0	-1,034	-31,514	-55,214	-68,405	-63,988	-55,647	-38,164	-43,053	-32,652	-26,145	-10,361	6,907	46,445	54,506	76,006	71,786	55,640	50,962
May	-159	-57	0	0	119	66	-11,825	-49,850	-64,228	-68,271	-67,002	-58,637	-44,747	-37,324	-21,340	-11,442	-3,363	1,858	71,274	71,548	75,606	63,719	50,145	38,173
Jun	-709	-774	0	0	0	1,261	-22,025	-36,792	-40,133	-36,506	-41,326	-41,988	-55,481	-52,052	-47,480	-36,251	-18,560	-671	79,567	87,561	63,838	43,307	37,937	52,667
Jul	-3,155	-4,659	-2,270	-705	-32	0	-8,330	-37,842	-50,554	-61,313	-63,915	-50,481	-35,644	-24,103	-20,624	-16,756	-3,788	30,378	92,582	78,613	60,279	29,018	7,285	28,383
Aug	-1,289	-809	-1,351	-4	0	484	-1,415	-38,867	-60,378	-68,441	-59,904	-46,160	-36,395	-30,464	-34,063	-19,431	-2,890	64,487	88,476	77,680	61,050	18,931	11,786	18,526
Sep	-3,640	-1,803	-968	-49	304	1,156	-60	-47,869	-60,557	-63,986	-55,743	-40,741	-27,443	-23,837	-20,801	-5,725	15,881	84,120	73,084	57,085	37,181	7,489	11,048	12,890
Oct	-4,846	-516	-718	-151	0	42	559	-17,973	-50,825	-57,456	-52,665	-43,306	-33,905	-30,246	-28,130	-10,080	42,884	78,758	54,708	39,778	18,371	12,648	15,140	18,306
Nov	-5,262	-302	-7	-93	-4	0	295	-587	-22,694	-33,827	-24,538	-23,050	-21,646	-24,415	-21,451	-1,044	35,520	35,216	25,025	21,726	12,262	7,795	9,289	4,935
Dec	-9,524	-652	-65	-60	0	0	0	17	-3,618	-9,229	-15,069	-14,460	-16,401	-13,911	-7,515	-1,180	21,469	13,603	9,779	10,963	6,873	5,147	4,694	5,385

N. Cal offshore wind Average Output (MW)

Offshore Wind	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	46,544	48,809	50,423	49,361	48,941	47,510	45,661	44,916	44,770	43,179	45,359	45,312	43,146	46,618	52,959	56,983	58,635	60,425	62,695	60,309	54,961	51,677	51,267	52,073
Feb	59,893	57,983	56,422	54,731	51,343	50,857	52,161	52,860	49,839	48,328	49,816	52,244	55,682	59,095	61,914	64,039	69,630	72,387	75,464	73,840	71,956	68,865	65,763	62,167
Mar	57,378	56,735	57,312	55,523	53,098	54,450	55,079	53,001	52,566	51,931	52,038	53,576	53,659	54,086	56,139	58,907	61,523	65,719	66,532	64,001	64,539	62,467	62,765	62,045
Apr	67,261	65,082	63,292	60,391	59,289	58,095	58,451	49,272	46,467	48,547	49,963	50,526	53,483	55,489	58,322	58,543	58,623	73,992	74,348	72,248	69,157	68,903	67,906	66,922
May	87,731	87,337	85,640	86,647	82,778	82,218	66,600	62,398	59,225	57,960	59,187	62,600	64,964	68,284	70,115	67,193	69,290	87,312	97,855	98,440	97,623	97,037	93,202	92,103
Jun	74,069	74,720	74,400	74,287	72,280	71,204	54,662	53,208	51,723	53,178	53,841	57,298	58,861	59,200	58,816	58,600	61,302	72,629	81,460	81,111	79,470	78,413	76,921	75,962
Jul	56,019	57,536	58,487	58,313	57,540	57,737	53,981	54,092	54,911	53,596	55,201	56,303	57,207	57,189	58,807	60,020	62,466	64,786	65,436	64,384	59,708	56,871	55,784	56,539
Aug	59,843	61,019	60,186	59,998	58,247	57,538	55,471	54,123	52,685	53,808	53,448	56,261	59,274	61,935	66,897	66,677	70,089	73,844	72,566	71,868	66,140	63,601	62,241	61,858
Sep	46,693	45,412	44,817	43,919	44,749	44,471	43,095	42,155	40,884	40,381	40,734	40,319	41,321	44,152	45,432	45,511	47,960	50,078	49,802	50,069	46,926	45,612	44,705	44,807
Oct	37,321	33,213	31,782	30,980	31,420	32,302	31,755	32,383	32,579	33,584	34,276	36,129	38,095	40,380	43,497	50,360	53,162	54,499	55,768	52,921	49,141	44,130	42,179	39,787
Nov	40,237	39,289	41,188	42,574	43,617	42,263	45,168	47,064	45,789	44,081	43,335	41,894	42,100	41,972	42,771	43,495	44,053	46,892	47,987	46,896	46,152	44,905	43,219	41,710
Dec	45,075	44,138	45,526	45,335	45,928	42,951	45,235	45,851	44,597	49,216	51,077	50,208	49,500	49,880	49,940	51,460	52,696	51,995	51,200	50,007	45,831	45,781	44,510	42,486

PG&E Moss Landing – Las Aguilas 230 kV congestion under 500 kV N-1

Constraints Name	Costs ($K)	Duration (Hrs)	From Bus Name	From Bus ID	To Bus Name	To Bus ID	CKT
MOSSLNSW-LASAGLSRCTR 230 kV line, subject to PG&E N-1 Mosslanding-LosBanos 500 kV	35,473	1,198	MOSSLNSW	30755	LASAGLSRCTR	30798	1



- Series reactor was modeled
- Congestion increased compared with the last TPP results, mainly due to high volume of solar generators in the Fresno/Kern areas
- Congestion observed not only in summer months:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	0	0	0	0	0	0	0	0	0	1	2	3	2	4	4	2	0	0	0	0	0	0	0	0
Feb	0	0	0	0	0	0	0	0	6	12	12	9	9	9	11	10	7	0	0	0	0	0	0	0
Mar	0	0	0	0	0	0	0	3	11	16	15	17	15	17	13	10	9	0	0	0	0	0	0	0
Apr	0	0	0	0	0	0	1	11	15	15	18	19	14	13	12	12	8	0	0	0	0	0	0	0
May	0	0	0	0	0	0	2	5	7	8	11	7	6	5	6	3	4	0	0	0	0	0	0	0
Jun	0	0	0	0	0	0	5	13	14	15	10	9	6	7	8	6	4	0	0	0	0	0	0	0
Jul	0	0	0	0	0	0	3	21	25	21	20	15	12	11	8	4	3	0	0	0	0	0	0	0
Aug	0	0	0	0	0	0	0	26	29	26	24	20	19	19	16	15	12	0	0	0	0	0	0	0
Sep	0	0	0	0	0	0	0	17	20	21	20	17	16	15	15	16	8	0	0	0	0	0	0	0
Oct	0	0	0	0	0	0	0	3	10	19	15	10	12	13	11	8	0	0	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0	0	2	6	7	6	6	5	4	1	0	0	0	0	0	0	0	0
Dec	0	0	0	0	0	0	0	0	0	1	1	4	5	2	3	1	0	0	0	0	0	0	0	0

Path 15 corridor congestion

Constraints Name	Cost Total ($K)	Duration Total (Hrs)	*From Bus Name*	*From Bus ID*	*To Bus Name*	*To Bus ID*	*CKT*
P15 Midway-LosBanos	7,180	304					
MN_GT_11-GATES 500 kV line #1	7,161	227	MN_GT_11	300501	GATES	30055	1
GATES-GT_MW_11 500 kV line #1	4,964	370	GATES	30055	GT_MW_11	300551	1
LB_MN_11-MANNING 500 kV line #1	244	26	LB_MN_11	300505	MANNING	30052	1
PANOCHE-GATES E 230 kV line, subject to PG&E N-2 LB-Gates and LB-Midway 500 kV	117	53	PANOCHE	30790	GATES E	30902	1
PANOCHE-GATES E 230 kV line, subject to PG&E N-2 Gates-Gregg and Gates-McCall 230 kV	8	4	PANOCHE	30790	GATES E	30902	2
PANOCHE-GATES E 230 kV line, subject to PG&E N-2 Mustang-Gates #1 and #2 230 kV	1	4	PANOCHE	30790	GATES E	30902	2

- Path 15 corridor congestion occurs when the flow is from south to north, mainly due to
  - PG&E Kern and Fresno area renewable
  - Path 26 flow from south to north
- Path 15 corridor congestion increased compared with the results in the last TPP

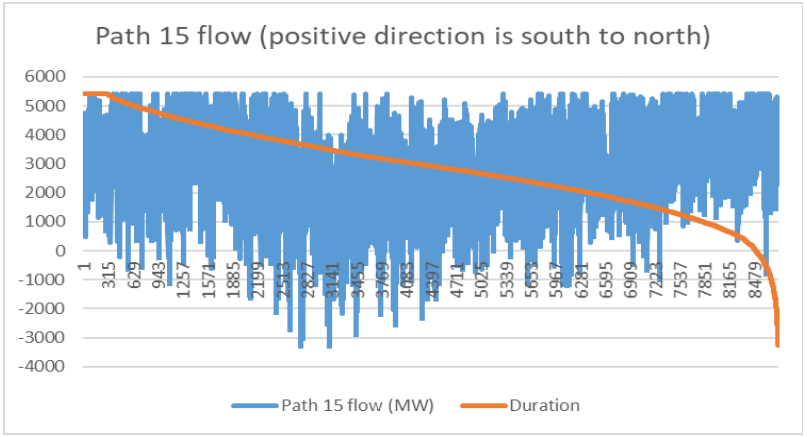
Path 15 flow and congestion patterns

Path 15 Average Flow (MW)

Path15 average flow	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	1,933	2,312	2,559	2,357	2,177	2,068	1,991	3,085	3,997	4,223	4,482	4,646	4,570	4,392	4,246	3,879	2,750	2,682	3,098	3,482	3,342	3,276	3,217	3,106
Feb	2,125	2,460	2,525	2,559	2,150	2,036	2,051	3,567	3,983	3,920	3,997	3,989	3,969	3,996	3,724	3,466	3,339	2,368	3,055	3,220	3,288	3,263	3,140	3,284
Mar	2,577	2,460	2,329	2,069	1,926	1,817	2,371	3,630	3,766	4,095	4,113	3,903	3,690	3,430	3,149	2,886	3,024	1,824	3,247	3,345	3,202	3,304	3,115	3,297
Apr	2,884	2,445	1,985	1,547	1,440	1,614	3,328	3,566	3,868	3,681	3,377	3,089	2,494	2,276	2,238	2,329	2,102	1,361	1,776	2,440	2,277	2,156	2,135	2,340
May	2,842	2,467	1,948	1,262	1,092	1,579	2,410	2,225	2,374	2,189	1,738	1,184	1,192	907	1,438	1,879	2,358	866	1,012	2,043	1,066	989	1,044	995
Jun	2,078	2,179	2,030	1,537	1,103	1,568	2,617	2,213	1,960	1,625	1,429	1,400	1,598	2,026	2,129	2,549	2,602	2,039	1,292	2,276	2,267	2,427	2,565	3,179
Jul	670	1,035	1,541	1,505	1,174	1,581	2,793	3,147	2,779	2,691	2,611	2,342	2,118	1,862	1,899	2,174	2,583	1,552	1,270	1,565	1,915	2,211	3,093	3,730
Aug	1,203	1,641	2,123	2,188	1,997	2,080	3,189	4,333	3,969	3,942	3,813	3,432	3,401	3,015	3,014	3,247	3,284	1,477	1,649	2,409	2,753	2,729	3,311	3,794
Sep	1,926	2,389	2,916	2,978	2,822	2,693	3,627	4,476	4,231	4,207	3,832	3,684	3,390	3,162	3,102	3,335	2,709	2,059	2,411	2,493	2,947	3,135	3,450	3,997
Oct	1,296	1,944	2,528	2,654	2,545	2,464	3,126	4,223	4,260	4,377	4,422	4,124	3,948	3,808	3,656	3,834	2,180	3,103	3,491	3,534	3,606	3,902	3,965	3,905
Nov	2,516	2,842	3,009	2,937	2,807	2,706	2,712	4,218	4,667	4,811	4,727	4,531	4,394	4,341	4,281	4,041	2,875	3,515	4,153	4,262	4,087	3,942	3,807	3,848
Dec	2,571	2,894	3,152	3,020	2,793	2,713	2,604	3,583	4,540	4,499	4,599	4,562	4,518	4,187	4,104	3,969	3,039	3,624	4,011	3,924	3,699	3,524	3,428	3,720

Path 15 congestion occurrences

Path 15 congestion	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	0	0	0	0	0	0	0	0	3	2	5	5	8	6	5	4	0	0	0	1	0	0	0	0
Feb	0	0	0	0	0	0	0	1	4	6	5	4	5	7	4	4	3	0	1	0	1	2	3	3
Mar	0	0	0	0	0	0	0	1	4	6	5	4	1	3	3	3	2	0	0	0	0	0	1	1
Apr	0	0	0	0	0	0	0	3	2	2	3	3	3	1	2	1	1	0	0	0	0	0	0	0
May	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0
Jun	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Sep	0	0	0	0	0	0	0	5	2	2	0	0	0	0	0	3	0	0	0	0	0	0	0	3
Oct	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Nov	0	0	0	0	0	0	0	3	7	8	10	6	7	5	4	2	0	2	2	4	1	1	2	0
Dec	0	0	0	0	0	0	0	0	4	3	7	6	5	5	5	4	3	4	5	3	2	3	3	3



SCE East of Pisgah and Lugo – Victorville congestion

Constraints Name	Costs Forward ($K)	Duration Forward (Hrs)	Costs Backward ($K)	Duration Backward (Hrs)	Cost Total ($K)	Duration Total (Hrs)	*From Bus Name*	*From Bus ID*	*To Bus Name*	*To Bus ID*
LUGO-VICTORVL 500 kV line, subject to SCE N-1 ElDorado-Lugo 500 kV	0	0	33,280	220	33,280	220	LUGO	24086	VICTORVL	26105
ELDORDO-MCCULLGH 500 kV line, subject to SCE N-1 ElDorado-Lugo 500 kV	15,159	1,585	0	0	15,159	1,585	ELDORDO	24042	MCCULLGH	26048
ELDORDO-MCCULLGH 500 kV line, subject to SCE N-1 Lugo-Mohave 500 kV	7,038	717	0	0	7,038	717	ELDORDO	24042	MCCULLGH	26048
P61 Lugo-Victorville 500 kV Line	1,341	13	126	129	1,467	142				

Upgrades identified in the last TPP may help to mitigate congestion in this area:

- Trout Canyon – Lugo 500 kV line
- Eldorado substation 500 kV short circuit duty reconfiguration

Other congestions

Constraints Name	Costs Forward ($K)	Duration Forward (Hrs)	Costs Backward ($K)	Duration Backward (Hrs)	Cost Total ($K)	Duration Total (Hrs)	*From Bus Name*	*From Bus ID*	*To Bus Name*	*To Bus ID*
CALCITE-LUGO 230 kV line #1	11,756	2,062	0	0	11,756	2,062	CALCITE	25500	LUGO	24085
COLLINSVILLE-PITTSBURG-E 230 kV line, subject to PG&E N-1 Collinsvile-Pittsburg-F 230kV	28,523	1,192	0	0	28,523	1,192	COLLINSVILLE	30446	PITTSBURG-E	30527
SLOAN_CYN_5-ELDORDO 500 kV line #1	6,380	808	0	0	6,380	808	SLOAN_CYN_5	189039	ELDORDO	24042
GAMEBIRD-GAMEBIRD 230 kV line, subject to VEA N-2 Pahrump-Gamebird 230 kV with RAS	0	0	3,025	979	3,025	979	GAMEBIRD	189043	GAMEBIRD	189020
GATES F-ARCO 230 kV line #1	0	0	8,355	1,272	8,355	1,272	GATES F	30906	ARCO	30935
ORO LOMA-EL NIDO 115 kV line #1	4,091	560	0	0	4,091	560	ORO LOMA	34162	EL NIDO	34168
LE GRAND-ADERASLRJCT 115 kV line, subject to PG&E N-1 Panoche-Mendota 115 kV	0	0	897	486	897	486	LE GRAND	34116	ADERASLRJCT	34198
ORO LOMA-EL NIDO 115 kV line, subject to PG&E N-1 Panoche-Mendota 115 kV	592	186	0	0	592	186	ORO LOMA	34162	EL NIDO	34168
NEWHALL-DAIRYLND 115 kV line, subject to PG&E N-1 Panoche-Mendota 115 kV	307	473	0	0	307	473	NEWHALL	34150	DAIRYLND	34154

Renewable curtailment in the Base portfolio PCM

Renewable zone	Generation (GWh)	Curtailment (GWh)	Total potential (GWh)	Curtailment Ratio
SCE Northern	41,209	3,591	44,800	8.02%
SCE Eastern	23,620	1,367	24,987	5.47%
PG&E Fresno	18,394	4,257	22,651	18.79%
NM	14,054	1,879	15,933	11.79%
SDG&E Bulk	11,693	0	11,693	0.00%
GLW/VEA	10,019	1,415	11,433	12.37%
AZ-PV	8,388	2,851	11,239	25.37%
PG&E OSW-Diablo	9,847	642	10,490	6.12%
SCE NOL	8,673	1,579	10,252	15.40%
PG&E Kern	8,246	866	9,113	9.50%
PG&E GBA	8,563	199	8,762	2.27%
SCE East of Pisgah	6,342	690	7,032	9.81%
PG&E OSW-Humboldt	6,231	45	6,276	0.71%
WY	4,738	963	5,702	16.90%
PG&E Central Coast	3,413	217	3,630	5.98%
PG&E North Valley	2,662	88	2,749	3.19%
ID	2,443	297	2,741	10.85%
NW	1,593	466	2,059	22.65%
AZ-Mead	869	106	975	10.85%
PG&E Sacramento	868	37	905	4.12%
IID	761	39	801	4.90%
SCE Metro	419	8	426	1.80%
SDG&E Eastern	156	0	156	0.00%
SDG&E Northeast	106	0	106	0.10%
PG&E Humboldt	5	0	5	8.14%
Total	193,312	21,602	214,915	10.05%

- Overall curtailment amount is similar to the last TPP's Sensitivity portfolio PCM results, which had similar total amount of renewable generator capacity
- Compared with the Sensitivity portfolio PCM in the last TPP
  - Curtailment reduced in some southern California areas and the GridLiance/VEA area, attributed to the transmission upgrades approved in the last TPP
  - Still, constraints such as Calcite-Pisgah, Gamebird transformer, and Eldorado-McCullough caused curtailment in the corresponding areas

Sensitivity portfolio preliminary PCM results

Sensitivity portfolio preliminary PCM - congestion

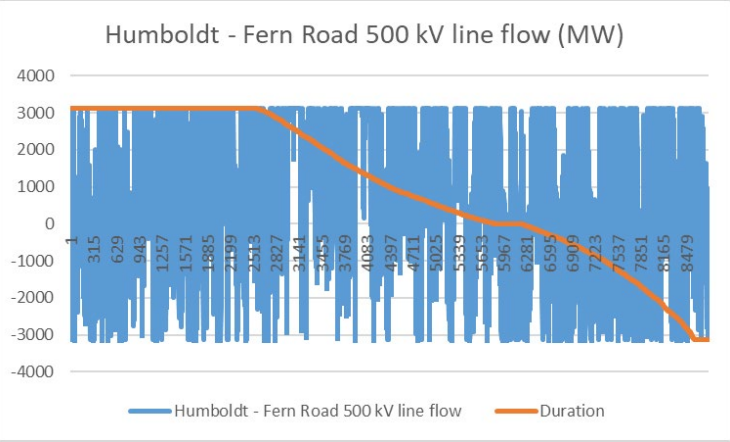
Area	Total Congestion Cost ($M)	Total Congestion Hours (Hrs)
PG&E Humboldt-FernRoad 500 kV	125.15	2,686
PG&E Fresno Henrietta 115 kV	119.37	2,338
PG&E Humboldt-Collinsville HVDC	108.17	1,957
PG&E Humboldt-BayHub HVDC	83.81	3,466
PG&E DiabloCanyon 500 kV	75.54	481
COI Corridor	53.25	970
Path 26 Corridor	34.73	1,950
Path 61 (Victorville-Lugo)	26.83	339
PG&E Collinsville corridor	25.15	1,818
Path 15 Corridor	22.07	706
PG&E Panoche/Oro Loma area	21.61	2,230
Path 46 WOR	11.82	12
SDGE/CFE	11.46	919
SCE East of Pisgah	5.02	847
SDG&E Southern	3.76	277
PG&E Mosslanding-Las Aguilas 230 kV	3.73	462
SCE North of Lugo	2.96	2,498
SCE Antelope 66kV	2.40	1,217
PG&E Sierra	1.75	420
SCE J.Hinds-Mirage	1.59	335
PG&E Fresno 230 kV	1.57	193
Path 49 EOR	1.54	2
PG&E POE-RIO OSO 230 kV	1.45	125
SDG&E Northern	1.30	734
SCE Northern	1.11	342
GridLiance/VEA	0.75	139
PG&E Tesla 230 kV	0.68	58
PG&E Fresno Los Banos 230 kV	0.66	98
SWIP South	0.65	64
Path 65 PDCI	0.59	42
PG&E Kettlman Tap-Gates 70 kV	0.52	1,324

- Offshore wind transmission upgrade:
  - Humboldt – Fern Road 500 kV AC and Fern Road – Vaca Dixon – Tesla 500 kV AC
  - Humboldt – Collinsville HVDC
  - Humboldt – Bayhub HVDC and Bayhub 230 kV upgrades
- Congestion on the offshore wind transmission upgrades was observed
- The offshore wind transmission upgrades, in the meantime, helped to mitigate COI corridor congestion
- Path 26 congestion reduced mainly because the offshore wind provided more push-back flow

Congestion on Humboldt offshore wind transmission

Constraints Name	Cost Forward ($K)	Duration Forward (Hrs)	Cost Backward ($K)	Duration Backward (Hrs)	Cost Total ($K)	Duration Total (Hrs)	*From Bus Name*	*From Bus ID*	*To Bus Name*	*To Bus ID*
HUMBOLDT-OSDC_1 500 kV line #1	108,168	1,957	0	0	108,168	1,957	HUMBOLDT	399100	OSDC_1	399103
HUMBOLDT-OFSDC_1 500 kV line #1	83,812	3,466	0	0	83,812	3,466	HUMBOLDT	399100	OFSDC_1	399105
HUMBOLDT-HB_FR_11 500 kV line #1	80,451	1,568	126	100	80,576	1,668	HUMBOLDT	399100	HB_FR_11	399101
HB_FR_11-HB_FR_12 500 kV line #1	26,647	541	72	60	26,720	601	HB_FR_11	399101	HB_FR_12	399102
HB_FR_12-FERN RD 500 kV line #1	17,816	383	37	34	17,854	417	HB_FR_12	399102	FERN RD	300060

- Humboldt – Fern Road 500 kV AC line congestion was observed mainly when the flow was from Humboldt to Fern Road
- Humboldt – Fern Road congestion can also happen when the flow was from Fern Road to Humboldt
  - This may happen when COI corridor was congested. Flow may be pushed in the direction from Fern Road to Humboldt to mitigate COI corridor congestion



Congestion on Morro Bay offshore wind transmission

Constraints Name	Cost Forward ($K)	Duration Forward (Hrs)	Cost Backward ($K)	Duration Backward (Hrs)	Cost Total ($K)	Duration Total (Hrs)	*From Bus Name*	*From Bus ID*	*To Bus Name*	*To Bus ID*
GATES-DIABLOCNYNSS 500 kV line #1	0	0	70,962	422	70,962	422	GATES	30055	DIABLO CNYNSS	30057
DIABLOCNYNSS-MIDWAY 500 kV line #2	4,573	59	0	0	4,573	59	DIABLO CNYNSS	30057	MIDWAY	30060

- Morro Bay offshore wind increased from 3100 MW in the Base portfolio to 5355 MW in the Sensitivity portfolio
- Morro Bay offshore wind was modeled at Diablo Canyon 500 kV bus
- No new transmission upgrade was modeled for Morro Bay offshore wind
- Congestion was observed in the months when the summer ratings of the lines were used

Gates-Diablo Canyon congestion occurrences

Gates-Diab	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apr	8	5	6	5	5	3	5	3	3	3	3	3	3	2	3	3	4	7	9	12	10	11	12	7
May	4	2	1	1	1	2	1	0	0	0	1	1	1	1	1	1	1	0	1	2	4	4	5	4
Jun	7	5	3	2	2	3	1	1	1	1	1	1	1	1	0	1	0	2	4	8	7	8	8	8
Jul	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug	2	2	2	2	0	0	0	1	1	1	1	2	2	3	3	5	6	5	5	7	4	5	5	5
Sep	2	3	4	3	3	3	3	2	1	1	1	3	3	3	1	3	3	3	3	3	3	3	3	4
Oct	1	1	0	0	0	0	0	0	1	0	0	0	0	0	2	3	4	4	4	5	4	4	2	2
Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Morro Bay offshore wind generation patterns

Morro Bay offshore wind generation monthly average output per hour (MW)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	1,742	1,736	1,743	1,716	1,690	1,645	1,540	1,455	1,477	1,471	1,509	1,443	1,398	1,467	1,704	1,889	1,947	2,060	2,181	2,112	1,948	1,818	1,791	1,820
Feb	2,239	2,184	2,122	2,069	1,901	1,840	1,916	1,890	1,575	1,525	1,509	1,628	1,802	1,961	2,218	2,407	2,599	3,080	3,141	2,981	2,822	2,589	2,462	2,324
Mar	1,861	1,780	1,758	1,598	1,459	1,442	1,462	1,300	1,221	1,247	1,366	1,458	1,501	1,546	1,685	1,808	1,933	2,232	2,268	2,169	2,158	2,027	1,966	2,035
Apr	2,937	2,866	2,808	2,667	2,634	2,474	2,252	1,728	1,753	1,782	1,834	1,859	1,957	2,039	2,219	2,215	2,331	3,233	3,330	3,305	3,213	3,214	3,165	3,059
May	3,568	3,506	3,382	3,415	3,272	3,156	2,237	2,038	1,918	1,905	1,966	2,063	2,184	2,324	2,379	2,413	2,478	3,174	4,060	4,105	4,070	4,022	3,775	3,754
Jun	3,091	3,013	2,988	2,982	2,888	2,776	1,897	1,750	1,664	1,673	1,664	1,837	1,932	1,951	1,892	2,032	2,112	2,935	3,410	3,464	3,380	3,374	3,278	3,155
Jul	1,546	1,535	1,509	1,468	1,382	1,362	1,144	1,139	1,135	1,186	1,257	1,334	1,389	1,453	1,553	1,647	1,807	1,932	1,984	1,953	1,727	1,570	1,486	1,470
Aug	1,952	1,925	1,884	1,889	1,788	1,764	1,671	1,593	1,555	1,662	1,650	1,845	1,977	2,073	2,297	2,285	2,532	2,782	2,739	2,726	2,469	2,280	2,235	2,077
Sep	1,575	1,507	1,518	1,489	1,503	1,538	1,478	1,375	1,357	1,349	1,355	1,413	1,476	1,512	1,557	1,589	1,762	1,866	1,878	1,898	1,730	1,585	1,474	1,449
Oct	1,258	1,108	1,041	1,051	1,020	1,065	1,070	1,079	1,109	1,113	1,145	1,199	1,294	1,411	1,654	1,932	2,127	2,162	2,133	2,017	1,814	1,611	1,485	1,318
Nov	1,310	1,302	1,352	1,405	1,460	1,469	1,524	1,636	1,503	1,466	1,399	1,314	1,269	1,278	1,317	1,430	1,481	1,651	1,718	1,574	1,531	1,453	1,363	1,366
Dec	1,274	1,237	1,247	1,165	1,210	1,194	1,275	1,185	1,206	1,268	1,344	1,258	1,269	1,297	1,299	1,406	1,444	1,509	1,498	1,546	1,403	1,340	1,295	1,216

Other noticeable changes in congestion compared with the Base portfolio PCM results

- Moss Landing – Las Aguilas 230 kV congestion reduced significantly
  - The Sensitivity portfolio has less renewable in PG&E Fresno and Kern areas than the Base portfolio
  - Also, Humboldt Bay offshore wind generation was delivered to the Bay area through the HVDC lines, which help to mitigate flow from Las Aguilas to Moss Landing
- Panoche/Oro Loma area congestion increased due to the Sensitivity portfolio does not include generators at Le Grand
  - Generators at Le Grand can provide push-back flow to some 115 kV lines in this area to mitigate congestion

Renewable curtailment

Renewable zone	Generation (GWh)	Curtailment (GWh)	Total potential (GWh)	Curtailment Ratio
SCE Northern	37,866	2,216	40,082	5.53%
PG&E OSW-Humboldt	30,224	1,193	31,417	3.80%
SCE Eastern	19,015	911	19,926	4.57%
PG&E OSW-Diablo	16,799	1,321	18,120	7.29%
PG&E Fresno	14,888	1,749	16,637	10.51%
NM	14,075	1,858	15,933	11.66%
SDG&E Bulk	10,310	0	10,310	0.00%
SCE NOL	7,539	976	8,515	11.46%
PG&E GBA	7,267	168	7,434	2.26%
GLW/VEA	6,644	499	7,142	6.98%
SCE East of Pisgah	6,443	589	7,032	8.37%
AZ-PV	4,913	1,462	6,375	22.94%
WY	4,879	823	5,702	14.44%
PG&E Kern	4,863	313	5,176	6.06%
PG&E Central Coast	2,848	207	3,054	6.77%
ID	2,422	319	2,741	11.64%
NW	1,604	455	2,059	22.11%
PG&E North Valley	1,388	18	1,406	1.31%
AZ-Mead	855	120	975	12.28%
PG&E Sacramento	741	66	807	8.13%
IID	764	36	801	4.56%
SCE Metro	416	10	426	2.38%
SDG&E Eastern	156	0	156	0.00%
SDG&E Northeast	106	0	106	0.17%
PG&E Humboldt	4	1	5	12.44%
Total	197,027	15,311	212,338	7.21%

- Curtailment ratio in the Sensitivity portfolio PCM is less than in the base portfolio PCM
  - More offshore wind and less inland renewable in the Sensitivity portfolio than in the Base portfolio
- The Humboldt offshore wind transmission upgrades help to mitigate Humboldt wind curtailment. The curtailment ratio of Humboldt wind is 3.80%

Next Steps

Economic planning study requests received

No.	Study Request	Submitted By	Location
1	Pacific Transmission Expansion Project (PTE)	California Western Grid Development, LLC	Northern/Southern California
2	Path 15 conversion to HVDC	Center for Energy Efficiency and Renewable Technology	Northern California
3	Beatty – Esmeralda Project	GridLiance West	Southern Nevada
4	Valley Power Connect Project (NGIV2)	IID/Citizen Energy/Valley Power Connect LLC	Arizona/Southern California
5	SWIP North	LS Power	Idaho/Nevada
6	Moss Landing – Las Aguilas 230 kV line congestion	Vistra	Northern California

Preliminary list of high priority study areas to receive detailed consideration

- Preliminary high priority study areas were proposed based on the preliminary production cost simulation results for the base portfolio and the economic study requests:
  - PG&E Fresno area congestion
    - Moss Landing - Las Aguilas 230 kV congestion reevaluation
    - Henrietta 115 kV congestion
  - GridLiance/VEA area and SCE East of Pisgah area congestion
  - Path 15 corridor congestion
- The list may change with considering stakeholder comments and detailed planning study results

Next steps of PCM simulation and economic assessment

- Continue to develop and enhance the CAISO Planning PCM, including but not limited to
  - Incorporating transmission upgrades to be recommended for approval in this TPP cycle
  - Updating transmission constraints identified in the reliability and policy studies
- Conduct production cost simulations using updated PCM for the Base and Sensitivity portfolios
- Conduct economic assessment for identified high priority upgrades or studies

Wrap-up
Reliability Assessment and Study Updates

Kaitlin McGee
Sr. Stakeholder Engagement and Policy Specialist

2023-2024 Transmission Planning Process Stakeholder Meeting
November 16, 2023

Comments

- Comments due by end of day December 4, 2023

- Submit comments through the ISO's commenting tool, using the template provided on the process webpage:
- https://stakeholdercenter.caiso.com/RecurringStakeholderProcesses/2023-2024-Transmission-planning-process