The global future offshore wind – how to make offshore wind more cost efficient?

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Levelised cost of electricity for different technologies

The rapid cost reductions in the industry, have made offshore wind power competitive relative to conventional power generation based on fossil fuels.

EUR/MWh, 2018 prices, Northwest Europe

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Source: Bloomberg New Energy Finance – 2H 2018 LCOE Update, current LCOE.
Exchange rate EUR:USD: 0.88. YoY inflation 2017-2018: 1%.
Ørsted overview
Ørsted develops energy systems that are green, independent and economically viable

- Revenue (2018): DKK 76.9 bn (USD 11.6 bn)
- EBITDA (2018): DKK 30.0 bn (USD 4.5 bn)
- Credit Rating: Moody’s Baa1 (stable), S&P BBB+ (stable)
- 6,080 employees
- Active in Scandinavia, United Kingdom, Germany, The Netherlands, France, USA, Taiwan and Japan

**Offshore**
- Global leader in offshore wind with 5.6 GW operational capacity
- Develop, construct, own and operate offshore wind farms
- Significant and attractive build-out plan of 4.3 GW towards 2022
- Ambition of 15 GW installed offshore wind capacity by 2025

**Onshore and PV**
- US onshore wind portfolio with 813 MW operational capacity
- Develop, construct, own and operate onshore wind farms
- 522 MW under construction and a pipeline of more than 1.5 GW
- Energy storage solutions with the first 20 MW battery storage project in operation
- Solar: first large-scale solar PV project Permian Solar 400 MW
- Agreement to acquire the solar and storage development subsidiary of US-based Coronal Energy

**Bioenergy**
- #1 in Danish heat and power generation with 25% of market
- Converting heat and power plants from coal and gas to biomass
- Innovative waste-to-energy technology (Renescience)

**Customer Solutions**
- Develop green, innovative and cost efficient solutions for our B2B customers
- Provide competitive route-to-market for own and customers’ generation portfolio
- Optimize activities within natural gas
- Market trading operations to optimize hedging contracts

**Major Shareholders (voting share %)**
- Danish State 50%
- Seas NVE 10%
- Capital Group 5-10%
**Ørsted’s strategic playing field**
A purpose-driven, global, green energy leader

<table>
<thead>
<tr>
<th>Renewables generation</th>
<th>Storage</th>
<th>T&amp;D</th>
<th>Consumption</th>
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<tr>
<td>Offshore wind</td>
<td>Electricity storage</td>
<td>Electricity transmission and distribution</td>
<td>Wholesale</td>
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<td>Onshore wind</td>
<td>Power-to-gas</td>
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<td>Corporate customers</td>
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<td>Solar PV</td>
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<td>Residential customers</td>
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<td>Bioenergy</td>
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<td>Electric vehicles</td>
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- **Invest to grow**
- **Explore potential**
- **Exit**
- **No presence**
Significant transformation of Ørsted over the past decade

Green energy today accounts for 80% of our heat and power generation

**CO₂ emissions reduced by almost three quarters**  
- 2007: 462 g/kWh  
- 2018: 131 g/kWh  
- Reduction: 72%  

**Operating profit (EBITDA)**  
- 2007: 9.3 DKK bn  
- 2018: 15.0 DKK bn  
- Share of operating profit: 37%  

**Capital employed**  
- 2007: 57 DKK bn  
- 2018: 87% DKK bn  

**International expansion**  
- Share of operating profit (EBITDA): 12%  
- International share: 85%  

Note 1: Figures taken from Ørsted’s Annual Report 2018 and Capital Markets Day 2018  
Note 2: Excludes EBITDA contribution from new partnerships (EBITDA increased from USD 1.4 bn in 2007, to USD 2.3 bn in 2018)  
Note 3: Capital employed increased from USD 8.6 bn in 2007, to USD 12.5 bn in 2018
Ørsted strategic transformation

Green share of power generation ~99% in 2025, approximating zero emissions

Note 1: Figures taken from Ørsted’s Annual Report 2018
Ørsted pioneered the offshore wind power industry...

Ørsted cumulative constructed offshore wind power capacity, MW

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<tbody>
<tr>
<td>Capacity (MW)</td>
<td>5</td>
<td>50</td>
<td>476</td>
<td>1,004</td>
<td>1,371</td>
<td>2,098</td>
<td>2,487</td>
<td>3,009</td>
<td>3,849</td>
<td>5,602</td>
<td>7,583</td>
<td>9,870</td>
<td>12,874</td>
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<td>Pre-2009: Project by project</td>
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<td>Post-2009: Industrialised approach to planning and execution of offshore wind projects</td>
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Selected projects:

- **Vindeby**
  - First offshore wind farm in the world
  - Turbine capacity: 0.45 MW
  - Nr. of turbines: 11
  - Rotor diameter: 35 m
  - Distance to shore: 1.8 km

- **Horns Rev 1**
  - First large scale offshore wind farm in the world
  - Turbine capacity: 2 MW
  - Nr. of turbines: 80
  - Rotor diameter: 80 m
  - Distance to shore: 18 km

- **Walney Extension**
  - The largest operational offshore wind farm in the world
  - Turbine capacity: 7-8.25 MW
  - Nr. of turbines: 87
  - Rotor diameter: 154-164 m
  - Distance to shore: 19 km

- **Hornsea 1**
  - The world's largest offshore wind farm once constructed
  - Turbine capacity: 7 MW
  - Nr. of turbines: 174
  - Rotor diameter: 154 m
  - Distance to shore: 120 km

Ørsted pioneered the offshore wind power industry...
Ørsted Offshore overview

North America
- Bay State Wind
- Revolution Wind
- South Fork
- Block Island
- Ocean Wind
- Garden State
- Skipjack
- Coastal Virginia

Europe
- Walney Extension
- Walney 1 & 2
- Isle of Man
- Barrow
- Burbo Bank Ext.
- Burbo Bank

Asia Pacific
- Formosa 1
- Formosa 1.2
- Changhua 1 & 2a
- Changhua 2b, 3, 4

In operation
- West of Duddon Sands
- Hornsea 3
- Hornsea 1
- Hornsea 2
- Race Bank
- Anholt
- Vindelby
- Nysted
- Gode Wind 1
- Gode Wind 2
- Gode Wind 4
- Gode Wind 3
- Gode Wind 1
- Borkum Riffgrund 1
- Borkum Riffgrund 2
- Borkum Riffgrund West 1&2
- OWP West

Under construction
- London Array
- Gunfleet Sands 1 & 2
- Gunfleet Sands 3
- Hornsea 3 & 4
- Hornsea 1 & 2
- Race Bank
- Hornsea 1 & 2
- Anholt
- Vindelby
- Nysted
- Gode Wind 1
- Gode Wind 2
- Gode Wind 4
- Gode Wind 3
- Gode Wind 1
- Borkum Riffgrund 1
- Borkum Riffgrund 2
- Borkum Riffgrund West 1&2
- OWP West

Under development
- Coastal Virginia

Decommissioned after 25 years
- Coastal Virginia

Note 1: In addition to these wind farms, Ørsted is constructing the 12 MW Coastal Virginia demonstration project in the US on behalf of Dominion Energy. Further Ørsted has a 35% share in Formosa 1 in Taiwan.
Overview of Ørsted’s global partnerships
Ørsted has a long standing and proven track record in developing successful partnerships

**European partnerships**¹

- **United Kingdom**
  - Walney Extension (50%)
    - 659 MW (2017)
  - Walney 1 & 2 (50.1%)
  - West Duddon Sands (50%)
    - 389 MW (2010)
  - Gunfleet Sands (50.1%)
    - 173 MW (2016)
  - Burbo Bank Extension (50%)
    - 258 MW (2016)
  - Lincs (25%)
    - 270 MW (2017 / 2018)

- **Denmark**
  - Race Bank (50%)
    - 573 MW (2016)
  - Horns Rev 1 (50%)
    - 104 MW (2006)
  - Anholt (50%)
    - 400 MW (2011)
  - Nysted (42.7%)
    - 166 MW (2010)
  - Gode Wind 2 (50%)
    - 263 MW (2014)
  - Gode Wind 1 (50%)
    - 344 MW (2015)
  - Borkum Riffgrund 1 (50%)
    - 312 MW (2012)
  - Borkum Riffgrund 2 (50%)
    - 465 MW (2017)

- **Germany**
  - London Array (25%)
    - 630 MW (2009 / 2014)
  - Burbo Bank Extension (50%)
    - 258 MW (2016)

- **Taiwan**
  - Formosa 1 (35%)
    - 128 MW (2016 / 2018)

- **United States**
  - Revolution Wind (50%)
    - 704 MW (2019)

**North American partnerships**¹

- **United States**
  - Garden State (50%)
    - 800 MW (2018)
  - South Fork (50%)
    - 130 MW (2019)
  - Bay State Wind (50%)
    - 800 MW (2016)

**Asia Pacific partnerships**¹

- **Japan**
  - Formosa 1 (35%)
    - 128 MW (2016 / 2018)

**Note 1:** The percentage in brackets represents Ørsted ownership interest and year when the partnership was created.

**Note 2:** In 2017 Ørsted and Dominion Energy entered into a strategic partnership in which Ørsted will construct two 6-megawatt turbines off the coast of Virginia Beach.
By 2030 offshore wind power will be truly global...
Strong growth in established and new offshore wind power markets

Installed capacity, GW

Offshore wind capacity with firm political commitment

Targets in existing footprint markets
- The UK government has a CfD roadmap with bi-yearly auctions of 2-4GW towards 2030 to reach 30GW
- Target of 15GW offshore wind by 2030
- Offshore Wind Energy Roadmap 2030 outlines 11.5GW by 2030 through 1GW per year post 2023
- MA 2027 (2033) target: 1.6 (3.2) GW. VA 2028 target: 2.0GW
- NI 2030 target: 3.5GW. NY 2030 (2035) target: 2.4 (9.0) GW. MD 1.5 GW (requiring COD by 2030)
- CT 2.0 GW target (no terminal date provided) additive to the capacity already procured (~0.5GW)
- Current 2025 target of 5.5GW already been reached through grid allocation and price auction
- Outlined plan for three 800MW (2.4GW) offshore wind projects before 2030 by the Danish Government leading to a total of 5GW in 2030
- Authorities of Belgium have announced plans for offshore wind targets of 2.2GW by 2020 and 4GW by 2030

Targets in next horizon markets
- 2030 target of 10GW for wind power (inc. onshore). New legislation in 2018 to develop offshore wind. Ørsted/TEPCO partnership in 2019
- The Indian government has target of 5GW before 2022 and 30GW by 2030
- The South Korean government has a total wind target of 18GW by 2030 of which 13GW is allocated to offshore wind
- France has a 2023 target of 3GW installed and 6GW in the pipeline post 2024
- Polish government released draft New Energy Plan setting out offshore wind targets of 5GW by 2030, 6GW by 2035 and 10.3GW by 2040

Note 1: Firm political commitment is defined by a country’s public offshore wind target by 2025/2030

Source: Bloomberg New Energy Finance (BNEF), 2H 2018 offshore wind market outlook
A strong integrated end-to-end business model

- **Develop**
  - Identify and mature projects
- **Build**
  - Manage construction, sourcing and supply
- **Operate**
  - Conduct life-cycle maintenance
- **Own**
  - M&A, attract capital through partnerships, asset management

- Full-time employees:
  - ~2,450

- Ability to **design and optimise** projects with a ‘total life-cycle cost of wind farm’ mindset
- Experience and expertise along the entire value chain allow for better understanding and management of risks
- End-to-end model reduces LCoE through **fast** feedback and **learning** across the entire organisation

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**Full-time employees**

<table>
<thead>
<tr>
<th>Company</th>
<th>Employees</th>
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<tbody>
<tr>
<td>Northland Power</td>
<td>40</td>
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<tr>
<td>Equinor</td>
<td>70</td>
</tr>
<tr>
<td>CIP</td>
<td>75</td>
</tr>
<tr>
<td>SSE</td>
<td>100</td>
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<tr>
<td>WPD</td>
<td>160</td>
</tr>
<tr>
<td>Innogy</td>
<td>250</td>
</tr>
<tr>
<td>E.ON Vattenfall</td>
<td>250</td>
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<tr>
<td>Osted</td>
<td>650</td>
</tr>
<tr>
<td>Total</td>
<td>2,450</td>
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O&M strategy

Scale in geographic centres

- Operational offshore wind farms
- Offshore wind farms under construction
- Cluster

1. **UK West coast (East Irish Sea):** Barrow, Burbo Bank, Burbo Bank Extension, West of Duddon Sands, Walney 1, Walney 2, Walney Extension
2. **East UK North:** Westermost Rough, Lincs, Race Bank, Hornsea 1, Hornsea 2
3. **East UK South:** London Array 1, Gunfleet Sands 1, Gunfleet Sands 2, Gunfleet Sands 3
4. **Germany:** Borkum Riffgrund 1, Borkum Riffgrund 2, Gode Wind 1, Gode Wind 2
5. **Danish waters 2:** Anholt, Avedøre, Nysted, Horns Rev 2
6. **Dutch waters:** Borssele 1 & 2

**Synergies**
- Lower logistics costs
- Fewer technician hours
- Fewer facilities needed
- Lower inventory levels

**Notes:**
1. London Array is operated by London Array Limited
2. Horns Rev 1 is operated by Vattenfall however owned 40% by Ørsted
Ørsted U.S. Offshore Wind

Ørsted U.S. offshore wind portfolio

Unique position with large adjacent projects

In operation
- **Block Island (30 MW)** operational since December 2016. 20-year PPA, starting price USD 236/MWh and 3.5%

Under construction
- **Coastal Virginia Offshore Wind** 12MW (EPC contract)

Awarded
- **South Fork (130 MW)** COD expected in 2022. 20-year PPA with LIPA
- **Skipjack (120 MW)** COD expected in 2022. 20-year OREC contract, starting price USD 171/MWh and 1% price escalator
- **Revolution Wind (704 MW)** COD expected in 2023. 400 MW long-term PPA with National Grid approved by Rhode Island Regulators. Connecticut separately selected 300 MW from Revolution Wind to power that state (a PPA for 100 MW is currently under negotiation)

Projects under development
- **Bay State Wind** up to 2 GW
- **Ocean Wind** up to 3.5 GW
- **Garden State** up to 800 MW off the coast of Delaware / New Jersey
- **Revolution Wind** up to 1.2 GW in Massachusetts adjacent to Revolution Wind and Bay State Wind

Note 1: in 2017 Ørsted and Dominion Energy entered into a strategic partnership in which Ørsted will construct two 6-megawatt turbines off the coast of Virginia.
Innovation as key to lowering cost of energy...

- Optimised methods for foundation design
- Implementing installation concepts
- Front runners in maturing the supply chain for offshore wind power
- Extensive collaboration with universities and research institutions globally
- Digitalization concepts, applications and processes
- Risk aware on new wind turbine technology
Making offshore wind energy even more cost competitive
Multiple levers to drive down cost in offshore wind power

1. Scale
   - Turbines and rotor size
   - Lease areas
   - Vessel size
   - Cable capacity

2. Innovation
   - Foundation design
   - Electrical systems
   - Windfarm layout
   - Optimized installation methods

3. Industrialisation
   - Transition from single supply to multiple global suppliers
   - Long-term target based collaboration with key suppliers

Rapid technological development
Wind turbine rotor diameter, year of commissioning

Boeing 747, 76m
80 m 90 m 107 m 120 m 154 m 164 m 220 m

1. In Mar. 2018 GE unveiled a 12 MW turbine. Each Haliade-X unit will be capable of powering 16,000 homes and producing 67 GWh per year, based on wind conditions on a typical German North Sea site.