Analyzing the Opportunity for Offshore Wind to Power Green Hydrogen Production in California

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BACKGROUND

- Green hydrogen production is considered a strong option to decarbonize the energy-intensive transportation sector.
- The U.S. DOE has created a $7 billion funding opportunity for states to create clean hydrogen hubs (H2Hubs) as part of the Bipartisan Infrastructure Law [1].
- The DOE's initiative Hydrogen Shot seeks to reduce the cost of clean hydrogen to $1 per kilogram in one decade ("1 1 1") [2].
- California's offshore wind projects within the Humboldt and Morro Bay WEAs could power clean hydrogen production at a coastal H2Hub rather than waste power during periods of curtailment.
- Cost of electricity (which would be at or near an offshore wind farm's LCOE) is one of the drivers of a H2Hub's LCOH.

OBJECTIVES

- To provide an overview of green hydrogen policy.
- To present the cost drivers of hydrogen hub facilities.
- To explore whether the LCOE for floating offshore wind projects in the California WEAs will decrease enough by H2Hubs' operation in 2032 to make feasible the opportunity for offshore wind to power green hydrogen production in California.
- To recommend how government and industry stakeholders can lower LCOH and maximize the success of synergizing H2Hubs and offshore wind.

METHODS

- LCOE is calculated from seven main inputs: (1) bathymetry, (2) wind speed, (3) significant wave heights, (4) distance to marshalling port, (5) distance to O&M port, (6) distance to onshore substation, and (7) subsea sediment thickness.
- Using LCOE projections from NREL, LCOE is adjusted for 2032, when H2Hubs will be operating.
    - 30% decrease from 2022 to 2032 for a mid-level deployment in either the Humboldt or Morro Bay WEAs [3].
- LCOH is calculated from five inputs: (1) hub capacity, (2) FOW farm capacity factor, (3) H2Hub CapEx, (4) H2Hub OpEx (including cost of electricity, water, and electrolyser costs), and (5) a discount rate.
- Compared resulting LCOH to a target cost rate of $5/kg, at which hydrogen can compete with fossil fuel alternatives.

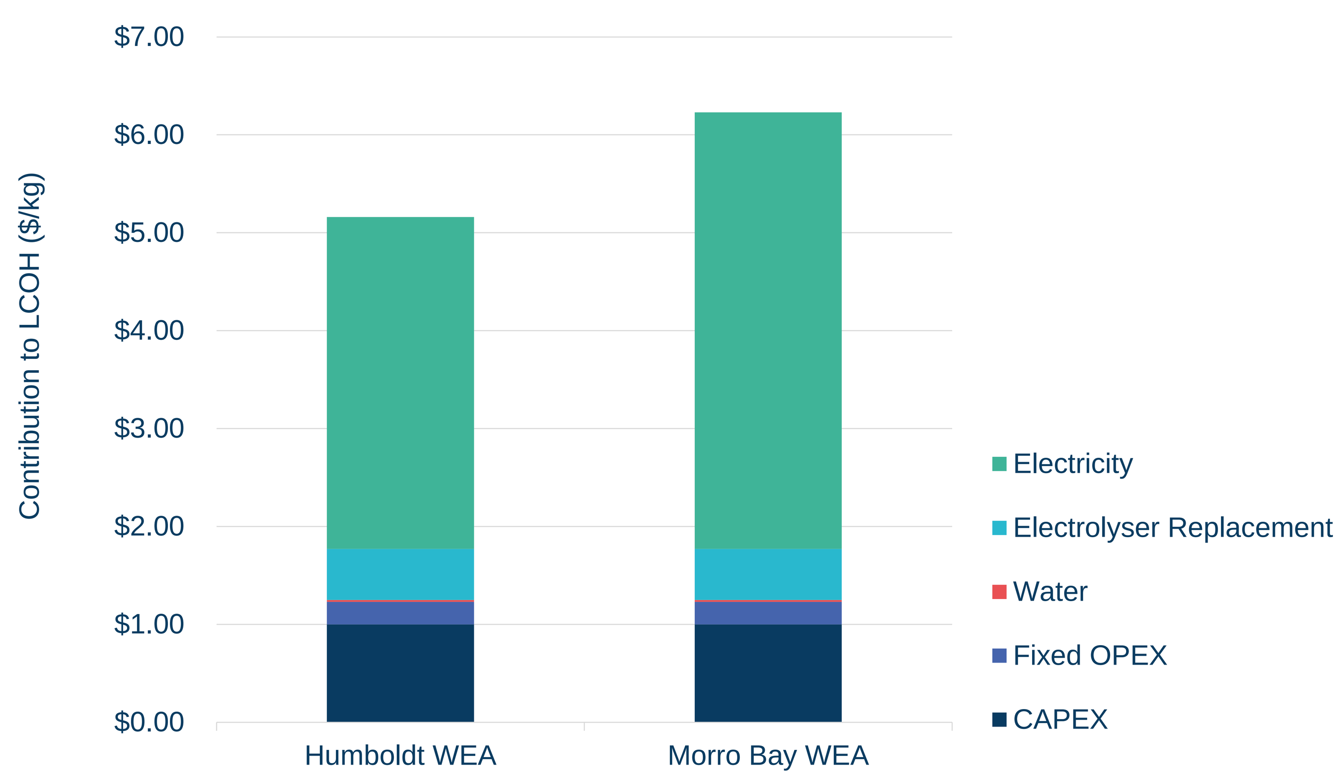
RESULTS

HUMBOLDT WEA

- **The mean LCOE of the WEA is $87.55/MWh in 2022 and $61.6/MWh adjusted for 2032.**
- **Resulting LCOH is $5.15/kg, where the contribution from electricity is $3.39/kg.**

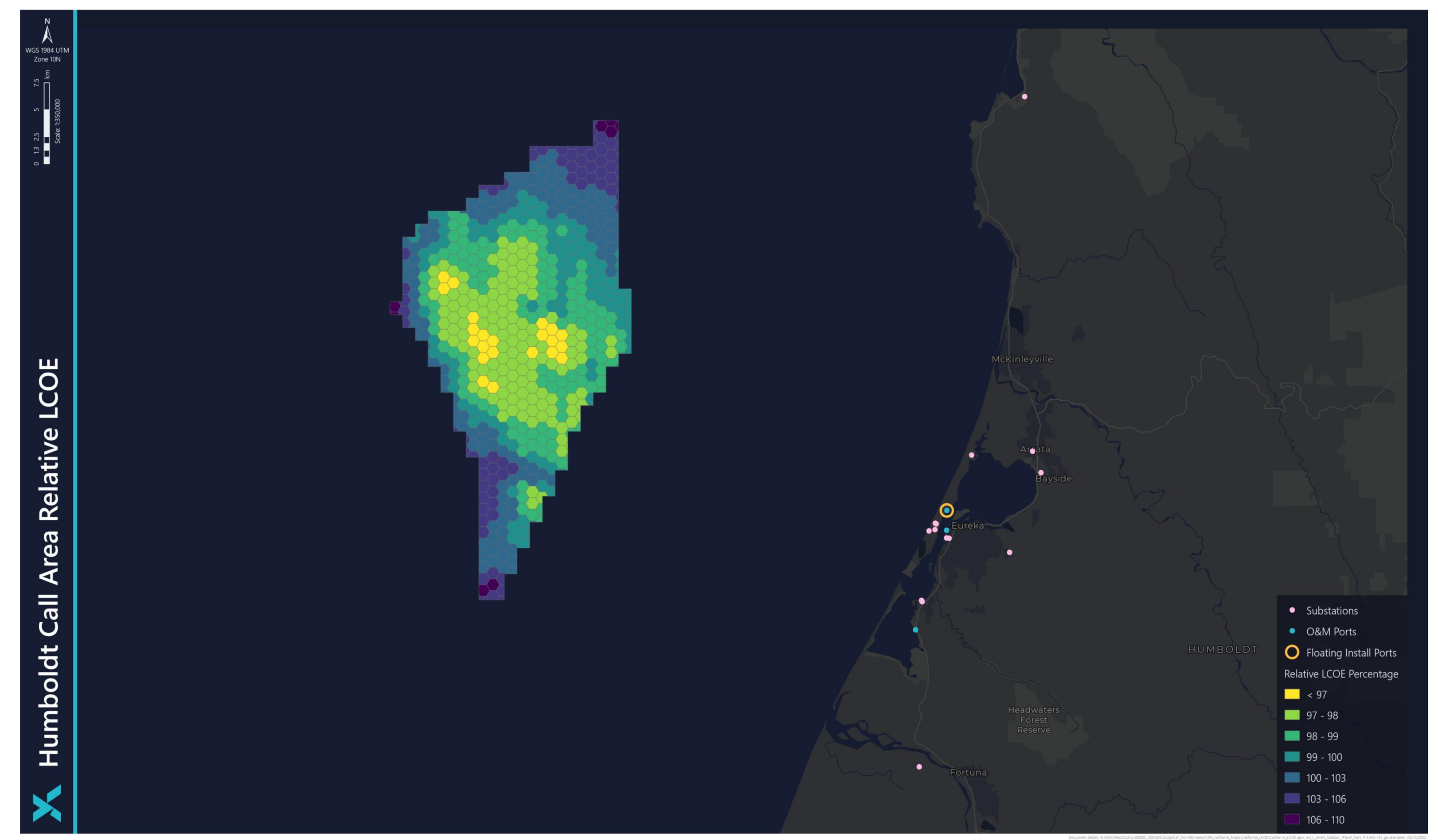
MORRO BAY WEA

- **Mean LCOE is $115.89/MWh in 2022 and $81.1/MWh adjusted for 2032.**
- **Resulting LCOH is $6.22/kg, where the contribution from electricity is $4.46/kg.**

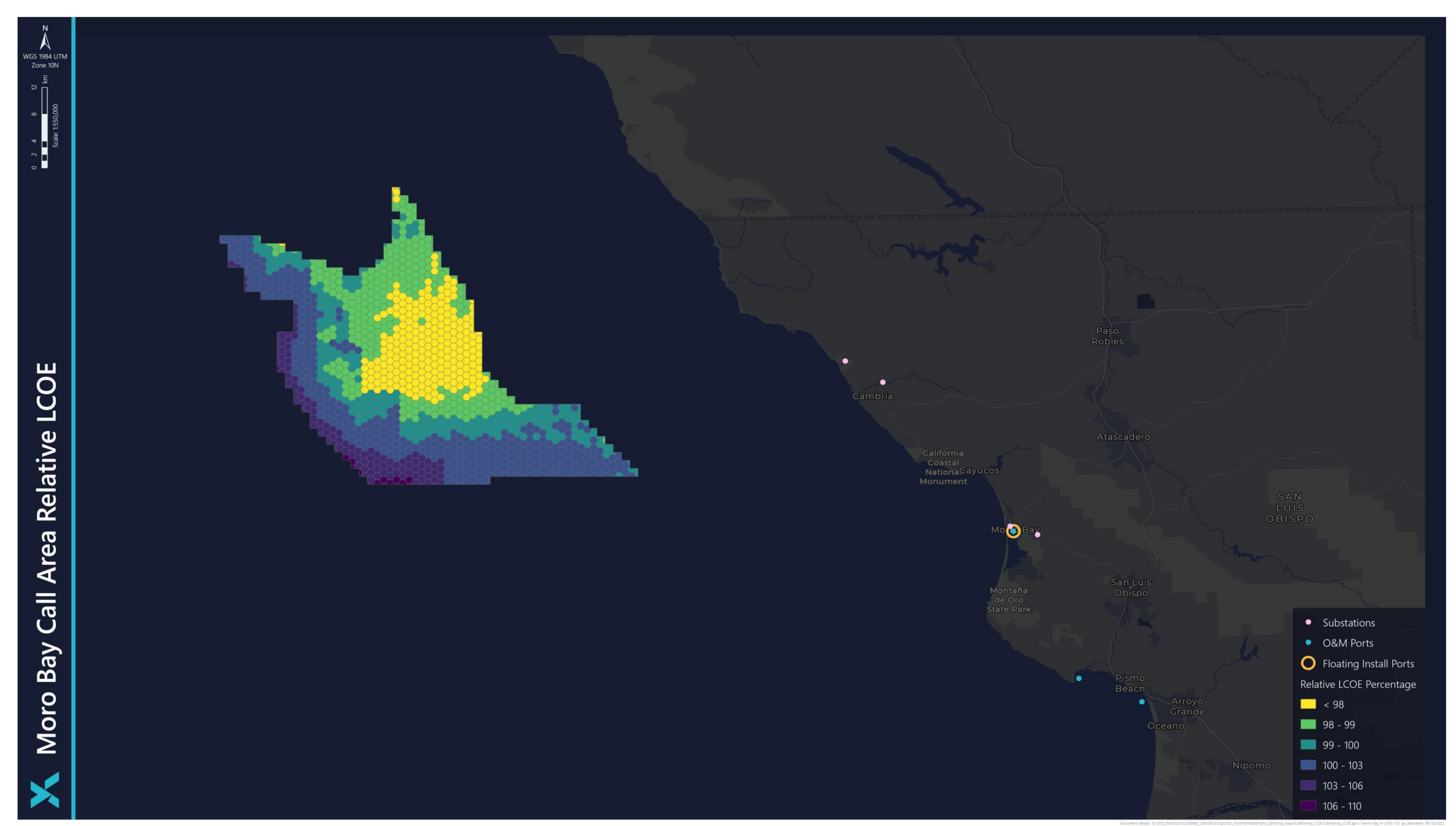


Drivers of LCOH for the two California WEAs.

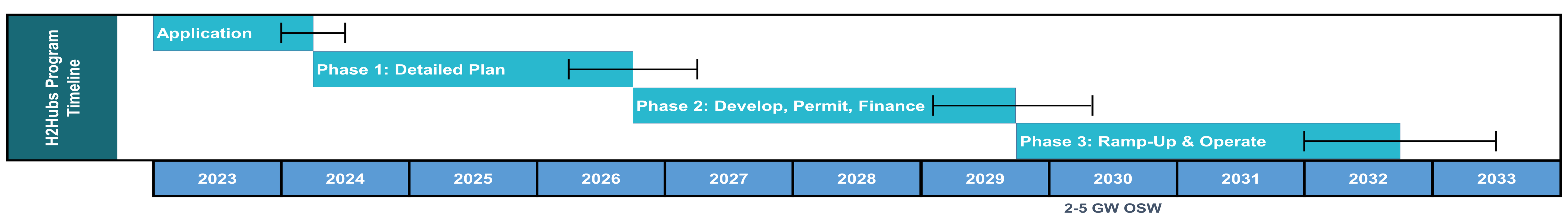
- Main drivers of LCOH:
    - H2Hub CapEx
    - OpEx fixed over 42 years
    - Water costs (at $0.003/gallon)
    - Electrolyser replacement costs (70% of initial CapEx every 50,000 hours)
    - Electricity (dependent on LCOE of the generator)
- Non-electricity drivers contribute a total of $1.77/kg to the LCOH of a 300MW H2Hub.
- A 300MW H2Hub can require over 380,000 gallons of water per day.



Map of LCOE values relative to the mean LCOE of the Humboldt WEA, which is $87.55/MWh.



Map of LCOE values relative to the mean LCOE of the Morro Bay WEA, which is $115.89/MWh.



Timeline of the various phases of H2Hub projects, based on the program's expected timeframe, which anticipates H2Hubs in operation by 2032. The black lines show the potential variance of the phase durations. Based on the state of California's offshore wind procurement goal, offshore wind farms totaling 2-5GW of capacity will be in operation by 2030.

CONCLUSIONS

- In 2032, the LCOH of a H2Hub powered by offshore wind would be competitive with LCOE for fossil fuel alternatives, especially for a project in the Humboldt WEA where wind speeds are higher on average (driving down LCOE)
- While utility-scale solar projects have cheaper LCOE than offshore wind projects, they are less compatible with H2Hubs because of their lower capacity factors
- Costs of electricity are the overwhelming driver of LCOH, and costs of water are nearly negligible
- Analysis assumes electrolyser costs are fixed, but these could drop by 70% by 2030 [4], driving LCOH down even further.
- The Hydrogen Shot 1 1 1 goal is highly ambitious. The current CapEx costs for H2Hub development and electrolyser demand (55 kWh/kg) could be improved through the program's R&D investment, but without major subsidies, electricity costs will be a barrier to 1 1 1.
- Although water costs are a negligible driver of LCOH, water regulation may be a challenge in the drought-prone state of California. Research into pairing a H2Hub with a desalination plant could be very valuable.

REFERENCES

1 United States, Congress, Office of Clean Energy Demonstrations. *Bipartisan Infrastructure Law: Additional Clean Hydrogen Programs (Section 40314): Regional Clean Hydrogen Hubs Funding Opportunity Announcement*, 2022.

2 United States, Congress, Office of Energy Efficiency & Renewable Energy. *Hydrogen Shot*, 2022.

3 United States, Congress, Office of Energy Efficiency & Renewable Energy, and Philipp Beiter et al. *The Cost of Floating Offshore Wind Energy in California Between 2019 and 2032*, 2020.

4 IEA (2022), *Global Hydrogen Review 2022*, IEA, Paris https://www.iea.org/reports/global-hydrogen-review-2022

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