Introduction to Offshore Wind – Development, Construction and Operations
Sophie Hartfield Lewis

Agenda
• Introduction to Orsted
• What we do
• Development
• Execution
• Operations
• Challenges/Opportunities
• Strategic Working
Ørsted develops energy systems that are green, independent and economically viable

- Revenue (2017): DKK 59.5bn
- EBITDA (2017): DKK 22.5bn
- 5,638 employees
- Active in Scandinavia, United Kingdom, Germany, The Netherlands, USA and Taiwan

Offshore wind
- Global leader in offshore wind with 5.1 GW installed
- Develop, construct, own and operate offshore wind farms
- Significant and attractive build-out plan of 3.8 GW towards 2022
- Ambition of 11-12 GW installed offshore wind capacity by 2025

Onshore wind
- US onshore wind portfolio with 513 MW
- Develop, construct, own and operate onshore wind farms
- 300MW under construction and a pipeline of more than 1.5GW
- Highly experienced and successful team

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)
- Energy storage solutions

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 10%

Process to divest Distribution and Residential Customer business has been initiated
Love your Home
Unparalleled experience and track record

25+ years of experience and track record in the offshore wind power sector

1991

2018

24 offshore wind farms in operation

6 offshore wind farms under construction

5.1 GW Constructed capacity

~ 2,300 Dedicated employees

3.8 GW under construction

14 million people with clean electricity

~ 1,100 turbines World’s leading operator

20 Partnerships

Global footprint

North America

- Bay State Wind Constitution Wind
- Ocean Wind Coastal Virginia

Europe

- West of Duddon Sands
- Walney Extension
- Walney 1 & 2
- Isle of Man
- Barrow
- Burbo Bank Ext.
- Burbo Bank
- Lincs
- Gunfleet Sands 1 & 2
- Gunfleet Sands 3
- London Array
- Borssele 1 & 2
- Horns Rev 1 & 2
- Hornsea 1
- Hornsea 2
- Hornsea 3 & 4
- Race Bank
- Gode Wind 1
- Gode Wind 2
- Gode Wind 3
- Gode Wind 4
- Gode Wind 5
- Borkum Riffgrund 1
- Borkum Riffgrund 2
- Borkum Riffgrund West 1 & 2
- OWP West
- Anholt
- Middelgrunden
- Avedøre
- Vindeby
- Nysted

Asia Pacific

- Formosa 1.1
- Formosa 1.2
- Greater Changhua projects

- Avedøre
- Taipei office

In operation

Under construction

Under development

Decommissioned after 25 years

Ørsted Offshore Wind Power overview

Coastal Virginia

Boston office

North America

Bay State Wind Constitution Wind

Ocean Wind Coastal Virginia

Europe

West of Duddon Sands

Walney Extension

Walney 1 & 2

Isle of Man

Barrow

Burbo Bank Ext.

Burbo Bank

Lincs

Gunfleet Sands 1 & 2

Gunfleet Sands 3

London Array

Borssele 1 & 2

Horns Rev 1 & 2

Hornsea 1

Hornsea 2

Hornsea 3 & 4

Race Bank

Gode Wind 1

Gode Wind 2

Gode Wind 3

Gode Wind 4

Gode Wind 5

Borkum Riffgrund 1

Borkum Riffgrund 2

Borkum Riffgrund West 1 & 2

OWP West

Anholt

Middelgrunden

Avedøre

Vindeby

Nysted

Asia Pacific

Formosa 1.1

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Greater Changhua projects

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20 Partnerships
Ørsted acquired Deepwater Wind and creates leading US offshore wind platform

Attractive portfolio with significant synergy potential

- Two companies’ offshore wind assets and organisations will be merged into the leading US offshore wind platform “Ørsted US Offshore Wind”
- Merger will combine Deepwater Wind’s expertise in originating, developing and permitting in the US with Ørsted’s leading global engineering, construction and O&M capabilities
- Healthy value creation spread on top of our cost of capital – significant additional strategic upside
- Acquiring 100% at a purchase price of USD 510 million
- Current portfolio of 30MW in operation, 810MW capacity with PPAs secured or under negotiation and approx. 2.5GW of development capacity

Deepwater portfolio at a glance

Attractive, geographically diverse, and timing compatibility portfolio of offshore wind assets along US East Coast which offers significant synergy potential

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

- **South Fork (90MW):** COD expected in 2022. 20-year PPA with LIPA

- **Skipjack (120MW):** COD expected in 2022. 20-year OREC contract, starting price USD 171/MWh and 1% price escalator

- **Revolution Wind (600MW):** COD expected in 2023. Long-term PPAs currently under negotiation in Rhode Island (400MW) and Connecticut (200MW)

- **Approx. 2.5GW of development capacity:**
  - 1.3GW in Massachusetts adjacent to Revolution Wind and Bay State Wind
  - 1.2GW in Garden State Offshore Energy, a 50/50 joint venture with PSEG off the coast of Delaware and New Jersey

Portfolio compatibility Ørsted & Deepwater Wind

Note 1: Transaction is subject to clearance by the US competition authorities and expected to close by end of 2018
In November 2018, Ørsted entered into an agreement to acquire Lincoln Clean Energy to enter the U.S. onshore wind market\(^1\)

**Acquisition highlights**

- Investment case with healthy economics based on prudent assumptions about key value drivers and market developments
- Transaction in line with strategy to pursue value creating growth opportunities in other green energy technologies
- Acquiring 100% of equity placing an enterprise value on LCE at USD 580 million \(^2\)
- Recently commissioned portfolio of 513MW, 300MW under construction and a pipeline of more than 1.5GW to be completed by 2022
- US onshore wind market has significant long-term growth potential and expands our presence in a key growth market
- Highly experienced and successful team to execute Ørsted’s long-term US onshore wind growth strategy
- Ørsted to add value with financing, execution and procurement capabilities

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Note 1: The transaction is subject to approval by the US competition authorities and is expected to close prior to the end of 2018
Note 2: End of 2018 value
Ørsted pioneered the offshore wind industry

Unrivalled track-record in offshore wind
Ørsted cumulative constructed offshore wind power capacity (MW)

Pre-2009: Project by project
Post-2009: Industrialised approach to planning and execution of offshore wind projects

Selected projects

**Vindeby**
First offshore wind farm in the world

- Turbine capacity: 5 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

Note 1: Ørsted will, in accordance with the Dutch tender regulation, build Borssele 1 and 2 within four years from August 2016 with a flexibility of 1 year

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Ørsted Environment, Consents and Property Team
Supporting Projects Cradle to Grave

Project Development
- Site Selection & Feasibility
- Developing a Consenting Strategy
- EIA & Environmental Surveys
- Secure all permits and approvals

Project Execution
- Consent compliance
- Manage discharge of consent conditions
- New consent applications and variations

Operations
- Consent compliance
- Environmental monitoring
- New consent applications / variations
- Decommissioning

Consenting Authority Contact & Management

Environmental & Planning Law

Stakeholder Management & Negotiation

Managing biological & human environment experts

Internal interface, budgeting, risk management and reporting

Due Diligence

Environmental Impact Assessment → Consent Compliance → Environmental Monitoring = Legal compliance

Environmental Management
Offshore Wind Timescales

- Environmental Impact Assessment and Main Consent Application
- Onshore Cables
- Onshore Substation
- Offshore Substation
- Foundations
- Offshore Cables
- Wind Turbines

2-4 years

12-24 months Construction

25 years plus O&M
Development
Potential Environmental Impacts to be considered – environment:

- Designations
- Conservation value
- Marine mammals
- Air Emissions
- Benthos
- Fish & Shellfish
- Bathymetry
- Archaeology
- Coastal processes
- Bats & Birds

Potential Environmental Impacts to be considered – social:

- Local Impact Assessment
- Commercial & Sport Fisheries
- Shipping and navigation
- Archaeology
- Leisure and Tourism
- Visual impacts
- Supply chain

Potential Environmental Impacts to be considered – other infrastructure:

- OWFs
- Aggregates
- Cables and Pipelines
- Ports and Navigational Dredging
- Disposal Sites
- General Obstructions
- Carbon Capture and Storage
- Aquaculture
Onshore Works: Planning

▪ Preliminary surveys, identification of
  - Major obstacles
  - Landowners
  - Protected areas
  - Need for horizontal directional drilling

▪ Geotechnical surveys of soil conditions

▪ Drawing of cable route, based on
  - Geotechnics
  - Access to cable site
  - Construction logistics
  - Minimal disruption to public life, transport etc.
  - Minimal environmental impact

▪ Acquisition of permits
  - Permanent permits for cable and substation sites
  - Temporary permits for construction areas

• UK Evolution
  - previous cable routes onshore 5-10km now looking at 50km.
Submission

Hornsea Project One – 176 Documents
Hornsea Project Two – 181 Documents
Dogger Bank Creyke Beck – 182 Documents
East Anglia Three – 295 Documents
Hornsea Project Three – 183 Documents

All 1GW plus Projects
Construction
Construction Planning

- Geotechnical and Geophysical Surveys
- Rehearsal of Concept Drill
- Multimillion Euro contracts
- Strict deadlines

Flexibility

Consideration of Linked Activities

No Unplanned Delays
Onshore Substation Installation

- Pre-manufactured electrical equipment is transported to substation site
- Construction of buildings
- Testing of HV equipment commences, incl. safety tests
- Apart from substation sites, the land is reinstated and returned to previous users
Onshore/Intertidal Cable Installation in Europe

- Work area is fenced and wildlife is moved off site
- Top soil is removed and surface is prepared for temporary structure
- Cable laying begins, combination of different methods to minimise disruption
  - Open trenches
  - Horizontal directional drilling (eg under roads/railways)
  - Installation of ducts (tubes to contain future cables)
- Cables are subsequently pulled through, typically 1km at a time.
Offshore Substation Installation

- Often first component installed on site
- Jacket floated to site on barge
- Jacket lifted off barge and lowered to seabed
- Piles placed onto sea bed and then piles are driven into seabed
- Pile/jacket connections are grouted
- Using a single lift, topside is lifted off barge and lowered into position on top of jacket interface
Monopile and Transition Piece Installation
Impacts and Mitigation – Hornsea Project One
Offshore Array Cables

Transfers electricity from turbines to offshore substation

First pull-in:
- Cable is connected to pre-installed messenger wire at the OSS/turbine foundation’s cable entry hole
- Pulled in from top of transition piece.

Surface laying:
- Cable is rolled out and laid on surface/in trench.
- If laid on surface, will be buried

Second pull-in:
- Cable is cut on ship and attached to foundation messenger wire
- To ensure cable is not bent beyond tolerance, a special quadrant (semicircle-shaped cable holder) is lowered below sea level during pull-in from foundation.

Offshore Export Cable

Transferring high-voltage electricity from the OSS to the transition joint bay (TJB)

Offshore Substation pull-in:
- Use of quadrant and messenger wire as w/ array cables

Depending on cable length, cables may have to be jointed at sea

Crossings of pipelines and other subsea cables are often necessary
- Protection layer of rocks is laid on top of existing cable, and on top of export cable once laid

Variety of Burial Methods:

Pre-trenching: separate operation to cut/dig trench
- Backfilled after operation or naturally backfilled by ocean currents

Simultaneous burial
- Use of special plough to cut groove and lay cable underground
- Cable is brought into groove from plough head

Post-lay burial
- Trencher (jetting or cutting) fluidize the soil on one or both sides of cable and cable sinks into the seabed
- Progress rate depending on soil type and strength
- Cable Protection
Wind Turbine Installation

- Once foundation and transition piece has been installed, wind turbine components are loaded onto vessel.
  - A modern installation vessel can carry up to 8 turbines at a time.
- Vessel ‘jacks up’ and then using the installation vessel’s crane, the turbine is installed piece-wise:
  - Turbine tower
  - Nacelle (houses electrical components and generator)
  - Blades
- Installation follows the sequence of cable and foundation installation to get the turbines energised and generating electricity as soon as possible.
Burbo Bank Extension Installation
Operations and Maintenance
Current UK O&M Portfolio

384 WTGs
1.85 GW

West of Duddon Sands
Walney 1&2
Barrow
Burbo Bank
Burbo Extension
Walney Extension

251 WTGs
1.2 GW

Westermost Rough
Gunfleet Sands 1/2/3
Race Bank
Lincs
Coming soon… Hornsea Project One
Inspection Activities

- Foundations, eg
  - Structure integrity
  - Weld anomalies
  - Steel corrosion
  - Paint damage
  - Occasional subsea inspection and inspection in confined space of foundation

- Blades
  - Use of high-quality camera equipment from turbine platform
  - Use of drones

- Export and Array Cables
  - Remote temperature monitoring along complete cable
  - Subsea inspections
Bird Guano

– Controlling the levels of guano was critical from a **health and safety perspective** to allow the site technicians to safely access turbines and carry out inspections and repairs.

– Solution:

– Deep clean (rather than ad hoc), then deployment of full mitigations – bird perches and snow fencing.
Potential Challenges for US?

• Shifting Regulatory Landscape
• Resourcing/Experience
• Consistency
• Potential lack of awareness of “solved issues” – eg EMF
• Lowering the Cost of Energy

• Further Offshore & Lowering the Cost of Energy
• Supply Chain Bottlenecks
• Grid connection constraints
• Limited choice of contractors/suppliers
• Health and Safety
• O&M Strategies
• Still a “young” industry
Opportunities - Environmental Skills required for Offshore Wind

Oceanographers
Statisticians
Metocean specialists
Ecologists
Economists
Traffic & Transport

Planning / Legal Support
PR / Communications
Environmental Impact Assessors
Marine Geologists
Marine Biologists
Ornithology & Marine Mammals Surveyors
Archaeologists
Acoustic Experts
Navigation Experts – Master Mariners
Aviation Experts / Pilots
Computer Graphics / Modellers
Health & Safety
IT / Data Management / GIS Operatives
Logistics Operations

Study sees 260% growth in UK offshore wind jobs by 2032, severe competition for talent

November 5 (Renewables News) - The UK offshore wind industry, which could add nearly 20 GW of capacity by 2032, is expected to face intense competition for skilled talent, a study by Energy & Utility Skills reveals.

Commissioned by the University of Hull’s Aura initiative and Green Port Hull, the study analyses a pipeline of 65 inerrer or planned offshore wind projects. It says the country could reach an installed offshore wind capacity of 35 GW by 2032, up from 6.4 GW operational in 2017, under an “ambitious, yet credible” scenario. Currently there are 8.1 GW under construction, 8.5 GW consented and 12.1 GW being planned.

A likely three-fold increase in the number of operational offshore wind turbines is to result in significant employment growth compared to current levels. According to the study, direct employment in the sector could jump to 36,000 jobs in 2022 from 10,000 in 2017.

Most of the new wind capacity is expected to occur in the North Sea and much of the employment growth will also be there. Estimates of capacity additions and jobs growth for the top offshore wind expansion regions in the UK are available in the table below, as presented in the “Skills and Labour Requirements of the UK Offshore Wind Industry” study.

The Baltic offshore wind park. Source: EDF Energy (www.edfenergy.com)
Map of all the Strategic working groups

ORJIP ➔ DEPONS ➔ SNSOWF ➔ OWPB ➔ OWSMRF

WOW03/04 Community Benefit fund ➔ Bird tagging – Hornsea One ➔ Seal tagging – Race Bank ➔ Westermost Rough – Lobster and Crab Monitoring ➔ HFIG
Where should I build my offshore wind farm?
What to look for when choosing the location for an offshore wind farm

**Things we like**

- Grid connection close to landfall
- Stable and sandy sea-bed
- Large capacity regional ports in the area
- Windier the better!
- Shallow seas (20-50 m)
- Big area to power more homes

**Things we try to avoid**

- Environmental considerations - birds and marine animals
- Oil and gas activities
- Shipping lanes
- Uneven sea bed
Where should I locate my offshore wind farm?

**Zone 1**
- Very high wind speeds
- Average water depth 30-40 m, although deep pits in areas
- Sandy/rocky sea bed
- 100 km from shore
- Small area
- Large port located nearby
- Rare bird species nesting in the local area

**Zone 2**
- Medium wind speeds
- Average water depth 25-30 m
- Sandy sea bed
- 25 km from shore
- Medium area
- National grid substation located close to the coast
- Oil and gas activities
- Area is used for fishing

**Zone 3**
- Low/medium wind speeds
- Average water depth 30 m
- 16 km from shore
- Sandy sea bed
- Large area
- Major shipping route passes through the western section of the zone
- Visible from the coast
Our three potential zones