THE CROWN ESTATE

Offshore wind operational report

2019

thecrownestate.co.uk

The Crown Estate

The Crown Estate manages a unique portfolio, which includes the seabed, natural marine resources and much of the foreshore around England, Wales and Northern Ireland.

In this capacity we are responsible for awarding seabed rights for offshore renewable energy projects as well as marine minerals, cables and pipelines. We play a unique role in developing and helping sustain UK energy supply and infrastructure, working in collaboration with a wide range of organisations.

Established by an Act of Parliament, we return all our profit to Treasury for the benefit of the nation. This has totalled £2.8bn over the last ten years.

Scotland

The seabed around Scotland is managed by a separate organisation, Crown Estate Scotland.

This report has been produced by The Crown Estate but for completeness, publicly available data on offshore wind in Scotland has been included in key sections, such as offshore wind farm status and national metrics.

We have also included a page on offshore wind management in Scotland, provided by Crown Estate Scotland (page 7).

32TWh
2019 UK OFFSHORE WIND ELECTRICITY PRODUCTION

13m tonnes
AVOIDED CO_2

10%
PROPORTION OF TOTAL UK ELECTRICITY GENERATED BY OFFSHORE WIND IN 2019

30%
UK OFFSHORE WIND GENERATED ENOUGH ELECTRICITY IN 2019 TO SUPPLY THE NEEDS OF 8.3M HOMES, AROUND 30% OF THE UK TOTAL

Hornsea 1 offshore wind farm (Ørsted)

Introduction

This operational report, covering 2019, is testament to the professionalism and vitality of the UK offshore wind sector.

With over 40 wind farms and around 2,200 turbines now generating in UK waters, it's easy to forget that less than 20 years ago the first-ever offshore turbines were installed in the North Sea. Those trailblazing turbines at Blyth, a project I was privileged to manage, kick-started the remarkable progress of offshore wind in UK waters and proved an invaluable testing ground for offshore wind construction, operations and maintenance. In Blyth's lifetime, the UK offshore wind sector has matured almost beyond recognition, and the project's safe decommissioning in 2019 marks a historic milestone for our industry.

20 years on, this maturity is reflected in the sector's strong collaboration on key strategic issues such as data collection and environmental performance. Many wind farms have post-construction environmental monitoring programmes in place. A strong evidence base is vital to ensure the great shift to offshore wind occurs in a sustainable manner – after all, the seas around our country are home to a staggering number of animal and plant species, many of which are already under pressure. We are playing our part, including with the Marine Data Exchange, one of the world's largest open-access databases of marine spatial information, an overview of which is provided in this report.

Speaking of pressure, as I write this in March 2020, daily life for many of us has changed beyond recognition because of the Covid-19 pandemic. Yet, the global offshore wind sector continues to perform remarkably strongly, as demonstrated by its contribution to the supply of energy, now around 10% of UK electricity generation. Operations and maintenance teams are keeping the critical national infrastructure of our wind farms running.

Long-term growth outlook is strong, underpinned by fundamentals such as the UK's legal commitment to net zero by 2050. As we anticipate a gradual return to a form of normal business, the performance and resilience of the sector in 2019 has confirmed its credentials for sustained growth in the year ahead and the decades to come.

Huub den Rooijen
Director of Energy, Minerals and Infrastructure
The Crown Estate

Figure 1: UK electricity generation mix 2019*

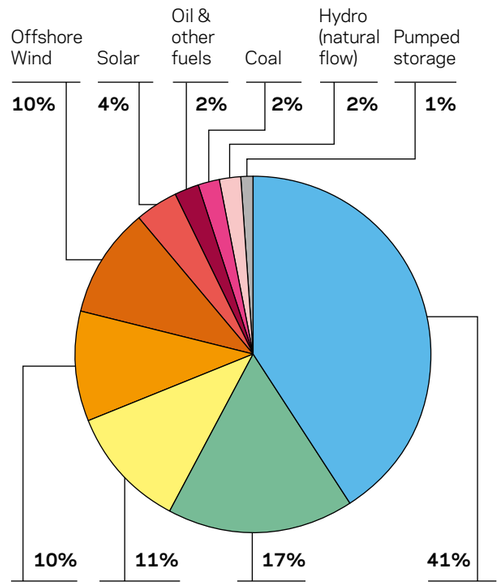
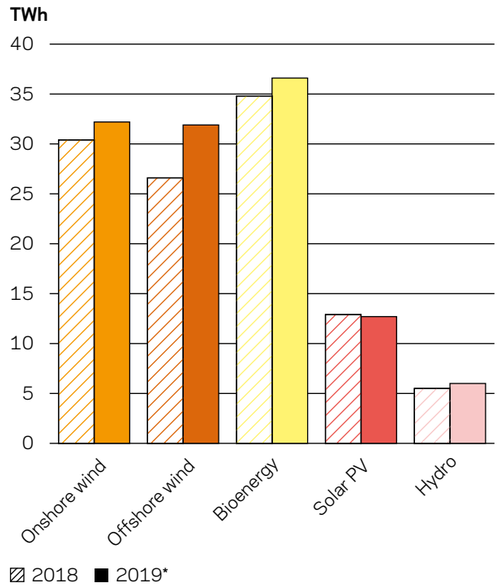


Figure 2: Renewable electricity generation by fuel type



*Source: BEIS energy statistics (provisional figures)

Offshore wind farm status

The UK continues to lead the charge in offshore wind across Europe.

1.8GW of new wind farm capacity became fully operational in 2019, as Beatrice in Scotland and Hornsea 1 off the east coast of England were both fully commissioned. At 1.2GW Hornsea 1 became the largest offshore wind farm in the world. Construction commenced on East Anglia ONE in the North Sea and on Neart na Gaoithe in the Firth of Forth. At the other end of the spectrum, Blyth – the UK's first and smallest offshore wind farm at just 4MW – was decommissioned 19 years after installation. Further information on this project can be found on pages 28-29.

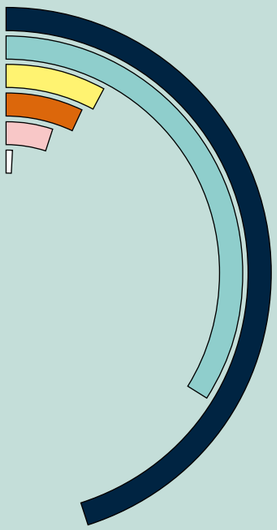
Figure 4 shows the UK now has over 14GW of total capacity either fully operational (9.7GW) or under construction (4.4GW). The actual grid connected capacity at the end of 2019, including the connected capacity at under construction sites, was 9.9GW. This means that 45% of all grid connected capacity in Europe is located in the UK, as shown in figure 3. The World Forum Offshore Wind places the UK as number one in the world for offshore wind installed capacity, followed by Germany and China.

The major change during 2019 was to those projects with government support on offer. In the autumn, the results of Round 3 of the Contracts for Difference (CfD) allocations were published at landmark strike prices, the lowest being £39.65/MWh. Six projects were successful, including several of the Dogger Bank projects, enabling almost 5.5GW of further capacity. This brought the total capacity of sites – operating, under construction and awarded a CfD – to 19.6GW.

Since the first UK offshore wind farm was commissioned in 2000, a huge collective effort has been made to achieve almost 10GW of capacity in operation by 2020 and another 4GW under construction. With a typical project taking ten years from planning to final commissioning and downward pressure on CfD prices, considerable renewed vigour is now needed to achieve the Government ambition of 40GW by 2030.

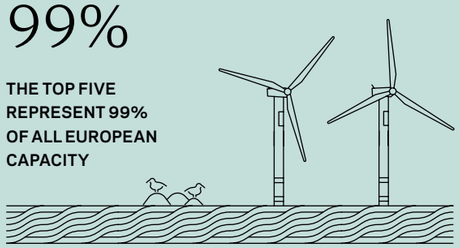
Figure 3: Current European offshore wind generating capacity based on grid-connected turbines, including sites under construction

	MW	Turbines	%
UK	9,983	2,230	45%
Germany	7,445	1,469	34%
Denmark	1,703	559	8%
Belgium	1,556	318	7%
Netherlands	1,118	365	5%
Rest of Europe	306	111	1%



99%

THE TOP FIVE REPRESENT 99% OF ALL EUROPEAN CAPACITY

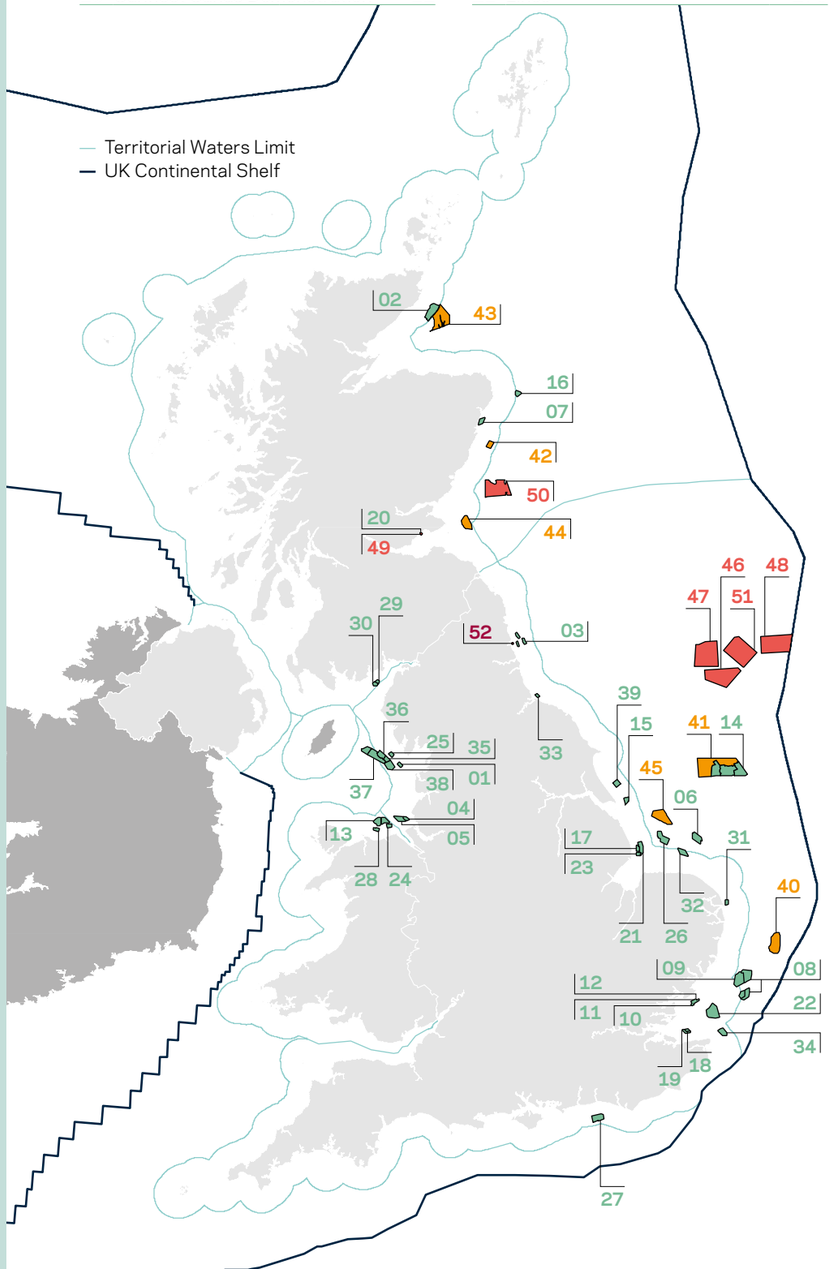


Source: Wind Europe bit.ly/3enNzt7

Figure 4: UK offshore wind project pipeline as at 31 December 2019

Operational: Total capacity of wind farms that have been fully commissioned

	Capacity MW
01 Barrow	90
02 Beatrice*	588
03 Blyth Demonstration (Phase 1)	42
04 Burbo Bank	90
05 Burbo Bank Extension	259
06 Dudgeon	402
07 European Offshore Wind Deployment Centre*	93
08 Galloper	353
09 Greater Gabbard	504
10 Gunfleet Sands Demonstration	12
11 Gunfleet Sands I	108
12 Gunfleet Sands II	65
13 Gwynt y Môr	576
14 Hornsea 1	1,218
15 Humber Gateway	219
16 Hywind Scotland	30
17 Inner Dowsing	97
18 Kentish Flats	90
19 Kentish Flats Extension	50
20 Levenmouth Demonstration*	7
21 Lincs	270
22 London Array	630
23 Lynn	97
24 North Hoyle	60
25 Ormonde	150
26 Race Bank	573
27 Rampion	400
28 Rhyl Flats	90
29 Robin Rigg East*	84
30 Robin Rigg West*	90
31 Scroby Sands	60
32 Sheringham Shoal	317
33 Teesside	62
34 Thanet	300
35 Walney 1	184
36 Walney 2	184
37 Walney Extension	659
38 West of Duddon Sands	389
39 Westermost Rough	210
TOTAL	9,701



Under construction: Total capacity of wind farms that are under construction or where the developer has confirmed a final investment decision, but are not yet fully operational

	Up to capacity MW
40 East Anglia ONE	714
41 Hornsea 2	1,386
42 Kincardine*	50
43 Moray East*	950
44 Neart na Gaoithe*	448
45 Triton Knoll	857
TOTAL	4,405

Government support on offer: Total capacity of wind farms that have secured a Contract for Difference

	Up to capacity MW
46 Dogger Bank A	1,200
47 Dogger Bank B	1,200
48 Dogger Bank C	1,200
49 Forthwind*	12
50 Seagreen Phase 1*	454
51 Sofia Offshore Wind Farm Phase 1	1,400
TOTAL	5,466

Total capacity of wind farms that have been decommissioned

	Up to capacity MW
52 Blyth	4
TOTAL	4

*Asset managed by Crown Estate Scotland

Offshore wind assets

There are now more than 2,000 grid-connected wind turbines on the UK seabed. In Figure 6, we've categorised them as Operational if the site was fully commissioned by the end of December 2019. In fact there were 2,230 grid connected turbines as some capacity was already generating at sites classed as Under Construction.

During the year, eight offshore wind farms were under construction, several of which began generating and two became fully operational. This added half of all new offshore wind capacity built in Europe and more than a third of all new global offshore capacity in 2019.

It was a landmark year for UK offshore wind with the final turbine installed at Hornsea 1, now the largest offshore wind farm globally and capable of supplying the electricity needs of one million UK homes. In 2019, the average turbine capacity installed reached 7.0MW, an increase of 18% compared to last year. There were also announcements about the next generation of wind turbines, including that SSE and Equinor intend to use the GE Haliade-X 12MW turbine at their proposed Dogger Bank wind farm sites.

Figure 5: Asset activity in 2019

Wind farms having achieved Final Investment Decision (FID)

Neart na Gaoithe

Wind farms under construction

East Anglia ONE
Hornsea 1
Hornsea 2
Kincardine
Moray East
Neart na Gaoithe
Triton Knoll

Wind farms achieving first power

East Anglia ONE
Hornsea 1

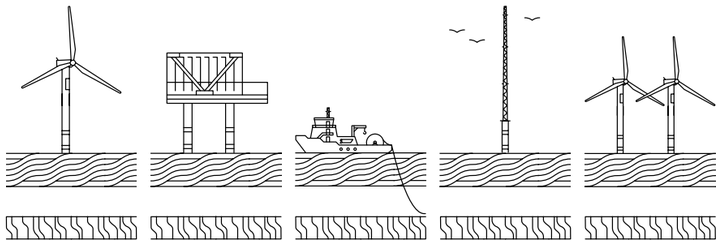
Wind farms completed

Beatrice
Hornsea 1

Wind farms decommissioned

Blyth

Figure 6: UK offshore wind assets as at 31 December 2019



	OFFSHORE TURBINES	OFFSHORE SUBSTATIONS	EXPORT CABLES	MET MASTS	WIND FARMS
Operational:	2,189	32	74	11	39
Under construction:	652	10	13	0	6
TOTAL:	**2,841**	**43**	**87**	**11**	**45**

Operational: Wind farms that have been fully commissioned and achieved Works Completion

Under construction: Wind farms having reached Final Investment Decision (FID) and those that are under construction but not yet fully operational. There is a reduction in the offshore turbines under construction since the 2018 report because planned turbine capacities have increased at Moray East, reducing the quantity of turbines needed.

Scotland

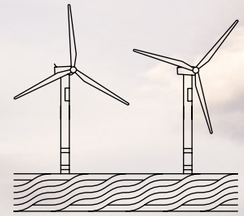
In Scotland, the seabed and around half of the foreshore is managed by Crown Estate Scotland, a public corporation separate to The Crown Estate which works to manage Crown Estate assets on behalf of Scottish Ministers.

Just over 890MW of capacity is currently in operation across seven Scottish offshore wind sites, with a further 1GW due to come online in phases by 2022. 2019 saw Beatrice wind farm in the Moray Firth reach full operation. At the time, it was the world's fourth-largest offshore wind installation with 588MW of installed capacity – enough to provide 450,000 homes with electricity.

Crown Estate Scotland will launch the latest round of seabed leasing for offshore wind developers in the first half of 2020. The project aims to bring significant additional installed capacity to Scottish waters by 2030 in line with the Scottish Government's sectoral marine plan, the consultation draft of which provides for up to 10GW of new development.

890MW

JUST OVER 890MW OF CAPACITY IS CURRENTLY IN OPERATION ACROSS SEVEN SCOTTISH SITES



Beatrice offshore wind farm (SSE)

Floating offshore wind sites in Scotland

Floating turbines are already in operation at two sites in Scottish waters: the Kincardine offshore wind farm and Hywind Scotland developments.

The larger of the two, Hywind Scotland, is the world's first fully operational floating wind farm. Located in the North Sea, it consists of five turbines, each with 6MW capacity, arranged across an area of around four square kilometres. The turbines are ballast stabilised, anchored to the seabed in water depths of between 95m and 129m, and are subject to average wind speeds of 10m per second. Hywind Scotland generated enough electricity in 2019 to power 36,000 homes. (Source: Equinor)

The Kincardine offshore wind farm currently operates a single test turbine with a capacity of 2.5MW. Over the next 2 years, an additional five turbines will be installed, each with a capacity of 9.5MW, taking the total capacity to 50MW.

Floating wind technologies are currently less widely deployed than the more mature, fixed solutions. With as much as 80% of the total potential for offshore wind believed to be in deep waters, it could play a significant role in meeting future energy requirements.

Crown Estate Scotland
Oighreachd a' Chrùin Alba

Health and safety

Health and safety performance in offshore wind is improving. Data in this section refers to the latest report[1] (2018) from G+, the global health and safety organisation for offshore wind, which reveals that 11 out of 12 categories of reportable incident showed an improvement between 2017 and 2018 as illustrated in Figure 7.

The UK outperformed the global industry in 2018 as its Lost Time Injury Frequency (LTIF[2]) and Total Recordable Injury Rate (TRIR[3]) were 1.48 and 4.43 respectively, while the global industry's LTIF and TRIR were 1.52 and 4.55 respectively.

Comparing the LTIF and TRIR of the three countries with the highest number of offshore wind farm sites – UK (40), Germany (14) and Denmark (6) – the UK again emerged with the best health and safety performance, as shown in Figure 8.

While there has been tremendous improvement in the UK and global industry, there is still scope for more. Out of the 256 high potential incidents that occurred in 2018, 66% were in the UK. High potential incidents are those that have the potential to cause fatal or life-changing injuries.

The improvement in overall performance of global offshore wind has been attributed to the maturity of the industry, which is in turn driven by:

- A strong focus on high potential hazards
- Improved technology
- Improved culture where stakeholders share lessons learned
- Improvement of working methods

Figure 9 shows the incident categories[4] for the UK, which highlights the need to continually improve health and safety performance.

Further breakdown of the data shows that of the 588 incidents, construction, development and operations sites contributed 208, 11 and 369 incidents respectively. Marine operations, access/egress and lifting operations were the top three work processes accounting for 19%, 12% and 10% respectively.

To drive improved performance, G+ continues to share learnings including improving safety designs, use of technology to reduce risks, and focusing on mental health and wellbeing.

The G+ 2018 incident data can be found at bit.ly/3er95NA

Figure 9: Incident categories for UK offshore wind industry in 2018

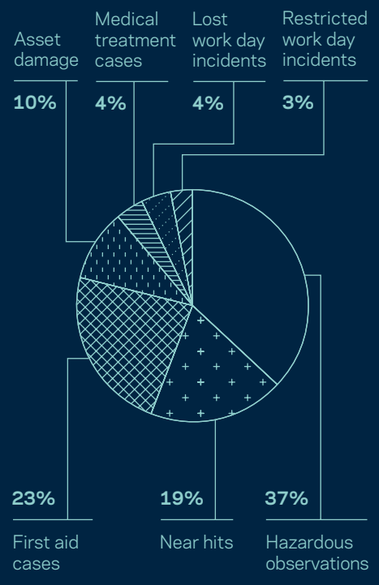


Figure 7: Global offshore wind industry incident comparison between 2017 and 2018

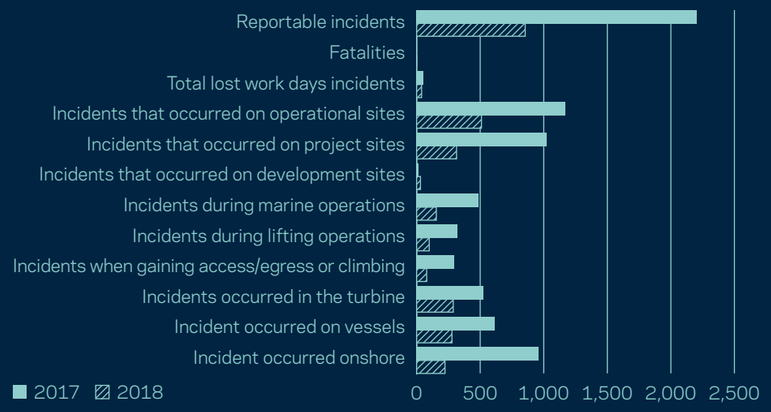


Figure 8: Countries with the highest number of sites in 2018

Country	Number of sites	LTIF	TRIR
UK	40	1.48	4.43
Germany	14	2.46	5.75
Denmark	6	2.88	10.96

1 A time lag in the data means 2019 global health and safety statistics are not yet available. We have reported on the recently published G+ 2018 incident data report.

2 LTIF = The number of recordable injuries (fatalities + lost work day incidents) per 1,000,000 hours worked.

3 TRIR = The number of recordable injuries (fatalities + lost work day incidents + restricted work day incidents + medical treatment injuries) per 1,000,000 hours worked.

4 As defined in the G+ Global Offshore Wind Health and Safety Organisation's 2018 incident data report.

Wind farm performance

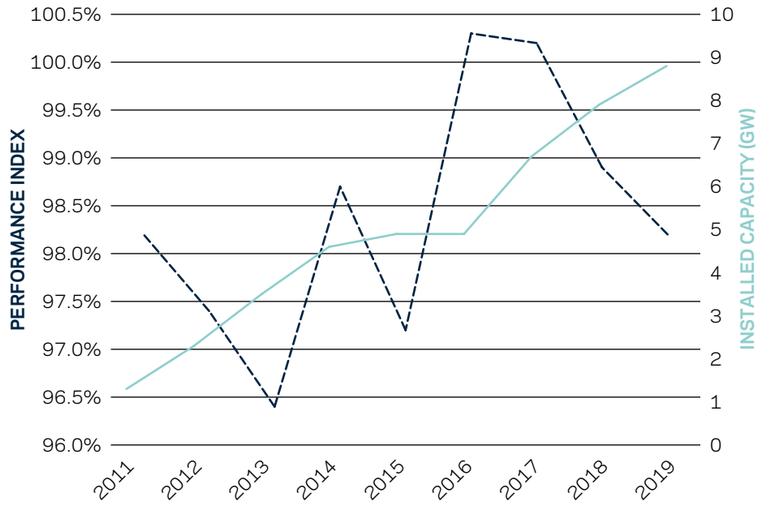
Fleet performance index

The fleet performance index compares metered electricity output against the expected output adjusted for actual wind speed during that period. It gives a direct measure of, and improves our ability to forecast, the performance of the offshore wind farm fleet in England and Wales, without any adjustment for outages. The analysis includes the whole system of fully operational wind farms and their associated transmission/export of electricity back to shore. The construction period is excluded.

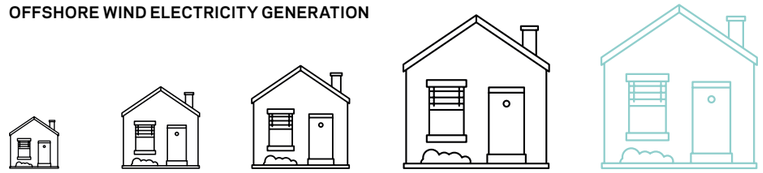
The expected power output is derived from hourly satellite measurements of local wind speed and theoretical wind turbine power curves. This calculation method carries a notable uncertainty, primarily due to indirect and low-frequency wind speed data. A more accurate calculation would necessitate 10-minute average wind speed data and project-specific power curves.

In 2019, the fleet performance index was 98.2% despite being affected by cable repairs and grid maintenance. This impressive performance reflects the quality of the hardware and the efficient management of the assets. Figure 10 shows the variation in fleet performance for the last nine years.

Figure 10: Fleet performance index



NUMBER OF HOMES THAT COULD BE SUPPLIED BY OFFSHORE WIND ELECTRICITY GENERATION



2013 2.7m (10%)

2015 4.4m (16%)

2017 5.3m (20%)

2019 8.3m (30%)

2020 (est.) *8.8m (32%)*

Capacity factor

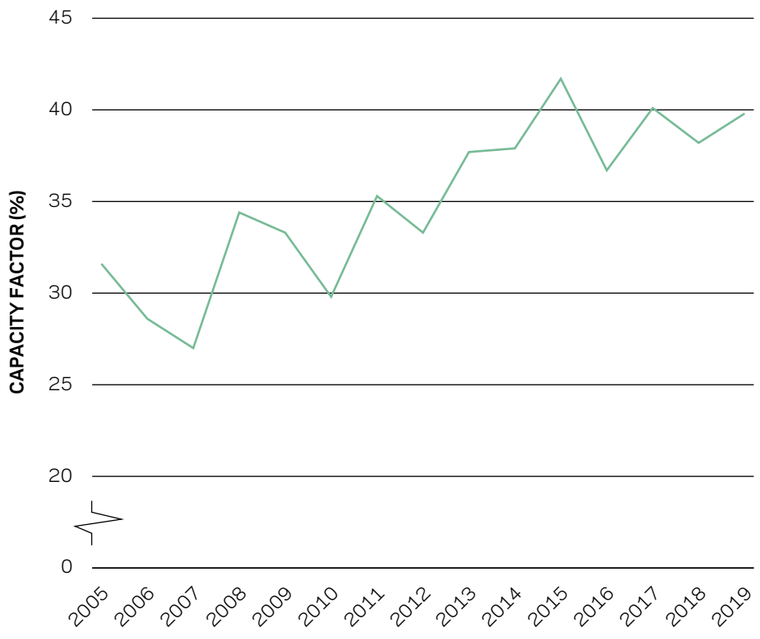
Figure 11 shows the evolution of the capacity factors of offshore wind farms in England and Wales between 2005 and 2019.

The capacity factor is the average power generated over a period, divided by the rated peak power. It indicates how fully a plant's capacity is used.

The capacity factor of offshore wind farms is usually higher than onshore wind farms due to stronger, more stable wind conditions at sea. This is particularly noticeable for the latest wind farms located further offshore.

In 2005, the capacity factor was around 30%. In 2019, it was almost 40%. It means the power output per unit capacity has increased by a third – a considerable improvement. This is because of the fine-tuning of service campaigns and maintenance contracts to optimise production-based availability of the plant. It is also because capacity factors of newer sites are higher and closer to 50%.

Figure 11: Capacity factor evolution



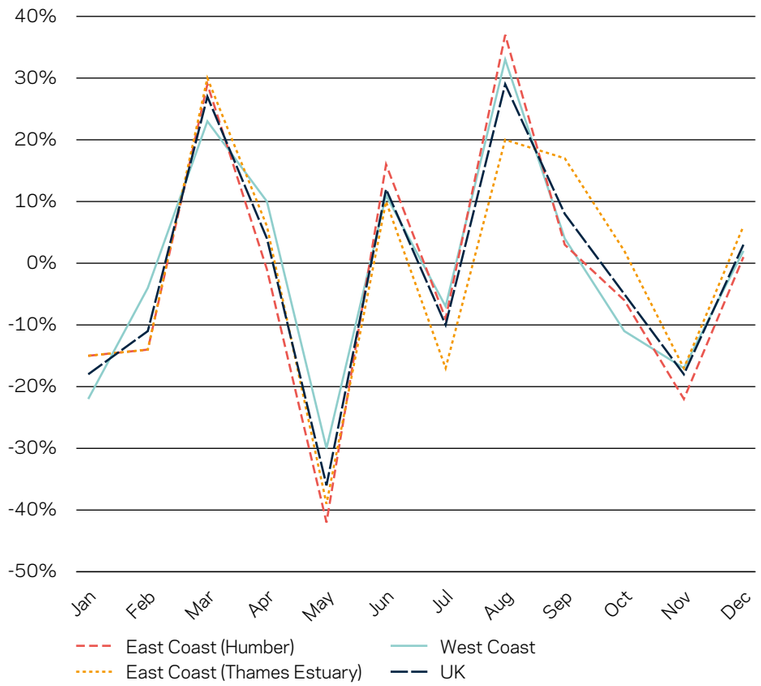
Wind variability

Wind farm output is dependent on wind speed. While the average output of a wind farm over its lifetime can be accurately calculated using long-term data, its performance over a short period of time is primarily dependent on local wind conditions.

Figure 12 shows the impact on energy production due to monthly wind speed variation in England and Wales.

March and August were significantly windier than expected, while January, May and November were significantly less windy than average conditions. Variations due to local wind conditions are expected, however there was less regional variability in 2019 compared to recent years. The overall energy deviation at the end of 2019 was 2.3% below the long-term average.

Figure 12: Monthly energy deviation due to wind speed in 2019



Sheringham Shoal offshore substation (Aerial Vision and Equinor)

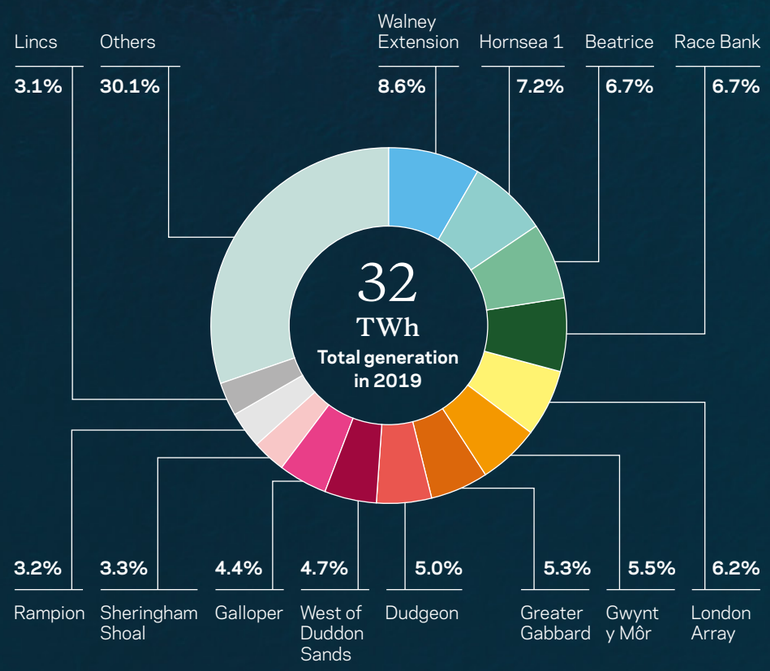
Offshore generation

Figure 13 shows that the top 5 wind farms generated more than a third of the UK's total offshore wind power in 2019.

The air flow at a higher altitude is stronger and less turbulent. This greatly reduces transient loads and improves power output. Taller turbines can therefore harness more power per unit capacity compared to smaller turbines.

The latest wind farms in operation have capacity factors in excess of 50% (the average production is more than 50% of the nameplate capacity).

Figure 13: Offshore wind electricity generation by UK asset in 2019



Offshore Transmission Owner (OFTO) performance

The OFTO offshore transmission system consists of 22 offshore substations, supporting over 5.6GW of generating capacity connected by 34 export cable circuits. These interface with either National Grid's National Electricity Transmission System (NETS) or the lower voltage distribution networks owned and operated by Distribution Network Operators (DNO). OFTO ownership details are on page 23.

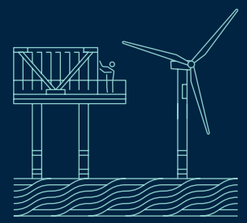
Transmission system availability for OFTOs is published by National Grid each July in the annual NETS Performance Report. The information in this section covers data up to March 2019.

The OFTOs are incentivised through the OFTO regulatory framework to provide prescribed minimum levels of availability. The default for this is 98%, with specific targets established for each OFTO. Figure 16 shows the general trend of annual availability.

National Grid collates availability data for each OFTO annually – this includes all outages that originate on an OFTO's system but excludes outages that originate elsewhere, for example on a wind farm generator or DNO system. The OFTO availability incentive then adjusts the reported outage data to calculate incentivised performance for each OFTO.

In 2018/19, average OFTO availability was 99.50%, higher than the previous year (98.22%), highlighting that there were fewer outages and that OFTOs maintained transmission system availability for the majority of the year, as shown in figure 15. This enabled the wind farms to transmit electricity to the National Grid with minimal disruption.

OFTOs can be unavailable for several reasons. These include planned outages required for maintenance or modification of the assets, unplanned outages as a result of plant or equipment failure, i.e. circuit trips/faults, or outages requested by the DNO. Figure 14 shows the breakdown of planned and unplanned system unavailability for 2018/19.



99.5%

ANNUAL AVAILABILITY OF OFFSHORE NETWORKS FOR 2018/19 WAS 99.50%

Figure 14: 2018/19 OFTO system unavailability

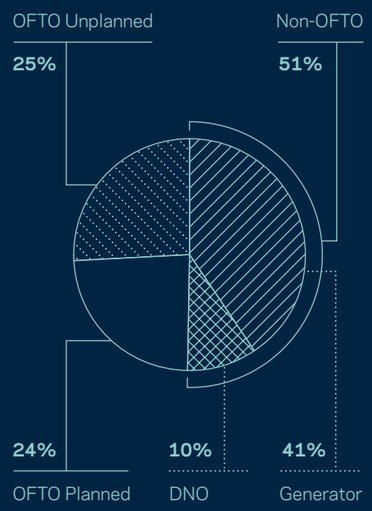


Figure 15: Offshore Transmission Networks % Annual System Availability

	2014-15	2015-16	2016-17	2017-18	2018-19
Barrow OFTO	100	99.88	100	99.99	100
Bubo Bank Extension OFTO	N/A	N/A	N/A	N/A	98.15
Dudgeon OFTO	N/A	N/A	N/A	N/A	100
Greater Gabbard OFTO	100	100	99.78	99.61	99.82
Gunfleet Sands OFTO	99.53	100	99.95	99.81	99.97
Gwynt y Môr OFTO	82.59	82.58	99.73	100	99.84
Humber Gateway OFTO	N/A	N/A	100	93.75	100
Lincs OFTO	100	100	99.93	99.78	100
London Array OFTO	99.90	99.98	98.88	99.80	99.94
Ormonde OFTO	99.93	100	99.59	100	100
Robin Rigg OFTO	100	99.99	99.99	100	100
Sheringham Shoal OFTO	99.84	100	99.95	99.23	99.40
Thanet OFTO	82.47	83.05	96.15	100	100
Walney 1 OFTO	100	100	99.62	99.70	100
Walney 2 OFTO	100	92	100	100	91.42
West of Duddon Sands OFTO	N/A	100	99.64	99.45	100
Westermost Rough OFTO	N/A	100	100	100	99.73

Dudgeon offshore substation (Roberg Gregory Yorke and Equinor)

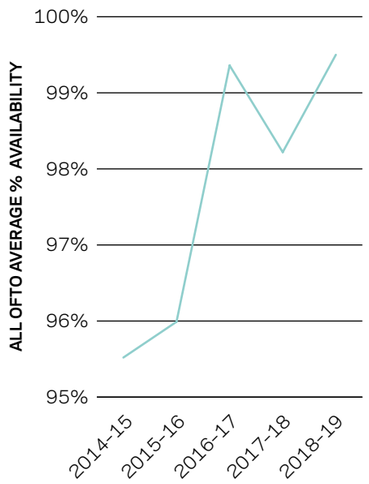
Moving towards a more integrated offshore grid

The theme of moving toward a more integrated or coordinated approach to offshore transmission gained increasing prominence during 2019. The Offshore Wind Sector Deal[1] identified that Government would work with the sector and wider stakeholders to address issues around a more strategic approach to offshore transmission. This implicitly recognises that the current approach of developing radial links is unlikely to be efficient or optimal with moving toward significantly higher deployment levels. Work has been progressing through the Offshore Wind Industry Council to distil the key issues with the current arrangements, both in the short term and also for longer term strategic development.

During 2019, we have been exploring the potential for offshore transmission infrastructure to be designed for a longer life than is currently the case for operating projects – potentially up to 60 years to facilitate two wind farm project life cycles. This would enable any subsequent re-powering and/or re-planting without the need to develop new transmission infrastructure in parallel. This will help to further reduce costs of offshore wind, limit seabed disturbance and mean infrastructure is more resilient. The Information Memorandum[2] we published at the outset of the Round 4 leasing process indicated that we were considering the possibility of introducing new requirements in lease agreements in this regard. Work on this was progressed in the early stages of the process, and we expect to make the results available during 2020.

We were encouraged to see Ofgem recognising the need to consider coordinated grid solutions for offshore wind in its Decarbonisation Action Plan[3], published in February 2020. Against the backdrop of Net Zero, Ofgem indicated it would work with Government, industry, the Electricity System Operator and The Crown Estate to develop coordinated solutions and in doing so, explore options for meshed grids rather than radial links. This is a positive development and we will devote time to this in 2020.

Figure 16: OFTO availability trend



1 HM Government bit.ly/2KbeM4k
2 The Crown Estate bit.ly/2z6o13T
3 Ofgem bit.ly/3evZNQL

Marine Data Exchange

The Marine Data Exchange (MDE), created by The Crown Estate, is the first online portal to manage offshore survey data collected throughout the lifetime of offshore wind farms.

In 2019, we added 29 surveys to the MDE, totalling 12TB of additional data, and invested in upgrades to the user experience. We facilitate access to this survey data and work closely with our customers to ensure that all survey data is made widely and freely available in a reasonable timeframe.

We know that survey data and evidence play a key role in the ongoing growth of the offshore wind industry and are committed to investing in the MDE to improve access and unlock the value in this wealth of data.

SHIPPING AND NAVIGATION
WAVE AND CURRENT RESOURCE DATA
BENTHIC ECOLOGY
METEOROLOGY
ARCHAEOLOGY
NOISE
OTHER
ENVIRONMENTAL STATEMENTS
GEOPHYSICAL
SEDIMENTOLOGY
GEOTECHNICAL
ONSHORE
INTERTIDAL ECOLOGY
EPIFAUNA AND FISH
MARINE MAMMALS
COASTAL PROCESSES
UNEXPLODED ORDNANCE
BIRDS
WIND RESOURCE DATA
METOCEAN

www.marinedataexchange.co.uk

Figure 17: 2019 public survey downloads by user type

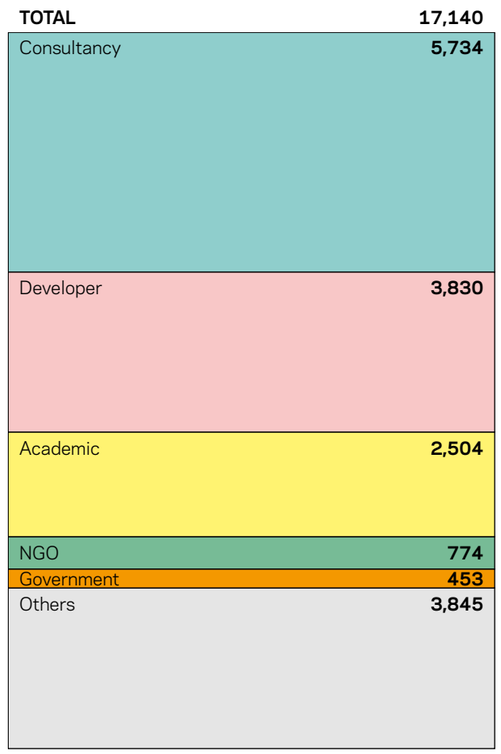
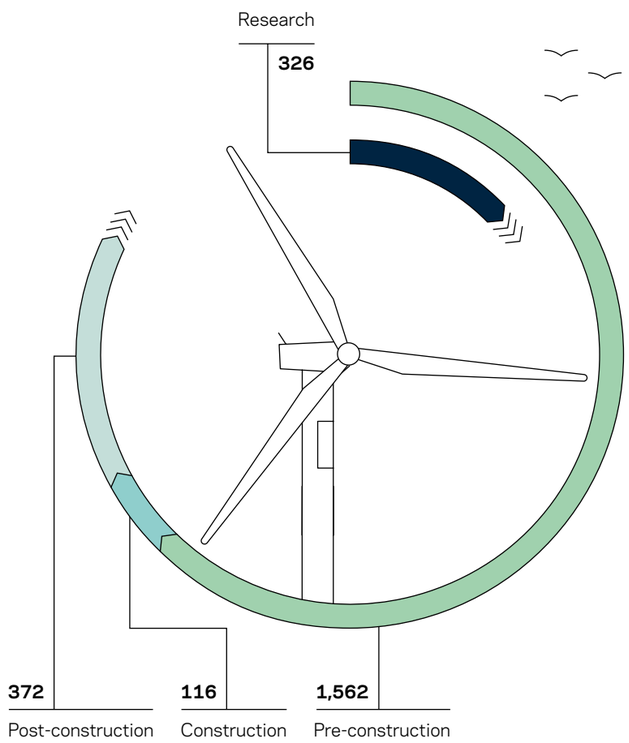


Figure 18: Survey data held on the MDE by development phase



2,311
SURVEYS

179TB
OF DATA

62%
PUBLICLY AVAILABLE

71%
INCREASE IN PUBLIC DOWNLOADS SINCE 2018

Figure 19: Survey data coverage on the Marine Data Exchange

Post-construction environmental monitoring survey data

The MDE holds extensive survey data across the lifetime of a project, including all monitoring data collected during and after the construction phase.

Almost half of all post-construction survey data held on the MDE is from environmental monitoring campaigns and this resource continues to grow as more wind farms become operational. The MDE acts to bring this data together in one place, generating an evidence base that can be used to identify trends across the offshore wind sector. It also provides useful insights into observed effects of wind farms on the marine environment compared to what was predicted during the planning and impact assessment phase.

The intensity of survey activity fluctuates over time, as some wind farms start their post-construction monitoring and others stop monitoring as they discharge their licence conditions. Throughout this, we work closely with offshore wind operators to understand what survey data has been collected, organise its upload to the MDE in line with consistent data standards and ensure that it can be reused by passing it through a quality assurance process. Some of the data that has been collected over the last three years is not yet on the MDE and this is reflected in the faint section of figure 21.

Figure 20: Post-construction environmental surveys held on the MDE by theme*

150

POST-CONSTRUCTION ENVIRONMENTAL MONITORING SURVEYS

*Surveys may contain more than one theme

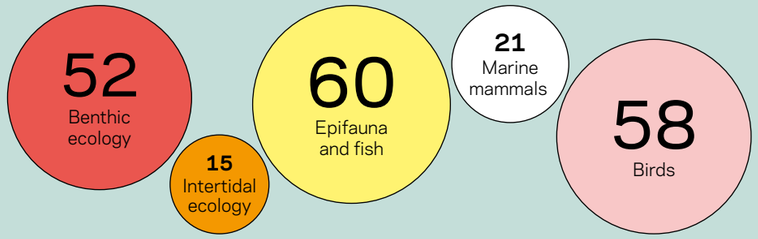
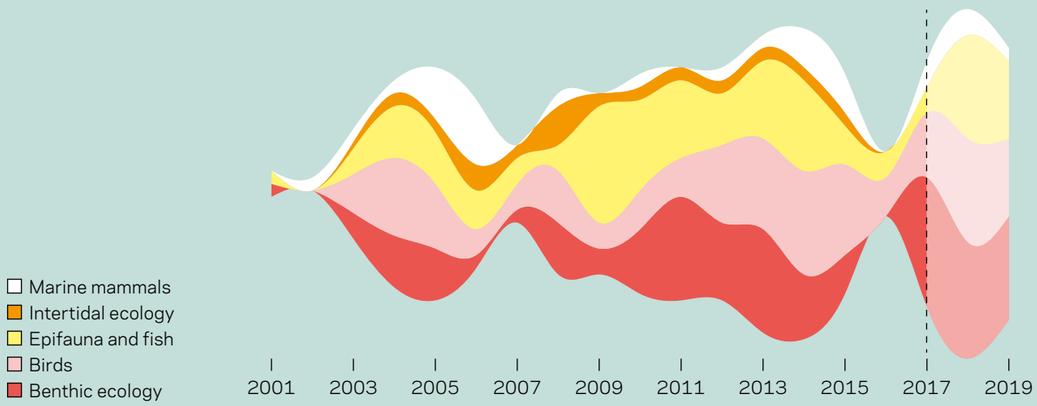


Figure 21: Post-construction environmental survey data collection by theme over time



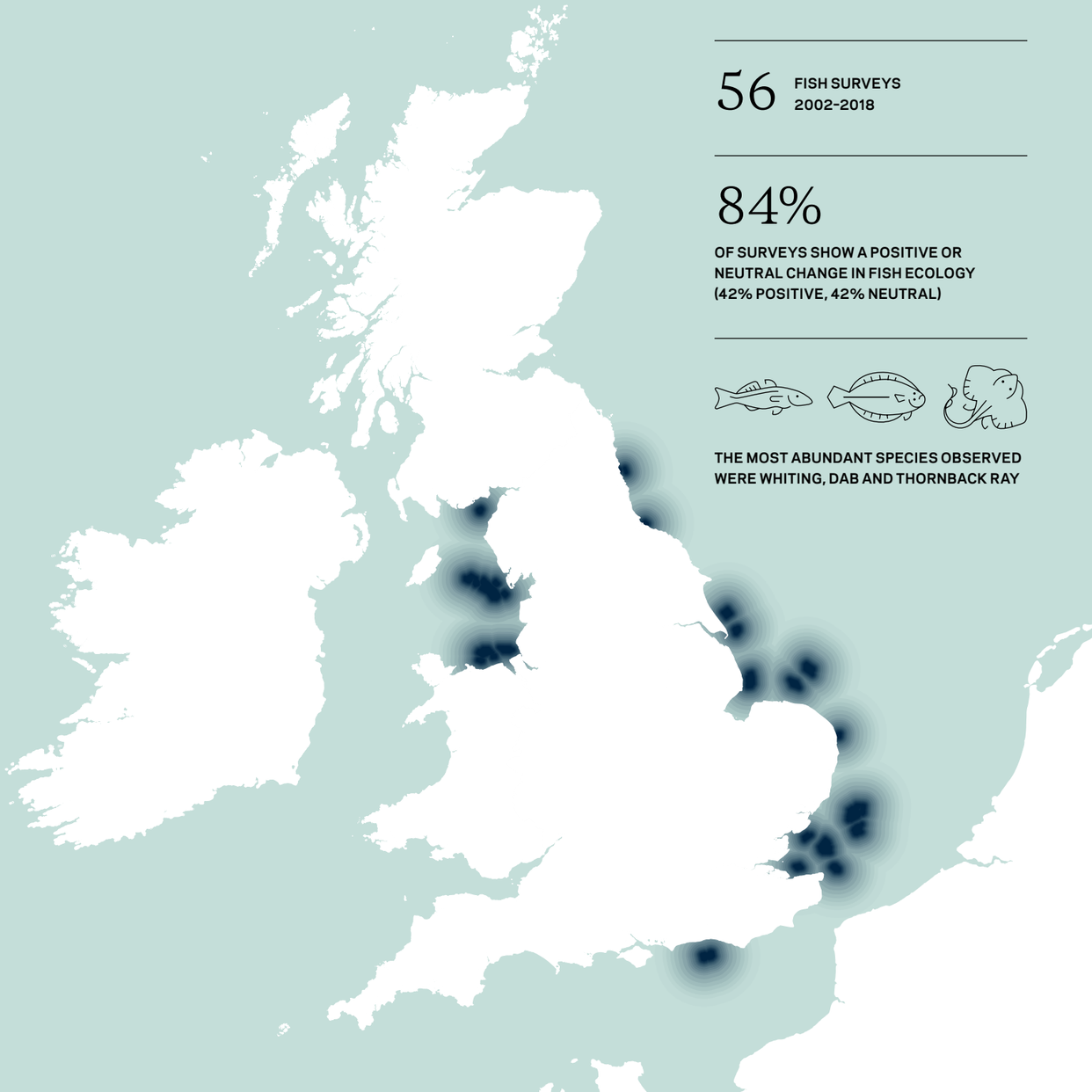
Case study: Data insights from the fish post-construction survey data

The value from the MDE evidence base comes from being able to draw insights from the data.

Here we have drawn comparisons from the post-construction and pre-construction fish survey data held on the MDE. Initial insights suggest that, from 56 surveys across 16 operational wind farm sites, almost 84% of surveys show a positive or neutral change in fish ecology.

Almost half of the surveys also found that there was no change in the species mix from pre-construction to post-construction, with the most abundant species remaining the same. Across all of the sites, the most abundant species observed in most surveys were whiting (*Merlangius merlangus*), dab (*Limanda limanda*) and thornback ray (*Raja clavata*), which is listed as Near Threatened on the International Union for Conservation of Nature Red List of Threatened Species. Whilst a number of survey catch methods were used, over 80% included otter and beam trawls.

Many of the thornback rays observed within the wind farm arrays were smaller than those found outside, suggesting that some wind farms could be acting as spawning grounds. Within one wind farm, there was a high abundance of pregnant females which would support this idea. In such circumstances, the concentration of crustaceans, their main prey type, was also high.



56 **FISH SURVEYS 2002-2018**

84%

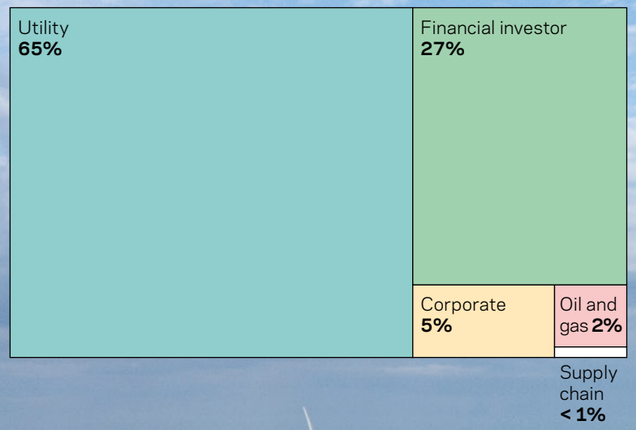
OF SURVEYS SHOW A POSITIVE OR NEUTRAL CHANGE IN FISH ECOLOGY (42% POSITIVE, 42% NEUTRAL)

THE MOST ABUNDANT SPECIES OBSERVED WERE WHITING, DAB AND THORNBACK RAY

Wind farm ownership

Hornsea 1 offshore wind farm (Ørsted)

Figure 22: Capacity ownership – offshore wind by category



Utility companies dominate the ownership of the generating and under-construction fleet in the UK at 65%, with financial investors having the next biggest share at 27%. The ownership share of financial investors in UK offshore wind increased just 1% on the previous year and has averaged 27% for the last three years. The figures suggest little change but it has been a very active part of the market as the UK fleet capacity has being growing, with financial investors increasing their MW capacity ownership by 90% over the last four years (see figure 28 on page 25).

Oil and gas presence in the sector remained at 2% in 2019, represented by Norwegian company Equinor. The share of the market owned by the supply chain dropped to less than 1% as Siemens sold its stake in Gwynt y Môr offshore wind farm. Meanwhile corporate ownership stayed steady at 5% of the market, represented by companies such as China Resources.

The Scandinavian presence has been much evident in the UK offshore wind sector and by 2019 some 38% of UK offshore wind was owned by Scandinavian utility and financial investors. Figure 24 on page 20 shows the ownership position of fully operational UK offshore wind farms in 2019.

Figure 23: Operational and under construction wind farm ownership as a percentage of total capacity in 2019

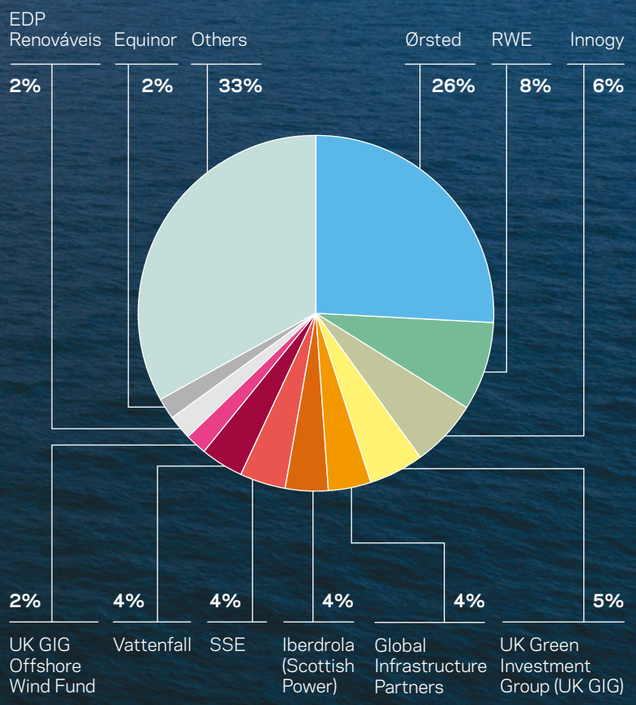


Figure 24: Fully operational offshore wind farm ownership as at 31 December 2019 – listed by dominant ownership share

Project	Operator	Share ownership %
Barrow	Ørsted	100% Ørsted
Burbo Bank	Ørsted	100% Ørsted
Gunfleet Sands Demonstration	Ørsted	100% Ørsted
Gunfleet Sands I	Ørsted	50.1% Ørsted; 24.95% Dev. Bank of Japan[1]; 24.95% JERA
Gunfleet Sands II	Ørsted	50.1% Ørsted; 24.95% Dev. Bank of Japan[1]; 24.95% JERA
Walney 1	Ørsted	50.1% Ørsted; 25.1% SSE; 24.8% PGGM
Walney 2	Ørsted	50.1% Ørsted; 25.1% SSE; 24.8% PGGM
Burbo Bank Extension	Ørsted	50% Ørsted; 25% KIRKBI Invest A/S; 25% PKA Holding ApS
Hornsea 1	Ørsted	50% Ørsted; 50% Global Infrastructure Partners (GIP)
Race Bank	Ørsted	50% Ørsted; 25% Macquarie European ...[2]; 12.5% Sumi...[3]; 6.3%[4]; 6.3%[5]
Walney Extension	Ørsted	50% Ørsted; 25% PFA Holding ApS; 25% PKA Holding ApS
West of Duddon Sands	Ørsted	50% Ørsted; 50% Iberdrola (ScottishPower)
Westermost Rough	Ørsted	50% Ørsted; 50% UK GIG[6]
Humber Gateway	RWE	100% RWE
Robin Rigg East	RWE	100% RWE
Robin Rigg West	RWE	100% RWE
Scroby Sands	RWE	100% RWE
Rampion	RWE	30.1% RWE; 25% UK GIG[6]; 24.9% Enbridge Inc.; 20% E.ON
London Array	London Array Ltd	30% RWE; 25% Ørsted; 25% Caisse dépôt & placem...[7]; 20% Masdar
Rhyl Flats	Innogy	50.1% Innogy; 24.95% Greencoat UK Wind; 24.95% UK GIG Offshore Win...[8]
Greater Gabbard	SSE	50% Innogy; 50% SSE
Gwynt y Môr	Innogy	50% Innogy; 30% Stadtwerke München; 20% Macquarie Infra ...[9]
Galloper	Innogy	25% Innogy; 25% Siemens Financial Ser...[10]; 25% UK GIG[6]; 12.5% ESB; 12.5% Sumi...[3]
Inner Dowsing	XceCo	61% UK GIG Offshore Wind Fund[8]; 39% BlackRock
Lynn	XceCo	61% UK GIG Offshore Wind Fund[8]; 39% BlackRock
Lincs	Ørsted	44% UK GIG Offshore Wind Fund[8]; 31% UK GIG[6]; 25% Ørsted
Beatrice	SSE	40% SSE; 35% Copenhagen Infrastructure Partners; 25% SDIC Power Holding
European Offshore Wind Deployment Centre	Vattenfall	100% Vattenfall
Kentish Flats	Vattenfall	100% Vattenfall
Kentish Flats Extension	Vattenfall	100% Vattenfall
Thanet	Vattenfall	100% Vattenfall
Ormonde	Vattenfall	51% Vattenfall; 49% AMF
Hywind 2 Demonstration	Equinor	75% Equinor; 25% Masdar
Sheringham Shoal	Equinor	40% Equinor; 25.3% Equitix; 20% UK GIG Offshor...[8]; 14.7% TRIG
Dudgeon	Equinor	35% Equinor; 35% Masdar; 30% China Resources
Blyth Demonstration	EDF Energy Renewables	100% EDF Energy Renewables
Teesside	EDF Energy Renewables	51% EDF Energy Renewables; 49% Dalmore Capital Ltd
Levenmouth Demonstration	ORE Catapult	100% ORE Catapult
North Hoyle	Innogy	100% Greencoat UK Wind

1 Development Bank of Japan
2 Macquarie European Infrastructure Fund 5
3 Sumitomo Corporation
4 Arjun Infrastructure Partners
5 Gravis Capital Management
6 UK Green Investment Group (UK GIG)
7 Caisse dépôt & placement Québec
8 UK Green Investment Group (UK GIG) Offshore Wind Fund
9 Macquarie Infrastructure and Real Assets
10 Siemens Financial Services

Offshore Transmission Owner (OFTO) ownership

A key part of the OFTO regime is the granting of offshore transmission licences on the basis of a competitive tender process. During 2019, one OFTO licence was granted and several tenders within Tender Round 6 were progressed, see Figure 25.

As we show in Figure 26, OFTOs continue to be operated by the main OFTO players: Transmission Capital Partners, Blue Transmission, Balfour Beatty, Diamond Transmission and Equitix. These are owned by infrastructure investment groups and venture capital companies that are taking a key role in financing offshore transmission infrastructure. Whilst most OFTO assets are managed by the owner, the operation and maintenance (O&M) is contracted to either the wind farm operator or another dedicated service provider.

Sheringham Shoal offshore wind farm (Alan O'Neill of Charles Hodge Photography and Equinor)

Figure 25: Offshore Transmission Tenders

Ofgem is responsible for managing the competitive tender process through which offshore transmission licences are granted. The following tenders are currently underway:

For more information on the tenders, visit Ofgem's website bit.ly/2z3BVDM

TENDER ROUND 5:

Licences granted 2019
- Race Bank – October 2019

Licences to be granted 2020
- Galloper – Preferred bidder appointed November 2018
- Walney Extension – Preferred bidder appointed March 2019
- Rampion – Preferred bidder appointed August 2019

TENDER ROUND 6:

Licences to be granted 2020
- Beatrice – Preferred bidder appointed December 2019

Preferred bidder to be appointed 2020
- Hornsea 1 – ITT stage commenced July 2019
- East Anglia ONE – ITT stage commenced February 2020

Figure 26: OFTO ownership as at 31 December 2019

	Export Cable Circuits	Offshore Substations	Ownership %	Operator	O&M Provider
Barrow OFTO	1	1	100% International Public Partnerships	Transmission Capital Services	Transmission Investment Services Limited
Burbo Bank Extension OFTO	1	1	50% Diamond ...[1] / 50% HICL ...[2]	Diamond Transmission Corporation	RES
Dudgeon OFTO	2	1	100% International Public Partnerships	Transmission Capital Services	Dudgeon Offshore Wind Limited
Greater Gabbard OFTO	3	2	100% Equitix Ltd	Equitix Management Services	EDS HV Management Limited
Gunfleet Sands OFTO	1	1	100% International Public Partnerships	Transmission Capital Services	Transmission Investment Services Limited
Gwynt y Môr OFTO	4	2	60% Balfour Beatty / 40% Equitix	Balfour Beatty Investments	Balfour Beatty Power Transmission & Distribution
Humber Gateway OFTO	2	1	80% Equitix / 20%...[3]	Balfour Beatty Investments	Balfour Beatty Power Transmission & Distribution
Lincs OFTO	2	1	100% International Public Partnerships	Transmission Capital Services	Transmission Investment Services Limited
London Array OFTO	4	2	50% Diamond ...[1] / 50% 3i Group plc	Frontier Power	London Array Limited
Ormonde OFTO	1	1	100% International Public Partnerships	Transmission Capital Services	Transmission Investment Services Limited
Race Bank OFTO	2	2	50% Diamond ...[1] / 50% HICL ...[2]	Diamond Transmission Corporation	RES
Robin Rigg OFTO	2	0	100% International Public Partnerships	Transmission Capital Services	RWE Renewables UK Operations Limited
Sheringham Shoal OFTO	2	2	50% Diamond ...[1] / 50% 3i Group plc	Frontier Power	Equinor
Thanet OFTO	2	1	80% Equitix / 20%...[3]	Balfour Beatty Investments	Balfour Beatty Power Transmission & Distribution
Walney 1 OFTO	1	1	50% Diamond ...[1] / 50% 3i Group plc	Frontier Power	RES
Walney 2 OFTO	1	1	50% Diamond ...[1] / 50% 3i Group plc	Frontier Power	RES
West of Duddon Sands OFTO	2	1	100% Dalmore Capital Ltd	Frontier Power	Ørsted & SPR
Westermost Rough OFTO	1	1	100% International Public Partnerships	Transmission Capital Services	Transmission Capital Services

1 Diamond Transmission Corporation Ltd (subsidiary of Mitsubishi Corporation) 2 HICL Infrastructure 3 Balfour Beatty

Investment

2019 saw a 40% increase in offshore wind transactions on the previous year. The most significant market change was the merger and complex asset swap of German utilities E.ON and RWE. This makes RWE the second biggest owner of offshore wind farms in the UK with just over 1GW of generating capacity. E.ON has transferred almost all of its offshore wind assets to RWE (see opposite) but retains a direct stake in Rampion. It also owned a majority share in innogy as of December 2019.

A significant investment was made in the summer by Macquarie's UK Green Investment Group when it purchased 40% of East Anglia ONE from Scottish Power Renewables and parent company Iberdrola. This £1.63bn transaction took place whilst the 714MW site was under construction, with final commissioning due late 2020. This propelled UK Green Investment Group to be the fourth biggest owner of UK offshore wind farms with just under 0.7GW of generating or under construction capacity.

Japanese corporate Marubeni exited the market by selling its shares in the Gunfleet Sands wind farms. This made way for a new entrant, Japanese energy company JERA, which bought into Gunfleet Sands. This continues the 2018 pattern of Japanese power companies buying into UK offshore projects with the intention of using that experience in the emerging Japanese offshore wind sector.

Danish utility Ørsted is at the front of the pack with 3.7GW of under construction or generating capacity. In February 2019, Ørsted entered into a ten year corporate Power Purchase Agreement (PPA) to supply electricity from Race Bank offshore wind farm to utility Northumbrian Water, the first of its kind in the UK. Further announcements followed in 2019. This is a sector which will likely grow as subsidy opportunity declines but it remains to be seen if there are enough corporates of suitable risk profile to satisfy the growth pipeline needed.

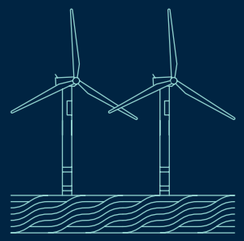


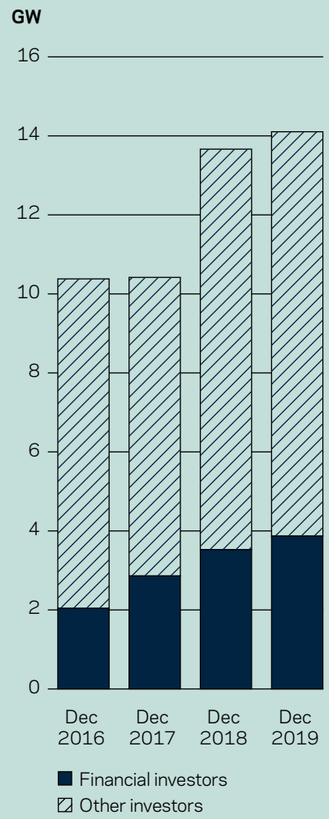
Figure 27: Transactional activities completed in 2019

Asset	Seller	Share before sale	Buyer	Buyer share after sale	Value	Timing
Gunfleet Sands I	Marubeni	24.95%	JERA	24.95%	Unknown	Jan-19
Gunfleet Sands II	Marubeni	24.95%	JERA	24.95%	Unknown	Jan-19
Walney 1	Ampere Equity Fund	9.9%	PGGM	24.8%	Unknown	Jul-19
Walney 2	Ampere Equity Fund	9.9%	PGGM	24.8%	Unknown	Jul-19
East Anglia ONE	Iberdrola (Scottish Power)	100%	UK GIG	40%	£1.63bn	Sep-19
Humber Gateway	E.ON	100%	RWE	100%	Unknown	Sep-19
London Array	E.ON	30%	RWE	30%	Unknown	Sep-19
Rampion	E.ON	50.1%	RWE	30.1%	Unknown	Sep-19
Robin Rigg East	E.ON	100%	RWE	100%	Unknown	Sep-19
Robin Rigg West	E.ON	100%	RWE	100%	Unknown	Sep-19
Scroby Sands	E.ON	100%	RWE	100%	Unknown	Sep-19
Gwynt y Môr	Siemens AG	10%	Macquarie Infrastructure and Real Assets	20%	Unknown	Oct-19
Race Bank OFTO	Ørsted	50%	Diamond Transmission Partners	100%	£500.9m	Oct-19
	Macquarie Capital	37.5%				
	Sumitomo Corporation	12.5%				
Neart na Gaoithe	EDF	100%	ESB	50%	Unknown	Nov-19

RWE/E.ON transaction at a glance:

- In spring 2018, RWE and E.ON announced a big asset swap.
- In 2019, approval was given by all national and European competition authorities.
- In autumn 2019, RWE transferred its majority stake in innogy to E.ON. In return, it got E.ON's renewables business, along with minority stakes in the German Gundremmingen and Emsland nuclear power stations.
- The offshore wind farms in the UK transferred to RWE include: Robin Rigg East and West, Scroby Sands, Humber Gateway, a stake in London Array and part of its stake in Rampion offshore wind farm (about 0.5GW in total).
- innogy has ownership interests in the following UK sites: Rhyl Flats, Greater Gabbard, Gwynt y Môr, Galloper and Triton Knoll (about 0.9GW). This didn't change in 2019 but innogy's beneficial ownership was transferred from German parent company RWE to E.ON, with E.ON now owning a majority shareholding of 76.8% in innogy in exchange for giving RWE a 16.7% share in E.ON. In 2020, as part of the overall deal, RWE will also receive innogy's renewables and gas storage businesses, as well as a stake in the Austrian energy company Kelag. RWE has founded a fourth subsidiary, RWE Renewables, which integrates both parts of the renewables business (innogy and E.ON).
- This transaction has enabled the two energy companies, both headquartered in Essen in Germany, to refocus: E.ON now has a clear focus on energy networks and customer solutions, while RWE is becoming a broadly diversified power producer with a large portfolio of renewable generating assets alongside a conventional energy generation portfolio. The asset swap makes RWE the world's second largest company in offshore wind, with a stated aim of being carbon neutral by 2040.

Figure 28: Operational and under construction portfolio ownership



Construction works at Hornsea 1 offshore wind farm (Ørsted)

Development portfolio and activities

The last 12 months have proven another transformational year for UK offshore wind, laying the foundations for continued responsible growth. The year ahead promises to maintain that momentum.

The Offshore Wind Sector Deal cemented a trajectory for the market to deliver 30GW by 2030. For our part, it included two clear commitments:

1. to undertake new leasing, and;
2. to establish a collaborative programme of enabling actions for future growth.

We're pleased to say both of these are advancing strongly.

New leasing activity

We concluded the plan-level Habitats Regulations Assessment (HRA) for the 2017 Extensions opportunity over the course of the 2019 (see bit.ly/39yUcVQ). The result is almost 3GW of new projects alongside existing operational wind farms.

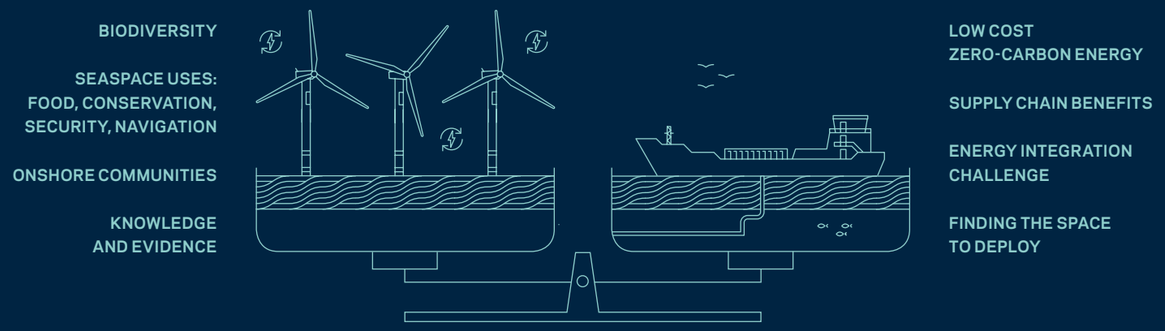
Offshore Wind Leasing Round 4 – our first major new leasing round in a decade – launched in September 2019 (see bit.ly/2QXV3Je), with the pre-qualification process concluded in early 2020. The two-stage Invitation to Tender (ITT) will be progressed during 2020. This will be followed by the Round 4 plan-level HRA prior to the award of rights.

To better inform the Round 4 plan-level HRA, we commissioned five priority research projects to help build a quality evidence base. We are pleased that a number of these have now been published with the final report set to be completed later in 2020. These can be viewed at bit.ly/2UAcceB

The outcome of the third Contracts for Difference (CfD) allocation round in September 2019 heralded a turning point for UK offshore wind. It saw the success of 5GW of projects on the Dogger Bank, at prices below the reference prices set by Government – essentially progressing without subsidy. When combined with projects either in operation or construction, a total over 19GW of capacity is now committed. In addition, Round 3 projects providing 16GW of capacity are progressing to be ready for future allocation rounds.

Round 4, combined with 2017 Extensions projects, adds to the existing development pipeline. Collectively, the UK operating portfolio and development pipeline could total more than 45GW in 2021, not including capacity that might be enabled by Crown Estate Scotland's leasing process. This exceeds the 40GW deployment ambition for 2030 set by the UK Government.

Figure 29: Balancing needs in the offshore wind sector for responsible future growth



Responsible future growth

In 2019, the UK became the first major economy to make a legally binding commitment to reduce greenhouse gas emissions to net zero by 2050. It is widely predicted that offshore wind will provide a significant and increasing role in this transition, but governments, stakeholders and industry will need to work together to make this a reality. As illustrated by figure 29, it will be critical to balance the benefits of such a scale-up with the pressures created in the environment, both offshore and onshore.

Our strategic enabling actions programme is intended to support this journey, via two broad ambitions:

- to provide high quality data and evidence to advance the understanding of offshore wind deployment and the impact on the marine and onshore environment
- to bring together all relevant parties to develop a common understanding and take coordinated actions to address challenges

Over the course of 2019 we worked to define the focus of the programme in partnership with Department for Business, Energy and Industrial Strategy and Department for Environment, Food & Rural Affairs; along with stakeholders. Together, we continue to take the necessary actions to responsibly enable future offshore wind projects.

To stay up to date on this important work, see bit.ly/3bAXnOc

Figure 30: UK offshore wind development pipeline and fixed offshore wind characterisation by The Crown Estate

Portfolio waterfall – all UK (gigawatts rounded)

2050 Net Zero scenarios (75GW+)

(Committee on Climate Change, 2019)

40-50% of the future portfolio yet to be identified within an increasingly busy sea space

30GW+

2030 'Increased ambition' (40GW)

(Queen's Speech, December 2019)

10GW

EXTENSIONS AND ROUND 4

2030 Established policy (30GW)

(Sector Deal, March 2019)

15GW

UNDER-DEVELOPMENT

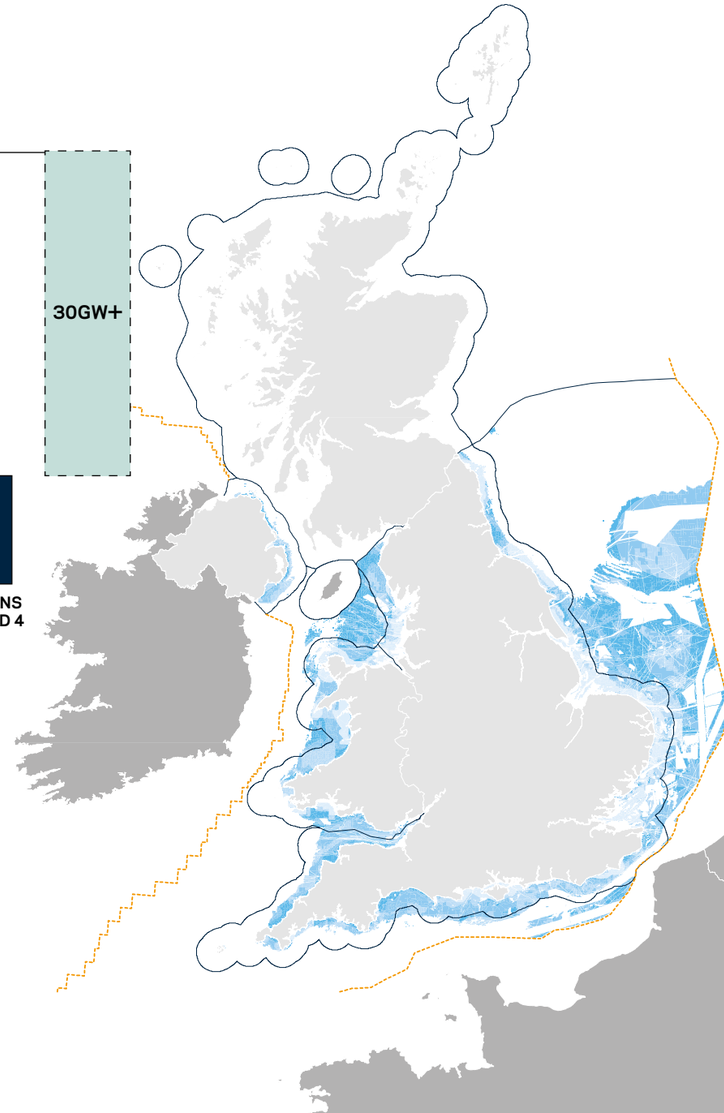
10GW

COMMITTED*

10GW

OPERATING

*Projects under construction or that have government support on offer



Decommissioning and recycling

Blyth the pioneer

On 17 May 2019, the north monopile of Blyth offshore wind farm was lifted from the seabed onto the Excalibur, the same vessel used to build it 20 years ago. All the offshore works were completed safely and without incident by Fugro GeoServices Ltd.

This concluded the decommissioning of a pioneering project which marked the beginning of remarkable progress for offshore wind power in UK waters. With two turbines totalling 4MW, they were, at the time, the most powerful offshore wind turbines in the world and the first offshore turbines installed in the UK. Current models are four times more powerful and installed in their hundreds on the UK's continental shelf.

It's hard to understate the game-changing role these two turbines have played in wind energy moving offshore. The first to be deployed anywhere in the North Sea, they kick-started the remarkable progress of offshore wind in UK waters; now home to over 2,000 turbines and set to play an increasingly vital role in our nation's clean energy transition.

The Blyth project has also set a very high standard for the decommissioning of offshore wind farms; complete removal of the asset and full restoration of the natural environment was made possible by E.ON and Fugro's outstanding work.

It was agreed to fully remove the cables and, at E.ON's suggestion, to use natural materials instead of grout to cover the foundation stubs.

The last foundation being lifted from the seabed in the middle of the night may have signalled the end of Blyth offshore wind farm, but its legacy lives on. One of the removed turbines will be installed in Blyth Harbour and used as a training facility. Parts of the other turbine will be refurbished and made available as spares for other assets.

The project demonstrated that good planning and efficient execution can enable cost-effective asset removal and restoration of the natural environment. Additionally, the efforts that have gone into the end of life planning at Blyth have enabled extensive re-use and recycling of materials to minimise landfill use.

Blyth offshore wind farm has shown that renewable energy can be harnessed in a truly renewable fashion, crucial in the future as more wind turbines are decommissioned.

Decommissioning works at Blyth offshore wind farm (E.ON)

The road to Net Zero is paved with recycled steel

Zero-carbon energy is a crucial component of the path to carbon neutrality, but it's not enough to limit global warming to 2°C[1]. Large quantities of carbon are either built into the products themselves in the form of plastics, or are integral to the chemical processes involved in their production, such as in steel and cement. Re-using the materials we have already produced will be unavoidable in a low-carbon economy.

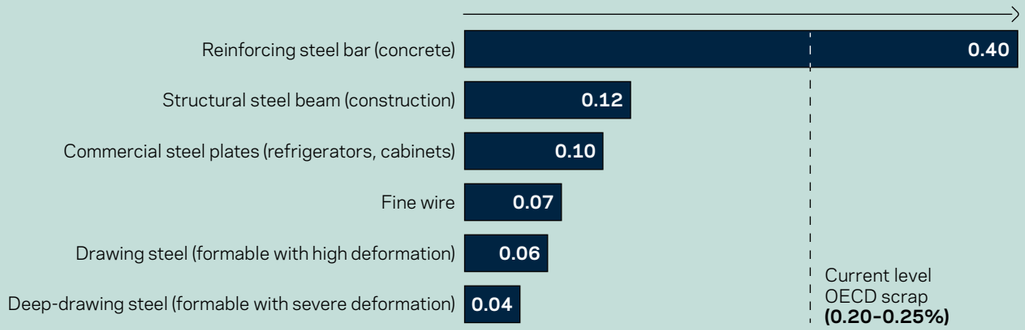
Most steel production is primary production, converting iron ore to steel using an oxygen furnace. On average, this emits over 2 tonnes of CO_2 per tonne of steel produced.

Secondary steel is made in electric arc furnaces (EAF), emitting one-fifth the CO_2 emissions of primary steelmaking, even when a significant proportion of the electricity comes from fossil fuels. If power from renewable sources is used in EAF, secondary steel can be almost entirely decarbonised. A more circular steel flow is therefore inherently far less emissions-intensive, and easier to decarbonise through the use of renewable energy. This encourages the retrieval of as much scrap steel as possible from decommissioned assets, particularly monopiles.

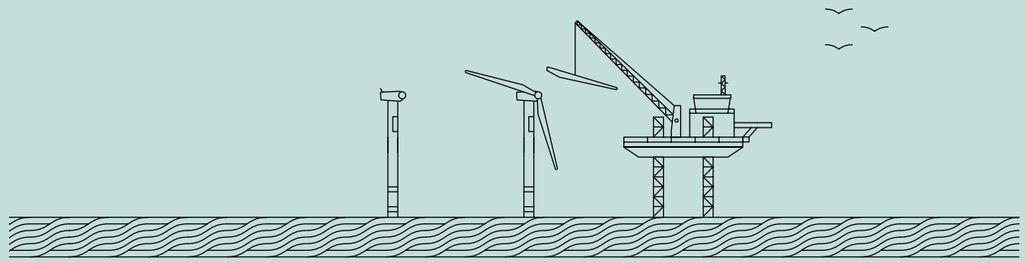
However, the entire recycling process must be carefully planned. Design, collection, sorting and recycling must ensure feedstock quality matches product requirements. Copper contamination is a major constraint: at 0.15% content by weight, steel becomes unusable for all but the most basic product groups. Figure 31 lists the maximum copper contamination limits for steel re-use purposes.

1 It should be noted that the Paris Agreement's goal is to limit the global temperature rise to well below 2°C above pre-industrial levels and to pursue efforts to limit the increase to 1.5°C. Global temperatures are already 1.0°C above pre-industrial levels.

Figure 31: Maximum copper content by steel product category (Wt% copper in steel)



Source: How Will Copper Contamination Constrain Future Global Steel Recycling? Daehn et al. (2017)



Skills

Skills development is a subject that has featured heavily in the sector throughout the year. For example, opportunities are being created in coastal communities as the industry continues to grow, so it's critically important to deliver a highly skilled, diverse workforce to meet the demand of the growing market. This reinforces the aspirations of the industry and the Sector Deal to develop the next generation, increase job mobility across the sector, and provide apprenticeships to inspire the young recruits of the future. In this section, we highlight some of the many initiatives currently underway across the operational offshore wind portfolio.

Apprenticeships

This year SSE, headquartered in Perth, is looking to recruit around 70 new apprentices. With the company investing £6bn over five years to help decarbonise the UK and Ireland, those entering the industry have a bright future. This programme sees recruits gain a range of skills and experience in positions including apprentice jointers, linespersons and electrical fitters working on the electricity network to deliver green energy to millions.

Many of these opportunities are in rural areas, providing support to local economies and communities across the UK. Most apprenticeships take four years to complete and are an opportunity to gain a nationally recognised qualification.

With government setting an ambitious target to achieve net zero by 2050, the new recruits will be at the front line of efforts to decarbonise the UK; from building wind farms to maintaining the flexible electricity grids needed to transport clean power.

One such apprentice is Jasmine Allen (right) from Beccles, Suffolk. The 19-year-old is starting life as a wind turbine technician. She has always been attracted to engineering careers after being inspired by her grandfather, who was an engineer in the car industry.

After leaving school aged 16, she enrolled at her local college on an Energy Skills programme before applying to SSE's Apprenticeship Programme. Jasmine said *"Growing up, I heard all the stories about grandad's job. Seeing how people in our family talked about his work and the things he achieved, I was attracted to the practical side of work, building and making things with my hands. I was really pleased to have been accepted to SSE's Apprenticeship Programme, it's another step in a career I am really excited about. It's great to think that I'll be working on the future of energy in renewables, in a challenging and hands-on environment."*

Former UK Government Education Minister, Kemi Badenoch, said: *"This is a fantastic opportunity to be at the forefront of tackling climate change in this country. As a former apprentice myself, I know first-hand how apprenticeships can change lives and improve businesses, so I'm really pleased to see that SSE is investing in apprenticeships and offering more young people the chance to gain the skills they need to forge successful careers."*

'Diversity in the industry' photos courtesy of Vattenfall

Diversity in the industry

The sector recognises that it needs to tap into the largest pool of talent possible and better reflect modern society by having a diverse and inclusive workforce. With a baseline of 16% of workers being women and an average workforce age of 38, the challenge is significant. The sector has set a target by 2030 of 33% of employees being women, increasing to 40% if feasible, including those undertaking training and university degrees.

Further diversity targets have been set to encourage the number of black, Asian and minority ethnic workers in the sector from 5% now to 9% in 2030 aiming for a more ambitious target if feasible.

ARMED FORCES COVENANT

Armed Forces Covenant

46% of UK offshore wind operators have signed up to the Armed Forces Covenant so far. This is a pledge to "acknowledge and understand that those who serve or who have served in the armed forces, and their families, should be treated with fairness and respect in the communities, economy and society they serve with their lives".

Vattenfall Wind Power Limited recently signed up to the Covenant: *"6% of our workforce already come from a military background. In signing the Covenant, our goal is to actively support those leaving the armed forces and introduce this pool of talented individuals to a career in our industry. Vattenfall prides itself actively driving forward inclusion and equality. This is just one area where we can have an important impact, showing that we value and respect Vattenfall colleagues who have served and continue to serve (i.e. reservists)".*

The Crown Estate intern partnerships 2019

Working in partnership with other organisations in the marine sector, we welcomed four graduates into two marine internship programmes in 2019: Coast Explorer in Kent and Marine Futures in Cumbria. We asked each intern to complete a marine-related project of their choice. For the Coast Explorer programme, we also asked the group to conduct a joint project.

The projects covered a wide range of topics, giving our interns further insights into a career in the marine sector:

- Offshore wind farms: Fossil fuel use and carbon emissions
- International policy drivers for the development of noise mitigation methods for offshore wind farm construction
- Understanding the existing practices and initiatives to reduce marine litter and plastic pollution within The Crown Estate, and to recommend innovative solutions to raise awareness and to maximise impact of these initiatives
- Assessing the feasibility of a Nephrops creel fishery in West of Walney Marine Conservation Zone.

For more information on these projects, see bit.ly/2UYtfHn

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Information sources we have used to compile data include:
BEIS DUKES statistics; Crown Estate Scotland; Katrin E. Daehn, André Cabrera Serrenho, and Julian M. Allwood (2017); Global Offshore Wind; G+ Health and Safety Organisation; National Grid; Ofgem; World Forum Offshore Wind; Wind Europe.

CO_2 avoided due to renewable energy
This represents the carbon dioxide that would have been emitted by traditional power stations to generate electricity in the absence of renewable energy. A study of greenhouse gas emissions of the UK electricity system by R.C. Thomson (2014) demonstrated that wind power displaces coal – and gas-fired power stations, and that partial loading of fossil-fuelled power stations has an efficiency penalty of 11%. The CO_2 emissions avoided by offshore wind can be calculated by using Department for Business, Energy and Industrial Strategy (BEIS) emissions statistics for 'all fossil fuels' and subtracting 11% to account for the induced efficiency penalty. The Crown Estate uses this method to measure the benefit of offshore wind.

Cover: View from meteorological mast at Gwynt y Môr offshore wind farm (Rory McKerrell, innogy).

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