



Offshore Wind in Europe

Key trends and statistics 2018

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This report summarises construction and financing activity in European offshore wind farms from 1 January to 31 December 2018.

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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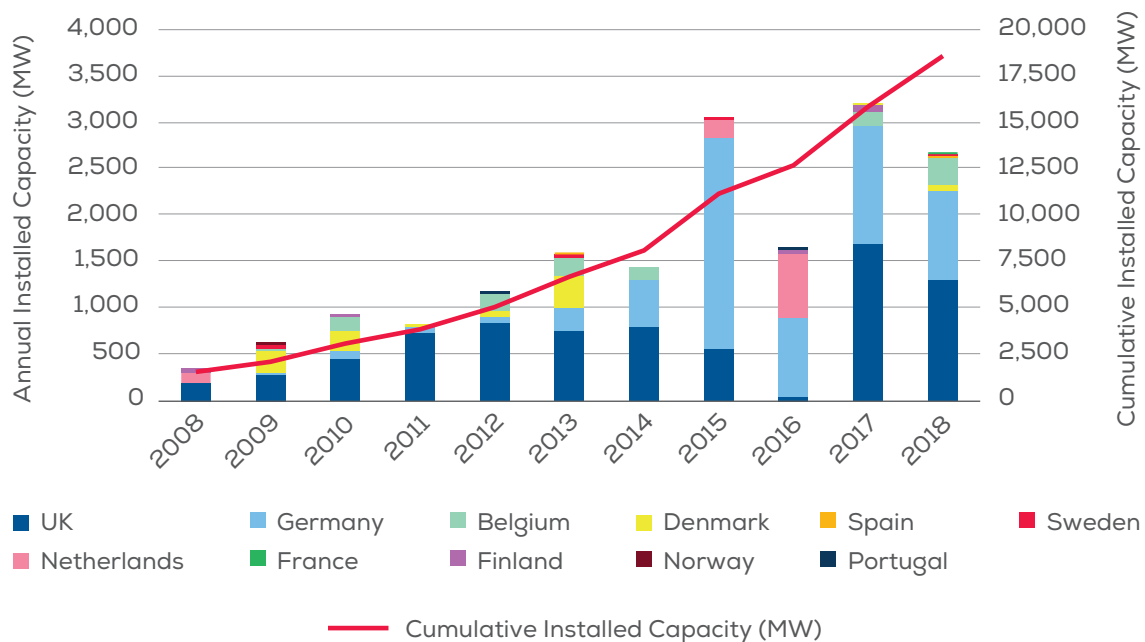
EXECUTIVE SUMMARY

In 2018 Europe connected 409 new offshore wind turbines to the grid across 18 projects. This brought 2,649 MW of net additional capacity.

Europe now has a total installed offshore wind capacity of 18,499 MW. This corresponds to 4,543 grid-connected wind turbines across 11 countries.

FIGURE A

Annual offshore wind installations by country and cumulative capacity (MW)

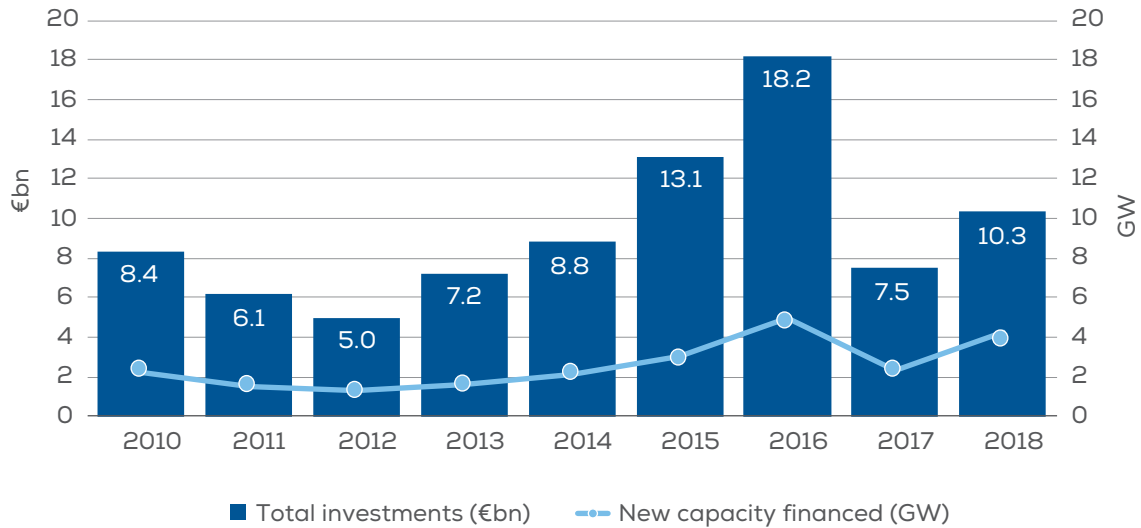


Source: WindEurope

Separately, twelve new offshore wind projects reached Final Decision Investment (FID) in 2018. Investments in new assets amounted to €10.3bn. This financed 4.2 GW

of additional capacity, which will come on line in the next couple of years.

FIGURE B
New offshore wind investments and capacity financed: 2010-2018 (€bn)



Source: WindEurope

Installations in 2018

- Europe added 2,649 MW of net offshore capacity. This is 15.8% lower than in 2017, which was a record year.
- The 2,649 GW represent 409 grid-connected offshore wind turbines across 18 wind farms.
- 15 wind farms were completed (fully grid-connected). Another 3 got partial grid connection and will continue to connect turbines in 2019. Construction work started on other 6 wind farms where no turbines have yet been grid-connected.
- Installations in the UK and Germany accounted for 85% of all new additions.
- Siemens Gamesa Renewable Energy and MHI Vestas Offshore Wind accounted for 95% of all the connected turbines in 2018 (62% and 33% respectively).
- For the first time in Europe, GE Renewable Energy connected their latest turbine: the Haliade 150-6 MW. 20 of these turbines were grid-connected at the Merkur wind farm, Germany.

Cumulative installations

- 4,543 offshore turbines are now installed and grid-connected, making a cumulative total of 18,499 MW.
- Including sites with partial grid-connected turbines, there are now 105 offshore wind farms in 11 European countries.
- The UK has the largest amount of offshore wind capacity in Europe with 44% of all installations in MW. Second is Germany with 34%, followed by Denmark (7%), Belgium (6.4%) and the Netherlands (6%).

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

- The average size of newly-installed offshore wind turbines in 2018 was 6.8 MW, a 15% increase on 2017. The UK connected the largest turbine in the world (the V164-8.8 MW from MHI Vestas Offshore Wind).
- The average size of wind farms in construction in 2018 was 561 MW. In the UK, construction work started on the largest wind farm in the world: the 1,200 MW Hornsea One project.
- The world's current largest operational wind farm – Walney 3 extension (657 MW) – was fully connected in the UK.
- The largest wind farm in Germany – Borkum Riffgrund II (465 MW) – was fully commissioned.
- The largest wind farm in Belgium – Rentel 309 MW – was fully connected.

Financing highlights

- Investments in new offshore wind amounted to €10.3bn, a 37% increase from 2017.
- Twelve projects reached FID, totalling 4.2 GW of additional capacity.
- The 37% increase in investments generated an 86% increase in capacity financed.
- Refinancing of offshore wind farms hit a record level of €8.5bn, bringing total investments including transmission lines (€0.7bn) to €19.6bn.
- Non-recourse debt for new and operational wind farms raised €16.5bn.
- There were 3.8 GW of project acquisition activity and 2.3 GW of potential projects acquired at the pre-development stage.



Photo: Ørsted

1. OFFSHORE WIND INSTALLATIONS

1.1 OVERVIEW

Europe connected 2,649 MW of net offshore wind power capacity in 2018. This is 15.8 % lower than in 2017, which was a record year. It added 2,660 MW of new (gross) capacity. 7 turbines were fully decommissioned at the Utgrunden I wind farm in Sweden, which was commissioned back in 2000. This accounts for the decommissioning of 10.5 MW in 2018¹. Installations were in line with previously forecasted scenarios².

The UK and Germany connected slightly less capacity than in 2017, with 1,312 MW and 969 MW respectively. Denmark had new connections for the first time since 2013

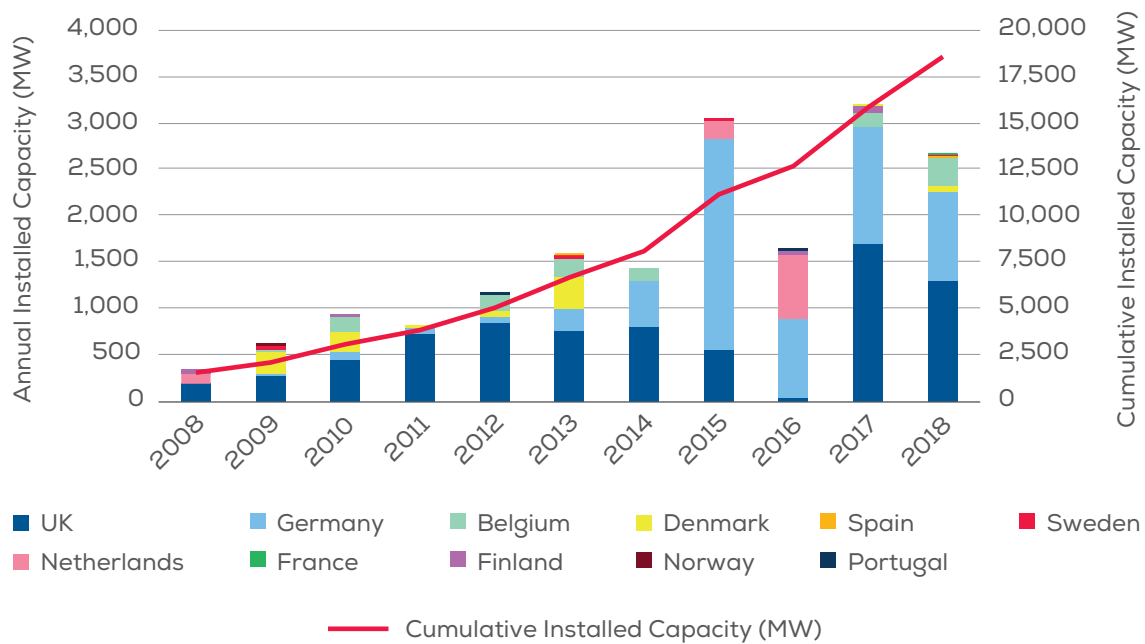
(61 MW), and Belgium doubled its annual installations in comparison to 2017 (309 MW). The Netherlands did not grid-connect any offshore wind, but is set to have a record year in 2019 with about 1 GW of new offshore installations³.

Europe's cumulative offshore wind capacity reached 18,499 MW at the end of 2018. Including sites with partial grid connection, there are now 105 offshore wind farms in 11 European countries and 4,543 grid-connected wind turbines.

1. Separately, 2.75 MW were boosted into 3.3 MW due to rotor and blade upgrades in 5 turbines. See page 14 for more info.
2. WindEurope Market Outlook, September 2017.
3. WindEurope Market Outlook, September 2017.

FIGURE 1

Annual offshore wind installations by country and cumulative capacity (MW)



Source: WindEurope

TABLE 1

Overview of grid-connected offshore wind power projects at the end of 2018

COUNTRY	NO. OF WIND FARMS CONNECTED	CUMULATIVE CAPACITY (MW)	NO. OF TURBINES CONNECTED	NET CAPACITY CONNECTED IN 2018	NO. OF TURBINES CONNECTED IN 2018
TOTAL	105	18,499	4,543	2,649	409
United Kingdom	39	8,183	1,975	1,312	222
Germany	25	6,380	1,305	969	136
Denmark	14	1,329	514	61	42
Belgium	7	1,186	274	309	8
Netherlands	6	1,118	365	0	1
Sweden	4	192	79	-10	-7
Finland	3	71	19	0	0
Ireland	1	25	7	0	0
Spain	2	10	2	5	1
France	2	2	2	2	2
Norway	1	2	1	0	0

Cumulative installed capacity at the end of 2018

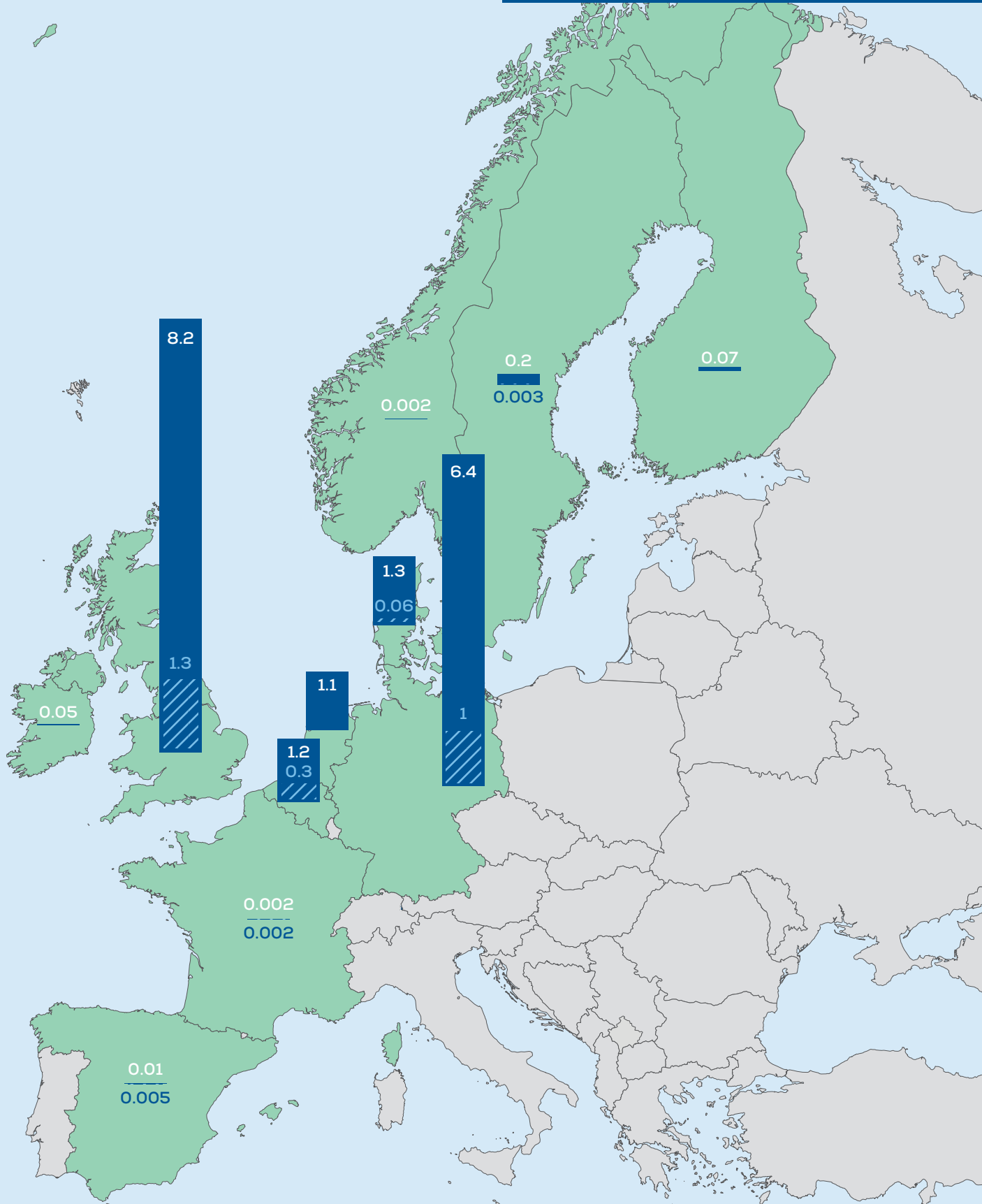


Gross installations in 2017



2.6 GW
OF NEW OFFSHORE WIND POWER IN EUROPE

18.5 GW
TOTAL EUROPE



1.2 NATIONAL BREAKDOWN OF 2018 INSTALLATIONS

The United Kingdom with 1,312 MW represented 49% of Europe's gross capacity brought online in 2018. Out of the 7 wind farms that got grid-connected, 6 were fully commissioned and one (Beatrice 2) started to connect turbines to the grid. The Walney 3 Extension wind farm was completed in October 2018, becoming the largest operational offshore wind farm worldwide with 87 turbines and a capacity of 657 MW. One floating turbine, Kincardine Pilot, was connected off the Scottish coast.

Germany with 969 MW across 3 wind farms represented 36% of the European gross capacity brought online in 2018. One of them, Borkum Riffgrund II (465 MW) was fully connected to the grid, becoming the largest offshore wind farm in Germany to date.

Belgium, with 309 MW connected to the grid from the fully completed Rentel wind farm, represented 12% of the European gross capacity brought online in 2018.

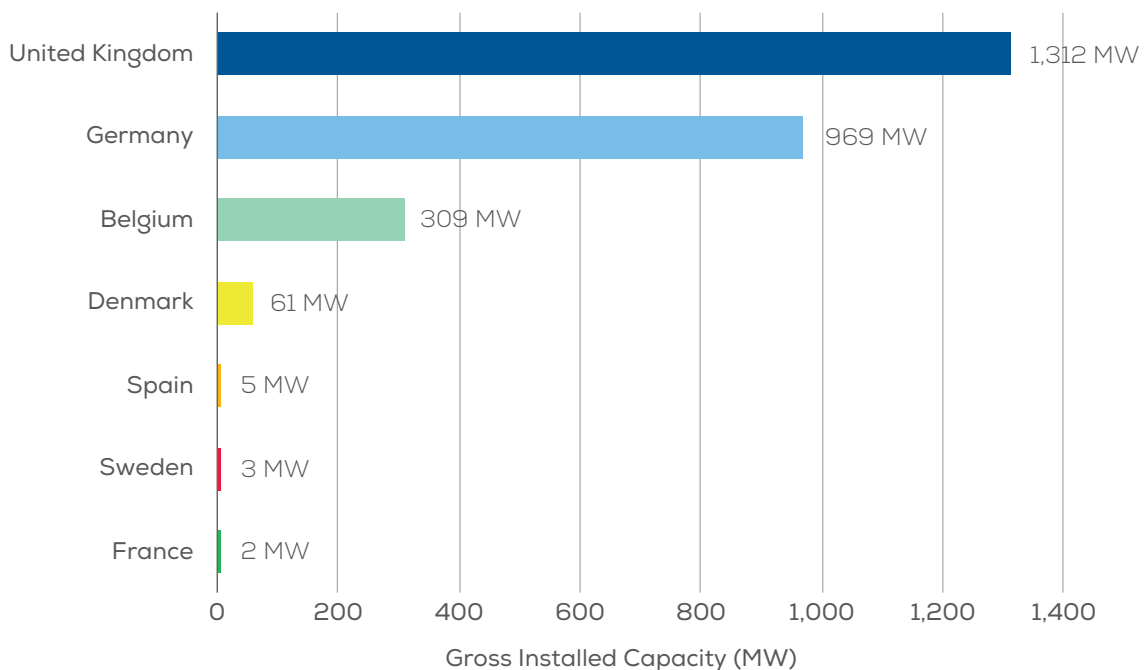
Denmark connected 61 MW from Horns Rev 3, which should be completed in 2019 with a total 407 MW of capacity.

Spain saw the connection of its second offshore wind turbine off the coast of Grand Canaria. This interesting project, realised under the EU-funded ELICAN project, has a self-installing telescopic substructure for low-cost craneless installations, allowing for deep offshore projects.

France saw the grid connection of two floating offshore wind turbines. The Floatgen project (2 MW) off the coast of Brittany, and the Eolink 1/10 project, which connected a prototype turbine of about 200 kW in Brittany.

Sweden did not install any new offshore wind farms. However, 5 turbine rotors (including the blades) in the Bockstigen wind farm were boosted, increasing the rated power of each turbine from 550 to 660 kW. The Utgrunden I wind farm decommissioned 7 turbines, totalling 10.5 MW.

FIGURE 2
Annual offshore wind capacity installations per country in 2018 (MW)

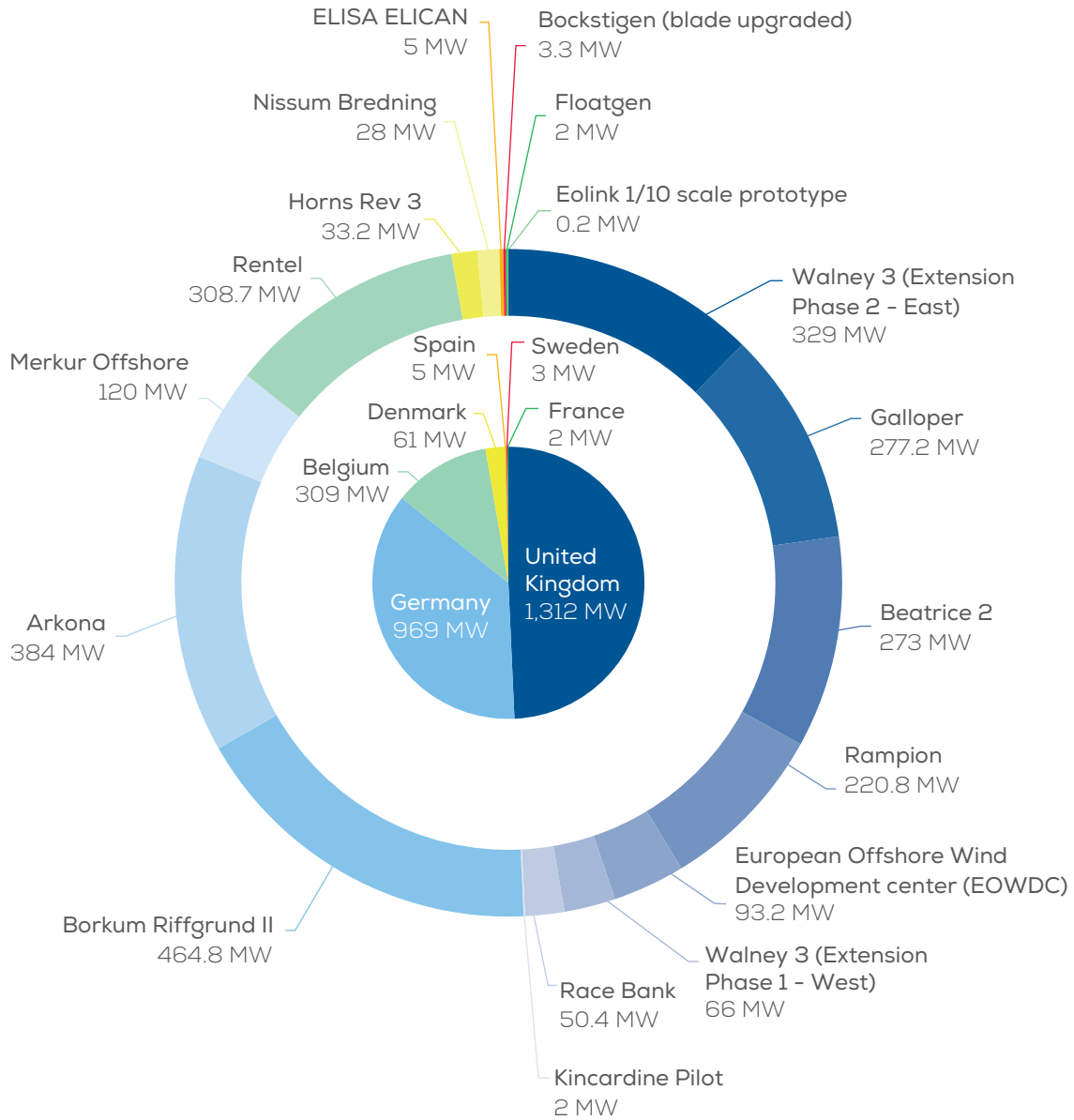


Source: WindEurope

In total 24, offshore wind farms across 7 countries had works going on in Europe in 2018. 18 of these connected turbines to the grid, and 6 did not connect any turbine

but started work with foundation installations (see tables 2 and 3).

FIGURE 3
Projects connected to the grid per country (MW)



Source: WindEurope

TABLE 2

Summary of work carried out at European offshore wind farms with grid connection during 2018

COUNTRY	WIND FARM	CAPACITY CONNECTED IN 2018 (MW)	NUMBER OF TURBINES CONNECTED IN 2018	TYPE	STATUS ⁴
United kingdom	Walney Extension Phase East	329	47	Bottom-fixed	●●●●●
	Galloper	277.2	44	Bottom-fixed	●●●●●
	Beatrice 2	273	39	Bottom-fixed	●○○○○
	Rampion	220.8	64	Bottom-fixed	●●●●●
	EOWDC	93.2	11	Bottom-fixed	●●●●●
	Walney Extension Phase West	66	8	Bottom-fixed	●●●●●
	Race Bank	50.4	8	Bottom-fixed	●●●●●
	Kincardine Pilot	2	1	Floating	●●●●●
Germany	Borkum Riffgrund II	464.8	56	Bottom-fixed	●●●●●
	Arkona	384	60	Bottom-fixed	●●●●●
	Merkur Offshore	120	20	Bottom-fixed	●●○○○
Belgium	Rentel	308.7	42	Bottom-fixed	●●●●●
Denmark	Horns Rev 3	33.2	4	Bottom-fixed	●○○○○
	Nissum Bredning	28	4	Bottom-fixed	●●●●●
Spain	ELISA ELICAN	5	1	Bottom-fixed	●●●●●
Sweden	Bockstigen (boosted)	3.3	5	Bottom-fixed	●●●●●
France	Floatgen	2	1	Floating	●●●●●
	Eolink Prototype	0.2	1	Floating	●●●●●

4. One bar <25% grid connected. 2 bars <50% grid connected. 3 bars <75% grid connected. 4 bars <100% grid connected. 5 bars: fully grid connected

TABLE 3

Summary of work carried out at European offshore wind farms without grid connection during 2018

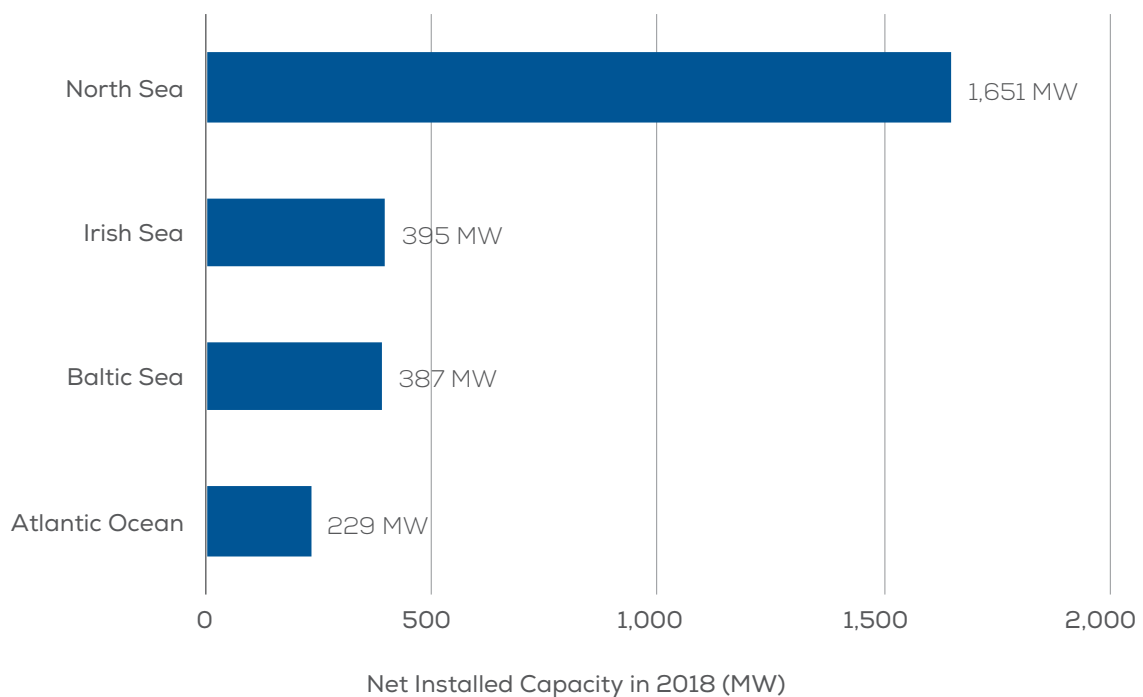
COUNTRY	WIND FARM	FOUNDATIONS INSTALLED IN 2018	TOTAL NUMBER OF FOUNDATIONS	TYPE OF FOUNDATIONS
United Kingdom	East Anglia 1	37	102	Jacket
	Hornsea One	156	174	Monopile
Germany	Deutsche Bucht	29	31	Monopile
	Hohe See	63	71	Jacket
	Trianel Windpark Borkum 2	32	32	Monopile
Belgium	Norther	44	44	Monopile

The North Sea registered the largest amount of grid connections (1,651 MW), representing 62% of the installations. This was followed by the **Irish Sea** (15%), with the Walney 3 extension Phase 2 - East and Walney 3 extension Phase 1 - West. **The Baltic Sea** saw 14% of the instal-

lations, driven by connections in the Arkona wind farm. **The Atlantic Ocean** registered 9% of the new installations, driven by the work in Rampion wind farm.

FIGURE 4

Gross annual installations by sea basin in 2018 (MW)



Source: WindEurope

1.3 CUMULATIVE INSTALLATIONS

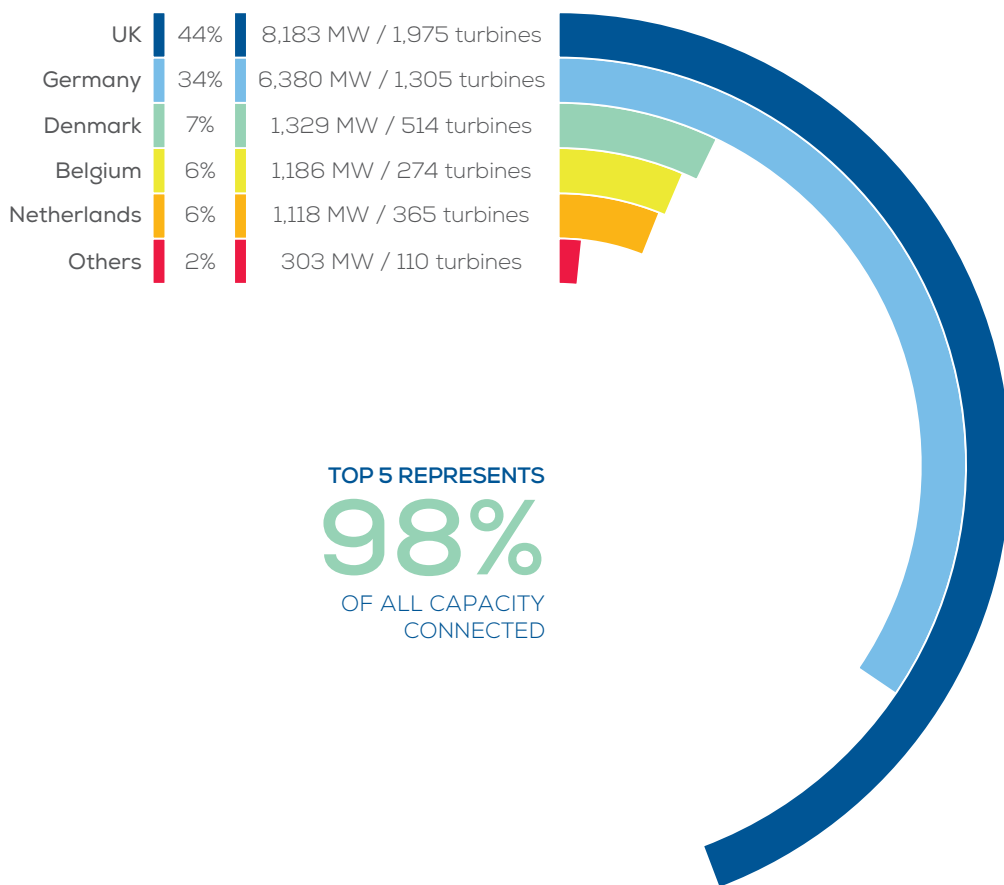
By the end of 2018, there were 18,499 MW of installed capacity, with a total of 4,543 turbines connected to the grid across 11 countries. 98% of this capacity is concentrated in just five countries.

The UK has the largest amount of offshore wind capacity in Europe with 44% of all installations. Germany is second,

with 34%, followed by Denmark (7%), Belgium (6.4%) and the Netherlands (6%).

Other countries – including Spain, Finland, France, Sweden, Norway and Ireland – cumulatively represent only 2% of the installed capacity.

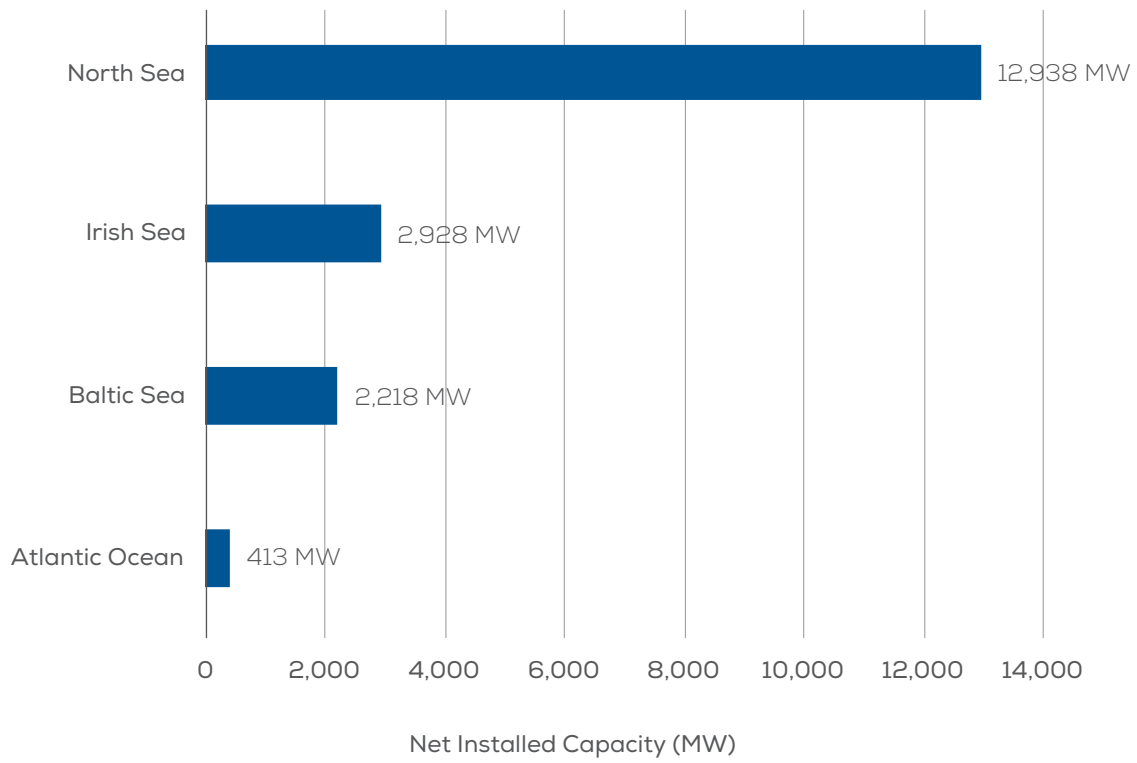
FIGURE 5
Cumulative Installed capacity (MW) and number of turbines by country



Source: WindEurope

The North Sea accounts for 70% of all offshore wind capacity in Europe, followed by the Irish Sea with 16%, the Baltic Sea with 12%, and the Atlantic Ocean with 2%.

FIGURE 6
Cumulative Installed capacity by sea basin (MW)



Source: WindEurope

2.

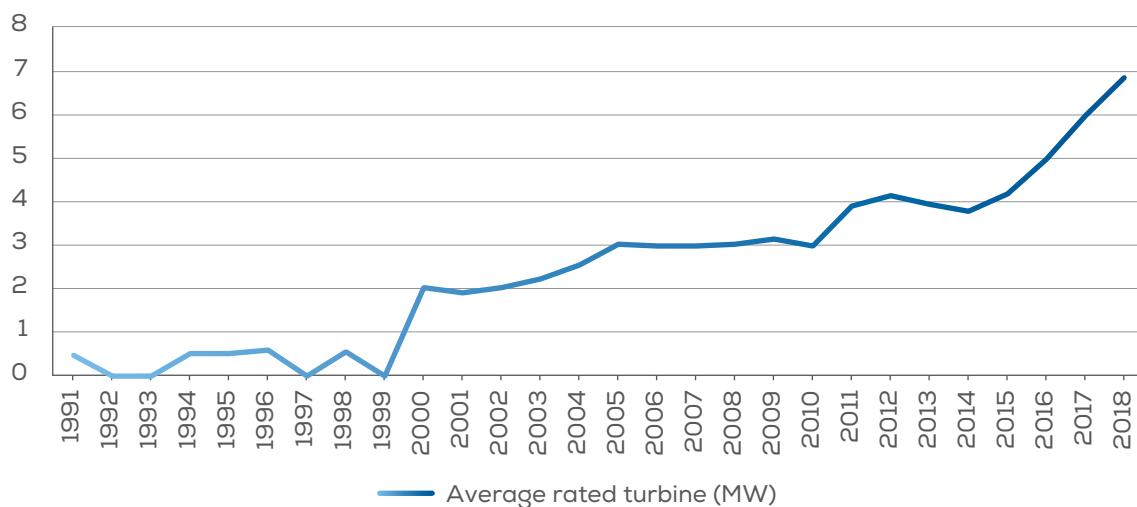
TRENDS: TURBINE SIZE, WIND FARM LOCATION

2.1 WIND TURBINE RATED CAPACITY

In 2018 the average rated capacity of newly installed turbines was 6.8 MW, 15% larger than in 2017. Since 2014 the average rated capacity of newly installed wind turbines has grown at an annual rate of 16%.

The largest turbine in the world was installed in the United Kingdom in 2018. Two V164-8.8 MW from MHI Vestas Offshore Wind, with a rotor diameter of 164 m, were connected at the European Offshore Wind Development Centre (EOWDC) wind farm.

FIGURE 7
Yearly average of newly installed offshore wind turbine rated capacity (MW)



Source: WindEurope

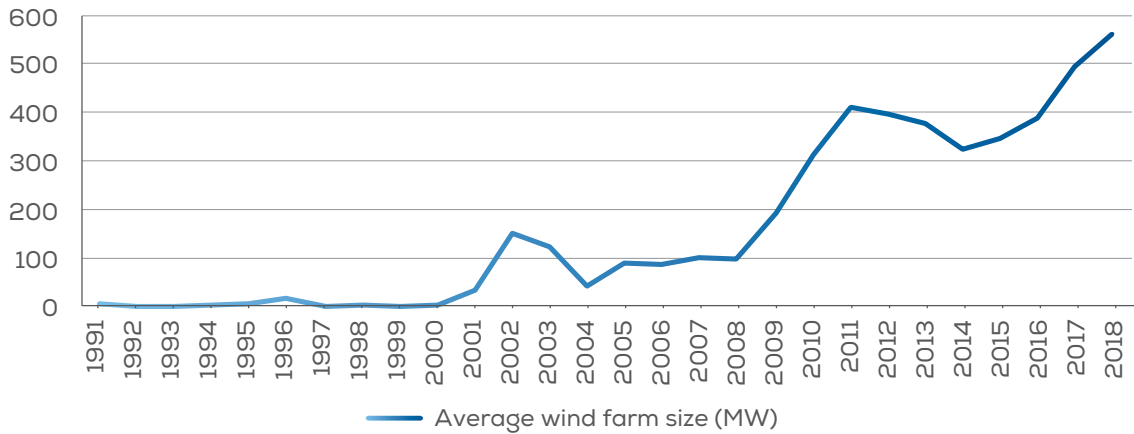
2.2 WIND FARM SIZE

In the last ten years, the average offshore wind farm has increased in size from 79.6 MW in 2007 to 561 MW in 2018. The 1,200 MW Hornsea One project (174 turbines) is the largest offshore wind farm to reach Final Investment

Decision (FID) to date. Its construction started in 2018, with 156 foundations already installed by the end of the year. So far, no turbines have been installed.

FIGURE 8

Average size of commercial offshore wind farms in construction and grid-connected in the given year



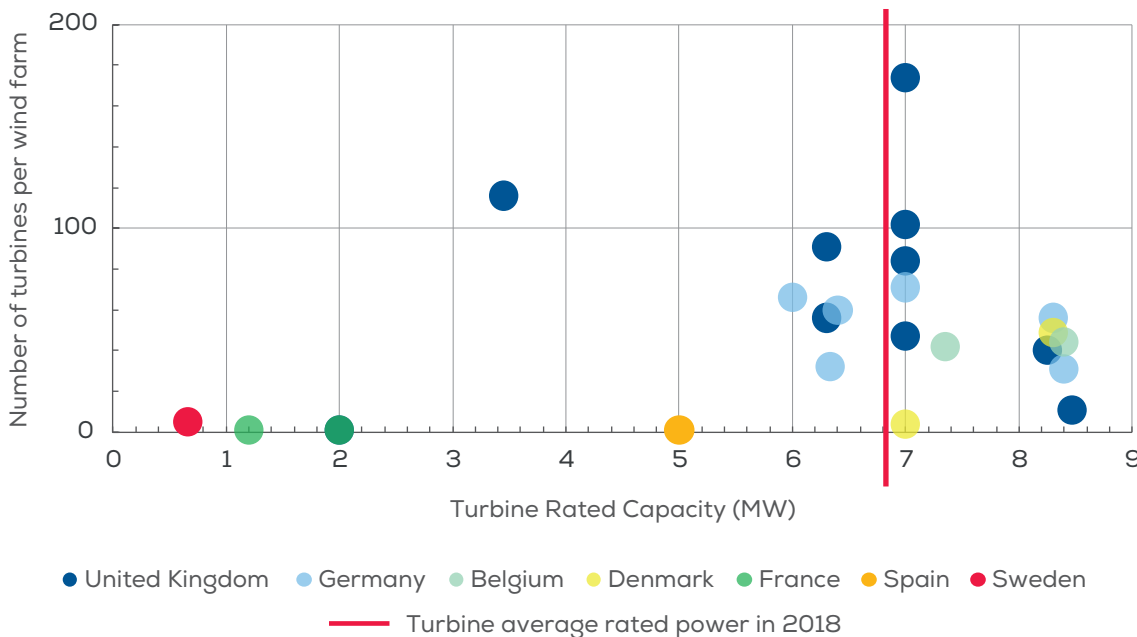
Source: WindEurope

Most of the wind farms in construction are using turbines above 6 MW (the average rated power for the turbines is 6.8 MW, indicated by the red line in figure 9). The only

wind farms using turbines below 6 MW are Rampion in the United Kingdom and a few demonstration projects (mostly floating).

FIGURE 9

Average turbine rated capacity and number of turbines of wind farms under construction in 2018



Source: WindEurope

2.3 WATER DEPTH AND DISTANCE TO SHORE

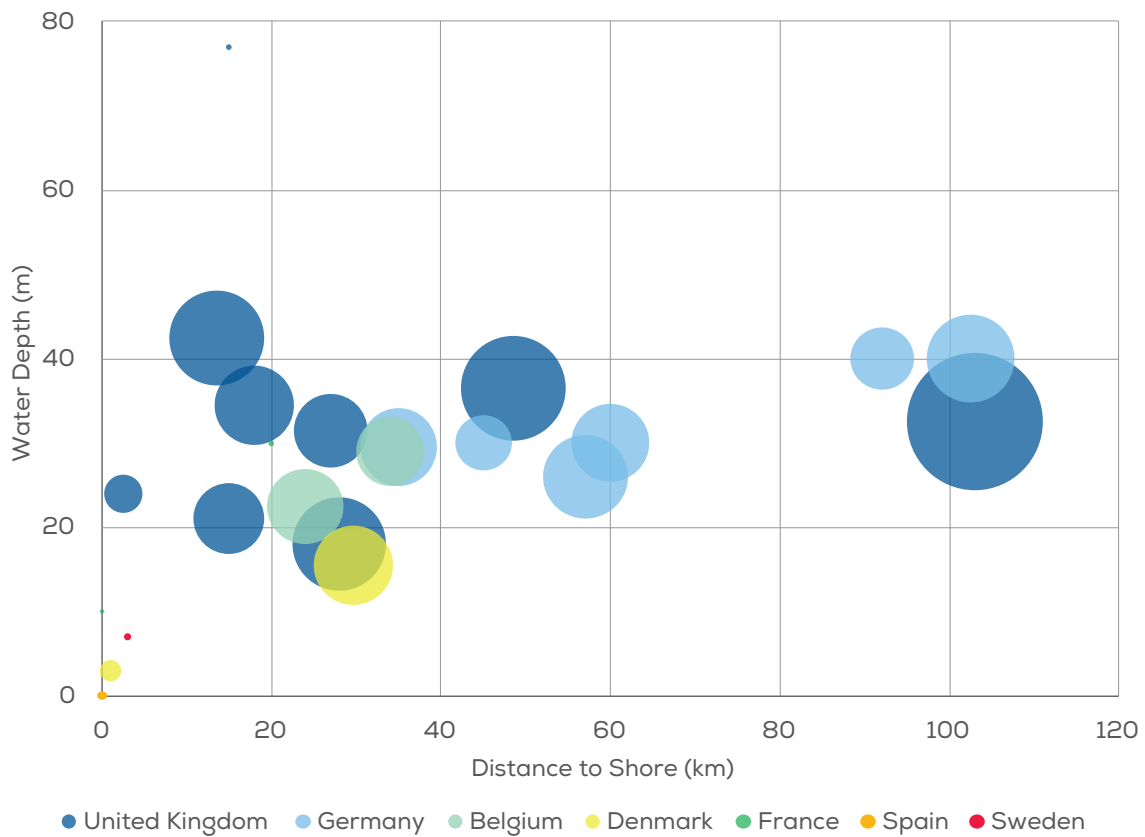
The average water depth of offshore wind farms under construction in 2018 was 27.1 m, slightly less than in 2017 (27.5 m). The average distance to shore of those projects was 33 km, a decrease on the previous year (41 km).

Kincardine Pilot, a floating demonstration project off the coast in Scotland, has an average water depth twice as deep as all the bottom-fixed offshore wind farms, with 77 m.

Hornsea One in the UK and EnBW Hohe See in Germany are the projects located farthest from the shore, 103 km away. Deutsche Bucht, also in Germany, follows at 93 km from the shore.

FIGURE 10

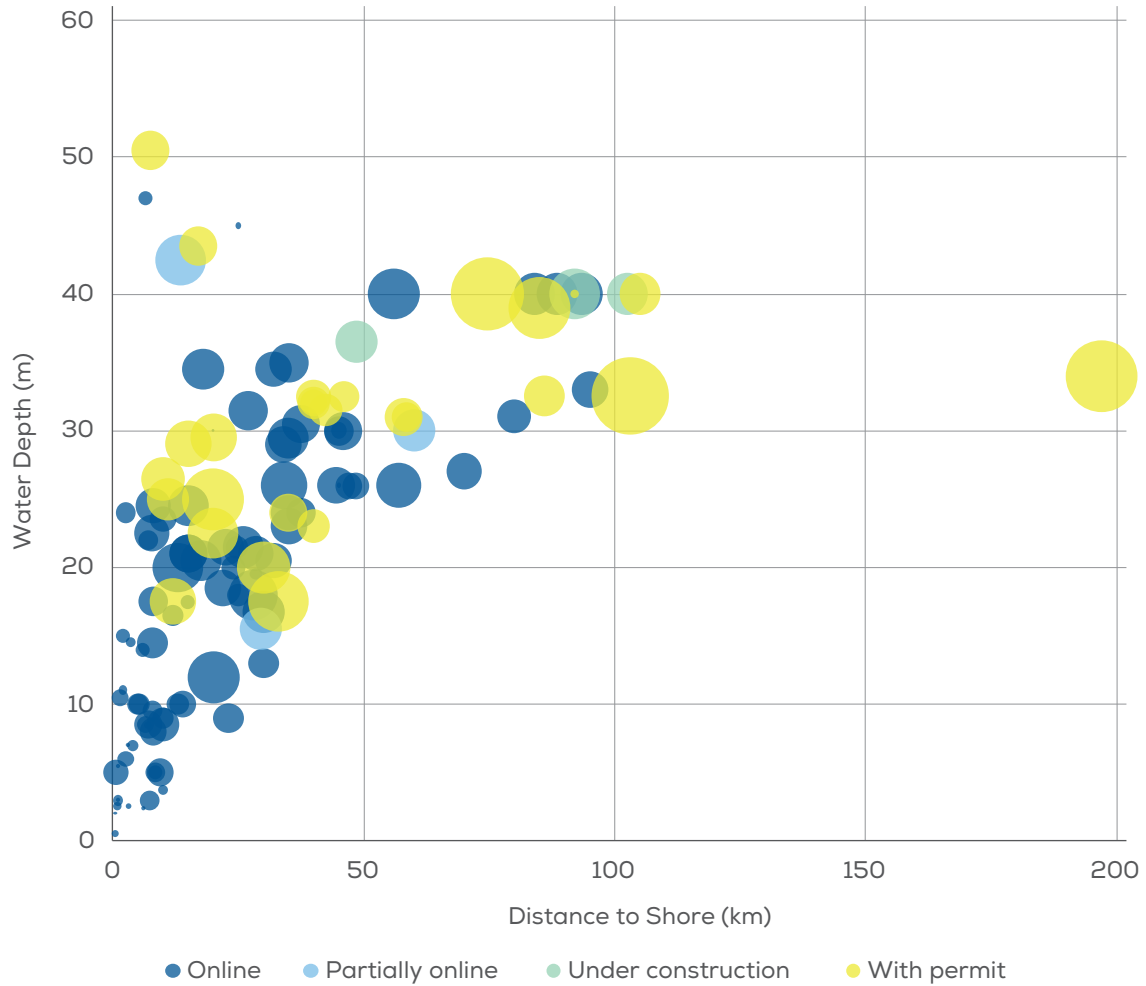
Average water depth and distance to shore of offshore wind farms under construction in 2018. The size of the bubble indicates the overall capacity of the site



Source: WindEurope

FIGURE 11

Average water depth and distance to shore of bottom-fixed offshore wind farms, organised by development status. The size of the bubble indicates the overall capacity of the site.



Source: WindEurope



Photo: GE Renewable Energy

3. INDUSTRY ACTIVITY AND SUPPLY CHAIN

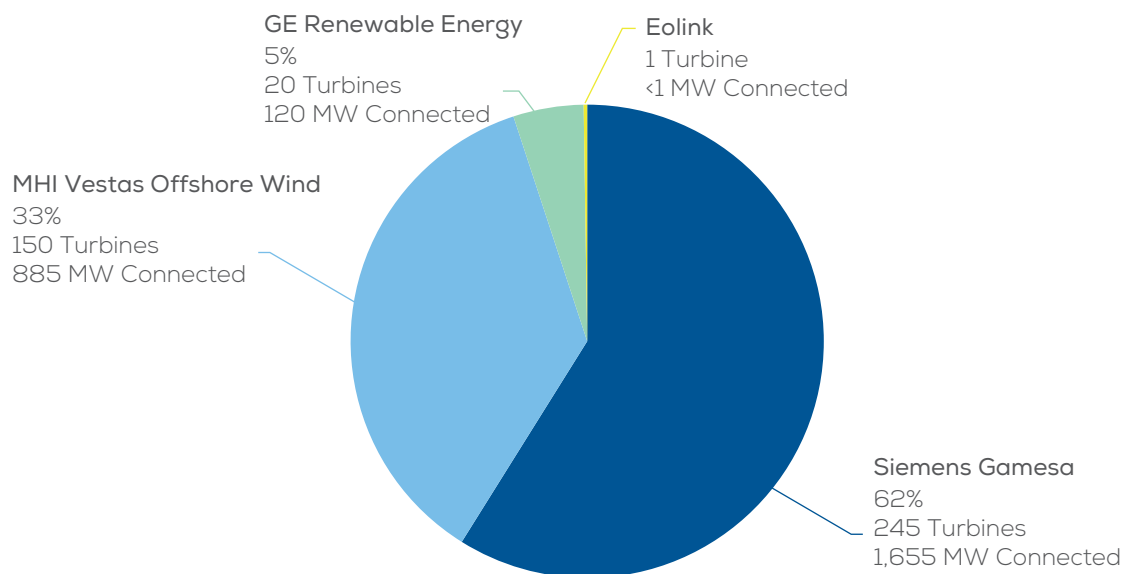
3.1 WIND TURBINE MANUFACTURERS

Siemens Gamesa Renewable Energy⁵ supplied 62.2% of all the new capacity in 2018. MHI Vestas Offshore Wind followed with 33.3%. Other turbine suppliers include GE renewable Energy and Eolink (prototype).

GE Renewable Energy connected its Haliade 150-6 MW turbine for the first time in Europe. In 2018, 20 of these turbines were connected at the Merkur offshore wind farm in Germany (another 44 will be connected in 2019).

FIGURE 12

Wind turbine manufacturers' share of the 2018 annual capacity (MW) and number of turbines connected to the grid



Source: WindEurope

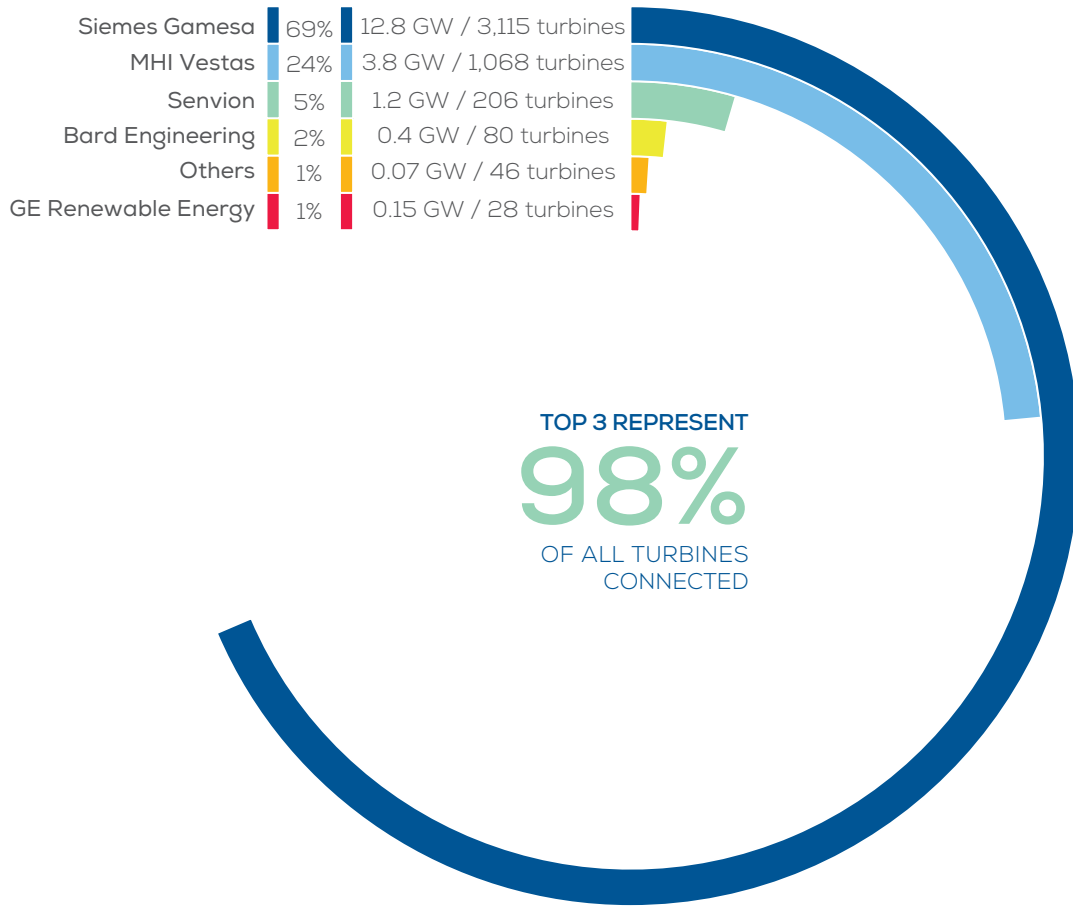
5. Adwen offshore company has been merged with Siemens Gamesa.

Siemens Gamesa Renewable Energy has the most off-shore wind turbines in Europe with 69% of the total installed capacity (see figure 13). MHI Vestas Offshore Wind is the second largest turbine supplier with 24%, followed

by Senvion (5%). These 3 manufacturers represent 98% of the total number of turbines connected in Europe at the end of 2018.

FIGURE 13

Wind turbine manufacturers' share at the end of 2018



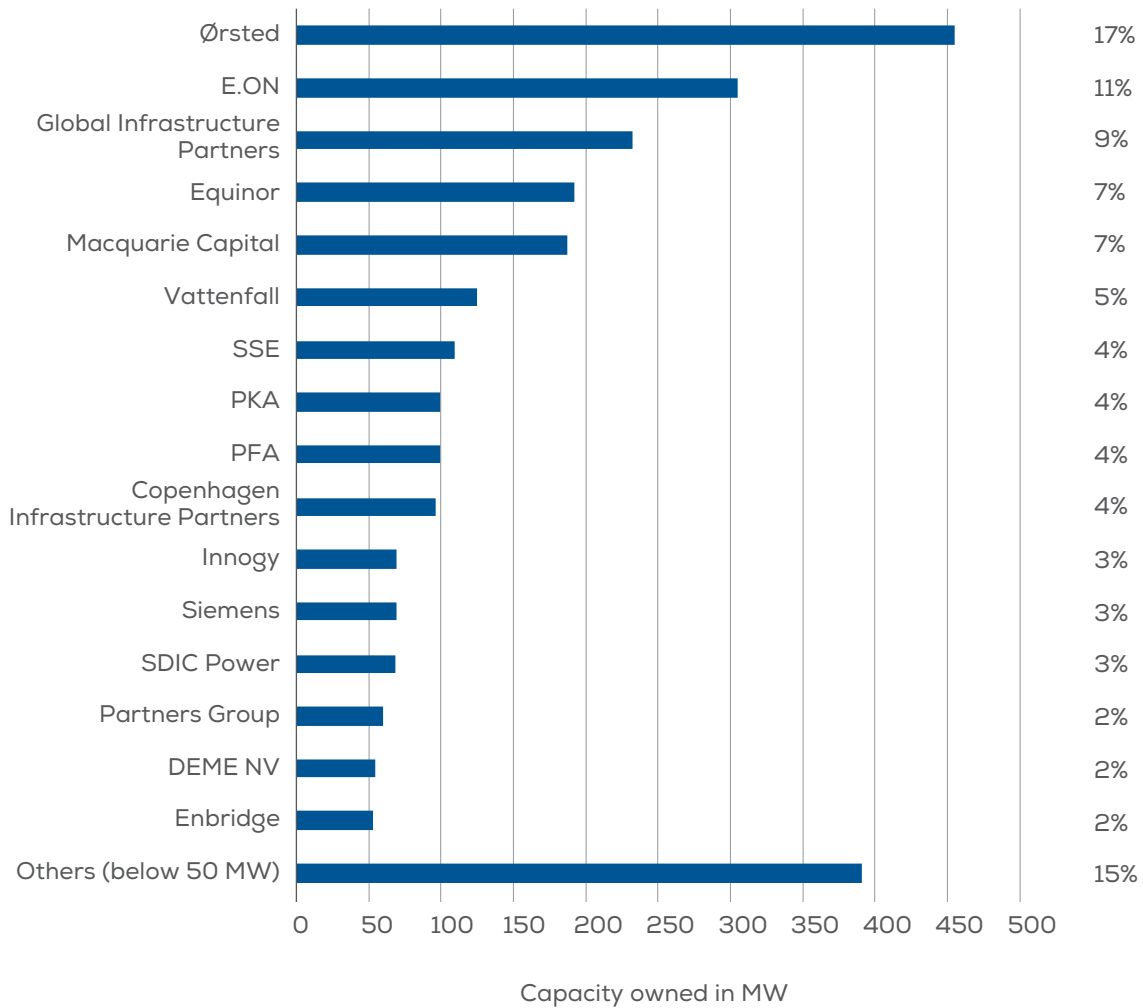
Source: WindEurope

3.2 WIND FARM OWNERS

Ørsted connected the largest amount of wind capacity in 2018, representing 17%⁶, followed by E.ON with 11%. Global Infrastructure Partners with 9%, Equinor with 7%,

and Macquarie Capital with 6% complete the top five owners with new capacity last year. Together they account for 51% of all new capacity in 2018.

FIGURE 14
Owners' share of 2018 annual installations (MW)



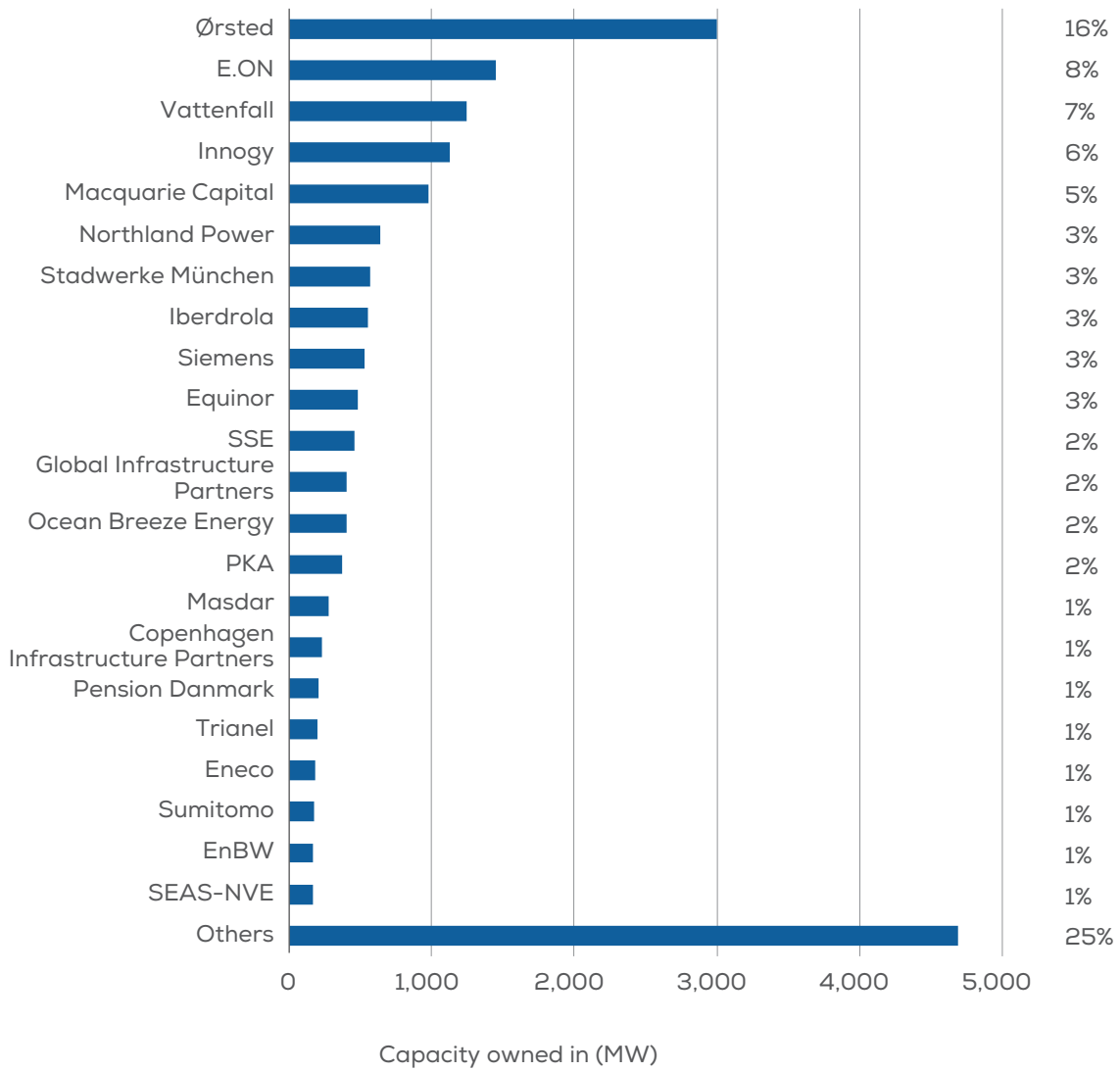
Source: WindEurope

6. 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.

Ørsted is the largest owner of offshore wind power in Europe with 16% of the total capacity at the end of 2018 (figure 15). E.ON is the second largest owner with 8%,

followed by Vattenfall (7%), Innogy (7%), and Macquarie Capital (5%). The top five owners represent 42% of all installed capacity in Europe, similar to 2017.

FIGURE 15
Owners' share of total cumulative installed capacity at the end of 2018 (MW)



Source: WindEurope

3.3 SUBSTRUCTURES AND FOUNDATIONS

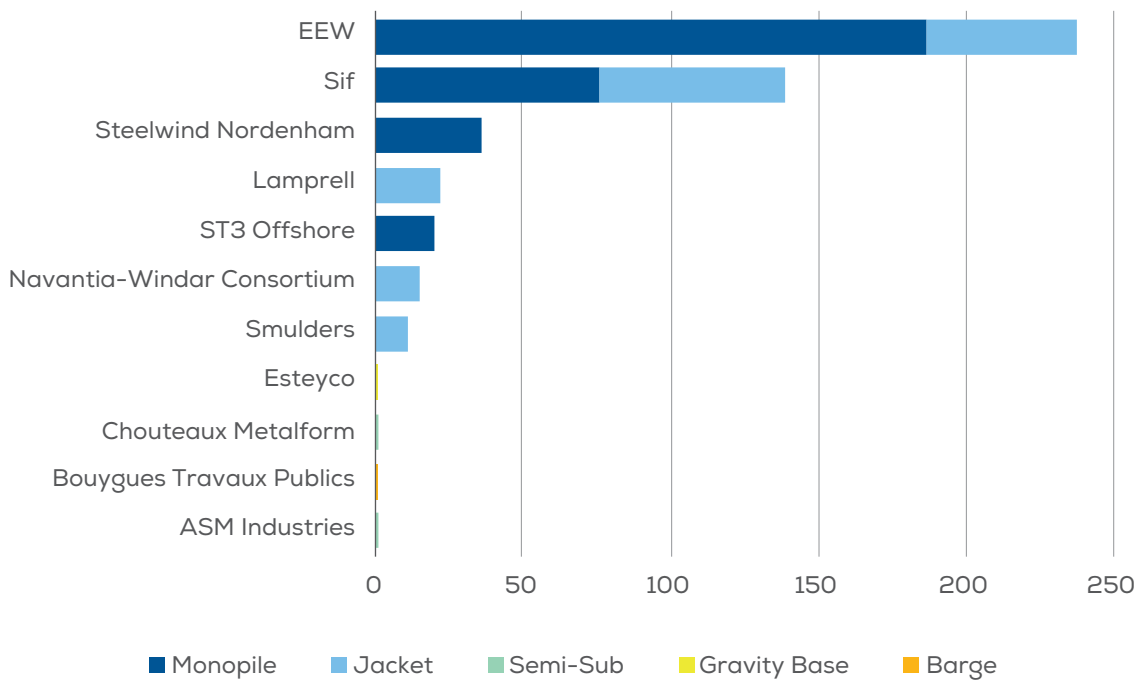
Monopiles remained the most popular substructure type in 2018, representing 66% of all installed foundations, a decrease compared to 2017 (86%). Jackets were the second most used substructure, with 162 jackets installed in 2018, representing 33% of all foundations installed.

One floating barge was commissioned for the Floatgen project and 2 floating semi-sub structures were commis-

sioned respectively for the Eolink Prototype and the Kin-cardine project.

On the supplier side, EEW installed 49% of all foundations in 2018, followed by Sif (29%) and Steelwind Nordenham (7%).

FIGURE 16
Foundations installed in 2018 by manufacturing company⁷



Source: WindEurope

7. Shares are calculated according to the actual number of individual foundations installed in 2018. 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.

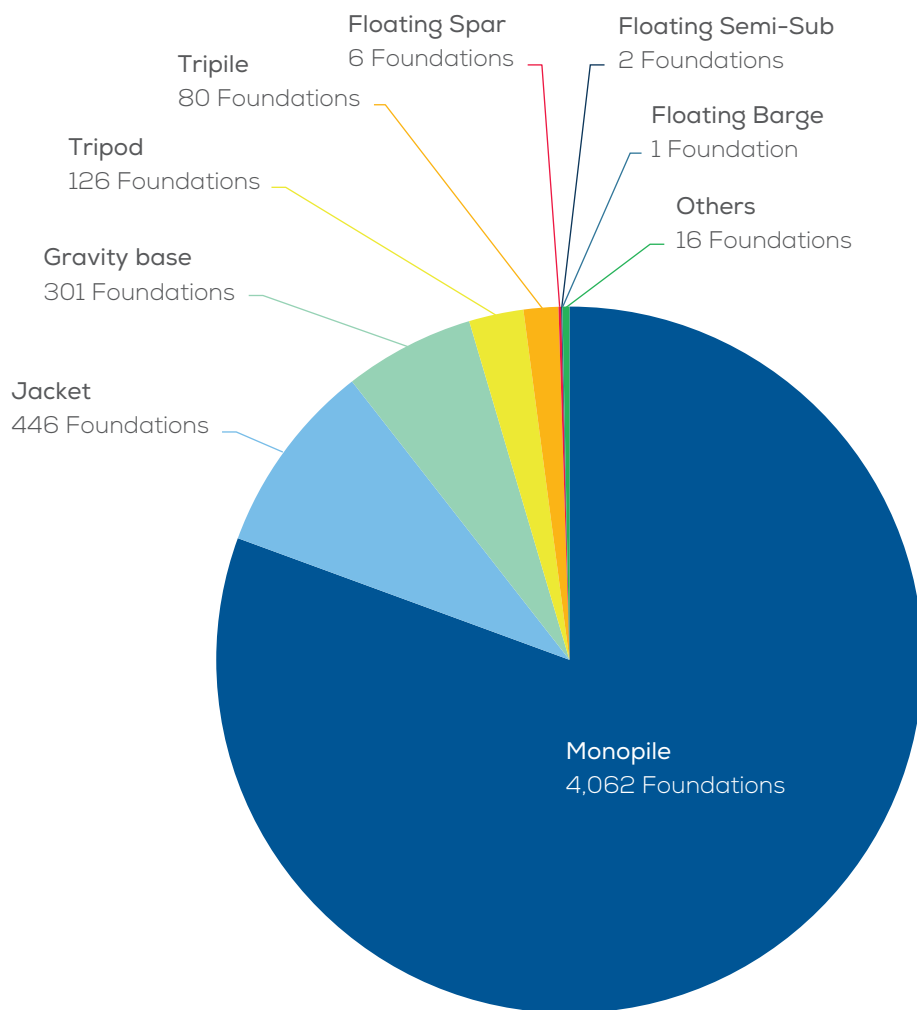
Regarding the total installed fleet (see figure 17), Monopiles represents 81.9% of all installed substructures in Europe.

Tripile (1.8%) and Tripod (2.8%) saw no additional installations in 2018. And the share of jacket foundations (6.6%) rose due to construction at Beatrice 2, East Anglia 1 and EOWDC. At the latter, Vattenfall installed the first commercial suction-bucket jackets (one suction-bucket jacket

was previously installed to support the substation at Bor-kum Riffgrund I).

A new type of substructure was introduced in Europe with the commissioning of the Floatgen project, using Ideol's floating solution, the Damping Pool (Barge).

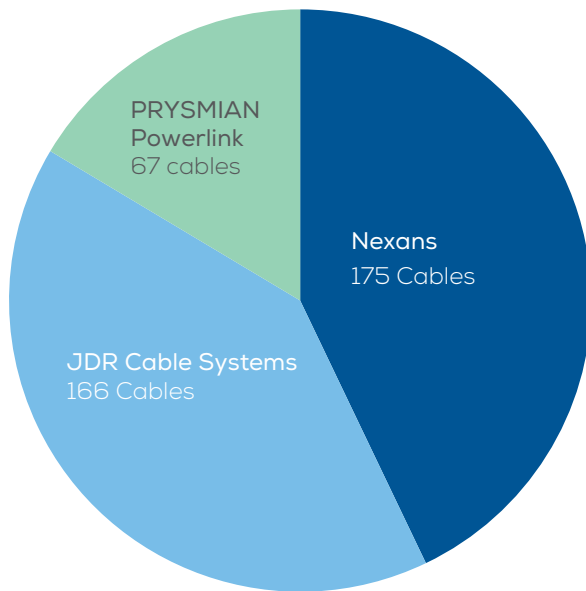
FIGURE 17
Share of substructure types for grid-connected wind turbines at the end of 2018



Source: WindEurope

3.4 CABLES

FIGURE 18
Share of energised intra-array cables by supplier in 2018

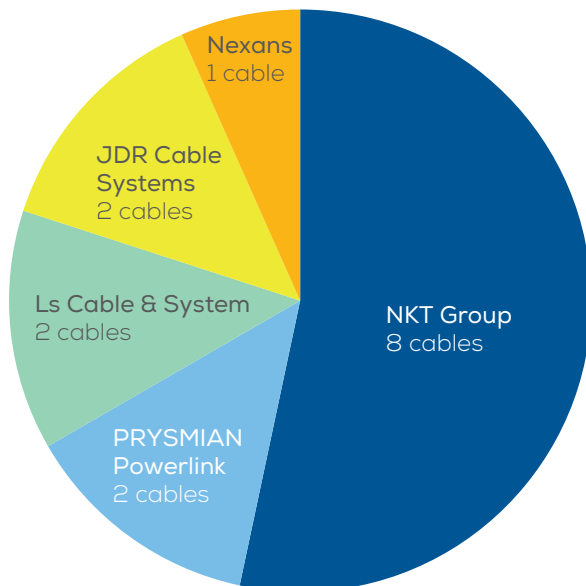


Source: WindEurope

42% of new intra-array cables⁸ energised in 2018 were from Nexans. JDR Cable Systems (32.1%) and Prysmian (16.1%) were the other suppliers with energised intra-array cables.

With the commissioning of the Blyth offshore wind farm last year, Nexans has now supplied 2 new wind farms with its new 66 kV cable technology.

FIGURE 19
Share of energised export cable by supplier in 2018¹⁰



Source: WindEurope

In terms of export cables⁹ in 2018 (figure 19), 8 export cables manufactured by NKT Group were energised, representing 53.3% of the annual market.

Prysmian, Ls Cable & System, and JDR Cable Systems each had a 13.3% share, and Nexans represented the remaining 6.7%.

8. Shares are calculated taking into account the number of grid-connected turbines in each wind farm during 2018.

9. In Germany, the export cable is the cable connecting the offshore HVDC substation to the land. In other countries the export cable is understood as the cable connecting the wind farm to land.

10. Shares are calculated by taking into account the number of export cables in fully completed new wind farms.



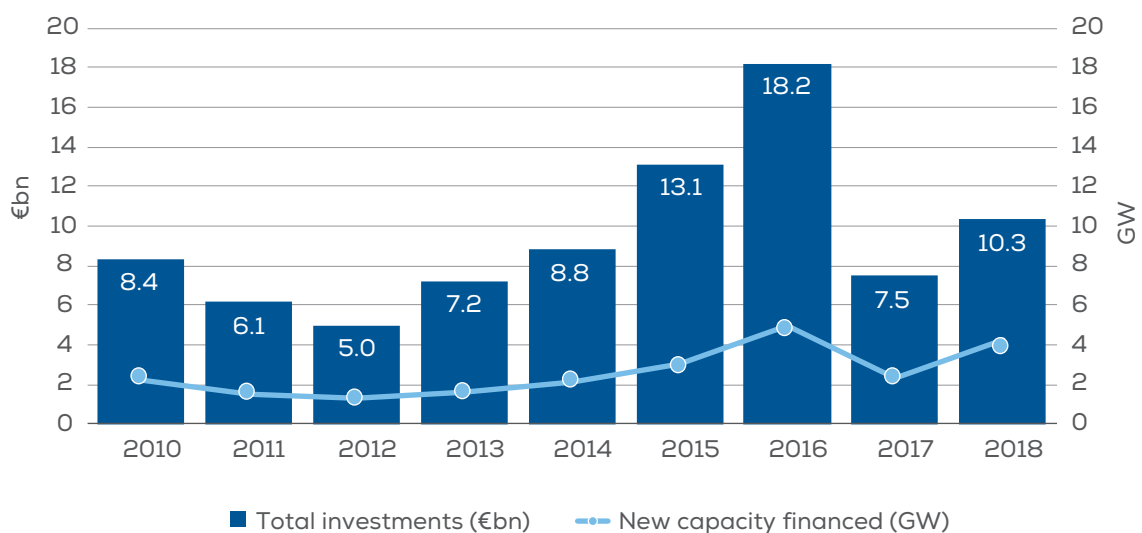
4. INVESTMENTS

4.1 FINANCING ACTIVITY IN 2018

New offshore wind investments in Europe increased to €10.3bn, up 37% from 2017. After the drop in Final Investment Decisions (FID) in 2017 as the market transitioned to auctions, investments in offshore wind recovered to the

third highest level on record. Project costs in 2018 were lower than in the previous three years, allowing 4.2 GW of additional capacity to be financed. This is the second highest amount after a record year in 2016.

FIGURE 20
New offshore wind investments and capacity financed: 2010 – 2018 (€bn)



Source: WindEurope

12 projects reached Final Investment Decision (FID) in 2018, 95% of which were concentrated in four countries: the UK, Belgium, Denmark and the Netherlands. The majority of the new capacity financed – a total of 52% – was

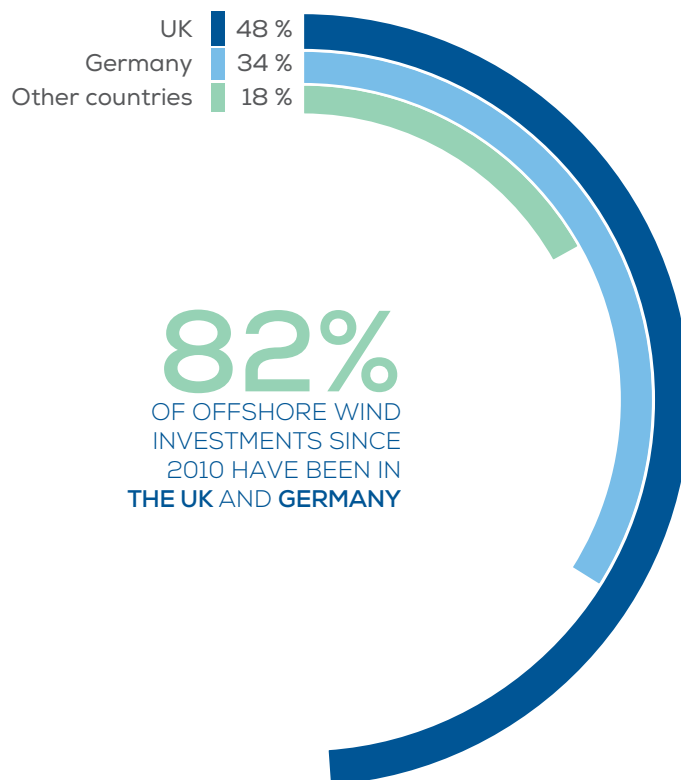
in the UK, including Triton Knoll and Moray East, totalling 1.8 GW of capacity between them. Other significant projects were Kriegers Flak (606 MW) in Denmark and Seamide (487 MW) in Belgium.

TABLE 4
Investment in European offshore wind farms in 2018

	TOTAL INVESTMENTS (€BN)	NEW CAPACITY FINANCED (MW)	NUMBER OF PROJECTS
United Kingdom	5.4	1,858	3
Netherlands	1.4	732	1
Denmark	1.1	605	1
Belgium	1.8	706	2
Germany	0.4	258	2
Italy	0.1	30	1
Portugal	0.1	25	1
Norway	0.0	4	1
Total	10.3	4,217	12

Since 2010 the UK has attracted 48% of new investments, worth €40bn, making it the biggest offshore wind market over the last nine years. Germany follows with 34% or €28bn invested over the same period.

FIGURE 21
Offshore wind investments by country since 2010

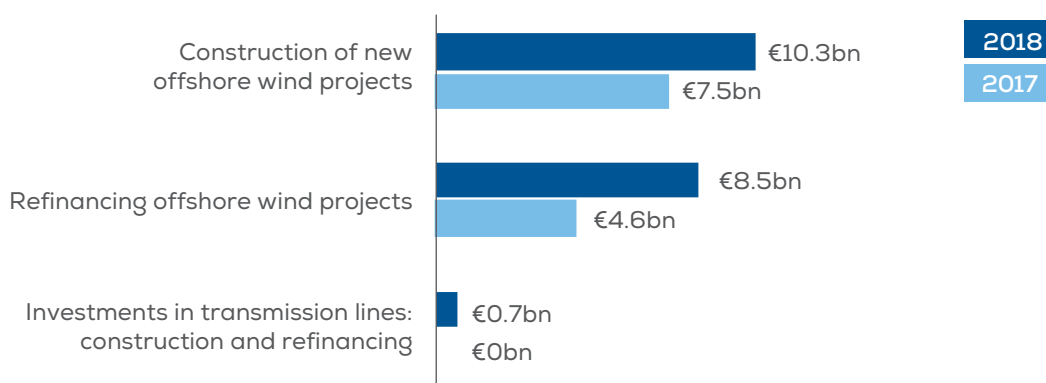


Source: WindEurope

In addition to the investments in new wind farms, 2018 also saw €8.5bn in refinancing transactions, an 85% increase over 2017. With the addition of new investments

in transmission assets of €0.7bn, offshore wind generated a total financing activity of €19.6bn.

FIGURE 22
Investments in the offshore wind sector in 2018 (€bn)



Source: WindEurope

4.2 OFFSHORE WIND DEBT FINANCE

Non-recourse debt continues growing in offshore wind financing. In 2018, lenders extended a record €16.5bn of non-recourse debt across twenty transactions for the financing of both new and operational wind farms.

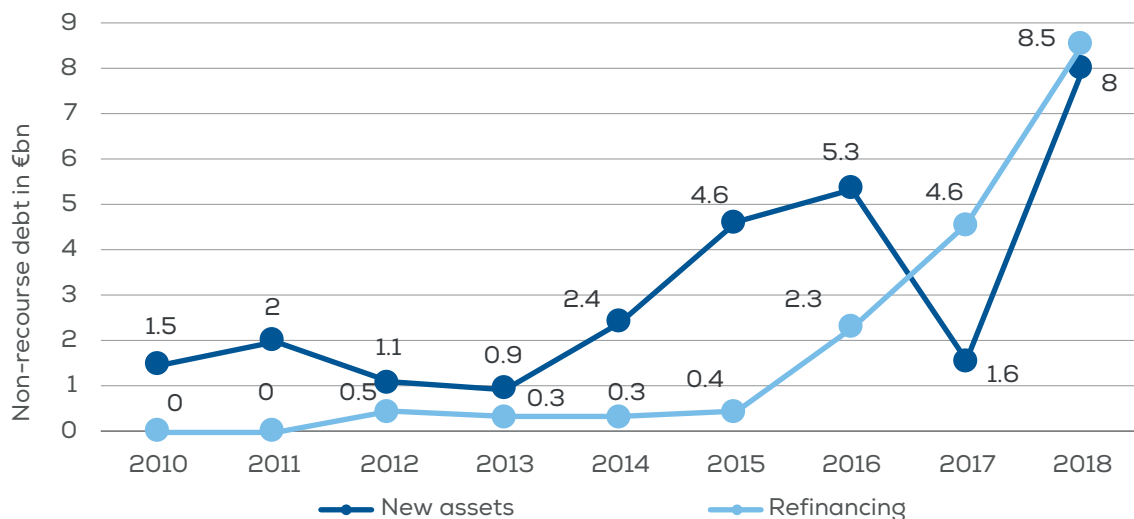
Non-recourse debt for new asset finance amounted to €8bn in 2018, driven mainly by Moray East and Triton Knoll wind farms in the UK, Borssele III & IV in the Netherlands and Seamade wind farm in Belgium.

Refinancing of operational wind farms raised €8.5bn across nine transactions in the Netherlands, Belgium, Germany and the UK. This is the fourth consecutive year that refinancing has risen steeply. Project sponsors continue

to use the favourable market conditions and increased liquidity to restructure their project debt.

The attractive sector yields have diversified the profile of lenders. A mix of 50 lenders were active in 2018, a substantial increase to those present in 2017, including multi-lateral financial institutions, insurance companies, export credit agencies, and commercial banks. As confidence continues to increase further in the European offshore wind sector, Japanese banks continue to strengthen their presence in the market.

FIGURE 23
Non-recourse debt trends per type of transaction (€bn)

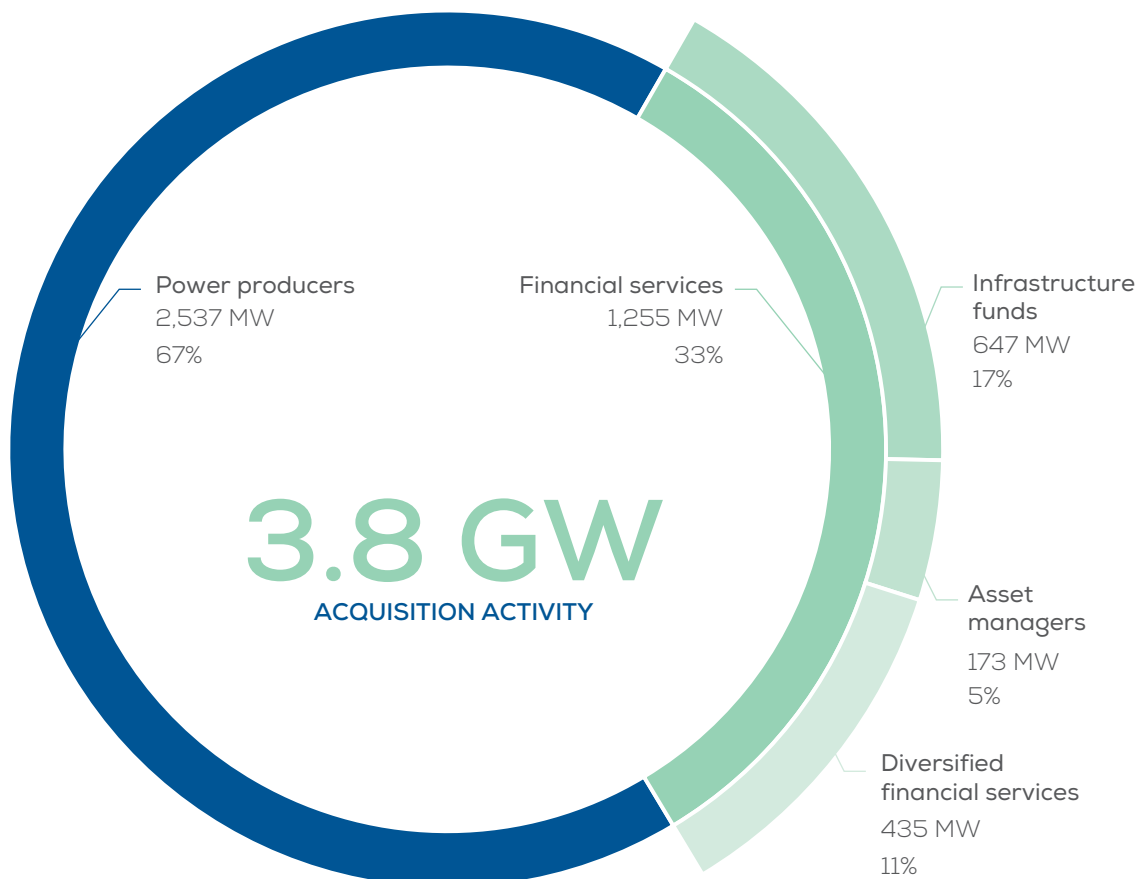


Source: WindEurope

4.3 ACQUISITION ACTIVITY

Project acquisition activity¹¹ increased 30% compared to 2017, totalling 3.8 GW. The equity mix continues to be approximately one third coming from financial investors, and two thirds from power producers.

FIGURE 24
Project acquisition activity in 2018 by type of investor



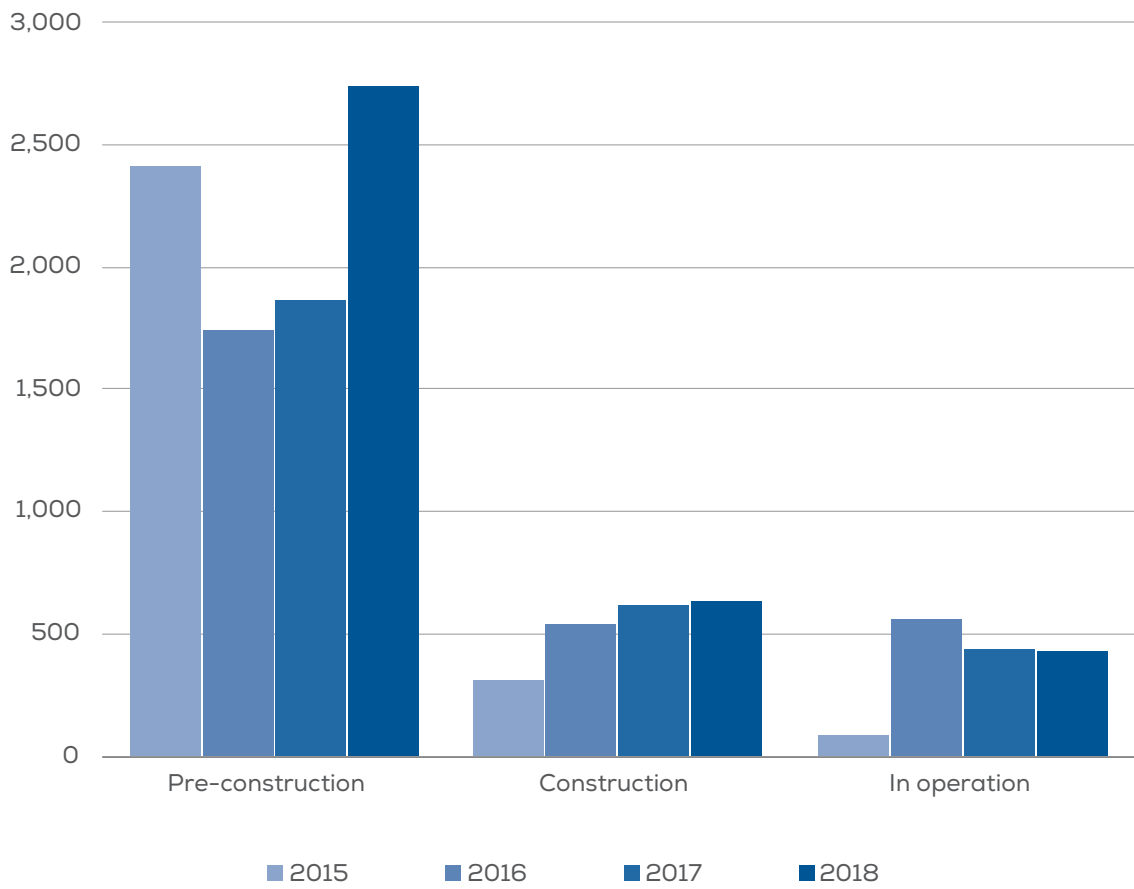
Source: WindEurope

The majority of transactions happened at the pre-construction stage, the most critical phase for a project's fundraising, with a record of 2.7 GW acquired. Meanwhile, 2018 bucked the trend of previous years, where

transactions at the construction and operation phase had increased significantly. There were 630 MW acquired at the construction phase and 425 MW at the operational phase, a 2% increase and a 4% decrease, respectively.

11. Excluding pre-development phase of projects.

FIGURE 25
Acquisition activity per project stage 2015-2018



Source: WindEurope

In addition to those listed above, acquisitions in the pre-development stage amounted to the equivalent of 2.3 GW of potential projects.

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.

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