DOCKETED	
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Project Title:	California Offshore Renewable Energy
TN #:	250371
Document Title:	May 25, 2023 Workshop on AB 525-Assessing Transmission Upgrades and Investments for OSW Development off the Coast of California
Description:	Slide deck of presentations for the May 25, 2023 AB 525 Workshop on Assessing Transmission Upgrades and Investments for Offshore Wind Development off the Coast of California
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Organization:	California Energy Commission
Submitter Role:	Commission Staff
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AB 525 Workshop
Assessing Transmission Upgrades and Investments for Offshore Wind Development off the Coast of California

May 25, 2023

AM Workshop Schedule

1. Welcome
2. Opening Remarks
3. Overview of AB 525
4. Purpose of Workshop
5. Integrated Resource Plan Overview
6. CAISO Transmission Studies
7. Schatz Offshore Wind Transmission Studies
8. Public Comment
9. Lunch Break

PM Workshop Schedule

1. Welcome Back
2. Opening Remarks
3. Guidehouse Transmission Technologies Assessment
4. New Jersey's Offshore Wind Transmission
5. California Offshore Wind Lessee Perspectives on Transmission
6. Facilitating Offshore Wind Transmission
7. Public Comment
8. Closing Remarks

Opening Remarks

Overview of AB525
Rachel MacDonald

AB 525 Legislative Findings

If developed at scale, offshore wind can:

- ✓ Provide economic and environmental benefits.
- ✓ Advance progress toward California’s renewable and climate goals.
- ✓ Diversify the state’s energy portfolio.
- ✓ Realize economic and workforce development benefits.
- ✓ Contribute to renewable resource portfolio that can serve electricity needs and improve air quality in disadvantaged communities.
- ✓ Offer career pathways and workforce training opportunities.

Offshore wind should be developed in a manner that protects coastal and marine ecosystems.

AB 525 Required Interim Work Products

August 10, 2022

Evaluate and quantify maximum feasible capacity of offshore wind

Establish megawatt planning goals for 2030 and 2045

February 28, 2023

Complete a preliminary assessment of economic benefits related to seaports and workforce development needs and standards

May 10, 2023

Develop a permitting roadmap

Purpose of Workshop
Jim Bartridge

AB 525 Offshore Wind Transmission

AB 525 requires CEC to:

- Assess transmission investments and upgrades necessary to support the 2030 and 2045 offshore wind planning goals
- Identify relevant information on the cost of subsea high-voltage transmission
- Assess the existing transmission infrastructure and associate upgrade costs to support offshore wind energy development
- Consult with CPUC and CAISO

Key Analytical Inputs

- CPUC Integrated Resource Planning (IRP)
- CAISO Transmission Planning Process (TPP) Offshore Wind Transmission Studies
- 2020/2022 Studies by Schatz Energy Research Center, Cal Poly Humboldt
- Current DoD funded Schatz Energy Research Center
  - Northern California & Southern Oregon Mission Compatibility and Transmission Infrastructure Assessment
- Guidehouse Transmission Technology Assessment – interconnection technology and costs and emerging technologies

David Withrow
California Public Utilities Commission

The CPUC's Integrated Resource Planning (IRP) Process and Transmission Planning

CEC Workshop on AB 525

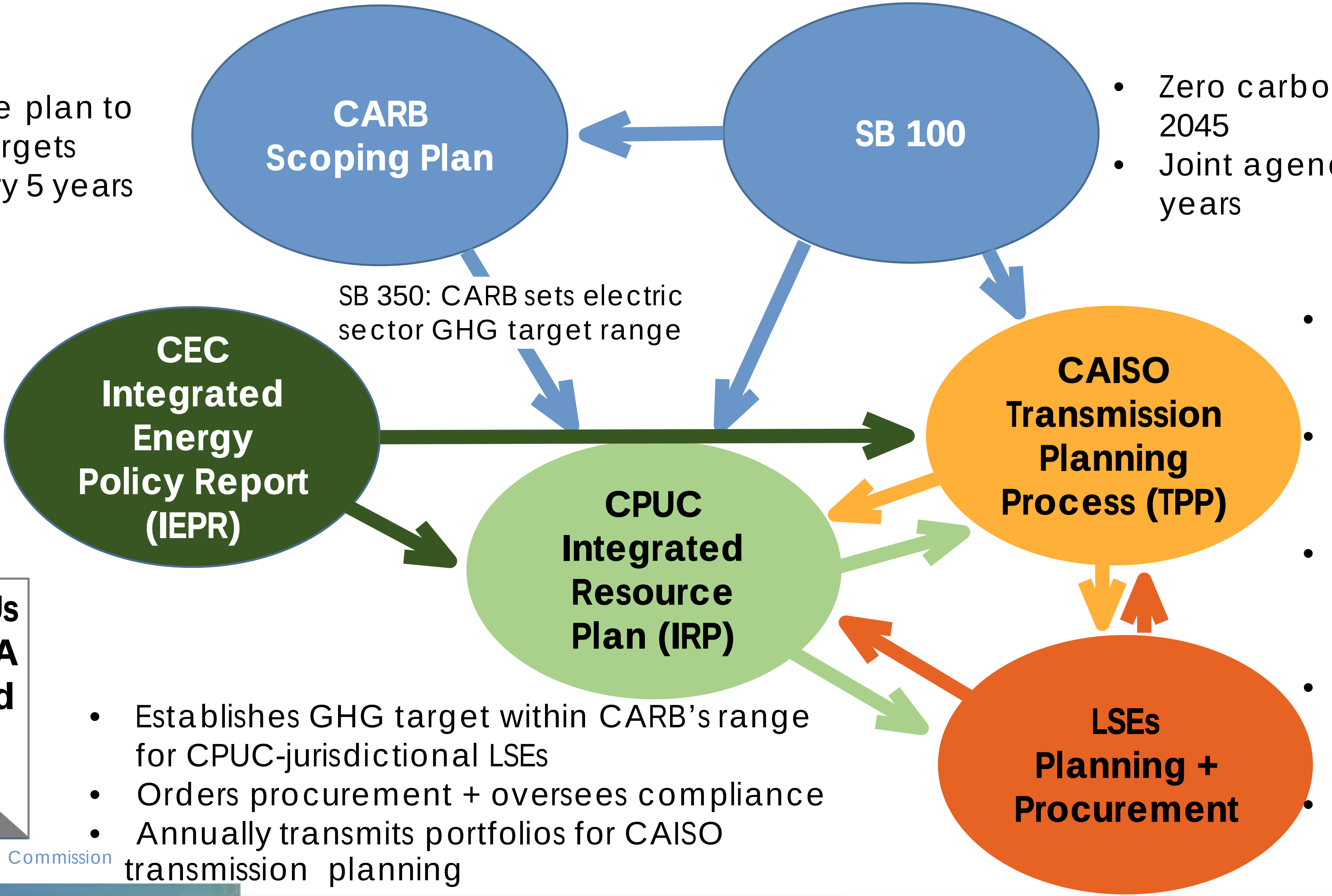
May 25, 2023

California Public Utilities Commission

California's Electricity Planning Ecosystem

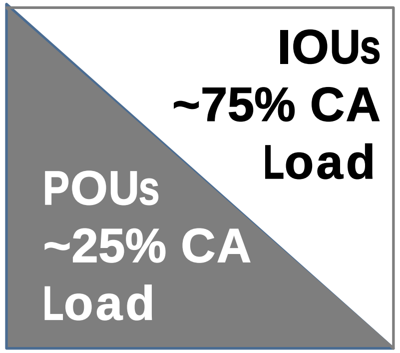
- Economy-wide plan to reach GHG targets
- Updated every 5 years

- Zero carbon electricity by 2045
- Joint agency report, every 4 years



- Demand forecast for infrastructure planning
- Updated annually

- Assess transmission needs
- Conceptually approves new projects
- Updated annually



- Establishes GHG target within CARB's range for CPUC-jurisdictional LSEs
- Orders procurement + oversees compliance
- Annually transmits portfolios for CAISO transmission planning

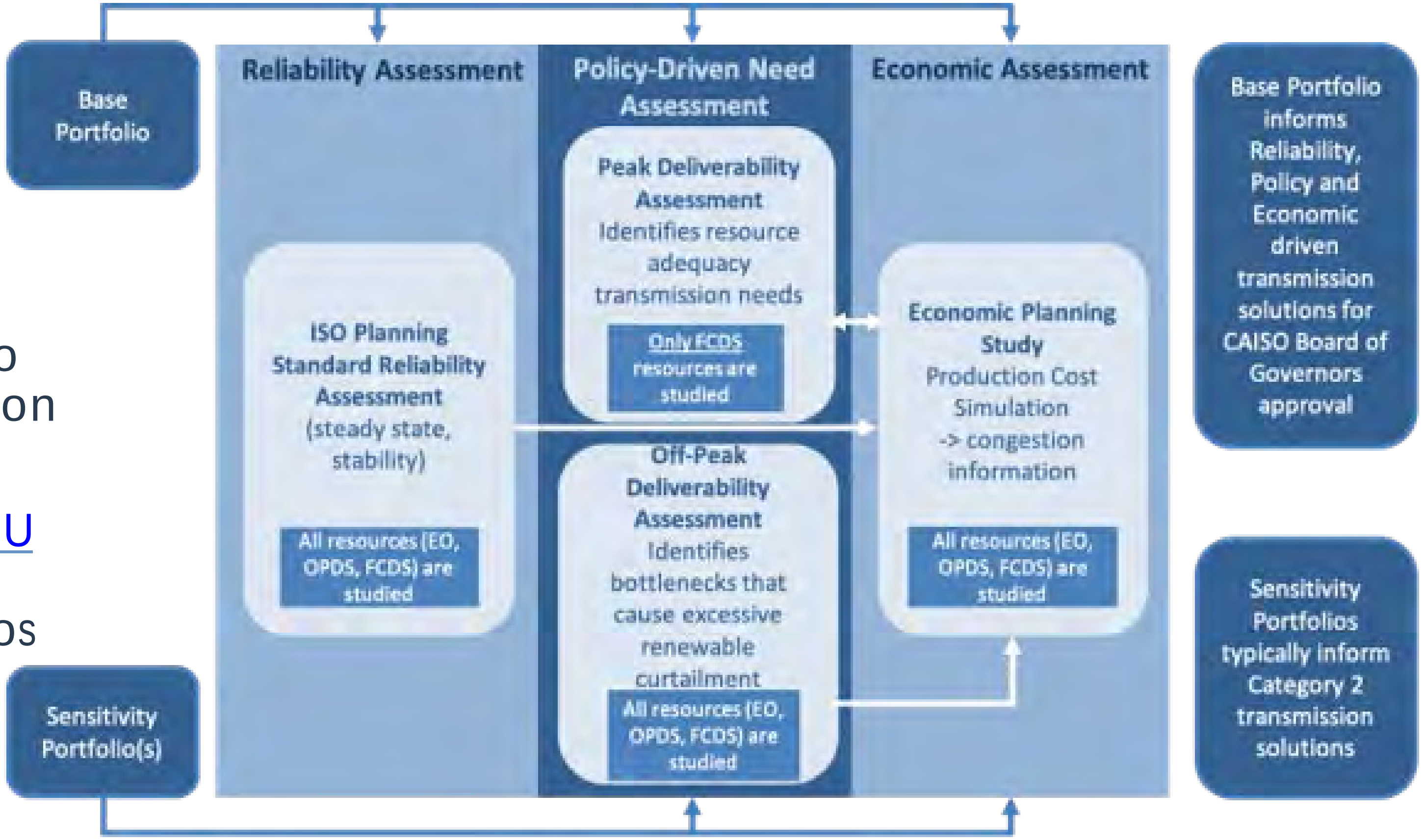
- Plans filed per SB 350 + CPUC guidance
- Procurement in compliance w/ CPUC directives

Overview of Integrated Resource Planning

- California today is a complex landscape for resource planning:
  - Multiple Load Serving Entities (LSEs) including:
    - Investor-Owned Utilities (IOUs)
    - Community Choice Aggregators (CCAs)
    - Energy Service Providers (ESPs)
- A key objective of <u>integrated</u> resource planning is to reduce the cost of achieving GHG reductions and other policy goals by looking across individual LSE boundaries and resource types to identify solutions to reliability, cost, or other concerns that might not otherwise be found.
- Each IRP cycle seeks to ensure that the electric sector is on track to supply 100% of all retail sales of electricity from renewable and non-carbon resources by end of 2045.
  - IRP modeling is continuously updated. IRP workshop on latest “Inputs and Assumptions” draft updates to be conducted in June 2023.
- IRP planning and procurement tracks seek to ensure that the electric sector maintains a robust decarbonization trajectory.

IRP Role in the CAISO's Transmission Planning Process

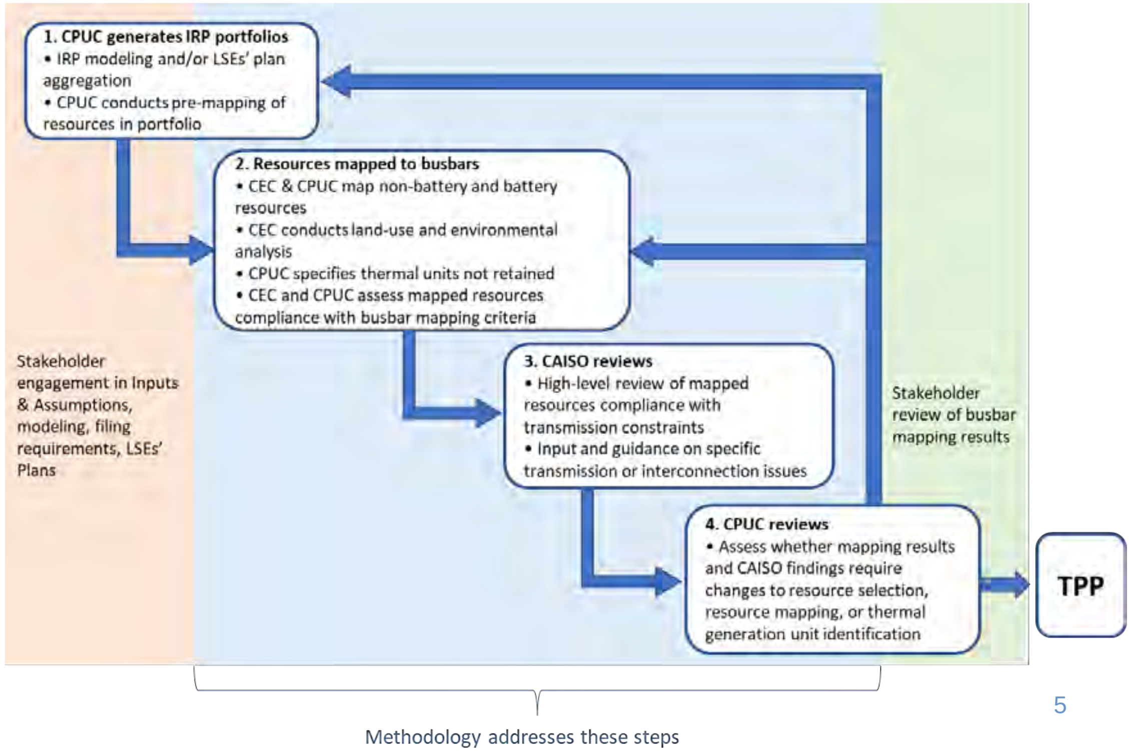
- The CAISO's TPP is an annual comprehensive evaluation of the CAISO's transmission grid to:
  1. Address grid reliability requirements,
  2. Identify upgrades needed to successfully meet California's policy goals, and
  3. Explore projects that can bring economic benefits to consumers.
- Historically has focused on grid needs up to 10-years into the future, but will now focus on 15-year horizon.
- In accordance with a December 2022 MOU between the CAISO, the CPUC, and the CEC, the CPUC develops resource portfolios used by the CAISO in the TPP.
- The CPUC typically transmits multiple distinct portfolios developed in the IRP process:
  - Reliability and Policy-Driven Base Case portfolio
  - Policy-Driven Sensitivity portfolio(s)



Role of Busbar Mapping in IRP and TPP

- **Resource to Busbar Mapping** ("busbar mapping"): The process of refining the geographically coarse portfolios developed through IRP to specific interconnection locations (i.e. substations) for analysis in the CAISO's annual Transmission Planning Process (TPP).
  - First conducted as "proof of concept" for the 2018-2019 TPP portfolio
  - Formalized into a joint effort by a working group comprised of CPUC, CEC, and CAISO staff.
  - Mapping is conducted based on stakeholder vetted methodology.

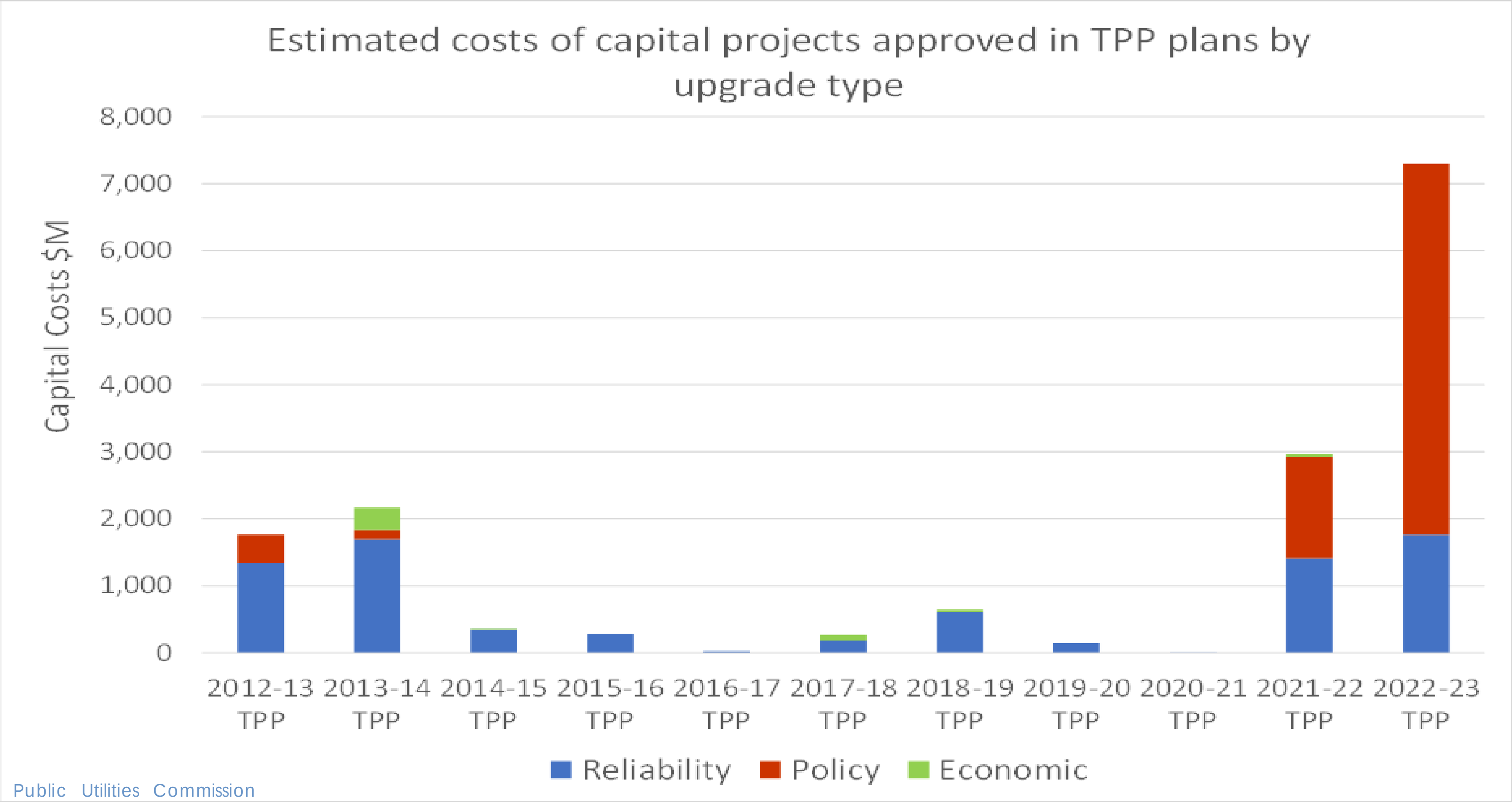
- **Busbar Mapping Scope:** Mapping focuses on utility-scale generation and storage resources that are not already in baseline.
- **Busbar Mapping Methodology:** Methodology document states guiding principles, establishes mapping criteria, and outlines the iterative inter-agency mapping process.
  - Current Methodology makes minor refinements to previous version used for the 22-23 TPP mapping efforts, but further proposed updates for 24-25 TPP are forthcoming.



2022-2023 TPP Cycle (just completed)

- CPUC adopted in D.22-02-004 the “Preferred System Plan”, a portfolio of resources that would achieve a 38 MMT target for GHG emissions by 2030, which drops to 35 MMT by 2032.
  - CAISO analyzed this base portfolio, which included 1.7 GW of offshore wind in 2032, along with a high electrification load forecast.
  - CAISO also was asked (see Transmittal Letter) to analyze a portfolio with a 30 MMT emission limit using high electrification demand assumptions. This sensitivity portfolio includes 4.7 GW of offshore wind in 2035.
- CAISO’s 2022-2023 Transmission Plan reflects the transmission that will be needed to reliably serve load, assuming these inputs of future resources and load assumptions.

CAISO-approved Transmission 2013 -2023



2023-2024 TPP Cycle (In progress)

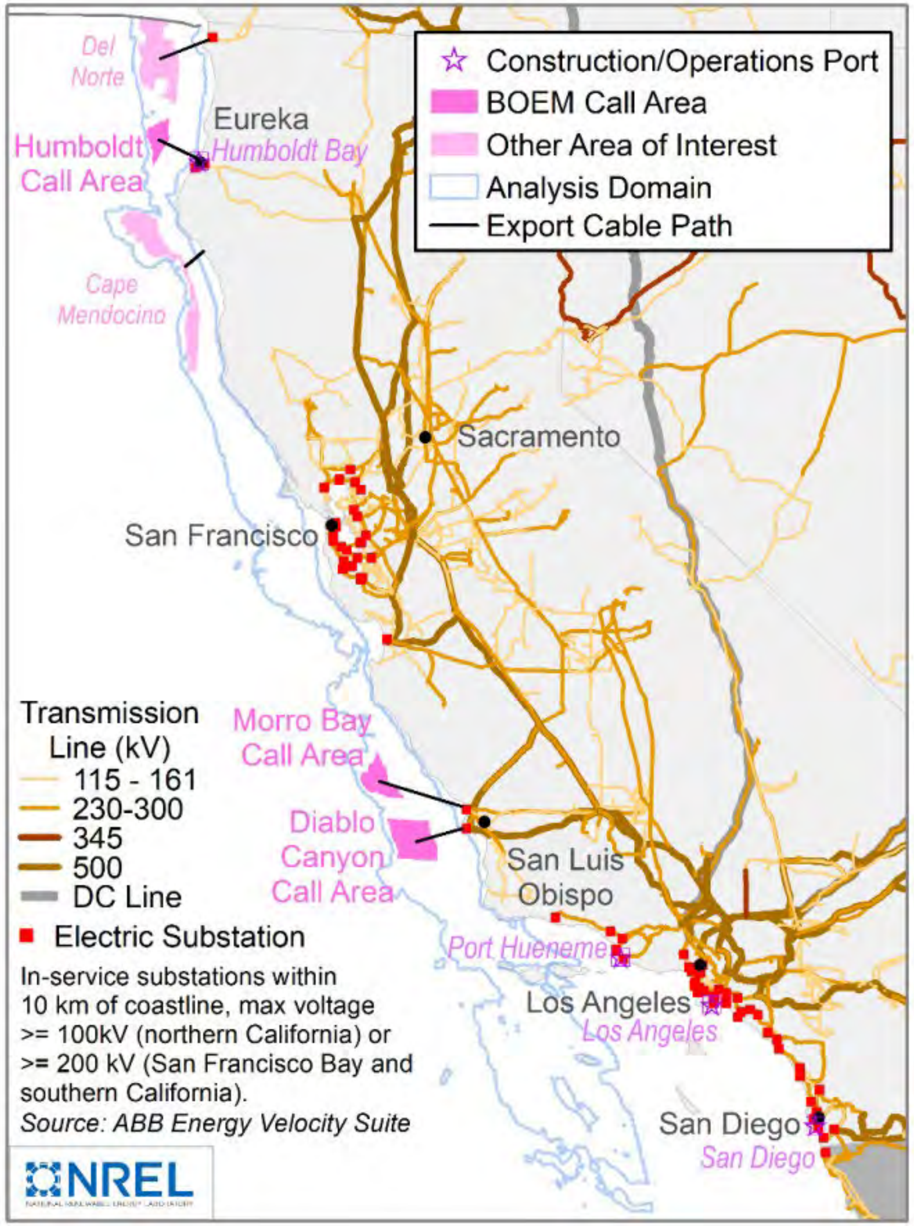
- In February 2023, CPUC conveyed (D.23-02-040) the portfolios to be analyzed by the CAISO in the current TPP.
- The actionable base case portfolio has a 30 MMT emissions target in 2030 with load assumptions reflecting high electrification.
  - 85 GW (nameplate) of new resources
  - Includes 4.7 GW offshore wind in 2035:
    - 3.1 GW in Morro Bay
    - 1.6 GW in Humboldt area
- CPUC also conveyed a sensitivity portfolio designed to identify transmission needs associated with large amounts of offshore wind.
  - 5 GW central coast
  - 8 GW north coast

Process for Portfolio Development for 2024-2025 TPP Cycle

- *October 2023*: CPUC expects to invite stakeholder comments on staff recommendations for the portfolios (with busbar mapping methodology) to be analyzed by the CAISO in 2024-25 TPP.
- *November 2023:* Stakeholder comments due
- *December 2023*: Proposed Decision on TPP portfolios
- *First Quarter 2024*: Commission Decision on TPP portfolios
- *First Quarter 2024*: CAISO initiates 2024-2025 TPP

Offshore Wind In Recent TPP Base Case Portfolios	2022-2023 TPP	2023-2024 TPP	
Potential Offshore Wind Locations	2032 (MW)	2033 (MW)	2035 (MW)
Morro Bay Wind Energy Area	1,588	3,100	3,100
Diablo Canyon Dormant Call Area	-	-	-
Humboldt Wind Energy Area	120	161	1,607
Del Norte Interest Area	-	-	-
Cape Mendocino Interest Area	-	-	-
Total	**1,708**	**3,261**	**4,707**

Recent Offshore Wind Portfolios for TPP Sensitivities	2021-2022 TPP		2023-2024 TPP
Potential Offshore Wind Locations	Core Sens. Study (MW)	High-Level Eval. (MW)	Core Sens. Study (MW)
Morro Bay Wind Energy Area	2,324	2,324	5,355
Diablo Canyon Dormant Call Area	4,419	4,419	-
Humboldt Wind Energy Area	1,607	1,607	2,600
Del Norte Interest Area	-	6,605	3,445
Cape Mendocino Interest Area	-	6,216	2,000
Total	**8,350**	**21,171**	**13,400**



Jeff Billinton
California Independent System Operator

Transmission Planning for Offshore Wind

Jeff Billinton
Director, Transmission Infrastructure Planning

May 25, 2023

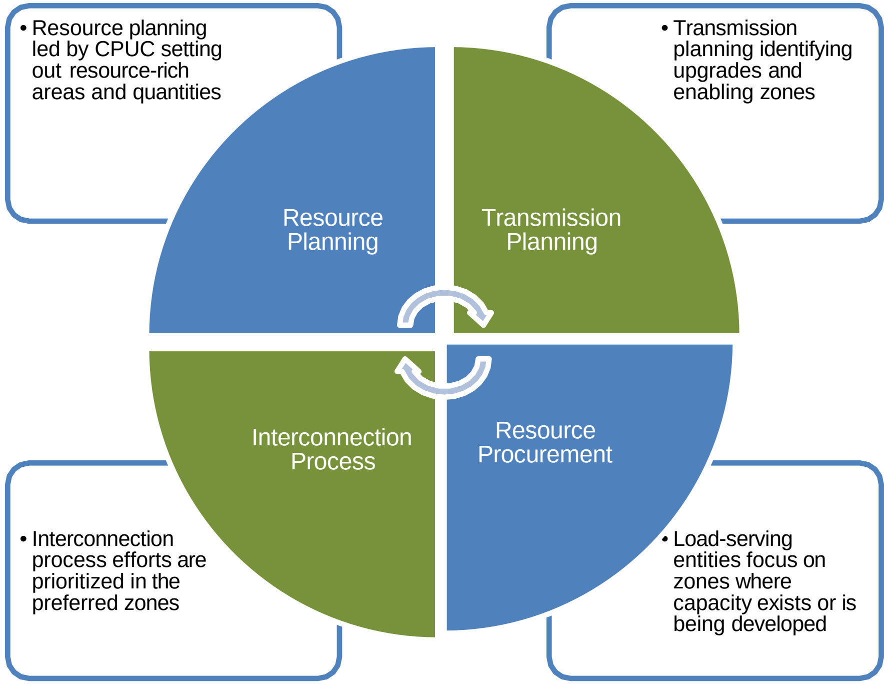
CEC – AB525: Offshore Wind Transmission Workshop

Transmission Planning Process

- The CAISO conducts an annual tariff based transmission planning process to assess needs for reliability, policy and economic driven transmission

- The CAISO issued its first 20-Year Transmission Outlook in May 2022 that:
  - help the state to further refine resource planning,
  - scope the challenges we face,
  - and provide longer term context for decisions made in the 10-year transmission plan process.

The ISO annual transmission process 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 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

Offshore Wind Portfolios provided by CPUC for the ISO Transmission Planning Studies

	ISO Annual Transmission Planning Process						
	2021-2022 TPP			2022-2023 TPP		2023-2024 TPP	
	Base Portfolio	Sensitivity Portfolio	Sensitivity Portfolio Outlook	Base Portfolio	Sensitivity Portolio	Base Portfolio	Sensitivity Portolio
Morro Bay Call Area	-	2,324	2,324	1,588	3,100	3,100	5,355
Diablo Area	-	4,419	4,419	-		-	-
Humbolt Call Area	-	1,607	1,607	120	1,607	1,607	2,600
Del Nort Area	-	-	6,605	-		-	3,445
Cape Mendicino Area	-	-	6,216	-		-	2,000
Total	-	8,350	21,171	1,708	4,707	4,707	13,400

The ISO recommends for approval transmission projects that are found needed to meet the needs of the base portfolio

	20-Year Transmission Outlook	
	May 2022	2024 Update
North Coast	4,000	-
Central Coast	6,000	-
Morro Bay Call Area		TBD
Humbolt Call Area		TBD
Del Nort Area	-	TBD
Cape Mendicino Area	-	TBD
Total	10,000	

Annual Transmission Planning Process Links
https://stakeholdercenter.caiso.com/RecurringStakeholderProcesses/2021-2022-Transmission-planning-process

https://stakeholdercenter.caiso.com/RecurringStakeholderProcesses/2022-2023-Transmission-planning-process

https://stakeholdercenter.caiso.com/RecurringStakeholderProcesses/2023-2024-Transmission-planning-process

20-Year Transmission Outlook Link
https://stakeholdercenter.caiso.com/RecurringStakeholderProcesses/20-Year-transmission-outlook

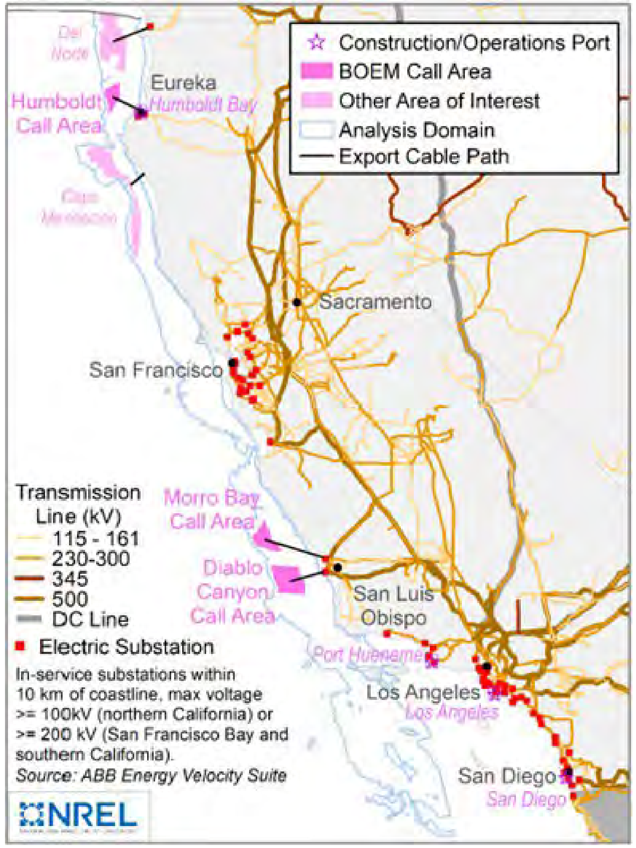
Areas Identified for Offshore Wind in the Transmission Assessments

<u>North Coast Offshore Wind Areas</u>

- Humboldt Call Area
- Del Norte area (potential interest)
- Cape Mendocino area (potential interest)

<u>Central Coast Offshore Wind Areas</u>

- Morro Bay Call Area
- Diablo Canyon Call Area (currently inactive)

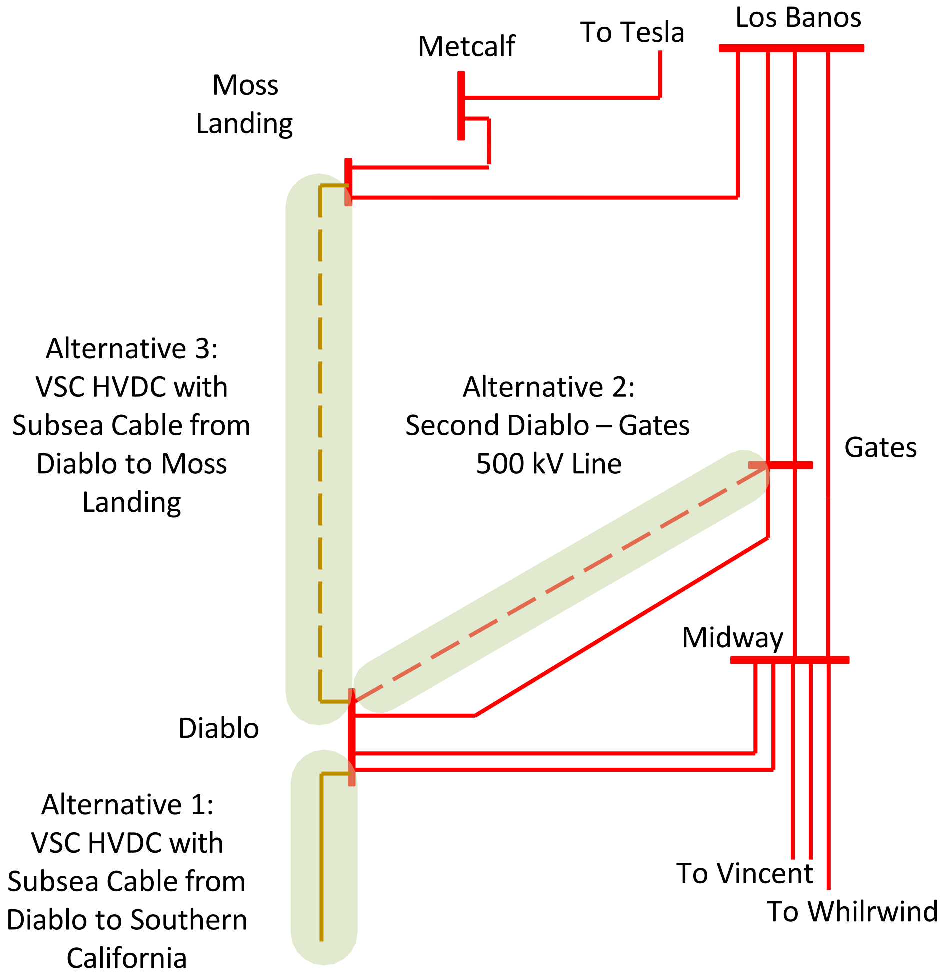


[Source: The Cost of Floating Offshore Wind Energy in California Between 2019 and 2032 (nrel.gov)](#) (Page 39)

Central Coast – Offshore Wind Assessment and Transmission Alternatives

- The ISO's analysis has identified that 5.3 GW of resources can connect to the 500 kV system in the Diablo/Morro Bay area after the retirement of the Diablo Nuclear Power Plant

- To increase the offshore capacity beyond 5.3 GW three alternatives were considered.

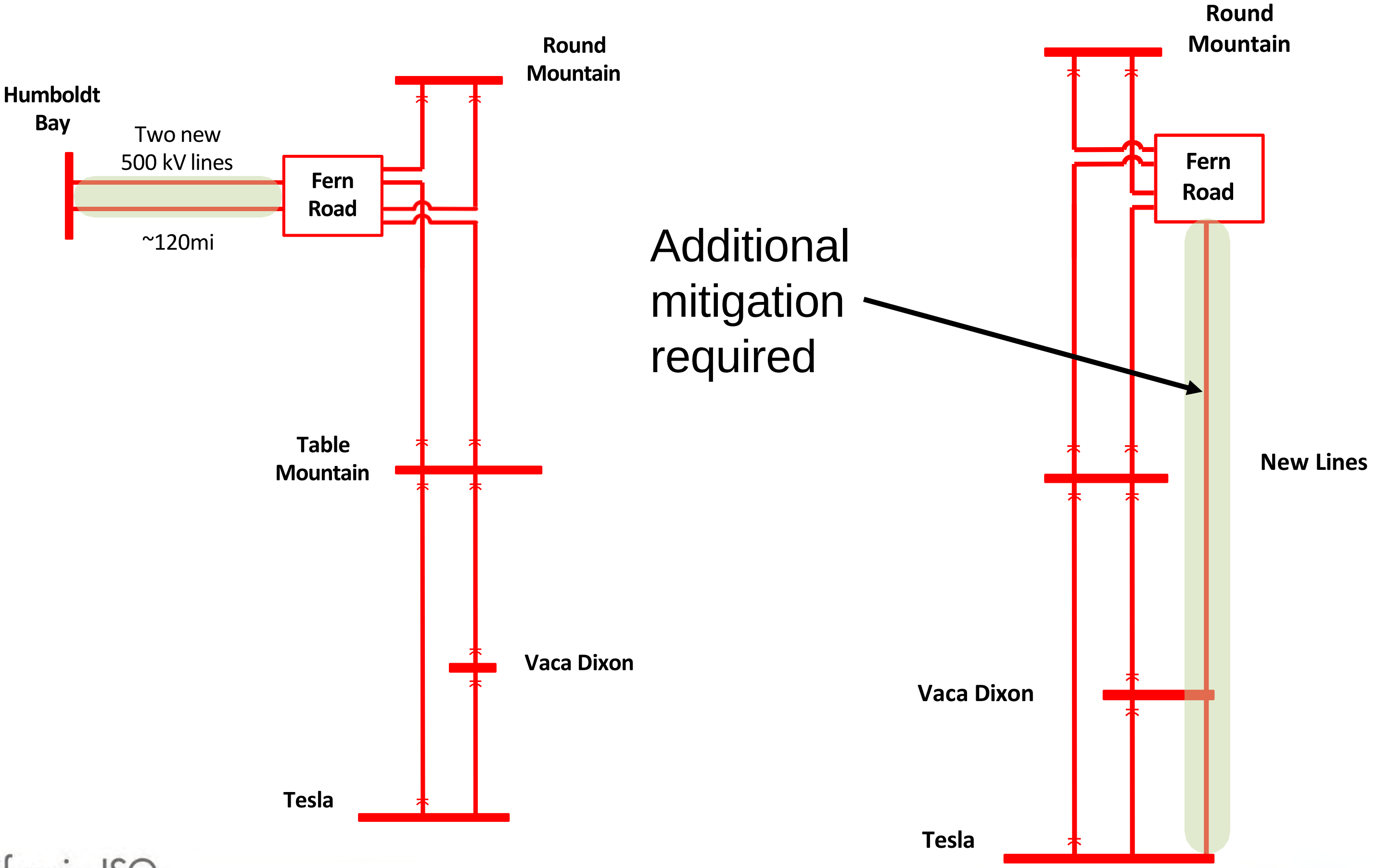


Alternatives for the Humboldt Call Area

- Three transmission alternative have been assessed to access the offshore wind (~1600 MW) in the Humboldt call area
  - Option 1 - 500 kV AC line to Fern Road 500 kV substation
  - Option 2 - VSC-HVDC subsea cable to a converter station in the Bay area with AC connections to 230 kV substations in the Bay area
  - Option 3 - HVDC Bipole to the Collinsville 500/230 kV substation

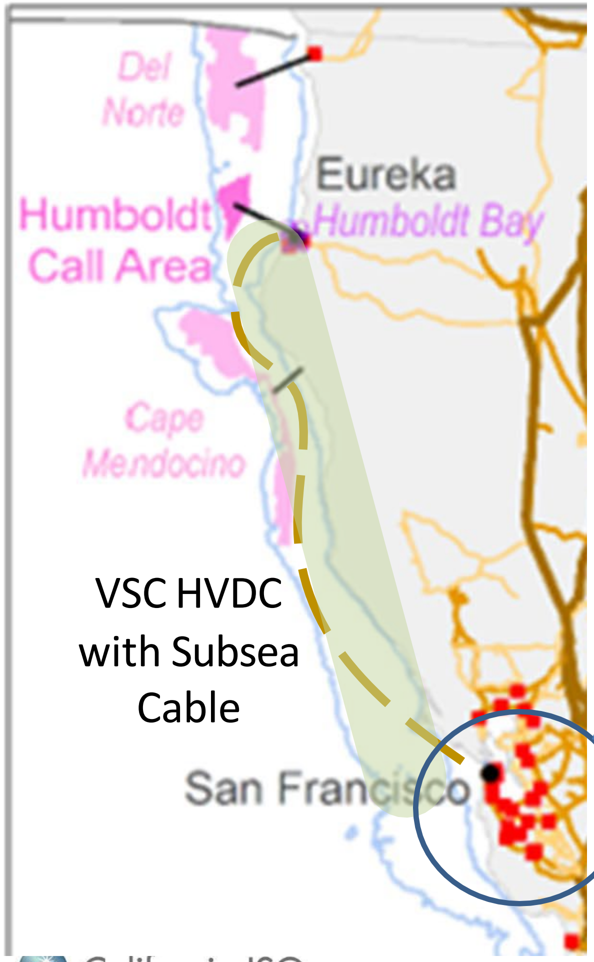
Humboldt 1.6 GW Interconnection Alternatives(1/3)

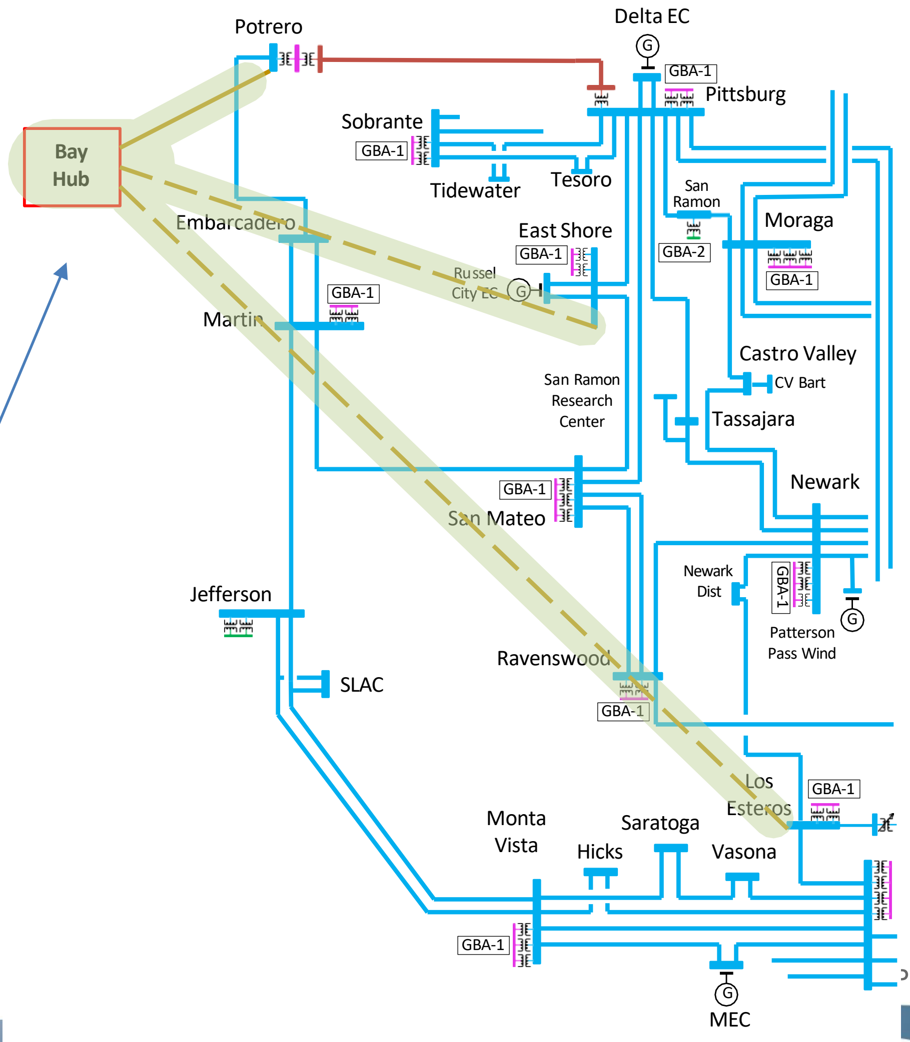
- Option 1: 500 kV AC line to Fern Road 500 kV substation.
  - Fern Road 500 kV substation is planned to be in service by June 2024 as part of Round Mountain DRS project and is located 11 miles south of Round Mountain substation.



Humboldt 1.6 GW Interconnection Alternatives (2/3)

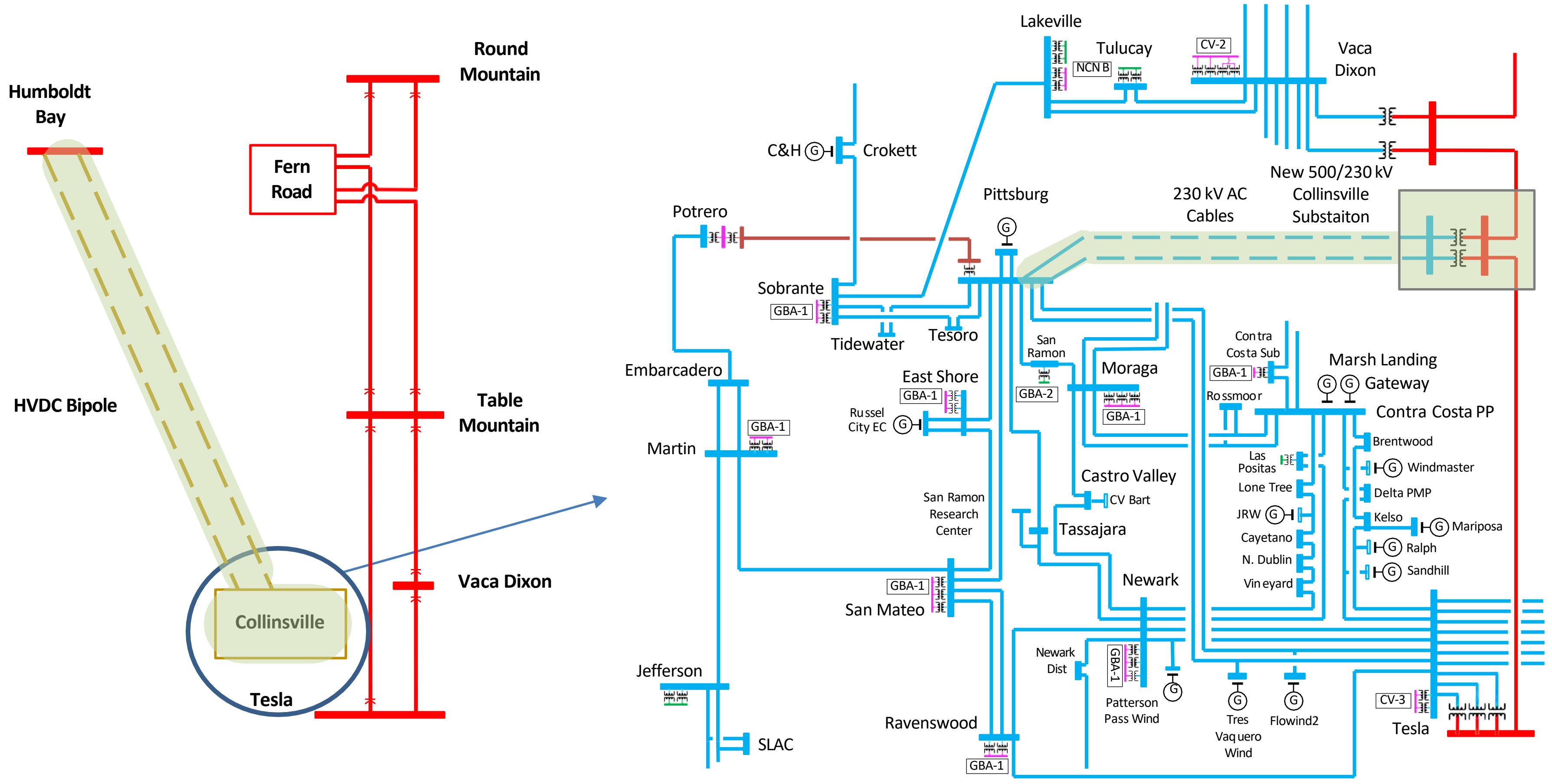
- Option 2: VSC-HVDC subsea cable to a converter station in the Bay area with 3 AC connections to Potrero, East Shore, and Los Esteros





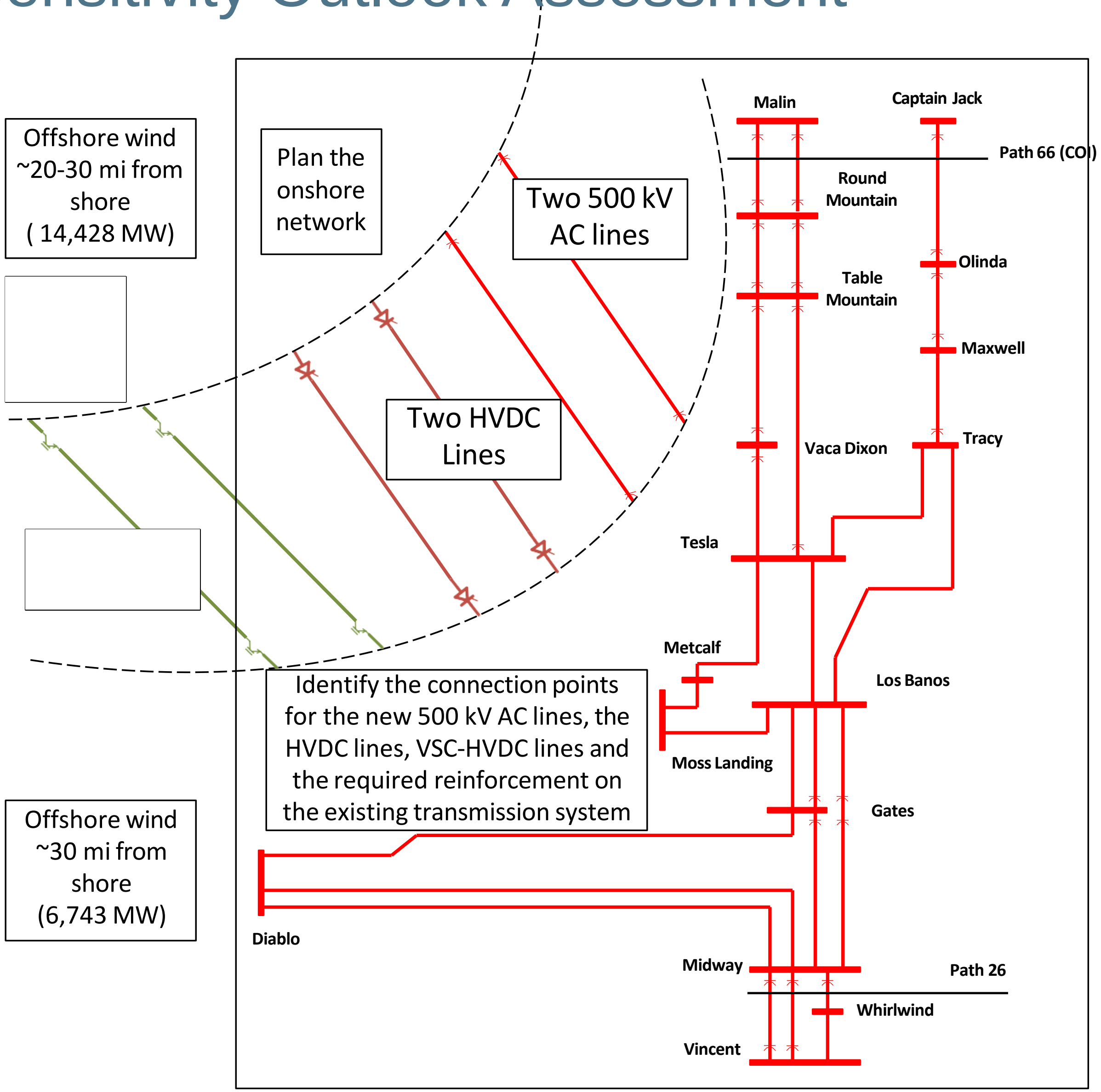
Humboldt 1.6 GW Interconnection Alternatives (3/3)

- Option 3: HVDC Bipole to Collinsville 500/230 kV substation.



2021-2022 TPP – Sensitivity Outlook Assessment

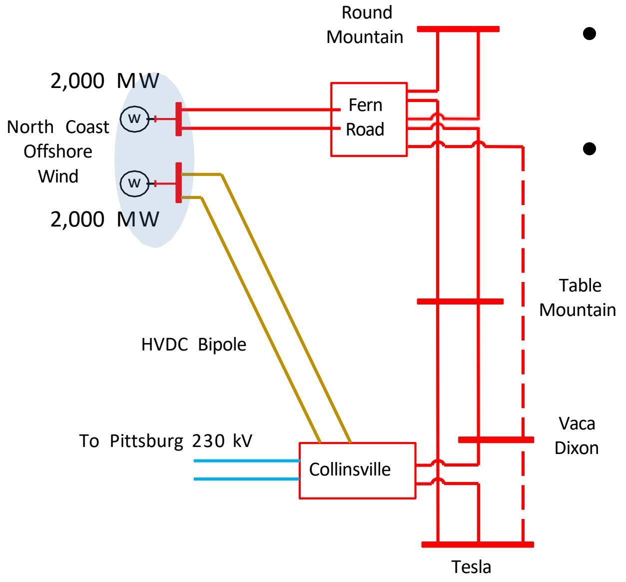
A review of possible transmission capacity and technology option configurations assessed to integrate 14.4 GW of offshore wind in the north coast



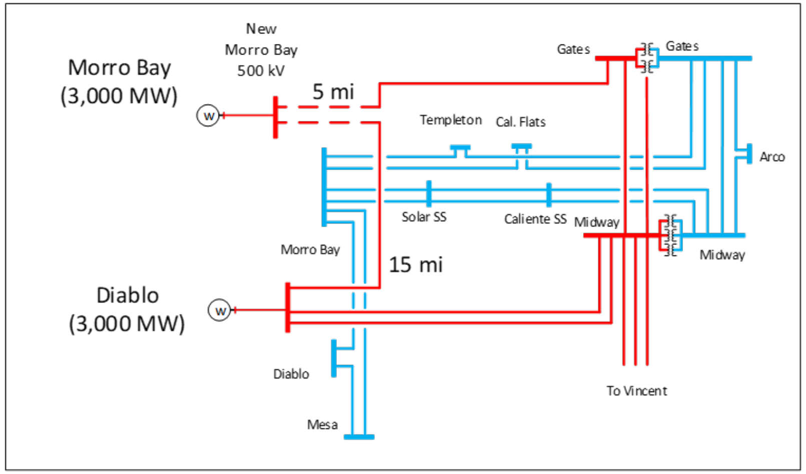
Consideration for Transmission Development

Technology		Maximum Rating Assumptions		Comments
		Normal Rating	Emergency Rating	
500 kV AC	Overhead line	Up to 3,200 MVA	Up to 4,500 MVA	Based on recent 500 kV projects in CAISO
VSC HVDC	Underground/subsea	2,000 MW	2,400 MW	Based on projects around the world and discussions with OEMs
	Overhead line	3,000 MW	3,600 MW	
CAISO Planning Standard				
Maximum Gen Drop following N-1 (NERC P1)		1,150 MW		
Maximum Gen Drop following N-2 (NERC P7)		1,400 MW		

20-Year Transmission Outlook
Offshore Transmission Development Assessment



- Central coast offshore wind interconnecting to existing 500 kV in Diablo/Morro Bay area
- North coast offshore wind requires transmission development to interconnect to existing system
  - 500 kV AC interconnection to Fern Road
  - HVDC line to Collinsville
  - interconnect 500 kV AC and HVDC systems together and the offshore wind farms in two wind development areas
  - Potential for offshore grid development and strengthening of interconnection to Pacific Northwest



Transmission Development	Description	Cost Estimate
Offshore Wind		**$8.11 B**
Humboldt Bay Offshore wind area	Total of 4,000 MW offshore wind connected through two of the following options: - Option 1 (Fern Road): $2.3 B - Option 2 (Bay Hub): $4.0 B - Option 3 (Collinsville): $3.0 B Facilities required to interconnect the transmission options connecting to the different offshore wind areas: $0.5B-$1.0 B.	$5.8 B–$8.0 B
Diablo – Morro Bay Offshore wind area	- Total of 6,000 MW offshore wind. Connected to Diablo 500 kV and the new Morro Bay 500 kV substation. - The cost estimate is only for a 500 kV switching station and looping in the existing Diablo – Gates 500 kV line into it.	0.11 B

2023-2024 Transmission Planning Process Offshore Wind Assessment

- The CPUC has provided in Decision 23-02-040* the base and sensitivity portfolio for the 2023-2024 transmission planning process
- In addition, the ISO will be undertaking an update of the ISO's 20-Year Transmission Outlook in parallel with this year's planning cycle
- The ISO will recommend transmission projects for approval based upon a need in the base case
  - Will consider in the alternative analysis the sensitivity portfolio or longer term needs in the project development

	2023-2024 TPP	
	Base Portfolio	Sensitivity Portolio
Morro Bay Call Area	3,100	5,355
Diablo Area	-	-
Humbolt Call Area	1,607	2,600
Del Nort Area	-	3,445
Cape Mendicino Area	-	2,000
Total	4,707	13,400

* https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M502/K956/502956567.PDF

Flexibility for Longer Term Potential Development

The alternative assessment to meet the base portfolio needs in 2023-2024 transmission planning process will need to take into consideration flexibility to fit into longer term potential development scenarios that include the:

- Uncertainty in location, capacity and timing of future call areas
- Potential offshore grid considerations
- Increased transfer capacity between California and Pacific Northwest

Floating Offshore Wind

All the following technologies required to transmit power from large scale floating offshore wind projects to the shore are at early stages of development and are not commercially available yet:

- Floating AC substations and associated dynamic high voltage AC cables
- Floating HVDC converter stations and associated dynamic high voltage DC cables
- Offshore multi-terminal DC grid
- Subsea AC substations
- Power flow, dynamic and EMT models

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Arne Jacobson, James Zoellick, and Greyson Adams
Schatz Energy Research Center

Northern CA and Southern OR Offshore Wind

Workshop on Assembly Bill 525: Assessing Transmission Upgrades and Investments for Offshore Wind Development Off the Coast of California

May 25, 2023

California Energy Commission Agreement #700-22-002
Schatz Energy Research Center

Introductions

Project Sponsors and Core Steering Group Members

Agreement No. 700-22-002

Project Team

Team lead: Arne Jacobson; **Project manager**: Jim Zoellick; **Team members**: Charles Chamberlin, Eli Wallach, Ian Guerrero, Andrew Harris, Greyson Adams, Lorelei Walker*

+ Anton Fund Interns: Claire Ingvoldsen*, Donovan Wakeman*

*Student researchers

Partners

Agenda

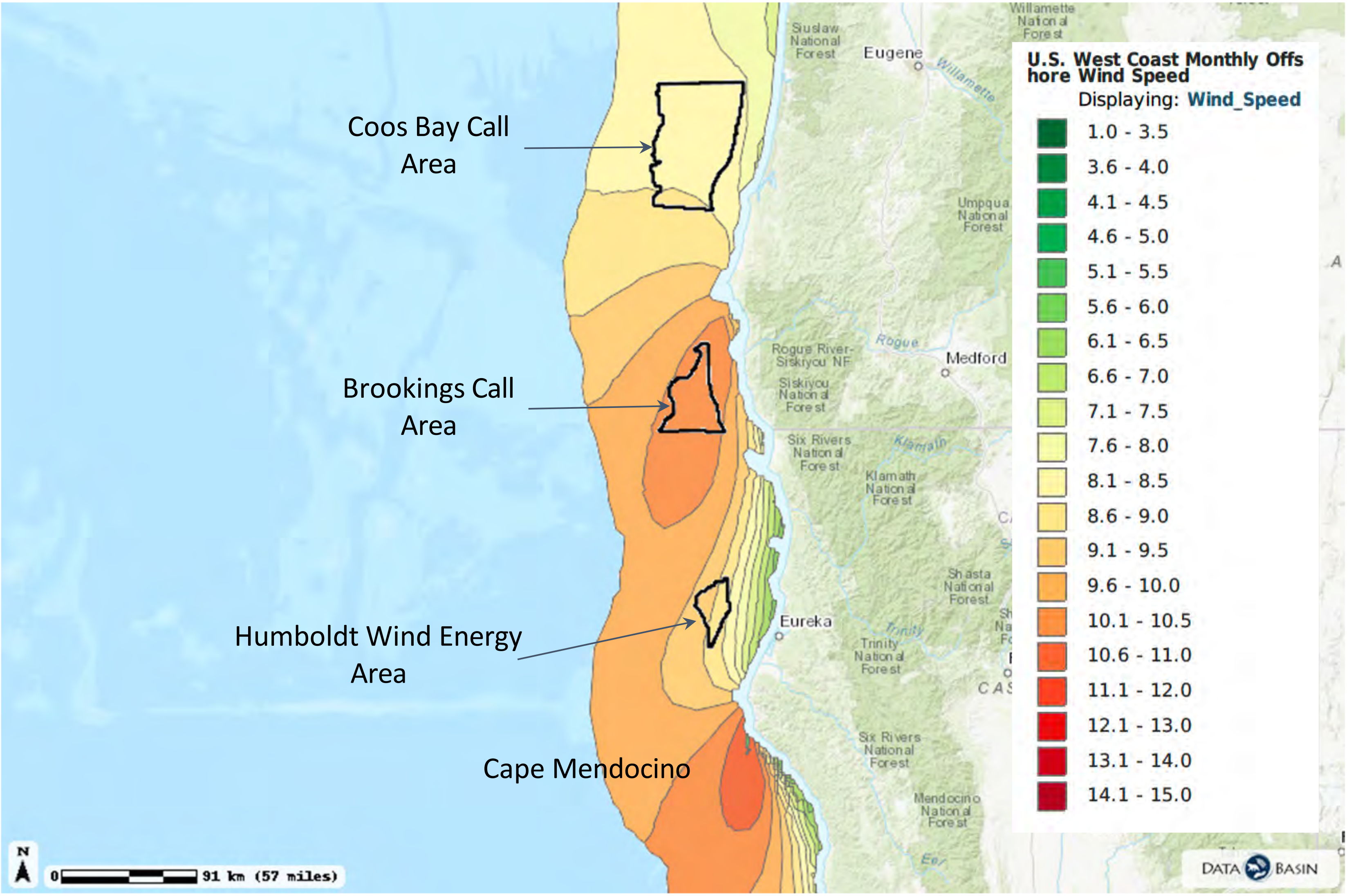
1. Study Scope and Objectives
2. Background
3. OSW Development Scenarios
4. Transmission Alternatives
5. Key Take-Aways
6. Next Steps

Credit: Senu Sirnivas/NREL

Offshore Wind Transmission Analysis Objectives

Schatz Energy Research Center

Objective of Current Analysis: Assess alternatives for transmission for multiple large-scale offshore wind development scenarios involving sites between Coos Bay and Cape Mendocino.



Source: https://caoffshorewind.databasin.org/maps/5ed0ccff046c4893920101231aaea78d/active/#

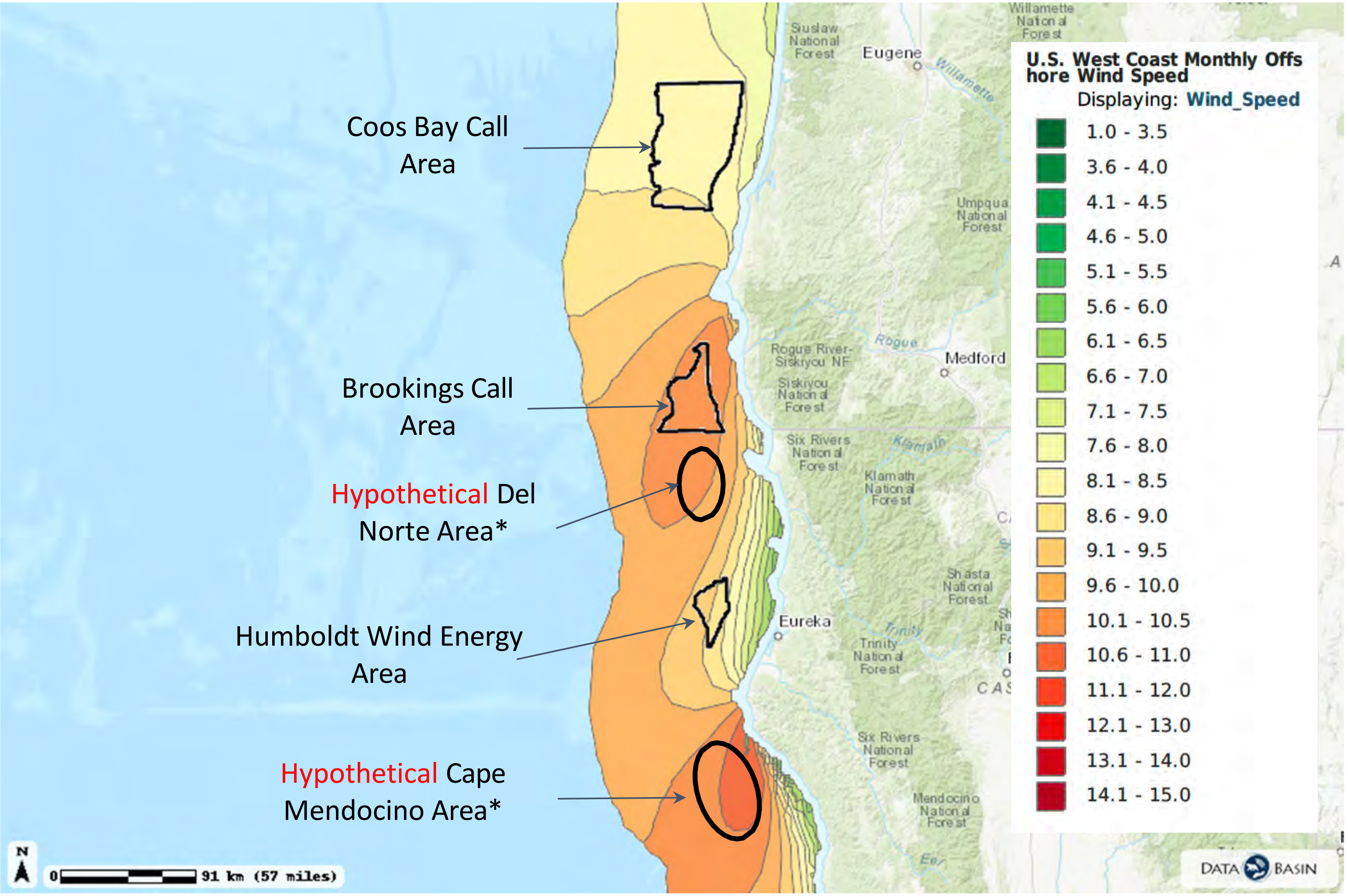
Offshore Wind Transmission Analysis Objectives

Schatz Energy Research Center

Objective of Current Analysis: Assess alternatives for transmission for multiple large-scale offshore wind development scenarios involving sites between Coos Bay and Cape Mendocino.

Additional areas offshore from Del Norte County and Cape Mendocino may be created in the future (but for now these are hypothetical).

*The boundaries shown for the hypothetical areas are not based on analysis.



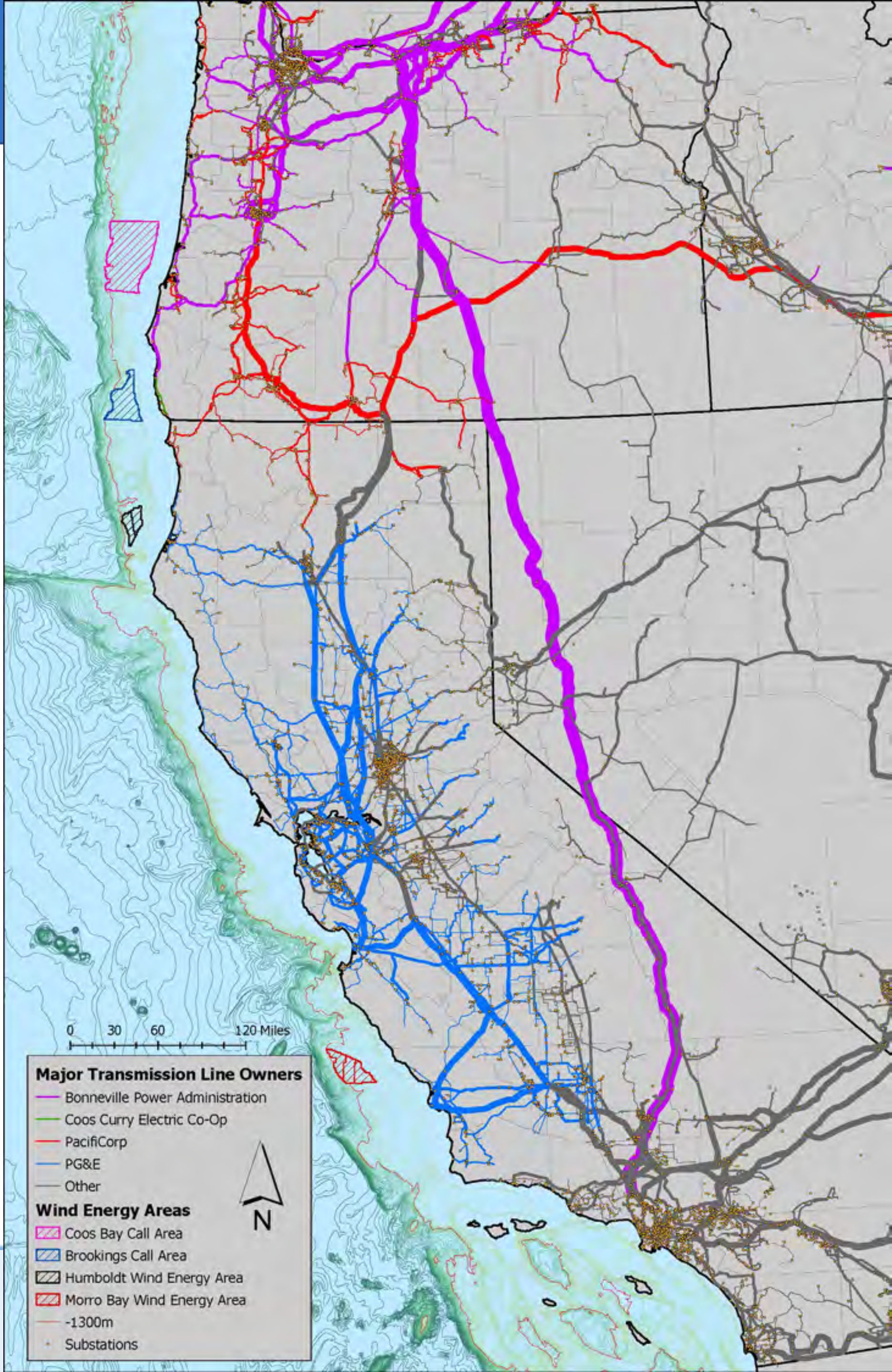
Source: https://caoffshorewind.databasin.org/maps/5ed0ccff046c4893920101231aaea78d/active/#

Existing Transmission Infrastructure

For large-scale offshore wind development, delivering electric power to major load centers will require upgrades to transmission infrastructure.

Electric demand on the coast near identified offshore wind areas is small, and existing transmission infrastructure is limited.

The primary transmission corridors are far inland (e.g., in or near the I-5 corridor in Oregon and California).



Schatz Energy Research Center

Offshore Wind Generation Scenarios

Schatz Energy Research Center

The analysis considered three scales of offshore wind development…

Mid Range	3.1 GW	9.3 GW	12.4 GW
High	9.8 GW	16.0 GW	25.8 GW

Offshore Wind Generation Scenarios

The analysis considered three scales of offshore wind development…

Development Scenario	OSW Capacity S. Oregon	OSW Capacity N. California	W y
Low	3.1 GW	4.1 GW	
Mid Range	3.1 GW	9.3 GW	W
High	9.8 GW	16.0 GW	W

… and 10 transmission alternatives (power flow)

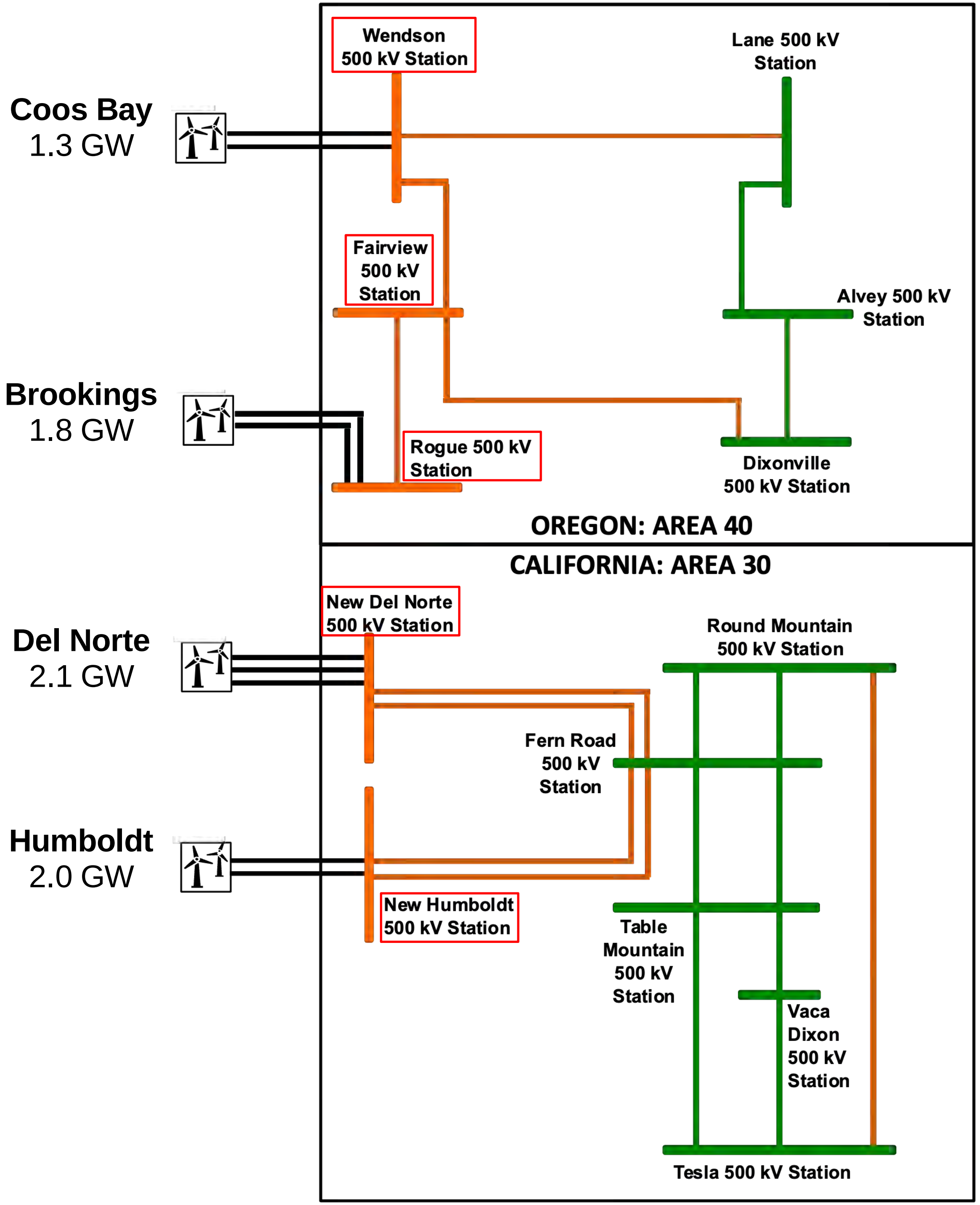
Development Scenario	Total OSW Capacity	# of Transmission Alternatives
Low	7.2 GW	2
Mid Range	12.4 GW	6

230 kV transmission line near Langlois, Oregon

Transmission Analysis

Schatz Energy Research Center

- Transmission analysis follows standard transmission planning methodologies
  - Meets NERC Reliability Standards
  - Meets WECC Regional Criteria
  - Meets CAISO Planning Standards
  - Uses WECC year 2032 Anchor Data Set
- Conduct steady-state power flow reliability analysis, summer peak case
- Conduct production cost study using ABB GridView software
- Assess cost and benefits for each alternative



Alternative 1b (7.2 GW)

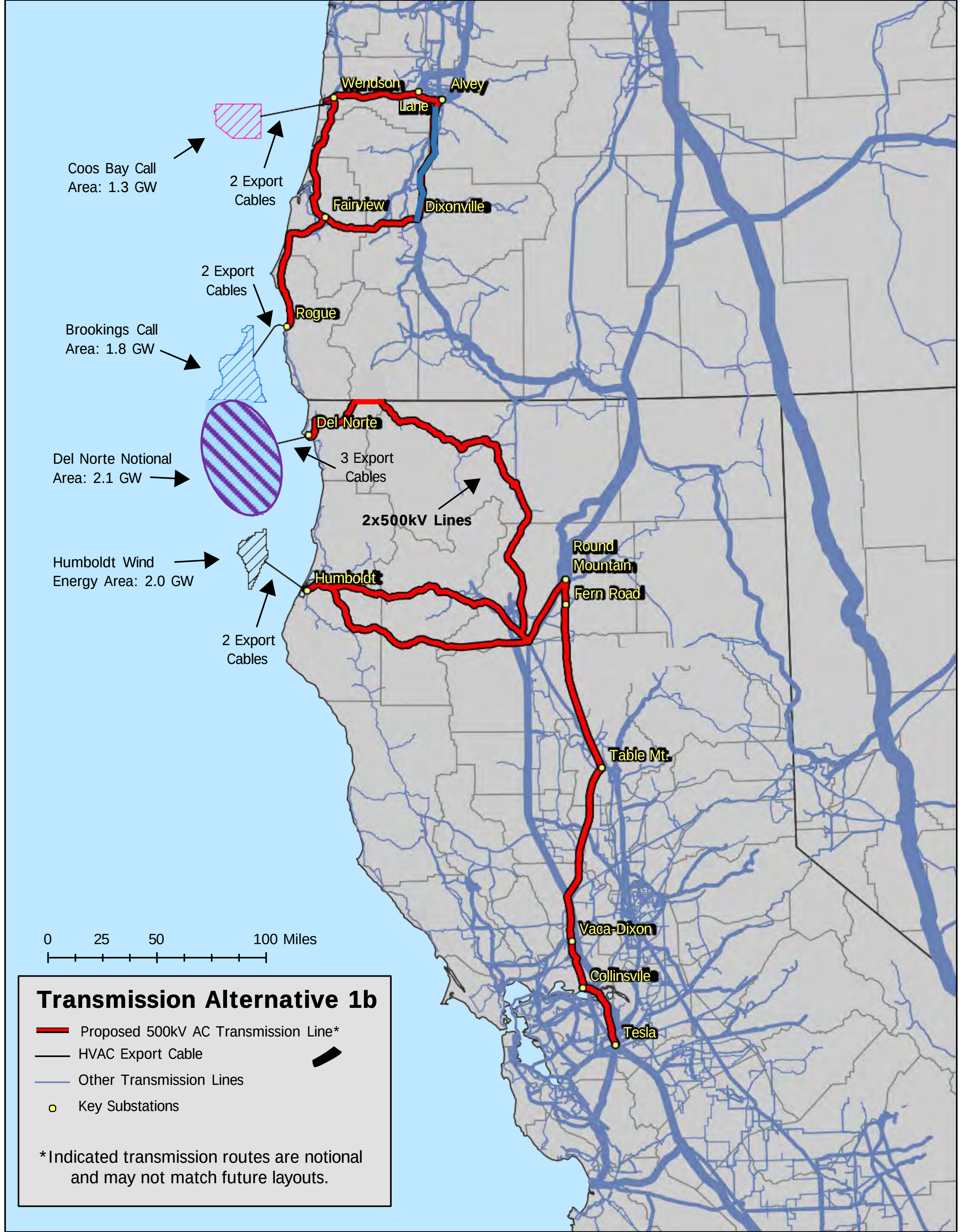
Key Points:

- Low development scenario
- Separate grids for OR and CA
- Oregon approach follows recent NorthernGrid study (500 kV loop)
- CA approach builds on CAISO Transmission Planning Studies
- Incorporates existing technologies, all HVAC transmission

Legend:

- New HVAC Facility
- New 500 kV HVAC Facility
- Existing 500 kV HVAC Facility
- New HVDC Facility
- Offshore Wind Facility
- Indicates power provided to local distribution system

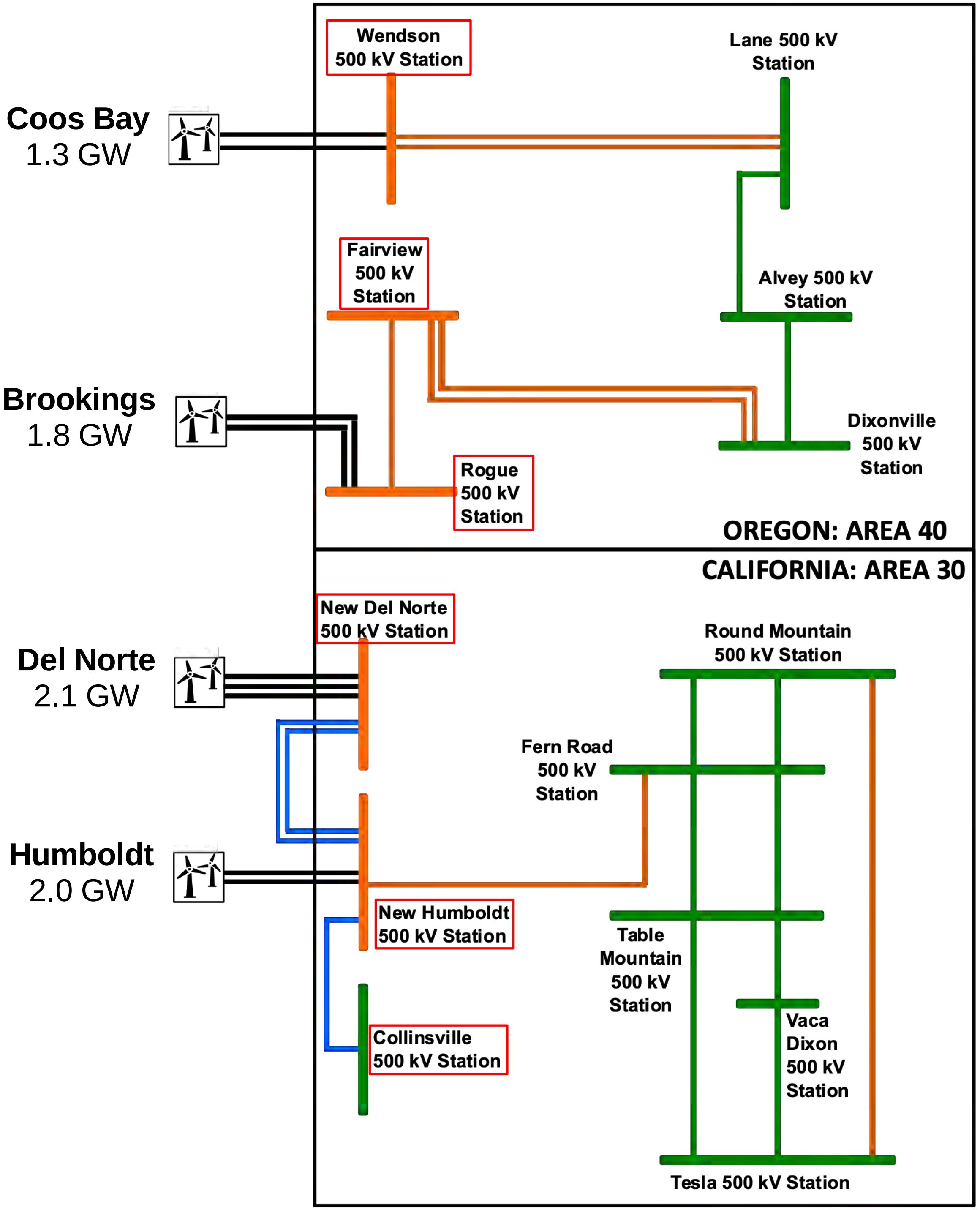
Schatz Energy Research Center



Alternative 1b

(7.2 GW)

Note: Transmission line routes are notional and generally follow existing rights of way. Eventual transmission routes may differ.



Alternative 2c (7.2 GW)

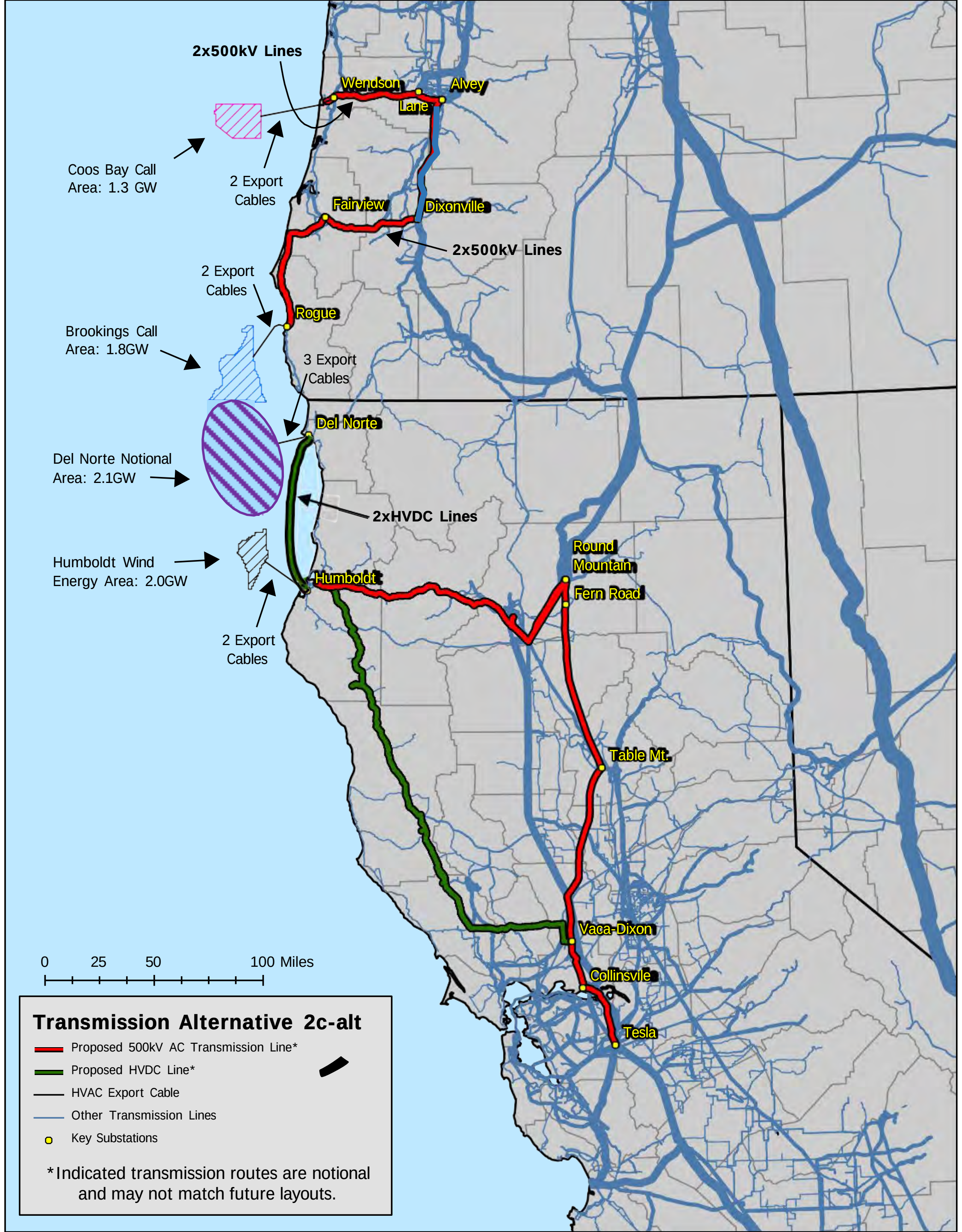
Key Points:

- Low development scenario
- Alternate approach in OR
- Employs onshore and offshore HVDC transmission
- Still relies on existing technologies (relies on onshore HVDC conversion stations)

Legend:

- New HVAC Facility (black line)
- New 500 kV HVAC Facility (orange line)
- Existing 500 kV HVAC Facility (green line)
- New HVDC Facility (blue line)
- Offshore Wind Facility (wind turbine symbol)
- Indicates power provided to local distribution system (red box)

Alternative 2c
(7.2 GW)



Note: Transmission line routes are notional and generally follow existing rights of way. Eventual transmission routes may differ.

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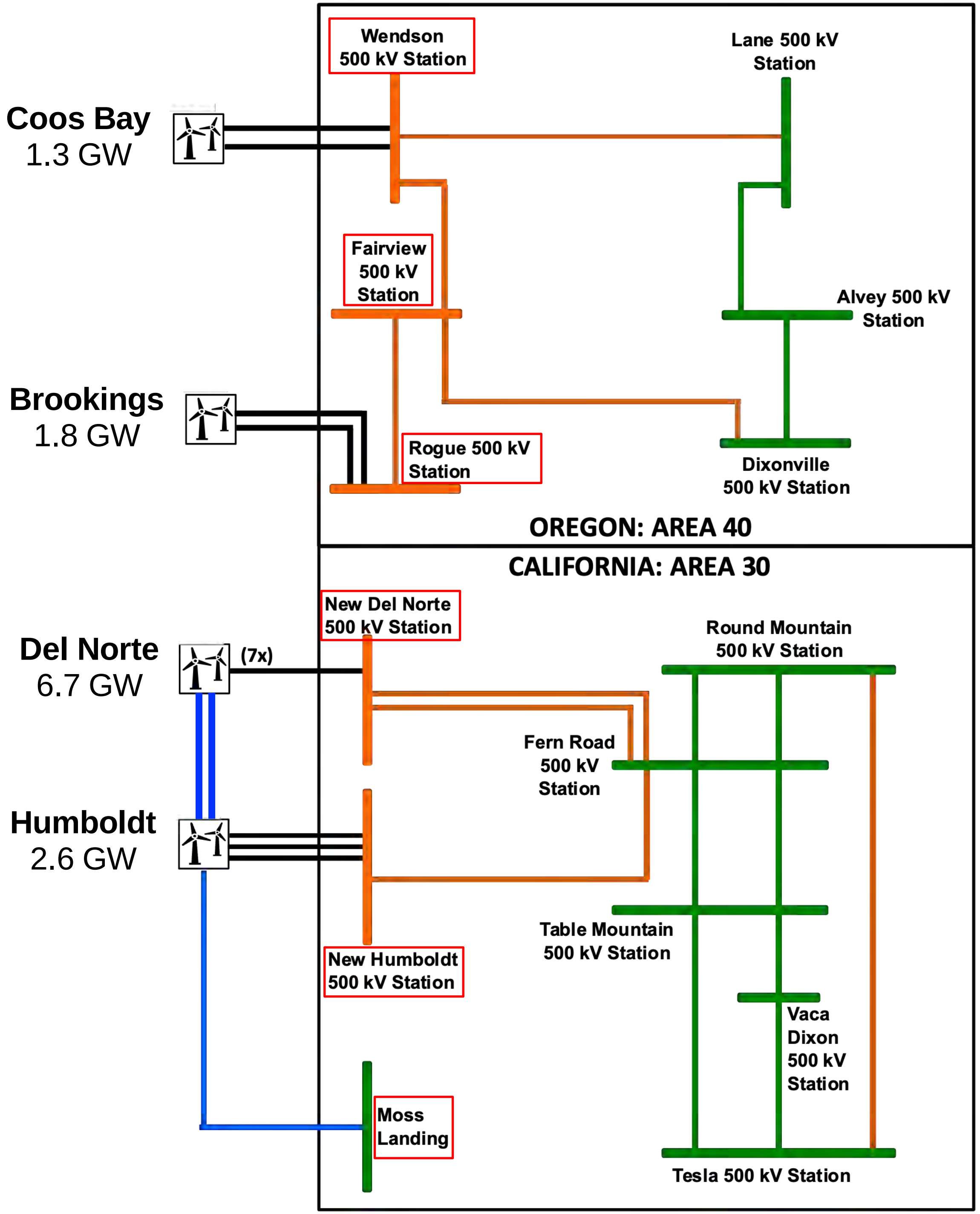

Alternative 5 (12.4 GW)

Key Points:

- Mid-range development scenario
- 500 kV loop in OR
- CA approach uses offshore HVDC transmission, relies on floating HVDC conversion stations
- Employs long distance undersea HVDC cable to Moss Landing

Legend:

- New HVAC Facility
- New 500 kV HVAC Facility
- Existing 500 kV HVAC Facility
- New HVDC Facility
- Offshore Wind Facility
- Indicates power provided to local distribution system

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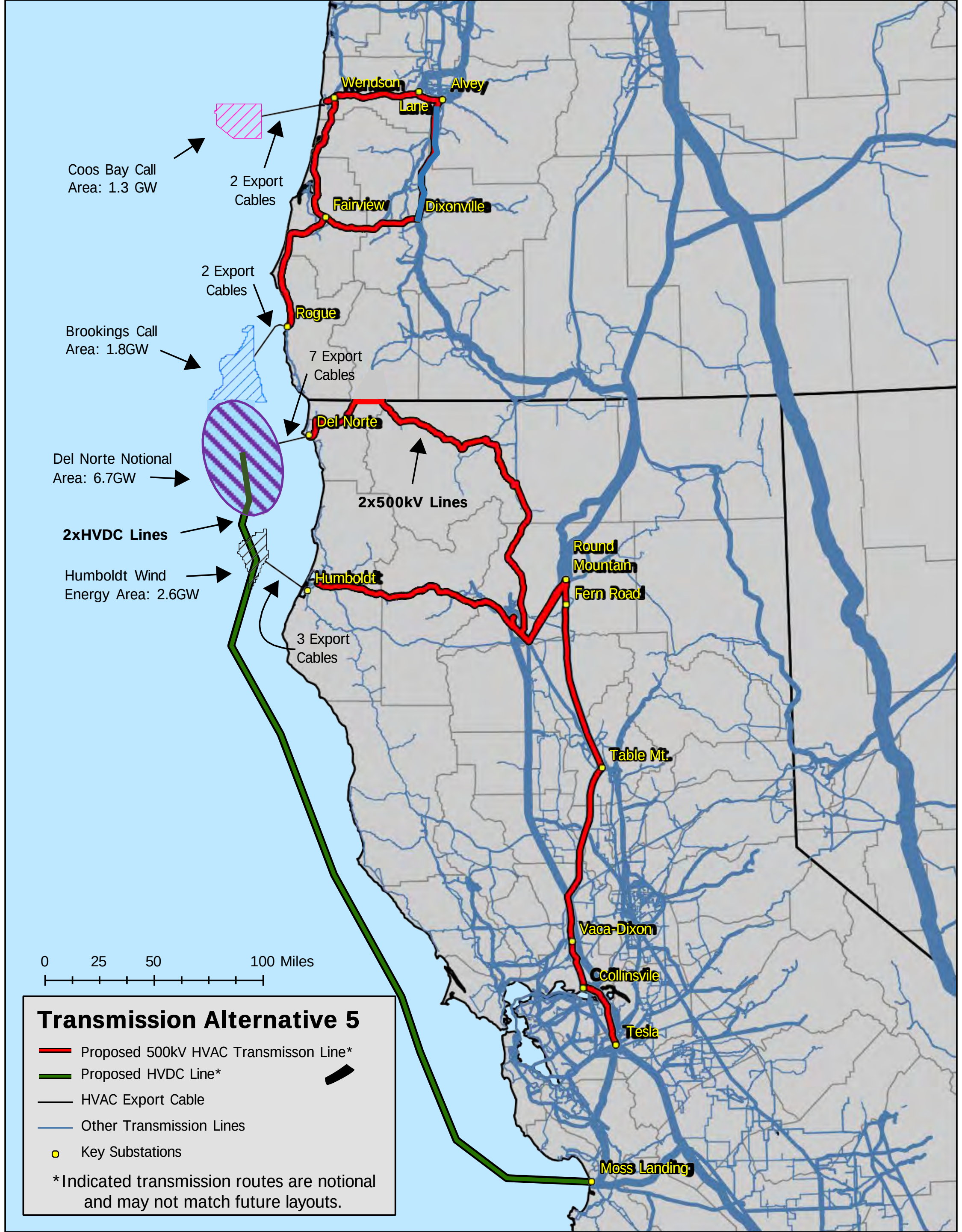
Alternative 5
(12.4 GW)



Note: Transmission line routes are notional and generally follow existing rights of way. Eventual transmission routes may differ.

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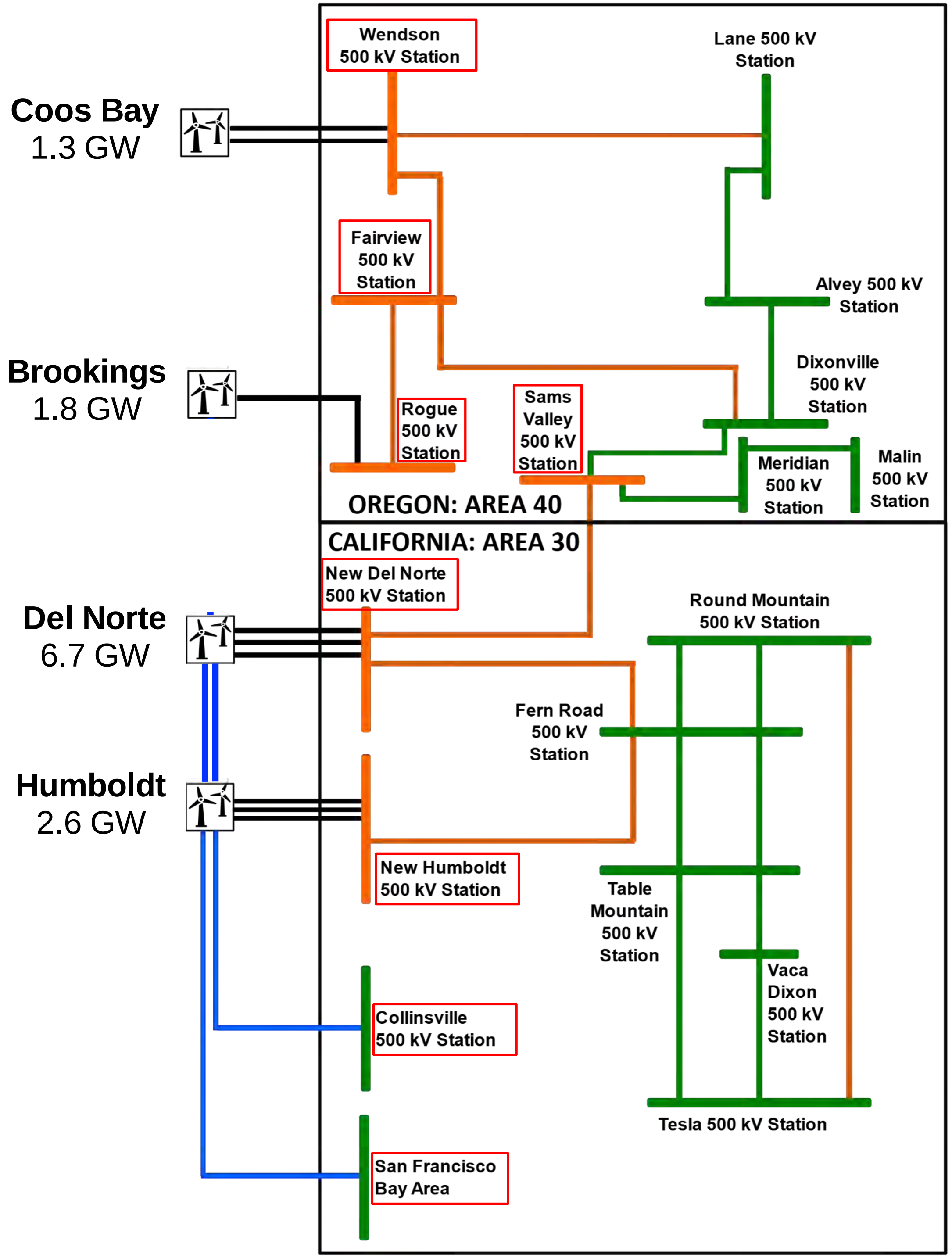

Alternative 6a (12.4 GW)

Key Points:

- Mid-range development scenario
- Onshore & offshore interconnections between OR and CA grids
- Employs offshore HVDC transmission, floating HVDC conversion stations & long distance undersea HVDC cables

Legend:

- New HVAC Facility
- New 500 kV HVAC Facility
- Existing 500 kV HVAC Facility
- New HVDC Facility
- Offshore Wind Facility
- Indicates power provided to local distribution system

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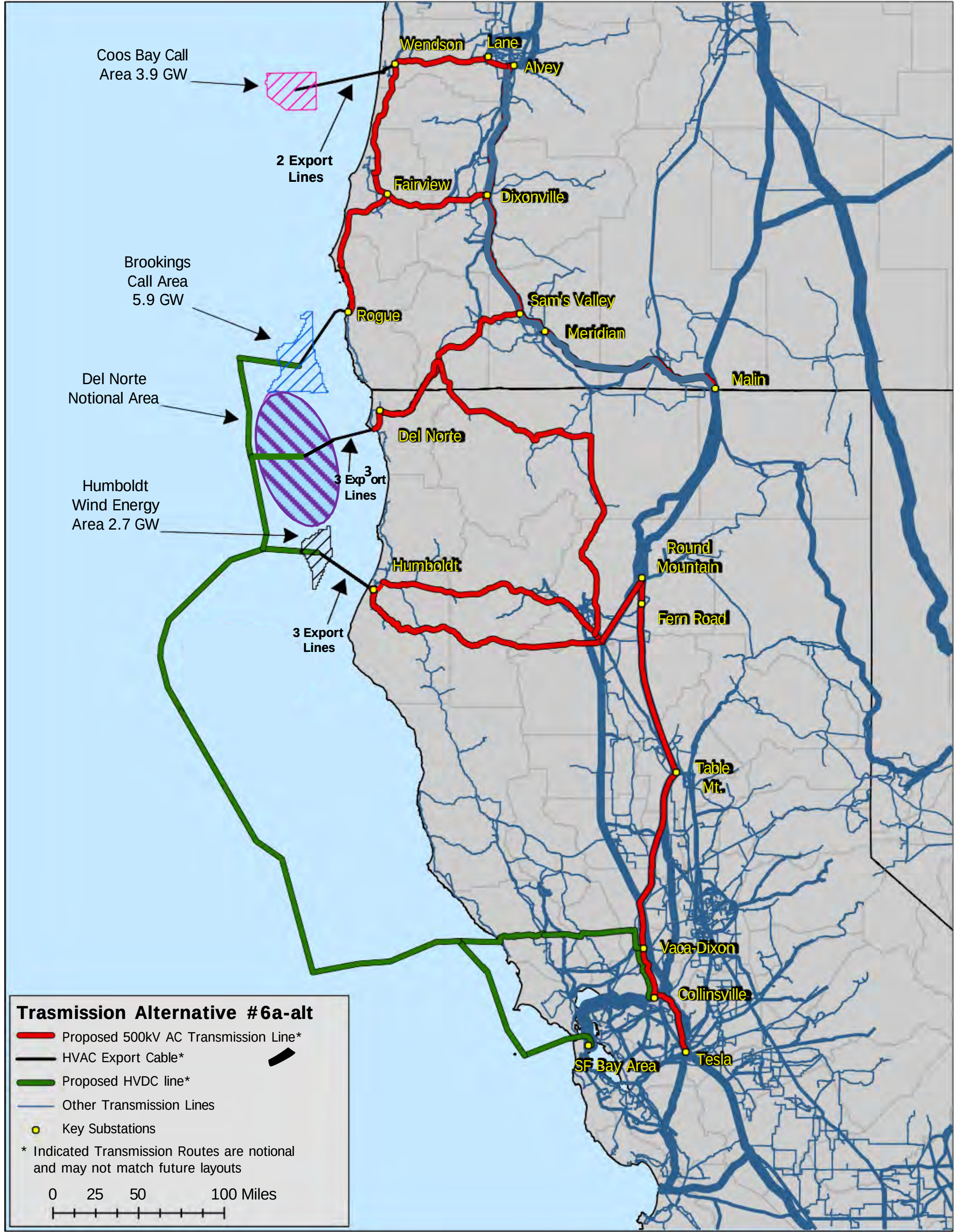
Alternative 6a
(12.4 GW)



<u>Note</u>: Transmission line routes are notional and generally follow existing rights of way. Eventual transmission routes may differ.

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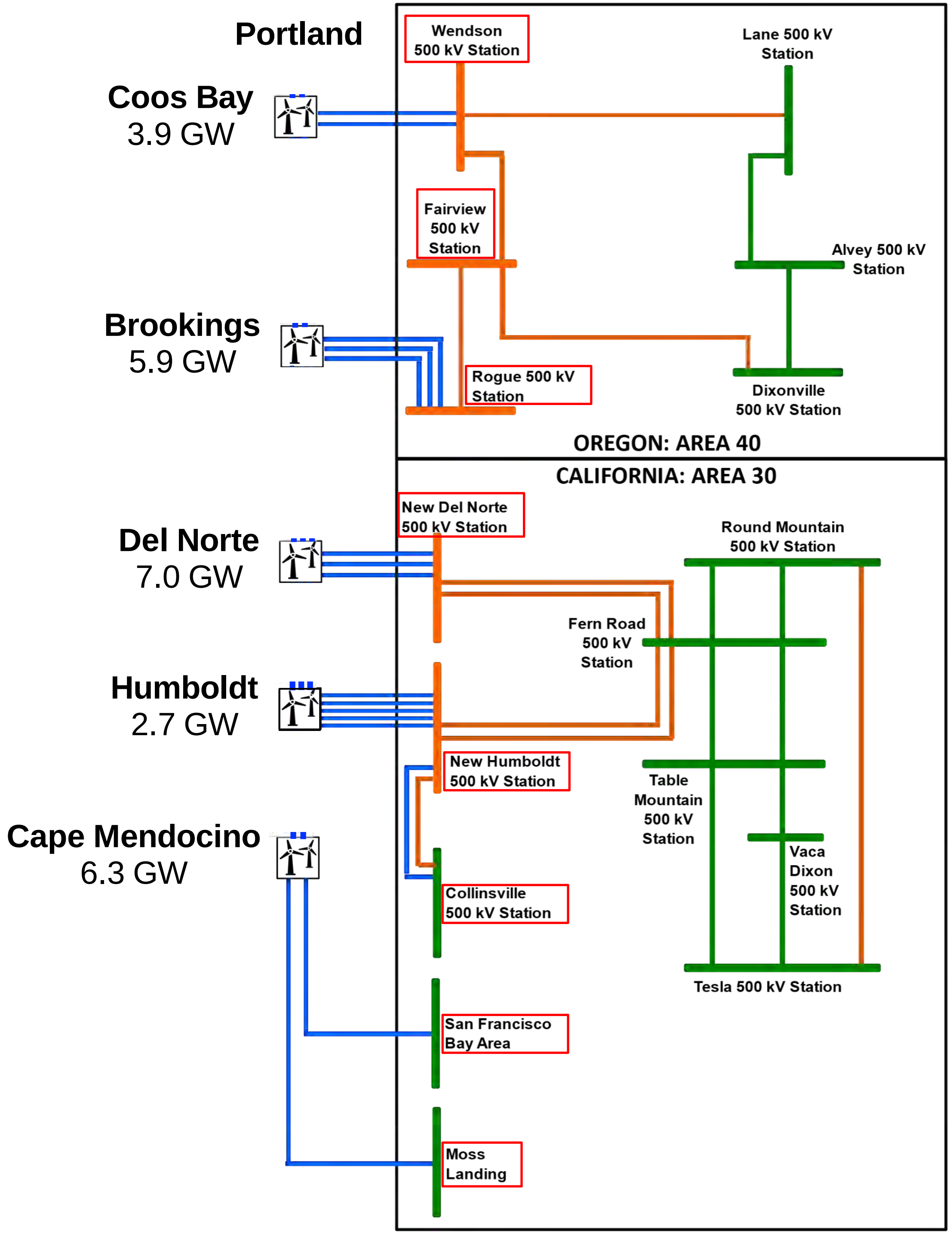

Alternative 9b (25.8 GW)

Key Points:

- High development scenario
- Employs offshore mesh HVDC transmission network
- Employs floating HVDC conversion stations & long distance undersea HVDC cables

Legend:

- New HVAC Facility
- New 500 kV HVAC Facility
- Existing 500 kV HVAC Facility
- New HVDC Facility
- Offshore Wind Facility
- Indicates power provided to local distribution system

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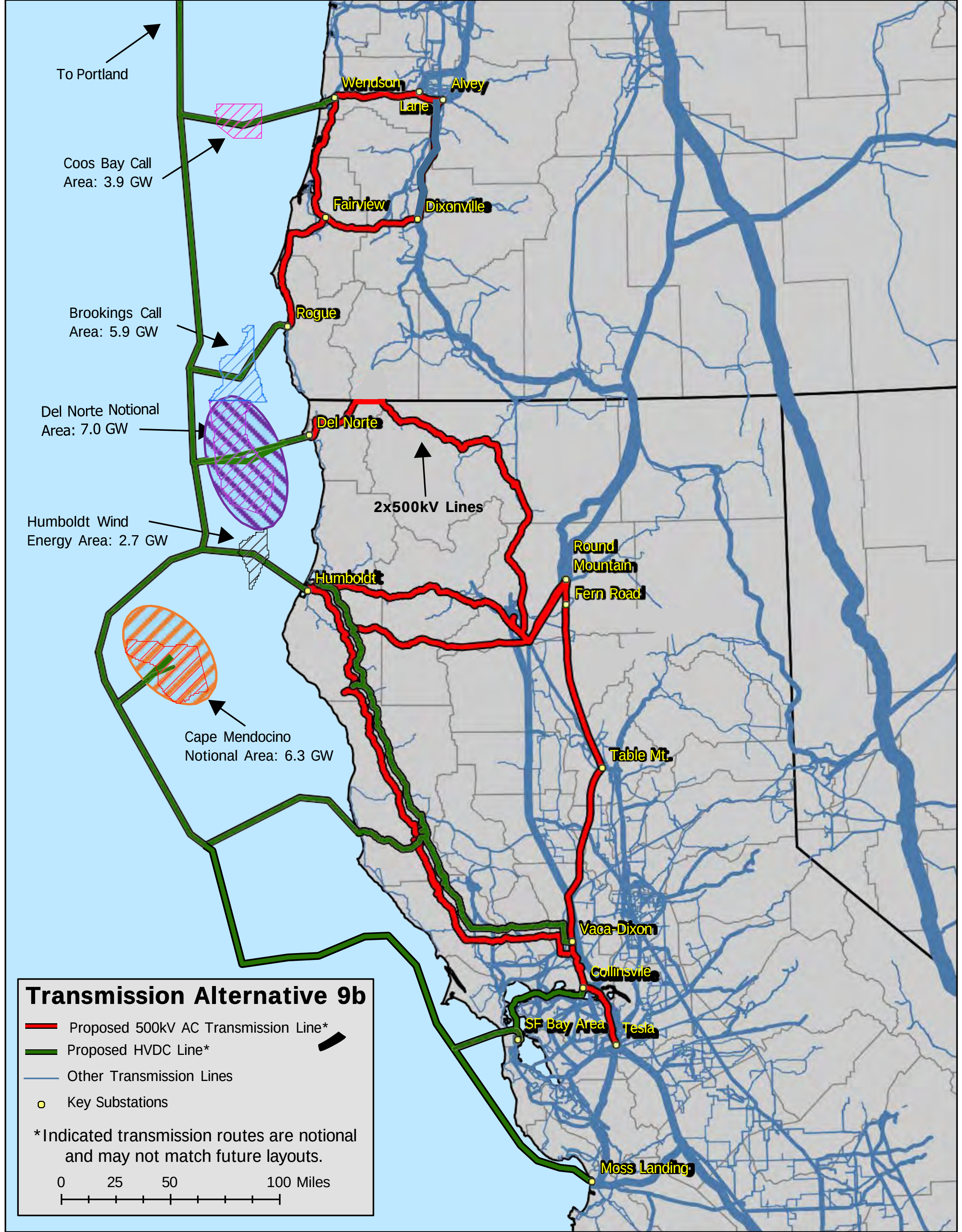

Alternative 9b
(25.8 GW)

Note: Transmission line routes are notional and generally follow existing rights of way. Eventual transmission routes may differ.

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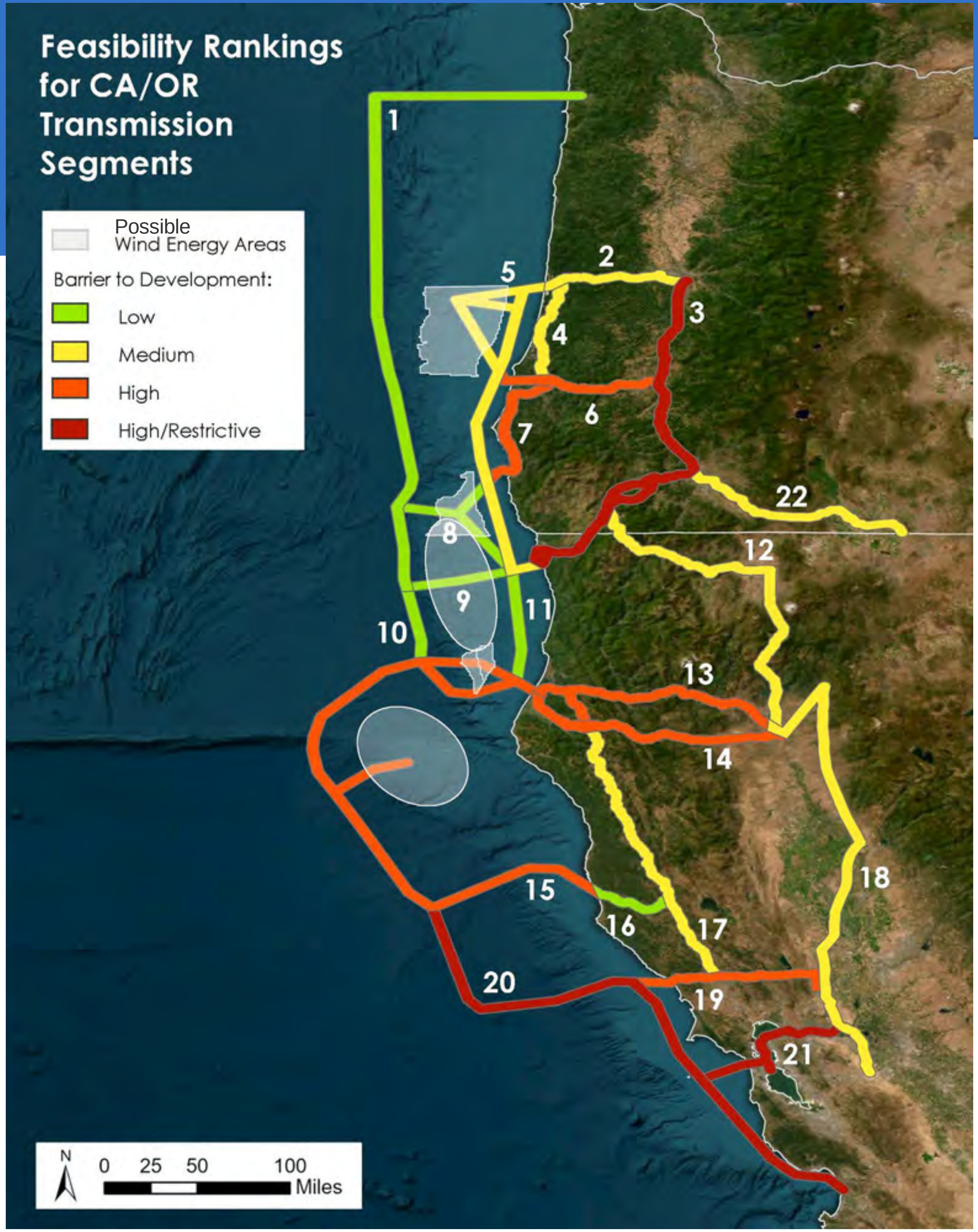
Transmission Corridors
ent

- Transmission line routes are notional and generally follow existing rights of way. Eventual transmission routes may differ.
- High level assessment indicates that offshore cable routes are more challenging from Cape Mendocino heading south.
- Onshore cable routes show mixed levels of barriers to development, including sensitive habitats, land use & permitting challenges.



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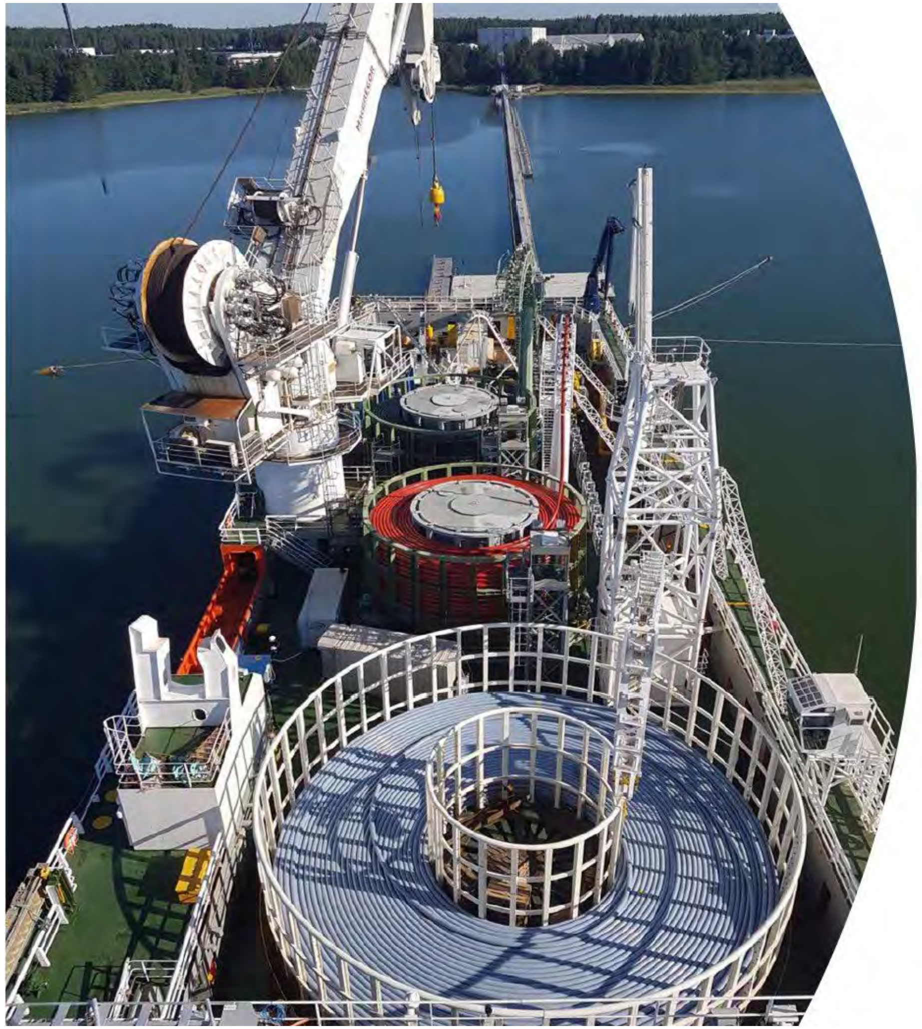
Undersea Transmission Preliminary Assessment

Schatz Energy Research Center

Undersea Transmission - Cable Routes and Onshore Landings

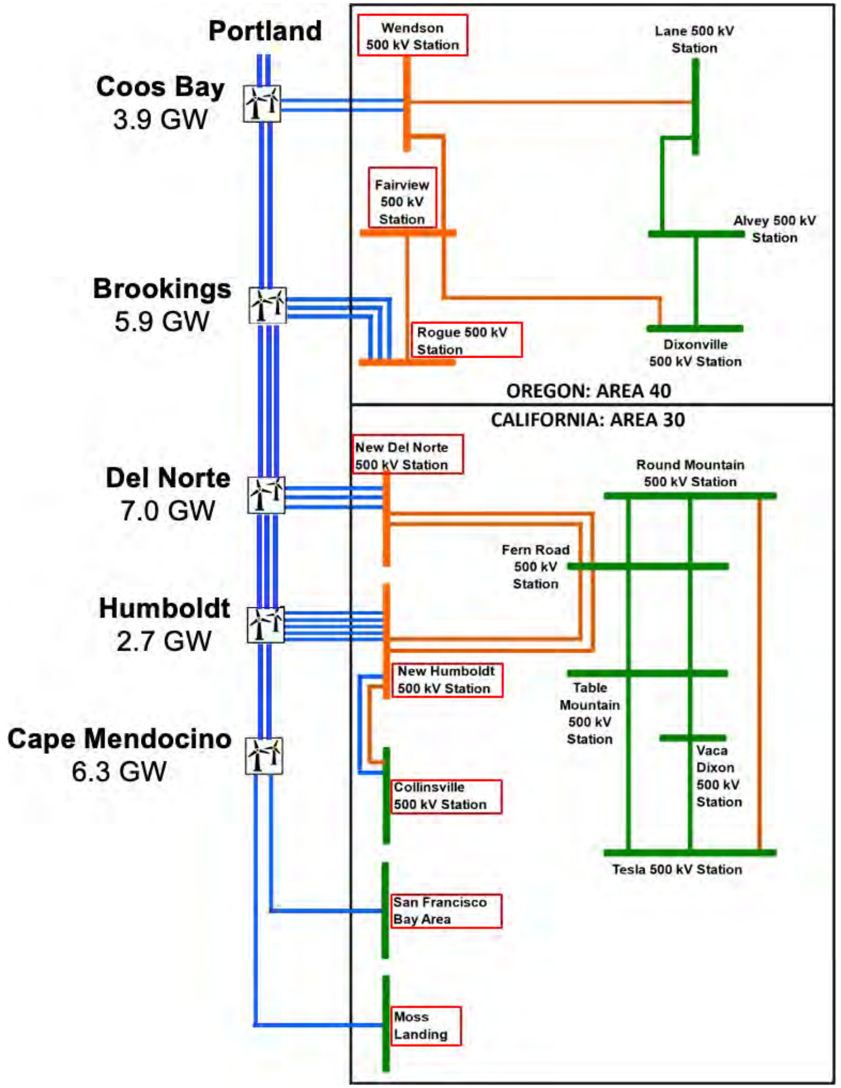
- Conducting high level assessment of offshore infrastructure and export cable layouts.
- Focusing on identifying siting challenges & opportunities, as well as layout feasibility.
- Assessment for existing and future technology for export and interconnection options in challenging new marine environments.



Cable Lay Vessel - Source: Inertek, Anbaric Export Cables into New York Harbor, July 2020

Key Findings and Recommendations

- Transmission infrastructure is limited in coastal areas of NW CA and SW OR, and significant investments in transmission are needed to enable development of OSW at scale.
- Transmission planning for OSW development should utilize a staged approach that considers how OSW may develop over time to meet state and national goals.
- To support large-scale OSW development, it is likely that both overland and undersea transmission will be utilized.
- Effective undersea transmission alternatives will benefit greatly from technologies that are not yet commercially available (but are expected in the next 1-2 decades), such as floating high voltage DC conversion systems.



Key Findings and Recommendations

- Successful transmission development requires consideration of multiple factors, such as environment & permitting, land ownership, rights-of-way, and military mission compatibility.
- To ensure community support, transmission solutions should strike a balance between delivering power to major load centers at reasonable cost and ensuring that coastal communities and communities along transmission corridors receive benefits (e.g., improved electricity reliability).
  - Achieving both objectives involves tradeoffs, and some alternatives (e.g., high voltage DC transmission lines) offer advantages for bulk power delivery while having drawbacks in relation to supporting improved electricity reliability and capacity for communities along transmission corridors.

Immediate Next Steps

- Complete analyses that are underway, including:
  - Power flow and production cost analysis of transmission alternatives (power flow = 10 alternatives; production cost = 6-7 alternatives)
  - Economic benefit-cost analysis of alternatives
  - Preliminary assessment of environmental and permitting issues for land and undersea transmission routes
  - Preliminary assessment of technology advancement needs in relation to undersea high voltage AC & DC transmission
- Draft final report (July 2023)

Credit: Senu Sirnivas/NREL

Contact Information


Photo credit: Maia Cheli

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www.schatzcenter.org/wind

Questions and Answers

Public Comment Instructions

Rules

- 3 minutes per person

Zoom

- Click "raise hand"

Telephone

- Press *9 to raise hand
- Press *6 to (un)mute

When called upon

- Unmute, spell name, state affiliation, if any

Written Comments:

- Due: June 9, 2023 by 5:00 p.m.
- Docket: 17-MISC-01
- Submit at: https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=17-MISC-01

3-MINUTE TIMER

Closing Remarks

Lunch Break
Return at 1:30 pm

Welcome Back
Rachel MacDonald

Opening Remarks

PM Workshop Schedule

1. Welcome Back
2. Opening Remarks
3. Guidehouse Transmission Technologies Assessment
4. New Jersey's Offshore Wind Transmission
5. California Offshore Wind Lessee Perspective on Transmission
6. Facilitating Offshore Wind Transmission
7. Public Comment
8. Closing Remarks

Claire Huang and Lily Busse
Guidehouse

AB 525 Transmission Technologies Assessment

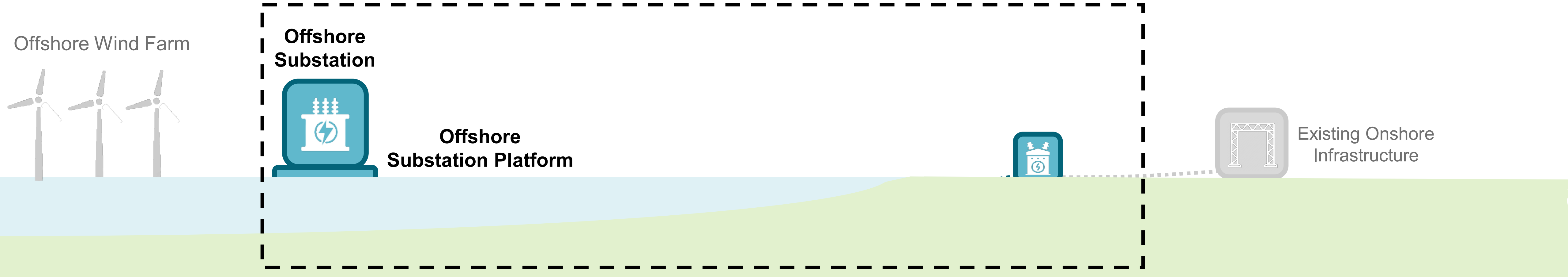
May 25, 2023

Agenda

- Background
- California Lease Areas
- Transmission Technologies
  - o Transmission Systems Overview
  - o Export Cables
  - o Substations
  - o Meshed Grids
- Interview Insights
- Q&A

Background

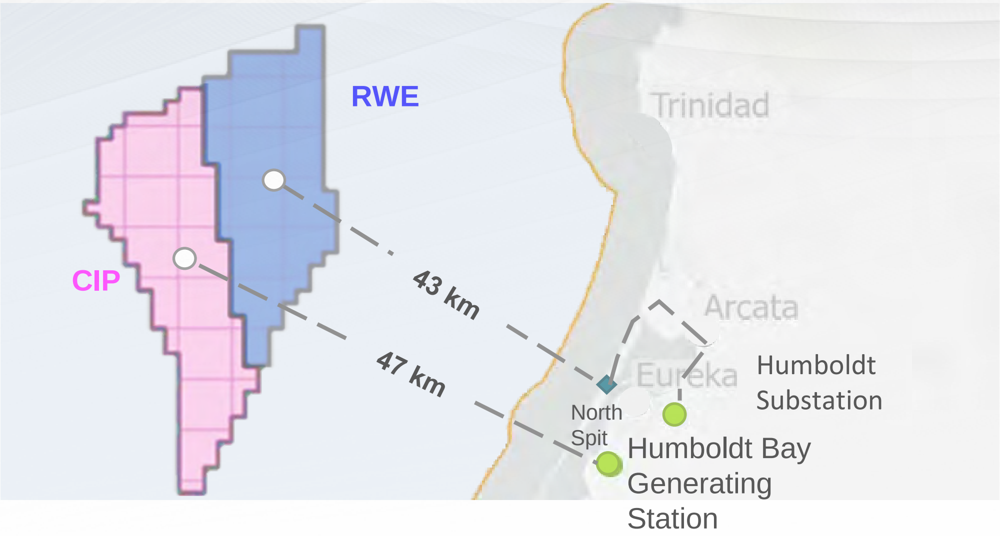
Purpose	Document the current state of existing and emerging technologies necessary for offshore wind transmission in California to inform the transmission chapter of the CEC's offshore wind strategic plan, as required by Assembly Bill 525
Scope	Transmission technologies: offshore substation, offshore substation platform, export cable, and onshore converter/transformer station
Methodology	• Secondary research: literature review of publicly available information • Primary research: interviews with offshore wind developers, transmission developers, and manufacturers

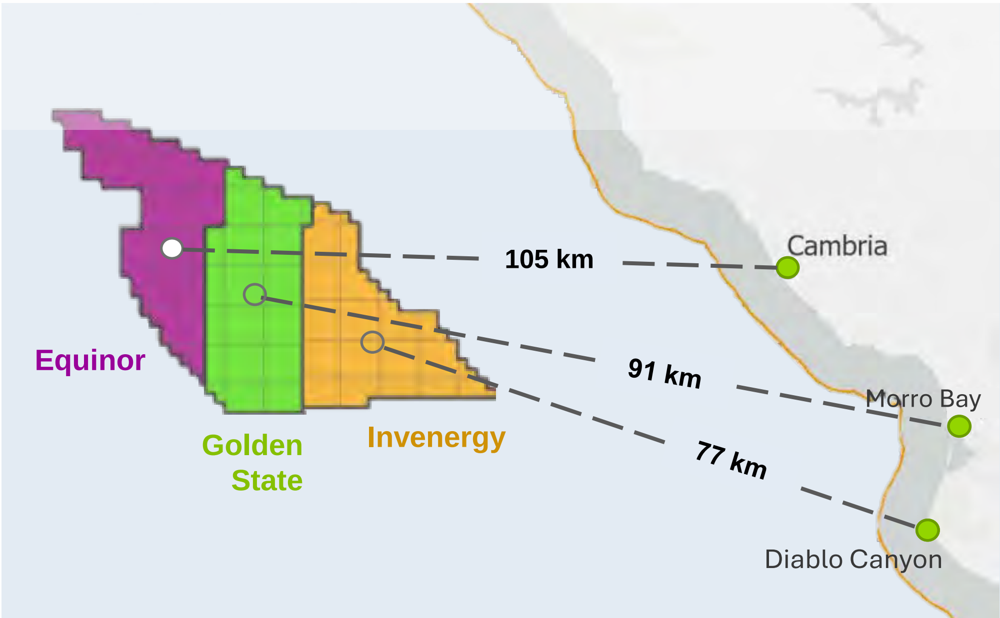


California Lease Areas

Provisional Winner	Acres	Potential Capacity (MW)	Avera Dept (m)	Average Distance from Shore (km)
RWE Offshore Wind Holdings, LLC	63,338	1470	723	43 (Eureka)
California North Floating, LLC (CIP)	69,031	1590	786	47 (Eureka)
Equinor Wind US, LLC	80,062	1800	1,12	105 (Morro Bay)
Central California Offshore Wind, LLC (Golden State)	80,418	1905	1,05	91 (Morro Bay)
Invenergy California Offshore LLC	80,418	1845	988	77 (Morro Bay)

- Water depth range: 700-1,200 m
- Distance to shore range: 40-105 km



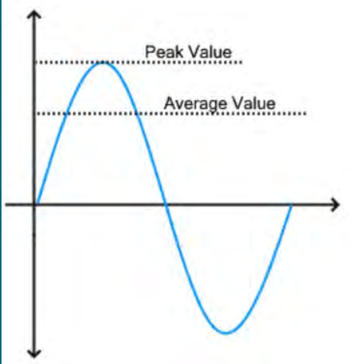
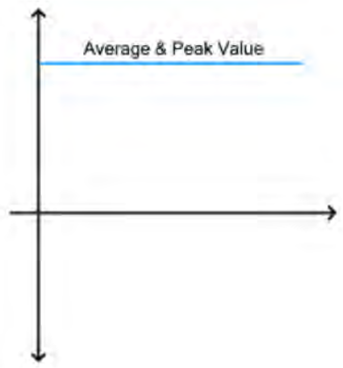


Note: For illustrative purposes. Approximate distances provided.

Transmission Technologies

Transmission Systems Overview

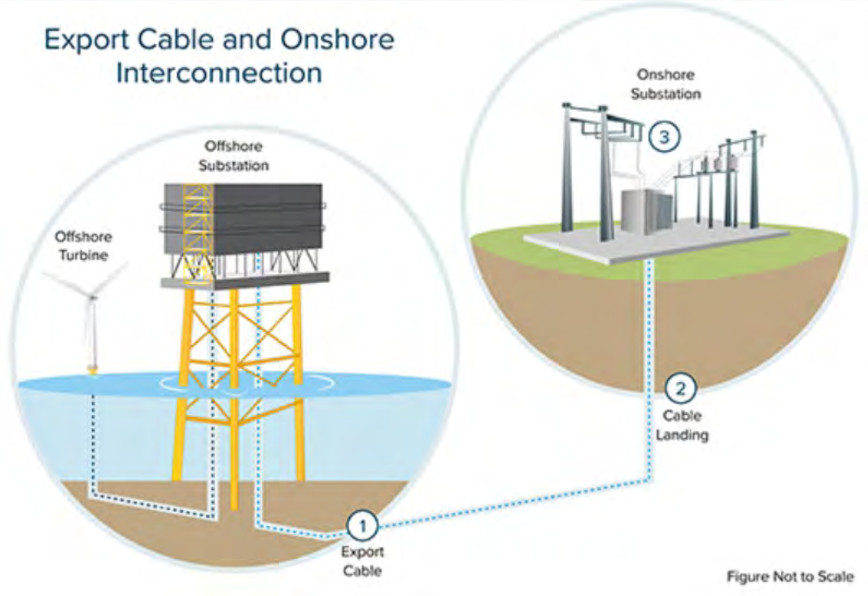
For long distances, power is transmitted at *high voltages* to reduce losses. Power can also be *alternating current* or *direct current*.

High Voltage Alternating Current (HVAC) 	• **Majority of onshore transmission is HVAC** • **HVAC is the status quo for offshore wind export, with 20+ years of experience** • **Current periodically reverses direction** • **Voltage is easily stepped up/down with a transformer** • **At longer distances, useful power decreases as reactive (unusable) power is produced**
High Voltage Direct Current (HVDC) 	• Exists for onshore transmission, but less common • Less established for offshore wind, but enables transmission at higher capacities and longer distances without reactive power losses • Current maintains the same magnitude and direction • For offshore wind transmission, requires converters to rectify or invert current from AC to DC or vice versa

Export Cables

Export Cables Overview

- Export cables are high voltage, subsea cables that transmit power from the offshore substation to the onshore substation
- Uses AC or DC technology
- Static or dynamic
- Come in a variety of types, sizes, voltage levels, insulation types, and are often custom made for each wind farm



Source: NYSERDA

Source: Boskalis

HVAC Export Cables 

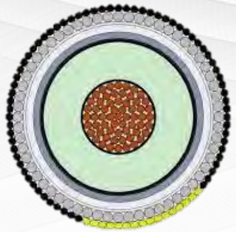
- Mature technology, well defined market, strong supply chain
- Common voltages:

132 kV → 220 kV → 275 kV → 420 kV (developing)

- Export capacity ranges between **300-500 MW**
  - o **700-1000 MW** in development
- Practical maximum length ~**100 km**
  - o Can be extended with the use of reactive power compensation
- Cost: **$3,600-5,000 $/km/MW**

Source: Nova Innovation

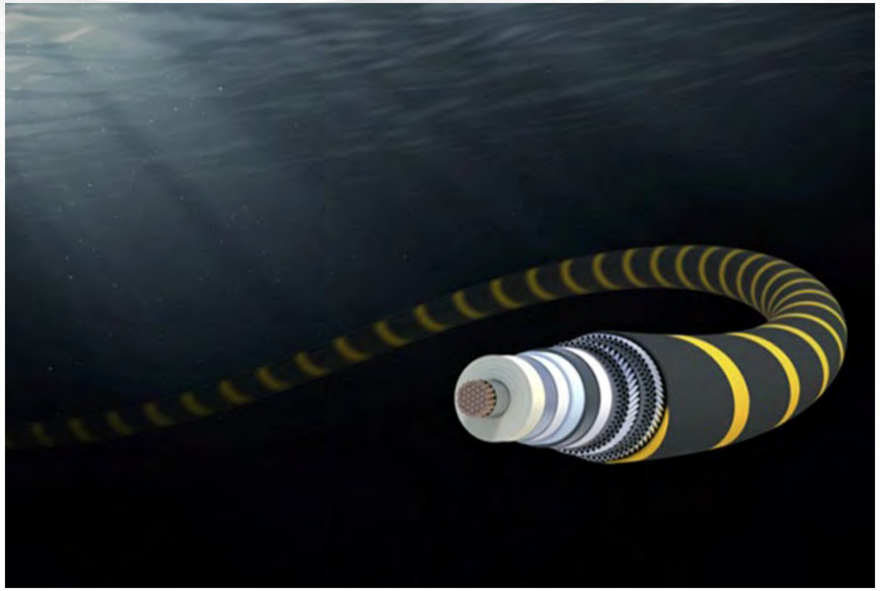
HVDC Export Cables



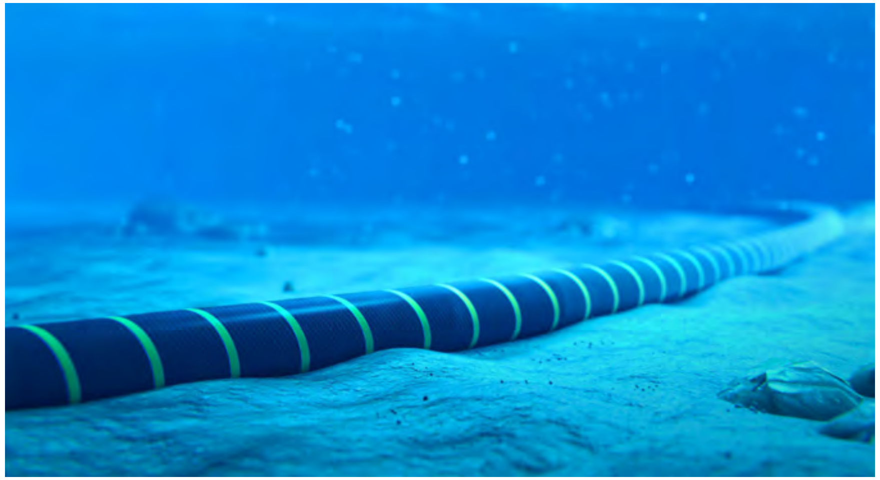
- Common voltages:

320 kV → 525 kV → 640 kV (developing)

- Transmission capacity between **1,300-2,600 MW**
- Theoretically unlimited in transmission length
  - Longest subsea HVDC cable is **720 km** in length
- Cost: **$1,476-4,900 $/km/MW**

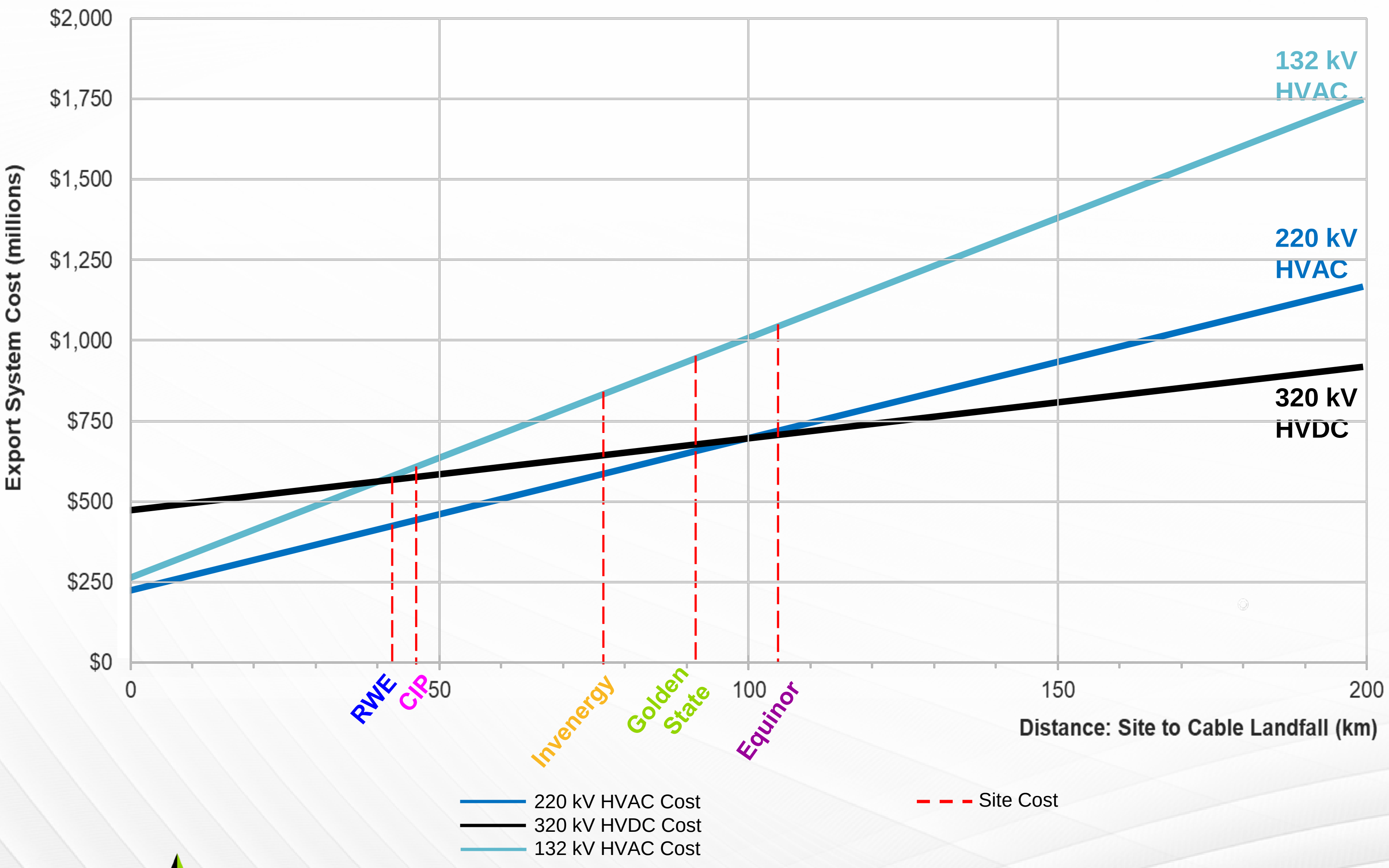


Source: Offshore Energy



Source: XLCC

HVAC vs. HVDC Cabling Technology



Key Takeaways:

1. **80-100km** breakeven point, beyond which HVDC is more economical.
2. Lessees in CA can consider HVDC over HVAC depending on point of interconnection.
3. There are many tradeoffs: cost of infrastructure, electrical losses, transmission power, cable corridor space, technological maturity, etc.

Interview Insight
Developers are open to both HVAC and HVDC options

Source: Adapted from NREL

Dynamic Export Cables

Serves the same purposes as a static export cable, but not attached to seabed

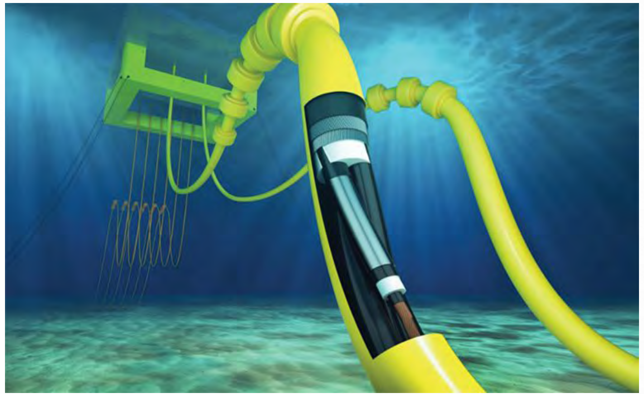
- o Subjected to constant ocean movements
- o Lead sheath is highly susceptible to fatigue
- o **Dynamic cables are key to enabling floating offshore wind farms**

HVAC

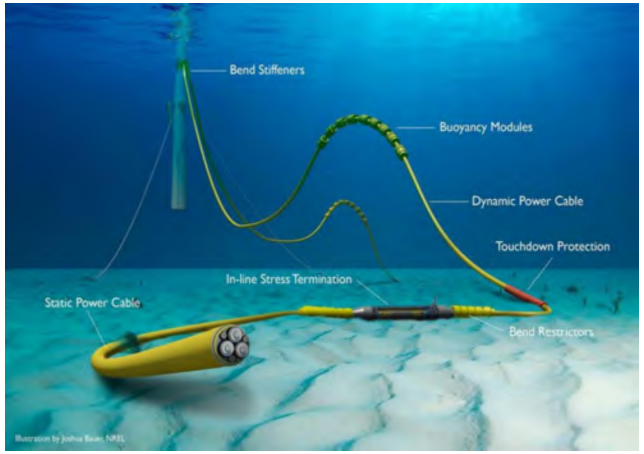
- Dynamic HVAC cables do exist, but not at the export level needed
- Lower voltage (33 and 66 kV) dynamic cables are available
- A few examples also seen in oil and gas
- Manufacturers are in the process of creating higher voltage AC dynamic cables: 132 kV and 220 kV

HVDC

- Dynamic HVDC cable technology does not exist
- Manufacturers are in the process of creating 150 kV dynamic HVDC cables
- Lack of market demand and supply chain constraints may impact availability



Source: Offshore Wind Power



Source: Global Underwater Hub

Substations

Substation Overview

A substation transforms and stabilizes voltage and provides grid protection.

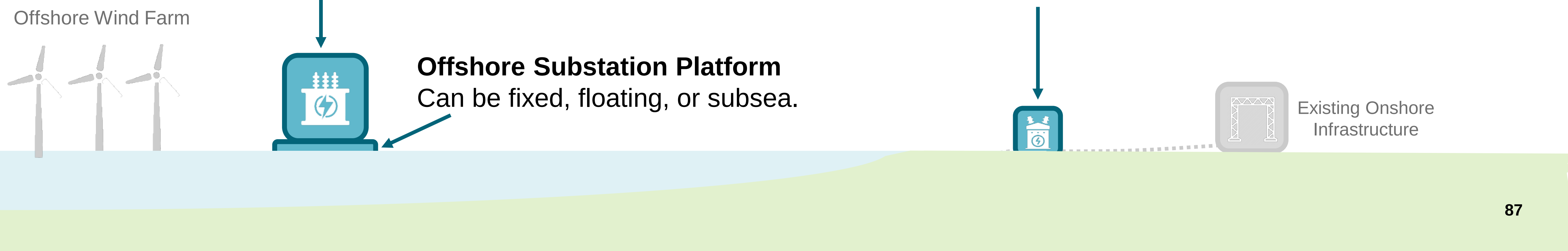
Source: T&D World

Offshore Substation
Collects power from offshore wind turbines and steps up the voltage for transmission to shore

Source: National Grid

Onshore Converter/Transformer Station
Receives high voltage power and transforms the power to interface with onshore transmission or distribution systems

Offshore Substation Platform
Can be fixed, floating, or subsea.

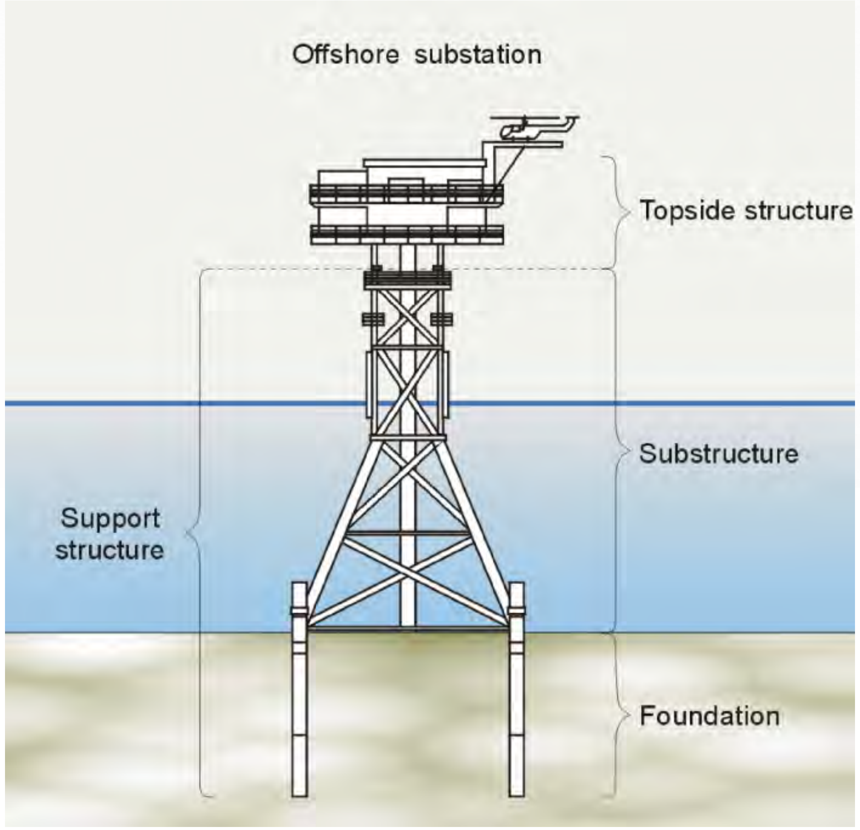


Offshore Substation Platform – Fixed

- Fixed platforms are used in water depths up to 100 m
- 3 typical substructures: jacket, gravity, and monopile
- Topside is the large structure on top containing all necessary electrical equipment. Approximate topside weight and dimensions:

HVAC	HVDC
• 2,000 – 4,000 tons • 50 m x 30 m x 15-50 m	• 13,000 – 20,000 tons • 72.5 m x 51 m x 25 m

- Dogger Bank is the first unmanned HVDC offshore substation, slashing topside size by 70%

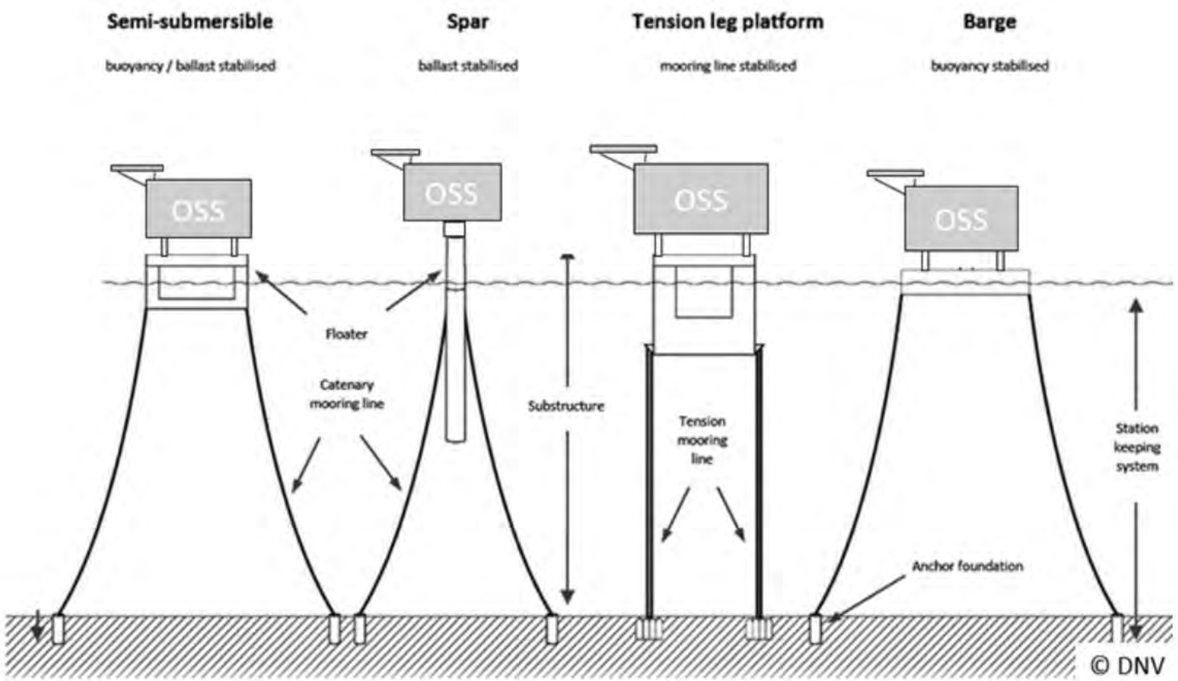


Source: Electrical Power Engineering Institute

Offshore Substation Platform – Floating

- Relatively new technology built on concepts from oil & gas and turbine platforms
  - o Semi-submersible, spar, tension leg platform, and barge designs
  - o Require dynamic export cables
- Electrical equipment is sensitive to vibrations of ocean, especially for DC
  - o All current designs are based off AC technology
- Several different designs are on the market, but not yet commercially available
- Example: Fukushima FORWARD
  - o 16 MW, 66 kV, decommissioned 2021

Interview Insight
Developers are confident in the technological feasibility of floating platforms



Source: DNV

Offshore Substation Platform – Floating

Fukushima FORWARD's advanced spar floating offshore substation

Ideol and AOE's barge design based on Ideol's shallow-draft Damping Pool concept

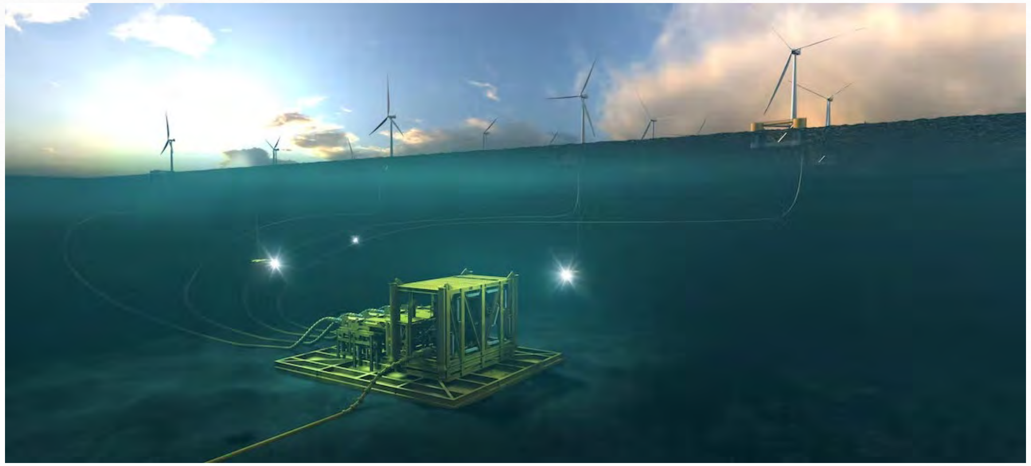
BW Ideol and Hitachi ABB Power Grids concept based on Ideols' shallow-draft platforms

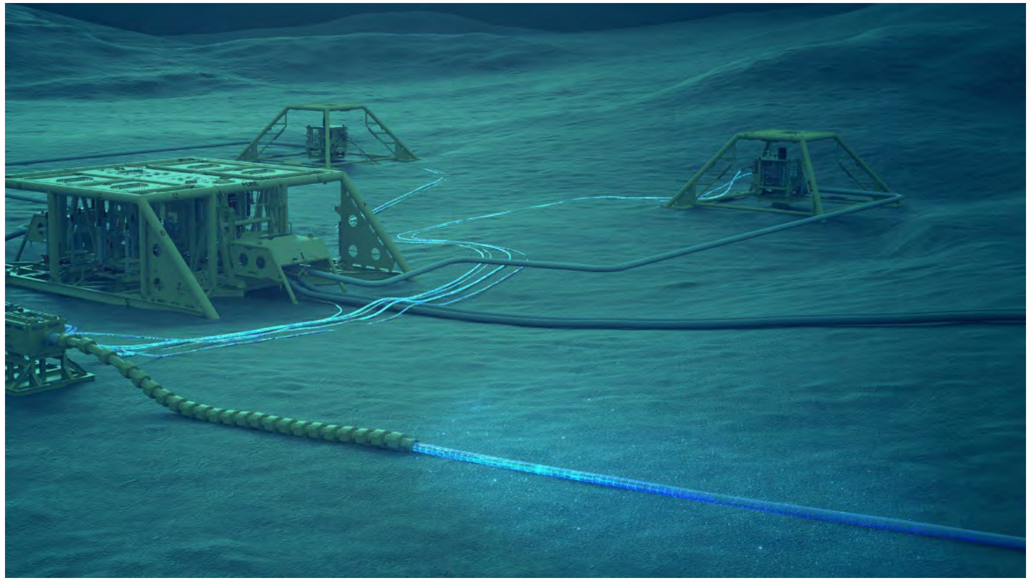
Semco Maritime's "FOSS 400" based on a three-column stabilized substructure design

Offshore Substation – Subsea

- Builds on concepts from oil & gas
- Design by Aker Solutions claims:
  - o Reduced costs
  - o Lower emissions
  - o No need for dynamic cables
  - o 30 years without need for maintenance, reducing personnel safety issues
  - o Depths up to 1,500 m
  - o Market ready in 2024

Interview Insight
Some developers are cautiously excited about the possibility of a subsea substation





Source: Aker Solutions

HVAC Substations – Electrical Components

- HVAC electrical technology is highly mature and has been used for offshore wind export for more than 20 years.
- Reactive power compensation components are needed for long-distance HVAC transmission

Offshore substation
• Step up transformer • Gas-insulated switchgear • Array cable connections • Low voltage and medium voltage systems • Auxiliary systems

Onshore substation
• Step down transformer • Switchgear (air- or gas-insulated) • Reactive power compensation components (typically) • Harmonic filters • Auxiliary systems

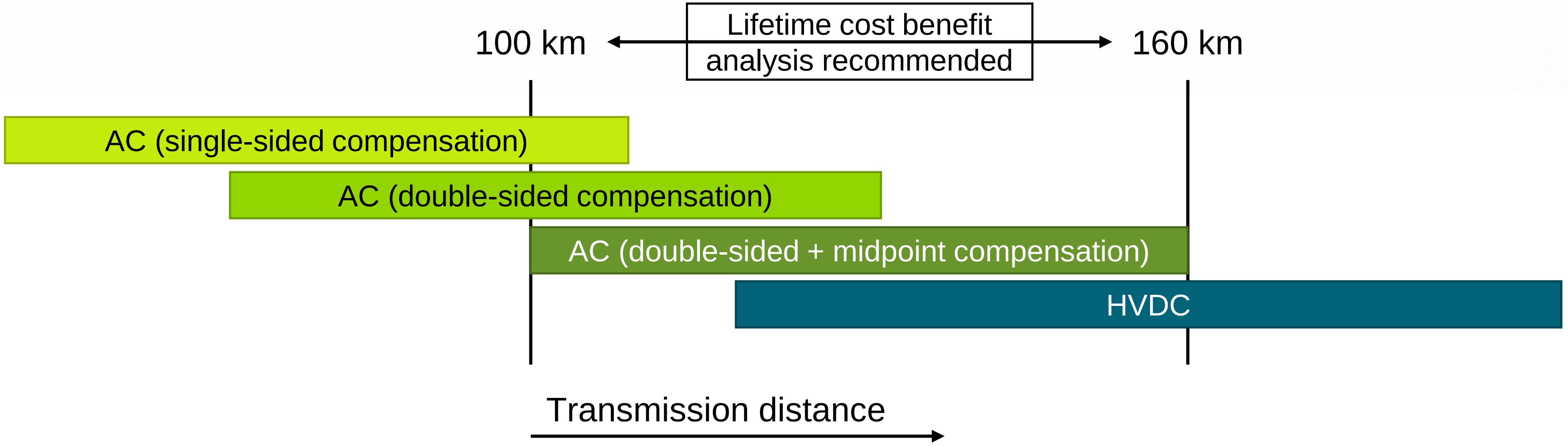
HVAC Offshore Substation and Platform Costs

Source	Year	MW Rating	$ Million	$/MW
NYSERDA Power Grid Study	2020	800	120	150,000
NREL ORBIT	2022	800	188.1	235,065
National Grid Study UK	2022	1000	143.8	143,753

Costs are assumed to be applicable for the year in which each study was published. Costs include both platform and electrical equipment costs.

HVAC Substations – Reactive Power Compensation

- The active power transmission capability for HVAC systems is limited for lengths greater than 80-100 km in subsea transmission, due to reactive power
- Reactive power compensation can be applied to extend transmission distance
- Reactive power compensation devices may include shunt reactors, static VAR compensators (SVCs), or synchronous static compensators (STATCOMs)



Source: Adapted from DNV

HVDC Substations – Electrical Components

- Less mature than HVAC, especially for offshore applications
- Grid protection components such as DC gas-insulated switchgear and DC circuit breakers are still developing, recently demonstrated in Progress on Meshed HVDC Offshore Transmission Networks (PROMOTioN) project

Offshore substation
• Step up transformer • Rectifier (AC to DC converter) • Gas-insulated switchgear • Array cable connections • DC circuit breaker (for meshed connections) • Low voltage and medium voltage systems • Auxiliary systems

Onshore substation
• Step down transformer • Inverter (DC to AC converter) • Switchgear (air- or gas-insulated) • DC circuit breaker (for meshed connections) • DC chopper • Auxiliary systems

HVDC Offshore and Onshore Substation and Platform Costs

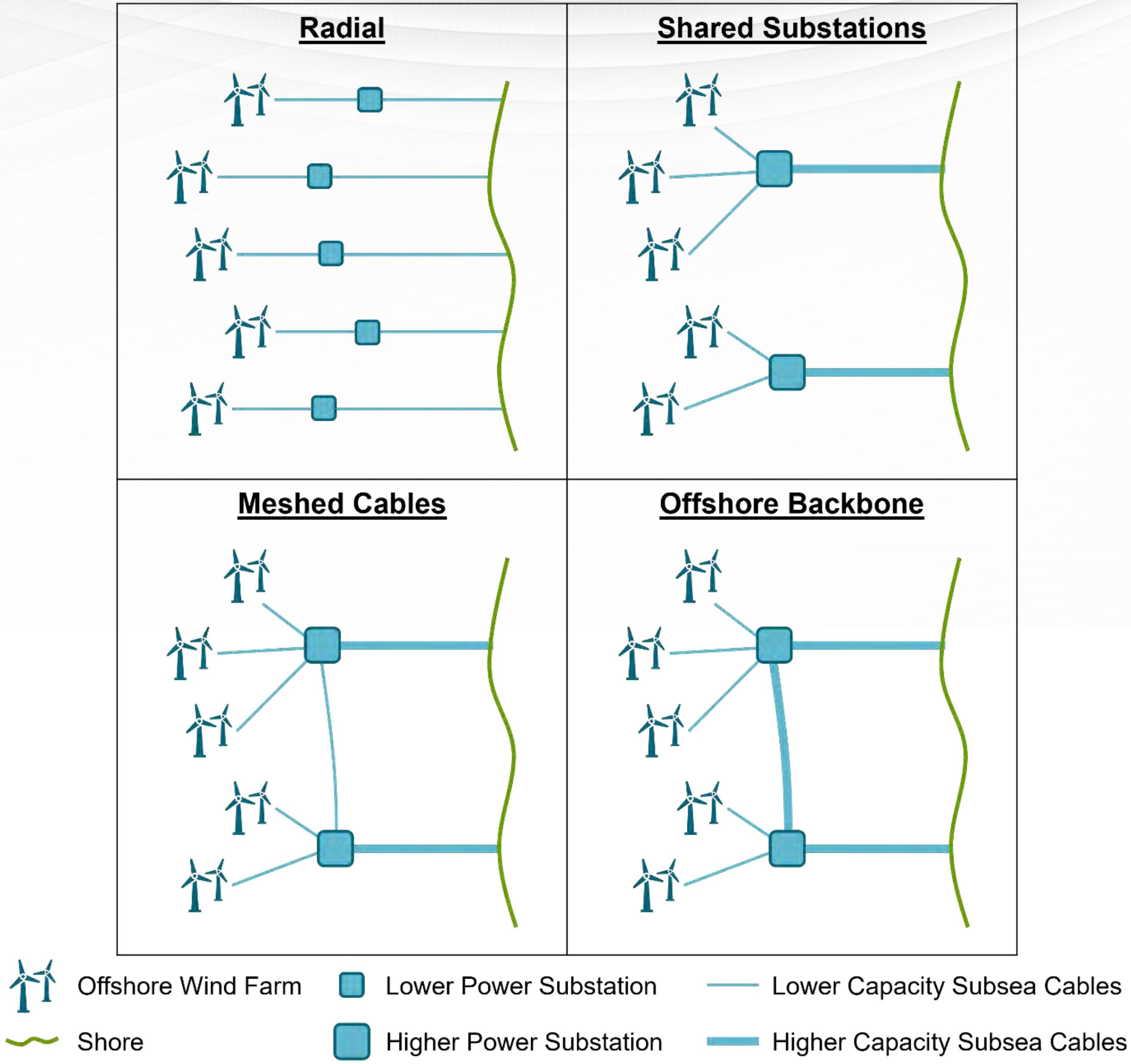
Source	Year	MW Rating	Offshore Substation		Onshore Substation	
			$ Million	$/MW	$ Million	$/MW
NYSERDA Power Grid Study	2020	1,200	$616.3	$513,583	$260.0	$200,000
NREL ORBIT	2022	800	$296.3	$370,368	$192.2	$240,227
National Grid Study UK	2022	1,000	$361.0	$361,015	$242.1	$242,129

Costs are assumed to be applicable for the year in which each study was published. Costs include both platform (for offshore) and electrical equipment costs.

Meshed Grids

Meshed Grids

- Meshed grid benefits:
  - o Better integration with the onshore energy system
  - o Allows for more OSW buildout
  - o Increased reliability and redundancy
- Can be HVAC or HVDC
- Policy direction can facilitate development of meshed grids
- Challenges:
  - o DC circuit breakers still developing
  - o Standards for interoperability and compatibility will be required
- Examples: New York, New Jersey, Great Britain



Interview Insights

Thoughts on Transmission and Interconnection

What we heard from developers…

Onshore grid constraints

- Transmission constraints in Humboldt
- Uncertainty around extension or decommissioning of Diablo Canyon nuclear power plant

Long-term transmission and interconnection planning

- Need for central, state-led transmission solution and policy-backed goals for offshore wind build-out
- Developers open to the idea of meshed grids, if state-led

Thoughts on Supply Chain Constraints

What we heard from developers…

California is the biggest/first major market signal to manufacturers for components such as dynamic cables and DC circuit breakers

Supply chains for HVDC substations and cables are limited and are booked out for the next several years by existing projects

Current global economic environment is constraining supply chain and driving increasing and unpredictable costs

CIP Copenhagen Infrastructure Partners

RWE

Invenergy

equinor

OW OCEAN WINDS

Q&A

Your Guides

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Guidehouse
Outwit *Complexity*

Questions and Answers

Andrea Hart
New Jersey Board of Public Utilities

Workshop on Assembly Bill 525

Assessing Transmission Upgrades and Investments for Offshore Wind Development off the Coast of California

Andrea Hart, Esq.

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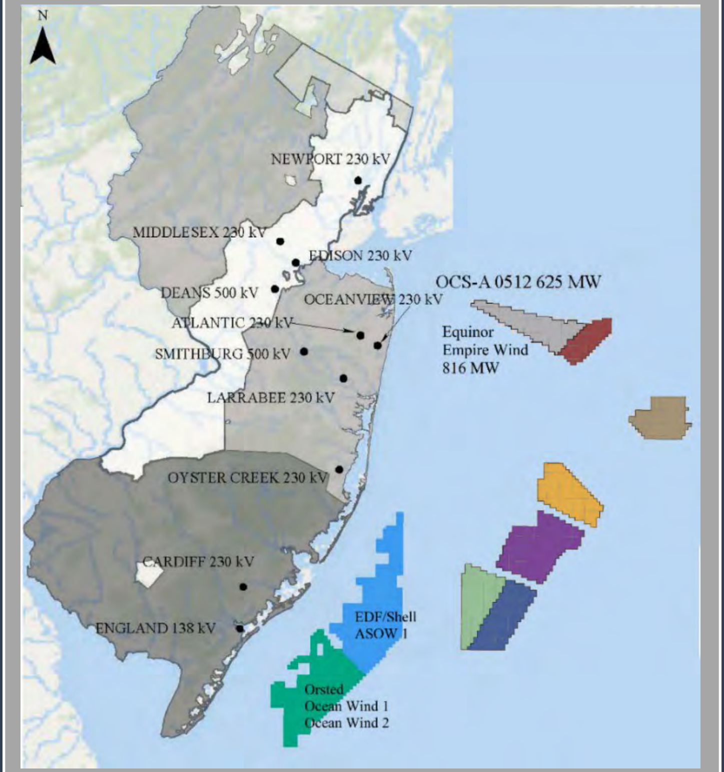
New Jersey's Offshore Wind Transmission

New Jersey's Offshore Wind Program

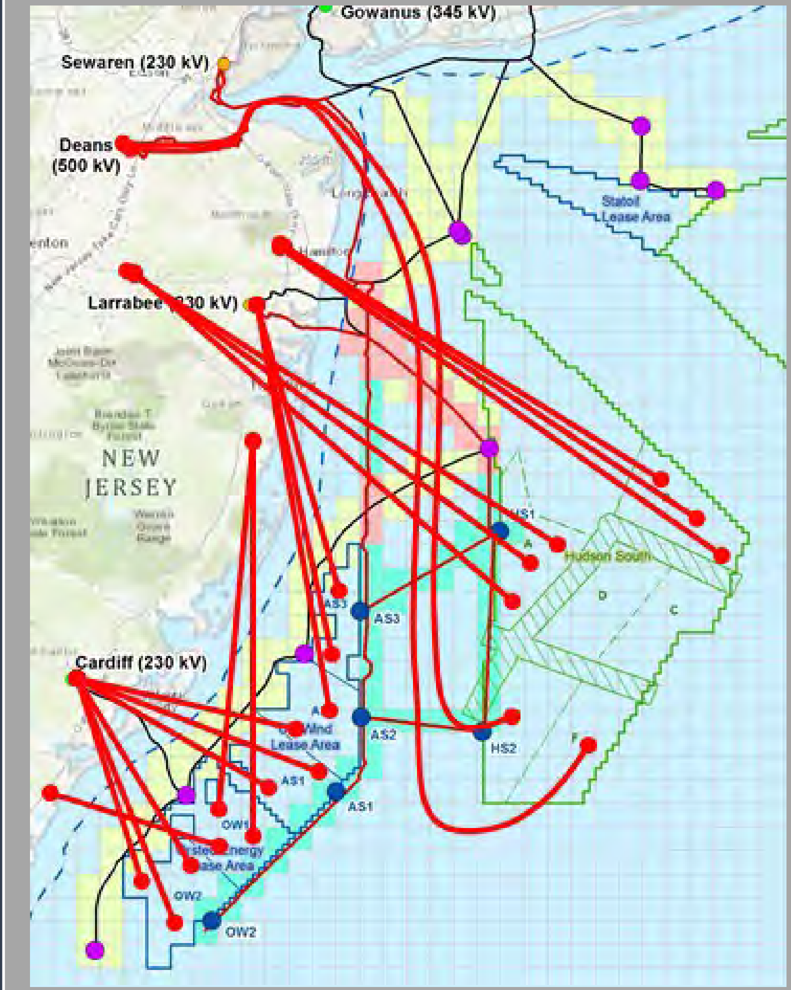
- 11 GW by 2040
- Solicitations #1 and #2
  - Ocean Wind 1, 1,100 MW
  - Ocean Wind 2, 1148 MW
  - Atlantic Shores 1, 1510 MW
- "Bundled projects" = each project is responsible for their wind farm *and* transmission

The Status Quo

lease areas

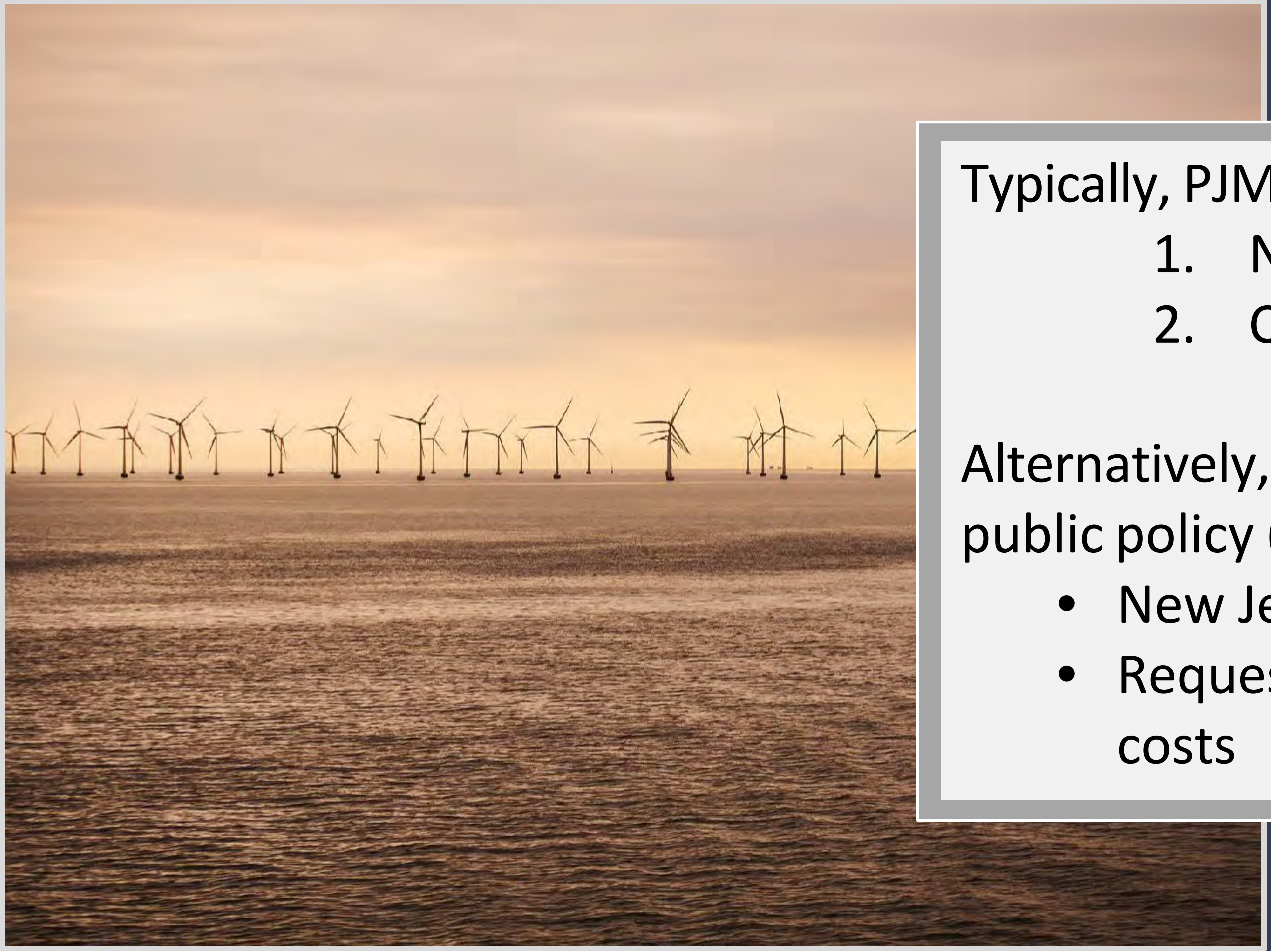


potential transmission interconnection routes



spaghetti dilemma

State Agreement Approach
A coordinated transmission solution



Typically, PJM identifies transmission upgrades based on:

1. Need
2. Cost

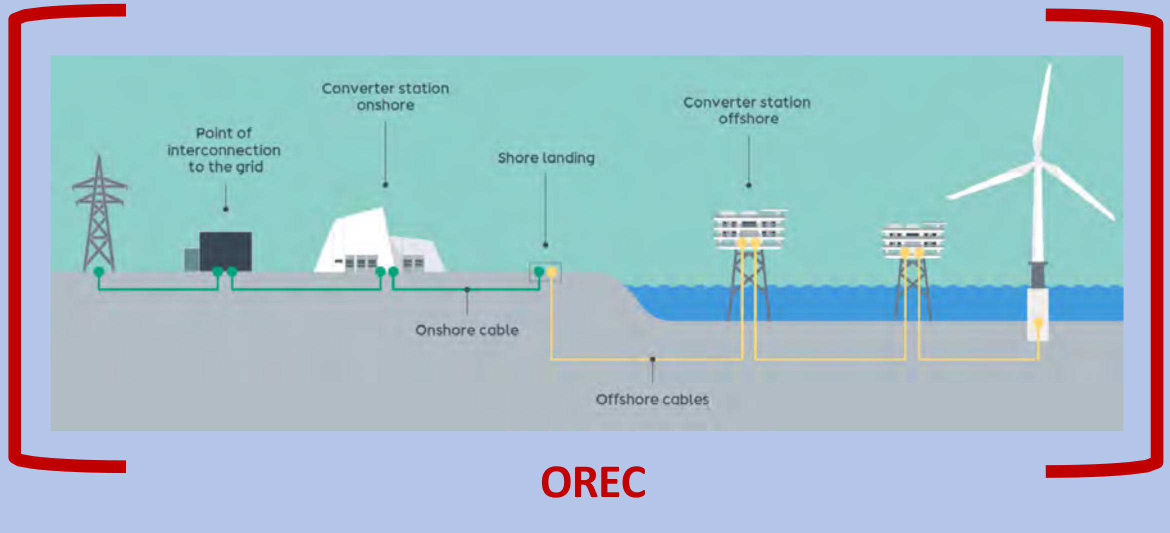
Alternatively, transmission upgrades based on: a state's public policy (State Agreement Approach)

- New Jersey's public policy = offshore wind
- Requesting state is responsible for 100% of the costs

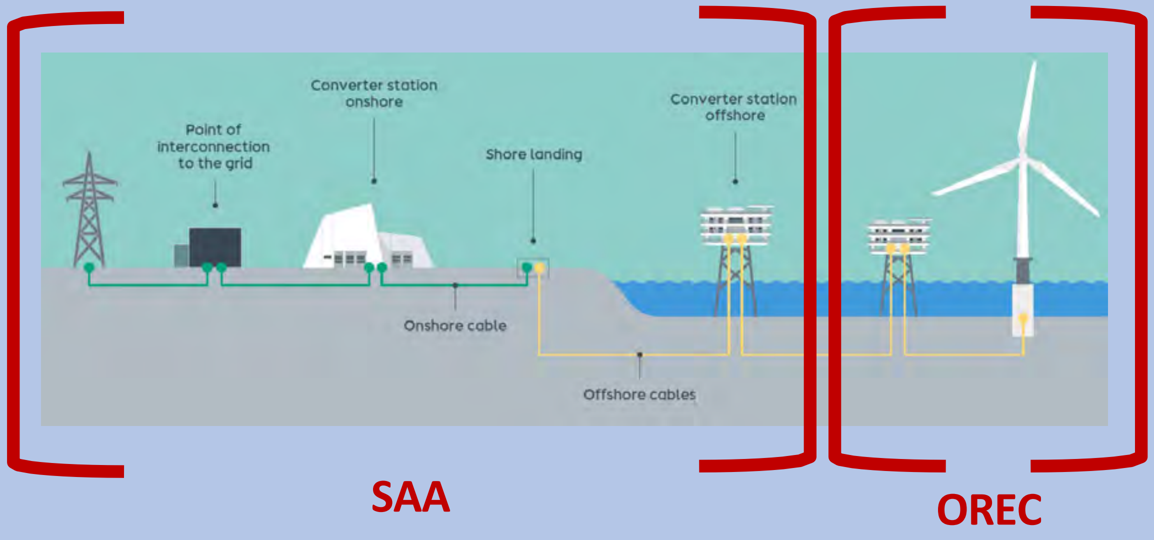
Transmission Costs

- "Bundled"—transmission costs part of project itself and therefore within OREC
- "Unbundled"—most transmission costs of the OSW project are paid for like a normal transmission project and are therefore <u>not</u> within the OREC

"<u>Bundled</u>"
Solicitations #1 and #2

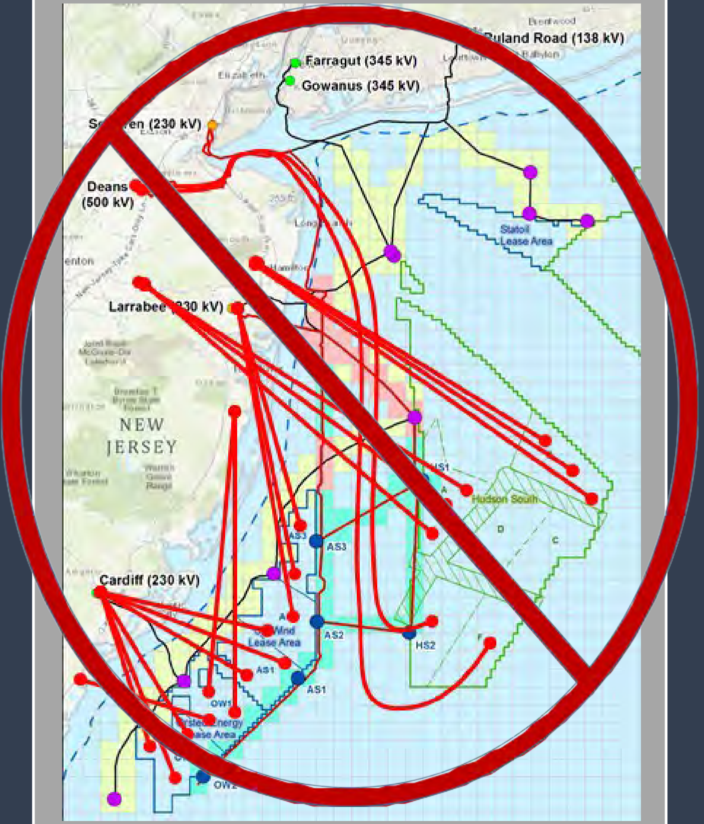


"<u>Unbundled</u>"
Future Solicitations + SAA



New Jersey’s SAA Goals

- Minimize environmental, permitting and fishing impacts
  - Minimize cables crossing shore
  - Minimize points of interconnection
- Encourage competition
- Lower cost and risk of OSW generation and transmission
- Maximize transmission developer expertise
- Lower OREC prices



New Jersey's SAA

PJM with BPU Staff developed the SAA solicitation

- Window Opened: April 15, 2021
- Window Closed: September 17, 2021

New Jersey's cleanenergy program™

New Jersey's SAA

<u>Option 1</u>

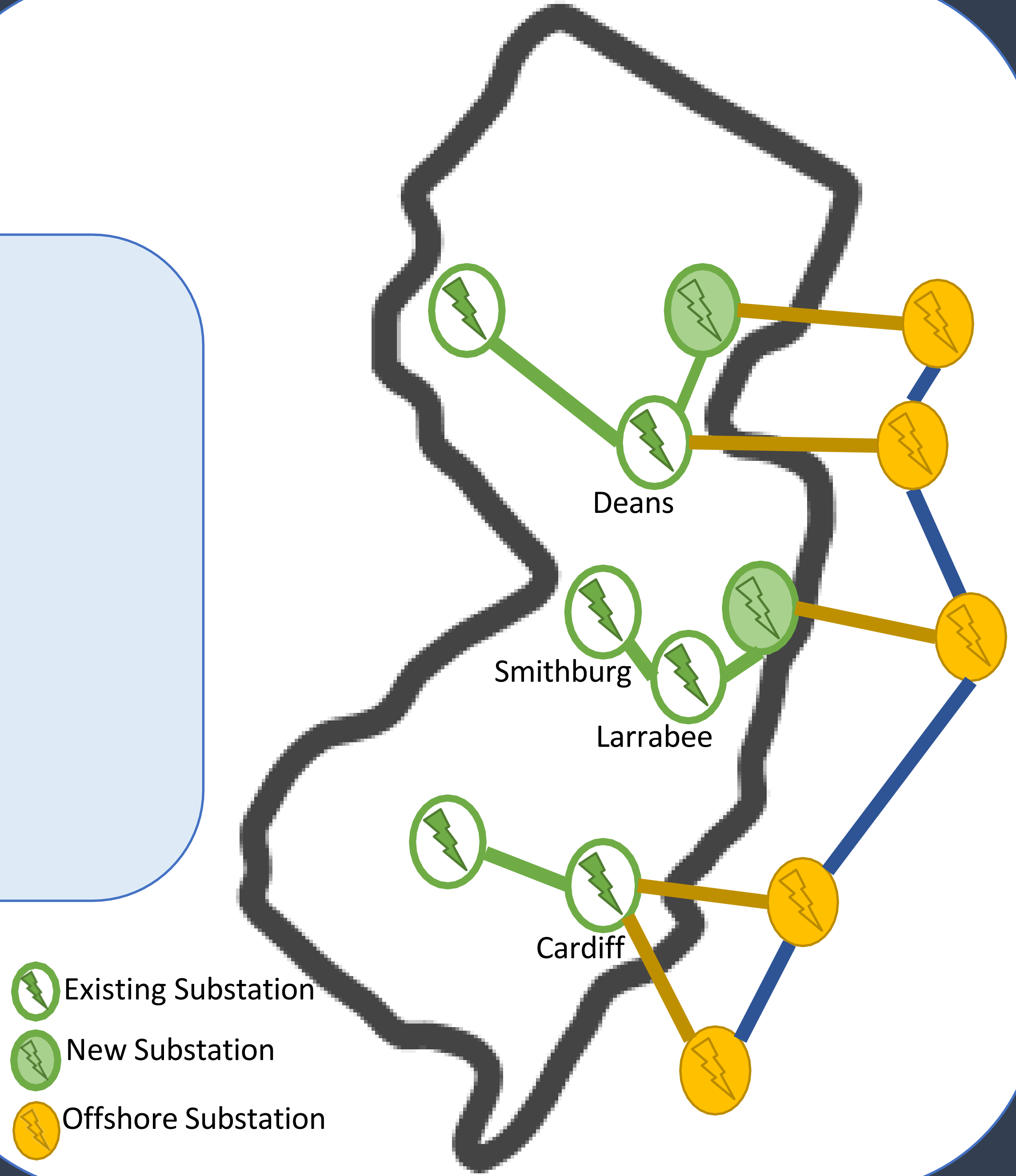
New or existing onshore upgrades

<u>Option 2</u>

New offshore substations over shore crossin substations

<u>Option 3</u>

"Network" or "backbone", interconnecting m offshore facilities

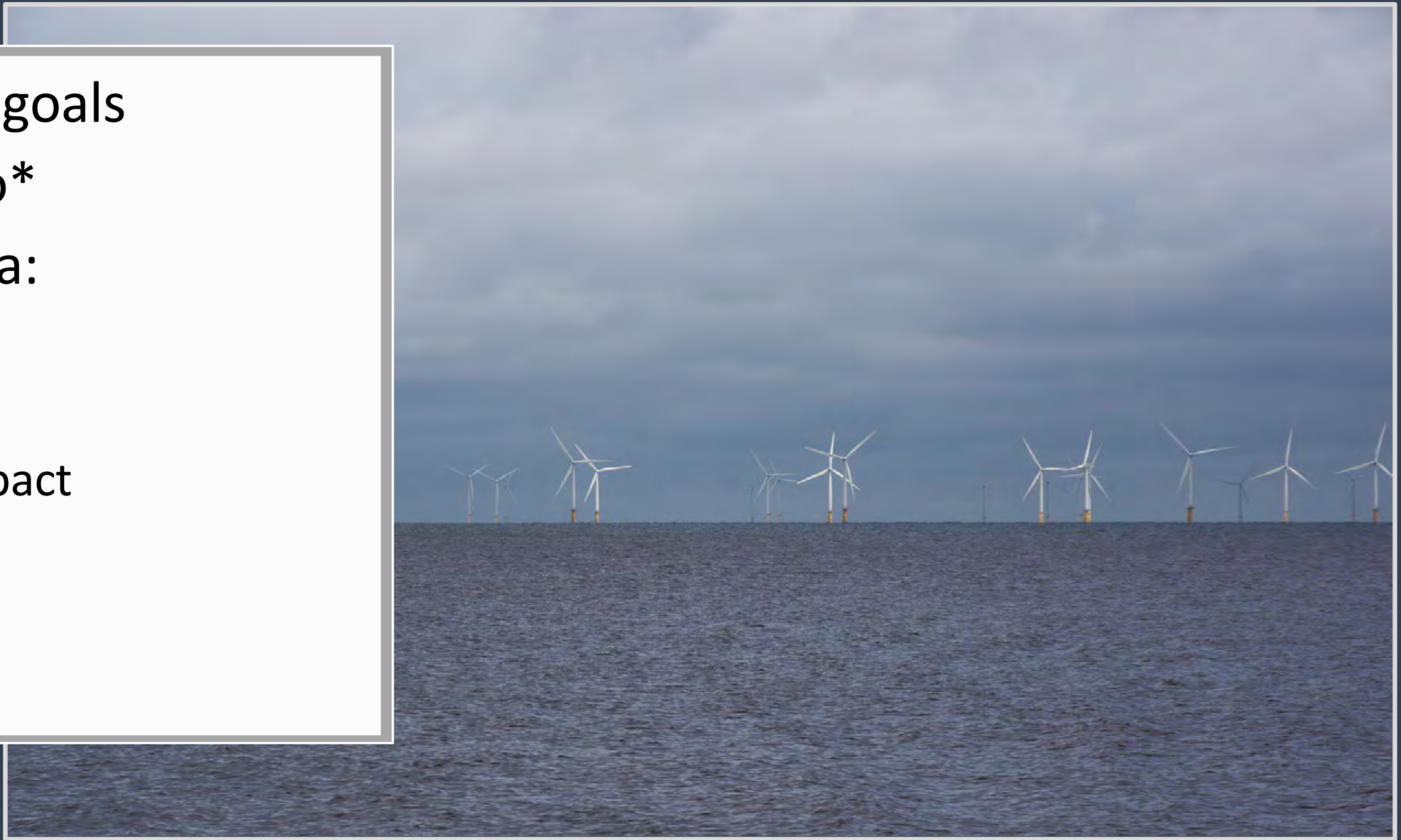


SAA Response—13 bidders with 80 proposals

SAA Bidder	Developer Type	Proposals	Option 1a	Option 1b	Option 2	Option 3
Transource	Non-Incumbent	4	4			
Public Service Electric and Gas (PSEG)	Incumbent	2	2			
PPL Electric Utilities (PPL)	Incumbent	1	1			
Rise Light & Power	Non-Incumbent	5	1	4		
Atlantic City Electric Company (AE)	Incumbent	5	4	1		
Jersey Central Power & Light (JCPL)	Incumbent	2	1	1		
LS Power	Non-Incumbent	9	3	5	1	
NextEra	Non-Incumbent	19	11		7	1
PSEG/Orsted	Combination	7			7	
Atlantic Power Transmission	Non-Incumbent	3			3	
Mid-Atlantic Offshore Development (MAOD)	Non-Incumbent	3			3	
ConEd	Non-Incumbent	1			1	
Anbaric Development Partners	Non-Incumbent	19			12	7
Total Proposals		80	27	11	34	8

Proposals Were Evaluated By:

1. Overarching SAA goals
2. Baseline Scenario*
3. Evaluation criteria:
   - Cost
   - Constructability
   - Environmental impact
   - Permitting
   - Reliability
   - Market efficiency



New Jersey's Board's Selection

Larrabee Tri-Collector Solution

- New substation and land
- Associated Option 1a upgrades

Costs: $1.08 billion for the full Larrabee Tri-Collector Solution

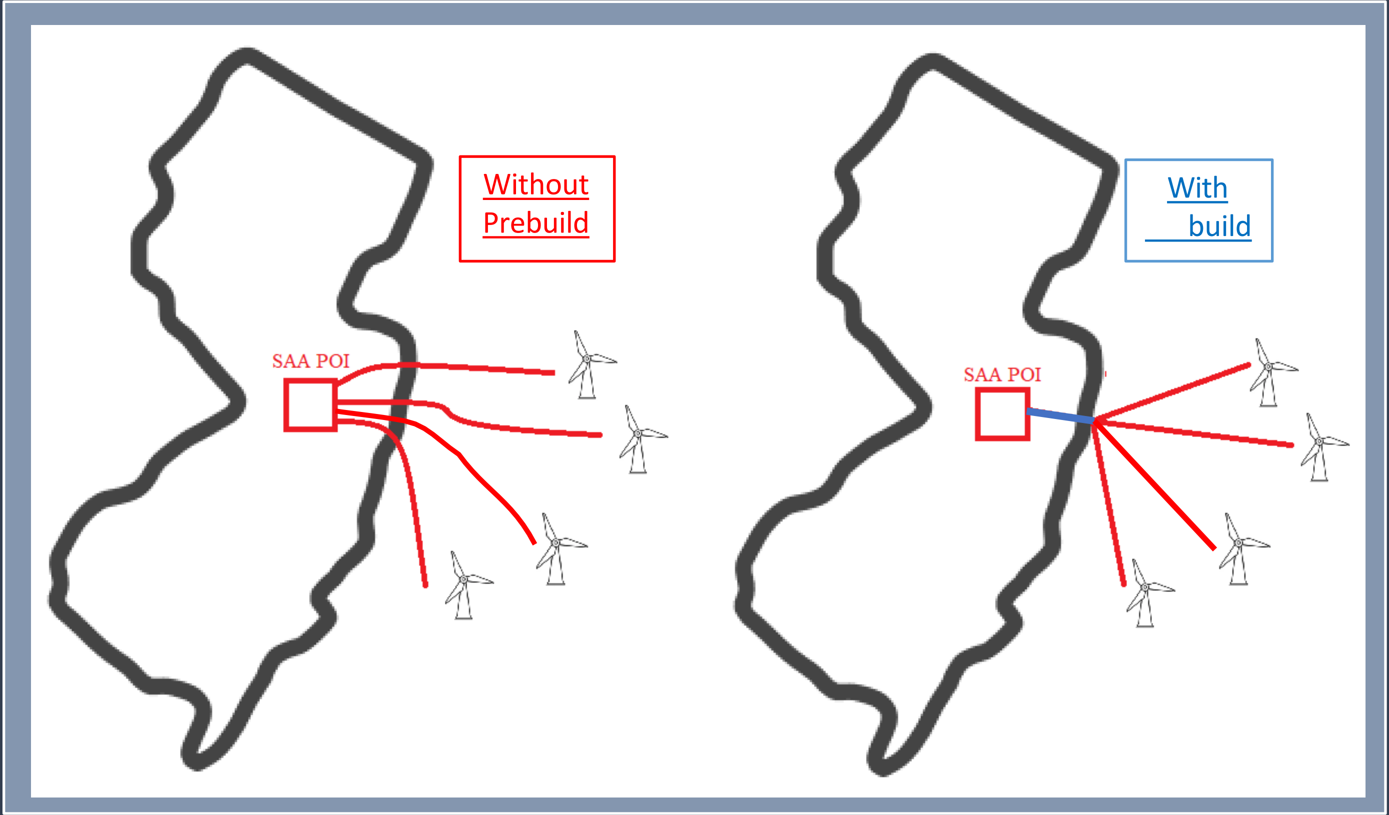
Savings: $900 million

The Prebuild Concept

<u>Goal</u>: minimize onshore cable route disruptions

- Environmental impacts
- Community impacts
- Risk of delays

<u>Concept</u>: the first generator builds all the necessary, un-energized infrastructure for its project *and* the future projects from shore to the POI



Future Coordinated OSW Transmission

Questions

Andrea Hart

Andrea.Hart@bpu.nj.gov

Follow NJBPU on social media:

10 Minute Break

Mohamed El Chehaly, Equinor
Saad Syed, Ocean Winds
Ajay Pappu, Invenergy

AB 525 – Morro Bay Leaseholders' Perspective on Transmission

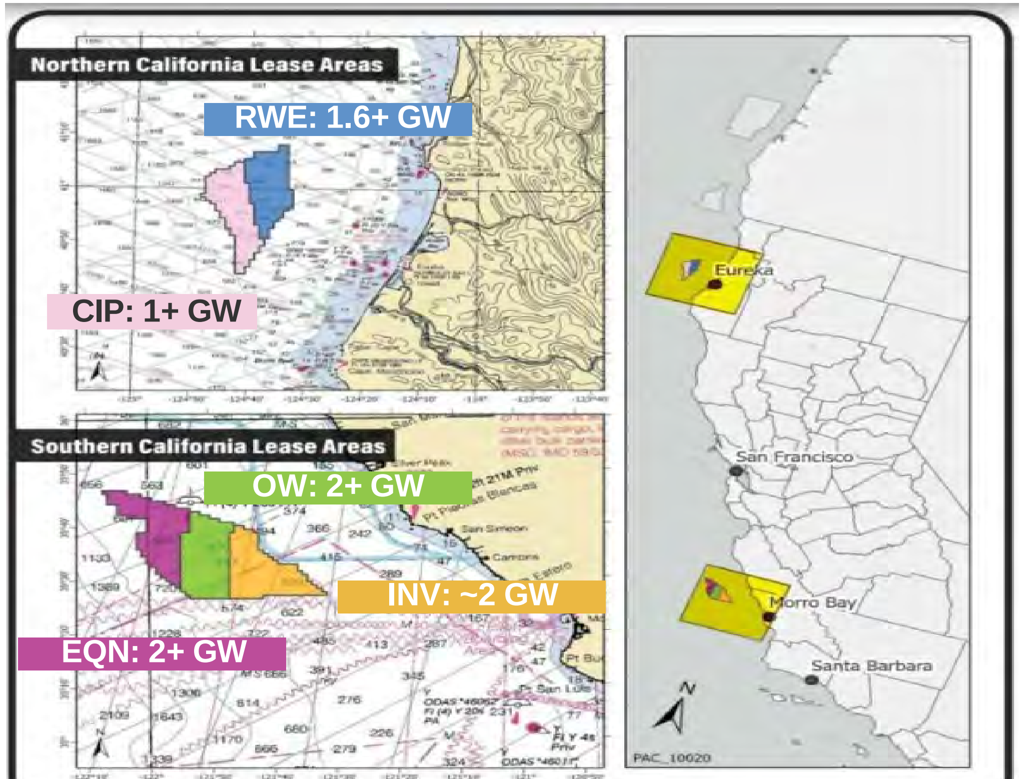
May 25th, 2023

Agenda

- Projected Capacity of CA Leases is about 10 GW
- Transmission Upgrades Should be Dedicated to OSW
- There are many Transmission Concerns with the Morro Bay Leases
- Key Takeaways for Transmission
- Appendix

Projected Capacity of CA Leases is about 10 GW

- NREL study[(1)] assumed **15 MW** WTGs
- DNV study[(2)] (May 22) for TKI Wind op Zee (TKI Offshore Wind): after 2030, WTGs projected to be **18-24 MW**
- **Requires staged approach to Transmission Projects – 2035 and 2045**



Source: Developers, BOEM

Project Sizes	TPP23-24 Base Case (MW)	TPP23-24 OSW Case (MW)	Leaseholders' Estimates (MW)
Humboldt	1,607	3,045	3,200 – 4,000
Morro Bay	3,100	5,355	5,500 – 6,000

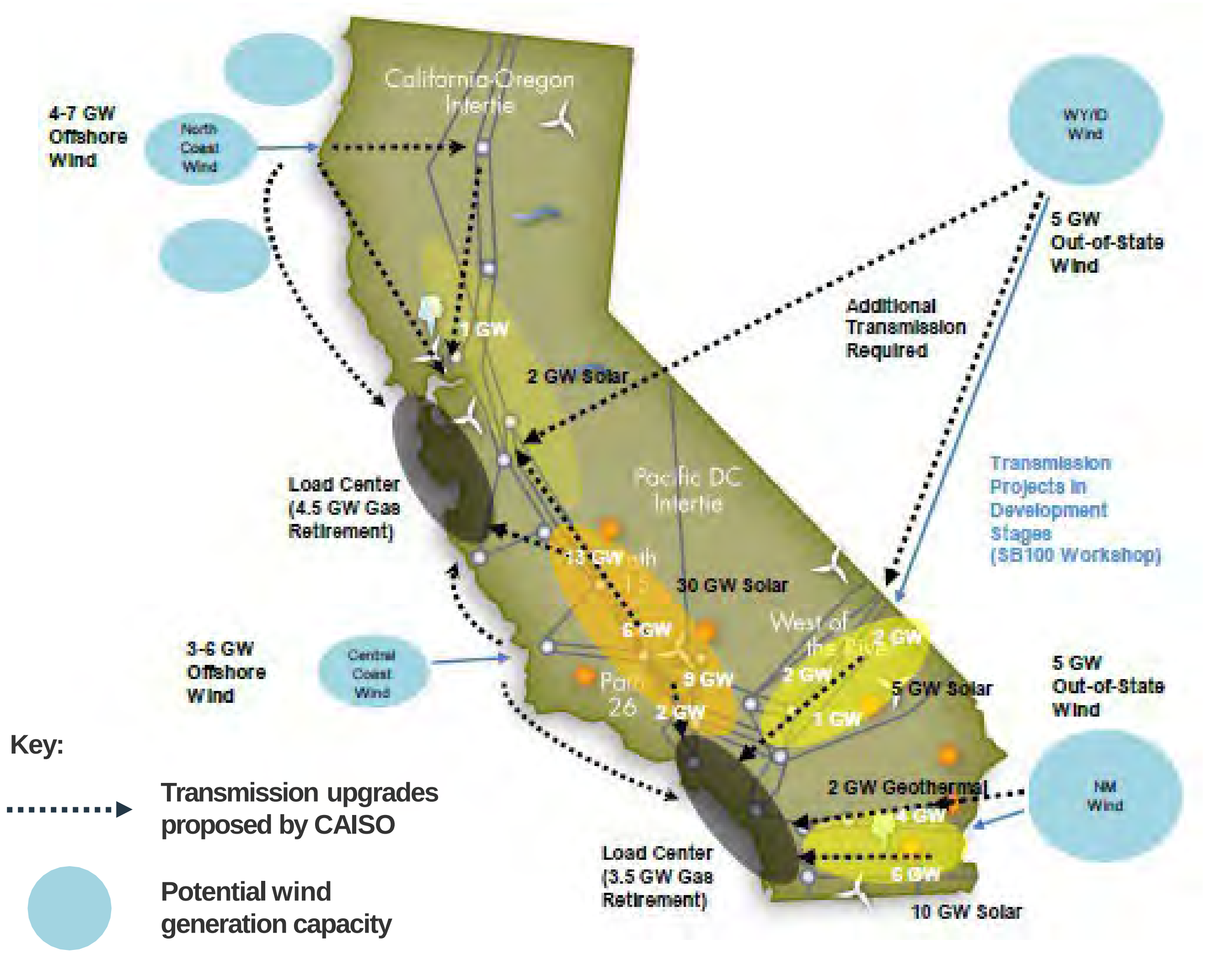
(1) NREL, *Assessment of Offshore Wind Energy Leasing Areas for Humboldt and Morro Bay Energy Areas, Californhiatt,ps://www.nrel.gov/docs/fy22osti/82341.pdf*

(2) DNV Services UK, Ltd, *Optimal offshore wind turbine size andstandardisation study*, https://topsectorenergie.nl/sites/default/files/uploads/20220519_RAP_DNV_Optimal_Offshore_Wind_Turbine_Size_and_Standardisation_F.pdf

Transmission Upgrades Should be Dedicated to OSW

- **Long lead time – similar to large scale transmission projects**
- **Need for policy-based transmission projects for OSW**
- Better align with Interconnection Process
  - OSW will not have an accelerated timeline in Cluster 15
- CAISO should dedicate upgrades to the actual resources modeled in the IRP

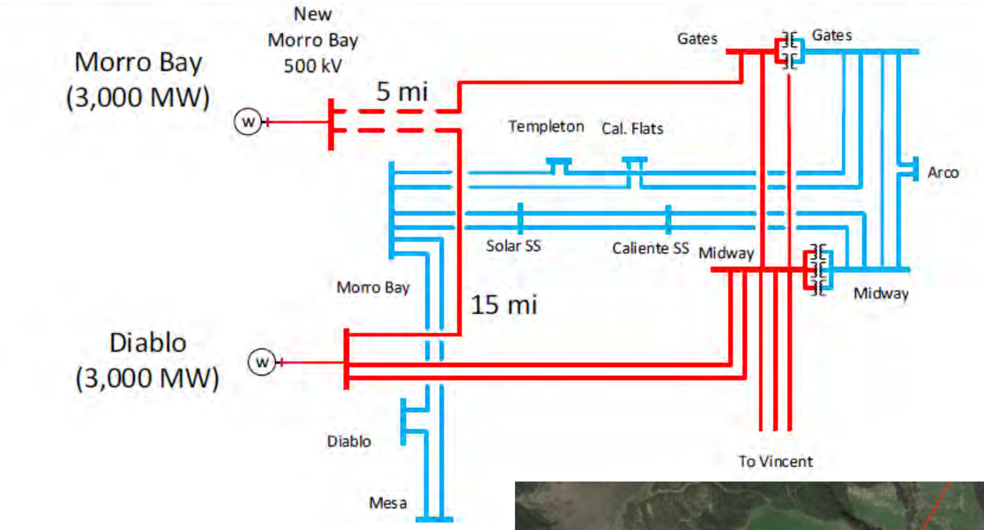
CAISO, 20-Year Outlook



Open

There are many transmission concerns with the Morro Bay Leases

- The risk of DCPP (plus retention of capacity rights for an additional 3 years)
- New Morro Bay 500 kV substation is needed to take on 6 GW
- Grid constraints and deliverability uncertainty
- 6+ GW of OSW triggering additional upgrades



Source: CAISO, 20-Year Outlook

equinor GOLDEN STATE WIND Invenergy

Key Takeaways for Transmission

The ability to achieve the climate and reliability goals requires a public policy determination for an interim goal of 10 GW for 2035 and 25 GW by 2045

- More than 6 GW of potential OSW at Morro Bay Leases
- DCPP is still an uncertainty
- **Upgrades dedicated to OSW should be reserved to OSW**
- Need for a new hub such as the Morro Bay 500 kV
- Potential need for a more regional approach with direct connections to load centers
- **Innovative transmission solution proposals in competitive solicitation similar to other ISOs**
- Third-party owned storage not guaranteed to be dispatched in a complementary manner with OSW

Appendix

Golden State Wind is a 50/50 JV of Ocean Winds and CPPIB, managed by OW

GOLDEN STATE WIND

OW OCEAN WINDS

CPP Investments

GOLDEN STATE WIND

- Morro Bay Central Lease Area (OCS-P 0564)
- OW is fully dedicated to offshore wind with a total portfolio of 16.6 GW (gross) with 15 projects in 7 geographies
- OW is a pioneer in floating offshore wind and the developer, majority owner, and operator of the 25 MW WindFloat Atlantic Project
- Extensive experience in developing cost-effective and comprehensive investments to support a durable, growing offshore wind industry.

About Ocean Winds

GOLDEN STATE WIND

Ocean Winds (OW) is an international company dedicated to **offshore wind** energy and created as a 50-50 joint venture, owned by **EDP Renewables** and **ENGIE**. Based on our belief that offshore wind energy **is an essential part of the global energy transition**, we develop, finance, build and operate offshore wind farm project all around the world.

When EDPR and ENGIE combined their offshore wind assets and project pipeline to create OW in 2020, the company had a total of 1.5 GW under construction and 4.0 GW under development. OW has been adding rapidly to that portfolio and is now on a trajectory to reach the 2025 target of 5 to 7 GW of projects in operation, or construction, and 5 to 10 GW under advanced development. Currently, **OW's offshore wind gross capacity already operating, in construction or with advanced development rights granted has reached 16.6 GW.**

OW, headquartered in Madrid, **is currently present in seven countries**, and primarily targets markets in Europe, the United States, selected parts of Asia, and Brazil.

More information: www.oceanwinds.com

OUR **GLOBAL FOOTPRINT**

Consists of **16.6 GW** (gross) with **15 projects** in **7 geographies**.

GOLDEN STATE WIND

Moray East
950 MW
Operation

Moray West
882 MW
Construction

Caledonia
2,000 MW
Development

Arven
1,800 MW
Development

Shetland Project
500 MW
Development

SeaMade
487 MW
Operation

BC-Wind
399 MW
Development

SouthCoast Wind
2,265 MW
Development

Bluepoint Wind
1,680 MW
Development

Golden State Wind
2,000 MW
Development

WindFloat Atlantic
25 MW
Operation

Tréport & Noirmoutier
Around 1000 MW
Construction

EFGL
30 MW
Construction

Korea Floating Wind
1,200 MW
Development

Hanbando
1,245 MW
Development

Bottom-fixed   Floating

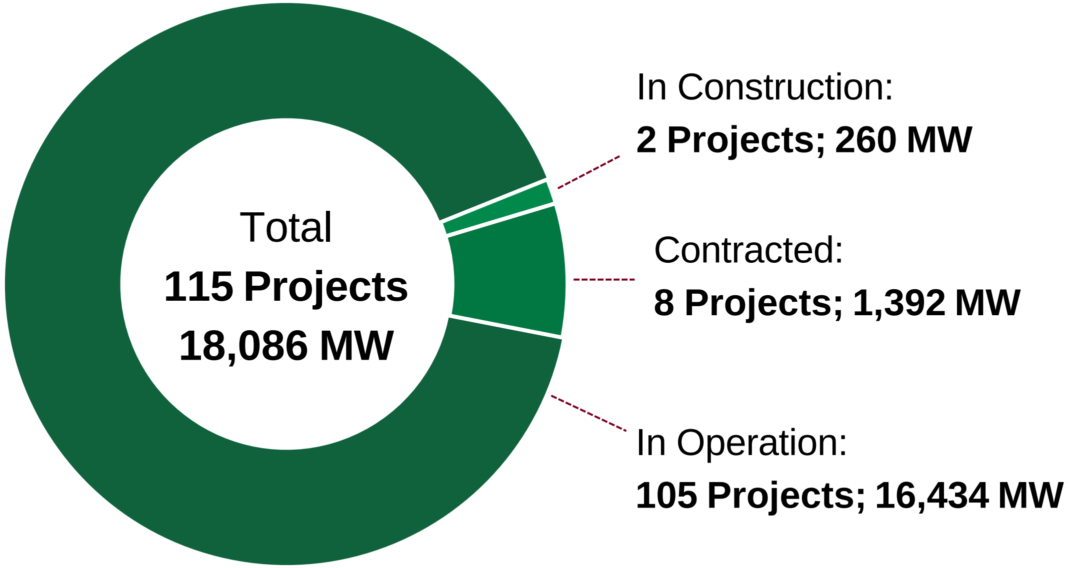
OW Offices   OW HQ

About Invenergy

- American-led company headquartered in the United States
- 30+ GW portfolio of sustainable energy solutions consisting of over 200 projects globally
- Over half of our project portfolio consists of onshore wind generation
- Our team is moving this expertise offshore in the New York Bight, Morro Bay, and is actively pursing opportunities internationally

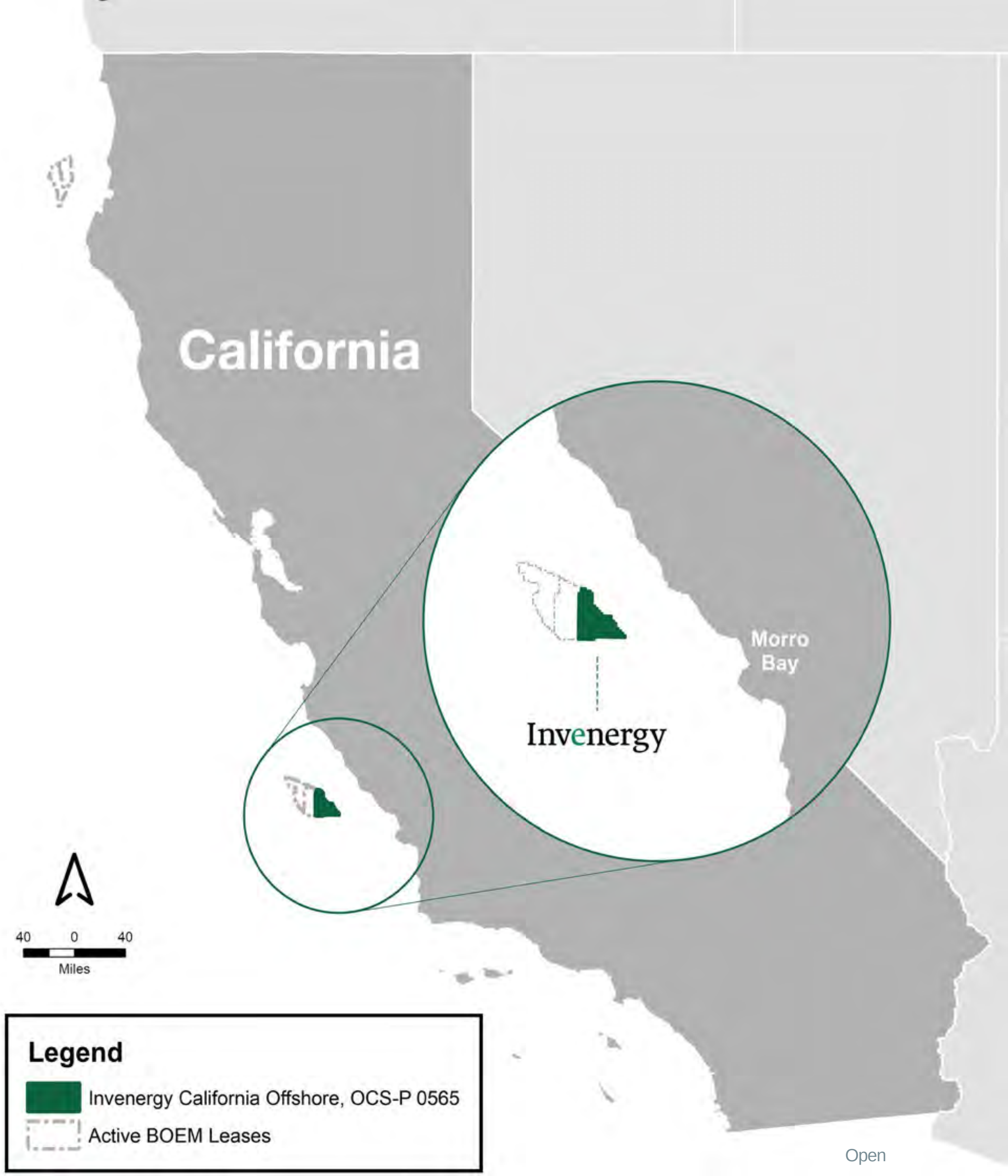
Invenergy

Invenergy Wind Portfolio



Project Profile

- Named only American-led provisional leaseholder by Bureau of Ocean Energy Management (BOEM) in December 2022
- Anticipating final lease agreement to be executed by June 1, 2023
  - Capacity: ~2,000 MW
  - Acres: 80,418
  - Avg. water depth: 994 - 1,197 m
  - Distance from shore: ~20 mi



High value growth in renewables

Equinor is a leader in America's growing offshore wind industry.

With one of the largest development portfolios, our current projects could fulfill 15% of the US government's 2030 goal of 30 GW of offshore wind.

We're making significant supply chain investments to grow US offshore wind at scale and support long-term jobs and economic growth in our communities.

3.3 GW

offshore wind capacity under development

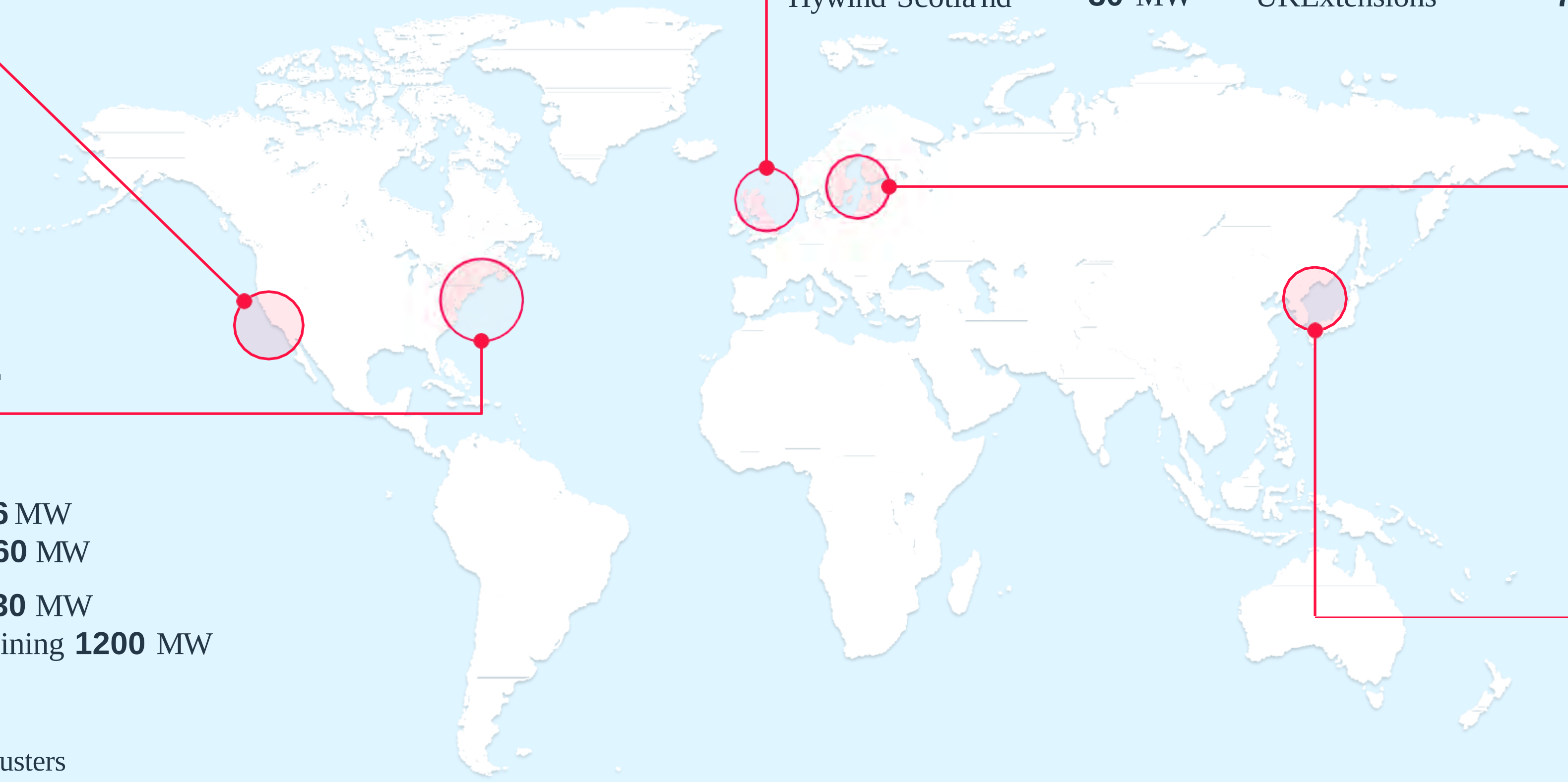
2 million

US homes could be powered by Empire and Beacon Wind

>50%

of Equinor capex towards renewables and low carbon solutions by 2030

How we are uniquely positioned



NORTH SEA

Producing:

Sheringham Shoal	**317** MW
Dudgeon	**402** MW
Hywind Scotland	**30** MW

In development:

Dogger Bank	**3.6** GW
Hywind Tampen	**88** MW
UKExtensions	**720** MW

US WEST COAST

Just won:

Morrow Bay West **2** GW

BALTIC SEA

Producing:

Arkona Germany	**385** MW

In development:

Baltyk I,II,III Poland	**~2.5** GW

US EAST COAST

In development:

Empire Wind I	**816** MW
Empire Wind II	**1260** MW
Beacon Wind I	**1230** MW
Beacon Wind Remaining	**1200** MW

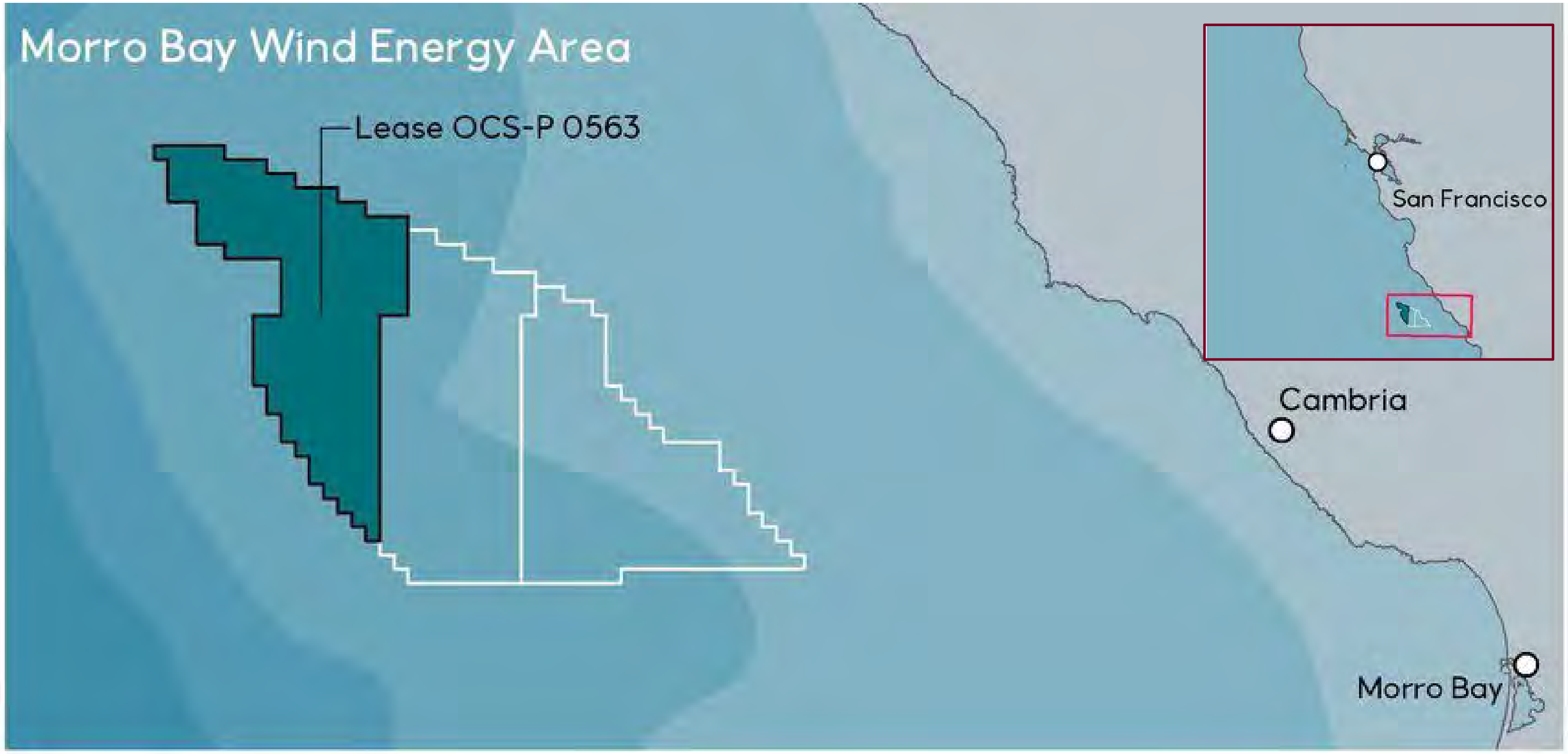
ASIA: Future growth

China, Japan, South Korea

Offshore wind clusters based on existing assets

Equinor's Morro Bay West lease has potential to deliver the world's largest floating offshore wind project to California

Lease area OCS-P 0563 can accommodate at least 2 gigawatts of floating offshore wind generation



Area: **80,062 acres**

Water depths: **988-1271m**

Generation Capacity: ⩾2 GW

Distance to shore: ⩾26 miles

Average Wind Speed: **9 m/s**

Legend

- Equinor wind lease
- Other wind lease

0 10 Miles

Tim McGinnis and Xiaping Zhang, RWE
Carrie Hitt, Vineyard Offshore Wind

California Offshore Wind Leaseholder Transmission Perspectives (Northern California)

Vineyard Offshore and RWE

May 2023

Who We Are:

COPENHAGEN INFRASTRUCTURE PARTNERS

VINEYARD OFFSHORE

- Copenhagen Infrastructure Partners (CIP) is the world's largest renewable energy investment fund.
- CIP's goal is to deploy $100 billion in clean energy investments by 2030. Global portfolio includes over 5,000MW of floating offshore wind development.
- CIP currently holds 2 federal offshore wind lease areas in the United States including Vineyard Northeast, and Vineyard MidAtlantic . Recently awarded provisional lease in Humboldt.
- Vineyard Offshore is the development team for CIP's offshore wind leases in the United States. This includes the first US commercial scale offshore wind project, which is currently under construction.

RWE is **#2 Offshore developer globally** with vast experience in the business …

~ 20 years in the Offshore business

110 years runtime of operating fleet

3.3 GW net Offshore wind portfolio by end of 2022

Unique commercialization capabilities

High-class partnerships

Excellent track record of delivering complex projects

842 turbines operated and maintained at sea

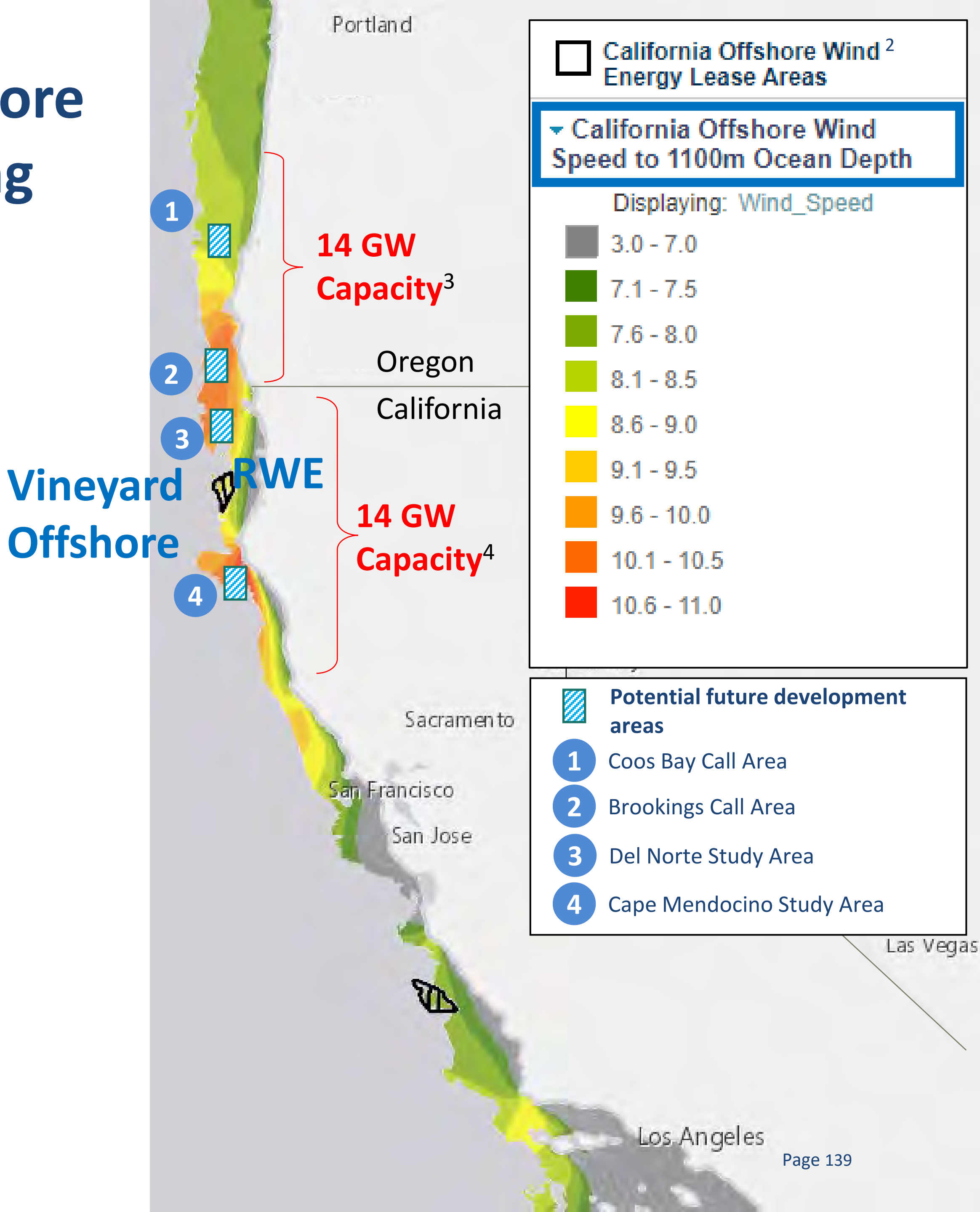
Expertise along the **whole value chain**

>10.000 person years of experience

Cutting edge technical capabilities

Northern CA & southern OR will form the core of offshore wind development due to strong wind resources

	Vineyard Offshore	RWE
Lease Name (Number)[1]	Humboldt SW (OCS-P 0562)	Humboldt NE (OCS-P 0561)
Water Depth[1]	614-1,137m	537-1,017m
Generation Capacity	1.0-1.6 GW	1.2-1.6 GW
Distance to Shore[1]	20 miles	20 miles
Avg Wind Speed (m/s)[2]	**8.6 to 9.5**	**8.5 to 9.5**



Sources:
1 "California Final Sale Notice" by United States Department of the Interior (Bureau of Ocean Energy Management)
2 "California Offshore Wind Energy Lease Areas" by Conservation Biology Institute is licensed under CC BY 4.0 / Modified Legend, Labels, etc.
3. "West Coast Offshore Wind Transmission Literature Review and Gaps Analysis" by US DOE (Brookings and Coos Bay Call Areas)
4. "CAISO Transmission Planning Process" by CAISO

In May 2024, CAISO should approve major transmission upgrades for Northern California lease areas

Transmission Issues

- The **Humboldt Region cannot currently connect any commercial scale offshore wind projects** due to a weak transmission system with limited interconnection capacity
- **Transmission permitting creates highest risk in project timelines** since offtake cannot be secured without clarity on the transmission in-service timeline
  - Also, the offshore wind construction schedule needs to be aligned with transmission delivery
- **CAISO's current planning portfolio has insufficient offshore wind capacity** to build out full potential of first two Humboldt leases

Transmission Needs

- **New Humboldt transmission must be approved as part of CAISO's current planning cycle** (2023-2024 TPP) to ensure offshore wind can be delivered by first half of 2030s
  - Approve upgrades by May 2024
  - Clarify Transmission permitting by end of 2027
  - Complete transmission construction by early 2030s
- Approved **transmission should be scalable** in capacity to account for more offshore wind farms in Northern CA, where the wind speed is highest
- The **Points of Interconnection should be near the coast** to ensure offshore wind projects can be economically viable
- **Efforts to streamline transmission permitting must start now** to mitigate risk of significant project delays and ensure development of viable shovel-ready projects

Reforming the planning process is needed to prepare for significant changes to California's future energy system

CEC

Every 2 years:
- Publish 15-yr demand forecast "Integrated Energy Policy Report (IEPR)"

CPUC

Every 2 years:
- Update Integrated Resource Plan (IRP)

CAISO

Annual Process:
- Update Transmission Planning Process (TPP)

CEC
- **Significant load growth** is anticipated over the long term due to electrification
- Planning horizons need to be longer
- Least-regrets decisions should be taken earlier

CPUC
- **Significant changes in generation mix** is anticipated to meet climate goals
- Procurement needs to be reformed to better prepare long lead-time resources like OSW
- Transmission permitting needs more certainty to de-risk new generation

CAISO
- **Significant changes in power flow patterns** anticipated to connect variable generation in new locations
- Overall planning process must account for very long lead-times to build new transmission

- Vineyard Offshore and RWE look forward to further coordination with west coast entities and stakeholders to advocate for studies and transmission upgrades to build these offshore wind projects

John White
CEERT/Gridlab Report

Public Comment Instructions

Rules

- 3 minutes per person

Zoom

- Click "raise hand"

Telephone

- Press *9 to raise hand
- Press *6 to (un)mute

When called upon

- Unmute, spell name, state affiliation, if any

Written Comments:

- Due: June 9, 2023 by 5:00 p.m.
- Docket: 17-MISC-01
- Submit at: https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=17-MISC-01

3-MINUTE TIMER

Next Steps

- Public comments due June 9, 2023
- Upcoming AB 525 Workshops:
  - June 1, 2023 - Identifying Additional Suitable Sea Space and Assessing Impacts and Mitigations for Offshore Wind Energy Development
  - June 2, 2023 - Permitting Roadmap