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Northern CA and Southern OR Offshore Wind Transmission Study

Presented by Arne Jacobson & Jim Zoellick
Schatz Energy Research Center
Cal Poly Humboldt
November 10, 2022

Introductions

Project Sponsors and Core Steering Group Members

CALIFORNIA ENERGY COMMISSION

Agreement No. 700-22-002

OREGON DEPARTMENT OF ENERGY

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

QUANTA TECHNOLOGY

NREL NATIONAL RENEWABLE ENERGY LABORATORY

MOTT MACDONALD

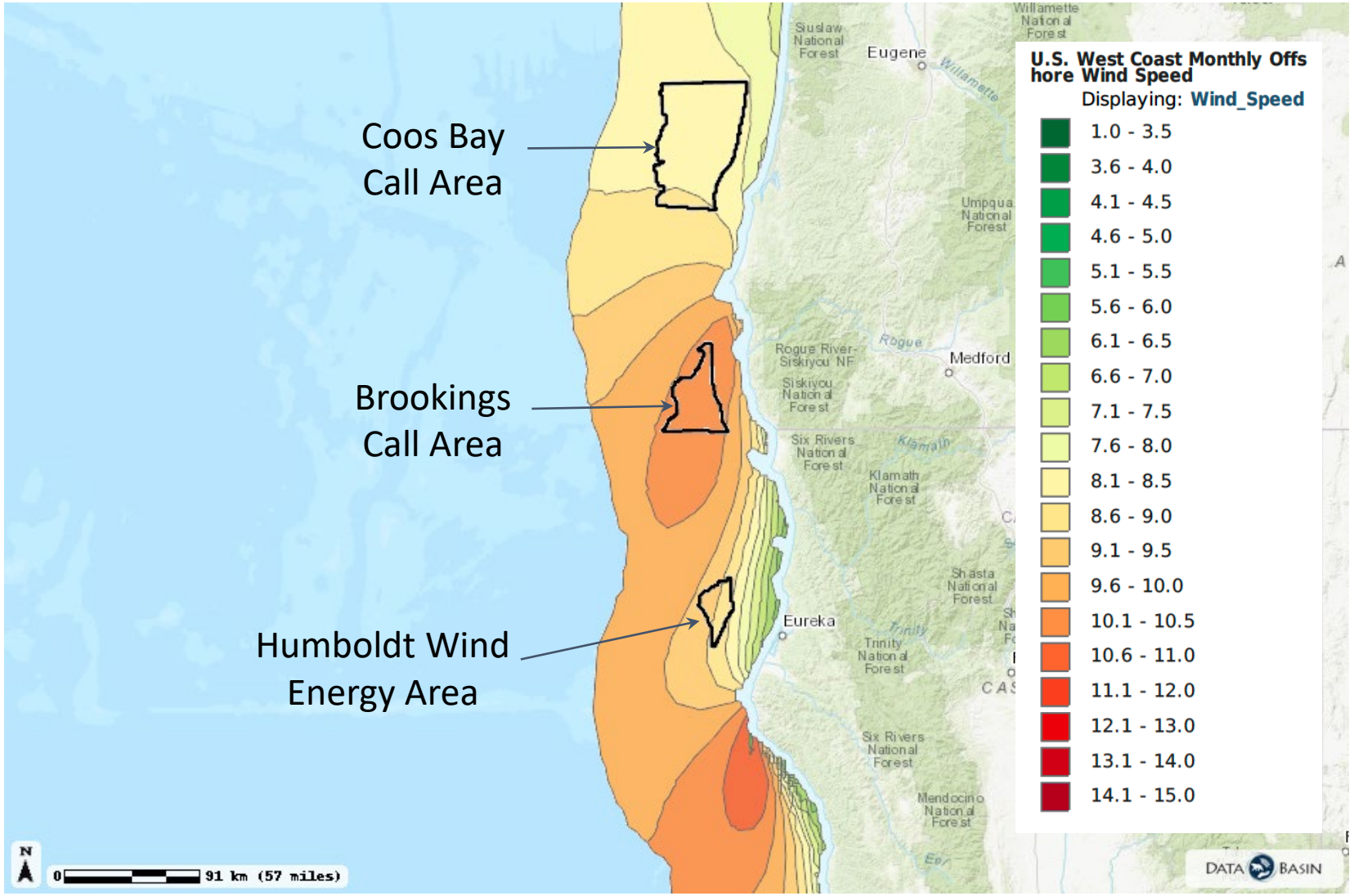
H. T. HARVEY & ASSOCIATES Ecological Consultants

CONAWAY GEOMATICS Inc.

Scope and Motivation for Current Effort

Large Wind Resource: The offshore wind resources in areas along the CA north coast and the OR south coast have great potential to contribute to the states' climate and clean energy goals.

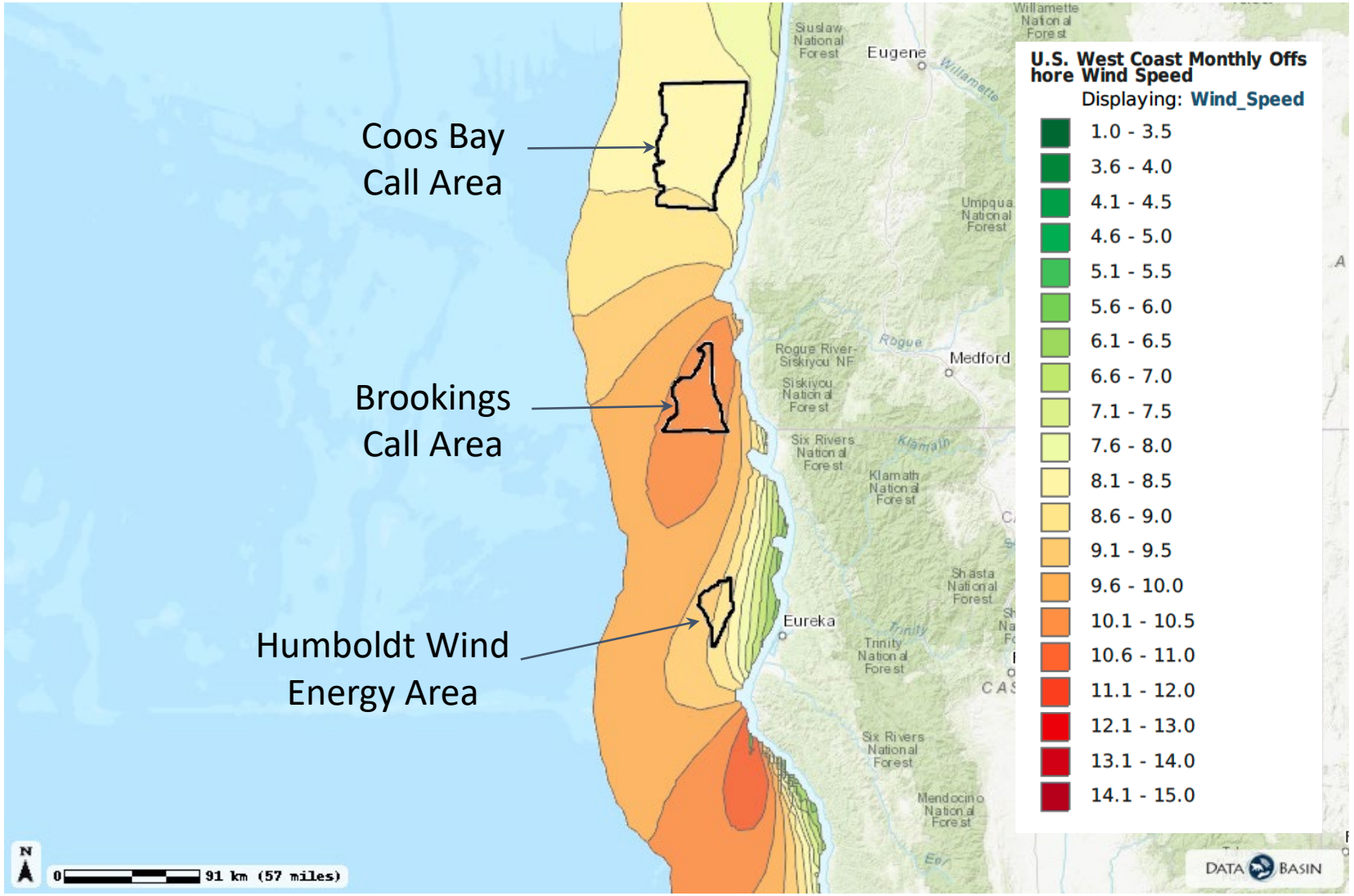
Limited Transmission: Transmission capacity is a barrier for developing offshore wind at scale in this region.



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

Offshore Wind Resource in N. California & S. Oregon

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



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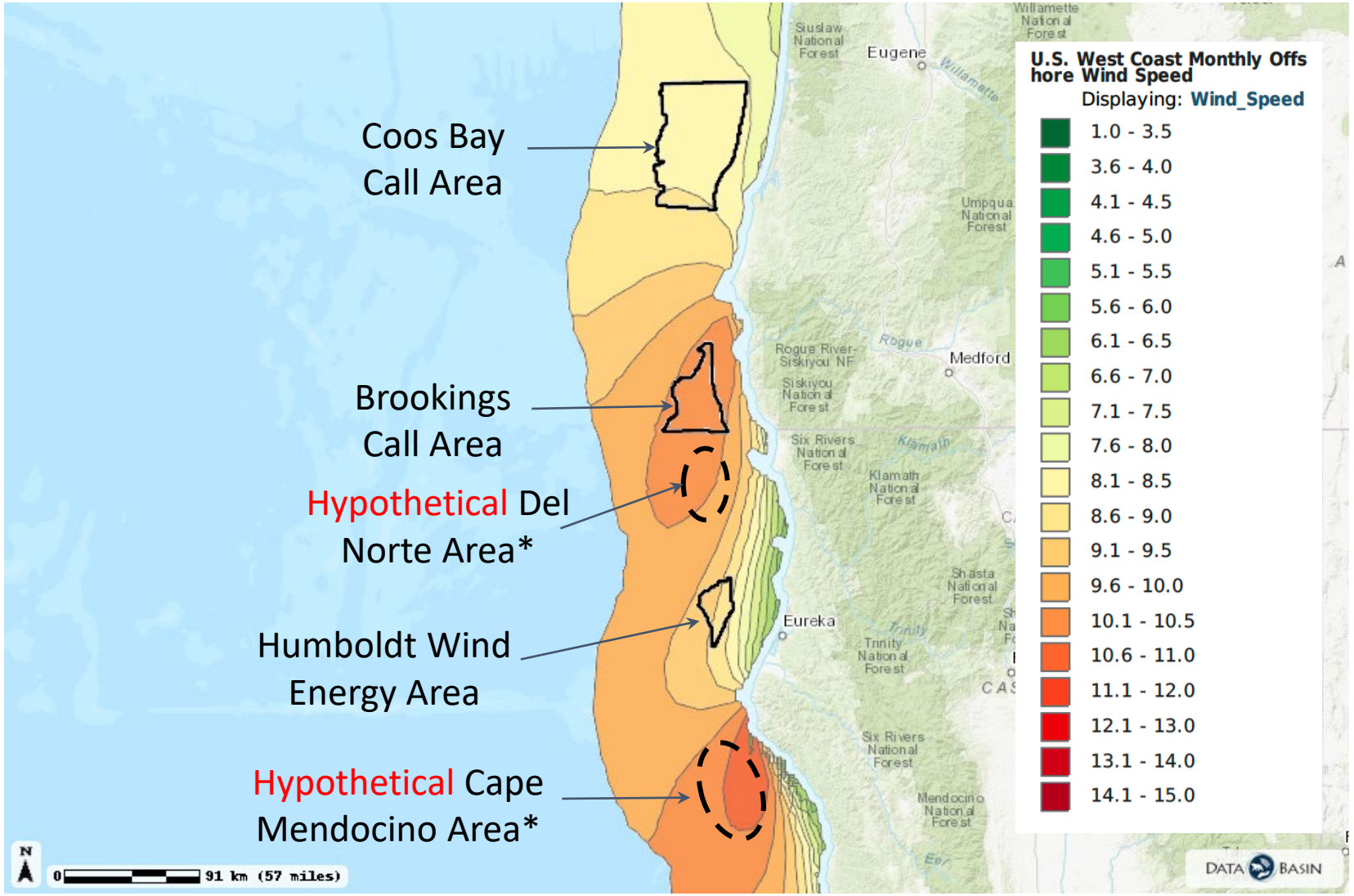
Additional areas offshore from Del Norte County and Cape Mendocino may be created in the future (but for now these are hypothetical).



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Building on Prior Studies

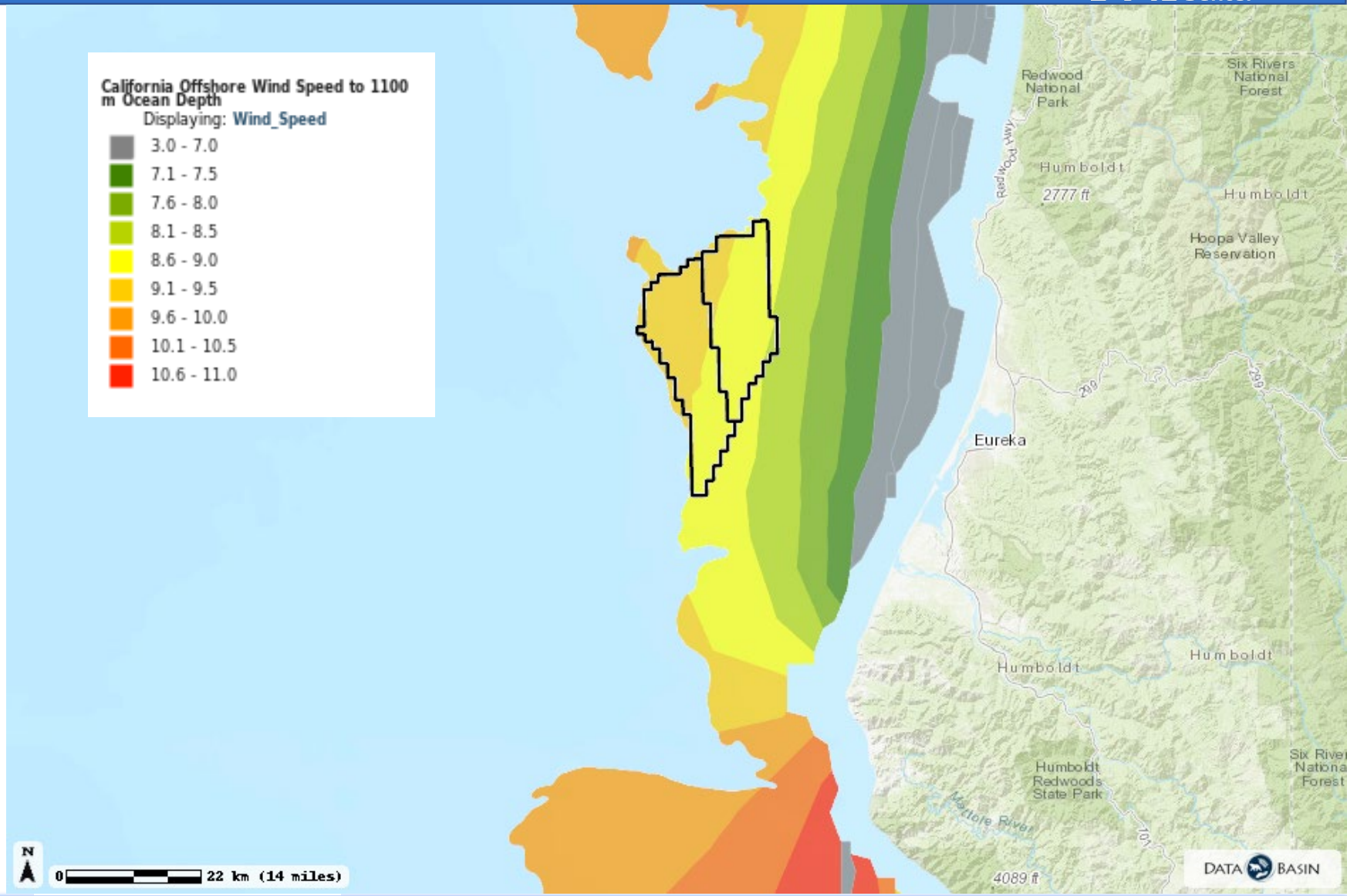
This work will build on prior analyses by our team and others

1. **Analyses of requirements and cost for full buildout of Humboldt Wind Energy Area (WEA):** Separate studies by (i) Schatz Center / PG&E and (ii) CAISO assessed overland and undersea transmission options for 1.6 to 1.8 GW of offshore wind capacity in the Humboldt WEA, indicating that $1.2 to $4.4 billion in investment would be needed.
2. **Analysis of options for initial development in the Humboldt WEA:** Study by Schatz Center / Quanta Technology / NREL indicated that ~150 MW of offshore wind capacity could be developed without transmission upgrades.
3. **Analyses of transmission and offshore wind on the Oregon Coast**: Analyses by (i) PNNL and (ii) NREL indicate that 2-3 GW of offshore wind along the Oregon Coast could be interconnected without significant upgrades to transmission infrastructure.

Humboldt Wind Energy Area

BOEM is holding a lease auction for the Humboldt WEA on Dec 6, 2022.

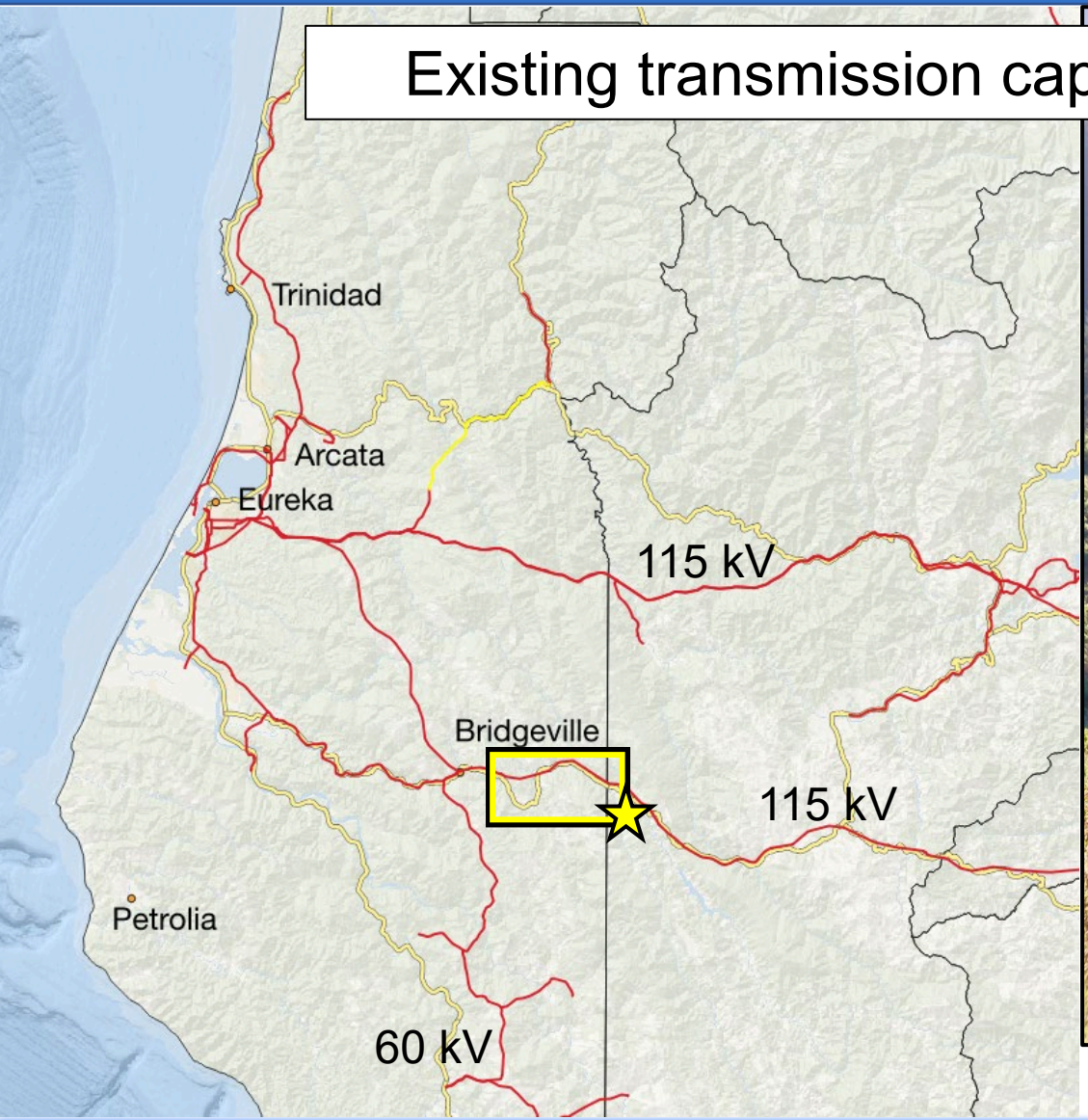
Wind farms in the Humboldt WEA that fully utilize the ~207 mi^2 area could have a combined installed capacity on the order of 1.6 to 1.8 GW.



Transmission Infrastructure is a Constraint on CA's North Coast

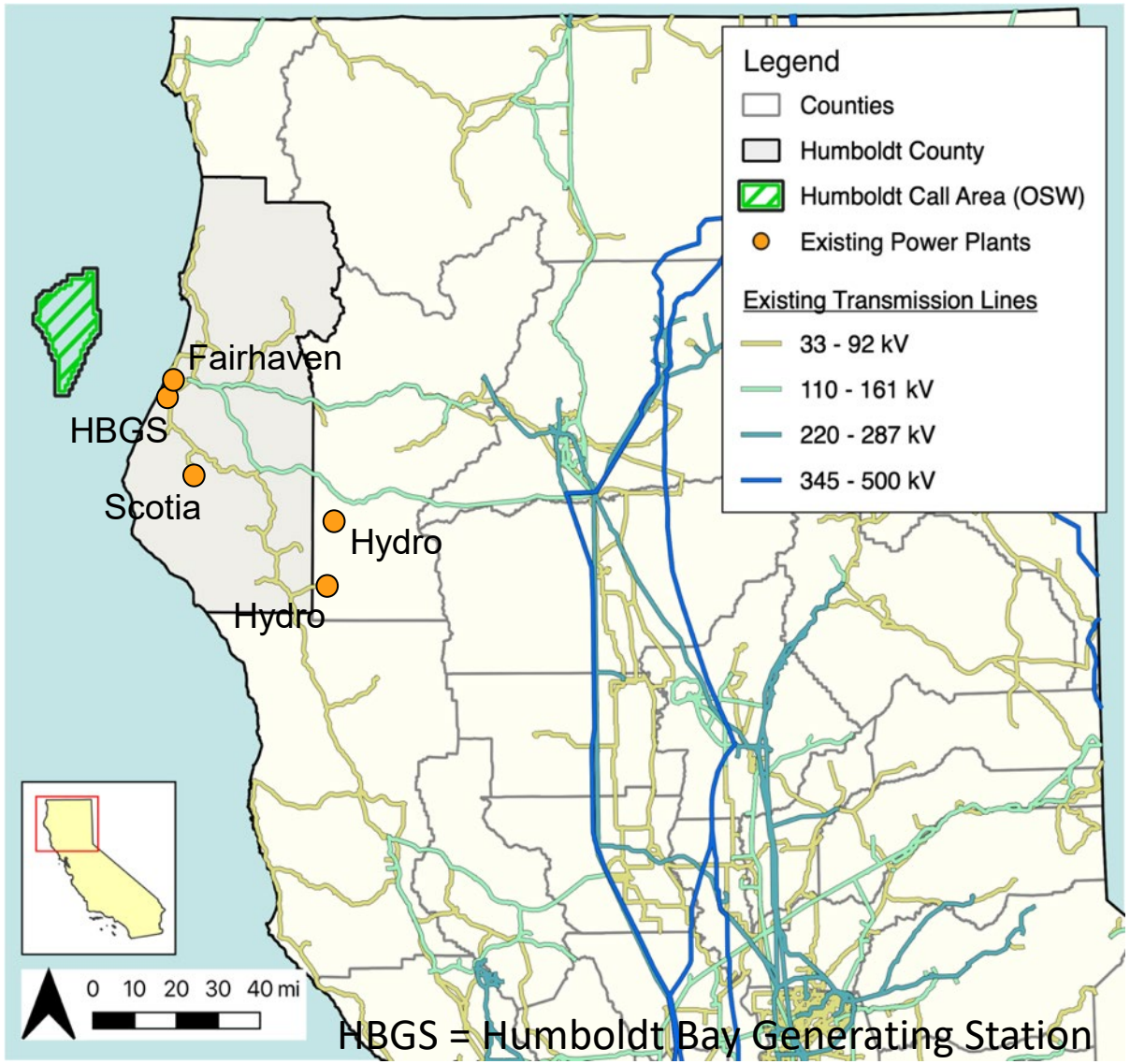
Schatz Energy Research Center

Existing transmission capacity is limited, and the terrain is rugged.



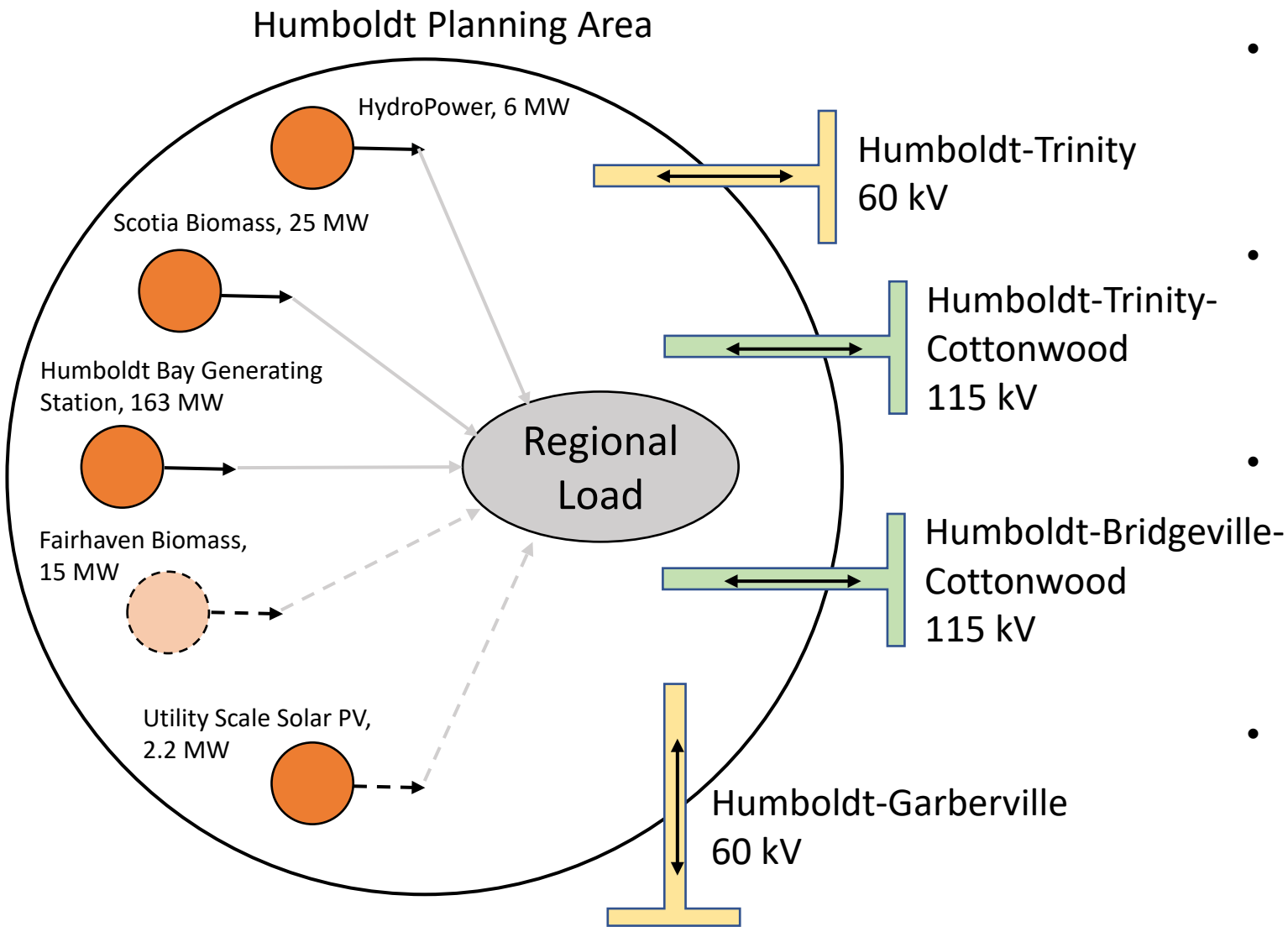
★ Photos taken outside Bridgeville, CA on Highway 36

Humboldt County Electricity System (Circa 2021)



- Humboldt County's electrical system is relatively isolated from the main CA grid.
- The regional load is concentrated in the Humboldt Bay area (avg load ~100 MW).
- Local generation is needed to power the region. The 163-MW natural gas fired Humboldt Bay Generating Station plays this role.
- Major transmission corridors run north and south in California, connecting large generators and load centers.

Humboldt County Electrical System (Circa 2021)



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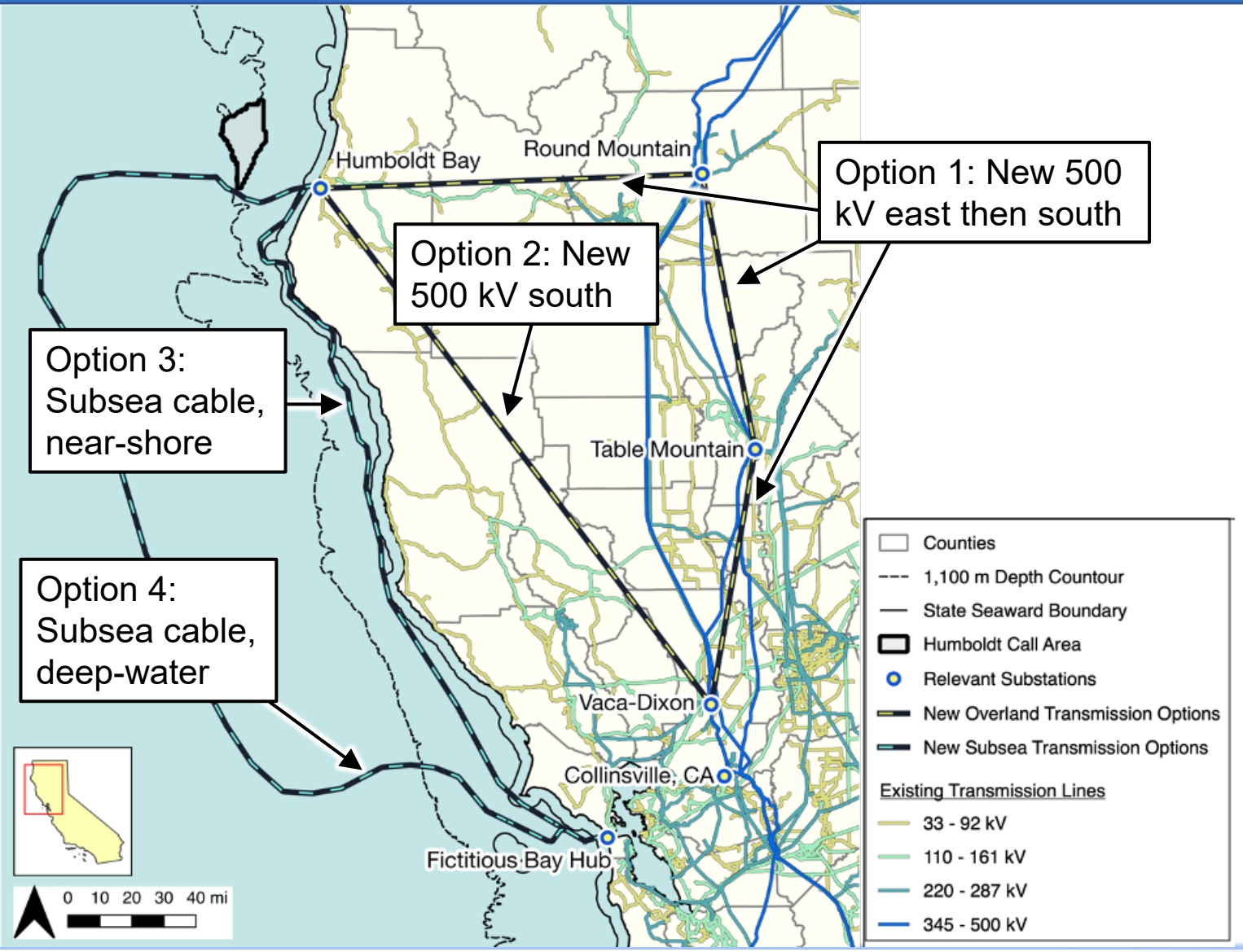
Required Transmission for a Full Humboldt WEA Buildout

- Analysis published in 2020 by PG&E and the Schatz Center identified several overland and undersea transmission alternatives for a 1.8 GW wind farm in the Humboldt WEA (see http://schatzcenter.org/pubs/2020-OSW-R4.pdf and http://schatzcenter.org/pubs/2020-OSW-R12.pdf)
- In 2022, the CAISO published a draft Transmission Planning report that included analysis of transmission alternatives for offshore wind in California. This included an estimate of requirements for 1.6 GW of offshore wind in the Humboldt WEA. (see http://www.caiso.com/InitiativeDocuments/ISOBoardApproved-2021-2022TransmissionPlan.pdf)
- Cost estimates for transmission upgrades to enable a full buildout of the Humboldt WEA were similar for the two studies.

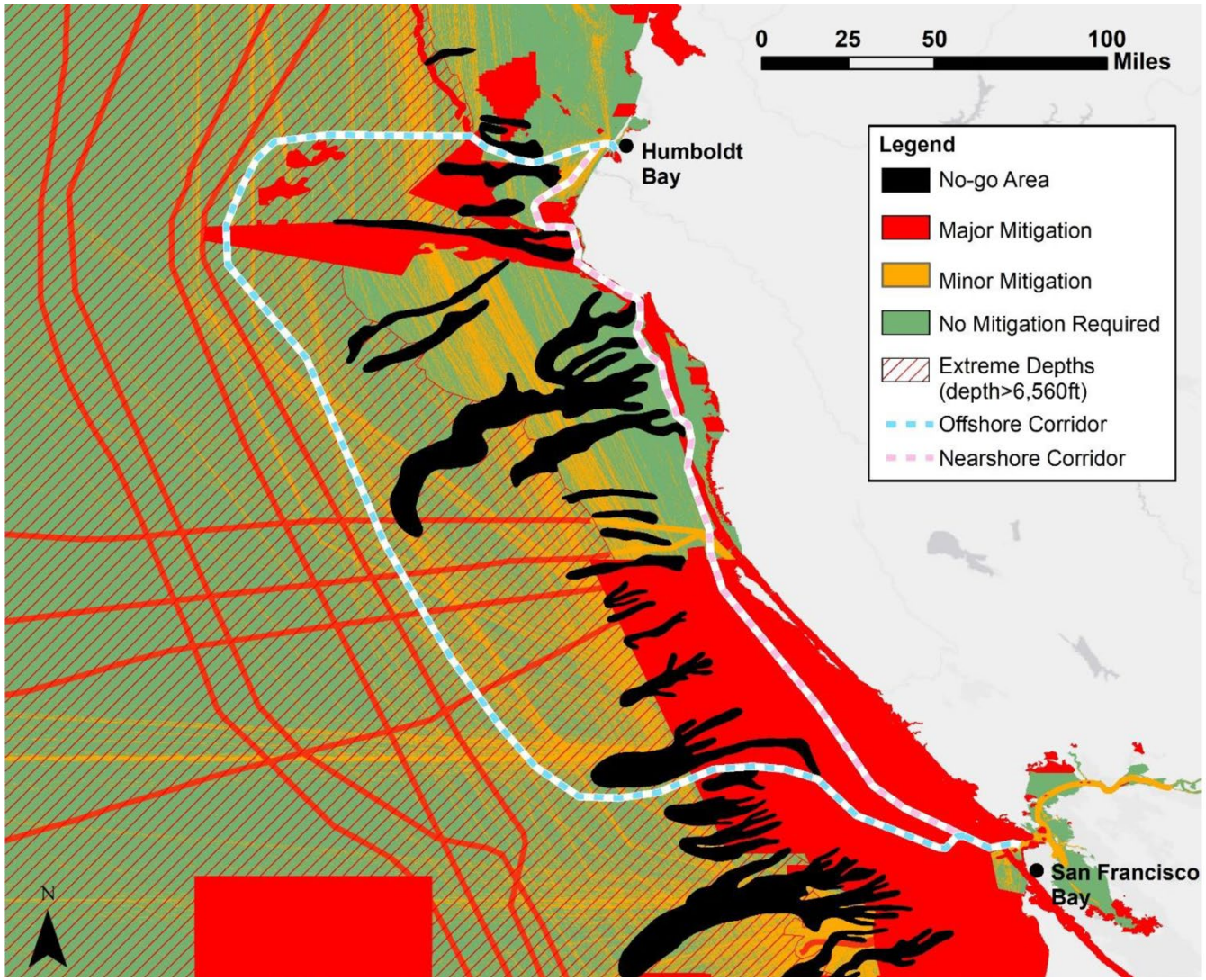
PG&E / Schatz Center Analysis of Transmission Alternatives (1.8 GW)



- Large scale offshore wind developments have several options for transmission upgrades including overland or undersea routes.
- Costs for upgrades to accommodate 1.8 GW of wind capacity were estimated at $1.7 to $3 billion for overland alternatives and $2.4 to $4.4 billion for undersea cable routes.

Source: Severy, et al., 2021: schatzcenter.org/pubs/2020-OSW-R12.pdf

Undersea Cable Corridor Alternatives
(developed by Mott MacDonald)

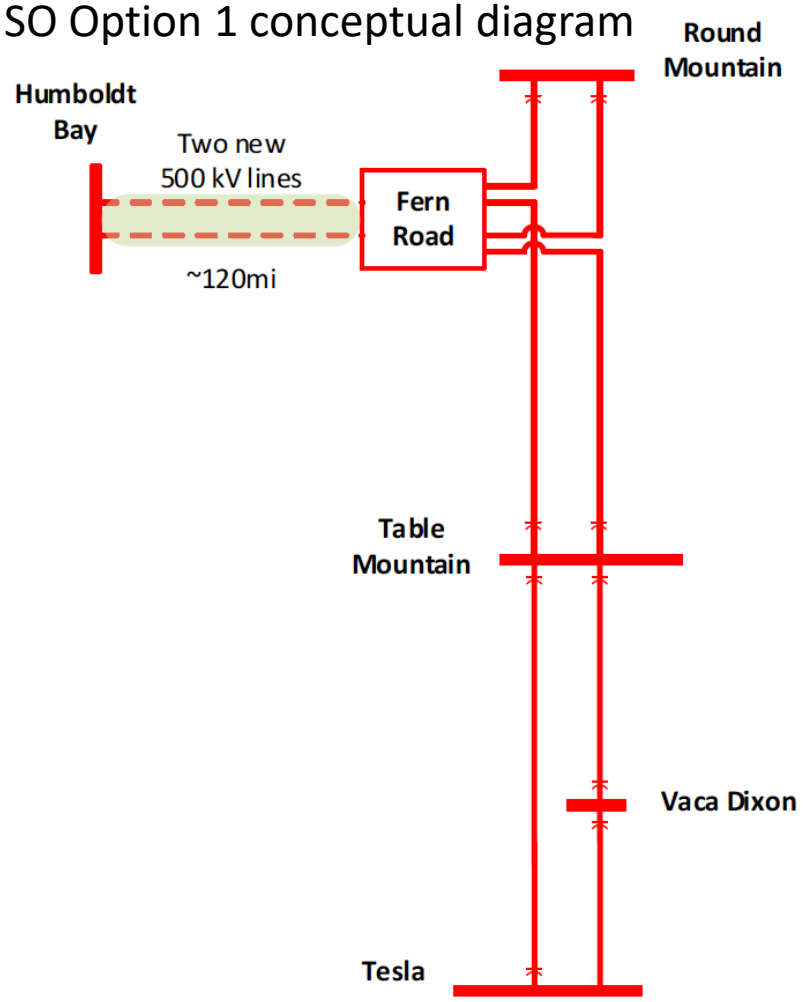


- The two subsea cable corridors were designed by considering technical, environmental, geological constraints.
- This map shows areas that must be avoided (black), areas where major mitigation may be required (red), and areas where minor mitigation may be required (orange).
- The corridors were developed to minimize the amount of mitigation required.

See http://schatzcenter.org/pubs/2020-OSW-R5.pdf

CAISO Analysis of Transmission Alternatives (1.6 GW)

CAISO Option 1 conceptual diagram



Source: California ISO 2021-22 Transmission Plan (draft from January 31, 2022)
http://www.caiso.com/InitiativeDocuments/Draft-2021-2022TransmissionPlan.pdf

California ISO

- The California Independent System Operator (CAISO) analyzed three options for connecting 1.6 GW of wind generation capacity in the Humboldt WEA.

- **Option 1**: 500 kV AC line to Fern Road substation (near Round Mountain substation) – estimated cost: $1.2 billion
- **Option 2**: High voltage DC undersea cable to the SF Bay Area – estimated cost: $4 billion
- **Option 3**: High voltage DC overland transmission line to the Collinsville substation (Solano County) – estimated cost: $3 billion

Options for a Small, Initial Project in Humboldt WEA

Objective of Analysis: Identify options for developing offshore wind within the bounds of existing regional transmission infrastructure (or with modest investment in transmission upgrades) and assess the economics (costs and revenue) of initial project options.

Scope of Work

- Analyzed transmission requirements for multiple offshore wind development scenarios in the Humboldt WEA, with wind farms up to ~500 MW. The analysis included high-level cost estimates using a System Impact Study approach as per CAISO guidelines.
- Conducted offshore wind revenue analysis for selected scenarios.
- Assessed wind farm economics for the selected scenarios.

Conclusions: Small Humboldt WEA Project Study

- CA's north coast offshore wind resource is very large
- Transmission challenges vary depending on the scale of development.
  - *A small commercial project can be built in the Humboldt Wind Energy Area without transmission upgrades if interconnected as "energy only."*
  - *Larger projects require significant investments in transmission infrastructure.*
  - *The recommended project size for an initial "energy only" project may be on the order of 140-150 MW (this result is sensitive to assumptions about load growth).*
  - *Small project economics are challenging, especially in the absence of federal tax incentives (PTC or ITC).*
  - *Storage can help improve project economics.*
  - *Hydrogen generation from curtailed and low-cost power is potentially viable for some local applications.*

Offshore Wind Resource in N. California & S. Oregon

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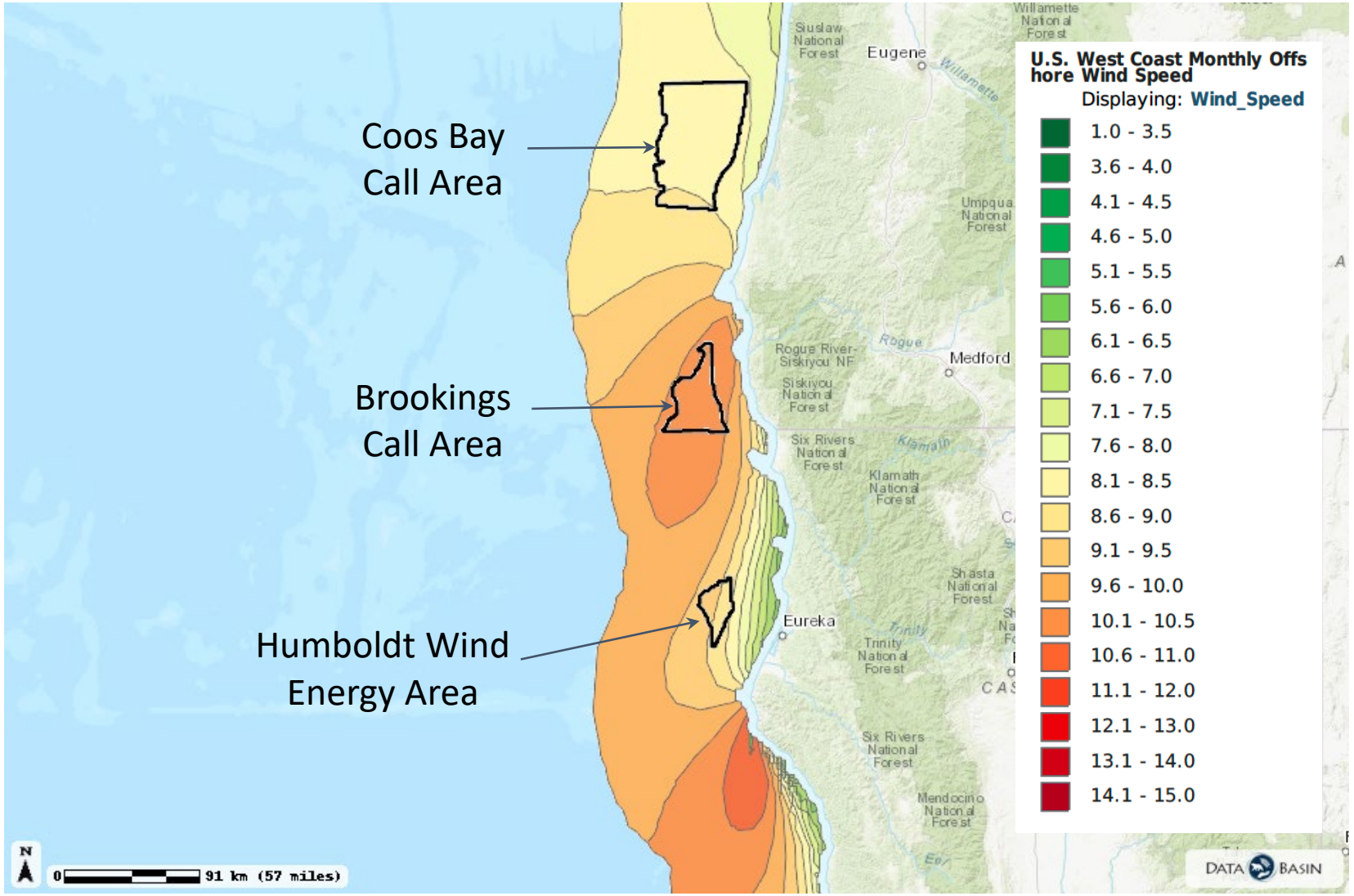

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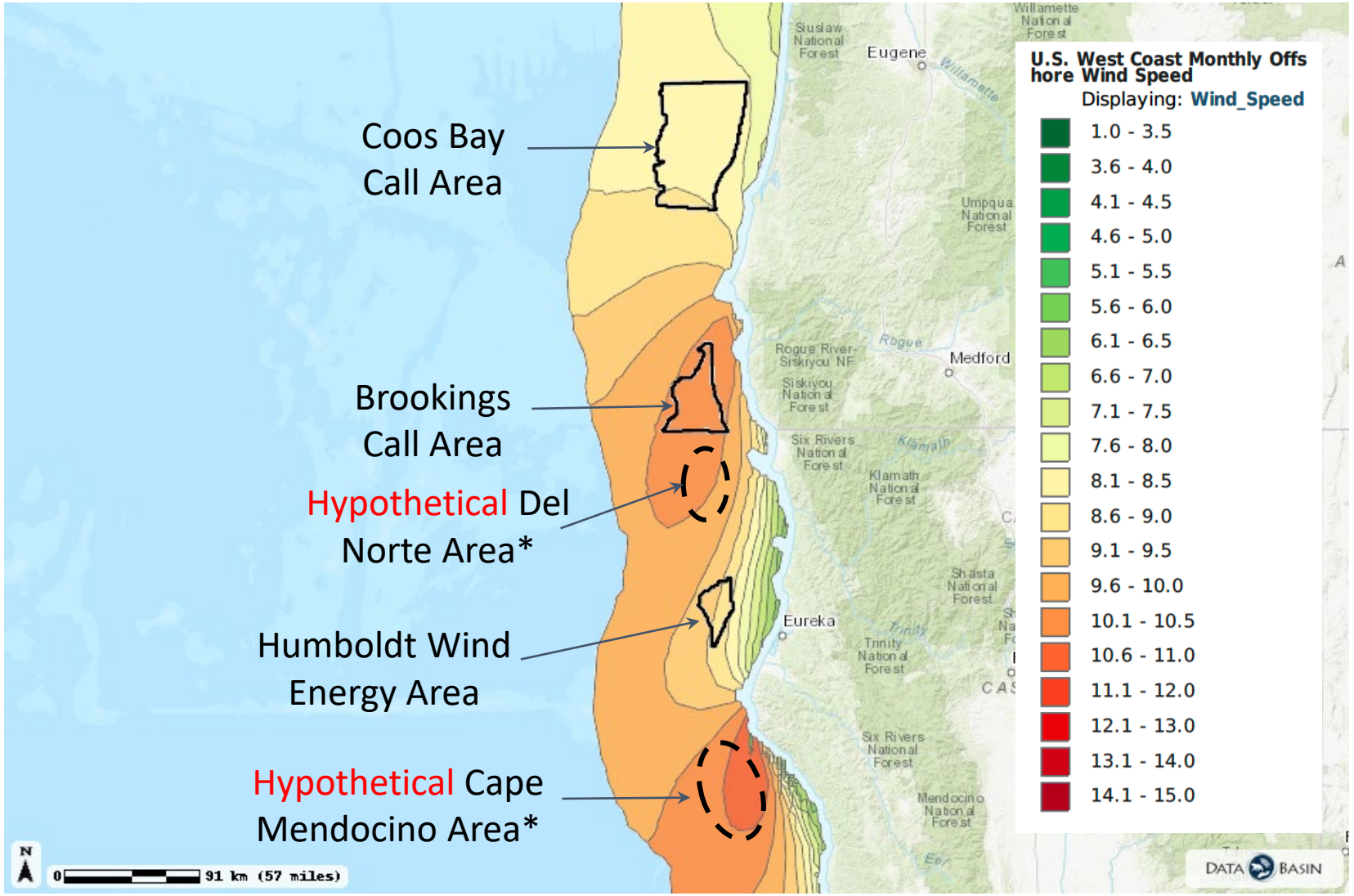
Offshore Wind Resource in N. California & S. Oregon

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

Consider existing and potential future areas for offshore wind farm development.



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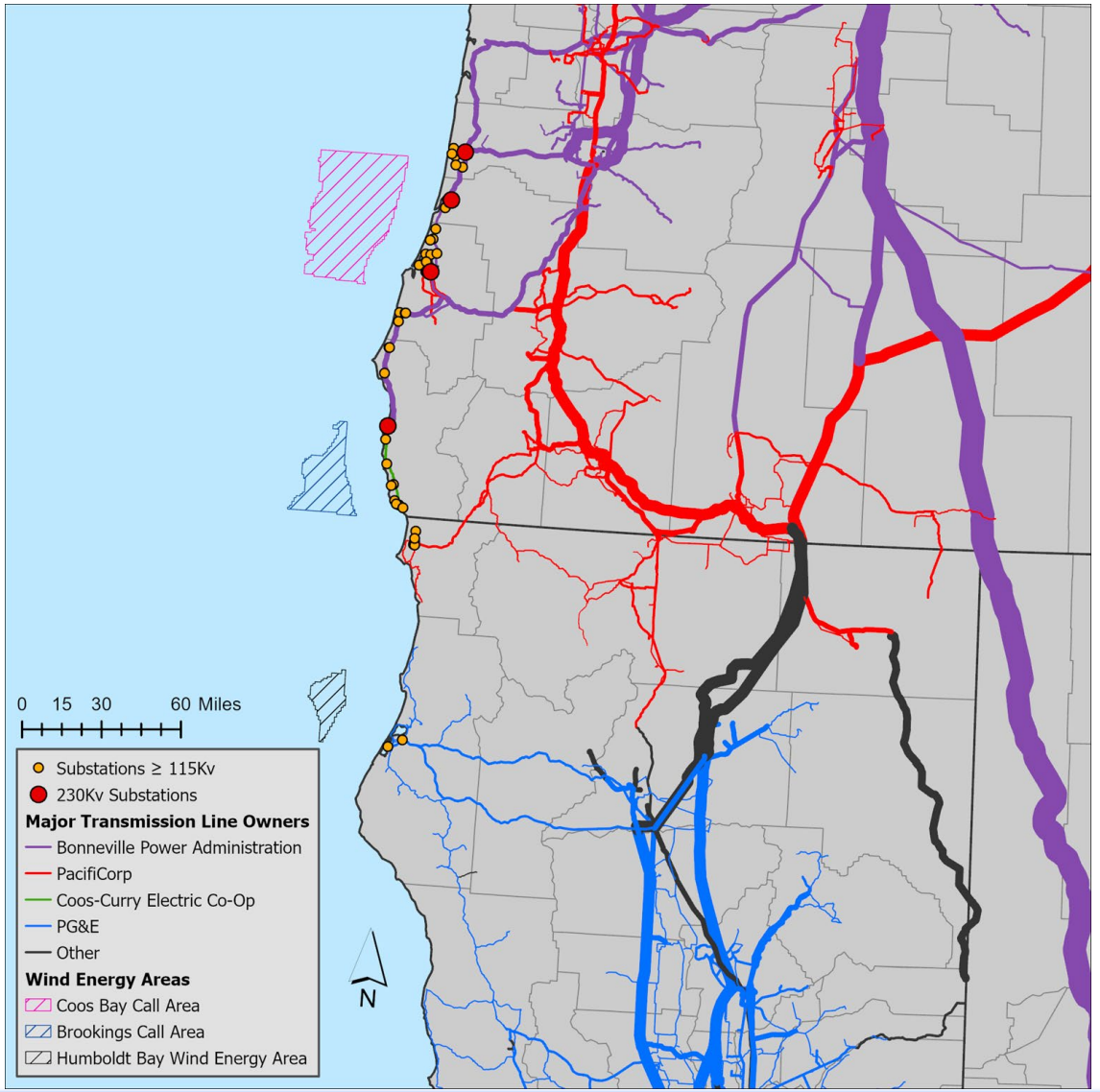
Existing Transmission Infrastructure

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 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).



Assessment Approach and Timeline

1) Assemble data and mapping information for existing infrastructure
2) Develop multiple scenarios for analysis:
   a. Total installed wind capacity ranging from ~5 to ~25 GW; most focus likely in midrange scenarios with ~10 to ~15 GW
   b. Overland and undersea cable routes
   c. High voltage AC & DC transmission options
3) Analytical approach
   a. Transmission power flow and cost analysis for 10 scenarios to determine transmission requirements and costs
   b. Production cost analysis for subset of 6-7 scenarios to determine wind farm revenue
   c. Economic cost and benefit analysis of wind farm operation

Image source: Wikipedia Commons (https://upload.wikimedia.org/wikipedia/commons/7/76/Agucadoura_WindFloat_Prototype.jpg

Assessment Approach and Timeline

4) Consider additional issues and constraints
   a. Existing uses of oceans and lands and associated community perspectives
   b. Potential routes and rights-of-way for new or upgraded transmission infrastructure
   c. Environmental considerations
   d. Regulations and permitting
   e. Military mission compatibility
   f. Wind farm operator market participation options

5) Anticipated timeline: Preliminary results by April 2023; final report by July 2023.

230 kV transmission line near Langlois, Oregon

Contact Information

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www.schatzcenter.org/wind

Photo credit: Maia Cheli