LCOE

Update of recent trends (Offshore)

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Offerings
Aegir Insights offers advanced solutions for offshore wind investment decisions and strategy

Aegir Quant
- Aegir Quant provides a holistic business case view by integrating technology modelling, annual energy production (AEP), CAPEX, OPEX, installation logistics, financials and more.
- A solution for advanced economic assessment of opportunities in both fixed-bottom offshore wind and floating wind projects.

Aegir GAMMA
- Aegir’s Geospatial Analytics Model and Mapping (GAMMA) provides high resolution market financial mapping as a supplement to traditional environmental constraints mapping.
- The solution helps clients develop long-term profitable investment plays based on site conditions, supply chain and local infrastructure.

Market Intelligence
- Comprehensive global coverage of +20 offshore wind markets. Market reports are regularly updated to reflect recent development.
- Market reports help developers pick the right markets by assessing market attractiveness and challenges, market reference cases and related LCoE levels.

Floating Intelligence
- Aegir offers a monthly release of floating project database and partnership analysis, a tool focused to help clients pick right markets, project and partners.
- The main features of the floating intelligence products include Global market forecasts, Country level project list, and Partnership network analysis.
Key highlights

1. Offshore wind is on course to play a key role in the decarbonization of the global economy

2. Cost reduction is mainly driven by upsizing of turbines and park size

3. Upsizing and systems engineering improvements will continue to reduce the cost of offshore wind

4. Headwinds from increasing inflation and raw material prices

5. Tenders on the rise will demand more from offshore wind energy
Offshore wind is the most rapidly growing renewable source

New Offshore wind installation 2010-2022 (MW)

- Europe
- Mainland China
- Rest

+19%

Sources: GWEC – 2022
Notes: 1) Including projects expected to be completed in 2022
Wind and solar in developed wind countries are below the fuel cost of fossil sources in Europe

LCOE offshore wind vs. onshore wind and PV

European Natural Gas and Coal² futures from Sep-22 to Dec-26

Sources: Aegir Insights (offshore wind), Danish Energy Agency (PV and Onshore wind), and CME Group (Coal and gas futures accessed 24-Aug-22)

Notes: 1) Fixed bottom for North Europe reference case, incl. transmission. 2) 2.46 MWh of electricity generated per ton of coal.
Deconstructing cost reduction shows the relative contributions from three key drivers: Project scale, turbine size and performance improvements.

**Project scale, 200 MW → 704 MW**
Positions increased from 50 to 176

- Increased project size drives cost down by almost 10 EUR/MWh.
- Cost reductions stem from (not exhaustive):
  - Scale benefits reducing relative contribution of fixed costs, decrease supply cost, etc.
  - Decreased OPEX/MWh due to scale

**Wind turbine size, 4 MW → 11 MW**
Positions decrease from 176 to 64

- Increased turbine size drives cost down by 31.5 EUR/MWh.
- Cost reductions stem from (not exhaustive):
  - Decreased CAPEX cost per MW
  - OPEX decrease by position reduction
  - Improved AEP due to better wind resource with higher hub height and more

**Project year 2015 → 2022**
Positions and park size kept constant

- Performance benefit with later COD drive cost down by 16%.
- Cost reductions stem from (not exhaustive):
  - Decrease in supply cost
  - Technical improvements reduce working time and increase availability
  - OPEX decrease w/ operational optimizations

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Sources: Aegir Insights analysis

Notes: 1) Real 2021, pre-tax 2) Other includes development cost, Resources cost, operations preparation, Construction management, insurance and decommissioning
LCOE Cost breakdown for a specific European offshore wind farm

LCOE cost breakdown for an offshore wind farm COD = 2015

IAC install 11%
Turbine install 11%
IAC supply 2%
Turbine supply 2%
Contingency 3%
MP & TP install 6%
MP & TP supply 9%
Transmission 9%
MP & TP supply 9%
Other 29%
OPEX 24%
Turbine supply 25%

LCOE cost breakdown for an offshore wind farm COD = 2022

Turbine install 1%
IAC install 1%
IAC supply 9%
MP & TP install 3%
MP & TP supply 4%
Transmission 14%
MP & TP supply 8%
Contingency 4%
Other 9%
OPEX 25%
Turbine supply 31%

Sources: Aegir Insights analysis, Siemens Gamesa
Notes: 1) Real 2021, pre-tax 2) Other includes development cost, Resources cost, operations preparation, Construction management, insurance and decommissioning
## Next generation of offshore wind turbine in the horizon

### New turbines announced in the market by mid-twenties

<table>
<thead>
<tr>
<th>Model</th>
<th>Company</th>
<th>Nameplate capacity (MW)</th>
<th>Serial production year</th>
<th>Height (m)</th>
<th>Blade Length (m)</th>
<th>Rotor Diameter (m)</th>
<th>W/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>SG 14-220 DD</td>
<td>Siemens Gamesa</td>
<td>14 MW</td>
<td>2024</td>
<td>Site Specific</td>
<td>108</td>
<td>220</td>
<td>368</td>
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<tr>
<td>SG 14-236 DD</td>
<td>Siemens Gamesa</td>
<td>14 MW</td>
<td>2024</td>
<td>Site Specific</td>
<td>115</td>
<td>236</td>
<td>320</td>
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<tr>
<td>Haliade-X</td>
<td>General Electric</td>
<td>14 MW</td>
<td>2024</td>
<td>260</td>
<td>107</td>
<td>220</td>
<td>368</td>
</tr>
<tr>
<td>V236-15.0</td>
<td>Vestas</td>
<td>15 MW</td>
<td>2025</td>
<td>280</td>
<td>116</td>
<td>236</td>
<td>343</td>
</tr>
<tr>
<td>MySE 16.0-242</td>
<td>MingYang Smart Energy</td>
<td>16 MW</td>
<td>2026</td>
<td>264</td>
<td>118</td>
<td>242</td>
<td>348</td>
</tr>
<tr>
<td>TBD</td>
<td>TBD</td>
<td>20 MW</td>
<td>2030</td>
<td>300</td>
<td>136</td>
<td>270</td>
<td>350</td>
</tr>
</tbody>
</table>

Sources: Aegir Insights analysis, Siemens Gamesa, Vestas, Ming yang, Wind Catching Systems

Notes:
Aegir forecasts that an average North European fixed-bottom offshore wind farm will reduce costs by almost 30% to ~35 EUR/MWh by mid-thirties.

Cost reduction forecasts, LCOE EUR/MWh

- Offshore wind Floating
- Offshore wind Fixed bottom

Sources: Aegir Insights analysis
Notes: 1) Real 2021, pre-tax 2) Other includes development cost, Resources cost, operations preparation, Construction management, insurance and decommissioning
Dark clouds of supply-led cost inflation and rising cost of debt are looming large

**Inflation rate**

- **Quaterly Inflation rate Euro Area**
- **20-year Breakeven Inflation Rate**

**Inflation effect**

- **Increase cost of debt** – The cost of debt will rise as the expected inflation rises, pushing up the risk-free rate and the default spreads.

- **Increase cost of equity** – Inflation will increase the risk-free rate, and the uncertainty about inflation will increase the equity risk premium, with the cost of equity rising for more riskier projects.

- **Decrease the willingness to invest** – Uncertainty about inflation will make it more difficult to justify large upfront investments

Sources: OECD, "Main Economic Indicators - complete database", Main Economic Indicators (database), http://dx.doi.org/10.1787/data-00052-en (Accessed on 08/16/2022)

Notes:
Lower capital costs help bring down weighted average cost of capital

Development in cost of capital for Western Europe (levered WACC pre-tax nominal) for selected industries\(^1\) from Jan-2015 to Jun-2022

Sources: Aswath Damodaran - www.damodaran.com/, Aegir insights
Notes: 1) Engineering/Construction, Green & Renewable Energy, Engineering/Construction, Oil/Gas (Production and Exploration) & Power. Debt share of 70% in 2015, 75% from 2016-2019 and 80% from 2020 in all years.
Raw material costs and shipping rates

Producer Price Index by type from 2015-2022, Index (Jan 2019 = 100), Monthly, Not Seasonally Adjusted

- Fabricated Steel Plate
- Iron and Steel
- Deep Sea Freight Transportation
- Copper and Copper Products

Notes:
Short term increase in LCOE due to inflation and rise in commodities

Effect on LCOE EUR/MWh\(^1\) from increasing WACC and raw materials

<table>
<thead>
<tr>
<th>Increase</th>
<th>Effect (EUR/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1% WACC</td>
<td>4.6</td>
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<tr>
<td>15% Capex</td>
<td>5.5</td>
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<tr>
<td>Shipping</td>
<td>0.4</td>
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<tr>
<td>Combined</td>
<td>10.8</td>
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</tbody>
</table>

Sources: Aegir Insights
Notes: 1) Real 2021, pre-tax 2) Shipping of monopiles and turbine components from Denmark to the Netherlands.
Offshore wind keep momentum and projected to grow 25% over the next decade

Offshore wind capacity built out

Sources: GWEC – 2022
Notes: 1) Including projects expected to be completed in 2022
Are we reaching the end for LCOE?

Criteria for offshore wind auctions

<table>
<thead>
<tr>
<th>Region</th>
<th>Country</th>
<th>Sustainability</th>
<th>Environmental impact</th>
<th>System Innovation &amp; integration</th>
<th>Local Content</th>
<th>Price</th>
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<tbody>
<tr>
<td>Asia</td>
<td>China</td>
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<td>EU</td>
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</table>

Sources: Aegir Insights, WindEurope
Notes:

● High Importance  ○ Low Importance
Experience
Aegir is founded by industry thought leaders having central roles in market development and investment analysis in Orsted and Vattenfall, covering offshore wind and PtX opportunities in global emerging markets

<table>
<thead>
<tr>
<th>Relevant expertise:</th>
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<th>Relevant expertise:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Strategic advisor to governments on market development of offshore wind and PtX</td>
<td>1. Advisor to developers on offshore wind promotion in emerging markets (e.g. GWEC)</td>
<td>1. Hydrogen and energy market policy</td>
</tr>
<tr>
<td>3. Project development and construction</td>
<td>3. Early-stage project assessment</td>
<td>3. Market strategy and general expertise in energy market dynamics</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Background:</th>
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<tbody>
<tr>
<td>• 19 years of energy sector experience spanning offshore wind, upstream oil and gas and investment banking</td>
<td>• 12 years of offshore wind experience covering development of large offshore wind projects and competitive bids in Orsted, and as Consultant for Copenhagen Infrastructure Partners, Bladt Industries and Stiesdal</td>
<td>• 10 years of energy sector experience covering technical valuation of offshore wind, market development and analysis, as well as energy policy and regulation in renewables and hydrogen</td>
</tr>
<tr>
<td>• Senior management positions in Orsted, Vattenfall and Stiesdal</td>
<td>• Commercial and project development expertise, as well as new technologies</td>
<td>• Senior advisor positions at the Danish Utility Regulator and the Danish Energy Association focusing on hydrogen and EU energy regulations</td>
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<tbody>
<tr>
<td>• Executive Education in Climate Policy, Economic Growth, Harvard Kennedy School of Government</td>
<td>• Executive courses in Climate Policy and Economic Growth, Harvard Kennedy School of Government</td>
<td>• Courses on European energy regulation and policy, Florence School of Regulation (European University Institute)</td>
</tr>
<tr>
<td>• LLM International Commercial Law, University of Edinburgh</td>
<td>• MSc in International Business, Copenhagen Business School / Indian Institute of Management Bangalore, India</td>
<td>• MSc, International Economic Consulting, Aarhus University, Denmark / Indian Institute of Management Calcutta, India</td>
</tr>
<tr>
<td>• MBA Finance, University of Calgary</td>
<td>• BSc in Business, Language and Culture, Copenhagen Business School / Queen’s School of Business, Canada</td>
<td>• BSc, Business Administration, Aarhus School of Business, Denmark / RMIT Melbourne, Australia</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Companies:</th>
<th>Companies:</th>
<th>Companies:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Orsted, Vattenfall, Stiesdal, Macquarie, Pengrowth</td>
<td>• Orsted, Treetop Partners, Novozymes</td>
<td>• Orsted, Vestas, Danish Utility Regulator, Danish Energy Association</td>
</tr>
</tbody>
</table>
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