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Estimating the Economic Potential of Offshore Wind in the United States

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National Renewable Energy Laboratory

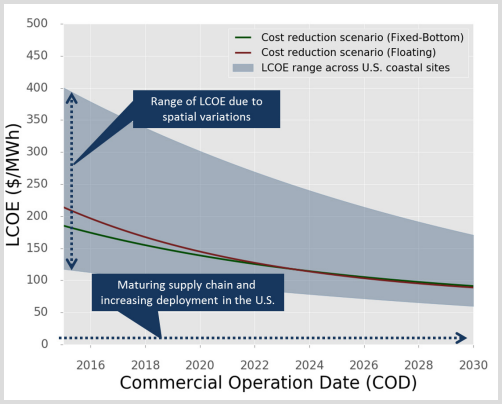

Figure 1. Modeled reductions in LCOE across U.S. coastal regions from 2015 to 2030

Notes: Levelized cost of energy (LCOE); Cost reduction scenarios approximate average spatial conditions across wind energy areas

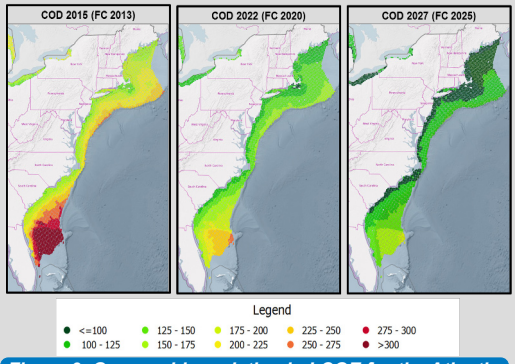

Figure 3. Geographic variation in LCOE for the Atlantic Coast region (2015–2025)

Notes: Commercial operation date (COD); Financial close (FC)

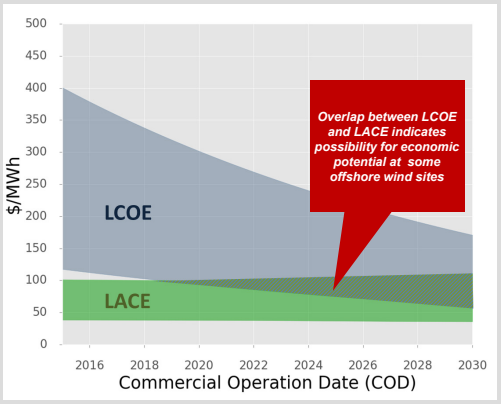

Figure 4. Comparison of LCOE and LACE estimates across U.S. coastal regions (2015–2030)

Analysis Purpose

To develop a high-level metric of economic viability for offshore wind by combining a resource, cost, and revenue assessment at a high geospatial resolution.

Key Findings

Reduced levelized cost of energy (Figures 1, 3, and 4)

- Offshore wind has the potential to achieve levelized cost of energy (LCOE) below $100/MWh at some U.S. coastal sites within the next decade
- Offshore-wind-modeled LCOE varies considerably across U.S. coastal sites as a result of geospatial cost variables, including the quality of wind resource, turbine accessibility, distance from shore, water depth, substructure suitability, and availability of critical infrastructure
- Offshore-wind-modeled LCOE decreases approximately 5% on average from year to year as a result of technology advancement and market development, including reduced capital expenditures (e.g., turbine, substructures, electrical infrastructure), operations, financing costs, and factors that raise annual energy turbine output
- Because of continued technological advances and increased deployment, floating technology has the potential to reach similar LCOE levels as fixed-bottom technology
- The modeled cost reductions in Figure 1 depend strongly on continued global technology innovation (e.g., increases in turbine size) in conjunction with increasing levels of domestic deployment and future market visibility, leading to the near-term establishment of a sustained domestic supply chain.

Growing economic potential (Figures 2 and 4)

- Offshore wind has the potential to become economically viable within the next decade in some U.S. regions where low offshore wind LCOE coincides with high electricity prices, even without consideration of policy incentives
- The Northeast and some regions along the Eastern Seaboard are likely to be among those with the highest economic potential for offshore wind within the next decade
- The growing economic potential over the next decade is primarily a result of decreasing LCOE in fixed-bottom and floating offshore wind technology and projected increases in wholesale electricity prices.

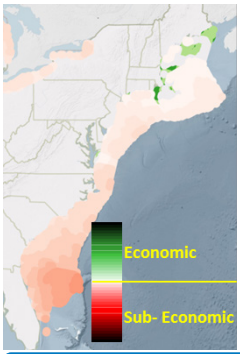

Figure 2. Geographic variation in offshore wind economic potential for the Atlantic Coast region (2025)

Method

Calculating LCOE (Figure 5)

- The LCOE for fixed-bottom and floating offshore wind technologies was calculated at more than 7,000 individual sites across the entire U.S. coast
- The offshore wind cost model combines wind plant performance modeling, economic modeling, and national geospatial data considering the following geospatial parameters:
  - Water depth
  - Wind resource
  - Wave regime
  - Seabed conditions
  - Prospective staging ports
  - Possible inshore assembly areas
  - Existing grid features and potential connection points
  - Environmentally sensitive areas
  - Competitive use areas.

LCOE formula (simplified):

$$LCOE = [(FCR * CAPEX) + OPEX] / AEP_{net}, \text{ where:}$$

LCOE: Levelized cost of energy ($/kWh)
FCR: Fixed charge rate (%)
CAPEX:Capital expenditures ($/kWh)
OPEX: Annual operating expenditures ($/kW/yr)
AEP_{net}: Net annual energy production (MWh)

- LCOE reductions are based on the KIC InnoEnergy cost evaluation platform DELPHOS[1]
- The LCOE metric excludes policy incentives (e.g., production tax credit or government loan guarantees).

Calculating levelized avoided cost of energy

- The levelized avoided cost of energy (LACE) for offshore wind was calculated for 71 U.S. coastal regions that coincide with the LCOE sites
- The offshore wind LACE model combines marginal generation price (proxied by wholesale electricity prices and marginal system costs) and capacity value data to estimate available revenue to potential offshore wind projects.

LACE formula (simplified):

$$LACE = [MP * CF_{net} * 8760h + CP * CC] / CF_{net} * 8760h, \text{ where:}$$

MP: Marginal generation price ($/kWh)
CF_{net}: Net capacity factor (%)
CP: Capacity value ($/kW/yr)
CC: Capacity credit (%)

- The LACE metric does not consider policy incentives (e.g., Renewable Energy Credits)

Economic potential

- Economic potential has been defined as the difference between a site- or region-specific LACE and corresponding LCOE. When this difference is positive, the electricity generation and capacity of a potential offshore wind project at this location was considered the economic potential
- Economic potential is based on a site-specific assessment and does not consider any export/import situations.

[1] *KIC InnoEnergy DELPHOS platform: http://www.kic-innoenergy.com/delphos/*

Main Limitations

Data use

- The economic potential metric is a high-level indicator of economic viability and not a projection of future deployment levels.

Models

- Supporting LCOE parameter and LACE studies were conducted with first-order tools and do not reflect detailed, project site-specific conditions.

Data

- The models described are static and consider economic potential at a particular point in time based on the vintage of underlying data and assumptions, including resource, cost of energy, avoided cost, and electricity price projections
- As resource, technology cost, deployment, transmission infrastructure, wholesale electricity price data, and other factors change, estimates of economic potential will change.

Availability of technology

- Some components of this analysis were derived without much empirical evidence (e.g., to date, no commercial-scale floating offshore wind projects have been installed)
- New components (e.g., dynamic high-voltage direct current cables) and equipment will be necessary to install projects in the range of site conditions considered.

Macroeconomic factors

- Exogenous factors (e.g., currency exchange rates, commodity prices) were considered as of 2015 and may change over time.

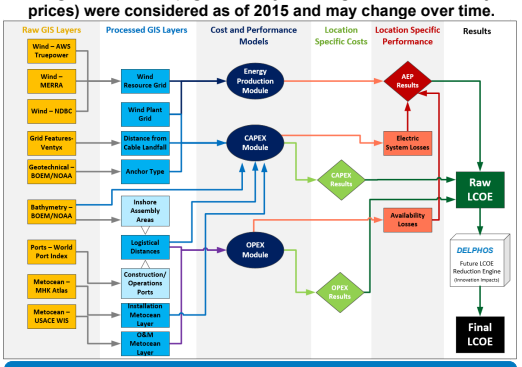

Figure 5. LCOE calculation steps and data sources

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Source: Beiter, P., W. Musial, A. Smith, E. Lantz, L. Kilcher, R. Damiani, M. Maness, S. Sirnivas, T. Stehly, V. Gevorgian, M. Mooney, G. Scott. (forthcoming). *A spatial-economic cost reduction pathway analysis for U.S. offshore wind energy development from 2015-2030.*

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