Methods for compiling North Sea offshore wind farm data

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Prepared by:

Emma Jane Critchley, Norwegian Institute for Nature Research, emma.critchley@nina.no

Lila Buckingham, Norwegian Institute for Nature Research, lila.buckingham@nina.no

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Background

There is currently no open-source dataset of offshore wind developments in Europe available in one location. While up to date information on offshore wind in the North Sea can be viewed on commercial websites (e.g. 4C Offshore) there is a high cost for accessing this data which is generally prohibitive for most researchers. We created this dataset to compile all freely available data on offshore wind developments in the North Sea up to 2030 from the multiple databases and websites that this information is currently contained within.

Inputs & methods

Initial spatial and metadata on offshore wind developments in the North Sea were collected from the EMODnet human activities last updated 19-12-2022. Data on existing wind farms were checked against the data freely available on 4C Offshore and wind farm developer websites. Where there was any discrepancy in the data across different sources, data from the developer website were taken as likely to be the most accurate source. The database was also cross-checked against all relevant government energy department websites to obtain the most up to date information on future windfarms. In many cases we found that new planning and scoping areas had been announced since December 2022, and therefore these had not been included in the EMODnet database. Additional spatial and metadata were taken from the following sources:

Belgium – Information: Belgian offshore wind energy | FPS Economy (fgov.be)

Belgium – Spatial data: Identification of the parcels for the construction of wind farms in the Belgian North Sea | FPS Economy (fgov.be)

Germany – Spatial data: BSH - Flächenentwicklungsplan 2023 (bsh.de)

Netherlands – Information: Wind op zee (windopzee.nl)

Netherlands – Spatial data: Designated wind areas NWP (rijkswaterstaat.nl)

Norway – Information: Summary – Part 1 (nve.no)

Norway – Spatial data: NVE data nedlast (nve.no)

Sweden – Spatial data: Vindbrukskollen (energimyndigheten.se)

United Kingdom (England, Wales and Northern Ireland) – Spatial data: The Crown Estate

United Kingdom (Scotland) – Spatial data: Crown Estate Scotland

Many planning and scoping areas included in countries' wind farm capacity plans for 2030 did not have an estimated date of operation, in which case 2030 was taken as the year they were expected to be operational by.

Spatial data (polygons) were not available for all planned wind farms in Norway, as some of the existing areas open for tender have recently been expanded. Existing wind farm areas open for tender were taken from the call documents and spatial data available on the NVE website. Additional wind farms of the size in sq. km indicated on the NVE website were evenly placed in the expanded area.

Wind turbines

Turbine location data for existing wind farms were taken from Martins et al. (2023)*. These data were cross-checked against the completed wind farm dataset to ensure that turbine numbers were correct. Turbine information (e.g. number of turbines, MW, rotor size etc.) for planned developments was taken from the developers' websites. Where turbine information was not available the IEA 15MW turbine was used as a proxy. Most developments in the North Sea constructed between now and 2030 are likely to use a turbine of minimum 15 MW (according to industry consultation), so this is a reasonable assumption. Larger turbines may be installed towards the end of the decade, however given current supply chain constraints it is hard to estimate how many will be installed by 2030. In the metadata, for any wind farm where a proxy turbine of 15 MW has been used the number of turbines in the wind farm was calculated by dividing the planned total MW capacity of the wind farm by 15.

In any cases where there was ambiguity about the number of turbines or MW, the largest turbine and greatest MW was used. Where turbine model was not available, turbine measurements were taken from turbines with a similar MW capacity.

To create spatial data for planned wind farms the expected number of turbines were randomly placed inside the windfarm polygon with roughly even spacing. This was done by first placing 10,000 random points within the wind farm polygon. These points were then clustered into the number of turbines to be placed in the wind farm, using k-means clustering results in the points being roughly evenly spaced. Industry guidance is that turbines should be a minimum of 7 rotor diameters apart, however this isn't always implemented in practice as the most efficient placement of turbines will vary with location. Even spacing across the wind farm polygon ensures that all areas are covered as much as possible.

*Martins, M.C.I., Carter, M.I., Rouse, S. and Russell, D.J., 2023. Offshore energy structures in the North Sea: Past, present and future. *Marine Policy*, 152. https://doi.org/10.1016/j.marpol.2023.105629

Datasets

Offshore wind farms in the North Sea by 2030: Metadata
File name = North_Sea_OWF_2030_metadata.csv

Offshore wind farms in the North Sea by 2030: Wind farm polygons
File name = North_Sea_OWF_2030_polygons.shp

Offshore wind farms in the North Sea by 2030: Wind turbine points
File name = North_Sea_OWF_2030_turbines.shp

File projection for .shp files: ESRI:102017 - WGS 1984 Lambert Azimuthal EqArea North Pole

Metadata fields

Note that metadata fields are consistent across all datasets.

Metadata field	Definition
Country	Country in which the wind farm is located.
Name	Wind farm name, taken from developer website for wind farms in production, construction and approved. Taken from government agency websites for planned wind farms.
Status	Whether the wind farm is in production, construction phase, has been approved for construction or is planned. Planned also refers to planning or scoping areas.
Year	Year the wind farm became operational or is expected to become operational for future wind farms.
Owner	The energy developer(s) that own the wind farm.
Turbine_type	Whether the turbines are fixed-bottom or floating.
Number_turbines	The number of wind farms in the wind farm. In the case of some planned wind farms this is given as an expected range.
Turbine_model	The turbine model used in the wind farm. In some case more than one turbine model is used in the wind farm.
Proxy_turbine	In the case where no turbine information was available this is the turbine model that was used as a proxy.
Turbine_MW	The MW capacity of the turbines in the wind farm. In some cases this is a range.
Rotor_radius	The radius of the wind turbine motor in metres, measured from the tip of the blade to the centre of the turbine hub.
Airgap	The estimated air gap between the bottom of the rotor sweep zone and the sea surface. This information was not available for all turbines, and is also dependent on wind farm location, time of year and sea state.
Data_source	Where the metadata was sourced from.

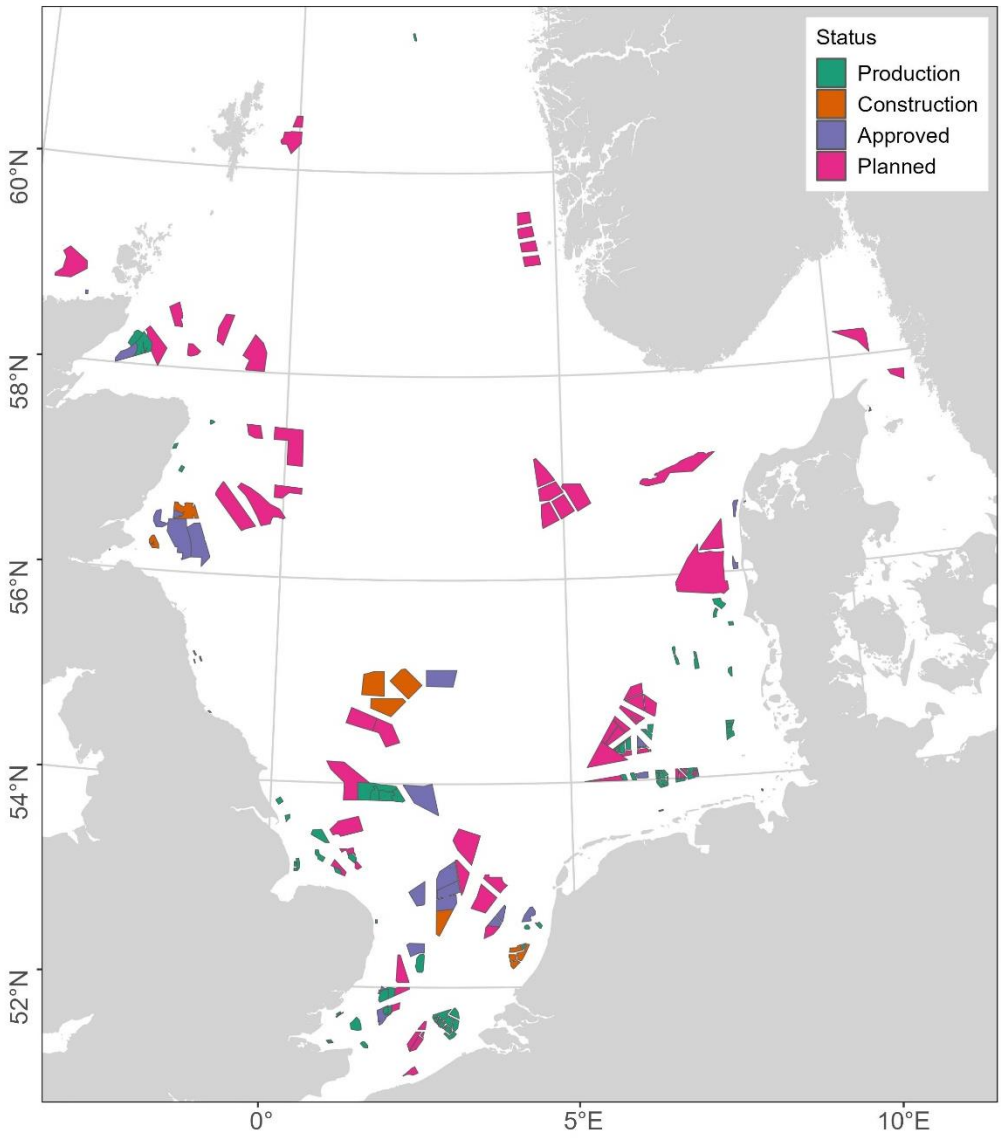

Figure 1. All wind farms expected to be operational in the North Sea by 2030 - status is correct as of July 2023. See metadata for expected year of operation for all future wind farms.