Offshore Wind: Current Status and Future Outlook

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Biography

- BSc in Physics from the University of Glasgow, **2011**
- Graduate consultant at Aquatera, **2011 - 2012**
- EngD jointly awarded by Universities of Edinburgh, Exeter and Strathclyde, **2017**
  - Industrial collaboration with Tidal Energy Ltd.
- R&D manager at Tocardo, a Dutch tidal turbine developer, **2016 - 2018**
- Research fellow at the University of Exeter, focusing on floating wind, **2018 - present**

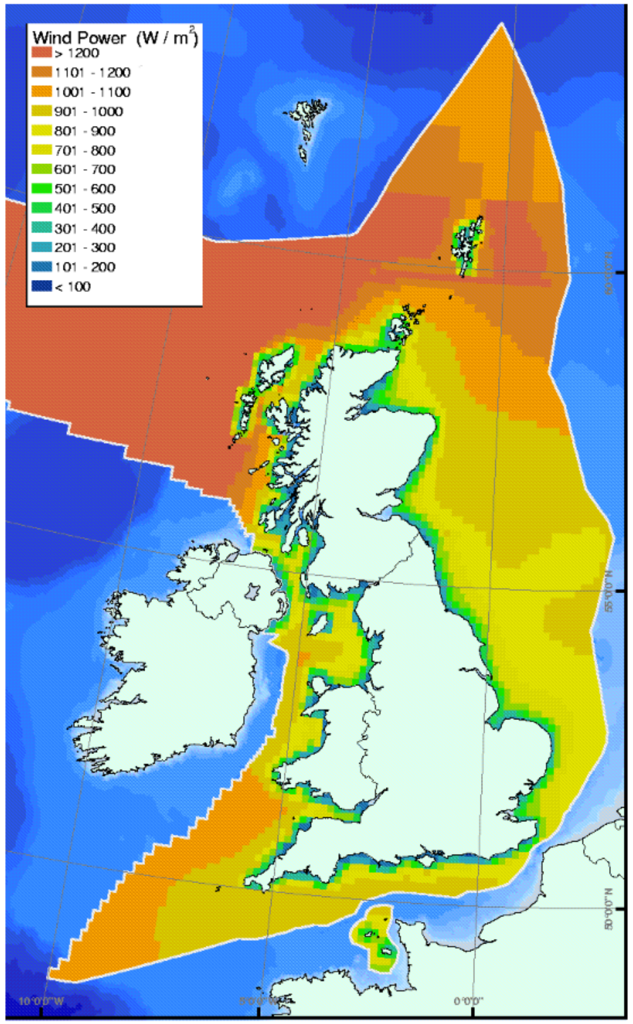
Outline

- **Offshore Wind**
  - The Opportunity
  - The Challenge
  - State-of-the-Art
  - Floating Wind
  - Outlook

Offshore Wind

- **The Opportunity**

- Better wind speeds found offshore
  - Stronger, more consistent and less turbulent
  - Improved power capture
  - Higher capacity factors
  - Better timing with demand (wind generally strongest in the afternoon)

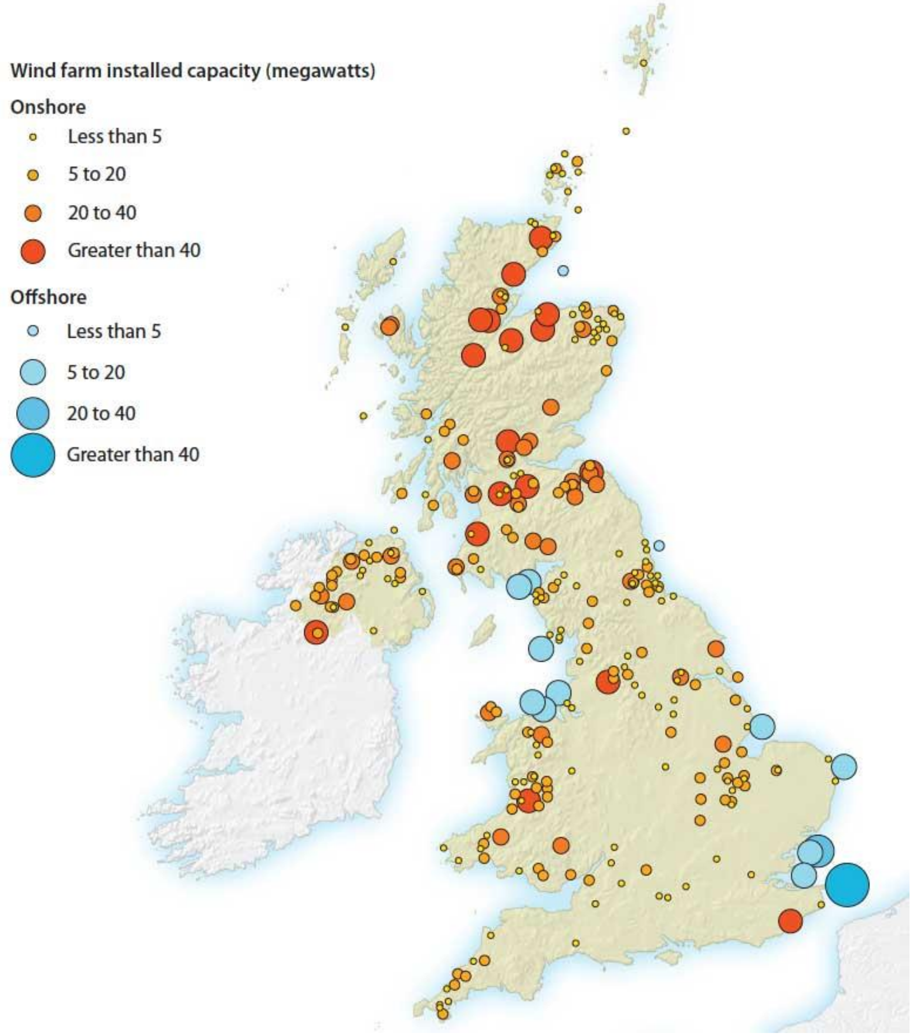


Offshore Wind

- The Opportunity

- A largely untapped resource
  - UK has the greatest offshore wind resource in Europe
  - UK Offshore wind potential: 25 GW by 2030
  - Current UK wind capacity : 20 GW (12 GW onshore, 8 GW offshore)

- High public support
  - 83% in favour of offshore wind*
  - Fewer NIMBY, noise, shadow issues



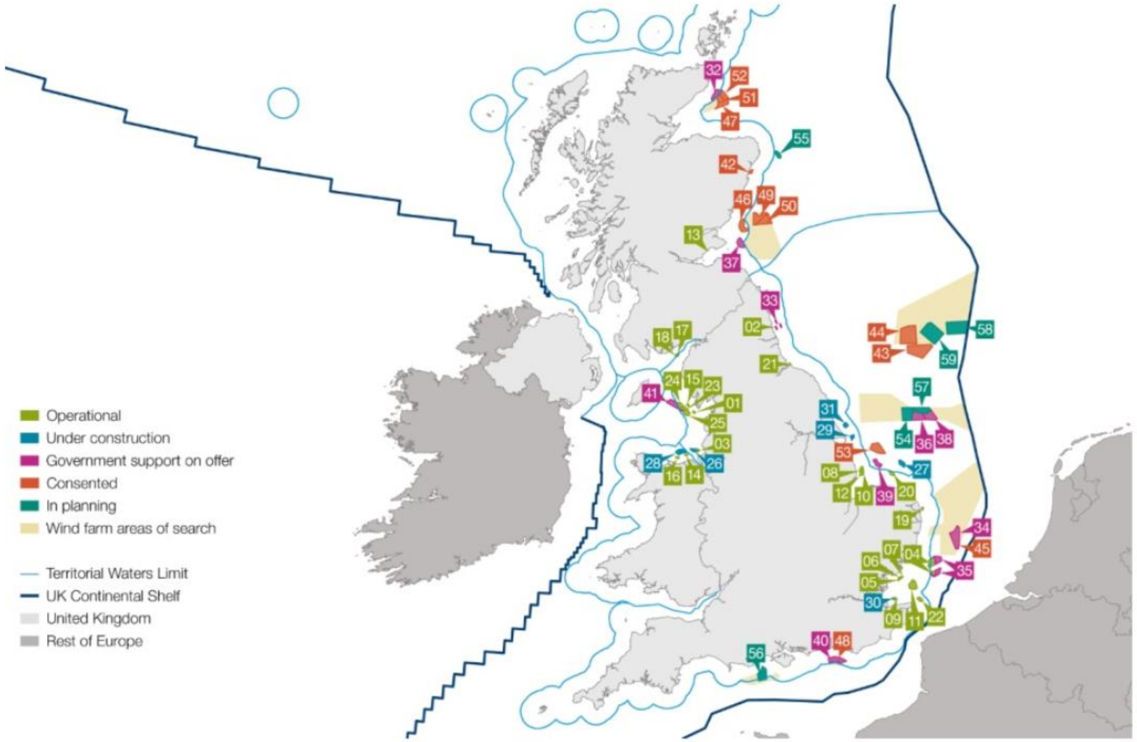
*UK Government's Energy & Climate Change Public Attitudes Tracker

Offshore Wind

- The Opportunity

- Turbines can be located closer to mass population centres
  - Populations often develop on coastlines
  - London array: 630 MW located 20 km off the Kent coast
  - Many suitable onshore sites undeveloped due to remoteness

Offshore wind (UK) map – May 2015



(c) Crown Estate

Offshore Wind

- The Challenge

- More environmental design considerations
  - Higher wind speeds
  - Waves
  - Tides
  - 1:100 year storm conditions

- Turbines subject to increased fatigue and ultimate loading
  - Cost implications

Offshore Wind

- The Challenge

- Installation and maintenance are both expensive and time intensive
  - Large vessel, e.g. jack-up, day rates £10k - >£100k
  - Lightweight vessels still required for trivial maintenance
  - All vessel operations limited by weather conditions

- Longer maintenance periods lead to reduced availability/power production

Offshore Wind

- The Challenge

- New stakeholder challenges
  - Exclusion zones for marine traffic and fishing industries during construction phase
  - Unknown environmental impacts:
    - Fish
    - Marine mammals
    - Birds
    - Seabed
  - Some public opposition still exists on ‘eyesores’ to coastlines

Offshore Wind

- State-of-the-Art

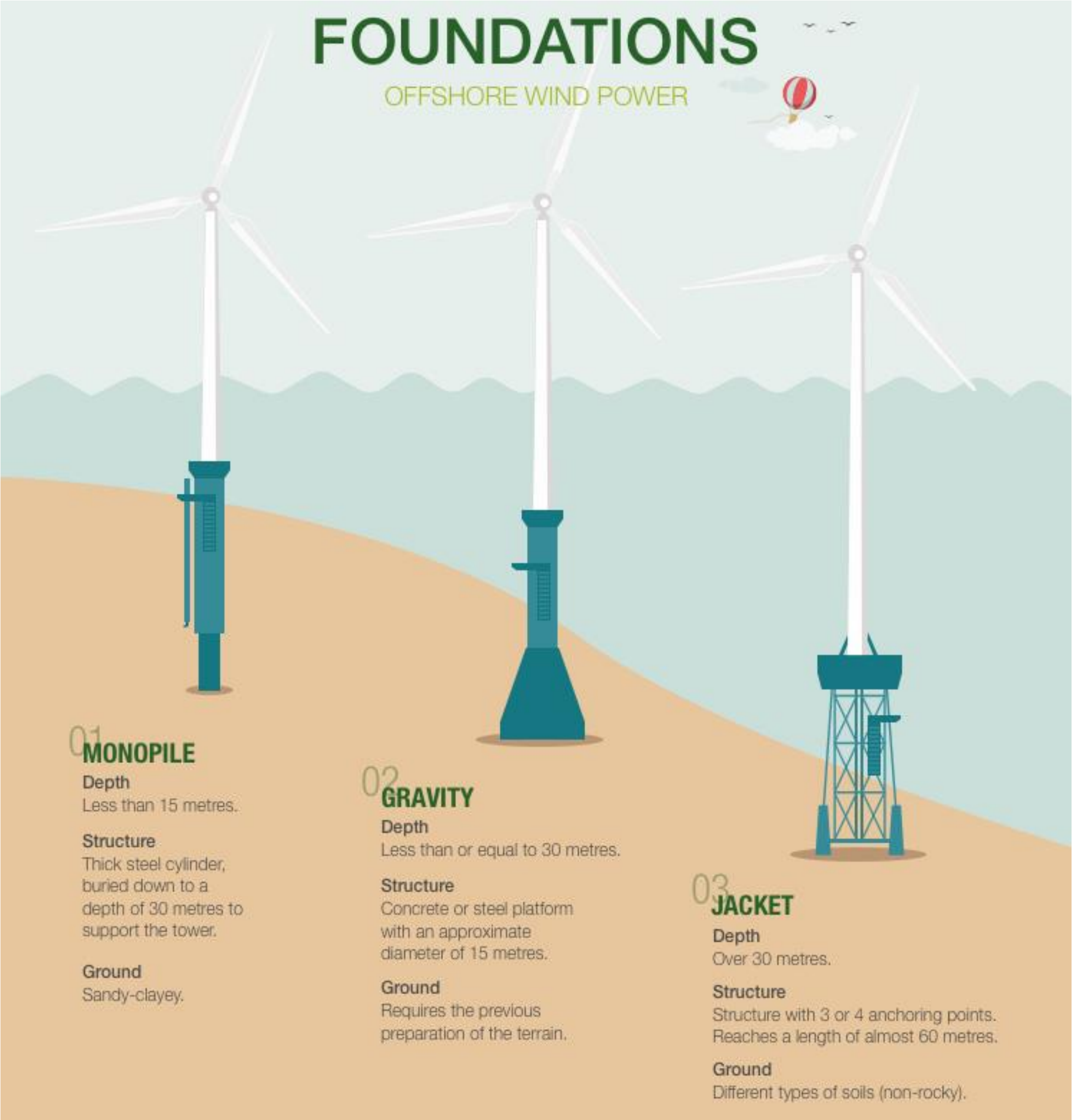
- Turbine size and power output considerably greater than onshore
  - Largest offshore: 8 MW
  - Largest onshore: ~4 MW

- 13 – 15 MW targeted offshore by 2025

Offshore Wind

- State-of-the-Art

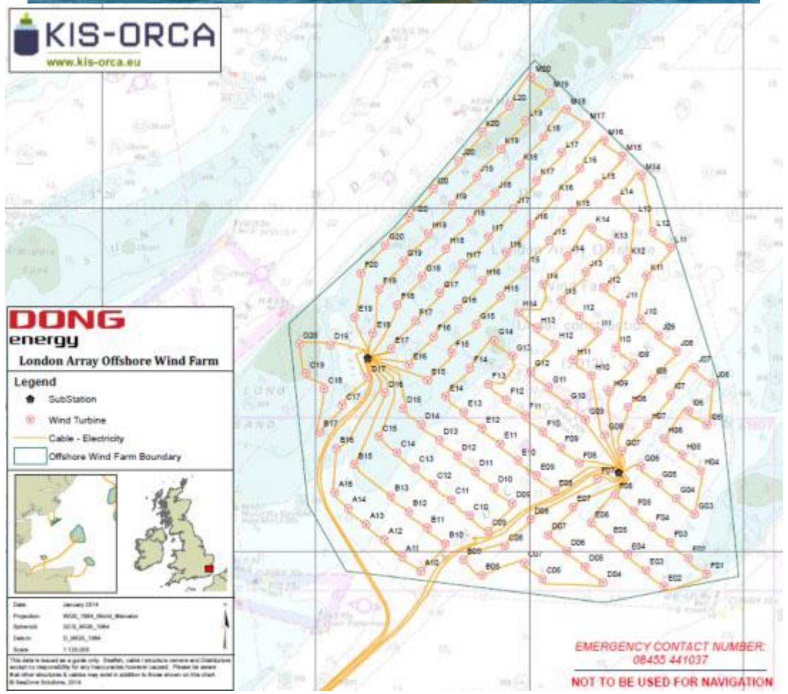
- Turbine foundation types comparable to those used in O&G industry
- Foundation selection primarily dictated by depth
- Monopiles currently account for >80% of installations
  - Reflection of the fact that most installations have taken place in shallow waters



Offshore Wind

- State-of-the-Art

- Offshore substations used to reduce the overall project cable length required
    - Reduces cabling costs (typically £100 per metre)
    - Substation steps-up the transmission voltage, leading to lower power losses
    - Can be equipped with boat landings, helicopter deck, accommodation to house offshore personnel



Offshore Wind

- State-of-the-Art

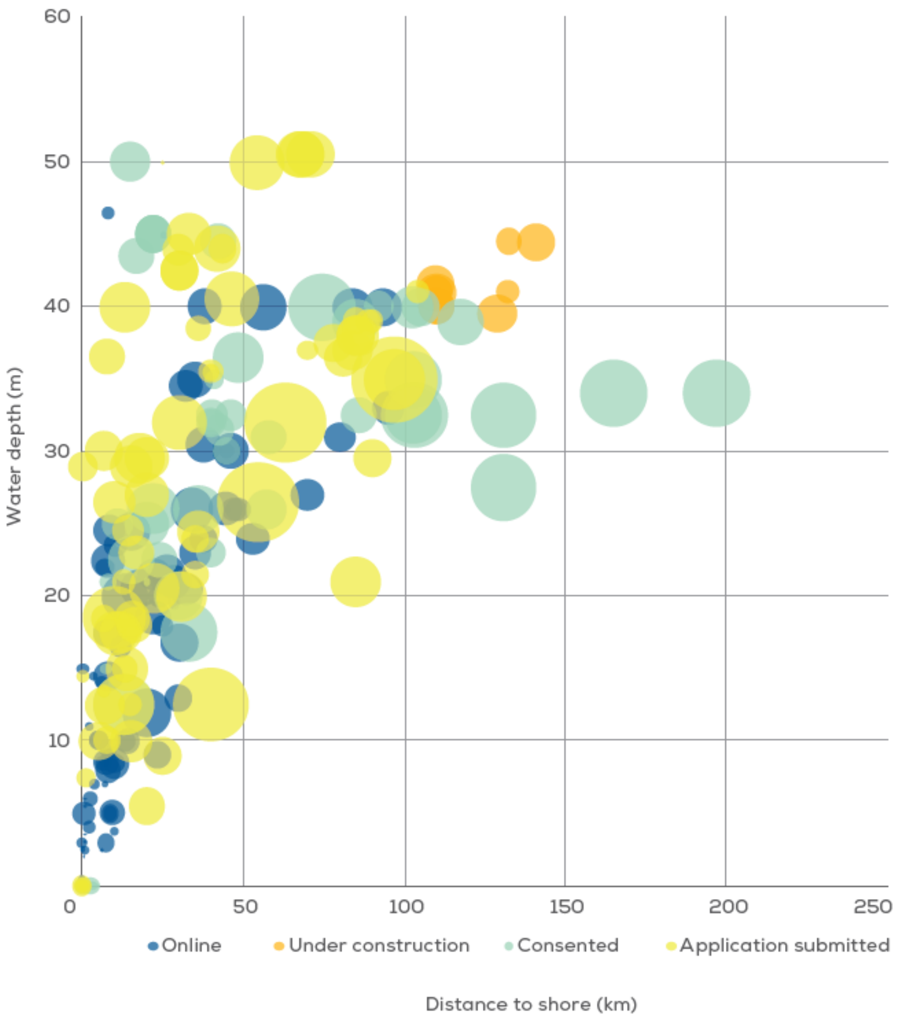
- Walney Extension off the Cumbria coastline currently the World's largest
  - Operational in 2018
  - 659 MW
  - 87 turbines
  - 21 – 37 m water depths
  - 80 km cable length

- Largest UK onshore: Whitelee wind farm – 539 MW, 215 turbines

Offshore Wind

- State-of-the-Art

- Current turbine foundations ultimately limited by depths of ~50 m
  - Several techno-economic challenges exist for depths >50 m
  - Construction and installation costs become too high



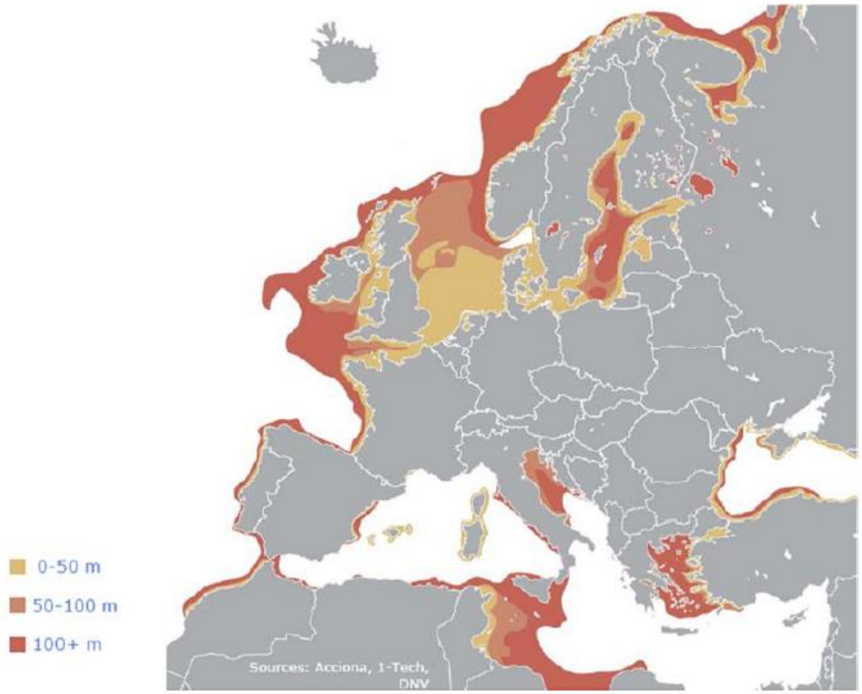
Source: WindEurope

Offshore Wind

- State-of-the-Art

- Constraints on depth are preventing offshore wind from accessing the lion's share of the resource
  - Only the low-hanging fruit has been captured so far
  - Particularly problematic for some countries, e.g. Japan

Figure 1.1.1.Sea depth around Europe (DNV-GL, 2014)



Country/Region	Share of offshore wind resource in deep water locations (>60m depth)
Europe	80%
USA	60%
Japan	80%

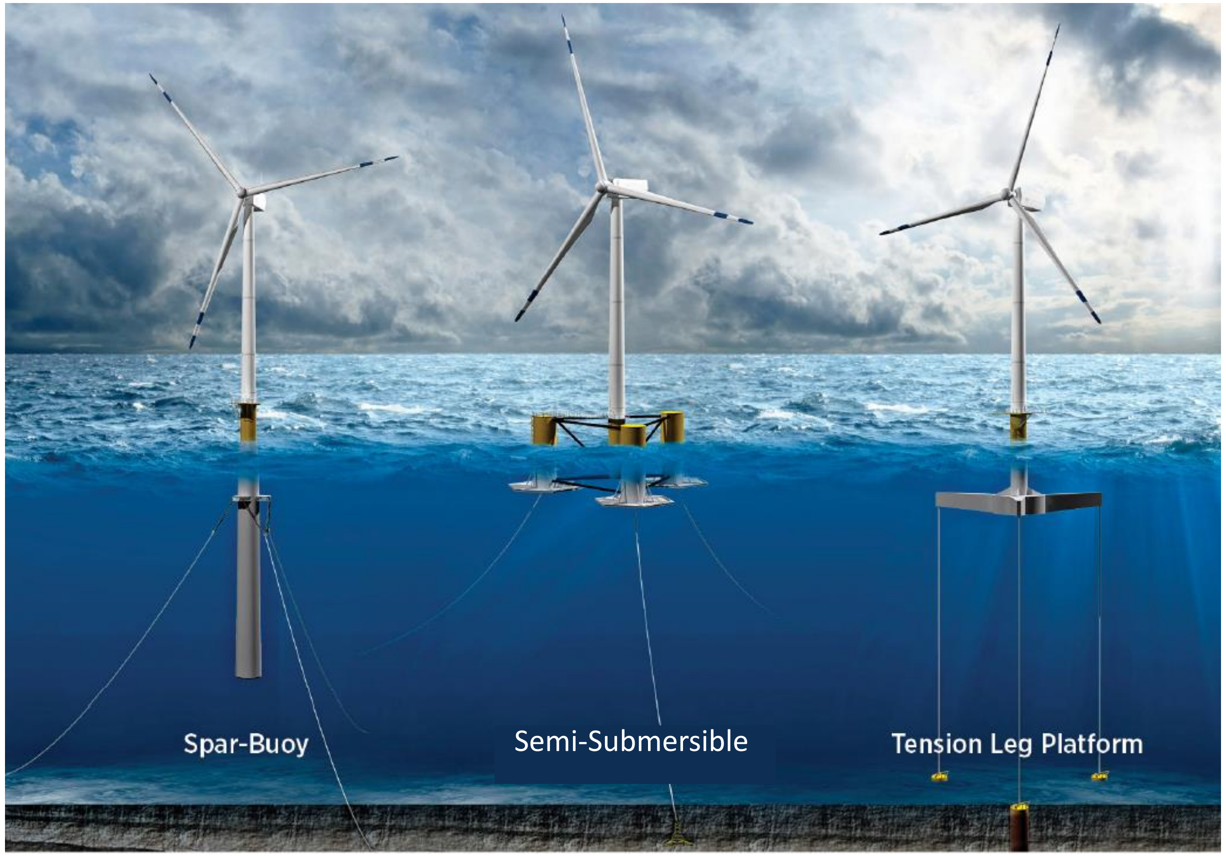
Source: The Carbon Trust

Offshore Wind

- Floating Wind

- Floating wind turbines could be the key to unlocking deeper offshore sites

- Three leading concepts based on floating O&G platforms:
  - Spar-Buoy: ballast stabilised
  - Semi-Sub: buoyancy stabilised
  - TLP: mooring stabilised



Offshore Wind

- Floating Wind

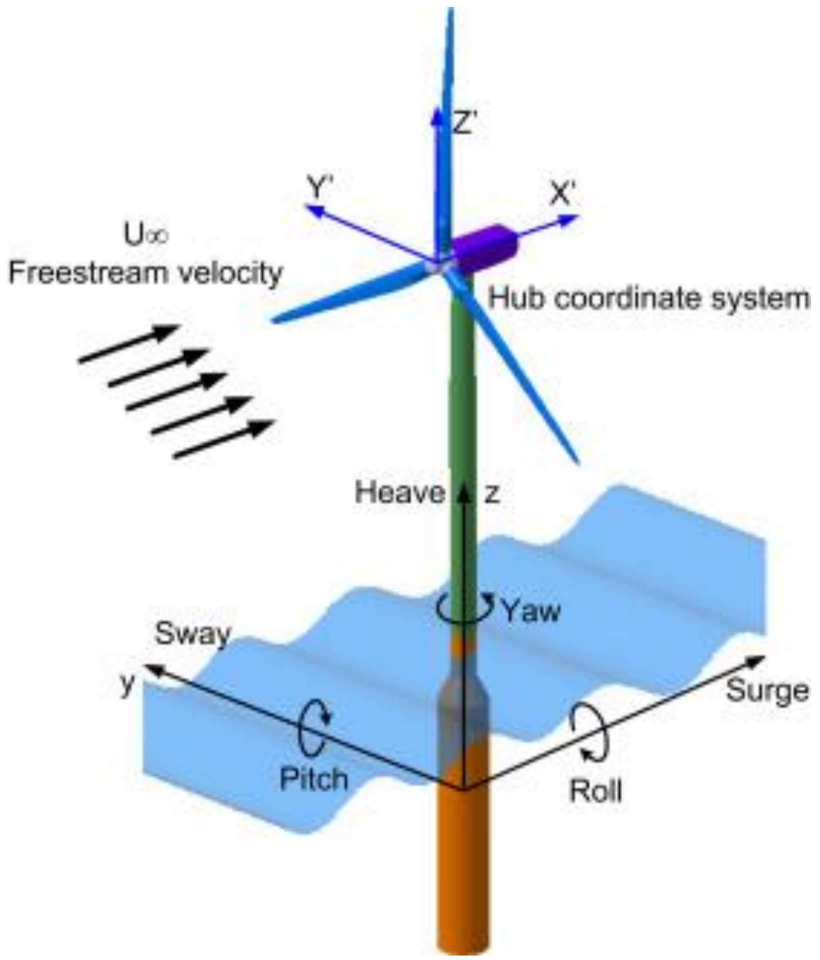
- World's first floating wind farm became operational in 2017
    - Located 25 km off the Aberdeenshire coastline
    - 95 – 120 m water depth
    - 5 x 6 MW wind turbines
    - Spar buoy foundations
    - Reported 65% capacity factor

Offshore Wind

- Floating Wind

- Compared with onshore or fixed-bottom offshore wind turbine, floating turbines have more complex coupled systems
  - Turbine dynamics
  - Platform dynamics
  - Mooring dynamics

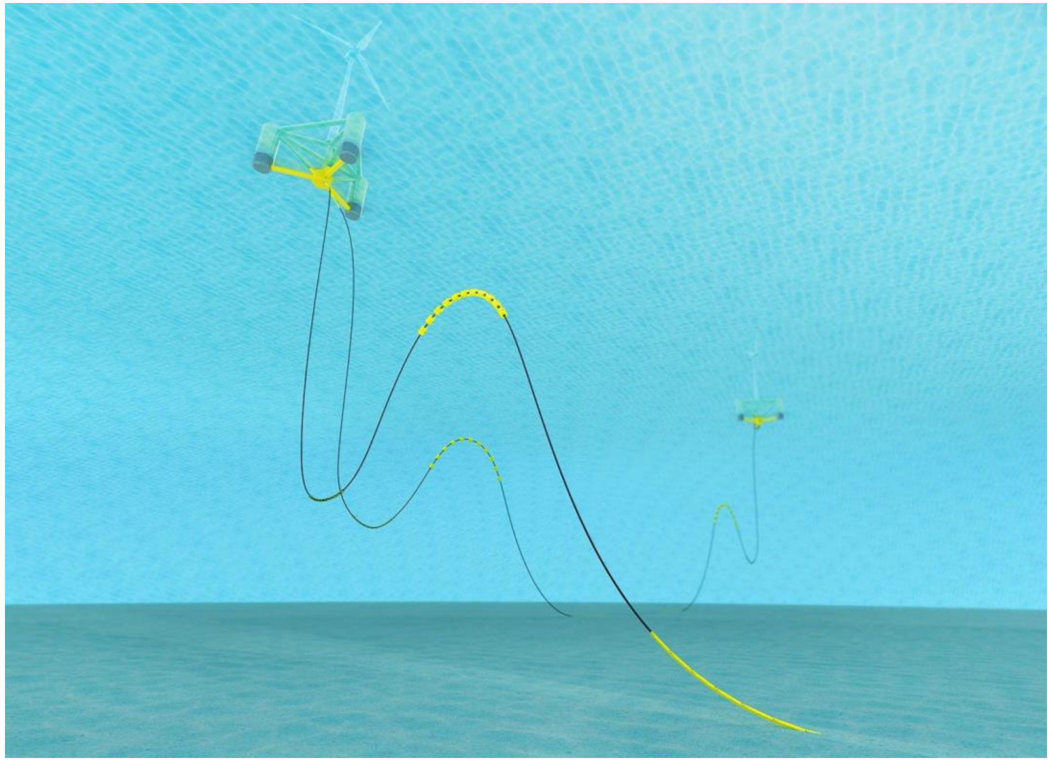
- Few tools currently available to model floating wind turbines
  - Conservative designs and over-engineering



Offshore Wind

- Floating Wind

- Additional sub-systems mean more failure modes
  - Floating platform
  - Mooring lines
  - Anchors
  - Dynamic power cables

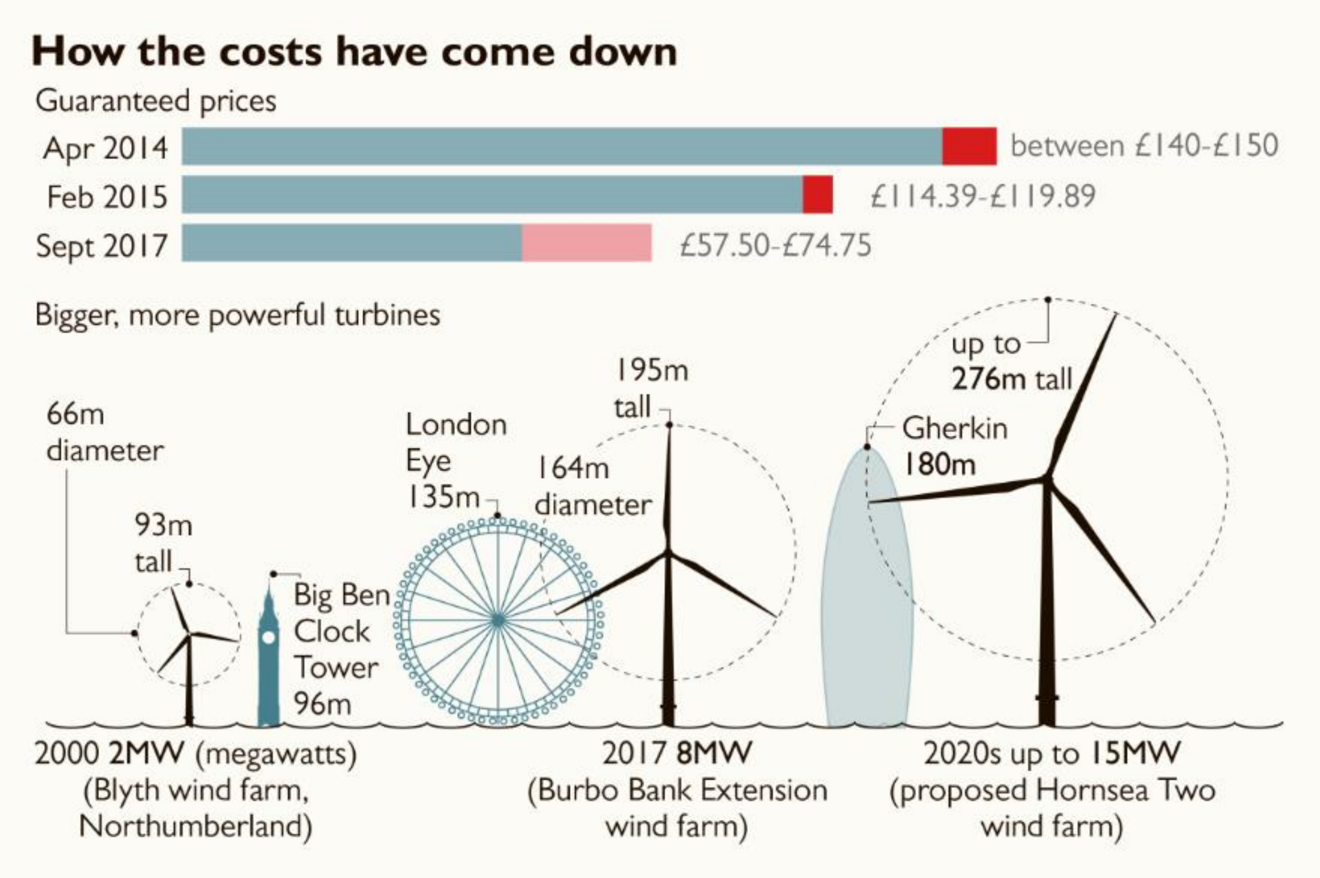


Offshore Wind

- Outlook

- Offshore wind costs have decreased significantly:
  - Strike prices as low as £57.50 for upcoming projects (2022/2023)
  - Prices have halved since 2015

- Cheaper than new gas and nuclear
  - £92.50 per MWh contract awarded to Hinkley Point C nuclear power station



Offshore Wind

- Outlook

- Current UK capacity could triple between 2020 – 2030
  - ➢ 8 GW at present
  - ➢ 25 GW possible by 2030
  - ➢ Could meet 30% UK electricity needs

- New projects (orange, red) to be located further from shore than existing projects (blue)
  - ➢ HVDC transmission technologies to be utilised

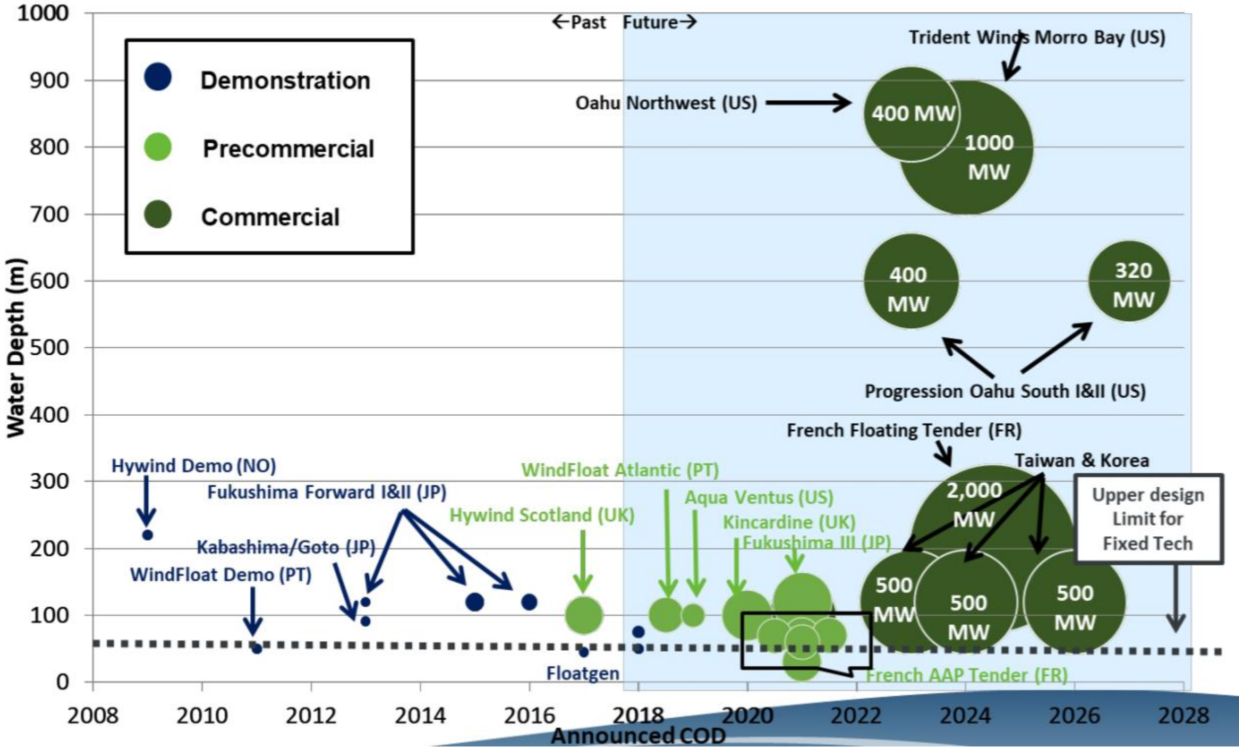
Source: RenewableUK

Offshore Wind

- Outlook

- Floating wind still at a demonstration level as it strives towards cost-competitiveness
  - ➢ Platform size and installation procedures key areas of cost reduction
  - ➢ Lack of technology convergence

- Will aim to follow a similar cost reduction trend to bottom-fixed offshore wind if suitable support mechanisms are in place



Thanks for listening

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