Offshore wind potential in Norway and the North Sea

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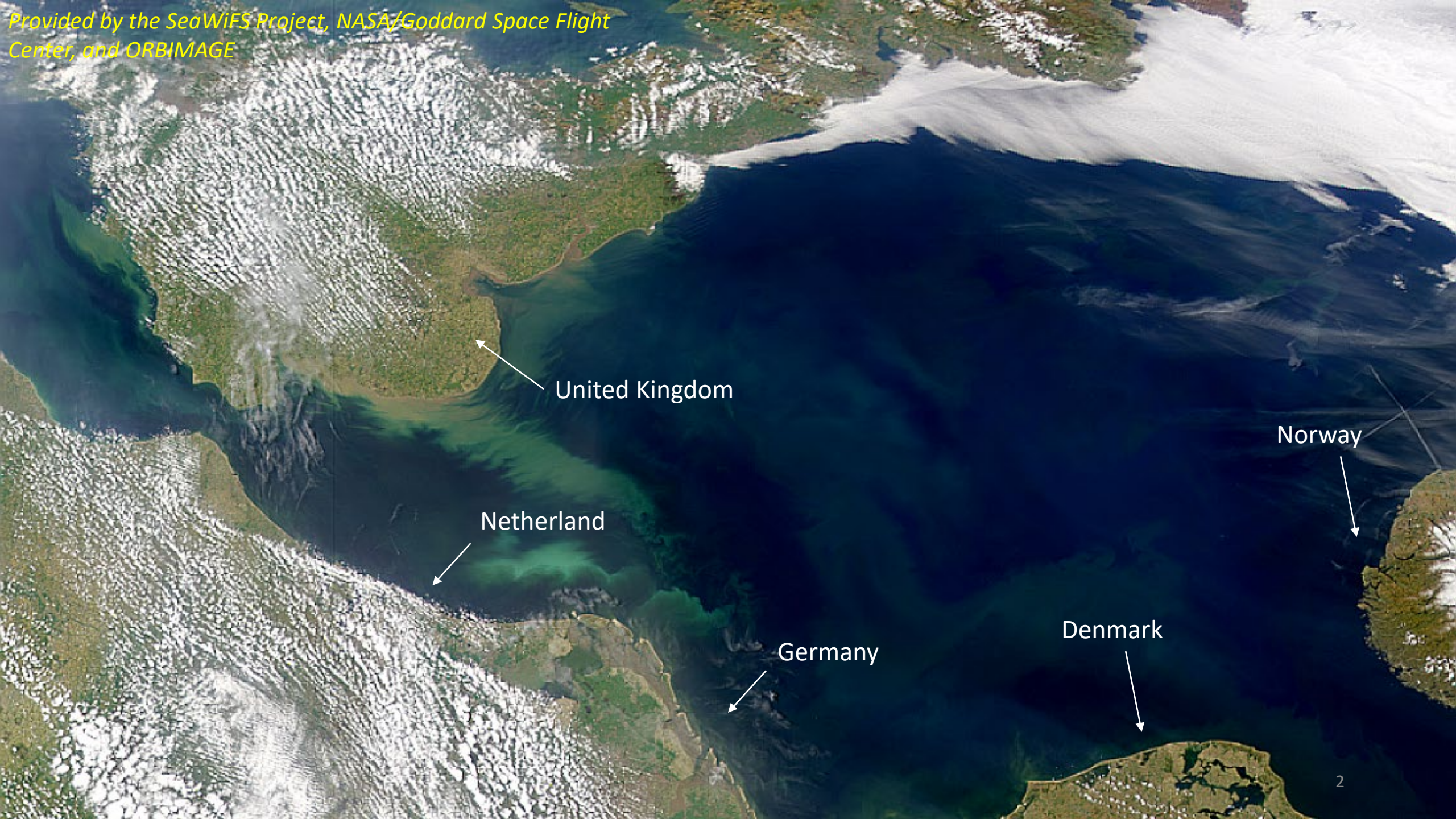
Provided by the SeaWiFS Project, NASA/Goddard Space Flight Center, and ORBIMAGE
United Kingdom
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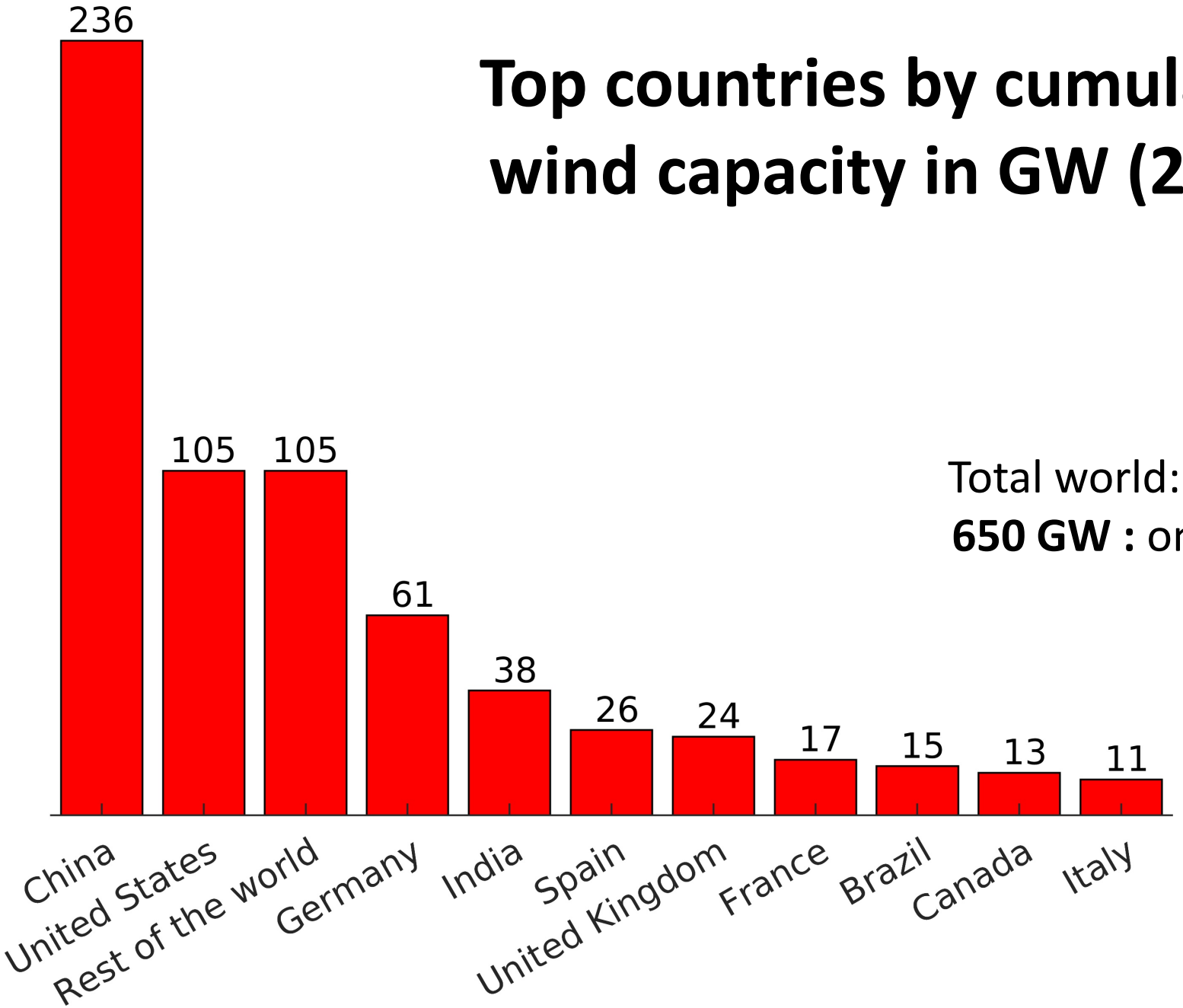
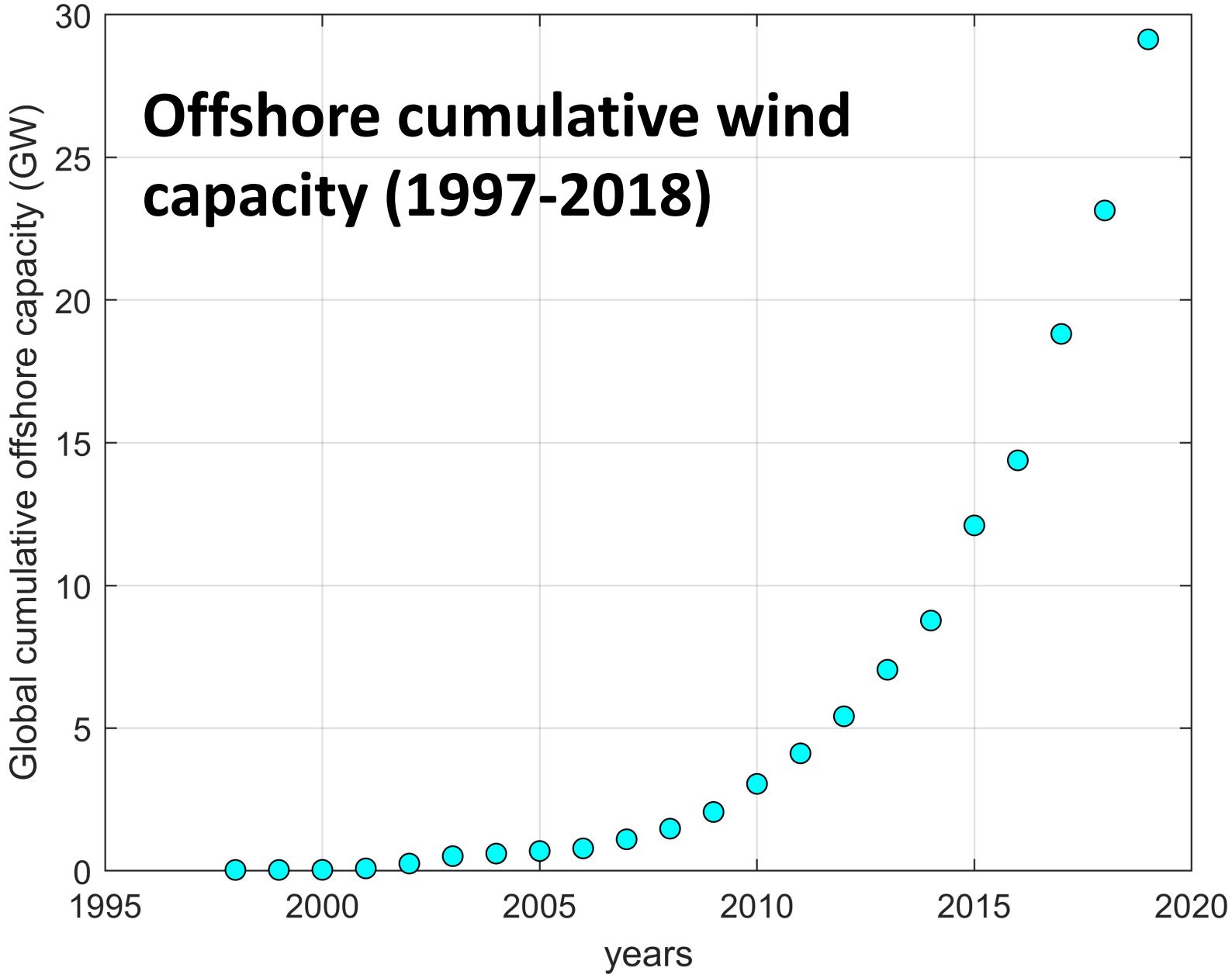
Top countries by cumulative wind capacity in GW (2019)



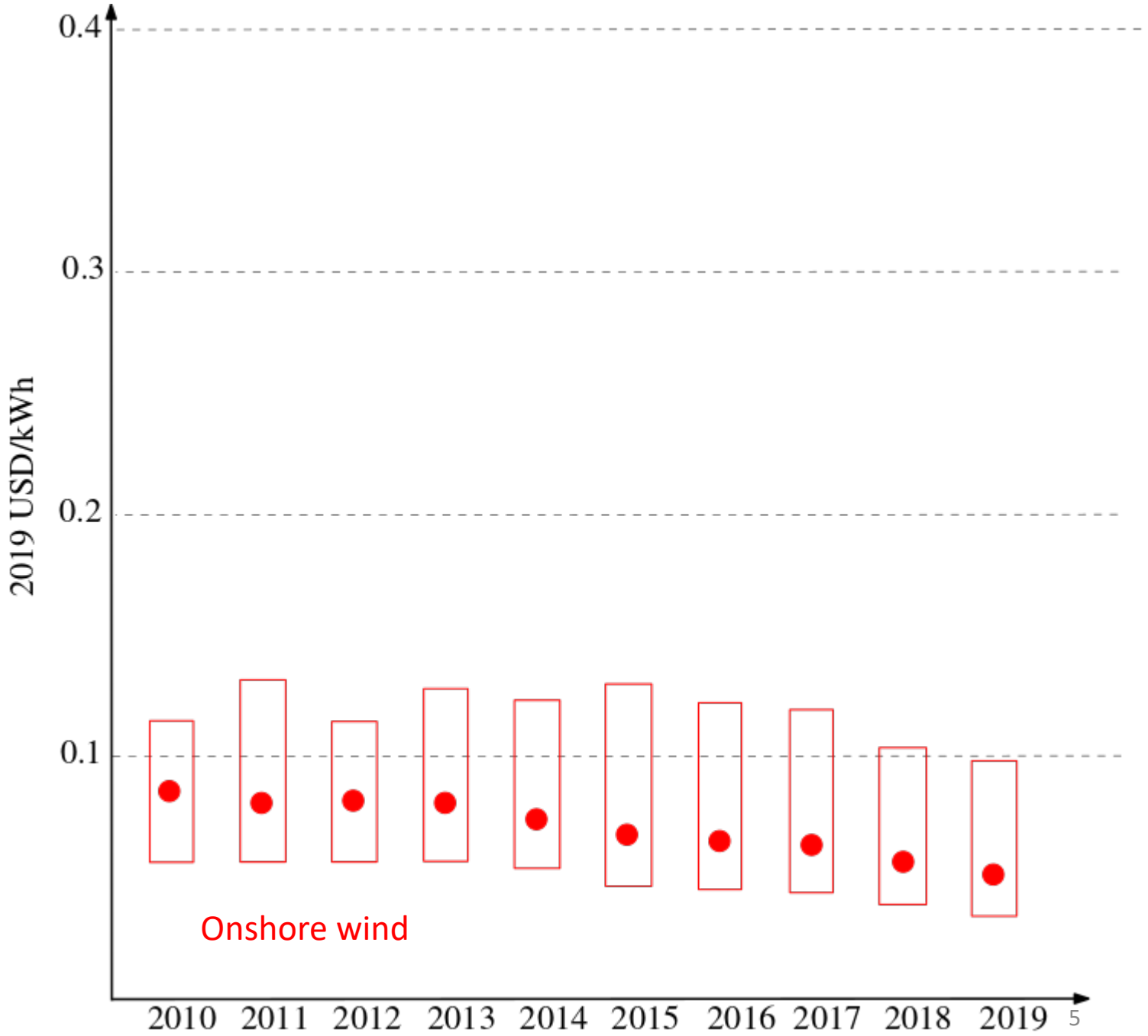
Total world:
650 GW : onshore (95%) + offshore (5%)

Source: *"GWEC Global Wind Report 2019". Global Wind Energy Council. 2020. pp. 44.*



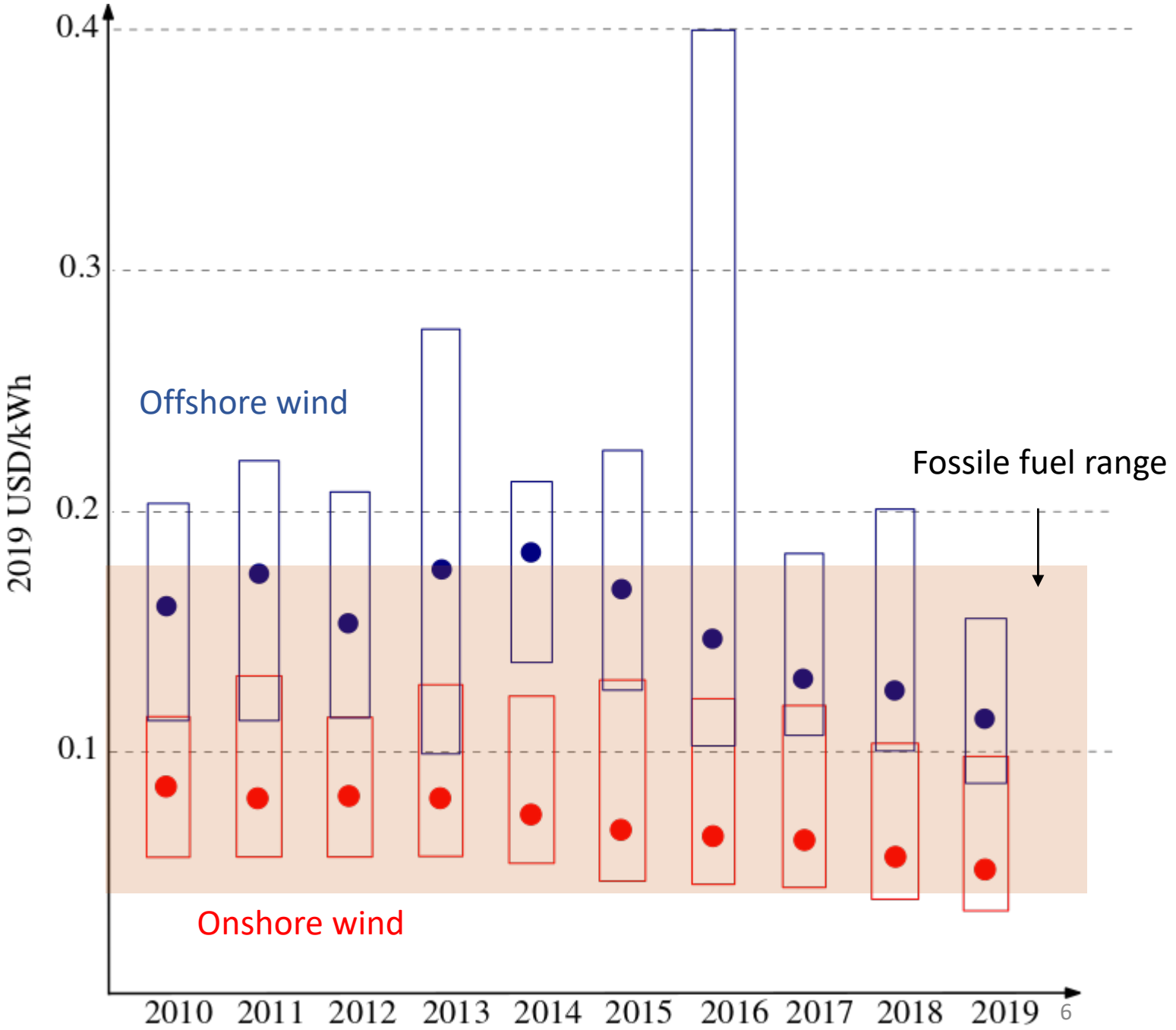
Sources: GWEC (2011–2019) and EWEA (1998–2010)

Global weighted average levelized cost of energy for onshore and offshore wind



Source: IRENA (https://irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jun/IRENA_Power_Generation_Costs_2019.pdf)

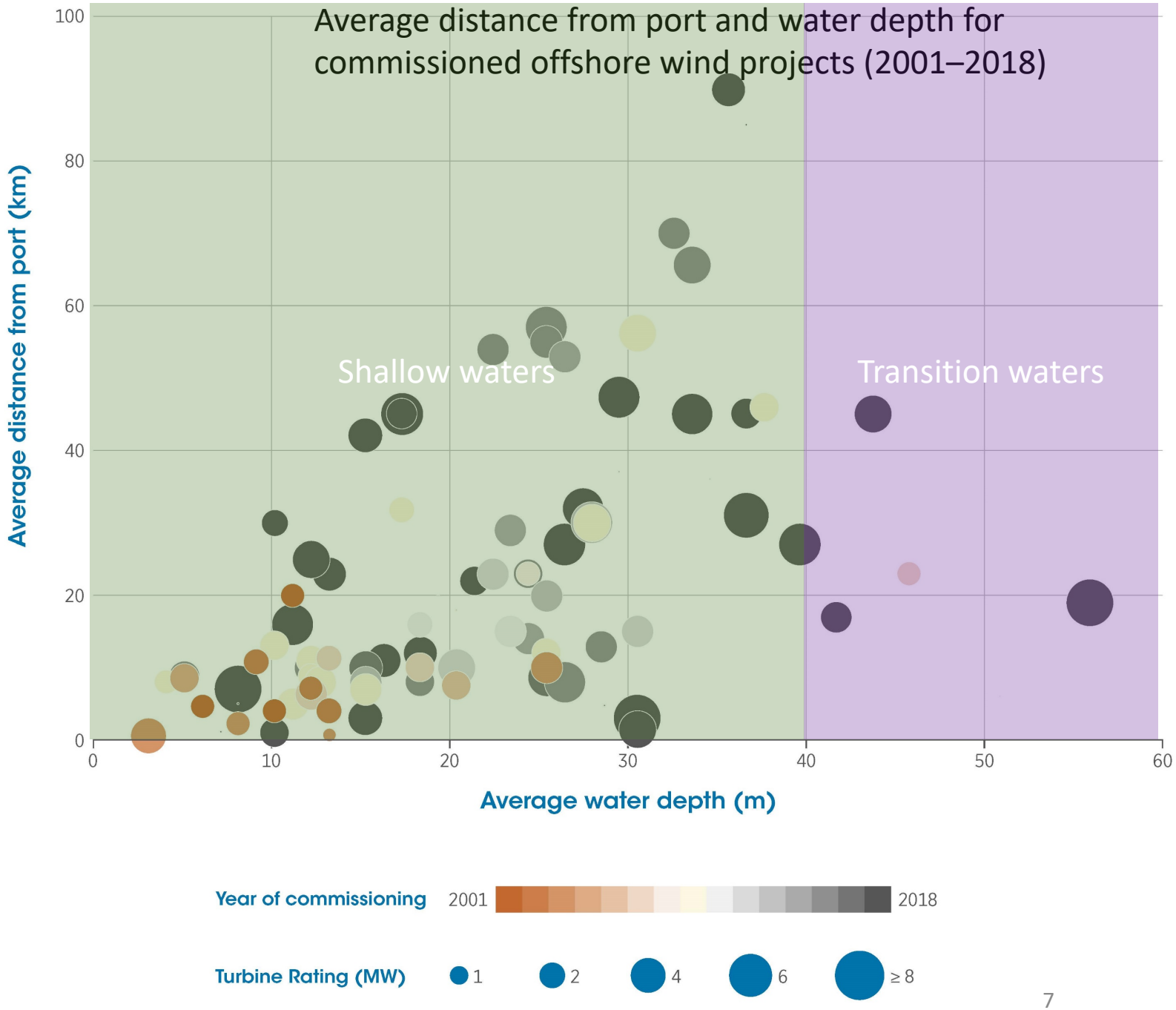
Global weighted average levelized cost of energy for onshore and offshore wind



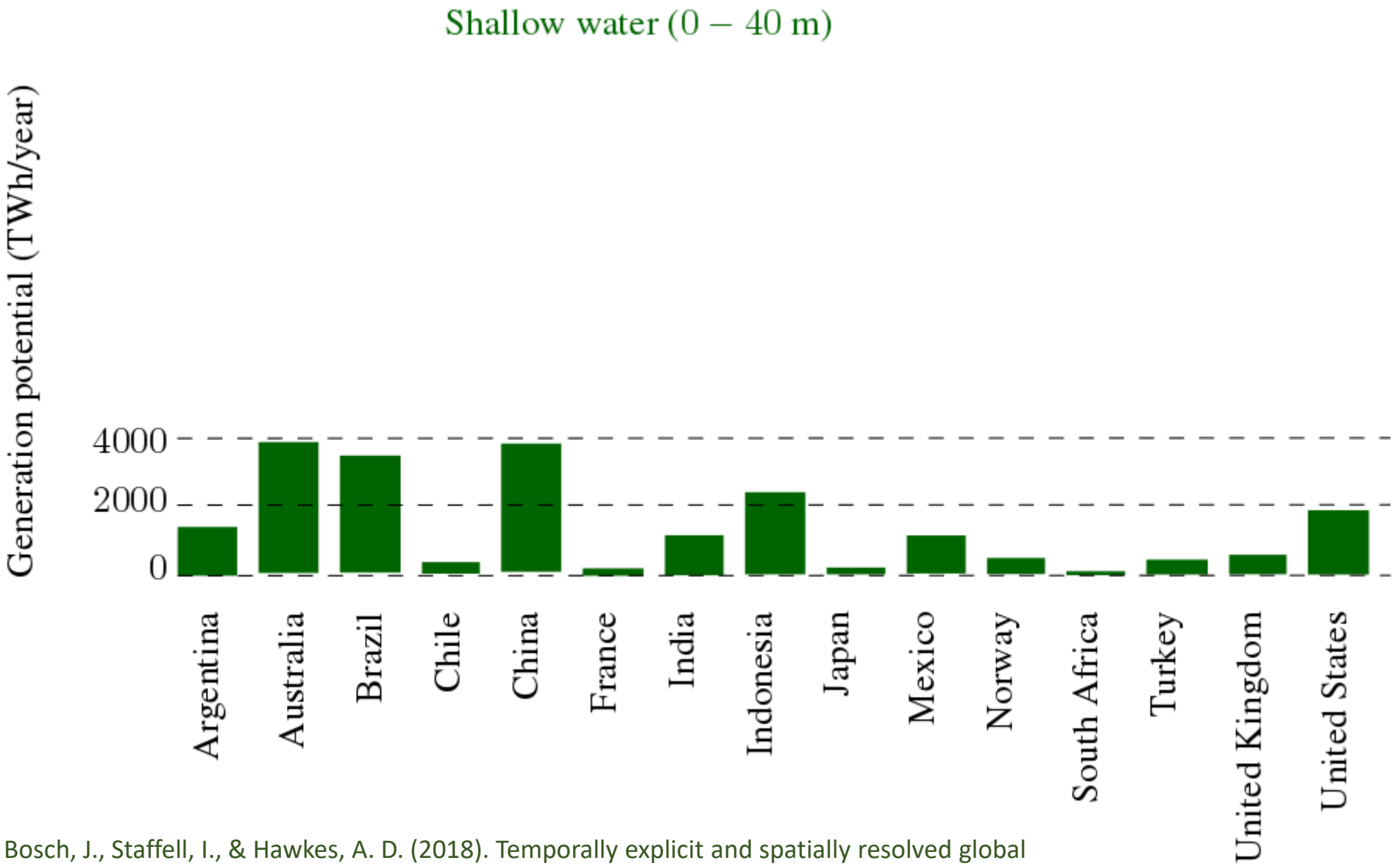
Source: IRENA (https://irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jun/IRENA_Power_Generation_Costs_2019.pdf)

Current status of offshore wind?

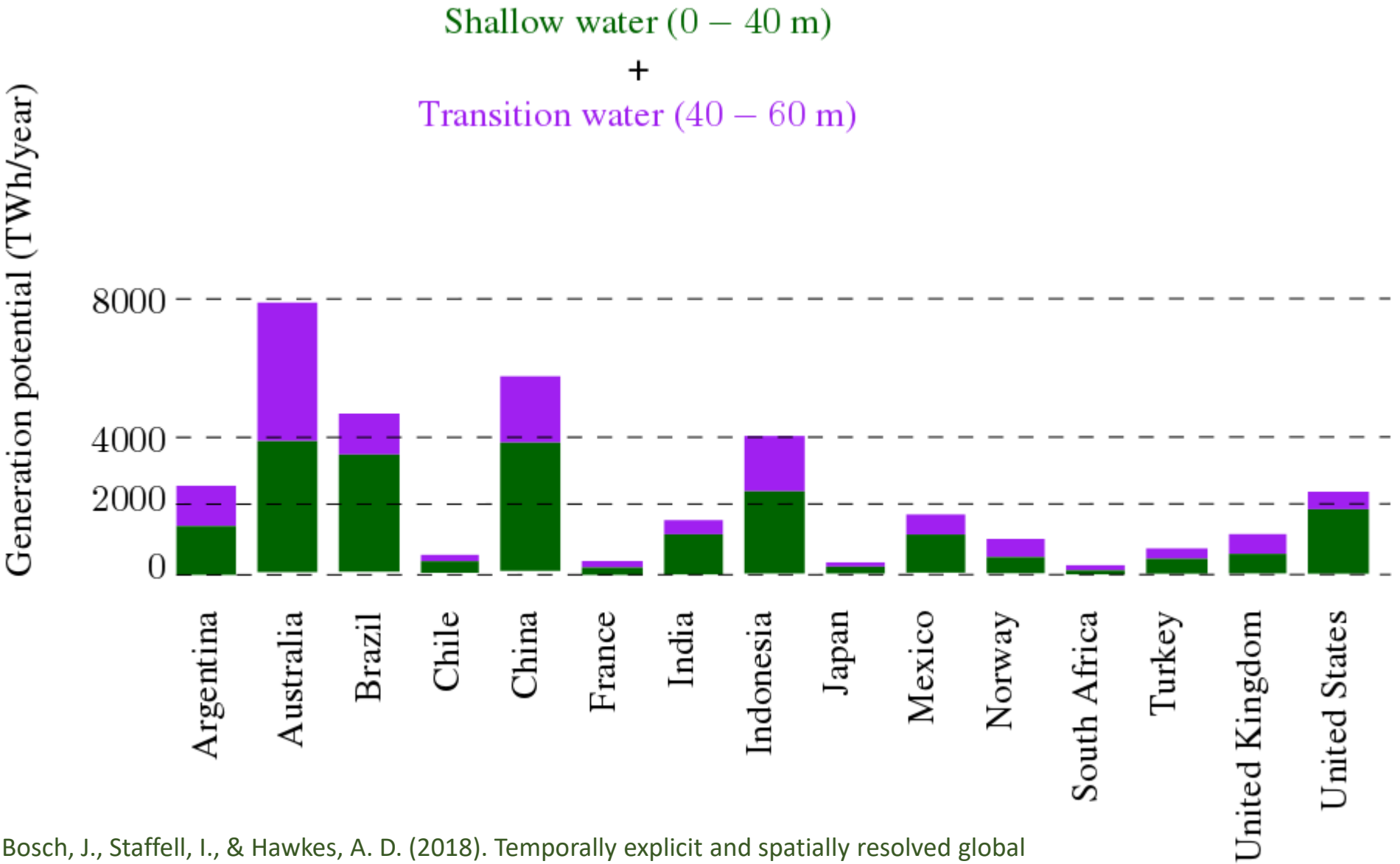
- Offshore wind power production is currently concentrated in shallow waters
- Offshore wind in transition waters have started being explored since 2018
- Deepwater areas are unexplored, except for experimental wind turbines



Source: International Renewable Energy Agency (IRENA). (2019). Renewable Power Generation Costs in 2018.



Adapted from Bosch, J., Staffell, I., & Hawkes, A. D. (2018). Temporally explicit and spatially resolved global offshore wind energy potentials. *Energy*, *163*, 766-781.



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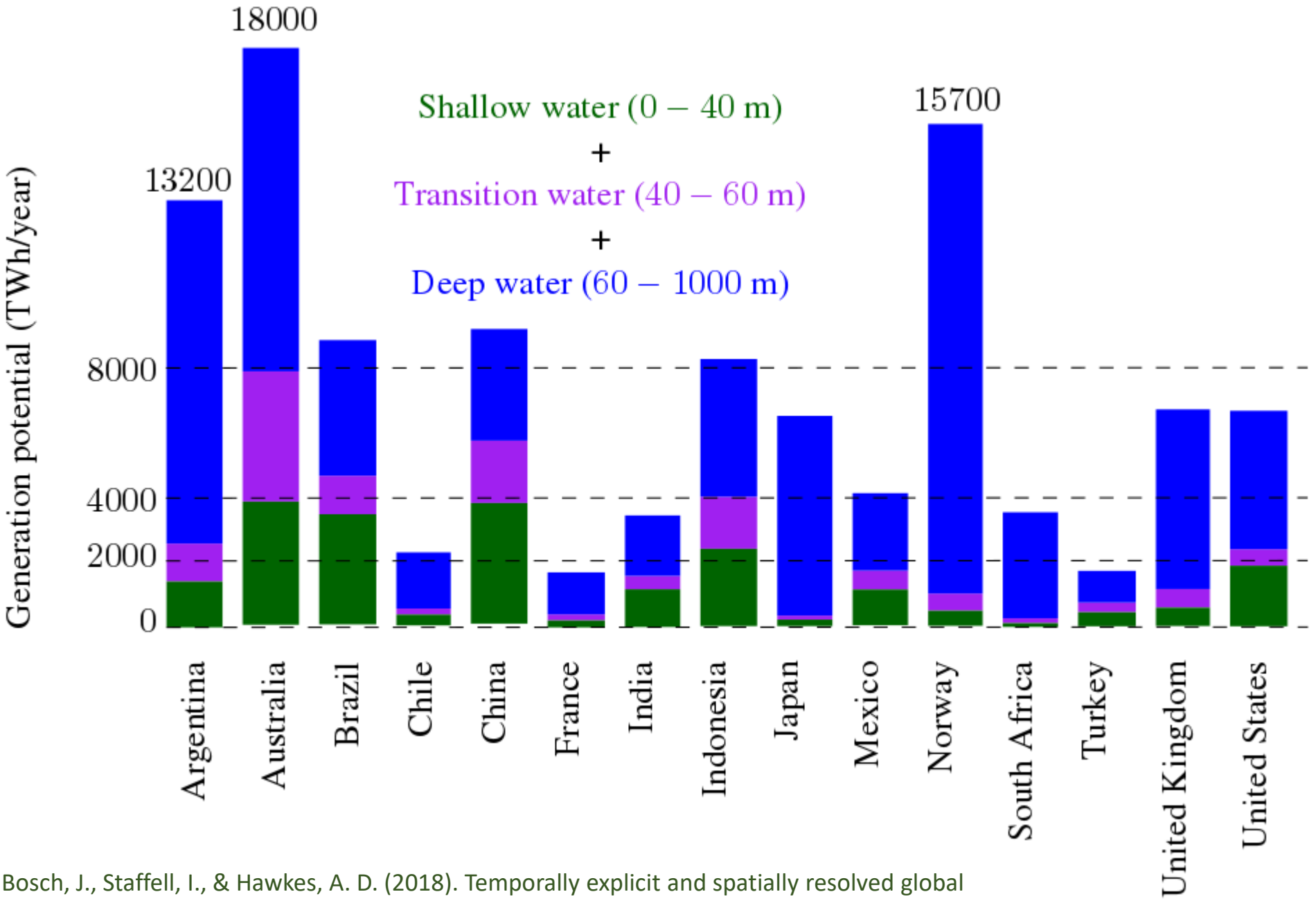

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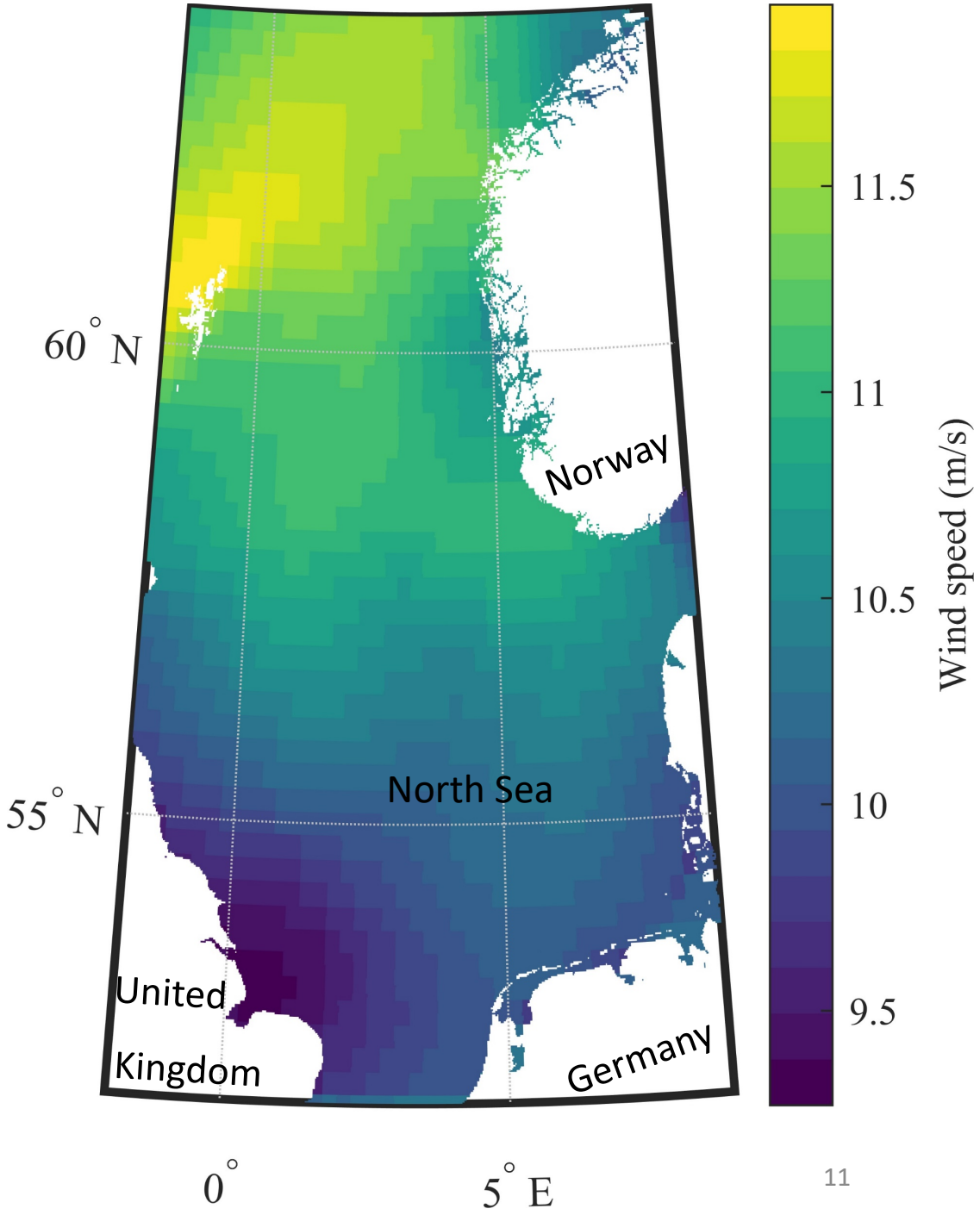
Offshore wind potential in Norway relies on fairly deep waters

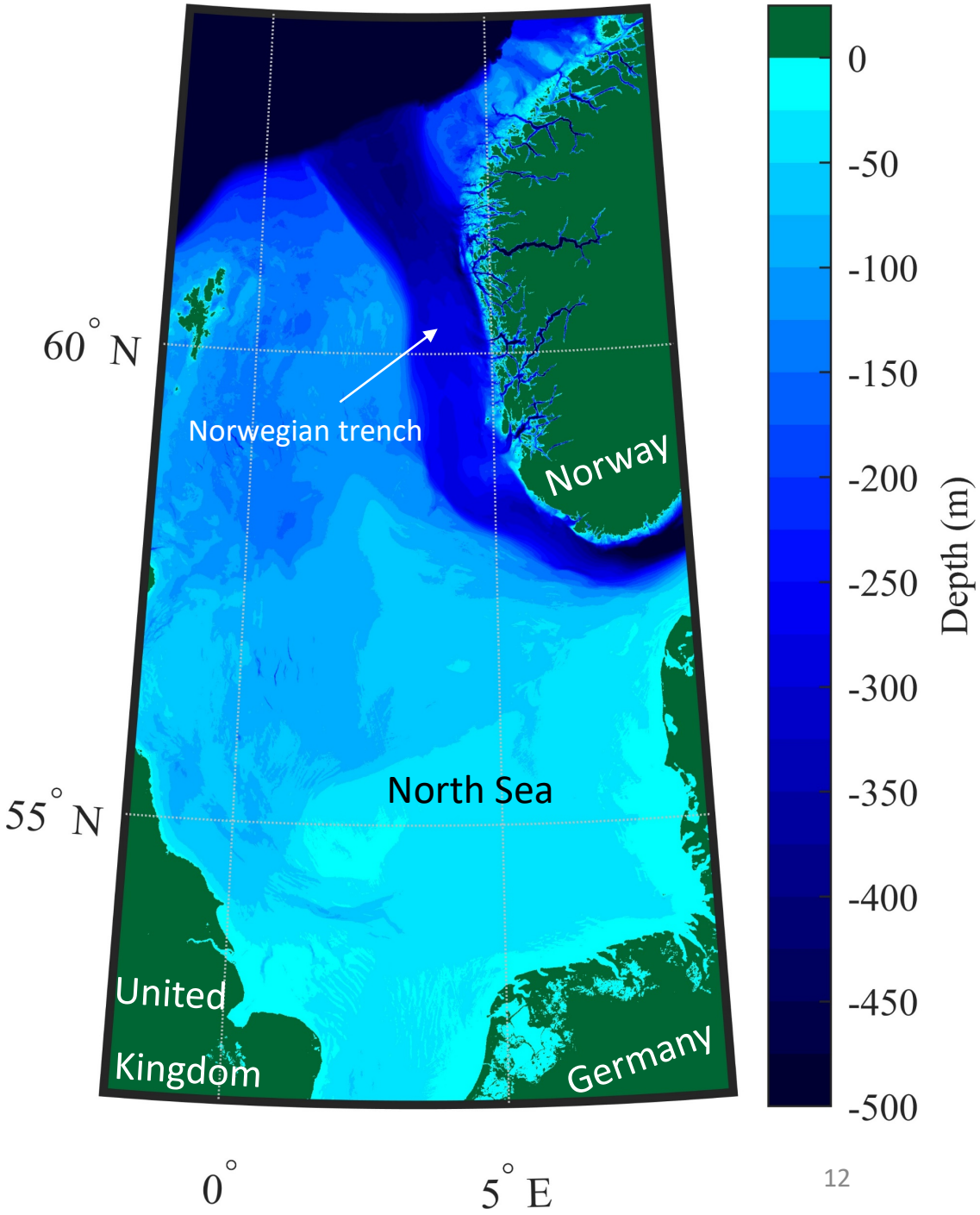
Exploiting deep-water offshore wind requires revolutionary wind-turbine **design**



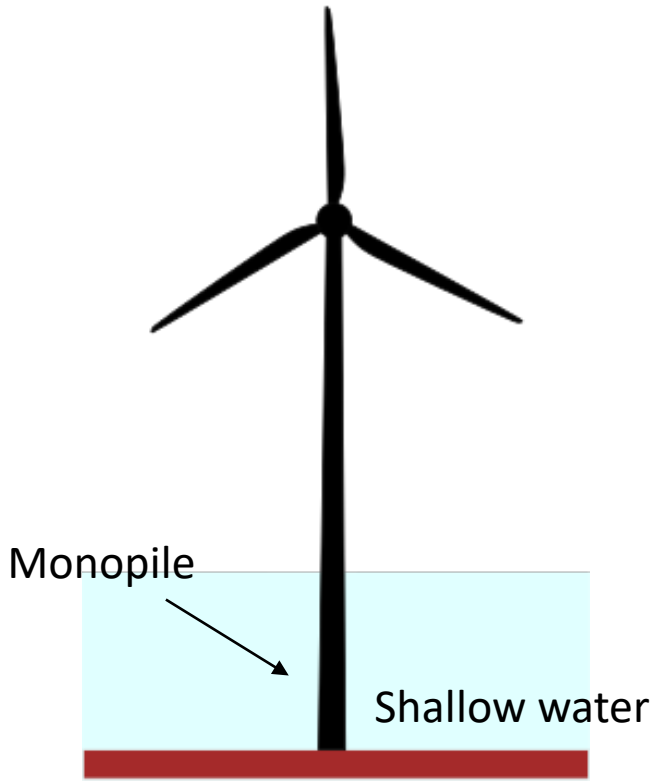
Source: NREL Global Offshore Wind GIS Data
Wind resource based on NOAA blended sea winds and monthly wind speed at 30km resolution, using a 0.11 wind sheer to extrapolate 10m - 90m. Annual average >= 10 months of data, no nulls.

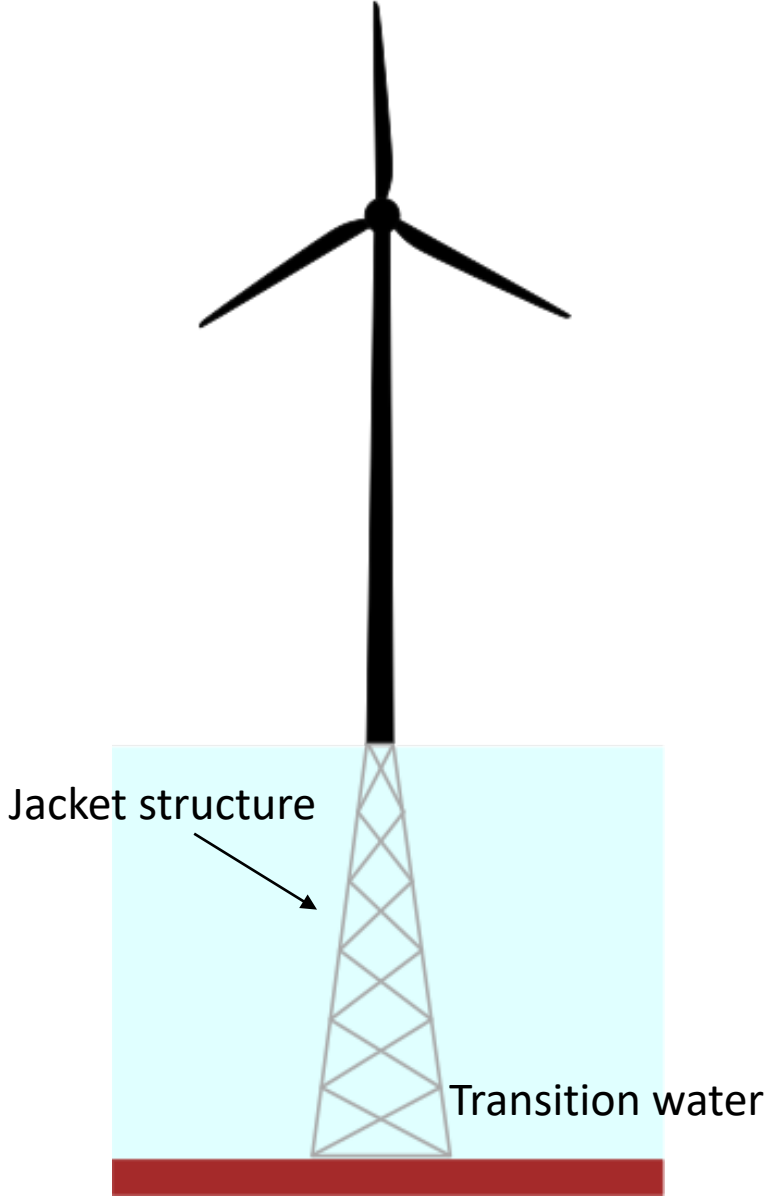
Offshore wind potential in Norway relies on fairly deep waters

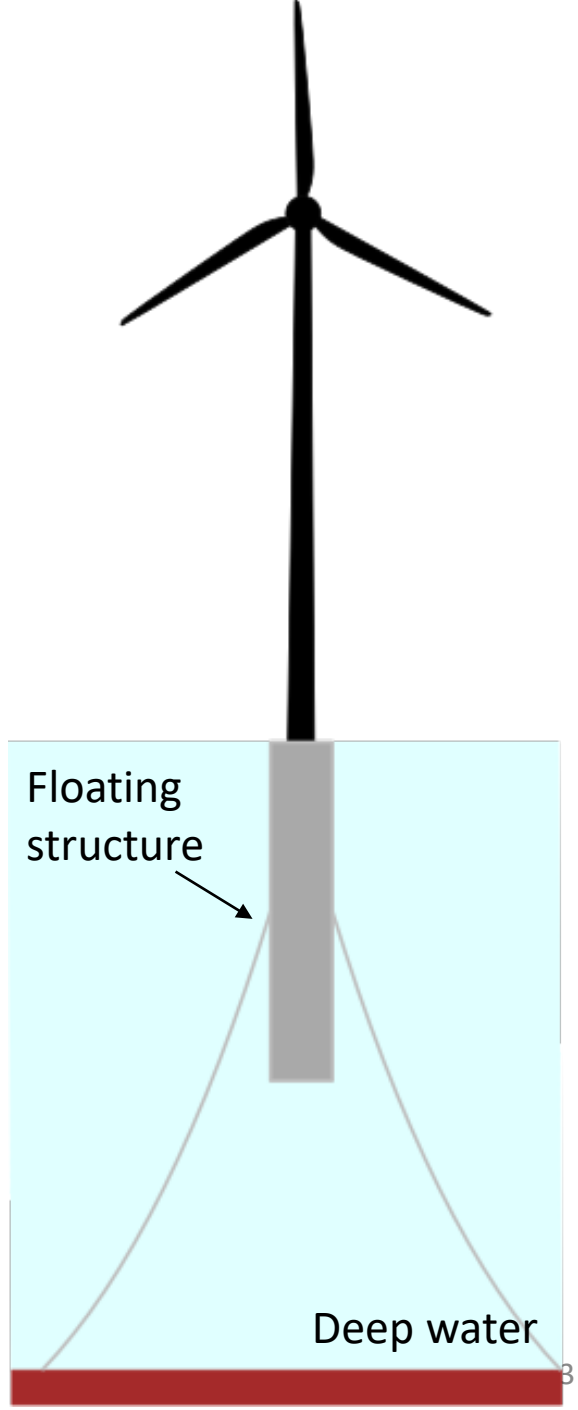
Exploiting deep-water offshore wind requires revolutionary wind-turbine **design**



Data taken from the GEBCO 2020 Gridded Bathymetry Data


Monopile
Shallow water

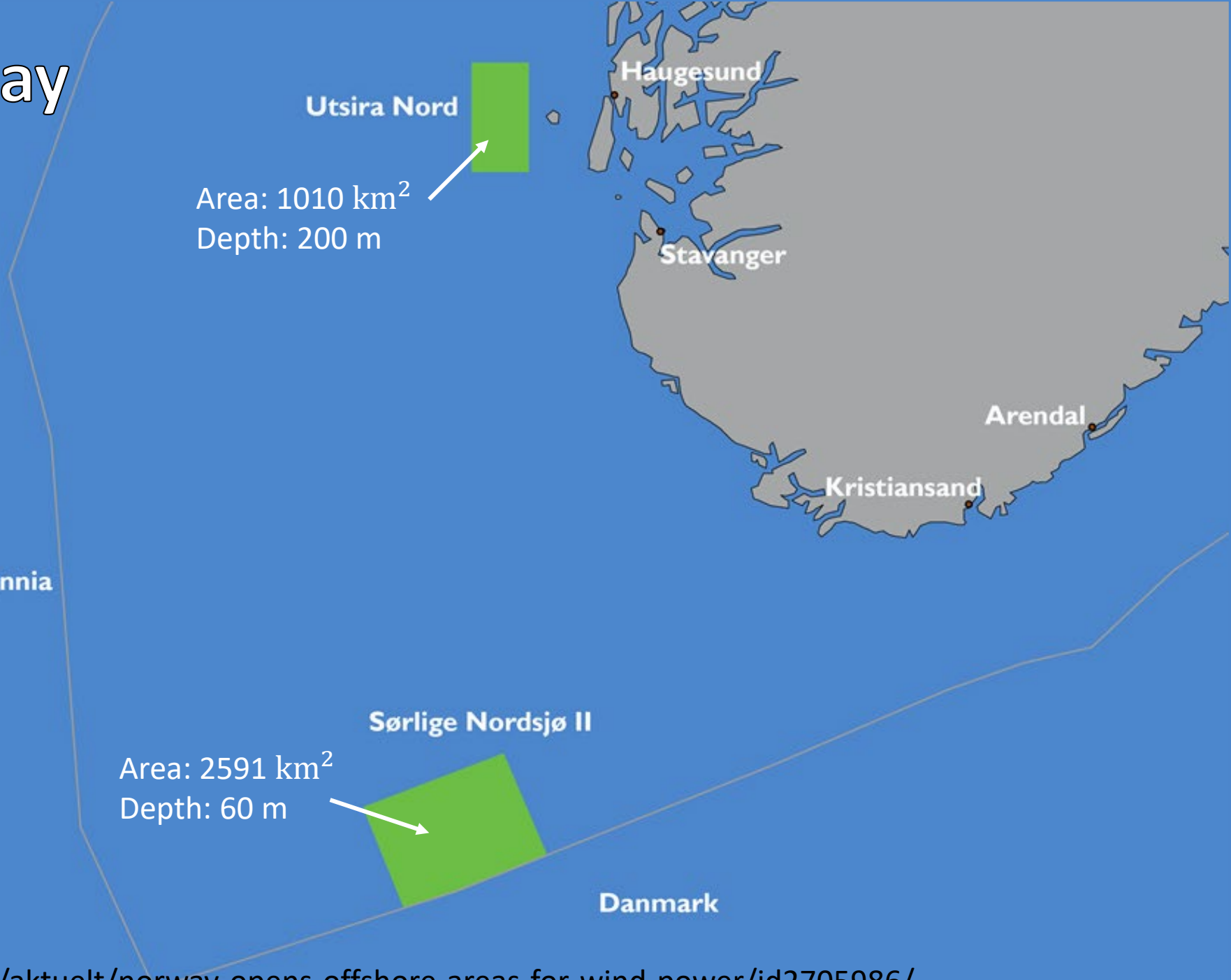

Jacket structure
Transition water


Floating
structure
Deep water

June 2020: Norway opens offshore areas for wind power

Possibility to submit license applications for offshore wind power projects in two areas

Potential capacity: 4.5 GW



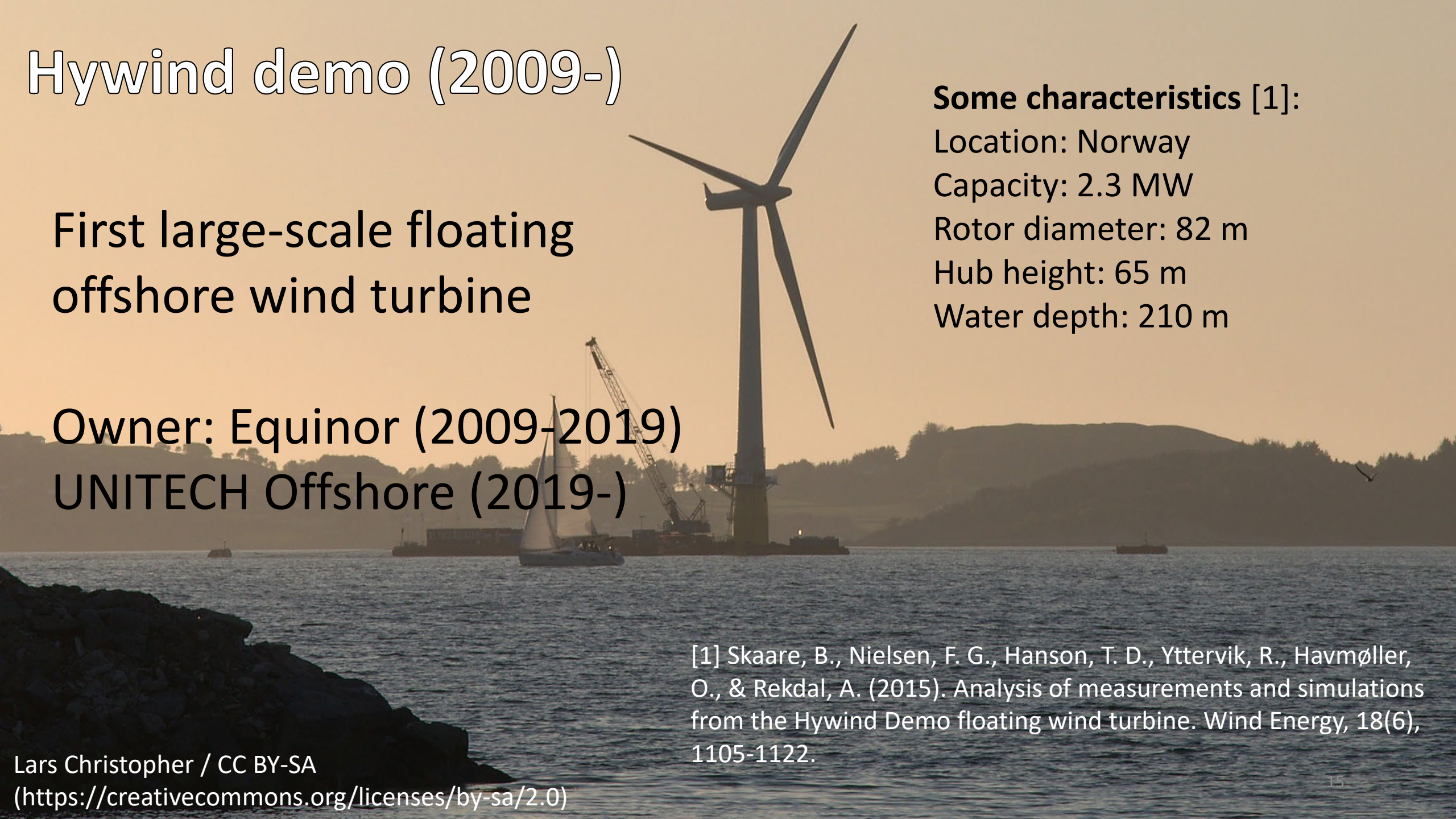
Source: https://www.regjeringen.no/en/aktuelt/norway-opens-offshore-areas-for-wind-power/id2705986/

Hywind demo (2009-)

First large-scale floating offshore wind turbine

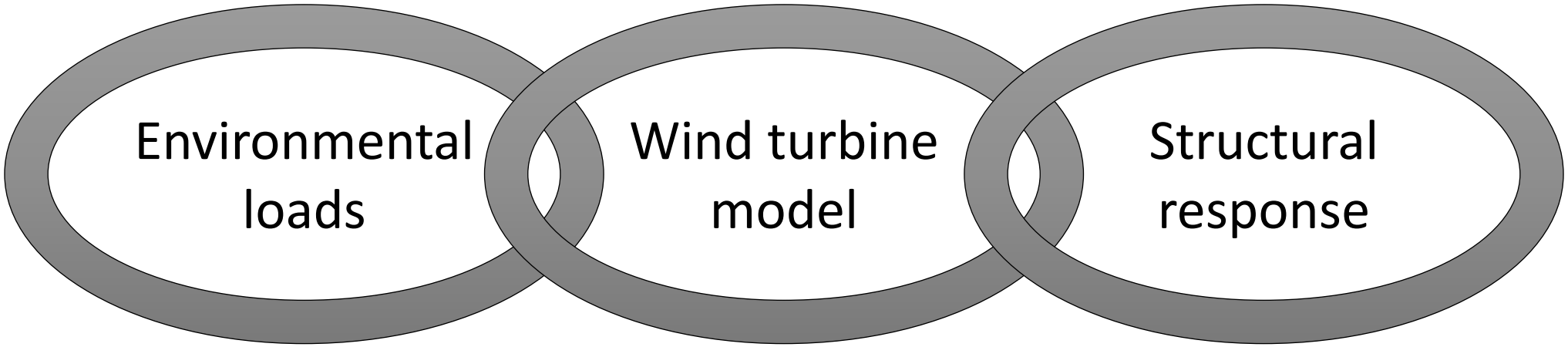
Owner: Equinor (2009-2019)
UNITECH Offshore (2019-)

Some characteristics [1]:
Location: Norway
Capacity: 2.3 MW
Rotor diameter: 82 m
Hub height: 65 m
Water depth: 210 m



[1] Skaare, B., Nielsen, F. G., Hanson, T. D., Yttervik, R., Havmøller, O., & Rekdal, A. (2015). Analysis of measurements and simulations from the Hywind Demo floating wind turbine. Wind Energy, 18(6), 1105-1122.

Designing a floating offshore wind turbine is challenging



Two of the three «grand challenges» in wind energy [1]

[1] Veers, Paul, et al. "Grand challenges in the science of wind energy." *Science* 3a66.6464 (2019): eaau2027.

There is a lack of knowledge on the environmental loading on floating wind turbines [1]

[1] Veers, Paul, et al. "Grand challenges in the science of wind energy." *Science* 3a66.6464 (2019): eaau2027.

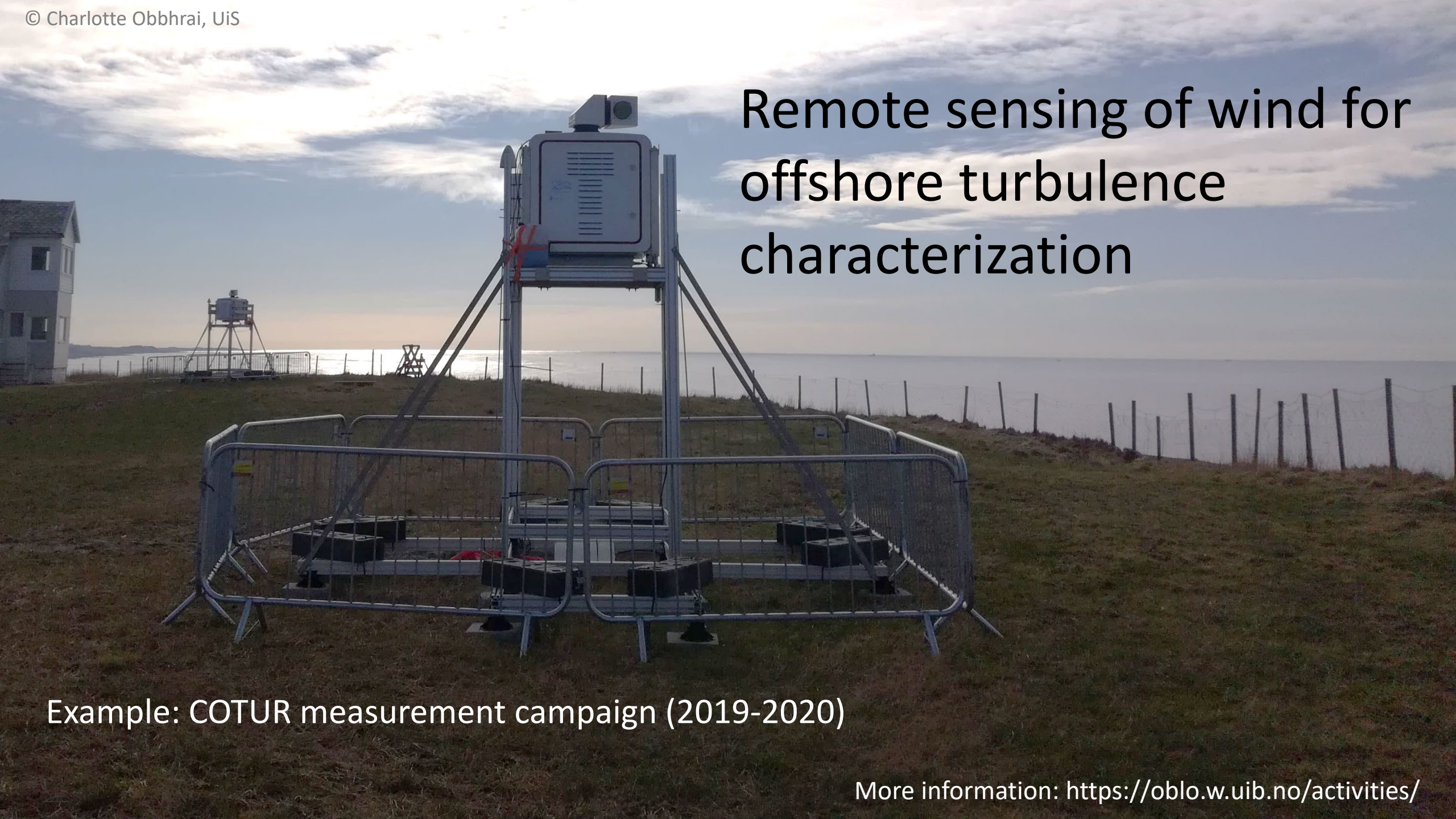
Measurement devices can be deployed on offshore research platforms

Example: OBLEX-F1 measurement campaign (2015-2016)

Alpha ventus wind park

FINO1 platform

More information: https://oblo.w.uib.no/activities/



Remote sensing of wind for offshore turbulence characterization

Example: COTUR measurement campaign (2019-2020)

More information: https://oblo.w.uib.no/activities/

Conclusions

- Norway has one of the largest offshore wind potential in the world.
- BUT it is mainly linked to water depths between 60 m to 1000 m.
- Floating offshore wind turbines may offer a possibility to harvest wind energy in deep-water areas.
- There are still considerable challenges for the deployement of offshore wind turbines at an industrial scale.


Provided by the SeaWiFS Project, NASA/Goddard Space Flight Center, and ORBIMAGE

Thank you