OCS Study
BOEM 2022-016

Transmission Alternatives for California North Coast Offshore Wind
Volume 1: Executive Summary

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Study collaboration and funding were provided by the U.S. Department of the Interior, Bureau of Ocean Energy Management (BOEM), Pacific Regional Office, Camarillo, CA, under Agreement Number M19AC00005. This report has been technically reviewed by BOEM, and it has been approved for publication. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Government, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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The Schatz Energy Research Center at Cal Poly Humboldt advances clean and renewable energy. Our projects aim to reduce climate change and pollution while increasing energy access and resilience. Our work is collaborative and multidisciplinary, and we are grateful to the many partners who together make our efforts possible. Learn more about our work at schatzcenter.org

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Jacobson, A., J. Zoellick, R. Anilkumar, Z. Alva, C. Chamberlin, A. Cooperman, G. Chapman, A. Daneshpooy, P. Duffy, W. Musial, A. Mustafa, A. Younes. (2022). *Transmission Alternatives for California North Coast Offshore Wind, Volume 1: Executive Summary*. Cal Poly Humboldt, Arcata, CA: Schatz Energy Research Center. schatzcenter.org/publications/

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1 INTRODUCTION

The offshore wind resource along California's north coast is among the best in the continental United States, and wind farms developed in the region have potential to make substantial contributions to the state's climate and clean energy goals. However, electric transmission capacity on the north coast is limited, and development of transmission lines with capacity to deliver multiple gigawatts of power to the state's main load centers will require substantial investment and may take a decade or more to plan, permit, and install (Severy, et al., 2021). As a result, an initial option for establishment of an offshore wind industry in the region could involve development of one or more small commercial wind projects that are scaled to match local loads and transmission capacity, requiring only modest investments in new transmission infrastructure.

This study was designed to identify options for developing offshore wind within the bounds of the existing regional transmission infrastructure and to assess the economics of the corresponding wind projects. The study was led by the Schatz Energy Research Center (Schatz Center) at Cal Poly Humboldt. Project partners included the National Renewable Energy Laboratory (NREL) and Quanta Technology, LLC. The work was carried out with funding from the Bureau of Ocean Energy Management (BOEM).

Most of the analysis presented in this report relates to the potential for development of offshore wind in the Humboldt Wind Energy Area[1] (WEA). This is a 207 square mile area located approximately 21 miles to the west of Humboldt Bay that has been designated by BOEM for possible wind farm development (BOEM, 2021). The study includes assessment of the potential for energy generation from wind power in three areas on California's north coast, including the Humboldt Wind Energy Area (Humboldt WEA) and notional areas offshore from Cape Mendocino and Crescent City (Younes, et al., 2022). This assessment represents an update to prior analysis reported in Severy, et al. (2020) and involves use of the National Renewable Energy Laboratory's CA20 offshore wind dataset. It also covers analysis of transmission infrastructure requirements, associated upgrade costs, and wind project economics for wind development in the Humboldt WEA, including wind farm scenarios ranging from 30 MW to 480 MW (Alva, et al., 2022; Daneshpooy and Anilkumar, 2022; Cooperman, et al., 2022). Throughout the study, the analysis was based on the deployment of 12-MW offshore wind turbines mounted on a floating semi-submersible structure. For the purpose of setting assumptions about the regional electrical system and project economics, the team assumed that the wind farm would come online in 2030.

2 HUMBOLDT REGION ELECTRICITY INFRASTRUCTURE

The Humboldt Area transmission system consists of 60-kV and 115-kV transmission facilities and multiple generation sources that include natural gas, biomass, solar, and hydroelectric power plants (Figure ES-1). The Humboldt Bay Generation Station (HBGS) and the other local plants serve the regional load, which currently has a demand that is usually on the order of 90 to 110 MW. Supplemental power is delivered from outside the region via the bulk Pacific Gas & Electric transmission system. Transmission infrastructure into and out of the area is limited to

[1] The Humboldt Wind Energy Area has been identified by the Bureau of Ocean Energy Management (2021), and this term is used throughout this report. BOEM previously referred to this area as the Humboldt Call Area.

four, 80 to 100 miles long transmission circuits. Two 115-kV circuits and one 60-kV circuit run along an east-west corridor from the Cottonwood Substation and one 60-kV circuit runs north-south from the Mendocino Substation.

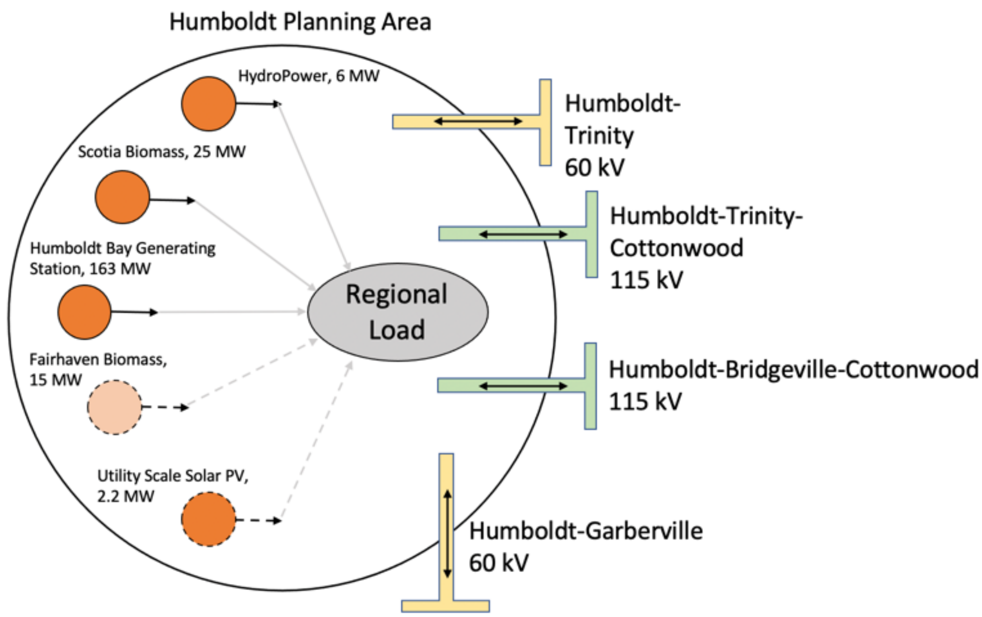

Figure ES-1: Simplified schematic of Humboldt's generation sources and transmission circuits

Figure ES-2 shows the location of the Humboldt Wind Energy Area and Humboldt County's transmission system relative to the major transmission corridor that runs north and south in California. The Humboldt Area transmission system is constrained, and the lines serving the area are not sized to accommodate a large import or export of power. Development of large-scale offshore wind that generates significantly more energy than can be used locally will require upgrades to the interconnecting transmission lines to export power to the state's major transmission system.

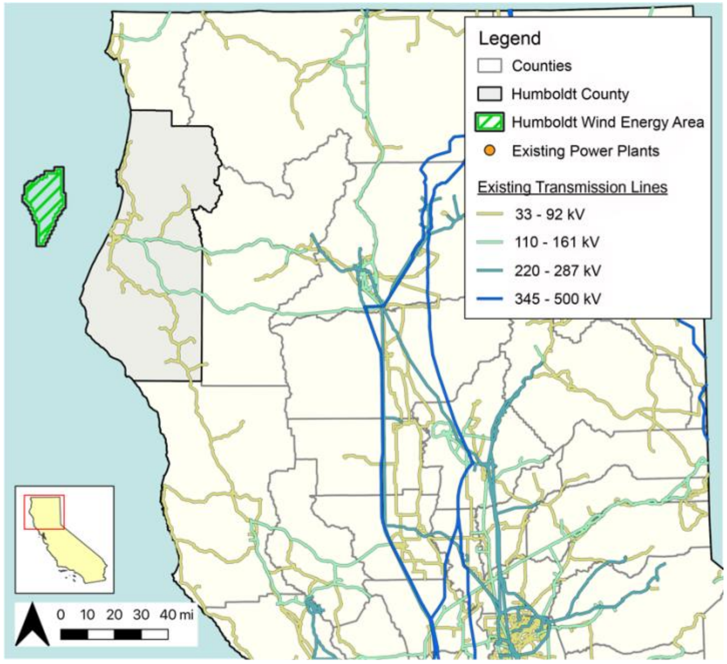

Figure ES-2: Map showing the electrical transmission system in Humboldt County and the northern part of California with respect to the offshore Humboldt Wind Energy Area

The base case regional load for 2030 drew information from a report published by the Redwood Coast Energy Authority (RCEA 2019). The base case is a business-as-usual profile and was calculated using a 2025 load forecast by The Energy Authority (TEA) and an assumed 1% load growth per year from 2025 to 2030. The hourly average load for the 2030 base case ranges from 67 MW to 137 MW, with demand falling between about 100 MW and 125 MW most of the time. The augmented load growth assumes additional electrified transportation and building heating loads relative to the base case while taking into account the projected solar generation from future customer net energy metering (NEM) photovoltaic systems. A third profile was also developed that is based on the augmented profile plus a continuous 20-MW load that is intended to represent installation of a new industrial fish farming facility in the Humboldt Bay area (GHD 2021).

3 Offshore Wind Resource and Regional Generation Potential

The study included an updated analysis of the potential for energy generation for a variety of offshore wind farm scenarios along California's north coast (Younes, et al., 2022). This portion of the work was led by the Schatz Center. The assessment utilized modeled wind speed data from NREL's CA20 dataset (Optis, et al., 2020). The results indicate that wind farms ranging from 48 MW to 480 MW in the Humboldt Wind Energy Area could operate with capacity factors on the order of 51 to 53% after accounting for expected efficiency and downtime losses. Larger projects in this wind farm size range are expected to have slightly lower capacity factors due to increased wake losses, and projects that are located further to the west in the Humboldt WEA are expected to have slightly higher capacity factors because wind speeds increase further from shore. The analysis also assessed the potential for wind generation in notional areas offshore from Cape Mendocino and Crescent City. The wind speeds in these areas were even higher than those in the Humboldt WEA, and the corresponding expected capacity factors were 57 to 58% and 54 to 55%, respectively (Younes, et al., 2022).

4 Transmission Upgrade Costs

The project team assessed multiple options for interconnecting offshore wind projects in the Humboldt WEA into the existing electrical grid. This analysis was led by Quanta Technology LLC, and it involved transmission system power flow analysis for 10 scenarios (Daneshpooy and Anilkumar, 2022).

The assessment considered wind farm development scenarios with interconnections that allowed Full Capacity Deliverability of the electricity, as well as Energy Only interconnection scenarios that involved some degree of wind energy curtailment. In cases where a project is to interconnect with Full Capacity Deliverability, the transmission system must be capable of accepting the full output that the power plant is expected to deliver at all times. If the existing grid infrastructure does not have sufficient capacity to ensure this, investments must be made to upgrade the system accordingly. In contrast, for cases where interconnection is on an Energy Only basis, transmission upgrades may be required to ensure system reliability, but no upgrades are required to ensure Full Capacity Deliverability. In such cases, the output of the wind farm would be temporarily limited (i.e. curtailed) during times when delivering the power would overload the transmission system.

The results of the power flow analysis indicate that the largest wind farm that could be connected with Full Capacity Deliverability without requiring upgrades to the existing transmission system is approximately 30 MW. Wind farms beyond that size with Full Capacity Deliverability would require transmission upgrades. The estimated transmission upgrade costs for 144 MW, 288 MW, and 480 MW offshore wind farms in the Humboldt WEA with Full Capacity Deliverability are included in Figure ES-3. These results assume the base case regional load for 2030.

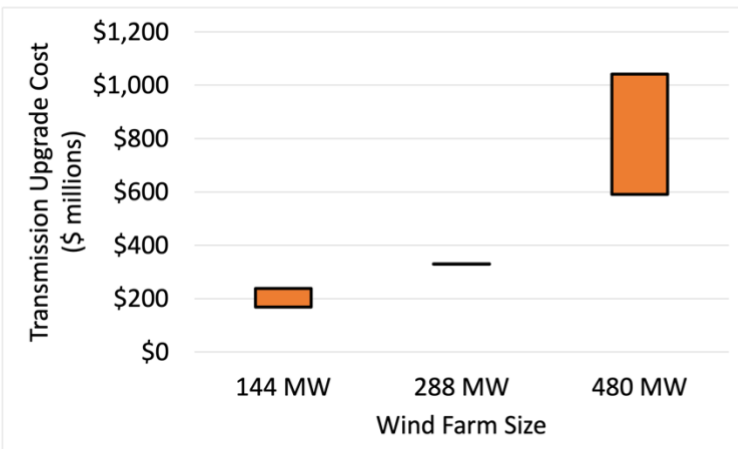

Figure ES-3: Estimated transmission upgrade costs for offshore wind farms in the Humboldt Wind Energy Area that interconnect to the electrical grid with Full Capacity Deliverability. A range of costs are included for the 144-MW and 480-MW cases, as there is some uncertainty regarding the range of upgrades that will be required in relation to the proposed offshore wind farm. For the 288-MW case, a single value is reported that represents the estimated cost of required upgrades.

5 POTENTIAL FOR OFFSHORE WIND DEVELOPMENT WITHOUT TRANSMISSION UPGRADES

According to the power flow analysis carried out by Quanta Technology (Daneshpooy and Anilkumar, 2022), the largest Energy Only project that could be connected to the regional electrical grid without requiring transmission system upgrades is on the order of 174 MW. This result assumes the base case regional load. If the load increases, somewhat larger Energy Only wind farms could be connected without triggering upgrades, as indicated in Table ES-1.

Table ES-1: Maximum wind farm size for projects connected to the electrical grid with Energy Only status that would not require transmission system upgrades as a function of the regional load

Wind Farm Maximum Size	Regional Load Case	Peak Load
174 MW	Base Case	136 MW
225 MW	Augmented Load	170 MW
231 MW	Aug. Load + 20 MW	190 MW

6 WIND PROJECT REVENUE GENERATION

As part of the transmission analysis conducted by Quanta Technologies (Daneshpooy and Anilkumar, 2022), an assessment of the revenue generation potential for select wind farms was performed using a production cost simulation approach that performed economic dispatch of generation resources and considered the impacts of curtailment, congestion trends, and interaction with other *must-run* generation in the area. The models used for these studies were obtained from the California Independent System Operator (CAISO), and the analysis assumed that the wind power generated would be sold in the CAISO wholesale market. If the power were sold via a bilateral power purchase agreement (PPA), revenue projections would likely be different.

The scenarios examined using the production cost approach included 144 MW, 168 MW and 288 MW wind farm sizes, as well as 144 MW and 168 MW wind farms paired with battery energy storage. These five scenarios used base case load assumptions. In addition, the 168 MW wind farm scenario was examined with the augmented load assumptions.

Revenue generation estimates included a production tax credit (PTC) of $25 per MWh, as is currently consistent with CAISO models. This assumes that the PTC will be available in 2030 and beyond. While there is currently proposed legislation that would accomplish this, the ultimate outcome is uncertain. Also, it is important to note that the PTC was found to play a significant role in the revenue generation potential for these simulated wind projects, accounting for approximately 40% to 60% of total revenues. This illustrates how important these tax credits are likely to be for the economic viability of these projects. We note that NREL also assessed possible use of the Investment Tax Credit (ITC) as part of the economic analysis performed for this study. Results are available in Cooperman, et al., (2022). As per current federal policy, project developers can apply either the ITC or the PTC to eligible projects (but not both).

Another key finding from the production cost analysis was that wind farm size and the relative magnitude of the local load have a very large impact on the Locational Marginal Price (LMP), and therefore on potential revenues. Currently, the Humboldt Area's electrification needs are predominantly served by in-county generation from the Humboldt Bay Generating Station (63%)

and the Scotia biomass plant (17%)[2], and supported by the 60 and 115 kV intercounty transmission lines. As the transmission capacity stands today, if a wind farm in the Humboldt WEA generated large amounts of power, the degree of transmission system congestion could be significant. This local oversupply relative to demand would reduce the local LMP, which leads to a non-intuitive phenomena where the development of larger wind farms would result in less total revenue being generated. Table ES-2 illustrates the impact of larger scale wind farms on curtailment, LMP, and revenues. Table ES-2 also illustrates the significant effect that the PTC has on revenues.

Table ES-2: Curtailment, locational marginal price and revenue projections for different wind farm sizes

Wind Farm Size	Load Case	Curtailment	Avg. LMP Price	Net Revenue (w/o PTC)	Net Revenue (w/ PTC)
144 MW	Baseline	4.4%	$32 per MWh	$21M	$37M
168 MW	Baseline	6.0%	$23 per MWh	$12M	$30M
168 MW	Augmented	5.8%	$26 per MWh	$16M	$34M
288 MW	Baseline	36.5%	$3.7 per MWh	$5.6M	$9M

7 Wind Project Economics

An economic analysis of the offshore wind deployment alternatives was carried out by NREL using information provided by the analyses carried out by the Quanta Technology and Schatz Center teams (Cooperman, et al., 2022). This analysis also drew from cost models and datasets developed by NREL, including the Offshore Regional Cost Analyzer (ORCA) for turbine procurement, operations and maintenance, and financing and the Offshore Renewables Balance-of-System and Installation Tool (ORBIT) to model procurement costs for additional offshore wind equipment and installation costs.

Capital costs for offshore wind plants in the Humboldt WEA with a commercial operations date (COD) of 2030 are presented in Figure ES.4. Although the relationship between total CapEx and plant capacity appears linear, examination of the CapEx per kilowatt shows a steep decrease between 24 and 144 MW, with a slower decline in costs for larger plant sizes. Trends in the levelized cost of energy (LCOE) are similar, starting above $95 per MWh and decreasing to $74 per MWh for a plant capacity of 480 MW.

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[2] These percentages reflect 2020 generation and load data for Humboldt County from the California Energy Commission's California Energy Consumption Database (https://ecdms.energy.ca.gov/) and QFER CEC-1304 Power Plant Owner Reporting Database (https://ww2.energy.ca.gov/almanac/electricity_data/web_qfer/index_cms.php).

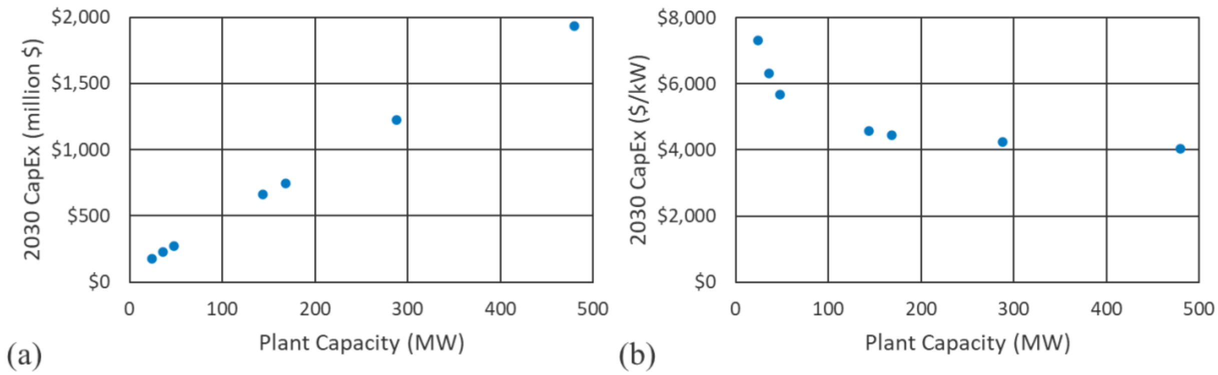

Figure ES.4. Capital expenditures (CapEx) for offshore wind plants in the Humboldt WEA with a 2030 COD for plant capacities between 24 and 480 MW. (a) total CapEx and (b) CapEx per kilowatt.

Table ES.3 summarizes the cost of energy and transmission upgrades for plant capacities up to 480 MW with Full Capacity Deliverability. Although transmission upgrades would be required for a plant capacity of 48 MW, the cost of those upgrades was not evaluated in this study. For the plant sizes considered, LCOE decreases as the plant capacity increases, but the combined cost of transmission and energy generation reaches a minimum at 288 MW unless upgrade costs for the 480-MW plant are minimized.

Table ES.3. Levelized cost of energy and transmission for Full Capacity Deliverability scenarios. The net AEP is the net average annual energy production, while LCOE and LCOT represent the levelized cost of energy and the levelized cost of transmission, respectively. Data were not available for the transmission upgrade costs for a 48-MW wind farm with full deliverability.

OSW Plant Capacity	48 MW	144 MW	288 MW	480 MW
OSW CapEx (million $)	273	661	1,225	1,935
Transmission CapEx (million $)	—	168 to 238	329	591 to 1,123
OSW OpEx (million $ per yr)	3.4	10.0	20.0	33.3
Net AEP (GWh)	219	660	1,317	2,160
LCOE ($ per MWh)	96	80	75	73
LCOT ($ per MWh)	—	12 to 17	12	13 to 25
LCOE + LCOT ($ per MWh)	—	92 to 97	87	86 to 98

The Energy Only scenarios summarized in Table ES.4 do not include transmission upgrades, but they have higher LCOEs than the equivalently sized Full Capacity Deliverability counterparts because their energy output is reduced by curtailment. However, the LCOE of the 144-MW Energy Only scenario is lower than the LCOE + LCOT (levelized cost of transmission) of the 144-MW Full Capacity Deliverability scenario, and the 168-MW Energy Only scenarios have marginally lower LCOEs than the corresponding 144-MW scenarios. At 288 MW, the level of curtailment is much higher, as is the LCOE. Larger plant capacities face greater curtailment because local electricity demand is met more often and the ability to deliver excess energy to the rest of the California grid is constrained. As noted above, this local saturation depresses the locational marginal prices, reducing revenues for larger plant capacities. The difference between wind farm revenues and cost (revenues per MWh – LCOE) is used as a proxy for profit. All plant capacities have a negative difference, indicating that revenues do not exceed the cost of the wind farm. Note that the revenue estimates presented in Table ES.4 assume availability of a $25 per MWh production tax credit. Without the PTC, the difference between wind farm revenues and costs would be considerably larger. Use of a 30% ITC in lieu of the PTC also helps improve economic outcomes for wind farm development, although it does not provide as much benefit as the PTC for the scenarios considered in this study.

Table ES.4. Levelized cost of energy and revenue for Energy Only deliverability scenarios. The revenue values assume use of a $25 per MWh production tax credit.

Scenario	144 MW baseline load	168 MW baseline load	168 MW augmented load	288 MW baseline load
OSW CapEx (million $)	661	748	748	1,225
OSW OpEx (million $ per yr)	10	12	12	20
Curtailment	4.4%	6.0%	5.8%	36.5%
Net AEP (GWh)	632	724	726	836
LCOE ($ per MWh)	84	83	83	119
Average LMP ($ per MWh)	33	16	22	-14
Revenue ($ per MWh)	58	41	47	11
Δ [Revenue – LCOE] ($ per MWh)	-26	-42	-36	-108

With the available information, the key dynamics illustrated by the above scenarios appear to be:

- Lower power plant costs per MWh (LCOE) for larger offshore wind plant capacities
- Substantial transmission costs per MWh (LCOT) for wind plants with Full Capacity Deliverability
- Suppression of revenue for Energy Only plants as capacity increases, caused by transmission constraints and local energy market saturation
- Lower LCOEs for the 144-MW and 168-MW Energy Only scenarios than the combined LCOE + LCOT of the 144-MW Full Capacity Deliverability scenario
- Negative values for "revenue minus LCOE" for all scenarios studied, meaning that the revenues do not exceed the costs within the project lifetime.

Among all of the scenarios considered, the 288-MW plant offered the lowest cost for Full Capacity Deliverability, while the 144-MW plant offered the most favorable difference between revenue and LCOE. It is additionally worth reiterating that the revenue values used in this analysis assume that all non-curtailed electricity is sold through CAISO market channels. As an alternative, a developer may sell some or all of the electricity through a PPA. If the terms of the PPA are sufficiently positive, this could result in higher revenues and therefore a more favorable economic outcome. Moreover, although not assessed in this analysis, offshore wind development can present opportunities for economic development that increase with project size, resulting in both costs and benefits for stakeholders in the Humboldt region (Hackett and Anderson, 2020). These regional costs and benefits can impact the community's acceptance of a proposed project and can also impact the regional PPA price that is deemed acceptable.

8 POTENTIAL FOR BATTERY STORAGE TO SUPPORT OFFSHORE WIND ECONOMICS

The project team also assessed the opportunity to pair battery storage with offshore wind farm alternatives in an attempt to mitigate curtailment issues and increase revenue potential. The battery assessment was a preliminary evaluation and included only two scenarios. Nonetheless, it offers some insights into the value of energy storage in this application. The scenarios evaluated included the 144-MW and 168-MW wind farm sizes. These wind farm capacities were chosen because they were close to the largest wind farm sizes that could be interconnected in the Humboldt Area assuming the base case load without the need for significant transmission upgrades, and because they were subjected to enough curtailment without energy storage to provide an opportunity for improvement. In both cases, the simulated battery was a 15-MW, 4-hour Li-ion battery. For the analyses, the battery was allowed to participate in the CAISO ancillary services market (regulation up and down, spin and non-spin), as well as to provide energy arbitrage services that can accrue benefit from significant energy price differentials over short time periods in the market.

Table ES-5 provides the results for the 144 MW and the 168 MW wind farms with and without battery storage. It can be seen that the impacts on curtailment are modest at best. However, in both cases there is a significant increase in the average LMP (15% to 20% increases). This is likely due to reductions in transmission congestion made possible through utilization of battery storage. While the battery storage does improve the net revenue and the net electricity value in both cases, the improvements are modest and are not substantial enough to provide a positive net electricity value. The battery storage has a greater impact toward improving the economic viability in the 168 MW case, but the best net electricity value was obtained for the 144 MW case with a storage battery. However, in summary is it important to note that this was intended only as an initial analysis of battery storage paired with offshore wind. It is recommended that a more robust assessment be conducted that considers more battery sizes and more varied scenarios in order to better determine the role that batteries could play in an offshore wind project on the North Coast.

Table ES-5: Curtailment, locational marginal price and revenue projections for two wind farm sizes with and without battery energy storage

Scenario	144 MW baseline load	144 MW + 15 MW, 4 hr storage	168 MW baseline load	168 MW baseline load + storage
OSW + storage CapEx (million $)	661	672	748	760
OSW + storage OpEx (million $ per yr)	10	11	12	12
Curtailment	4.4%	4.5%	6.0%	5.5%
Net AEP (GWh)	632	628	724	725
LCOE ($ per MWh)	84	86	83	85
Average LMP ($ per MWh)	33	36	16	22
Revenue ($ per MWh)	58	63	41	50
Δ [Revenue – LCOE] ($ per MWh)	-26	-24	-42	-35

9 Potential for Hydrogen Generation to Support Offshore Wind Economics

The pairing of an electrolytic hydrogen production facility with an offshore wind farm was also examined as an approach to mitigate the need for transmission upgrades. For this analysis a hydrogen generation facility was sized at 1,200 kg per day to provide hydrogen as a low-carbon transportation fuel for a Humboldt County fleet of light-duty fuel cell electric vehicles and fuel cell electric transit buses. A 168-MW wind farm was paired with the electrolytic hydrogen production facility. A wind farm of this size was chosen because it was nearly the largest wind farm that could be interconnected without requiring significant transmission upgrades, it was expected to provide enough curtailed wind energy to allow the hydrogen alternative to provide substantial economic benefit, and it was large enough to be able to generate the majority of the needed hydrogen with low-cost wind energy.

The analysis found that nearly 60% of the required hydrogen could be generated with wind energy that otherwise would have been curtailed, and the remainder could primarily be provided using low-cost wind energy generated by the 168 MW wind farm. The total amount of electricity consumed for hydrogen generation represented about 3% of the total annual electricity production from the 168-MW wind farm. The overall dispensed cost of hydrogen was estimated to be $5.28 per kg. This cost was deemed to be competitive with other sources of renewable hydrogen. Depending on the projected market cost of renewable hydrogen in Humboldt County, it was estimated that the annual net revenues from an electrolytic hydrogen production facility could total about $0.8 M to $2.4 M. This net revenue estimate includes revenues from the sale of Low Carbon Fuel Standard credits, and, to allow direct comparison with the other wind farm alternatives, it nets out the lost revenue associated with the direct sale of wind energy produced by the 168 MW wind farm. While this analysis indicates the hydrogen production alternative may be a viable economic option, a much more detailed, bankable analysis using specific project information is needed before an investment decision could be made.

10 Conclusions and Recommendations for Future Research

The findings in the series of reports produced by the partners in this study confirm that the wind resource on California's north coast is very large and has potential to make substantial contributions to the state's climate and clean energy goals. While the wind resource could enable development of large-scale wind farms, the existing transmission infrastructure limits the size of projects in the absence of significant investment in transmission upgrades. As a result, this study therefore focused on understanding possibilities for offshore wind development at a scale that is aligned with the existing infrastructure. The results of the analysis support the following conclusions.

- A small commercial offshore wind project can be built in the Humboldt Wind Energy Area without transmission upgrades if it is interconnected with Energy Only status, thereby accepting some degree of curtailment. Assuming the base case load, the largest project that could be developed without transmission upgrades is on the order of 174 MW. Somewhat larger projects could be possible if load growth exceeds the base case rate.
- Considering variations in offshore wind project development costs as a function of project size and the regional price dynamics associated with participation in the CAISO wholesale electricity market, the most favorable project size for an initial Energy Only project may be on the order of 140 to 150 MW. This result assumes the 2030 base case load, and the outcome is sensitive to assumptions about load growth. In addition, this result assumes revenue generation based on CAISO wholesale market participation. If a significant fraction of wind farm revenues are generated through one or more power purchase agreements, the results could differ – and could be considerably more positive – depending on the PPA terms.
- Developing an economically viable offshore wind project at a small scale is challenging, and all the alternatives considered in this study were projected to have financial losses over the project lifetime. This was true even when projects were able to access a $25 per MWh production tax credit or a 30% investment tax credit. In the absence of tax credits or other similar support, development of a small commercial offshore wind farm in the Humboldt WEA may be economically infeasible even with particularly favorable PPA terms.
- The inclusion of lithium-ion battery storage can help improve the economics of offshore wind projects in at least some scenarios.
- Hydrogen generation from curtailed and low-cost power may potentially be viable for some local applications, although more analysis is needed to confirm this result.

While the analysis from this study indicates that the economics of developing a small commercial wind farm in the Humboldt WEA are challenging, it may nonetheless be appealing to some developers to pursue such a project. This could be true if the developer is able to secure more favorable revenue outcomes through one or more negotiated PPAs and/or if the developer views a small project as an initial step toward wind farm development at a larger scale. This analysis also highlights the importance of identifying suitable transmission upgrade alternatives through the California transmission planning process (e.g. CPUC, 2020; Billinton, 2021), as additional transmission capacity will ultimately be necessary if the goal is to achieve larger offshore wind projects that can benefit from economies of scale.

While the completed analysis provides considerable information about the development of offshore wind at a small-commercial scale in the Humboldt WEA, some related topics would benefit from additional analysis. Our recommendations for future research include:

- Conduct additional analyses related to the inclusion of energy storage in offshore wind projects. The current analysis considered two cases, both of which involved lithium-ion battery systems with four hours of storage capacity. It would be valuable to expand this analysis to cover additional battery storage system sizes along with consideration of other storage technologies.
- Perform an in-depth assessment of the potential to integrate hydrogen production into offshore wind projects. In this study, we conducted preliminary analysis for the utilization of wind electricity to generate hydrogen to reduce the impact of curtailment. Additional work is needed to understand this opportunity more fully, and it would also be valuable to study the potential for hydrogen generation and utilization at a larger scale.
- Expand the geographic reach of the analysis. The current effort focused on offshore wind development in the Humboldt WEA. Other areas in the region, including offshore from Crescent City and Cape Mendocino, also have large potential for wind power generation. It would be valuable and informative to conduct feasibility analyses covering a variety of scenarios for these additional areas.
- Looking beyond California, it would be valuable to consider analysis of the transmission requirements for offshore wind development for multiple GW-scale project scenarios associated with sites between Cape Mendocino, California and Coos Bay, Oregon.

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