Offshore wind industry prepares to ride economic high tide

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It is the first time that data has been used at a national scale to judge how the beauty of the environment impacts onshore windfarm development. Credit: CC0 Public Domain

The U.S. offshore wind energy pipeline is predicted to exceed 25,000

megawatts (MW) by 2030. But, with only two commercial offshore wind plants currently operating in the United States, developers need accurate modeling to evaluate prospective new projects, weigh realistic costs against financial returns, anticipate the impact of technological and process innovations, and quantify risk factors. While technological advancements and improved supply chain efficiencies are helping reduce wind energy costs and generate more energy, offshore wind installations must meet development and operational cost targets to be competitive in the broader energy market.

National Wind Technology Center researchers at the U.S. Department of Energy's (DOE's) National Renewable Energy Laboratory (NREL) apply a wide range of modeling expertise and tools to help industry, government, and research partners gain crucial, objective understanding of the balance among potential offshore wind costs, revenues, and risks within the broader context of technical, legal, regulatory, tax, and policy issues.

"It's vital to understand the full range of factors that can affect offshore wind costs, from the evolution of new technologies to industry trends, installation practices, and operational constraints," said NREL Offshore Wind Platform Lead Walt Musial. "NREL's techno-economic expertise gives government decision makers, wind plant researchers, developers, and investors a comprehensive picture of future project costs, increasing the probability of success for this up-and-coming sector."

Grounded in robust, validated data, the laboratory's modeling efforts benefit from researchers' broad and deep knowledge of offshore technologies and issues. NREL directly models both capital and operational expenditures (CapEx and OpEx) to understand the total impact of project parameters and decisions on the levelized cost of energy (LCOE) and develops alternative metrics to provide additional insights not captured by LCOE. These cost models can consider one

project at a time or compare any number of hypothetical projects at different locations.

On the Level: Prospecting for Economic Feasibility

NREL analyzes offshore wind projects through the primary lens of economic viability. LCOE essentially estimates the revenue required to cover the total expense of building a wind system and operating it over its anticipated lifetime. As offshore wind technologies advance and demand grows, NREL and other industry analysts estimate that cost may reach an LCOE of $50–$70 per megawatt-hour (MWh) by 2030, potentially making offshore wind competitive in some U.S. electricity markets.

NREL analysts have used the laboratory's Offshore Regional Cost Analyzer (ORCA) to compute the LCOE of fixed-bottom and floating wind installations at thousands of U.S. offshore sites. That analysis helps identify the most economically attractive sites and, more importantly, the key drivers of offshore LCOE across the United States. ORCA makes it possible for NREL researchers to calculate LCOE for the technical resource potential of the entire United States, producing LCOE heat maps, future cost trajectories, and cost category breakdowns.

More tightly focused projects have assessed the future trajectory of LCOE for specific states as technology matures and infrastructure is built. NREL studies for the Bureau of Ocean Energy Management and the University of Maine have explored the potential for commercializing offshore wind in California, Oregon, and the Gulf of Maine, and NREL conducts ongoing work to evaluate floating offshore wind costs in Hawaii.

"Techno-economic analysis tools like ORCA allow us to combine a wealth of aggregate industry intelligence with state-of-the-art

engineering and economic modeling capabilities," said NREL Offshore Wind Market Analyst Philipp Beiter.

ORCA provides a comphrensive summary of the key CapEx, OpEx, energy production, and financial drivers for offshore wind projects. For a more detailed understanding of project-specific logistics and cost breakdowns, NREL has developed a process-based simulation model: the Offshore Renewables Balance-of-system and Installation Tool (ORBIT).

In Balance: Factoring Innovation into Construction and Operating Costs

Balance-of-system (BOS) costs—which encompass all construction expenses other than turbine CapEx—account for approximately 40% of a fixed-bottom offshore wind plant's life cycle costs. NREL's BOS cost models can be used to explore the cost and logistical impacts of new strategies, technologies, vessels, processes, and system designs. The ability to consider many "what-if" scenarios quickly helps alleviate uncertainty and lower the risks of adopting new approaches.

"Our team members have done a great job identifying the costs, logistics, and constraints associated with developing offshore wind projects," said NREL Offshore Wind Engineer Matt Shields. "But I think that where we can really add the most value is identifying the most promising cost-reduction pathways for future project development. This is critical for the growing U.S. offshore industry—differences in regulation and local manufacturing mean we cannot do things exactly the same as in Europe."

ORBIT provides estimates of the cost impacts of project size, turbine scaling, site characteristics, and a wide range of technology alternatives.

In addition to evaluating capital costs, BOS analyses can consider factors such as installation times, weather impacts, and marine mammal migrations to generate a comprehensive view of project uncertainty and risk. By interfacing with NREL's other system design and wind plant tools, ORBIT can also consider project-level tradeoffs involving the introduction of novel technologies or installation processes to understand how these impact overall project costs.

How will BOS costs and LCOE change as turbines grow larger? How do assembly bottlenecks at ports impact floating turbine installation times? Do the benefits of novel foundation designs outweigh their higher capital cost? ORBIT is addressing these questions and others for NREL's DOE sponsors and multiple industry partners.

NREL continues to expand its cost modeling capabilities to provide partners with a more complete tally of all entries in the offshore wind ledger.

Operations and maintenance (O&M) costs typically account for as much as 30% of a project's LCOE value. NREL is investing in new capabilities patterned on the ORBIT framework to assess the impact of different O&M strategies on cost, performance, availability, and reliability. This will round out NREL's ability to accurately predict cost-reduction pathways from all types of innovations.

Reaching Back to Shore: Determining Value to the Energy System

The NREL techno-economic research team works hand in hand with grid modeling, workforce development, and environmental specialists, taking an expanded view, looking at the value offshore wind can deliver to the U.S. electrical grid and broader economy by comparing the net

value of offshore wind with that of traditional land-based wind, solar photovoltaic energy, and natural gas.

"LCOE is a convenient summary measure of competitiveness if you are a researcher or developer evaluating a lease area," said NREL Senior Research Engineer Garrett Barter. "But there are many other stakeholders who value offshore wind differently, so we try to quantify those benefits too."

In response, NREL is examining other offshore wind benefits, such as secondary revenues, additional services to the utility grid besides simple power production, workforce impact, integration with other renewables, and land use—while continuing to focus on the overall economic potential of installations.

By calculating the investment and risks associated with offshore wind, and weighing them against the potential for positive returns, NREL and its partners are giving industry the knowledge and tools needed to gain a toehold in the energy marketplace—and significantly grow the nation's capacity to produce its own energy from clean, renewable, domestic sources.

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