7 MW LEVENMOUTH DEMONSTRATION TURBINE (SOURCE: ORE CATAPULT)

UNITED KINGDOM

High winds in spring 2020 combined with low energy demand due to COVID-19 allowed renewable energy to outpace annual fossil fuel generation for the first time. Electricity demand was at its lowest level in over a decade with 281 TWh final consumption, a 4.7% decrease from 2019.

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Industrial and non-domestic consumption dropped by 10% in contrast to domestic use which increased by 4%.[1] Wind energy provided over 56% of the total annual electricity generation from renewables (26% onshore and 30% offshore).[2]

The UK maintained its dominant position in offshore wind with installations growing 412 MW to 10.4 GW in 2020. Onshore wind capacity only increased by 157 MW, but this is set to accelerate with onshore wind projects allowed to compete in the same pot as solar energy in upcoming auctions.

The UK Government announced a ten-point green recovery plan in 2020 which included a rise in the

TABLE 1. KEY NATIONAL STATISTICS 2020: UNITED KINGDOM

Total (net) installed wind power capacity*	24.3 GW
Total offshore capacity	10.4 GW
New wind power capacity installed	570 MW
Decommissioned capacity (in 2020)	0.3 GW
Total electrical energy output from wind	75.6 TWh
Wind-generated electricity as percent of national electricity demand	22.8%
Average national capacity factor***	36%
Target	40 GW offshore by 2030

offshore wind target to 40 GW by 2030 and strategic investment to upgrade ports and manufacturing sites.

Research in the wind sector is focused on driving efficiency in O&M through collaboration between industry, academia and the public sector. Tackling the challenge of grid integration will be vital as wind energy grows to 40 GW. And it will be vital to develop the local supply chain, to maximise the benefit of the sector to the UK economy.

Market development

National targets and policies supporting development

In November 2020, the Government announced plans to Build Back Greener after COVID-19 through its ten-point plan, announcing 5 billion GBP to support a green recovery and planning to mobilise 12 billion GBP plus private investment to support 250,000 jobs by 2030 [4]. Regarding offshore wind, the plan increased ambition for capacity from 30 GW to 40 GW by 2030, including at least 1 GW of floating wind. Approximately 160 million GBP will be invested to upgrade ports and manufacturing infrastructure to be able to service this level of expansion. Advancing offshore wind could deliver support for up to 60,000 jobs in 2030, around 20 billion GBP of private investment by 2030 and savings of 21 MtCO2e between 2023 and 2032, or 5% of 2018 UK emissions. The plan also refers to actions for driving growth of low carbon hydrogen building on offshore wind strength which can accelerate the development of green hydrogen.

One month later in December 2020, most of these plans were included in a long-anticipated Energy White Paper highlighting the importance of carbon emission reduction and creation of jobs. This is intended to mark the start of a Green Industrial Revolution moving away from a fossil fuel-reliant system and embracing cleaner energy options. This included the establishment of a UK Emissions Trading Scheme (UK ETS) from 1 January 2021 to replace the current EU ETS at the end of the Transition Period.

Progress and operational details

Renewable energy generation grew 11% in 2020, and exceeded fossil-fuelled generation for the first time. In total, renewable capacity grew by just 2.0% during 2020, the lowest growth rate since 2010, however offshore wind generation played a large part to this output as it increased by 26% in one year due to the high wind conditions. Offshore wind supplied 41TWh of electricity and onshore 35TWh. New onshore wind installations were low with just 157 MW added in 2020 reaching 14.3 GW in total. Load factors for offshore wind was 45% and for onshore wind 28%.

Installed capacity of offshore wind increased by 412 MW, with construction facing delays due to COVID19 restrictions. The average rating of new turbines installed was 7 MW in 2020. Dogger Bank windfarm became the first windfarm in the world which will install the upgraded 13 MW GE Haliade-X wind turbines. The constant scaling-up of wind turbine size led Vestas develop a 14/15 MW turbine model to upgrade its turbine size offering as GE and Siemens Gamesa both boost their wind turbine models to reach 14 MW and 15 MW ratings.

The 714 MW East Anglia One windfarm was fully commissioned in the summer of 2020 after 20% of the turbine installation and around half the turbine connection work was completed during the lockdown.[3]

Matters affecting growth and work to remove barriers

The Sector Deal target from 2019 of 60% UK content in offshore wind projects is still in effect, and a competitive process launched to support modern, integrated portside infrastructure.

The next round of CfD auctions will split 12 GW into three different pots. Offshore wind will have its own dedicated pot, while onshore wind will make a comeback in Pot 1 of established technologies competing with solar. In Pot 2 of emerging technologies, floating wind will be included for the first time. The results of Leasing Round 4 in England and Wales as well as of Scotwind in Scotland will be critical to understand the current progression of the investment appetite. Seabed leasing rounds were delayed to Spring 2021 to incorporate revisions and feedback received from the industry. Loss of access to EU internal energy market is expected to create disruption to the energy cooperation through interconnectors and the international trading.[5] Likewise, a significant amount of R&D funding was through EU programmes like Horizon 2020.

Finally, pandemic and governmental restrictions created an uncertain environment for investments in renewable energy which may affect timelines and schedules of future work.

GE HALIADE-X WIND TURBINE (SOURCE: ORE CATAPULT)

R,D&D activities

National R,D&D priorities and budget

R&D funding launched in 2020:
Strength in Places Fund (UKRI)—Research funding to drive economic growth in specific UK areas.

Low Carbon Challenge Fund (Scottish Enterprise/ ERDF)—Enabling SMEs to unlock the opportunities of the climate emergency and contribute toward achieving Scotland's net-zero target.

Bilateral UK and US Offshore Wind R&D Programme (Innovate UK)—Enabling UK companies to partner with US consortia as part of the US National Offshore Wind Research and Development Consortium programme.

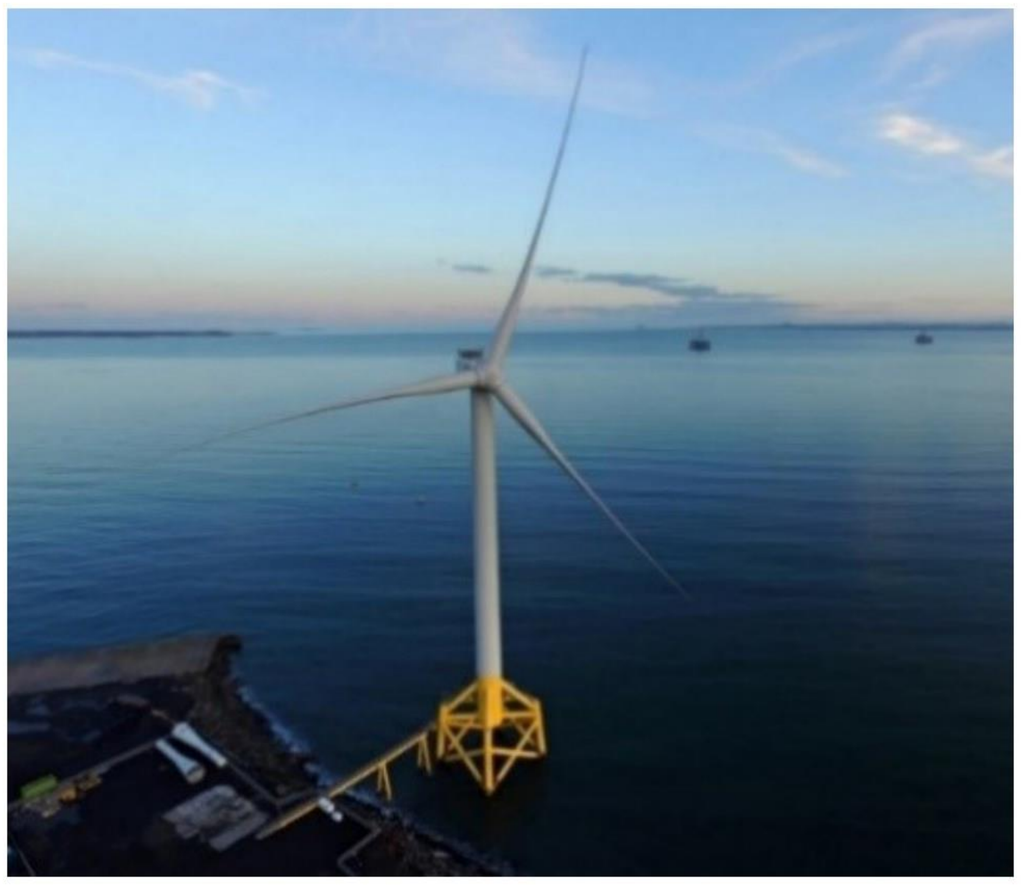
National research initiatives and results

Joule Challenge Phase 1: Building on previous work, ORE Catapult and the National Composites Centre reviewed key opportunities for producing wind turbine components using next generation advanced composites technologies. These could facilitate a step change in device capabilities, enabling 20 MW generation capacity for fixed foundation/ floating wind requirements.

Stay Ashore!: Research partnership aimed at minimizing time spent offshore, which will enhance both safety and operating costs for offshore wind farms, as part of GE's broader offshore wind strategy for the UK. Key activities in 2020 include machine learning driven condition monitoring and robotics challenges improving market access from UK supply chain to GE.

Leading Edge for Turbines (LEFT): Transfer of rotor blade leading edge protection technology from the helicopter to the wind industry. The technology demonstrated extremely high erosion resistance and potential to unlock far higher blade tip speeds, whilst providing lifetime leading edge protection. Demonstration and modelling showed the shields could survive extreme design load cases.

Power Available: Power available signals provide a live estimate of how much power a wind farm could produce if unconstrained and are used by system operators to help balance supply and demand using wind farms. A partnership between RenewableUK, National Grid ESO and the University of Strathclyde verified signal accuracy and developed a standard for signals used in National Grid's control room. Wind farms with power available signals can access new revenue streams from ancillary services.[6]



ORE CATAPULT'S 7 MW LEVENMOUTH DEMONSTRATION TURBINE (SOURCE: ORE CATAPULT)

HOME Offshore: A collaboration between the universities of Manchester, Durham, Warwick, Strathclyde, and Heriot-Watt, as well as 16 partner companies and research organizations to explore new modelling, data science, A.I., robotic technologies which de-risk offshore wind operations, reduce costs and make better use of existing assets.

Test facilities and demonstration projects

Levenmouth 7 MW Demonstration Turbine – TotalControl: Developing integrated wind power plant/wind turbine (WPP/WT) control strategies maximizing life-cycle profitability and validating through field tests. Computer-generated models of both the Levenmouth 7 MW turbine and a wind power plant have been developed. 2020 field tests evaluated the performance of ongoing controller functions such as parameter adaptation, loads estimation, and supervisory control utilizing both forward and rear facing LiDAR. This has allowed wake monitoring and validation of power effects/yaw set-point changes needed for wind farm control. [7]

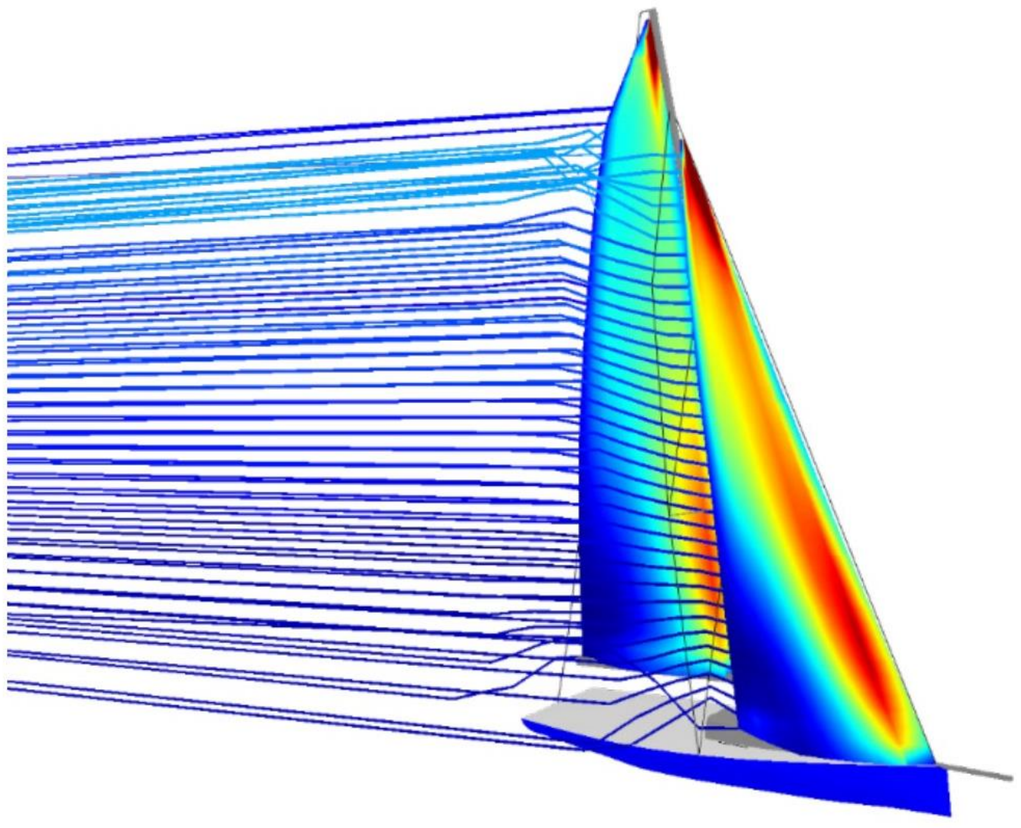
Gigastack Phase 2: Project to demonstrate technology for renewable hydrogen derived from offshore wind. Involves a Front-End Engineering Design ('FEED') study on a 100 MW electrolyser system using staged installations with a nominal capacity of 20 MW. The study will detail the actual design of a hydrogen production system connected to an offshore wind farm and industrial off-taker. [8]

ACT Blade: ORE Catapult designed a test rig and completed static testing on a 13 m textile wind turbine blade prototype. Final series of tests to be completed, ahead of trialling a prototype 27 m blade on an onshore turbine in 2021. [9], [10]

Black Start: Demonstration project to trial Dersalloch onshore wind farm's black start capabilities. The project used grid-forming technology called virtual synchronous machines to regulate the frequency and voltage of the power from the turbines and then integrate that supply with the grid and restore the blacked-out section. [11]

Collaborative research

Europe: UK involvement in the EERA [European Energy Research Alliance] joint programme for Wind (JP Wind) and ETIPWind [European Technology & Innovation Platform on Wind Energy] has allowed issues on an international stage to be progressed. Bringing together leading researchers, developers and OEMs involved in offshore renewables, these networks influence the EU's Strategic Energy Technology (SET) Plans incorporating wind energy. This marks out the priorities for future calls under the Horizon Europe programme starting in 2021



ACT BLADE GRAPHIC (LEFT) AND TESTING AT THE NATIONAL RENEWABLE ENERGY CENTRE, BLYTH (RIGHT) (SOURCE: ACT BLADE (L), ORE CATAPULT (R))

and has resulted in the following outputs in 2020:

- Publication of the EERA JPWind R&I Strategy [12]
- ETIPWind publication on Floating offshore wind: delivering climate neutrality [13]

USA: ORE Catapult has established a bilateral innovation programme on optimal sensor placement for offshore wind digital twin development to reduce unplanned maintenance events. Includes research on the US Block Island Windfarm and UK Levenmouth 7 MW demonstration turbine for novel predictive maintenance techniques.

China: ORE Catapult and Shandong University collaboration to investigate the control of wind turbine converters during grid faults, where the turbine is connected to the grid, but also has to support the grid by injecting active and reactive power according to grid codes. The work will improve reliability of turbine power converters.

IEA Wind Task 26: UK is leading work on a study on 'Offshore wind farms of the future', considering a number of case studies for the types of innovation in future projects including floating wind, co-location and energy islands. Publication expected in summer of 2021.

Impact of wind energy

Environmental impact

The special circumstances of 2020 led electricity demand to drop by 4.7% in 2020 accounting for 281 TWh. The key observations were the steep decline in industrial demand and an increase in overall domestic use.

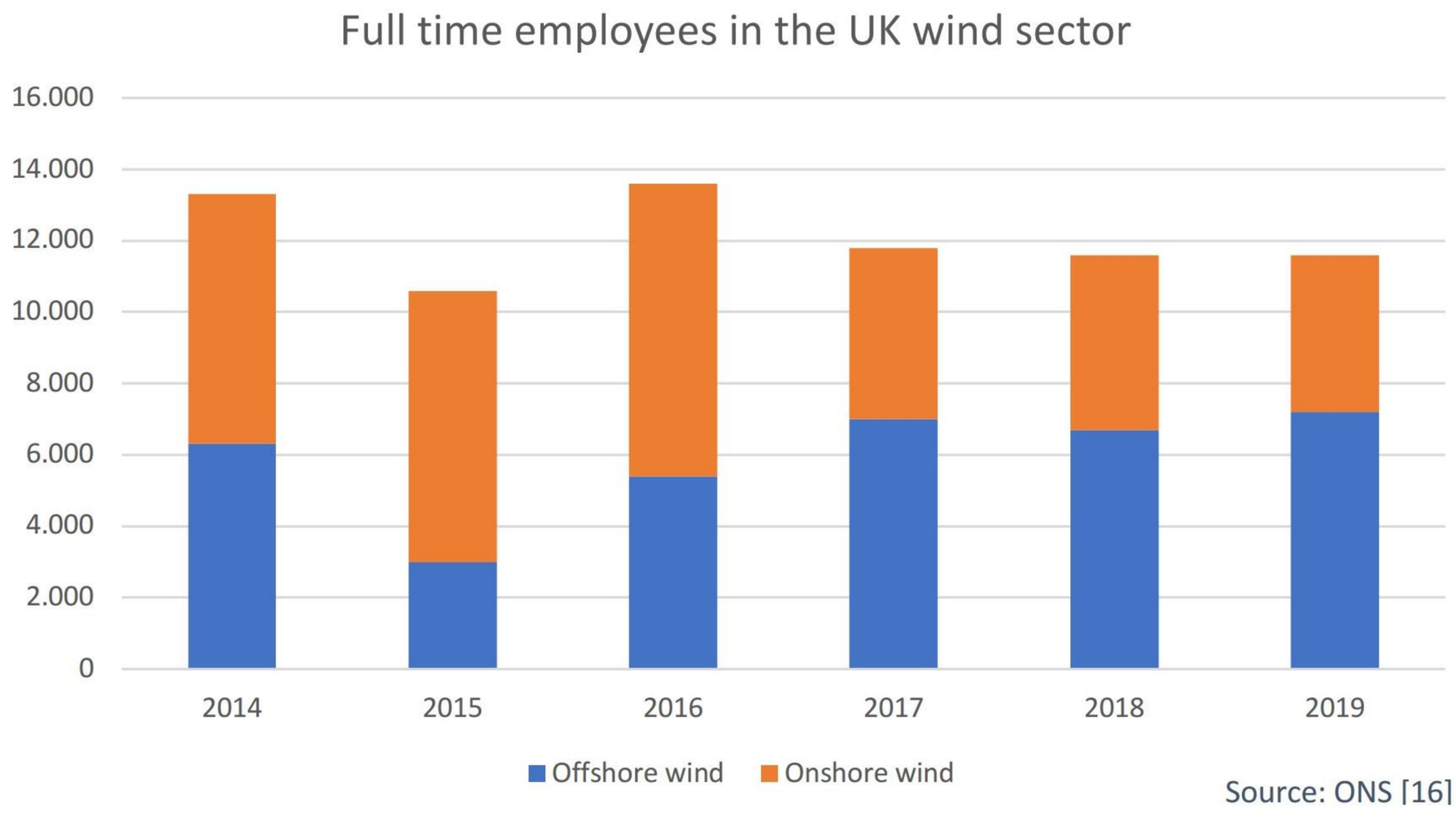
Year 2020 was also the greenest in terms of electricity generation. Renewable energy supplied 43% of the UK's electricity in 2020, up from 37% in 2019. Offshore wind increased its share of renewable electricity to 13% surpassing bioenergy and waste which accounted for 12.6% of total UK electricity. The annual average share of wind energy was 56% of all renewable energy generation, with a peak of 64% in the first quarter of 2020.[2] In particular, Scotland managed to meet 97% of its electricity demand from renewable energy sources in 2020, slightly missing its target of 100%.

According to the National Grid Electricity Systems Operator (ESO), the average carbon intensity in 2020 fell to 181gCO_2/kWh, a reduction of 66% over the last seven years.[14] The pandemic had a major impact on greenhouse gas emissions with total greenhouse gas emissions being 48.8% lower than they were in 1990. Transport and business were the main sector where carbon emissions fell, 19.6% and 8.7%, respectively, while residential sector show an increase of 1.8% as more people stayed home due to restrictions.[15]

Economic benefits and industry development

Turnover in the UK low carbon and renewable energy economy (LCREE) was estimated to be 46.2 billion GBP (53.5 EUR/64.3 billion USD) in 2019. The wind sector was responsible for 6.0 billion GBP of this, a decrease of 15% compared to 2018, due to inherent fluctuations on contract work of the sector.

In terms of employment, the total number of full-time employees (full-time equivalent) in the wind sector remained stable, although offshore wind showed an increase of 500 employees which lost from onshore wind between 2018 and 2019. Offshore wind value of the export market worth 479 million GBP compared to 71 million GBP for onshore [16]. Figures will not be published for 2020 until the end of 2021.



Source: ONS [16]

Next term

The UK Government's Department for Business, Energy & Industrial Strategy (BEIS) Floating Offshore Wind (FOW) Demonstration Programme launches in 2021 and is a competitive funding scheme to support the development and demonstration of innovative FOW technologies and components for the floating offshore wind industry.

Arup, in partnership with ORE Catapult and ABPmer, has been appointed by the UK Government's Department for BEIS, The Crown Estate and Crown Estate Scotland to research a range of scenarios for future offshore wind development. The project is part of the Offshore Wind Evidence and Change Programme led by The Crown Estate. The research will provide a greater understanding of the balance between technical, economic, environmental, and system constraints, and their interactions with the costs to deliver the UK's Net Zero ambition.[17]

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