HVDC Planning and Operation in CAISO

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California ISO

Within its balancing authority area, the California ISO:

- Maintains reliability on the grid
- Manages the flow of energy
- Oversees the transmission planning process
- Operates the wholesale electric market

For much of the western U.S., the ISO:

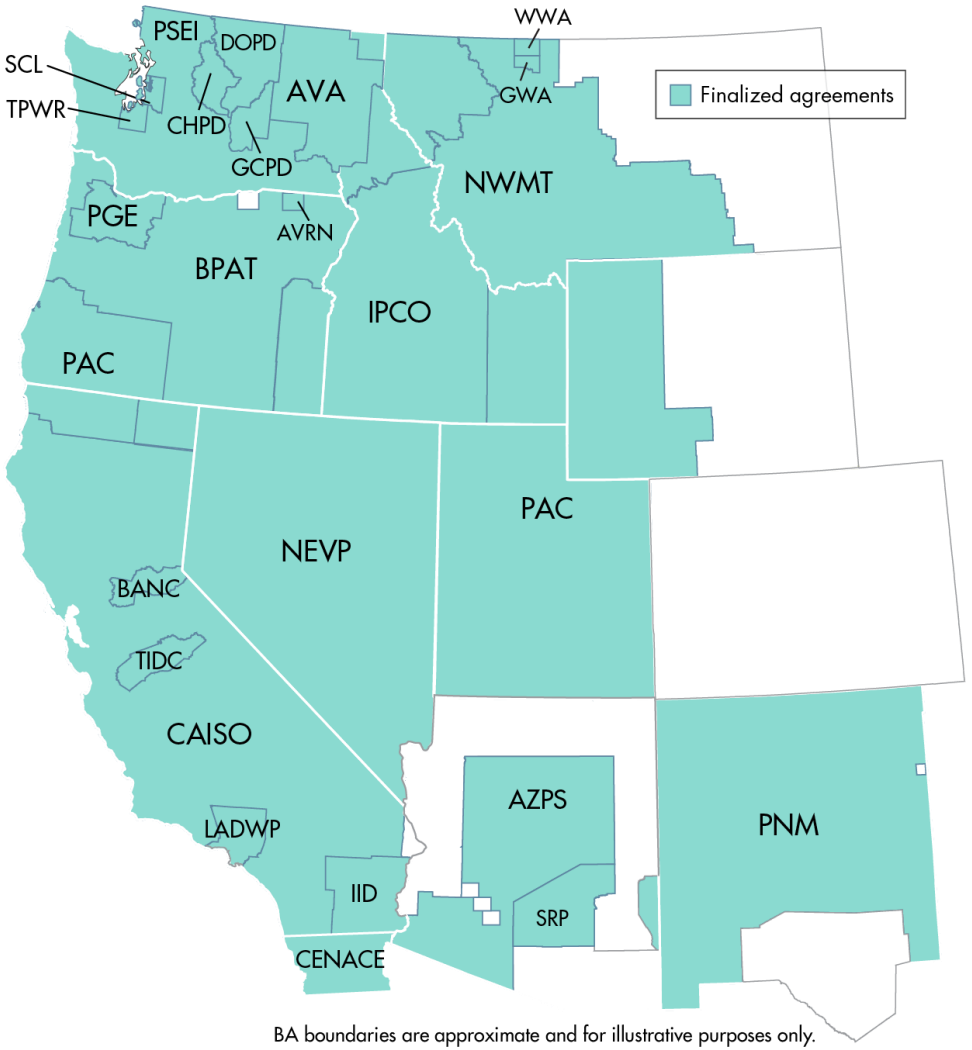
- Operates the Western Energy Imbalance Market (WEIM)
- Serves as Reliability Coordinator (RC West)

RC West

The ISO became the reliability coordinator for the majority of the Western Electricity Coordinating Council (WECC) in 2019.

Reliability coordinators:

- Have authority and responsibility for grid stability
- Monitor the interconnected grids in the West for compliance with federal and regional standards
- Authorize measures to prevent or avoid system emergencies in day-ahead or real-time operations
- Lead system restoration following major incidents



California ISO

California ISO facts

As a federally regulated nonprofit organization, the ISO manages the high-voltage electric grid California and a portion of Nevada.

52,061 MW record peak demand Sept. 6, 2022)

239.1 million megawatt-hours of electricity delivered (2022)

76,184 MW power plant capacity

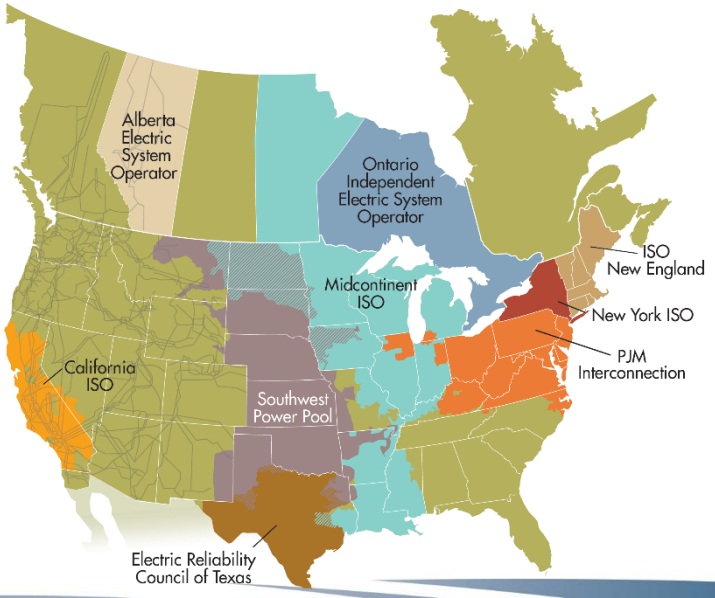
Source: ISO's Masterfile, August 2023

1,119 power plants

Source: California Energy Commission

26,000 circuit-miles of transmission lines

One of **9** ISO/RTOs in North America

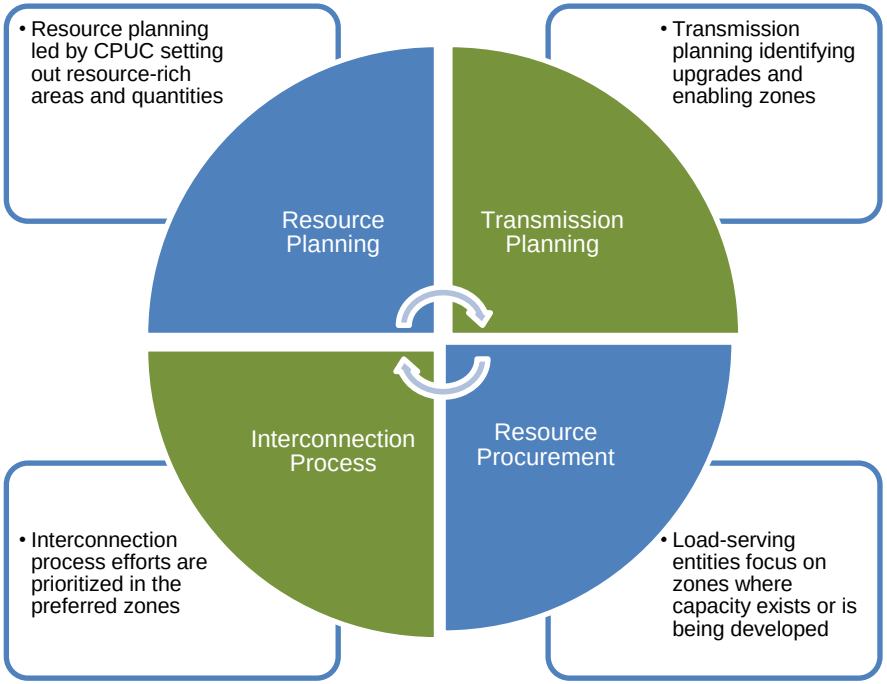


California ISO

Annual Transmission Planning Process

- Load forecast is provided by the California Energy Commission (CEC)
- Resource portfolio is provided by the California Public Utilities Commission (CPUC)
- This is also foundational to other aspects of the plan, which continues to evolve in each cycle:
- Three types of transmission projects may be identified in the process
  - Reliability assessment to meet the requirement of
    - NERC Reliability Standards
    - WECC Regional Criteria
    - ISO Planning Standards
  - Policy assessment
  - Economic (Market Efficiency) assessment

The Transmission Plan addresses the rapidly escalating need for new resources and sets the foundation for a focused zonal approach to resource development



The strategic direction for transformational change in process alignment was established in the CPUC/CEC/ISO Memorandum of Understanding signed in December, 2022 to:

- Tighten the linkage between resource and transmission planning, procurement direction, and the ISO interconnection process to the greatest extent possible.
- Create formal linkage between CEC SB 100/IEPR activities and the ISO and CPUC processes
- Reaffirm the existing state agency and single forecast set coordination

20-Year Transmission Outlook

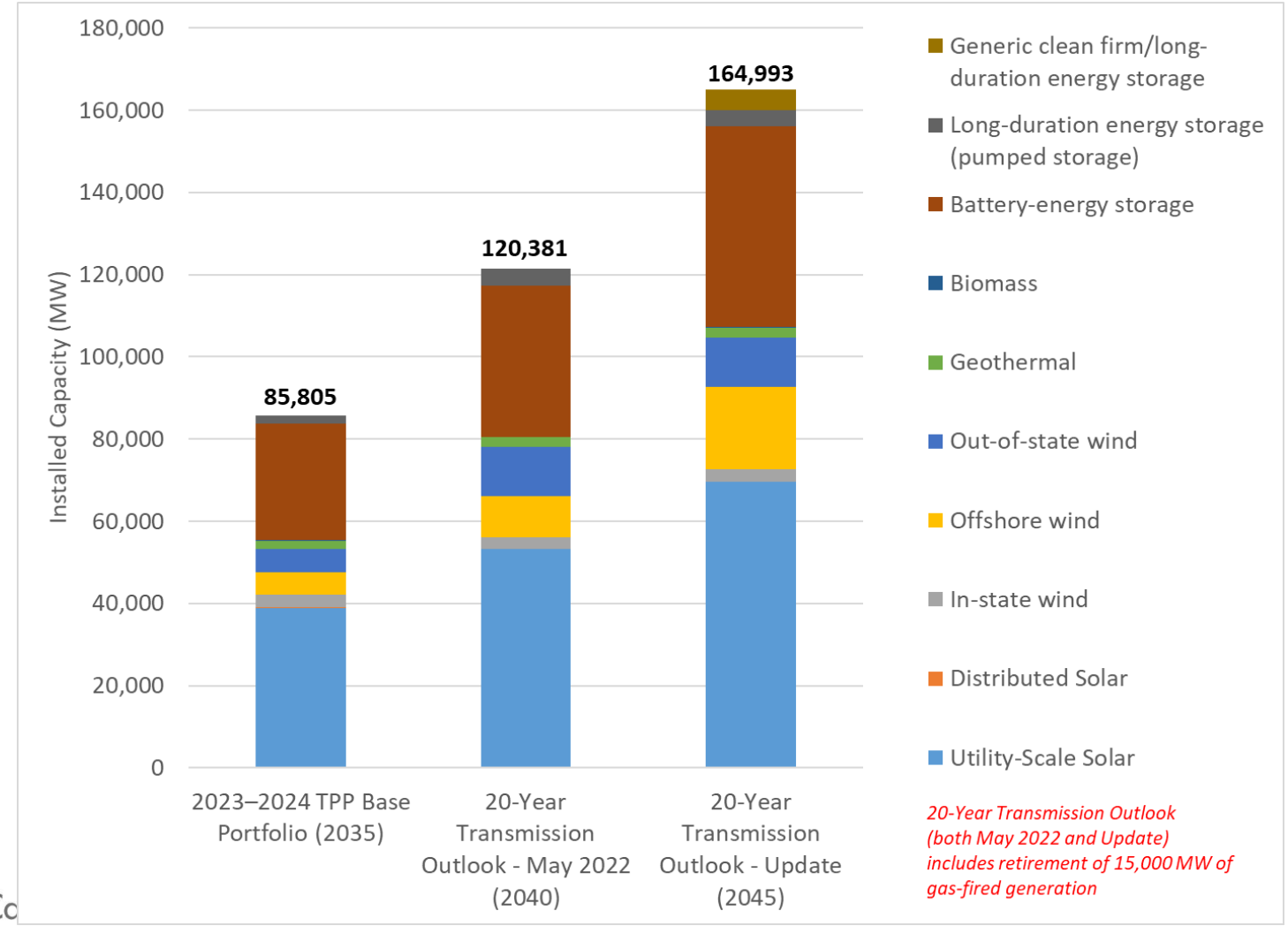
- The ISO produced its first ever 20-Year Transmission Outlook focused on providing a longer term view of transmission needed to reliably meet state clean energy goals

- Issued in May 2022 and posted on the ISO website
  http://www.caiso.com/InitiativeDocuments/20-YearTransmissionOutlook-May2022.pdf

Portfolios – 2023-2024 Transmission Planning Process and 20-Year Transmission Outlook

Resource Type (MW)	2023-2024 Transmission Planning Process		20-Year Transmission Outlook	
	Base Portfolio (2035)	OSW Sensitivity (2035)	May 2022 2040 SB100 Starting Point Scenario (MW)	Update New Resource Assumption in the 2045 Scenario (MW)
Natural Gas Fired Power Plants	-	-	(-15,000)	(-15,000)
Utility-Scale Solar	38,947	25,746	53,212	69,640
Distributed Solar	125	125	-	125
In-state wind	3,074	3,074	2,837	3,074
Offshore wind	5,497	13,400	10,000	20,000
Out-of-state wind	5,618	5,618	12,000	12,000
Geothermal	2,037	1,149	2,332	2,332
Biomass	134	134	-	134
Battery-energy storage	28,373	23,545	37,000	48,813
Long-duration energy storage (pumped storage)	2,000	1,000	4,000	4,000
Generic clean firm/long-duration energy storage	-	-	-	5,000

Portfolios – 2023-2024 Transmission Planning Process and 20-Year Transmission Outlook

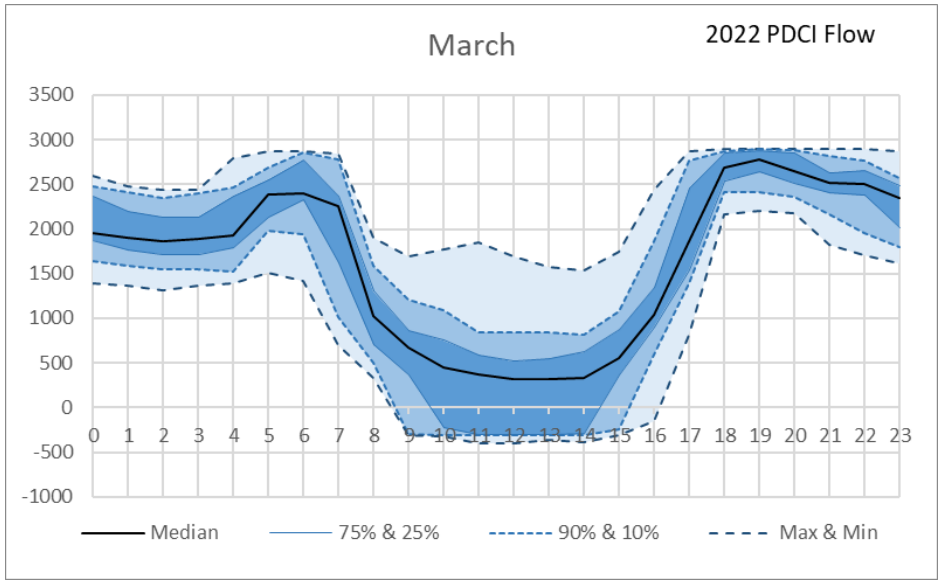


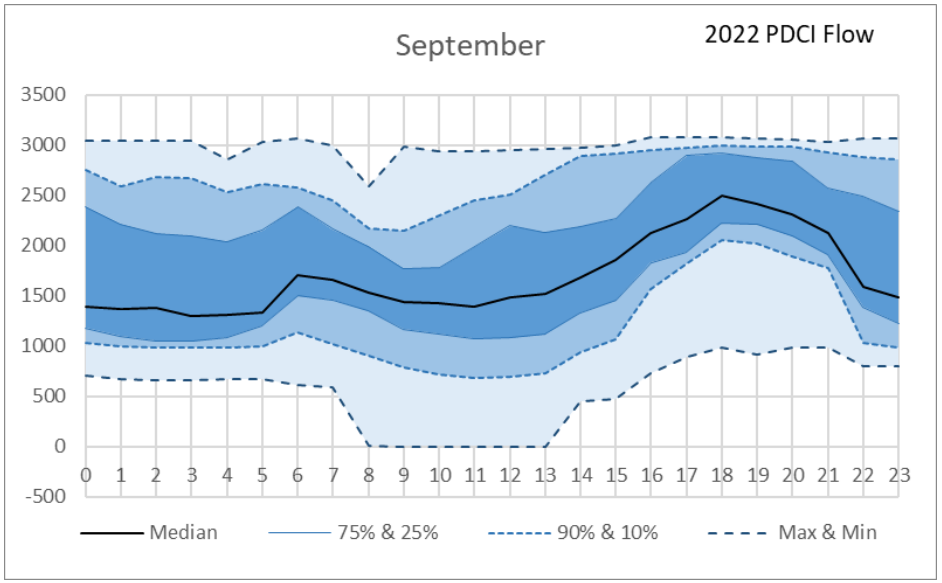
HVDC Planning and Operation in CAISO

Existing HVDC Projects in California

- There are 3 HVDC projects in operation in California
  - Pacific DC Intertie (PDCI)
    - 3,220 MW (N-S), 3,100 MW (S-N)
    - CAISO has scheduling right for 50% of the capacity
    - Is dispatched based on the market requirements
  - Trans Bay Cable
    - 400 MW VSC-HVSC with MMC technology
    - Is dispatched to serve load in San Francisco area
  - Intermountain Power Project DC Line (IPPDC)
    - 2,400 MW (NE-SW), 1,400 MW(SW-NE)

PDCI Dispatch in Operation

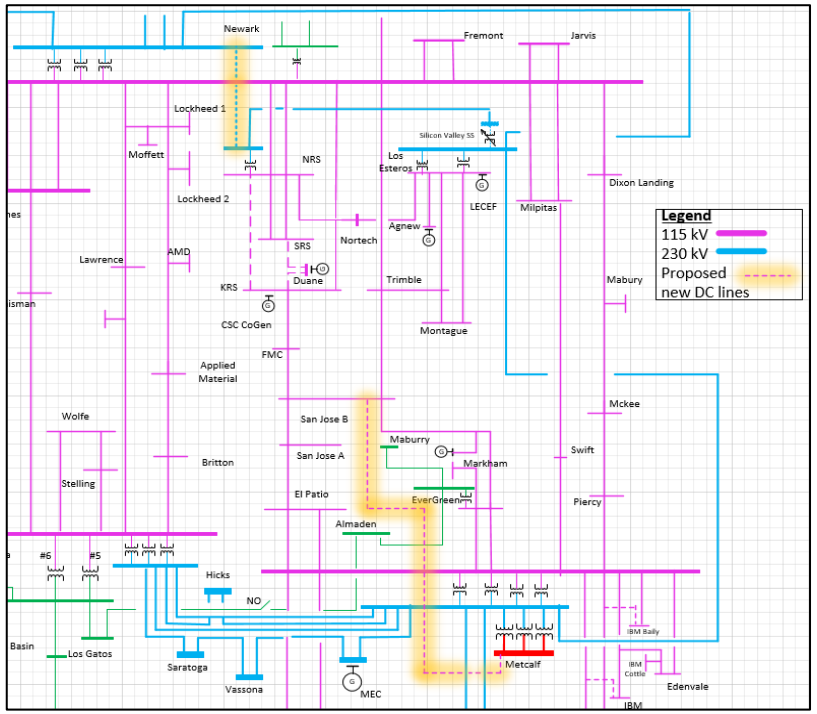




HVDC Projects Under Development

Planned San Jose Area HVDC Projects (expected ISD: 2028)

- In the 2021-2022 Transmission Planning Process it was identified that the existing transmission system in the San Jose area doesn't have the capacity to serve the forecast load.
- Alternatives Considered
  - 115 kV lines reconductoring
  - New 230 kV AC lines
  - Energy Storage
  - HVDC Lines



- Approved Project Scope
  - To build two HVDC lines,
    1) Newark 230 kV to NRS 230 kV
    2) Metcalf 500 kV to San Jose B 115 kV
  - The ultimate configuration is to connect the two HVDC lines to form a multi-terminal HVDC system
  - Flow control, voltage support at the terminals, and less challenges with going underground were the reasons to selects VSC-HVDC technology for this project.

HVDC Projects Studied in CAISO Planning Evaluations

HVDC Projects are Considered to Integrate Offshore Wind into CAISO System

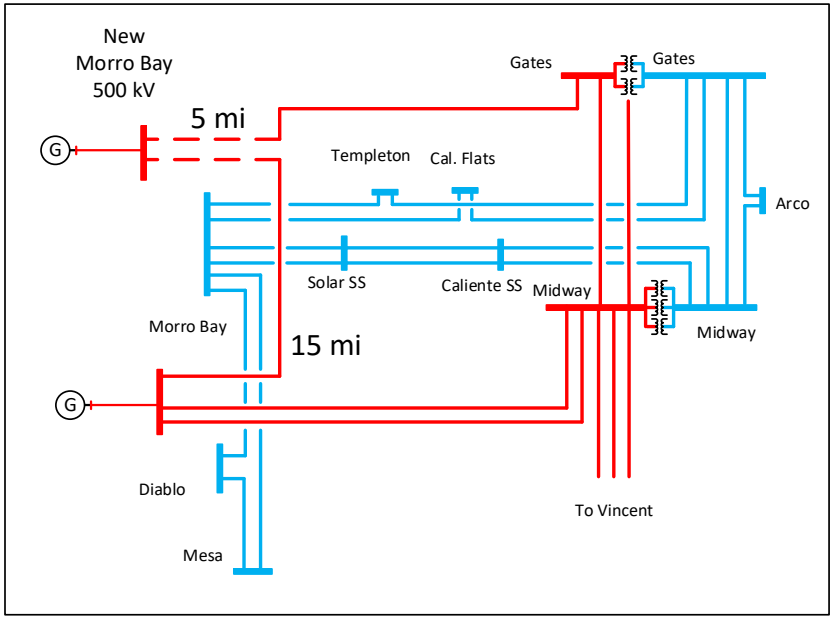
		2023-2024 TPP	
	20-Year Outlook	Sensitivity Portfolio	Base Portfolio
Del Norte	7,000	3,445	0
Humboldt Call Area	2,700	2,600	1,607
Cape Mendocino	4,900	2,000	0
Total	14,600	8,045	1,607

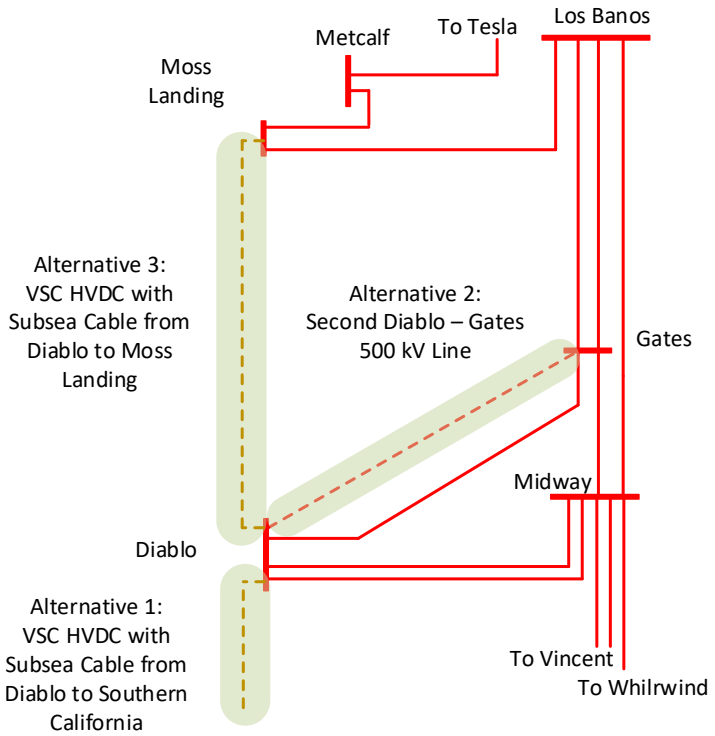
Source: [The Cost of Floating Offshore Wind Energy in California Between 2019 and 2032 (nrel.gov)](#) (Page 39)

		2023-2024 TPP	
	20-Year Outlook	Sensitivity Portfolio	Base Portfolio
Morro Bay	5,400	5,355	3,100
Total	5,400	5,355	3,100

Central Coast Offshore Wind Interconnection

- It the 2021-2022 Transmission Plan it was identified that up to 5.3 GW of generation could be integrated into the 500 kV system in Morro Bay / Diablo area.
- Additional transmission is needed to integrate more resources in the area

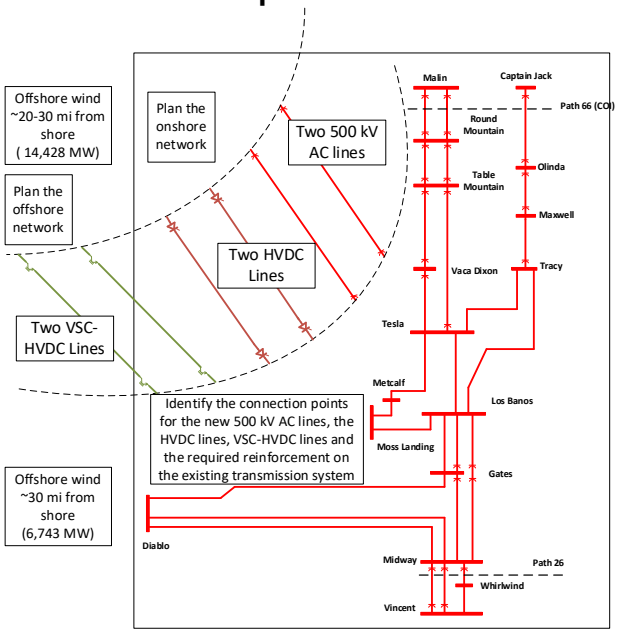




Transfer Path for North Coast OSW in the 20-year Outlook

- In the offshore wind sensitivity study in the 2021-2022 Transmission Plan a hybrid solution was evaluated to integrate 14,428 MW of OSW in the North Coast
- Same solution is expected to provide sufficient capacity as the transfer path for the 14,600 MW North Coast OSW in the portfolio for the updated 20-year outlook

High level assessment of a hybrid transfer path	
500 kV AC line to Fern Road	2
Onshore overhead VSC-HVDC to Collinsville	2
Offshore sea cable VSC-HVDC to Bay Area	2



Reference: 2021-2022 Transmission Plan (page 255)
http://www.caiso.com/Documents/ISOBoardApproved-2021-2022TransmissionPlan.pdf

Next Steps on Offshore Wind Studies

- Perform studies to identify system enhancements required for the integration of the offshore wind under 20-year outlook, 2023-2024 sensitivity portfolio, and 2023-2024 base portfolio.
- Propose project for approval for the integration of the offshore wind as part of 2023-2024 transmission plan
  - The overall objective is to propose a project that would have the capacity to integrate the offshore wind in the base portfolio, and has the flexibility for expansion to higher levels in the sensitivity portfolio and the 20-year outlook