Capacity of UK electricity generation assets in the 21st century, 2000 to 2019

Key headlines:

- UK electricity generation capacity rose steadily over the last twenty years with total installed capacity above 100 GW since 2017, and up a third since the turn of the millennium.
- During this time, there was a dramatic shift in the capacity mix, particularly in the last decade. Fossil fuel fired capacity declined from its 71.0 GW peak in 2010, while renewable electricity generation capacity rose rapidly. In 2019, the capacity share of renewables exceeded that of fossil fuel fired plants for the first time, with renewable generators providing 47.1 GW, and fossil fuel generators providing 43.9 GW.
- Nuclear plant capacity declined gradually over the past twenty years, with no new capacity since Sizewell B was commissioned in 1995. The total capacity in 2019 was 9.2 GW, which was 26 per cent lower than 2000 levels, following the closure of the eight remaining Magnox reactors during this time.
- Fossil fuel fired capacity has been in decline since 2010, predominantly driven by the phasing out of coal plants since 2013, while gas generation capacity has remained relatively stable in this time. Coal generators, which dominated the capacity mix in the 20th century and provided over a third of capacity in 2000, provided only 6.8 per cent of capacity in 2019, with just four coal plants currently in active operation at the time of writing. Oil and dual fuelled stations have also largely fallen out of the capacity mix, providing a combined share of less than two per cent in 2019.
- Renewable installed capacity currently stands at just over 48 GW (according to provisional figures for 2020), which is just under half the UK total. This compares to 3.0 GW of renewable capacity in 2000 and is five times higher than the 2010 value of 9.3 GW. This expansion was supported by subsidy schemes including the Renewables Obligation (RO), Feed-in-Tariffs (FITs) and Contracts for Difference (CfD).
- The dominant renewable technology in terms of capacity is onshore wind, which provided 14.1 GW in 2019, compared to 13.3 GW of solar and 10.0 GW of offshore wind capacity. Bioenergy provided 7.8 GW in 2019, having risen sharply since 2013 following the conversion of coal units to biomass at Drax and Lynemouth.

Introduction

This article examines changes and trends in the capacity of UK electricity generation assets in the period 2000 to 2019. In particular, the article draws attention to dramatic changes to capacity by fuel and technology, which drove changes in the generation mix. The data in this article are taken from chapters 5 and 6 of the Digest of United Kingdom Energy Statistics (DUKES) 2020; the definitions are thus identical to those in DUKES. Note that fossil fuel-fired capacity totals in this article include coal, oil, mixed and dual fuelled conventional steam stations, combined cycle gas turbine (CCGT) stations, gas turbines and oil engines and combined heat and power plants (electrical capacity only) as listed in DUKES table 5.7. Renewable electricity generation capacity includes hydroelectric (natural flow) stations, wind, solar, shoreline wave, tidal, bioenergy and waste as defined in DUKES table 6.4.

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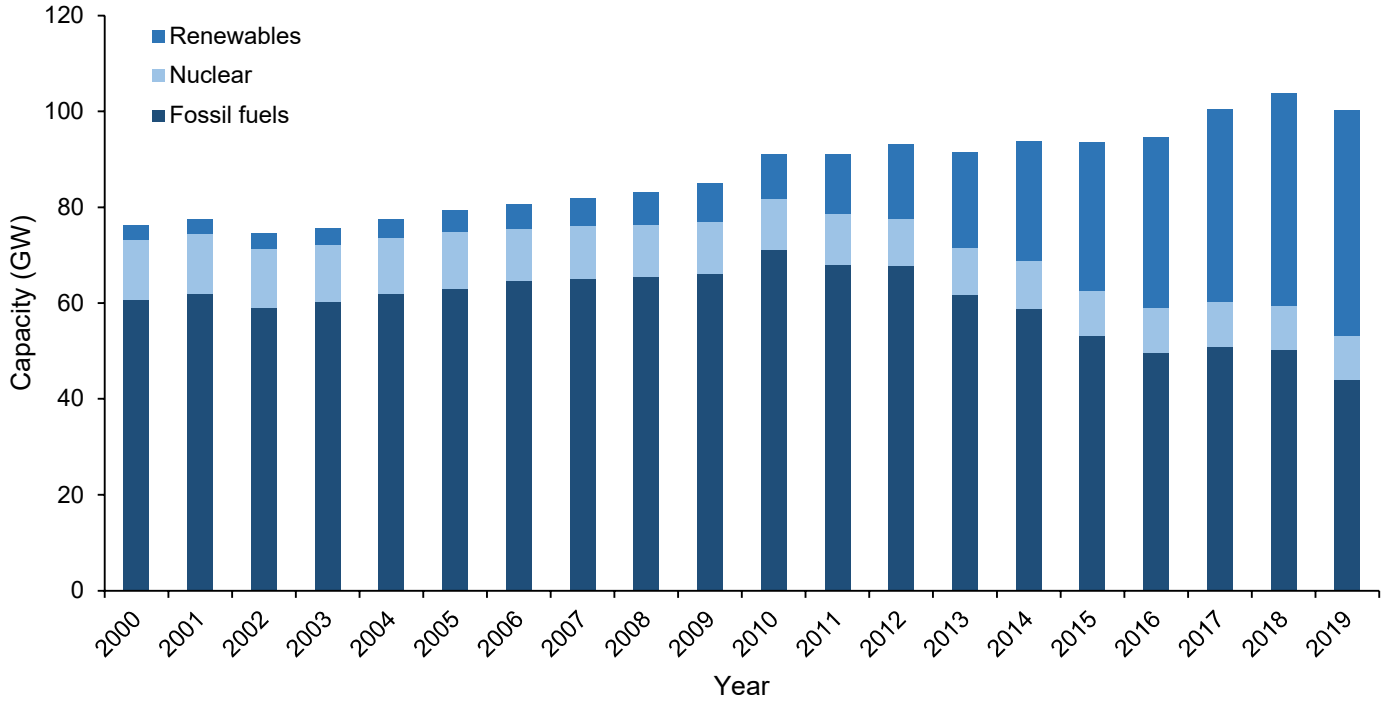
UK electricity generation capacity

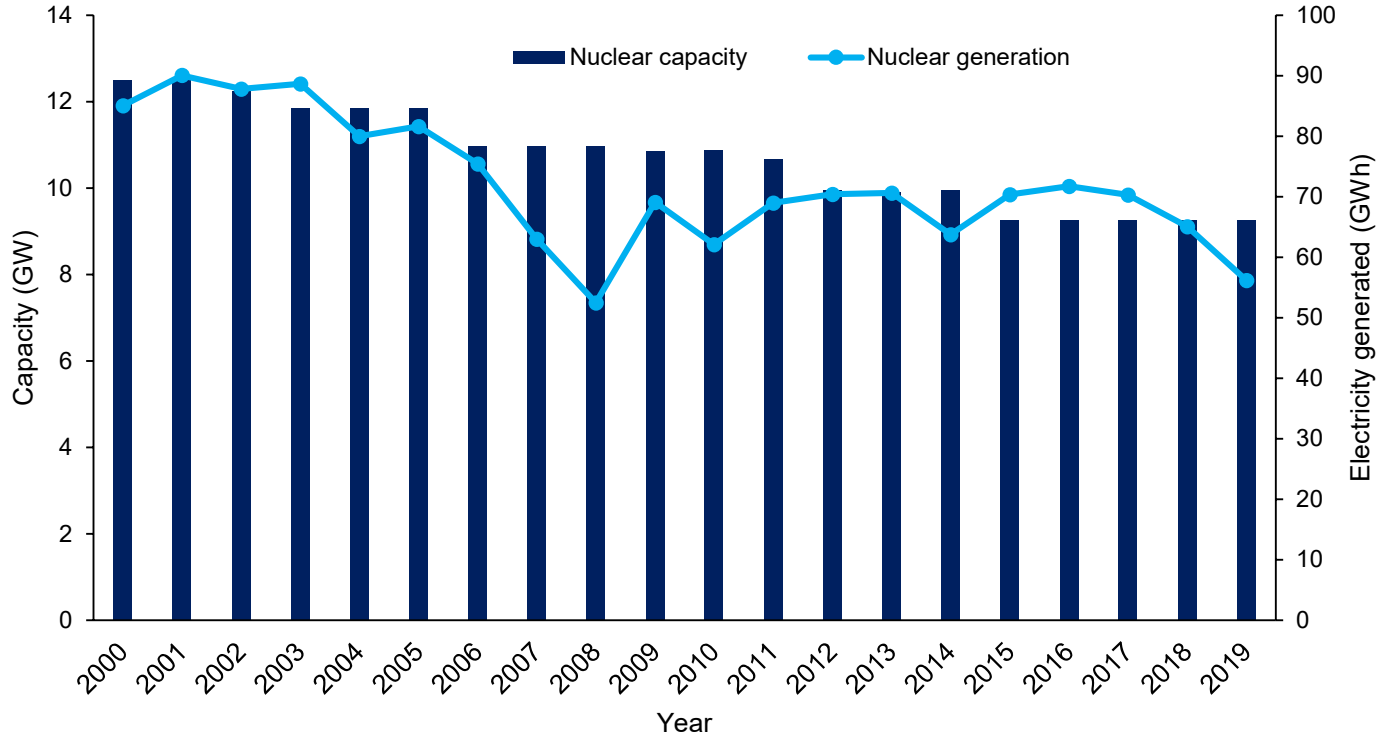
Since the beginning of the 21st century, total installed capacity of UK electricity generation assets has risen steadily, with a dramatic shift in the capacity mix resulting from the emergence of renewable technologies. Chart 1 presents electricity generation capacity in the UK by technology. In 2000, 80 per cent of installed capacity was from fossil fuel fired generators, a proportion which remained relatively stable until 2010, since when it has fallen year on year. The total capacity of all generators increased year on year from 2003 to 2012, primarily driven by the increasing capacity of gas generators, while renewable capacity only grew slowly over this time. Total fossil fuel capacity reached a peak of 71.0 GW in 2010, 17 per cent higher than in 2000, but has fallen steadily since. Renewable generators became significantly more abundant in the 2010s, particularly because of the rapid expansion of wind and solar generation assets. In 2010, the renewable capacity comprised one tenth of the total for the first time and the following year exceeded the share of capacity provided by nuclear. In the years following, renewable capacity rose sharply, increasing by a factor of five in the last decade. In 2019, renewable generators provided 47 GW of capacity which, at 47.0 per cent of total capacity, exceeded the share provided by fossil fuel generators for the first time.

Chart 1: Installed capacity of UK electricity generation assets by technology, 2000 to 2019.



Nuclear capacity has also fallen since 2000, but at a slower rate than fossil fuel capacity (see Chart 2). The last new nuclear power station, Sizewell B, was commissioned in 1995 at which time the nuclear capacity was 12.9 GW, about a fifth of the total UK capacity. In the years that have followed, all eight remaining Magnox reactors closed, including Wylfa in 2015, which was the last Welsh nuclear power station. There are currently 14 active Advanced Gas-cooled Reactors (AGRs) at seven plants and one Pressurised Water Reactor (PWR). Total nuclear capacity in 2019 was 9.2 GW, 26 per cent lower than 2000 levels. Apart from Sizewell B, the seven other active plants are scheduled to close by 2035, although 3.2 GW of this capacity will be offset by the commission of Hinkley Point C, which is currently under construction and expected to generate electricity for the first time in the mid-2020s. The UK's ageing nuclear power stations saw the decline of nuclear generation over the past two decades due to prolonged maintenance outages. This reduced operational nuclear capacity. In 2007 and 2008, nuclear generation fell sharply, which was particularly the result of maintenance at Hinkley Point B and Hunterston B which restricted operations. In 2019, nuclear generation was at the lowest value since 2008 due to long-term maintenance outages.

Chart 2: Nuclear electricity generation and capacity in the UK, 2000 to 2019.

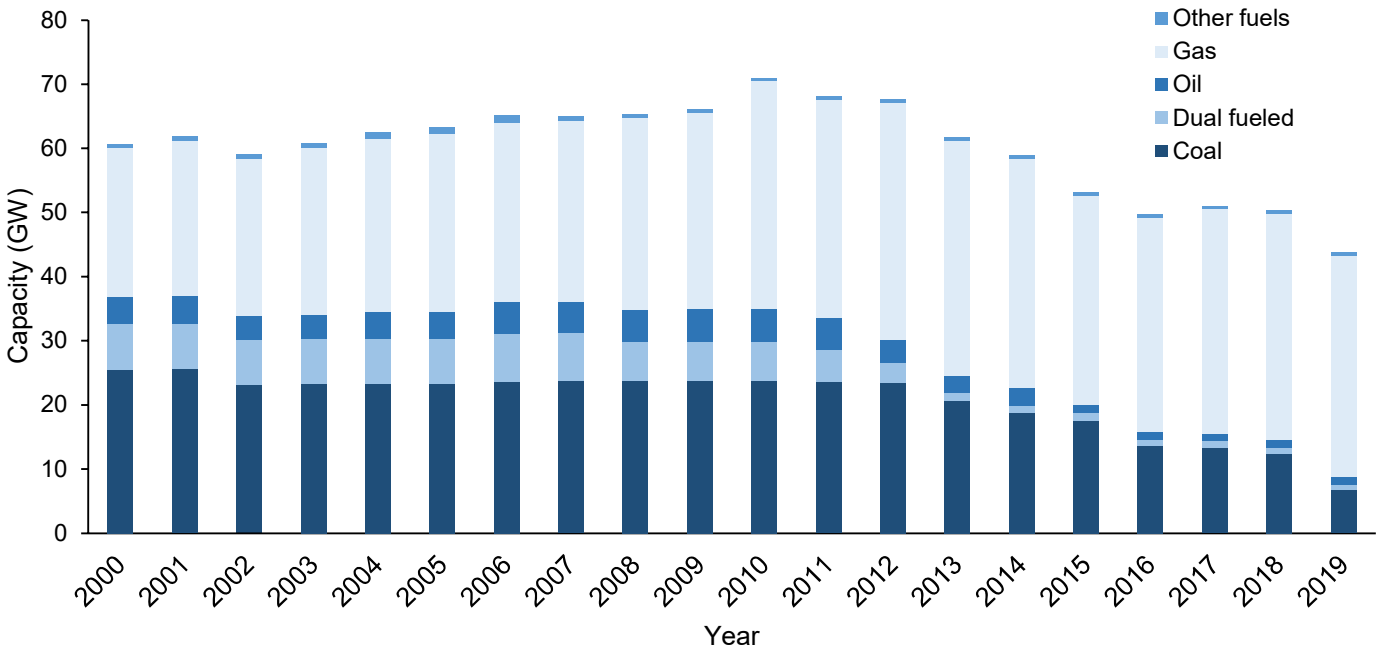


Fossil fuel-fired capacity

Within fossil fuel capacity, there has also been a significant shift in capacity by fuel. At the beginning of the 21st century, coal-fired capacity was just over 25 GW, with gas-fired capacity standing at 23 GW. Throughout the next decade, gas-fired capacity rose steadily to a peak of 37 GW in 2012, but coal-fired capacity remained relatively stable until the UK Government introduced the Carbon Price Floor (CPF) in April 2013. This increased the cost of coal-fired generation relative to gas and, along with the impact of EU regulations, led to the closure of almost all the UK's coal and oil plants, resulting in the swift decline of coal and oil generation capacities. Dual fuelled plants' capacity followed a similar trend to that of coal and oil since the majority of these stations have both coal and oil-firing capabilities. Whilst fossil fuel capacity declined overall in the last decade, gas-fired capacity remained relatively stable, fluctuating around the 35 GW mark. This is largely because of the rapid decline in coal capacity, which resulted in gas generators being required to meet the demand. The expansion of renewable technologies in recent years rendered gas generators less dominant in both the capacity and generation mixes, although they still provide more electricity and have a higher generating capacity than any other fuel. Gas generators provided 34.5 per cent of capacity in 2019, down from a peak of over two fifths of the total in 2013. Coal generators, which dominated the capacity mix in the 20th century and provided over one third of capacity in 2000, provided only 6.8 per cent of capacity in 2019. Oil and dual fuelled stations have also largely fallen out of the capacity mix, providing a total capacity of less than 2 per cent in 2019.

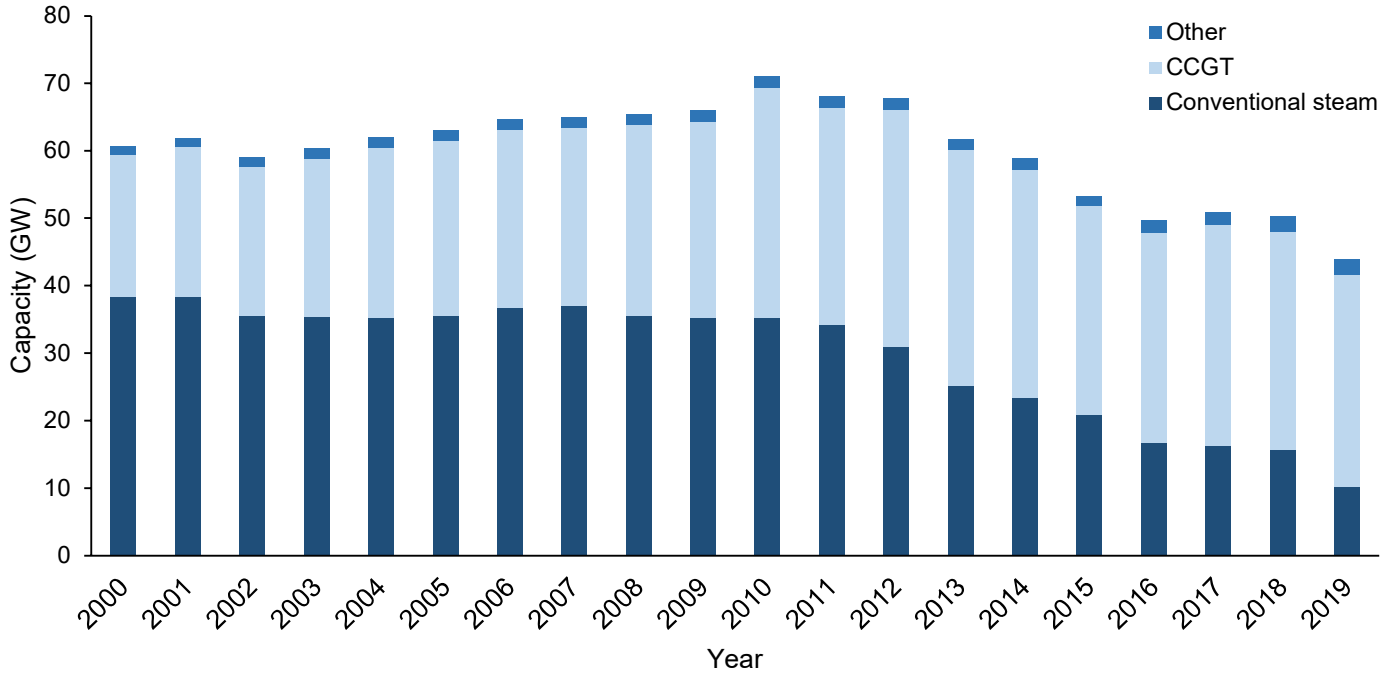
In 2019, coal capacity fell by a further 5.5 GW following the closures of Cottam, Aberthaw B and Eggborough. This was depleted further following the closure of Fiddlers Ferry in 2020. At the time of writing, just four coal plants remain in the UK. The three coal-only plants have a combined capacity of 5.3 GW, while Kilroot, which is a mainly coal-fired station with oil-firing capabilities, has a capacity of 0.6 GW. The UK's remaining coal plants are expected to be phased out by October 2024 as the UK works towards net zero carbon emissions by 2050. Drax will close its remaining coal units in 2021, whilst Kilroot plans to convert to gas by winter 2023. Plans for the closure of Ratcliffe and West Burton are yet to be finalised.

Chart 3: Installed capacity of fossil fuel-fired plants in the UK by fuel, 2000 to 2019.



These trends are mirrored in the installed capacity of different types of fossil fuel-fired plant over the time series. Chart 4 shows how installed capacity of different types of plant has varied over time based on the capacity figures by plant type published in DUKES table 5.7. The changes in gas generation capacity closely align with those for Closed-Cycle Gas Turbine (CCGT) stations, since the majority of gas generation capacity is from CCGT plants. Conventional steam plant capacity closely mirrors that of coal, since the majority of conventional steam stations are coal-fired, or dual-fuelled using mainly coal. In the past decade, conventional steam capacity has declined rapidly, following the winding down of coal and oil. Since the closure of Littlebrook D in March 2015, there have been no oil-fired conventional steam stations in the UK. It should be noted that conventional steam capacity in chart 4, as in DUKES 5.7, does not include bioenergy-fired conventional steam plants, for which capacity has increased in recent years following the conversion of coal plants to biomass firing capabilities at Lynemouth and Drax.

Chart 4: Installed capacity of fossil fuel-fired plants by type, 2000 to 2019.



Renewable technologies

The capacity of renewable technologies has expanded dramatically since the turn of the millennium, with both technological developments and streams of funding to endorse renewable electricity generation resulting in an upsurge in the number of renewable generators across the UK. Until 2005, renewable capacity made up less than 5 per cent of the total UK capacity, with most of this from hydro (natural flow) and bioenergy generators. The Renewables Obligation (RO) was introduced in 2002 to support large-scale renewable projects and helped instigate more widespread development of wind and solar farms across the UK. As a result, onshore and offshore wind capacity rose steadily in the 2000s, before starting to rise more rapidly towards the end of the decade. Most currently operational large-scale projects are supported by the RO, which closed to new capacity in March 2017, subject to a grace period.

Solar generation capacity rose sharply following the introduction of the Feed-in-Tariffs (FIT) scheme in 2010, which primarily supported small-scale generators with a capacity up to 5 MW. In 2010, less than 100 MW of capacity was from solar generators, less than 0.1 per cent of the UK capacity mix. However, by 2015 solar generators provided one tenth of the total for the first time, with solar capacity increasing over 100 times in five years to 9.5 GW. In the same year, onshore wind also exceeded a tenth of capacity with the capacity of renewable technologies providing a third of the total for the first time. Since the RO closed in 2017, the expansion of solar and onshore wind generation capacity has slowed with the number of new small-scale generators also falling due to the adjustment of the FIT scheme. The scheme finally closed to new capacity in March 2019, subject to a grace period and some time-limited extensions.

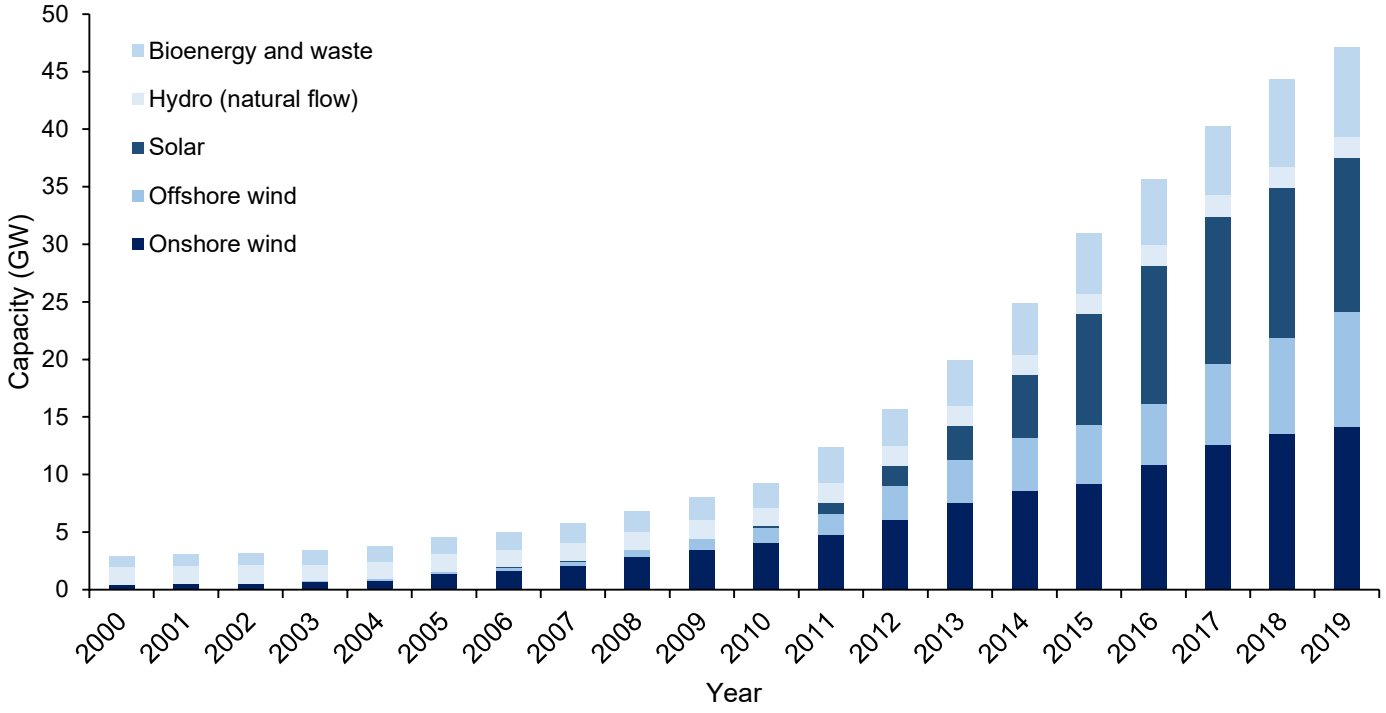
As coal plants closed in the UK, several large coal units were converted for biomass generation capabilities. Lynemouth's 420 MW coal unit was converted to biomass in 2018, while Drax, which is now the UK's largest bioenergy generator, has converted four of its coal units to biomass since 2013, which have a combined capacity of 2.6 GW. In 2019, these two sites constituted the overwhelming majority of the UK's plant biomass capacity which totals 4.5 GW, and a substantial part of the 7.8 GW of bioenergy and waste capacity.

The Contracts for Difference (CfD) scheme is now the government's main mechanism for supporting the development of renewable technologies. There have been three contract allocating rounds since 2014, with a fourth due to take place in 2021. Initial projects supported by the CfD scheme were first commissioned in around 2019, with CfD notably providing support to large offshore wind farms including Hornsea One and East Anglia One. The first phase of the 1.2 GW Hornsea One project came online in 2019, with the 0.7 GW East Anglia One project becoming fully operational in 2020. Following this, offshore wind generators provided over 10 GW of capacity in 2020. With the continuing upsurge in renewable generation capacity and the decline of fossil fuels, renewable technologies provided 47.0 per cent of capacity in 2019, exceeding the fossil fuel capacity share for the first time. The dominant renewable technology in terms of generation capacity is currently onshore wind, which provided 14.1 GW in 2019, which solar generators providing 13.3 GW.

As a particular result of the continued expansion of offshore wind, 2020 renewable capacity now stands at just over 48 GW, which is just under half the UK's total installed capacity. Provisional figures also indicate that renewable electricity generation in the UK exceeded that of fossil fuels for the first time in history in 2020.

Chart 5 illustrates the growth of installed capacity of different renewable technologies over the last twenty years. Note that in this chart, a very small amount of shoreline wave and tidal capacity is included in offshore wind.

Chart 5: Installed capacity of renewable generation assets, by technology, 2000 to 2019.



Derated renewable generation capacity

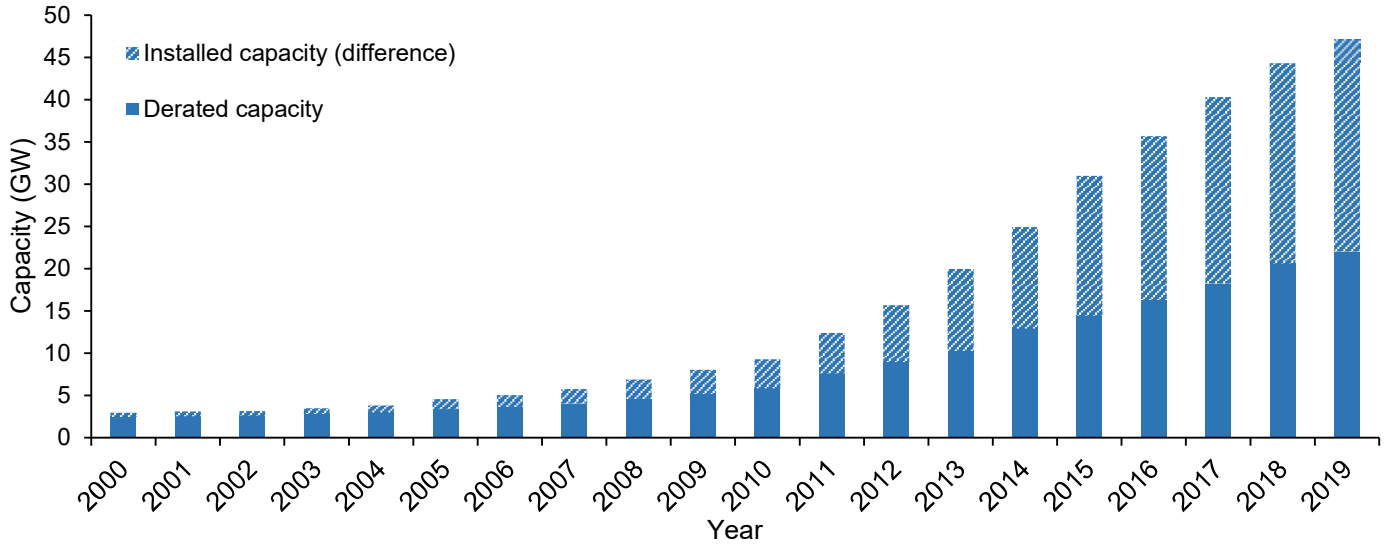
In charts 1 and 5, the electricity generation capacity of renewable technologies is shown on an installed capacity basis. Renewable generation capacity can also be represented on a derated basis which considers the intermittency of different renewable technologies, allowing for a more direct comparison with other technologies. The derated capacity is calculated by applying a scale factor to the installed capacity which accounts for the variability of the energy source (see Table 1).

Table 1: Scaling factors for calculating the derated capacity of renewable energy generation sources.

Technology	Scale factor
Wind	0.430
Solar photovoltaics	0.170
Small-scale hydro plants (capacity up to 5 MW)	0.365

Electricity generation in wind, solar and hydro stations is dependent on weather conditions, namely wind speeds, sun hours and rainfall respectively. The operational capacity of thermal renewable (bioenergy and waste) sources does not vary with weather conditions, whilst large-scale hydro stations are less dependent on rainfall. De-rated capacity is a useful metric for monitoring the capacity required to meet demand, since more intermittent renewable technologies cannot be relied upon to consistently generate electricity at their installed or ‘nameplate’ capacities. DUKES Chapter 6 provides load factors for renewable electricity generation for different technologies. These represent the amount of electricity generated as a percentage of the maximum load. Chart 6 shows how derated capacity has varied over time, alongside changes in renewable installed capacity.

Chart 6: Electricity generation capacity of UK renewable assets derated for intermittency, 2000 to 2019.



The future of electricity generation capacity in the UK

The capacity mix is certain to continue to change in the coming years, as the UK seeks to achieve its goal of net zero carbon emissions by 2050. The complete phase out of coal generation is expected by 2024, while all nuclear plants except Sizewell B and Hinkley Point C (which will begin generating in the mid-2020s) expected to cease operations by 2030. BEIS modelling suggests that overall demand for electricity could double by 2050, driven by a shift to electric vehicles and electricity replacing gas for heating. Generation capacity will therefore have to increase significantly in order to replace retiring capacity and keep pace with demand.

The government has set a target of having 40 GW of offshore wind capacity by 2030, with several onshore and offshore wind sites currently under construction and expected to become operational by 2023. A further 5.8 GW of remote island onshore wind and offshore wind capacity gained funding in the third CfD allocation round, with this expected to become operational by 2025. A further 12 GW of renewable capacity is aimed to be allocated in the fourth CfD allocation round, taking place in late 2021.

Hinkley Point C, which was the first nuclear power plant to begin construction in the UK in over 20 years is due to commission in the mid-2020s, with its two European Pressurised Reactors (EPRs) providing a combined 3.2 GW of capacity. With the existing nuclear fleet largely retiring over the next decade, the construction of two more EPRs at Sizewell C have been proposed by EDF Energy. The government will also provide funds for the development of Small Modular Reactors (SMRs) and Advanced Modular Reactors (AMRs), which aim to provide cost-competitive nuclear power by the early-2030s.

Fossil fuel fired generation is not expected to end completely, with ambitions for the deployment of power carbon capture, usage and storage (CCUS). The first gas-fired CCUS station is expected to be operational by 2030 for the generation of low carbon electricity.

Further information on the future of electricity generation in the UK can be found in the UK Energy White Paper, published in December 2020, which includes illustrative scenarios of how the electricity generation mix could look in 2050, based on BEIS modelling.

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Data for this article

The data used to produce this article can be found in the Digest of UK Energy Statistics (DUKES) chapters 5 and 6, as well as Energy Trends chapters 5 and 6 (see references below).

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