



Offshore Wind in Europe

Key trends and statistics 2019

Wind[°]
EUROPE

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This report summarises construction and financing activity in European offshore wind farms from 1 January to 31 December 2019.

WindEurope regularly surveys the industry to determine the level of installations of foundations and turbines, and the subsequent dispatch of first power to the grid. The data includes demonstration sites and factors in decommissioning where it has occurred. Annual installations are expressed in gross figures while cumulative capacity represents net installations per site and country. Rounding of figures is at the discretion of the author.

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TEXT AND ANALYSIS:

Lizet Ramírez, WindEurope
Daniel Fraile, WindEurope
Guy Brindley, WindEurope

EDITOR:

Colin Walsh, WindEurope

DESIGN:

Lin Van de Velde, Drukvorm

FINANCE DATA:

Clean Energy Pipeline and IJ Global
All currency conversions made at EUR/ GBP 0.8777 and EUR/USD 1.1117
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PHOTO COVER:

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MORE INFORMATION:

policy@windeurope.org
+32 2 213 11 68

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WINDFLOAT ATLANTIC

Portugal

Status:

Partially online

Capacity:

25 MW

No. of turbines:

3

Owners:

EDPR (54.4%), Repsol (25%)
& Principle Power (19.4%)

Turbine model:

V164-8.4 MW (MHI Vestas)

Inter-array cable:

JDR Cable systems

Export cable:

Hengtong

Foundation type:

Semi-sub

Foundation supplier:

ASM Industries (66%) &
Navantia-Windrar Consortium (34%)

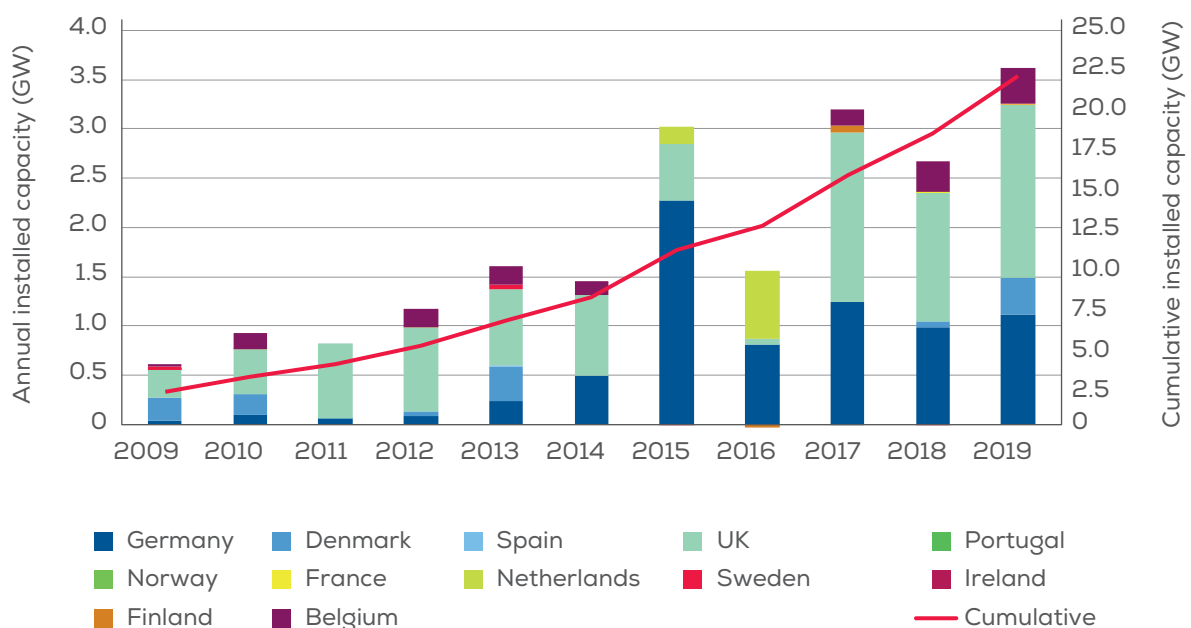
EXECUTIVE SUMMARY

Europe added 3,623 MW net offshore capacity in 2019. This corresponds to 502 new offshore wind turbines connected to the grid, across 10 wind farms.

Europe now has a total installed offshore wind capacity of 22,072 MW. This corresponds to 5,047 grid-connected wind turbines across 12 countries.

FIGURE A

Annual offshore wind installations by country (left axis) and cumulative capacity (right axis) (GW)



Source: WindEurope

Four new offshore wind projects reached Final Decision Investment (FDI) in four different countries during 2019, with construction starting in the coming years. Invest-

ments in new assets accounted to €6.0bn in order to finance 1.4 GW of additional capacity.

Installations in 2019

- Europe added 3,627 MW of new (gross) capacity. The UK (1,764 MW), Germany (1,111 MW), Denmark (374 MW), Belgium (370 MW) and Portugal (8 MW) supplied this new capacity to the grid.
- A net addition of 502 grid-connected offshore wind turbines across 10 wind farms were added from 1 January to 31 December 2019.
- 7 wind farms were completed (fully grid-connected). Another 3 have partial grid connection and will continue to connect turbines in 2020. Construction work started on 5 other wind farms where no turbines have yet been grid-connected.
- Siemens Gamesa Renewable Energy account for 62% of the turbines connected to the grid. MHI Vestas Offshore Wind connected 28% and supplied turbines to five countries.
- 2 turbines (2 MW each) were decommissioned at the Blyth Demonstrator in the UK.

Cumulative installations

- The installation and grid-connection of 5,047 turbines represents a cumulative 22,072 MW.
- There are now 110 offshore wind farms in 12 European countries (including sites with partial grid-connected turbines).
- The UK has the largest amount of offshore wind capacity in Europe, with 45% of all installations. Germany is second with 34%, followed by Denmark (8%), Belgium (7%) and the Netherlands (5%).
- Ørsted (16%), RWE (12%), Vattenfall (7%) and Macquarie (7%) are the largest owners of offshore wind farms.

Trends: turbine and wind farm size, depth, distance from shore, auctions

- The average rated capacity of turbines installed in 2019 was 7.8 MW, 1 MW larger than in 2018.
- The average size of wind farms in construction almost doubled in one decade (621 MW).
- The average distance to shore (59 km) and water depth (33 m) continue to increase even though most wind farms are bottom-fixed.
- All auction results in 2019 ranged between 40-50 €/MWh.
- Port of Rotterdam made history by installing the first GE Haliade-X 12 MW prototype.
- The first dynamic cable of 66 kV was installed by JDR for the Windfloat Atlantic.
- Hornsea One built the industry's first offshore reactive compensation platform.

Financing highlights

- In total 1.4 GW of new capacity reached Financial Investment Decision during 2019 in France, the Netherlands, Norway and the UK. The financing raised for the 4 wind farms was €6.0bn, 40% less than in 2018.
- Refinancing was also lower than in 2019, at €4.2bn, bringing total financing for the sector to €10.2bn.
- Non-recourse debt continues to be significant in offshore wind financing with €8.8bn lent in 2019. This represents the second highest annual amount after the record €16.5bn offered in 2018.
- 2019 saw €7.4bn of project acquisition activity, with 3.9 GW of projects in various stages of development acquiring new owners.
- 83% of acquisition investment was carried out by the financial services sector and two thirds of the acquisitions (by investment amount) was for operational wind farms.

BORSSELE 3&4

The Netherlands

Status:

Under construction

Capacity:

731.5 MW

No. of turbines:

77

Owners:

Partners Group (45%), Shell (20%),
Diamond Generating Europe
Limited (15%), Van Oord (10%) &
Eneco (10%)

Turbine model:

V164-9.5 MW
(MHI Vestas)

Inter-array cable:

Prysmian

Export cable:

NKT Group

Type of foundation:

Monopiles

Foundation supplier:

Sif



1.

OFFSHORE WIND INSTALLATIONS

1.1 OVERVIEW

Europe connected 3,623 MW of net offshore wind power capacity in 2019, setting a record in annual offshore installations. It added 3,627 MW of new (gross) capacity. The UK (1,764 MW), Germany (1,111 MW), Denmark (374 MW), Belgium (370 MW) and Portugal (8 MW) supplied this new capacity to the grid.

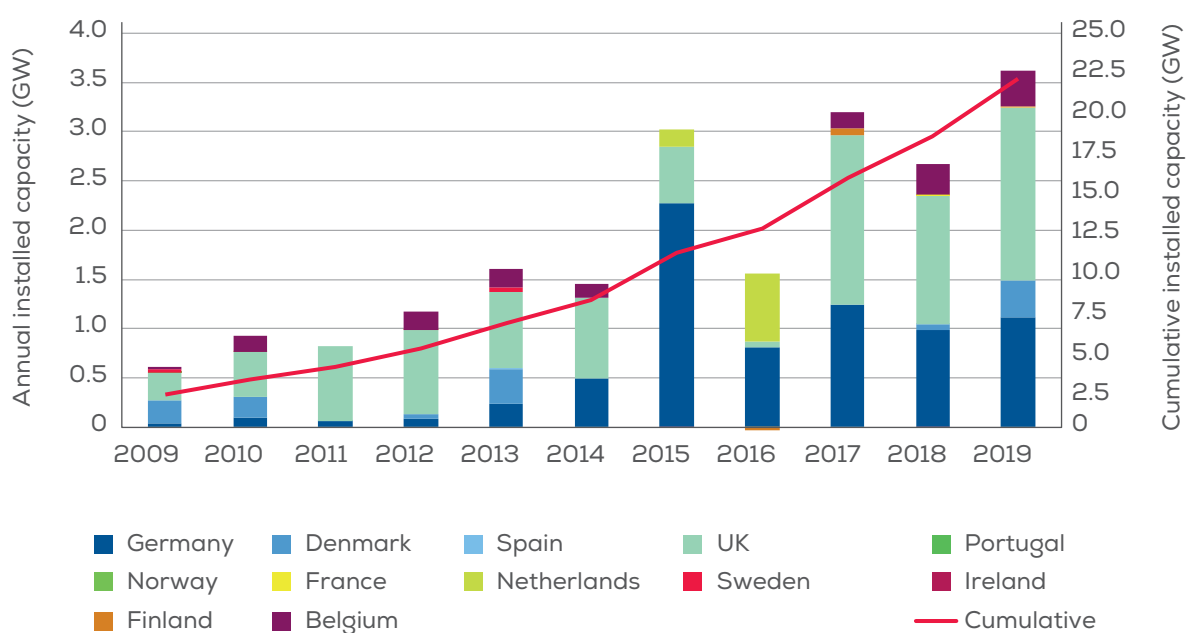
The UK, Denmark and Belgium set national installation records in 2019. The Netherlands did not connect any offshore turbine to the grid but started the installation of monopiles at the Borssele 3&4 sites, which are expected

to come online in 2020. Spain tested the first multi-turbine floating platform at the PLOCAN demonstration facilities in the Canary Islands. 2 turbines (2 MW each) were decommissioned at the Blyth Demonstrator in the UK.

Europe's cumulative offshore wind capacity reached 22,072 MW at the end of 2019. Including sites with partial grid connection, there are now 110 offshore wind farms in 12 European countries and 5,047 grid-connected wind turbines.

FIGURE 1

Annual offshore wind installations by country (left axis) and cumulative capacity (right axis)



Source: WindEurope

TABLE 1

Overview of grid-connected offshore wind power projects at the end of 2019

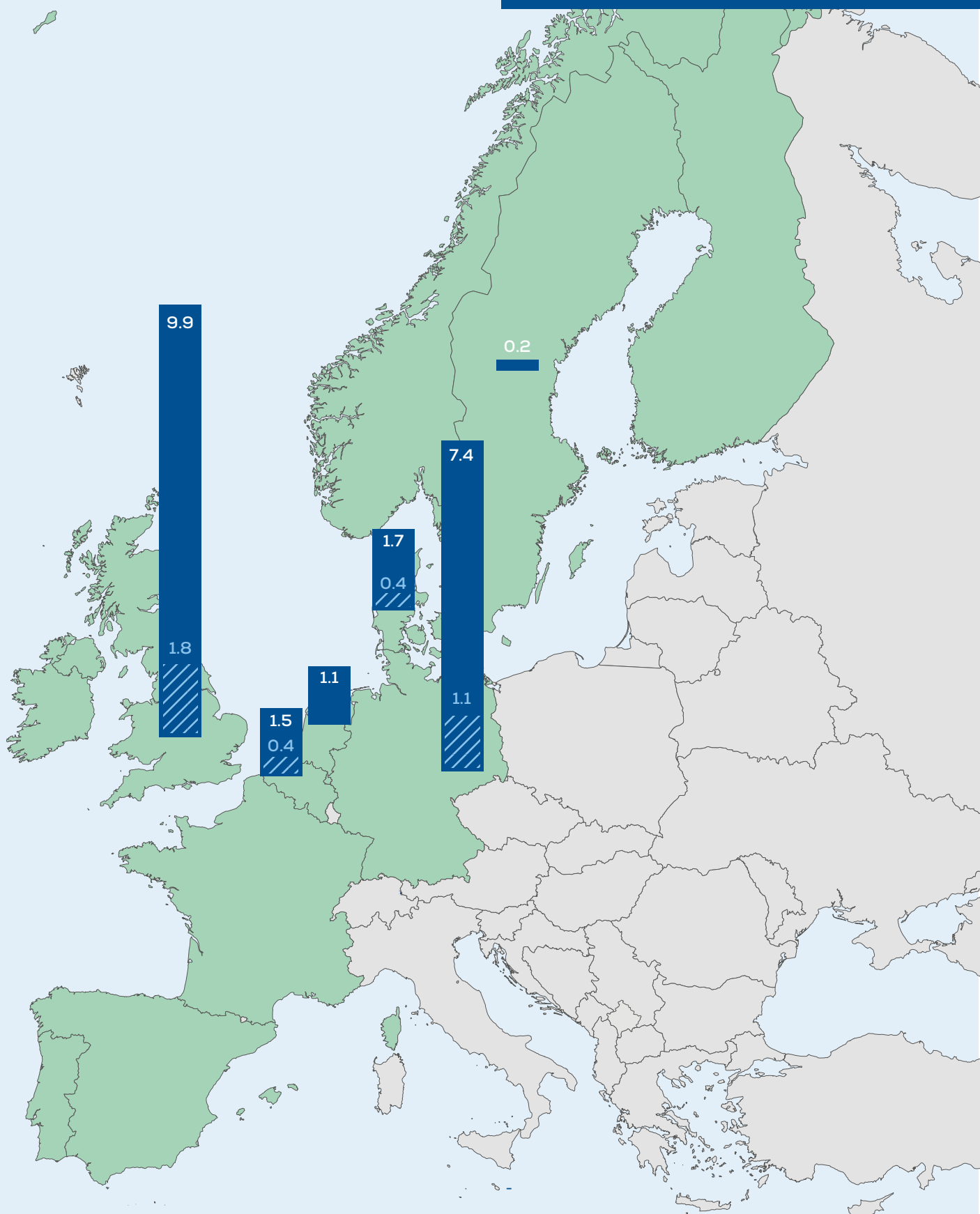
| COUNTRY | NO. OF WIND FARMS CONNECTED ¹ | CUMULATIVE CAPACITY (MW) | NO. OF TURBINES CONNECTED | NET CAPACITY CONNECTED IN 2019 (MW) | NO. OF TURBINES CONNECTED IN 2019 |
|--------------|--|--------------------------|---------------------------|-------------------------------------|-----------------------------------|
| UK | 40 | 9,945 | 2,225 | 1,760 | 252 |
| Germany | 28 | 7,445 | 1,469 | 1,111 | 160 |
| Denmark | 14 | 1,703 | 559 | 374 | 45 |
| Belgium | 8 | 1,556 | 318 | 370 | 44 |
| Netherlands | 6 | 1,118 | 365 | 0 | 0 |
| Sweden | 5 | 192 | 80 | 0 | 0 |
| Finland | 3 | 70.7 | 19 | 0 | 0 |
| Ireland | 1 | 25.2 | 7 | 0 | 0 |
| Spain | 2 | 5 | 2 | 0 | 0 |
| Portugal | 1 | 8.4 | 1 | 8 | 1 |
| Norway | 1 | 2.3 | 1 | 0 | 0 |
| France | 1 | 2 | 1 | 0 | 0 |
| Total | 110 | 22,072 | 5,047 | 3,623 | 502 |

1. It includes 14 demonstrators (single turbine or announced as demonstrator by developer).

Cumulative installed capacity at the end of 2019



3.6 GW²
OF NEW OFFSHORE
WIND POWER IN EUROPE
22.1 GW
TOTAL EUROPE



1.2 NATIONAL BREAKDOWN OF 2019 INSTALLATIONS

The UK, with a 1,764 MW record, represents nearly half (48.5%) of the capacity brought online in Europe in 2019. Beatrice 2 was fully commissioned last year with the installation of 40 turbines. Hornsea One connected all its turbines to the grid, after three years of construction work, making it the largest offshore wind farm in the world (1,218 MW). East Anglia Offshore Wind 1 is now partially online, with almost half of the wind farm capacity supplying power. Blyth Demonstrator Phase 1 becomes the first wind farm to be decommissioned in the UK removing 2 turbines of 2 MW each after 19 years of operation.

Germany connected 1,111 MW (30.5%) across 3 wind farms in 2019, an increase of 13% compared to last year. Merkur Offshore (252 MW), Deutsche Bucht (260.4 MW) and EnBW Hohe See (497 MW) are fully operational today. The EnBW Hohe See is the largest offshore wind farm in Germany to date.

Denmark connected 374 MW (10%), setting a national installation record. Horns Rev 3 wind farm was fully commissioned, with a total capacity of 407 MW. It is the largest operational wind farm in Denmark.

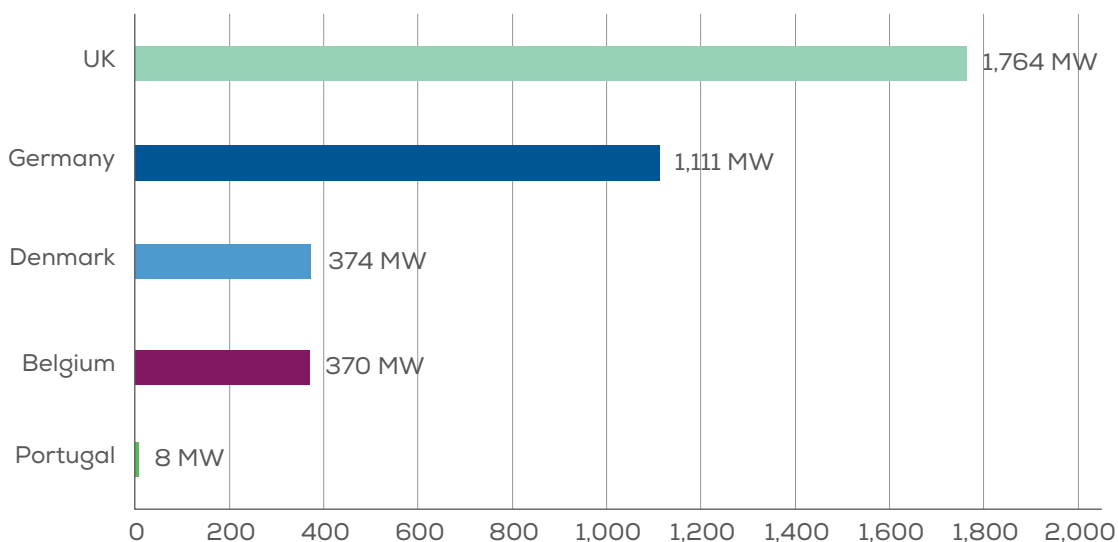
Belgium connected 370 MW (10%), setting a national installation record. Norther wind farm was fully commissioned after installing 44 units of the V164-8.4 MW. Norther is now the largest operational offshore wind farm in Belgium.

Portugal connected one of three turbines at Windfloat Atlantic Phase 1. This makes the V164-8.4 MW the largest installed floating turbine in the world. It uses semi-sub technology.

Spain tested the first semisubmersible multi-turbine floating platform. The Wind2Power 200 kW (1:6 scale prototype) was successfully tested offshore for 3 months at the PLOCAN test facility.

The Netherlands did not add capacity to the grid but concluded the installation of almost half of the monopile foundations at Borssele 3&4. The 731.5 MW wind farm is expected to be commissioned in 2021. In November the Port of Rotterdam made history by hosting the installation of the first GE Haliade-X 12 MW prototype.

FIGURE 2
Annual gross offshore wind capacity installations per country in 2019 (MW)



Source: WindEurope

2. Only showing those countries with more than 0.1 GW.

In total 15 offshore wind farms across 6 countries had works going on last year. 10 wind farms connected turbines to the grid (see table 2). 5 wind farms installed foundations but did not connect any turbine to the grid (see table 3).

Last year over 99% of installations happened in the North Sea. The Windfloat Atlantic saw 1 turbine grid-connected in the Atlantic Sea.

TABLE 2

The new offshore wind installations with grid connection in 2019

| COUNTRY | WIND FARM | CAPACITY CONNECTED IN 2019 (MW) | NUMBER OF TURBINES CONNECTED | TURBINE MODEL | TYPE OF FOUNDATION | STATUS ³ |
|----------|-----------------------------|---------------------------------|------------------------------|--------------------------|--------------------|---------------------|
| UK | Hornsea One | 1,218.0 | 174 | SWT-7.0-154 (SGRE) | Monopile | ●●●●● |
| | Beatrice 2 | 315.0 | 45 | SWT-7.0-154 (SGRE) | Jacket | ●●●●● |
| | East Anglia Offshore Wind 1 | 231.0 | 33 | SWT-7.0-154 (SGRE) | 3-Leg jacket | ●●○○○ |
| Germany | EnBW Hohe See | 497.0 | 71 | SWT-7.0-154 (SGRE) | Monopile | ●●●●● |
| | Deutsche Bucht | 260.4 | 31 | V164-8.4 MW (MHI Vestas) | Monopile | ●●●●● |
| | Merkur Offshore | 252.0 | 42 | Haliade 150-6MW (GE) | Monopile | ●●●●● |
| | Trianel Windpark Borkum 2 | 101.3 | 16 | 6.2M152 (Senvion) | Monopile | ●●●○○ |
| Denmark | Horns Rev 3 | 373.5 | 45 | V164-8.3 MW (MHI Vestas) | Monopile | ●●●●● |
| Belgium | Norther | 369.6 | 44 | V164-8.4 MW (MHI Vestas) | Monopile | ●●●●● |
| Portugal | Windfloat Atlantic Phase 1 | 8.4 | 1 | V164-8.4 MW (MHI Vestas) | Semi-sub | ●●○○○ |

Source: WindEurope

TABLE 3

Wind farms under construction in 2019 but not yet grid-connected

| COUNTRY | WIND FARM | FOUNDATIONS INSTALLED IN 2019 | TOTAL NUMBER OF FOUNDATIONS | TURBINE MODEL | TYPE OF FOUNDATION |
|-------------|---------------|-------------------------------|-----------------------------|--------------------------|--------------------|
| Germany | EnBW Albatros | 16 | 16 | SWT-7.0-154 (SGRE) | Monopile |
| Netherlands | Borssele 3&4 | 30 | 77 | V164-9.5 MW (MHI Vestas) | Monopile |
| Belgium | Northwester 2 | 23 | 23 | V164-9.5 MW (MHI Vestas) | Monopile |
| | Mermaid | 28 | 28 | SG 8.4-167 DD (SGRE) | Monopile |
| | Seastar | 30 | 30 | SG 8.4-167 DD (SGRE) | Monopile |

Source: WindEurope

3. One bar <25% grid connected. 2 bars <50% grid connected. 3 bars <75% grid connected. 4 bars <100% grid connected.

1.3 CUMULATIVE INSTALLATIONS

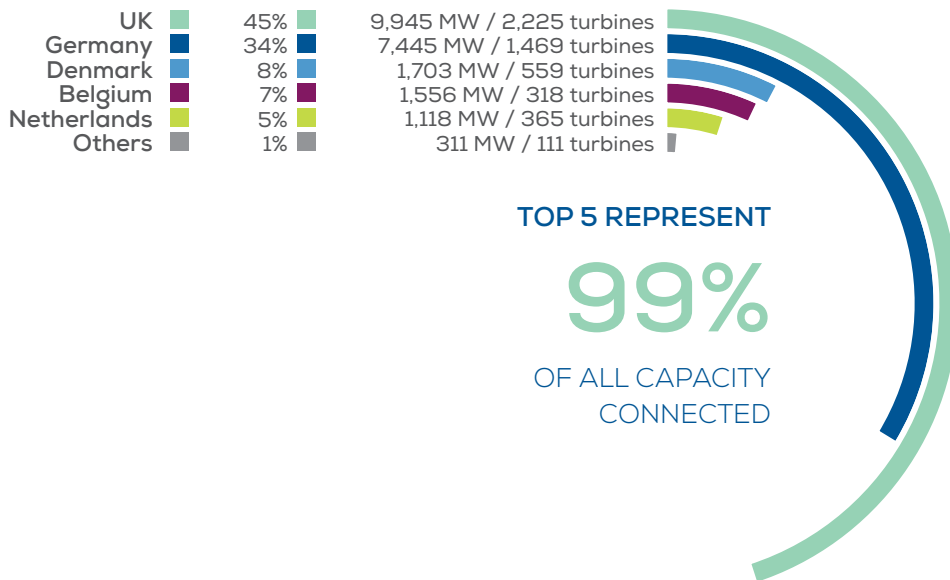
Today there are 22,072 MW of installed capacity across Europe. This is a total of 5,047 turbines connected to the grid across 12 countries. Five countries – the UK, Germany, Denmark, Belgium and the Netherlands – represent 99% of this capacity.

The UK has the largest amount of offshore wind capacity in Europe with 45% of all installations. Germany is second with 34%, followed by Denmark (8%), Belgium (7%) and the Netherlands (5%).

Other countries include Spain, Finland, France, Sweden, Norway, Ireland and Portugal. These countries collectively represent 1% of the installed capacity.

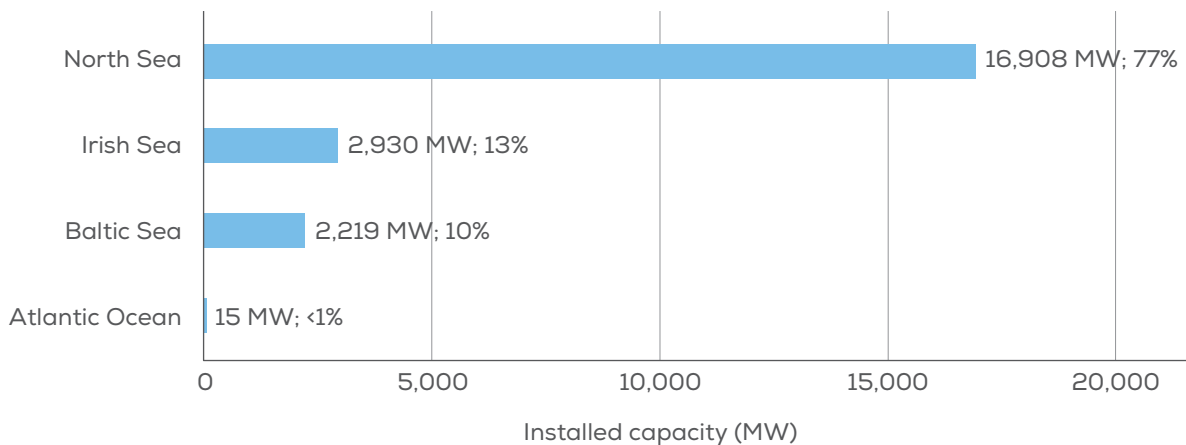
Cumulatively, the North Sea accounts for 77% of all off-shore wind capacity in Europe. The Irish Sea (13%), the Baltic Sea (10%) and the Atlantic Sea (<1%) follow this rank.

FIGURE 3
Cumulative installed capacity (MW) and number of turbines by country



Source: WindEurope

FIGURE 4
Cumulative installed capacity by sea basin (MW)



Source: WindEurope

HORNSEA ONE

UK

Status:

Fully grid-connected

Capacity:

1,218 MW

No. of turbines:

174

Owners:

Ørsted (50%) & Global
Infrastructure Partners (50%)

Turbine model:

SWT-7.0-154 (SGRE)

Inter-array cable:

JDR Cable Systems

Export cable:

NKT Group

Type of foundation:

Monopiles

Foundation supplier:

EEW



2.

TRENDS: TURBINE SIZE, WIND FARM LOCATION

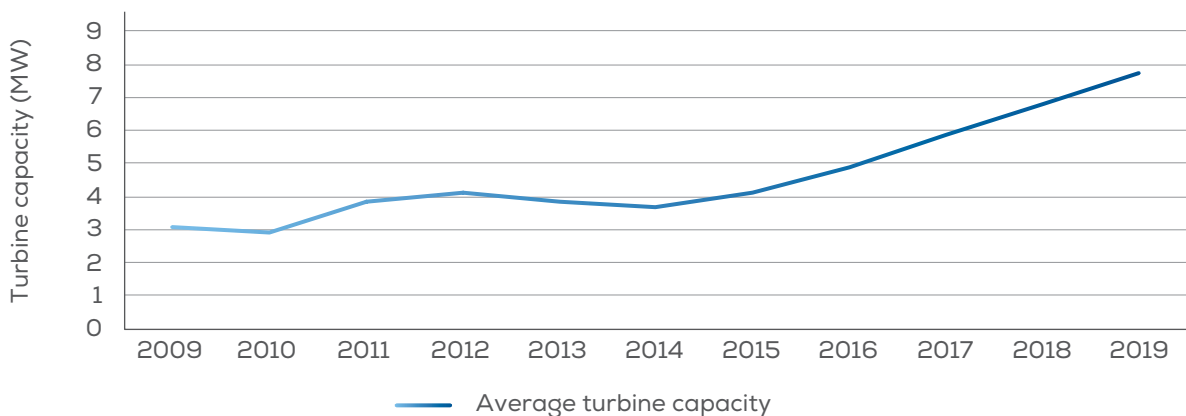
2.1 WIND TURBINE RATED CAPACITY

Offshore wind turbines continue to get more powerful. On average, turbine capacity has increased by 16% every year since 2014. The average rated capacity of turbines installed in 2019 is 7.8 MW, 1 MW larger than last year.

The MHI Vestas V164-8.4 MW was the largest turbine grid-connected in 2019. It stands on monopiles at

Deutsche Bucht (Germany) and Norther (Belgium). It is also the largest floating wind turbine at Windfloat Atlantic 1 (Portugal). Northwester 2 and Borssele 3&4 started the installation of foundations, preparing the ground to install the MHI Vestas V164-9.5 MW in 2020.

FIGURE 5
Yearly average of newly installed offshore wind turbine rated capacity (MW)



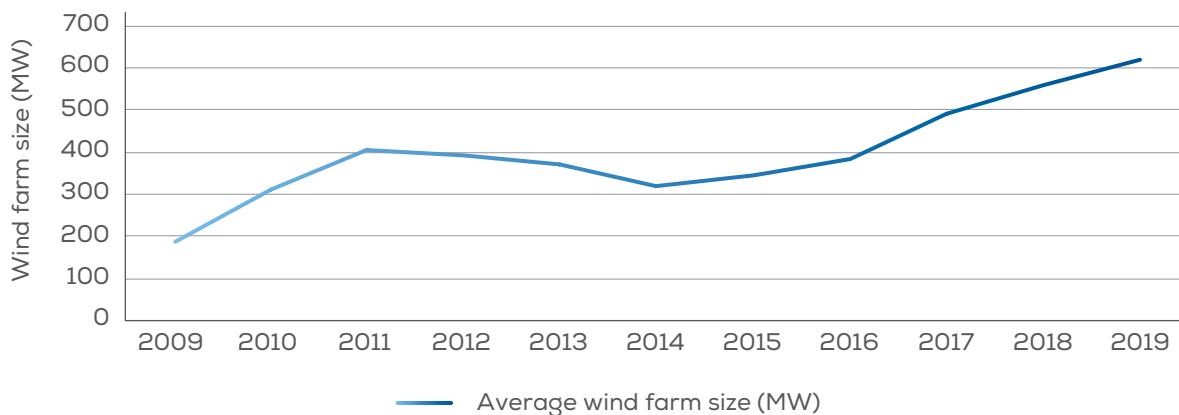
Source: WindEurope

2.2 WIND FARM SIZE

Offshore wind farms continue to get bigger. Size almost doubled over a decade from 313 MW in 2010 to 621 MW in 2019. The UK has the largest wind farms as a result of the extensive Exclusive Economic Zone (EEZ) surrounding

the country's coastline. The East Anglia (714 MW) and Hornsea One (1,218 MW) are both the largest offshore wind farms already supplying electricity to the grid.

FIGURE 6
Average size of commercial offshore wind farm projects in the year (MW)

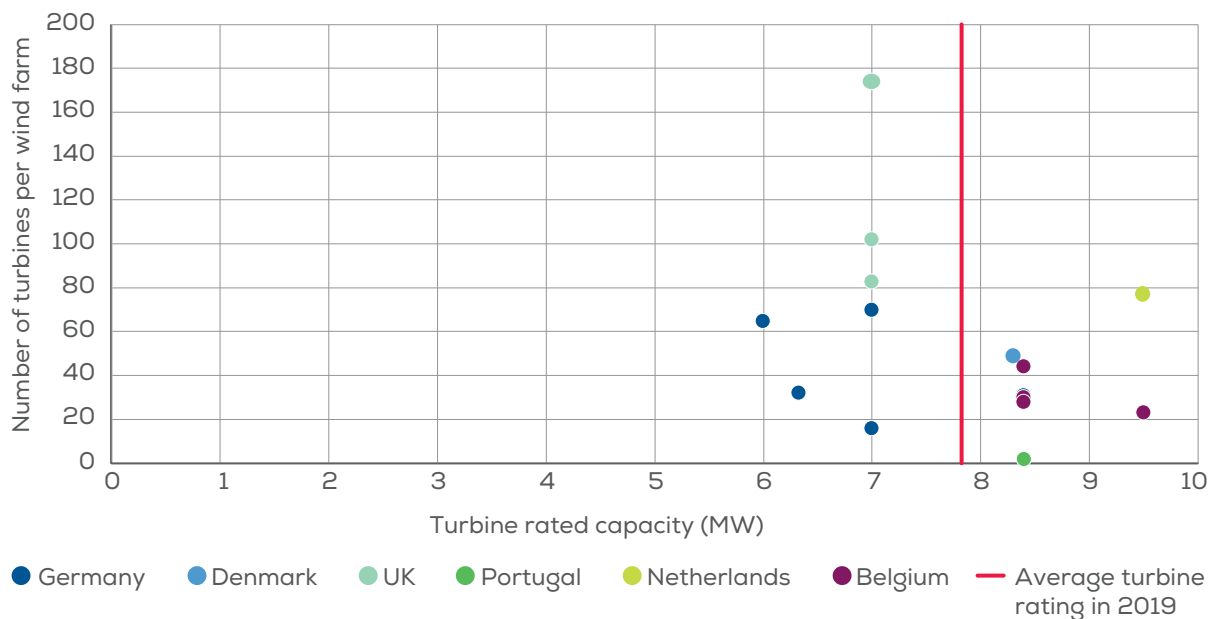


Source: WindEurope

Three quarters of the wind farms with activities currently at sea are using turbines of 7 MW and above (the average turbine rated power is 7.8 MW, indicated by the red line

in figure 7. The only exceptions are Merkur Offshore using the GE Haliade 150-6 MW and Trianel Windpark Borkum 2 with the 6.2 MW Senvion wind turbines.

FIGURE 7
Average turbine rated capacity and number of turbines at wind farms under construction in 2019



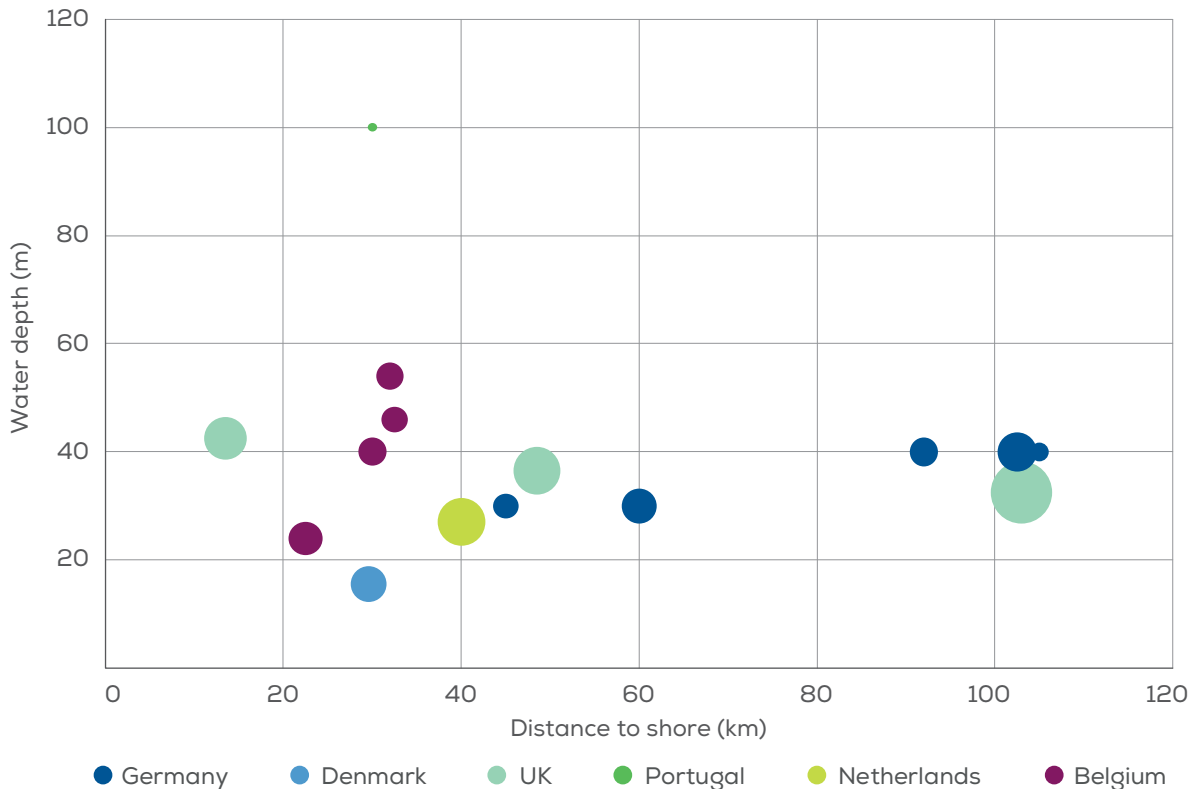
Source: WindEurope

2.3 WATER DEPTH AND DISTANCE TO SHORE

Wind farms are moving farther offshore and into deeper waters. This is a result of both better stable wind resources and the depletion of near-shore locations.

FIGURE 8

Average water depth and distance to shore of offshore wind farms under construction during 2019. The size of the bubble indicates the capacity of the site



Source: WindEurope

The average water depth of offshore wind farms under construction in 2019 was 33m, a slight increase from 2018 (30m). The deepest projects are Hywind demo (220m) and Hywind Scotland (108m) with spar-buoy. The Windfloat Atlantic is one of the deepest projects (100m) with turbines on the water. It uses a semi-sub foundation.

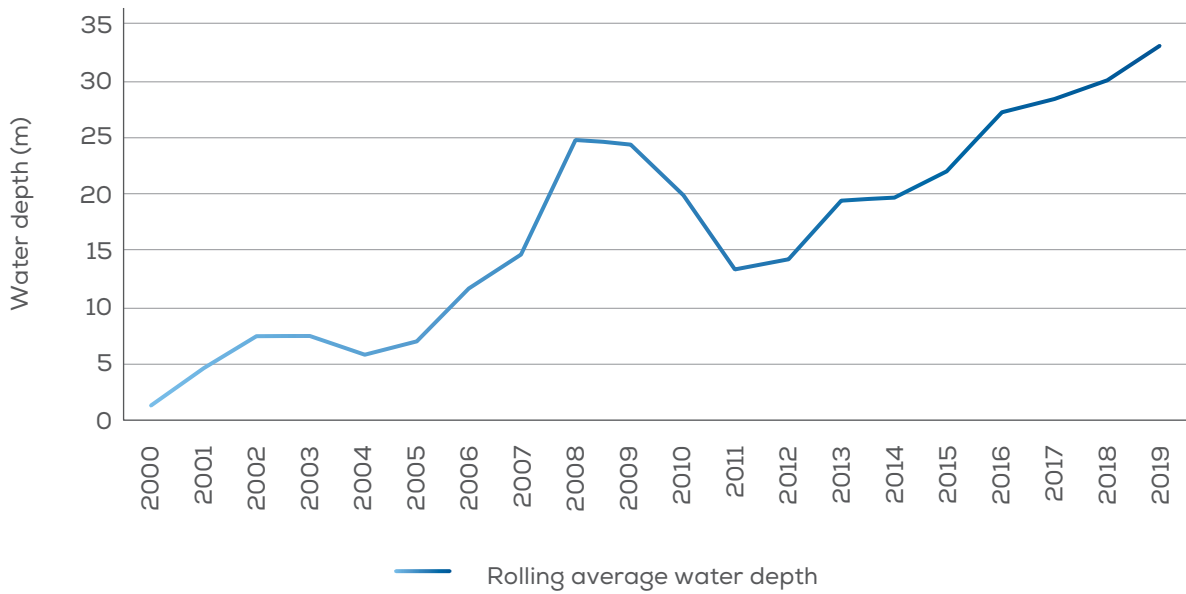
The average distance to shore of offshore wind farms under construction in 2019 was 59 km, a notable increase on last year's average (35 km). Hornsea One in the UK and EnBW Hohe See and EnBW Albatros in Germany are currently the farthest wind farms from shore with over 100 km each. Deutsche Bucht (Germany) follows with 92 km.

The three German wind farms export electricity to shore using the same offshore substation. TenneT GmbH owns and operates the BorWin 2 HVDC offshore substation at 300 kV. In the case of Hornsea One, the developer Ørsted has opted for HVAC at 220 kV and built the industry's first offshore reactive compensation platform to compensate for the losses of such a large AC transmission line.

New offshore wind farms under construction and with permits are moving farther away. The rolling averages of both water depth and distance to shore have a clear increasing trend (see figures 9 and 10)⁴.

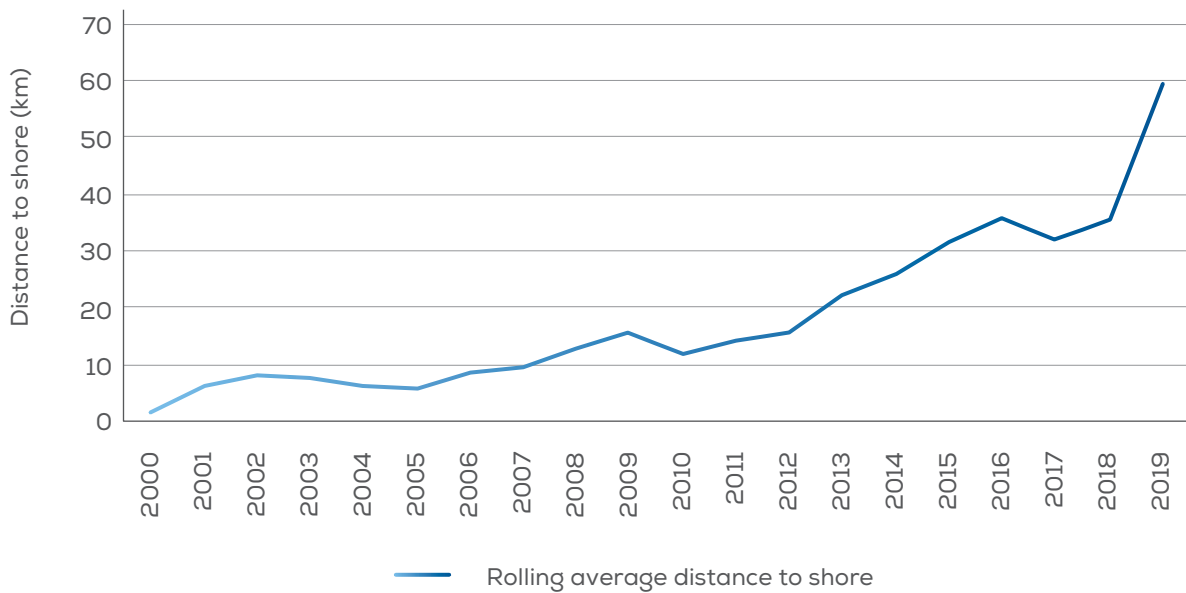
4. Rolling averages of three years have been used for water depth and distance to shore. A rolling average is the calculation of successive averages of different data subsets to identify long-term trends.

FIGURE 9
Rolling average water depth of online offshore wind farms



Source: WindEurope

FIGURE 10
Rolling average distance to shore of online offshore wind farms



Source: WindEurope

2.4 FLOATING WIND

Europe's floating wind fleet is the largest worldwide (70%) with a total of 45 MW by the end of 2019. This includes Hywind Demo (2.3 MW), SeaTwirl S1 (0.3 MW), Hywind Scotland (30 MW), Floatgen (2 MW), Kincardine Pilot (2 MW) and the Windfloat Atlantic Phase 1 (25.2 MW).

The Wind2Power 1:6 scale prototype of 200 kW, part of the WIP10+ European funded project, was successfully tested at PLOCAN site in the Canary Islands from June to October 2019.

Demonstration projects are testing different floating concepts with the objective to reduce cost or upscale previ-

ous demonstrators. The DemoSATH (SAITEC), TetraSpar (Stiesdal), SeaTwirl S2 (SeaTwirl), Eolink (Eolink), and EU projects such as FLOTANT and X1Wind are examples of these innovative designs.

The next three years will significantly increase this capacity with the installation of projects in the UK, France, Norway and Portugal. Pre-commercial projects for the next three years will range between 24 MW to 88 MW (see table 4). The average project size will be four times larger (35 MW) than the installations of the past 5 years.

TABLE 4
Floating wind farms coming online in the next three years

| COUNTRY | WIND FARM | CAPACITY (MW) | FLOATER TYPE | TURBINES NUMBER AND MODEL | EXPECTED COMMISSIONING DATE ⁵ |
|----------|-------------------------------|-------------------|--------------|-------------------------------|--|
| Portugal | Windfloat Atlantic Phase 1 | 25.0 | Semi-sub | 3 x V164-8.4 MW (MHI Vestas) | 2020 ⁶ |
| France | EolMed | 24.0 | Barge | 4 x 6.2M152 (Senvion) | 2021/2022 |
| | Provence Grand Large | 28.5 | TLP | 3 x V164-9.5MW (MHI Vestas) | 2021 |
| | EFGL | 30.0 | Semi-sub | 3 x V164-10.0 MW (MHI Vestas) | 2022 |
| | Eoliennes Flottantes de Groix | 28.5 | TLP | 3 x V164-9.5MW (MHI Vestas) | 2022 |
| UK | Kincardine | 50.0 ⁷ | Semi-sub | 5 x V164-9.5MW (MHI Vestas) | 2021 |
| Norway | Hywind Tampen | 88.0 | Spar-buoy | 11 x SG 8.0-167 DD (SGRE) | 2022 |

Source: WindEurope

The turbine size has significantly increased in floating projects, reaching same capacities as bottom-fixed wind farms.

France is currently the only country with auctions for floating wind in its National Energy and Climate Plan (NECP)⁸.

In 2021 France will launch the first 250 MW auction and in 2022 it will host two auctions of 250 MW each. The auctions have a target price of 120 €/MWh and 110 €/MWh respectively. The results of these auctions will determine the conditions for the next auctions from 2024⁹ onwards.

5. As announced by the developer or latest press release available.

6. Wind farm is partially online.

7. Kincardine will be in total 50 MW, adding 48 MW to the 2 MW floating turbine currently in operation.

8. Plan National Integre Energie-Climat de la France pour consultation du public (January, 2020).

9. Indicative auctions of 1,000 MW per year bottom-fixed or floating depending on prices and seabed conditions.

HORNS REV 3

Denmark

Status:

Fully commissioned

Capacity:

406.7 MW

No. of turbines:

49

Owners:

Vattenfall

Turbine model:

V164-8.3 MW (MHI Vestas)

Inter-array cable:

Prysmian

Export cable:

ABB

Type of foundation:

Monopiles

Foundation supplier:

EEW

3.

INDUSTRY ACTIVITY AND SUPPLY CHAIN

3.1 WIND TURBINE MANUFACTURERS

Siemens Gamesa Renewable Energy (SGRE) connected 62% of all the new grid-connected capacity in 2019. They supplied 323 turbines grid-connected (SWT-7.0-154 model) to three UK wind farms (Hornsea One, Beatrice 2, East Anglia Offshore 1) and two German wind farms (EnBW Albatros and Hohe See). Their newer model, SG 8.4-167 DD, will be installed in 2020 at the Mermaid and Sea Star wind farms in Belgium, where they are currently installing foundations. In November 2019 SGRE unveiled the first prototype nacelle of their newest model, the SG 193-10 MW. Commercial deployment is slated for 2022/2023, when they will be installed at the Hollandse Kust Zuid projects in the Netherlands.

MHI Vestas Offshore Wind connected 28% of all the new grid-connected capacity in 2019, supplying to five different European countries – Belgium, Denmark, Germany, the Netherlands and Portugal. All the turbines supplied used the same 164m long rotor, with variations in the nameplate capacity from 8 to 8.4 MW depending on the developer's choice. The most installed turbine was

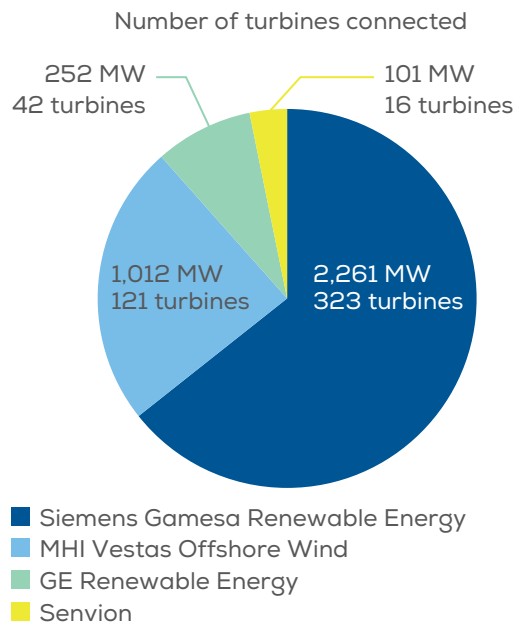
the V164-8.4 MW, with 75 turbines installed in Norther (Belgium) and Deutsche Bucht (Germany). Their MHI Vestas V164-9.5 will be installed in 2020 at Northwester 2 (Belgium) and Borssele 3&4 (The Netherlands) and the typhoon proofed newer model with 174 m rotor diameter will be installed in Arcadis Ost 1 and Baltic Eagle in 2022.

GE Renewable Energy supplied 7% of the connected turbines, connecting 42 units of the Haliade 70-6 MW at Merkur Offshore wind farm (Germany). In November 2019 the first GE Haliade-X 12MW prototype was installed at the Port of Rotterdam (onshore). The prototype already holds the record for generating 262 MWh in a span of 24 hours and has a selling agreement with the Dutch utility Eneco. SSE and Equinor have announced that they will use this turbine for the three Dogger Bank sites (1,200 MW each) won during the last UK auction in September 2019, expected to come online in 2024/2025.

Senvion supplied 3% of the connected turbines with 16 units at the Trianel Windpark Borkum 2 in Germany.

FIGURE 11

Wind turbine manufacturers' share of the 2019 installations (MW) and number of turbines connected to the grid

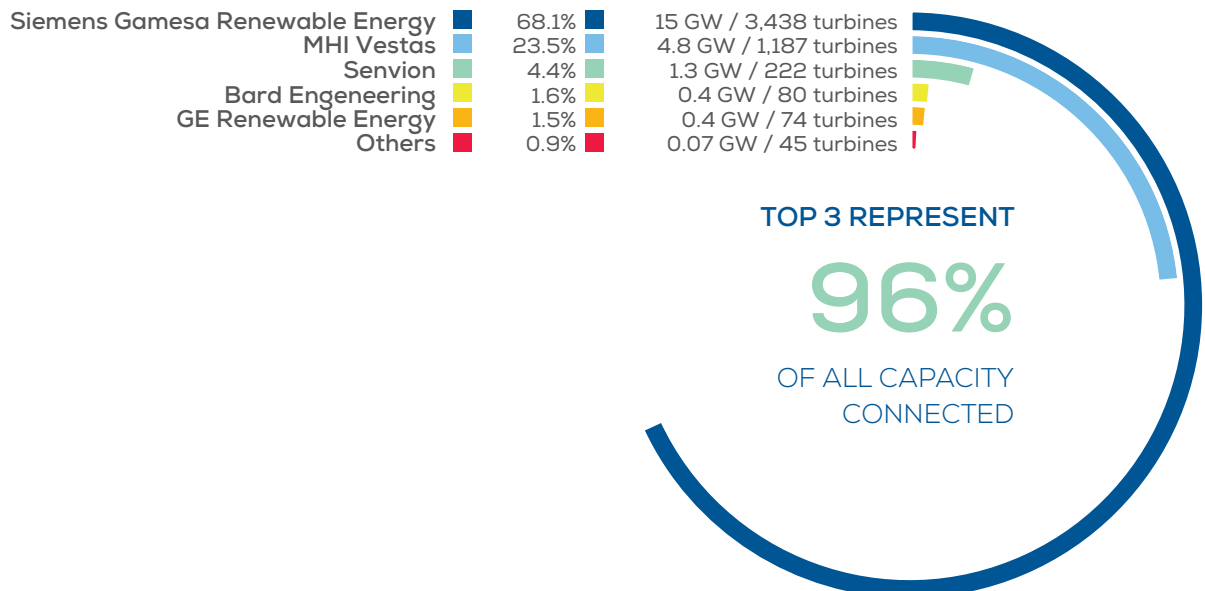


In cumulative terms, SGRE has the most offshore wind turbines in Europe with 68.1% of the total installed capacity (see figure 12). MHI Vestas Offshore Wind is the second largest turbine supplier with 23.5%, followed by Senvion (4.4%). These 3 manufacturers represent 96% of the total offshore capacity connected in Europe at the end of 2019.

Source: WindEurope

FIGURE 12

Wind turbine manufacturers' share at the end of 2019



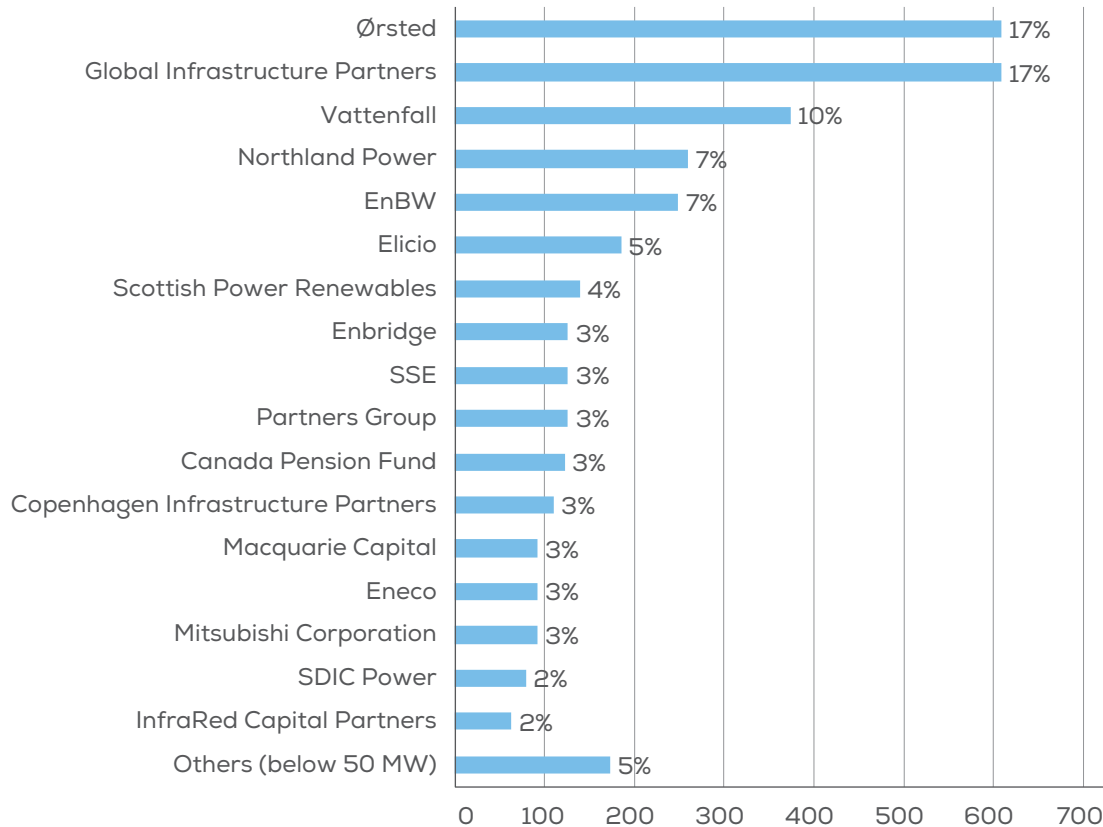
Source: WindEurope

3.2 WIND FARM OWNERS

Ørsted and Global Infrastructure Partners connected the largest amount of wind capacity in 2019, with 17% of the annual share each¹⁰. Vattenfall (10%), Northland Power

(7%) and EnBW (7%) all have a share of more than 5%. Together, the top five account for 58% of all new capacity in 2019.

FIGURE 13
Owners' share of 2019 annual installations (MW)



Source: WindEurope

Ørsted continues to have the largest share of offshore wind power in Europe with 16% of the total capacity at the end of 2019 (figure 14). RWE¹¹ comes second with 12% of the share after acquiring all the assets from Innogy

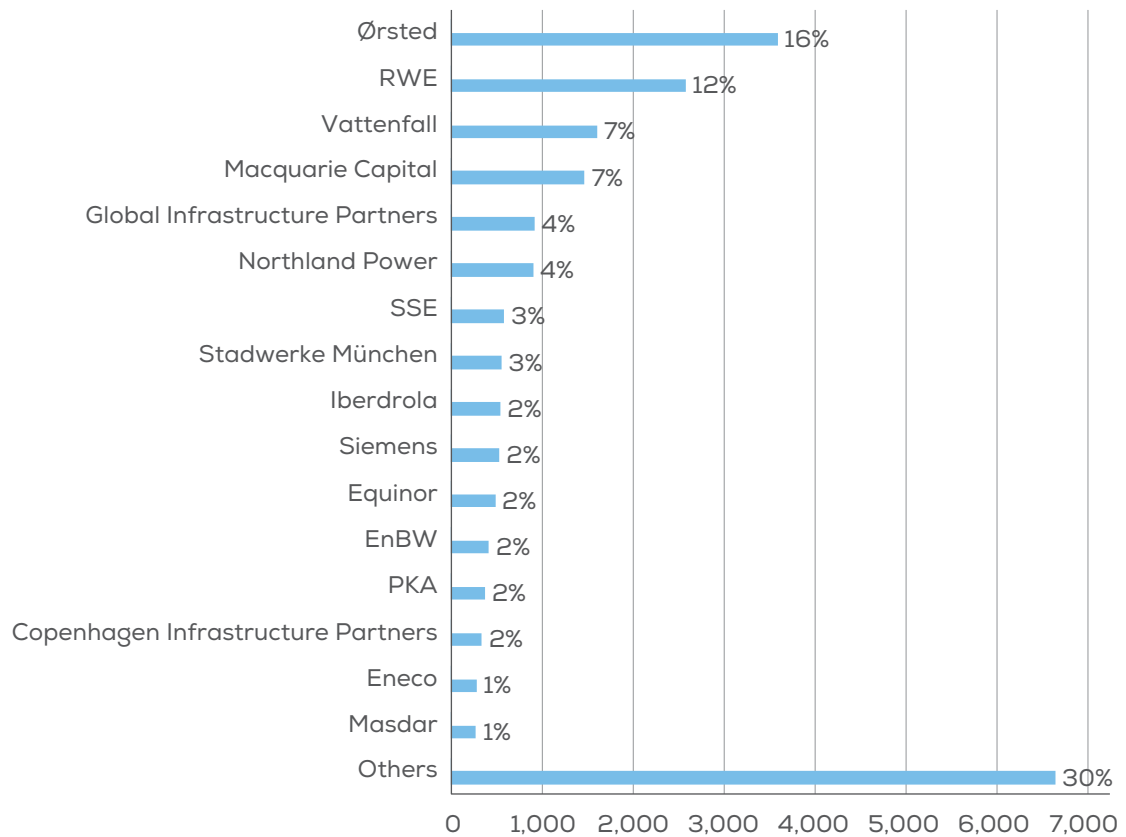
and E.ON Renewable Energy. Vattenfall (7%), Macquarie Capital (7%), Global Infrastructure Partners (4%) and Northland Power (4%) follow this rank. The top six owners represent half of all installed capacity in Europe.

10. Grid-connected market shares are indicative only. Projects owned or developed by several companies have been split according to their respective shares. Where the shares are not known, they have been split in equal parts between the partners.

11. All projects from E.ON and Innogy have been merged under RWE's ownership to estimate these shares

FIGURE 14

Owners' share of total cumulative installed capacity at the end of 2019 (MW)¹²



Source: WindEurope

3.3 SUBSTRUCTURES AND FOUNDATIONS

Monopiles remained the most popular substructure type in 2019 with 70% of all newly-installed foundations. Jackets were the second most used substructure, with 65 three-leg jackets installed in 2019 at East Anglia Offshore 1, representing 29% of all foundations installed.

One semi-sub floater was installed for the Windfloat Atlantic Phase 1 project. One semi-sub multi-

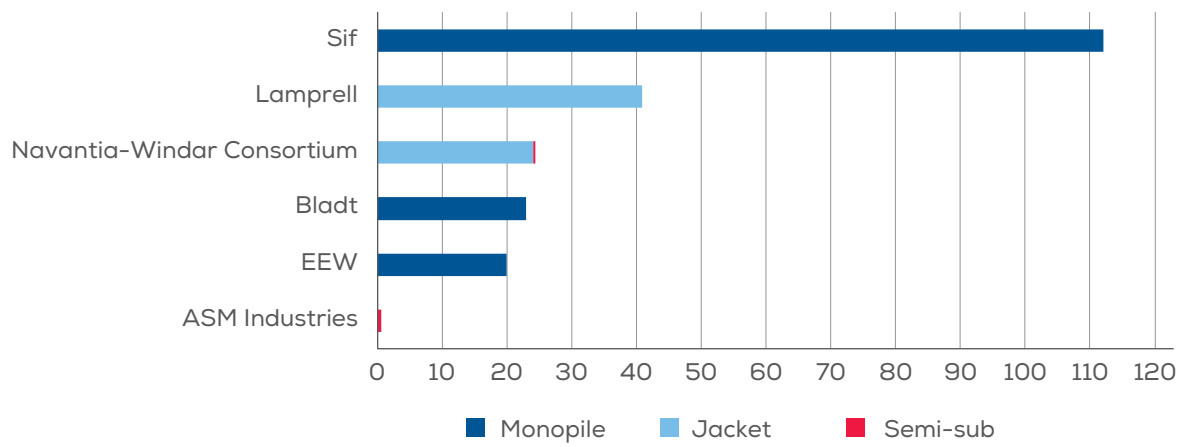
turbine floating prototype, Wind2Power, was tested in Spain for the WIP10+ project.

With regards to the suppliers, Sif supplied half of all foundations in 2019 followed by Lamprell (19%). Navantia-Windar Consortium (11%), Bladt (10%) and EEW (9%) had nearly the same share and ASM was supplier for the Windfloat Atlantic¹³.

12. Only displaying owner with over 250 MW in cumulative capacity.

13. Windfloat Atlantic Phase 1 is supplied by ASM Industries (2 floating platforms) and Navantia-Windar Consortium (1 floating platform).

FIGURE 15
Foundations installed in 2019 by manufacturing company¹⁴

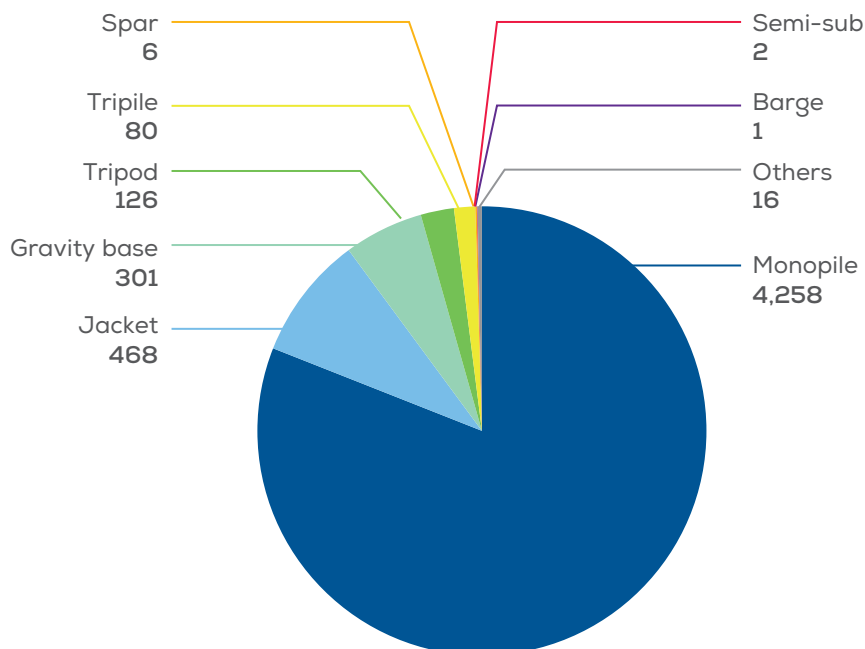


Source: WindEurope

Monopiles remain the most installed foundation, with 4,258 units (81%) up to date. This includes all foundations installed with and without grid connection. The jackets share (8.9%) increased with the installations at Beatrice 2 in 2019.

Gravity base (5.7%), tripod (2.4%), and tripile (1.5%) follow the cumulative share.

FIGURE 16
Number of foundations grid-connected by substructure type



Source: WindEurope

14. Shares are calculated according to the actual number of individual foundations installed in 2019. Where the project developer contracted more than one company to manufacture the foundations, and where the respective shares (in case of consortia/joint venture) were not specified, foundations installed were split in equal parts between the partners.

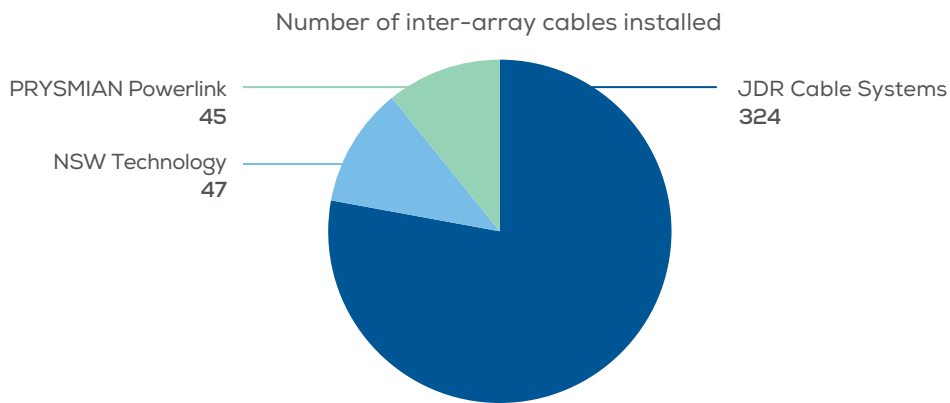
3.4 CABLES

The market for inter-array cables (i.e. the cables used to connect turbines with each other and with the main substations at the wind farm) continues to be dominated by three cable companies. In 2019 JDR Cable Systems represented over three quarters of all installations (78%). They

installed dynamic cables at 66 kV at Windfloat Atlantic in Portugal for the first-time.

NSW Technology and Prysmian both had 11% of the annual share.

FIGURE 17
Share of inter-array cable suppliers for energised cables in 2019

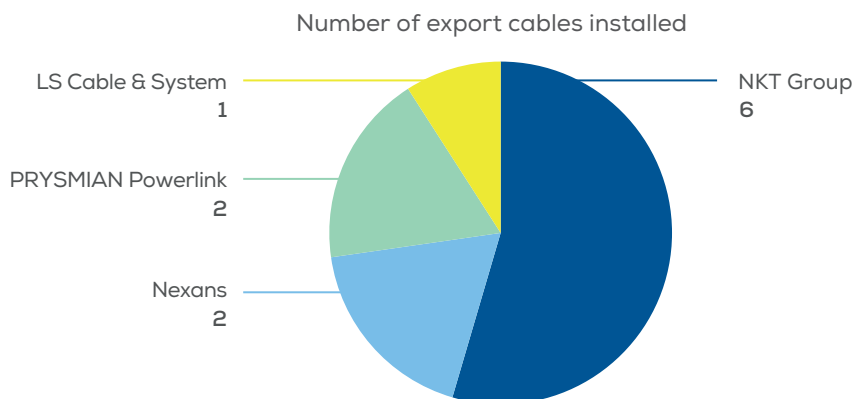


Source: WindEurope

NKT Group continues representing over half (55%) of the export cables installed, manufacturing 6 export cables energised in 2019.

Nexans (18%), Prysmian (18%) and LS Cable & System (9%) follow this. JDR did not supply any of the export cables energised in 2019.

FIGURE 18
Share of export cable suppliers for energised cables in 2019¹⁵



Source: WindEurope

15. Shares are calculated by taking into account the number of export cables in new wind farms fully completed. Number of cables energised include Hornsea One (3), EnBW Hohe See (1), Horns Rev 3 (2), Norther (1), Beatrice 2 (2), Deutsche Bucht (1), Merkur (1).

3.5 VESSELS

During 2019 at least 12 different vessel companies were active in the installation of foundations, turbines, inter-array and/or export cables¹⁶.

The heavy-lift jack-up vessel Innovation (Geosea) serviced the most wind farms, installing foundations at EnBW Albatros and Hohe See (Germany) and at Mermaid and Seastar (Belgium). Jan de Nul, Seajacks and Van Oord installed monopiles at one wind farm each. Scylla (Seajacks) installed monopiles at Deutsche Bucht and Deep Cygnus (Volstad Maritime AS) was the offshore vessel used to install the first unit at Windfloat Atlantic.

Turbines were installed and connected at 10 wind farms in 2019. Fred Olsen Windcarrier made most of the installations. Its Brave Tern and Bold Tern vessels were active in EnBW Albatros and Hohe See (Germany), East Anglia Off-

shore Wind 1 and Hornsea One (UK). Jan de Nul, Van Oord and A2Sea installed turbines in two wind farms each, and Swire Blue Ocean completed turbine installations at Beatrice 2 (UK).

Boskalis Subsea installed inter-array cables in East Anglia Offshore Wind 1 and EnBW Albatros. Nexus, the first cable-laying vessel from Van Oord, serviced Deutsche Bucht and Norther. Seaway 7 was active at Trianel Windpark Borkum 2.

The Livingstone cable-laying and multipurpose vessel from Tideway installed the export cable for Mermaid and Seastar. Nexus, from Van Oord, performed the export cable installation at Deutsche Bucht. DeepOcean supplied their first floating project with the installation at the Windfloat Atlantic using the T1 Trencher.

TABLE 5

Wind farms serviced by vessel provider that were installing turbines, foundations, inter-array and export cables in 2019

| VESSEL PROVIDER | INSTALLATION OF | | | |
|---------------------------|--|--|--|--------------------|
| | TURBINES | FOUNDATIONS | INTER-ARRAY CABLES | EXPORT CABLES |
| A2Sea | East Anglia Offshore Wind 1 Hornsea One | | | |
| Boskalis Subsea | | | East Anglia Offshore Wind 1 EnBW Albatros | |
| DeepOcean | | | | Windfloat Atlantic |
| Fred Olsen Windcarrier | EnBW Albatros EnBW Hohe See Horns Rev 3 Hornsea One | | | |
| Geosea | | EnBW Albatros EnBW Hohe See Mermaid Seastar | | |
| Jan de Nul | Northwester 2 Trianel Windpark Borkum 2 | Northwester 2 | | |
| Seajacks | | Deutsche Bucht | | |
| Seaway 7 | | | Trianel Windpark Borkum 2 | |
| Swire Blue Ocean | Beatrice 2 | | | |
| Tideway | | | | Seastar Mermaid |
| Van Oord | Deutsche Bucht Norther | Borssele 3&4 | Deutsche Bucht Norther | Deutsche Bucht |
| Volstad Maritime AS | | Windfloat Atlantic | | |

Source: WindEurope

16. Vessels used for pre-construction, other installation services and support are not accounted in this analysis.



BEATRICE 2

UK

Status:
Fully commissioned

Capacity:
588 MW

No. of turbines:
84

Owners:
SDIC Power (24%), SSE (40%)
& Copenhagen Infrastructure
Partners (35%)

Turbine model:
SWT-7.0-154 (SGRE)

Inter-array cable:
JDR Cable systems

Export cable:
Nexans

Foundation type:
Jackets

Foundation supplier:
EEW (66%) & Smulders (34%)

4.

INVESTMENTS & POLICY DEVELOPMENT

4.1 FINANCING ACTIVITY

New offshore wind investments (€6.0bn) were 40% lower in 2019 compared with 2018. Given the small number of large wind farms which reach Final Investment Decision (FID) each year and the heterogeneity of the national investment frameworks, investment figures can be volatile year on year. The financing for new offshore wind farms was dominated by the FIDs of Saint Nazaire offshore wind farm (480 MW) and Nearth na Gaoithe offshore wind farm (450 MW) in France and Scotland respectively. Both wind farms saw a higher capital expenditure (CAPEX) than seen recently, which has reversed the trend of decreasing CAPEX per MW financed in recent years.

Saint Nazaire is the first commercial offshore wind farm in France and was financed at €5.0m/MW which compares with an average CAPEX for offshore wind farms reaching FID in 2018 of €2.3m/MW. One of the reasons for this

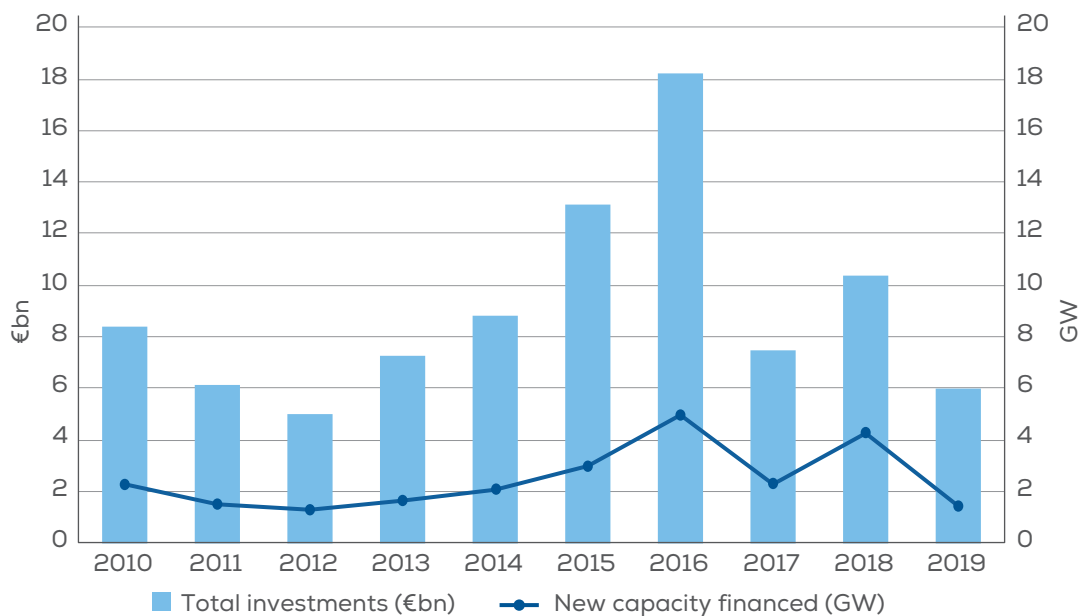
large difference is the fact that it is the first offshore wind farm in France and has been delayed due to permitting challenges and renegotiation of tariffs, resulting in less of the savings seen in recent transactions.

The Nearth na Gaoithe wind farm will be built in the Firth of Forth in Scotland. With an average depth of over 50m, the foundations will be jackets which tend to have higher associated costs than monopiles, potentially a factor in the higher than average CAPEX for the wind farm. Nearth na Gaoithe received support at the 2015 auction round in the UK and it has been financed at €5.1m/MW, including transmissions infrastructure to shore.

The pre-commercial 88 MW Hywind Tampen floating wind farm in Norway reached FID in 2019.

FIGURE 19

New offshore wind investments and capacity financed: 2010 – 2019 (€bn)



| | | | | | | | | | | |
|-----------------------------------|-----|-----|-----|-----|-----|------|------|-----|------|-----|
| Total investments (€bn) | 8.4 | 6.1 | 5.0 | 7.2 | 8.8 | 13.1 | 18.2 | 7.5 | 10.3 | 6.0 |
| New capacity financed (GW) | 2.2 | 1.5 | 1.3 | 1.6 | 2.1 | 3.0 | 5.0 | 2.3 | 4.2 | 1.4 |

Source: WindEurope

In total four projects reached Final Investment Decision (FID) in 2019, in the UK, the Netherlands, France and Norway.

TABLE 6

Investment in European offshore wind farms in 2019

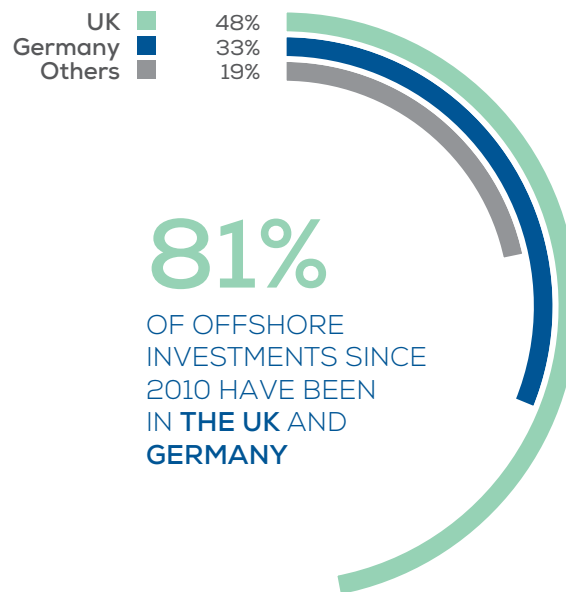
| COUNTRY | WIND FARM | CAPACITY (MW) | INVESTMENT (€bn) | COST (€m/MW) | EXPECTED COMMISSIONING DATE |
|--------------------|------------------|---------------|------------------|--------------|-----------------------------|
| UK | Neart na Gaoithe | 450 | 2.3 | 5.1 | 2023 |
| Netherlands | Fryslan | 383 | 0.8 | 2.0 | 2021 |
| France | Saint-Nazaire | 480 | 2.4 | 5.0 | 2023 |
| Norway | Hywind Tampen | 88 | 0.5 | 5.5 | 2022 |

Source: WindEurope

We saw a large and steady decrease in CAPEX per MW for offshore wind farms reaching FID between 2015 and 2018. The small number of FIDs in 2019, combined with two large wind farms being financed at over €5m/MW for reasons discussed above, have led to a reversal in this trend in 2019. We expect that this is a temporary reversal, influenced by the particularity of these projects. We expect to see further CAPEX reductions in future.

Since 2010 the UK has attracted 48% of new investments, worth €43bn, making it the biggest offshore wind market for capital spending commitments over the last nine years. Germany follows with 33% or €28bn in investments in the same period.

FIGURE 20
Geographical concentration of offshore wind investments since 2010



Source: WindEurope

In addition to the investments in new wind farms, 2019 also saw €4.2bn in refinancing transactions, less than half the debt refinanced in 2018, bucking the trend of increasing refinancing activity since 2015.

When a wind energy project is commissioned, its risk profile changes significantly. The risks present during construction are replaced by operational risks which impacts the probability of repaying lenders. In addition, lenders specialise in pricing risks at various stages of the development of a project. It is therefore common for a project to restructure its debts upon completion.

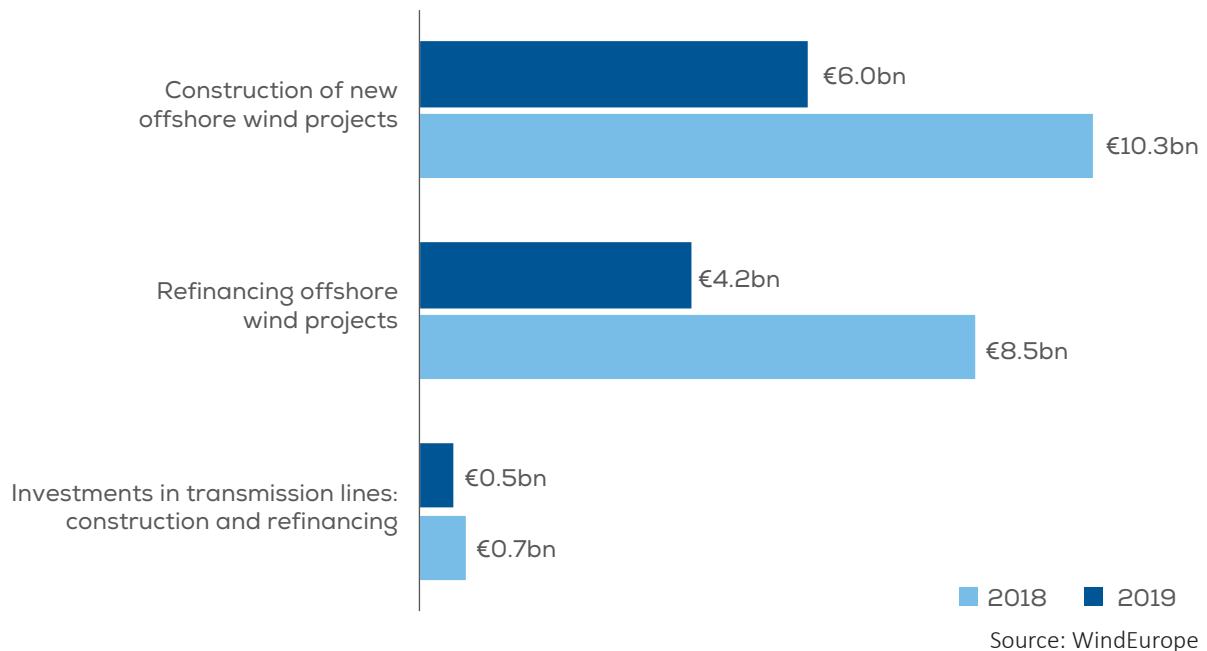
For example, banks might provide debt to cover the construction of the wind farm, which typically takes 2-3 years.

During this period the wind project is not producing any revenue. Additionally, there are risks such as losses from accidents or delays in construction (by bad weather, for example). Once the wind farm has been commissioned, the risks of construction are transferred to operation. Since there are fewer potential losses and risks for operational wind farms, these can attract better interest rates. The restructuring of debt in this way is known as refinancing.

In total offshore wind generated a financing activity of €10.2bn (new asset financing and refinancing), significantly less than the record €19.6bn financed in 2018.

FIGURE 21

Investments in the offshore wind sector in 2018 and 2019 (€bn)



In 2019, the Race Bank offshore transmission link was acquired by Diamond Transmission Partners for approximately €525m after being selected as the preferred bidder

by Ofgem in 2018. The acquisition includes the onshore and offshore substations and high voltage export cables.

4.2 OFFSHORE WIND DEBT FINANCE

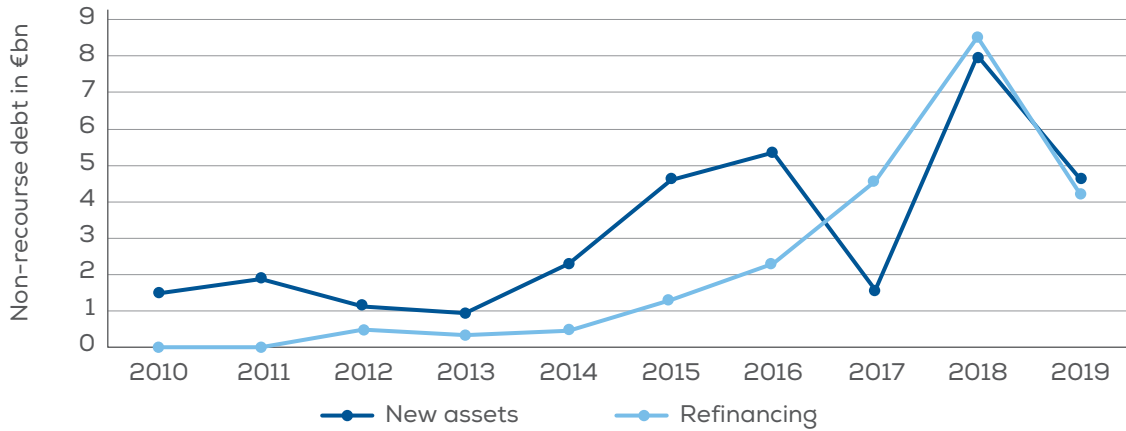
Non-recourse debt lending for new assets (i.e. lending from banks on a project-financing basis in which lenders do not have recourse to the sponsored assets) totalled €4.6bn in 2019. Given the low in 2017 followed by a record high in 2018, it is possible that these trends are a feature of the timing of transactions and in reality, non-recourse lending for new assets has remained fairly constant since 2015.

Non-recourse debt refinancing looks to have reversed the smooth trend of increasing amounts since 2015. Time will tell if this is a timing feature or if we saw a peak in 2018.

The amount of refinancing activity is often determined by the number of projects reaching their Commissioning Date and restructuring their debts.

The sector yields attract a diversified profile of lenders. A mix of 50 lenders were active in 2019, including multilateral financial institutions, insurance companies and commercial banks. In addition to the Japanese banks that have been investing in the European offshore wind industry for some time now, banks from China and South Korea are also entering the market.

FIGURE 22
Non-recourse debt trends per type of transaction (€bn)



| | | | | | | | | | | |
|--------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| New assets | 1.5 | 1.9 | 1.1 | 0.9 | 2.3 | 4.6 | 5.3 | 1.6 | 8.0 | 4.6 |
| Refinancing | 0 | 0 | 0.5 | 0.3 | 0.4 | 1.3 | 2.3 | 4.6 | 8.5 | 4.2 |

Source: WindEurope

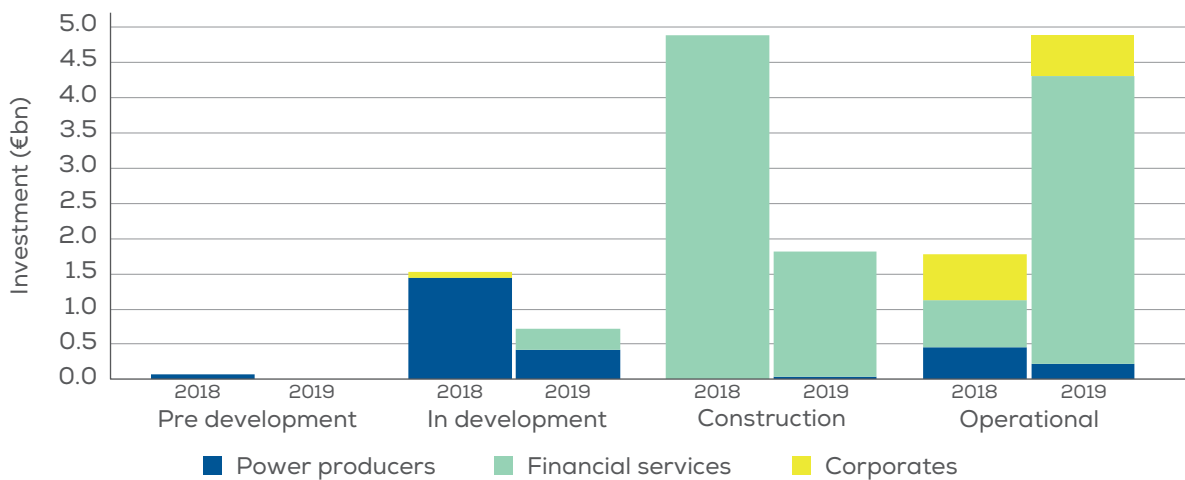
4.3 ACQUISITION ACTIVITY

Overall project acquisition activity in 2019 was lower compared to 2018, with €7.4bn acquiring projects for a total of 3.9 GW in all stages of development (in development, under construction and operational).

There was significantly more acquisition activity in operational wind farms in 2019, with almost €5bn changing

hands as investors sought operational assets. This is an increase from a little over €1.5bn in acquisitions of operational wind farms in 2018. There was a corresponding decrease in the acquisition of projects in construction from almost €5bn in 2018 to under €2bn in 2019.

FIGURE 23
Project acquisition investment activity in 2018 and 2019 by project phase and type of investor



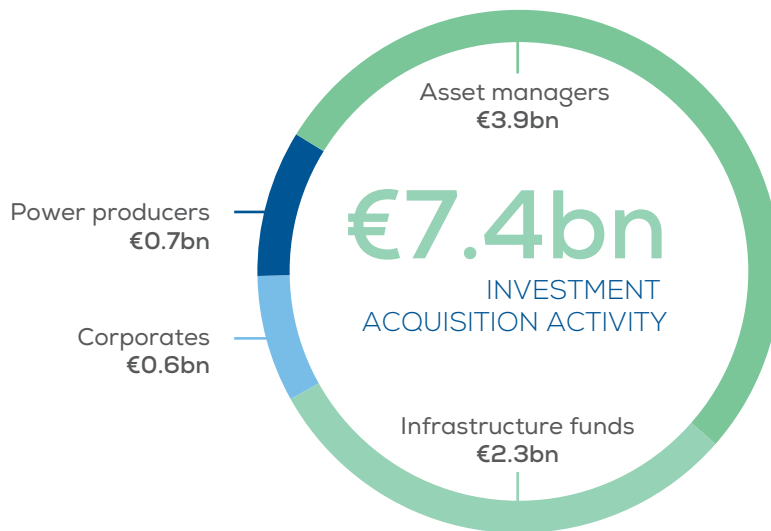
Source: WindEurope

Financial services (including asset managers and infrastructure funds) accounted for 83% of acquisitions in 2019, up from 73% in 2018. Financial services are less accustomed to the risks associated with the development and construction of wind farms and have historically been more comfortable with investments in operational wind

farms. This may help explain why there was a higher proportion of acquisitions of operational wind farms in 2019.

However, given the relatively small number of offshore projects, it is likely that trends were also determined by the availability of suitable projects.

FIGURE 24
Project acquisition investment activity in 2019 by type of investor



Source: WindEurope

4.4 OFFSHORE PPAS

The first offshore corporate Power Purchase Agreement (PPA) was signed in 2018 by the pharmaceutical firms Novozymes and Novo Nordisk for approximately 120 MW of the output of Kriegers Flak in Denmark. In 2019, 5 more corporate PPAs were signed for offshore wind farms. More than 360 MW of offshore wind has been contracted

to corporate buyers in the last 2 years. Offshore wind farm developers have started to look at corporate PPAs as a way to guarantee their revenue in the long-term. This is particularly important where zero-subsidy bids are being placed and developers are fully exposed to the wholesale market price.

TABLE 7

Investment in European offshore wind farms in 2019

| CORPORATE | COUNTRY | CAPACITY (MW) | WIND FARM |
|------------------------|---------|---------------|-----------------------------------|
| Covestro | Germany | 100 MW | Borkum Riffgrund 3 |
| Northumbrian Water Ltd | UK | 23 MW | Race Bank |
| Deutsche Bahn | Germany | 25 MW | Nordsee Ost |
| Google | Belgium | 92 MW | Elicio Norther Offshore Wind Farm |
| Bristol Airport | UK | 4 MW | NA |

Source: WindEurope

4.5 AUCTION RESULTS

2019 saw the largest offshore wind auction in the world. The UK's Round 3 awarded 5.5 GW of capacity with an average price of £40.63/MWh (€46.16/MWh)¹⁷ including grid-connection. The winners include the Sofia wind farm (1,400 MW) to be developed by Innogy (RWE), and three

zones (1,200 MW each) at the Dogger Bank to be developed jointly by Equinor (50%) and SSE Renewables (50%). The Forthwind project will test the largest 2-bladed offshore turbines of 6 MW designed by 2-B Energy.

TABLE 8

Offshore auction results in 2019

| COUNTRY | WIND FARM | CAPACITY | STRIKE PRICE (€/MWh) | TYPE OF SUPPORT | WINNER ¹⁸ | EXPECTED COMMISSIONING DATE |
|-------------|--------------------------|----------|----------------------|-------------------------|----------------------------|-----------------------------|
| Netherlands | Hollande Kust Zuid 3 & 4 | 760 | - | Zero-subsidy bid | Vattenfall | 2023 |
| France | Dunkirk | 600 | 44 | Feed-in-Premium | EDF, Innogy and Enbridge | 2026 |
| UK | Sofia | 1400 | 44.99 | Contract for Difference | Innogy | 2024 |
| | Seagreen Phase 1 - Alpha | 454 | 47.21 | Contract for Difference | SSE Renewables | 2025 |
| | Forthwind | 12 | 44.99 | Contract for Difference | 2-B Energy | 2024 |
| | Doggerbank Teeside A | 1200 | 47.21 | Contract for Difference | SSE Renewables and Equinor | 2025 |
| | Doggerbank Creyke Beck A | 1200 | 44.99 | Contract for Difference | SSE Renewables and Equinor | 2024 |
| | Doggerbank Creyke Beck B | 1200 | 47.21 | Contract for Difference | SSE Renewables and Equinor | 2025 |

Source: WindEurope

17. UK prices are 2012 indexed.

18. Innogy submitted and won these auctions before negotiating acquisition by RWE.

France's support mechanisms changed from a feed-in-tariff to run the first offshore wind auction in the country. The winner of the Dunkirk tender (Round 3), a consortium by EDF Renewables, Innogy (RWE) and Enbridge, had a record winning price of €44/MWh. The offshore substation was considered for the first time as part of the national TSO's responsibility, previously planned to be carried by the developer¹⁹.

4.6 POLICY DEVELOPMENT

2019 was the year for European countries to develop their National Energy and Climate Plans (NECPs) and set their own Renewable Energy targets to 2030. At the beginning of the year Europe's plans added up to 76 GW of offshore wind capacity by 2030. 12 months later, after intensive discussions among governments, the European Commission and the industry, these same plans now add up to a potential 100 GW²⁰. France set a positive example by including floating-specific auctions as part of its NECP. Such measures are crucial, giving long-term visibility to a sector that has huge potential and could deliver floating offshore wind farms in the next decade.

Many countries are still working out the design of policies and auctions. While some countries continue to rely on zero-subsidy schemes (the Netherlands), others are moving towards two-sided Contracts for Difference (CfD) after the success experienced in the UK. This is the case of Denmark, who will be offering CfDs for the first time for the Thor tender (1 GW). Other countries like Poland and Greece are still in discussions and consultations with stakeholders.

The UK government announced in spring 2019 an offshore Sector Deal, aiming to develop a strong industrial base in the UK to support its ambitious offshore wind plans. The agreement included not only the 30 GW target by 2030 but an available budget of up to £557m for future CfDs, plans to increase exports fivefold, and an increase in local content to develop the country's supply chain to triple the

The Netherlands Enterprise Agency (RVO) announced the winner of the Hollandse Kust 3&4 tender in the North Sea. Five consortiums submitted applications for this tender. This project gave Vattenfall the right to develop both the Hollandse Kust Zuid neighboring areas with a total capacity of 1.5 GW in the coming years. These sites are part of the national Offshore Wind Energy Roadmap to 2030 which sets a target of 11.5 GW in total by the end of the decade.

jobs, with a target of up to 27,000 jobs and at least 33% women in the sector.

Europe's offshore wind sector was under the spotlight in 2019. The International Energy Agency (IEA) published their Offshore Wind Outlook 2019 and stated that, by 2040, offshore wind could become Europe's main electricity source, playing a crucial role in Europe's journey to become carbon-neutral.

According to the European Commission's long-term decarbonisation strategy, Europe will need between 230 and 450 GW of offshore wind by 2050 to meet the Paris Agreement. Following the discussion on the long-term decarbonisation strategy, WindEurope's report 'Our energy, our future'²¹ was launched in November 2019. The report examines the need for space, grids and supply chain development. The report concludes that it is feasible to deploy 450 GW²² in a cost-efficient way, but warns about the need to rapidly increase the leasing of new sites.

The Energy Ministers from the 10 countries – Belgium, Denmark, France, Germany, Ireland, Luxembourg, the Netherlands, Norway, Sweden and the UK – met in December as the 'North Seas Energy Forum.' They met to revise the scope of their existing cooperation. Since 1 January Germany has presided over the cooperation, which will focus on maritime spatial planning, electricity grids, and developing hybrid offshore projects²³.

19. Connecting Offshore Wind Farms. A Comparison of Offshore Electricity Grid Development Models in Northwest Europe, Navigant, 2019.

20. Final number will be announced by the European Commission in 2020 after revising and aggregating the final National Energy and Climate Plans.

21. Available online at www.windeurope.org/450GW

22. "A clean planet for all" (November, 2018). 450 GW corresponds to one of the only two scenarios that limit temperature increases below 1.5°C (1.5 TECH).

23. Offshore hybrid projects combine offshore generation and transmission in a cross-border setting. Such projects can bring significant cost savings when compared to developing interconnections and national offshore wind farms separately. Read more in Our energy, our future: How offshore wind will help Europe go carbon-neutral (page 44).

WindEurope is the voice of the wind industry, actively promoting wind power in Europe and worldwide. It has over 400 members with headquarters in more than 35 countries, including the leading wind turbine manufacturers, component suppliers, research institutes, national wind energy associations, developers, contractors, electricity providers, financial institutions, insurance companies and consultants. This combined strength makes WindEurope Europe's largest and most powerful wind energy network.

Wind[•]
EUROPE

Rue Belliard 40, 1040 Brussels, Belgium
T +32 2 213 1811 · F +32 2 213 1890
windeurope.org