UK Electricity capacity and generation by fuel between 1920 and 2020

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Key headlines:

- In 1920, UK electricity generation capacity stood at just 2.5 GW. Over the next 100 years, capacity increased substantially, and by 2020 total installed capacity stood at 101.1 GW, a 41-times increase in total installed capacity over the period.
- The fastest rate of change occurred between 1955 and 1975, when the UK was gaining an average of nearly 2.5 GW of capacity per year.
- From the 1970s onwards the UK's capacity mix began to change considerably. Coal capacity dominated the previous decades, but the 1970s saw diversification into oil-fired and nuclear capacity. The privatisation of the energy industry in the 1990s and the subsequent 'Dash for Gas' led to coal-fired capacity dropping below 50 per cent of total capacity for the first time. 2000 onwards saw wind and solar as the fastest growing form of generation capacity.
- By 2020, coal fired capacity had fallen below 1930 levels.
- Much like capacity, electricity generation increased steadily from 1920 onwards, and experienced the fastest rate of change during a similar period to capacity, growing rapidly from 1950 until 1970. Electricity generation peaked in 2005, after which increased efficiency resulted falling generation.
- Generation follows a similar trend to capacity, with coal dominating the earlier period, up until around the mid-1950s. Diversification of the generation mix occurred from the 1970s onwards, and by the end of the period, gas had emerged as the dominant fuel type used in generation.
- Key historic events such as the miner's strikes on the 1970s and 1980s are clearly noticeable in the timeseries, as well as the shift to gas generation in the 1990s, demonstrating the responsiveness of the UK's energy generation sector to external circumstances.

Introduction

This special feature article examines the changes and trends in the UK's electricity capacity and generation mix by fuel type between 1920 and 2020. In particular, the article draws attention to the dominance of coal-fired capacity and generation early on, before greater diversification occurred from the 1970s onwards. The data in this article are taken from chapter 5 of the Digest of United Kingdom Energy Statistics (DUKES) 2022, historic copies of DUKES, DUKES long term trends tables (Electricity since 1920, DUKES 5.1.3), UK Energy in Brief, and supplementary internet research. Capacity data beyond 2000 is complemented by the more in depth 2021 Energy Trends special feature article 'Capacity of UK Electricity Generation Assets in the 21st Century, 2000 to 2019'. Data from 1996 to present can be found in DUKES table 5.7 for capacity by fuel and DUKES table 5.6 for generation by fuel. The accompanying excel spreadsheet to this article, 'Electricity capacity and generation from 1920 to 2020', features all the underlying capacity and generation data which informs this article, as well as a list of power stations which have operated in the UK during the period.

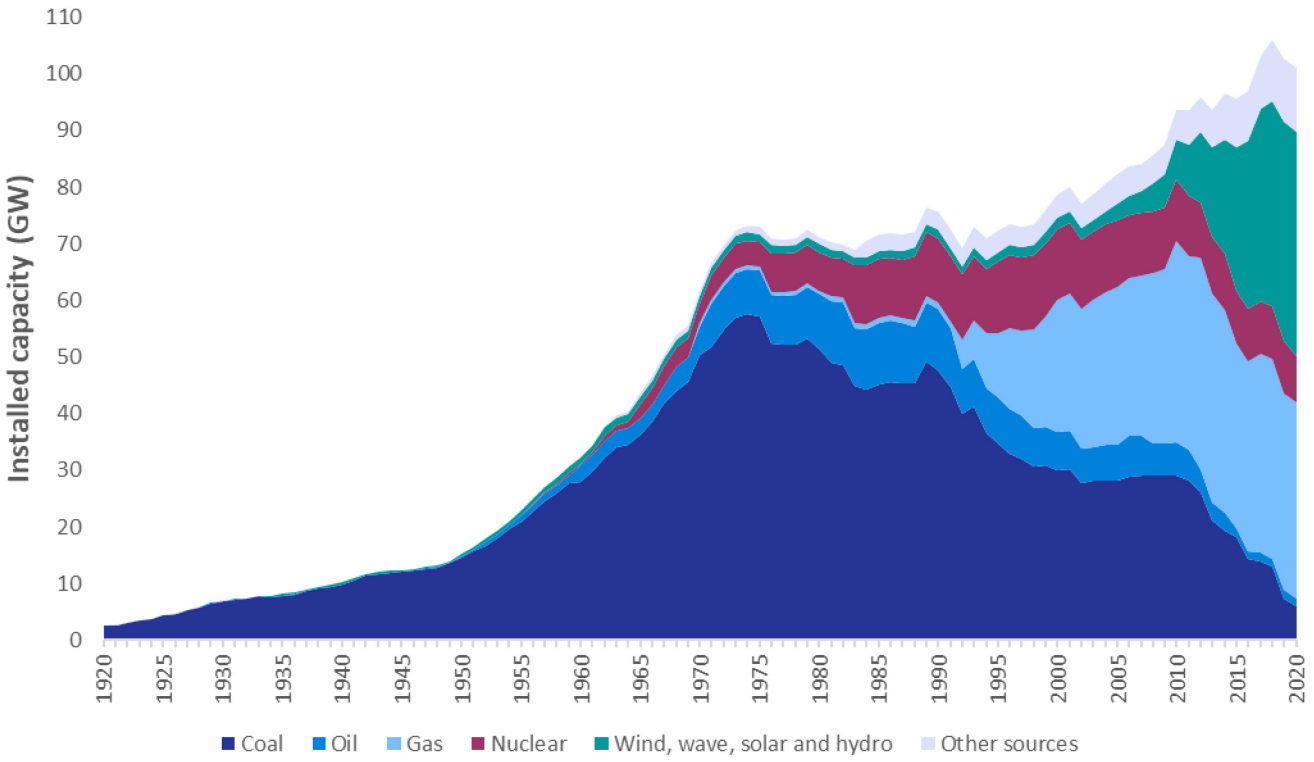
As a disclaimer, the data within this article and accompanying excel spreadsheet are experimental statistics and may be subject to revisions in the future. Brief caveats are stated at the start of each section, explaining the reasons for estimates having been made. For further information on caveats, as well as why and how estimates have been made, please see the Methodology Note at the end of this document.

UK electricity generation capacity between 1920 and 2000

Historically, capacity data in DUKES has been presented as a total only, or split by technology. This article aims to track a timeseries of installed capacity split by fuel for the first time. In addition to this, throughout the history of DUKES capacity has been measured in several different ways, each with merit for doing so at the time. This however presents a challenge when attempting to produce a single coherent timeseries. All references to capacity in the article are to total installed capacity, which refers to the maximum amount of electricity that a generating station can produce given the equipment, such as turbines, installed at the station. Existing data for installed capacity data from DUKES, estimates based on alternative capacity measures, and supplementary internet research have all been used to collate a list of power plants which have existed in the UK since 1920, and to calculate approximate measures for installed capacity by fuel. Further details of the approach can be found in the methodology note at the end of this document.

Between 1920 and 2020 total electricity generating capacity in the United Kingdom increased substantially. The world's first coal-fired power station, the Edison Electricity Light Station, was built in London in 1882. The plant had an installed capacity of 93 kW (0.093 MW) and was used to power 3000 incandescent lamps in the Holborn area. By 1920, the UK had 2.5 GW of generation capacity, 98.7 per cent of which was coal-fired power stations. By 2020, total generating capacity increased almost 4000 per cent to 101.1 GW. The mix of capacity also changed considerably during this period. Chart 1 presents approximate electricity generation capacity in the UK throughout the period, split by fuel type.

Chart 1: Approximate installed capacity of UK electricity generation assets by fuel type from 1920 to 2020.



Coal capacity maintained a share of over 90 per cent well into the 1950s, though towards the end of the decade dedicated oil burning plants began to make up a more noticeable share of capacity. Bankside B was the UK's first station to be constructed specifically to be oil-fired, though many existing coal-fired stations were converted to use oil. By 1955, more than 5 per cent of capacity was oil-fired. The following year saw the commissioning of the UK and the world's first commercial nuclear power station, Calder Hall, a 220 MW

Magnox reactor. By the end of the 1950s coal-fired generators still accounted for over 85 per cent of the UK's 30 GW total generating capacity.

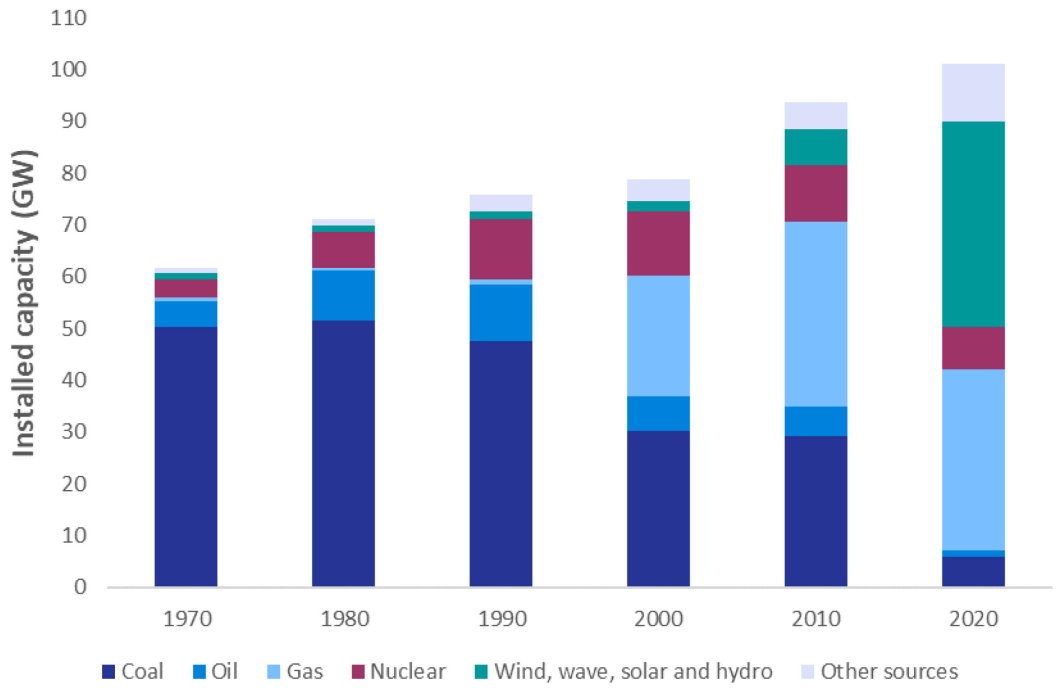
The 1960s saw coal continue to dominate as the UK's capacity mix slowly began to diversify. Oil-fired capacity continued to increase towards a 10 per cent share, equating to just shy of 5 GW of capacity by 1970. Nuclear capacity saw the greatest increase during this period. The opening of several stations of 400 MW capacity and above, including the 500 MW Hinkley Point A, saw nuclear capacity increase from 0.4 GW at the start of the decade to 3.4 GW by the end. The 1960s also saw the introduction of pumped hydro storage stations, with 360 MW Ffestiniog opening in 1963, followed by 440MW Cruachan in 1965. These provided a limited facility to store electricity for later use.

Coal continued to make up at least three quarters of the UK's capacity into the early-1970s, and it was during this period that peak coal-fired capacity was reached. In 1974, coal-fired generators provided 57.5 GW of the UK's total 72.1 GW capacity. Oil-fired capacity, the next largest total, stood at just 8.1 GW. 1974 was also significant as it saw the commissioning of the UK's largest power station to date, the coal fired Drax. By the time it was completed in 1986, Drax had a total installed capacity of 3,960 MW – this meant the capacity of Drax alone was 1.5 times greater than the capacity which had existed in the entire country in 1920.

It took until the early-1980s for the UK's coal capacity to drop below 70 per cent of total installed capacity, by which point more coal power stations were closing each year than were newly opened. Oil-fired capacity plateaued during the 1980s, maintaining just under 11 GW of capacity throughout the decade, which included three 2 GW sites; Pembroke A, Fawley, and Littlebrook D. Nuclear capacity almost doubled during the decade with 5.7 GW of new capacity.

Chart 2 shows that, from 1970 onwards, the UK's generation capacity mix has undergone a major diversification. The share of coal-fired capacity stood at 81.8 per cent in 1970; by 2020 it had declined drastically to a 5.9 per cent share.

Chart 2: The diversification of the UK's generation capacity mix between 1970 and 2020



The 1980s saw the commissioning of numerous small single cycle and open cycle gas plants, however it was not until the early-1990s, and the introduction of the Combined Cycle Gas Turbine (CCGT), that gas-fired capacity began its rapid expansion. In 1991 the UK's first CCGT plant opened at Roosecote. Still at just 229 MW, Roosecote was soon eclipsed by much larger plants, such as the 1,875 MW Teeside plant in 1992, 1,380 MW Connahs Quay in 1996, or the nearly 1,500 MW Didcot B in 1998.

The sudden expansion in gas fired generation capacity was the result of multiple determinants in what became known as the 1990s 'Dash for Gas'. Factors included privatisation of the UKs electricity industry in 1990, high interest rates encouraging the construction of quicker to build gas turbine power stations versus coal and nuclear plants, as well as the rapid decline in wholesale gas prices. In 1990 UK gas capacity stood at just over 1 GW, which represented just 1.3 per cent share of total capacity. By 2000 this capacity had increased substantially to 23 GW, which represented a 29.6 per cent share. The largest gas power plant in the UK to date is Pembroke CCGT, commissioned in 2012, with an installed capacity of 2,200 MW.

The expansion of gas, alongside continued coal plant closures, meant that by the mid-1990s coal-fired capacity fell below 50 per cent for the first time, constituting 48 a per cent share of the UK's 72.2 GW capacity in 1995. By 2000, coal capacity stood at 30 GW, and 38.2 per cent of the UK's 78.7 GW of total electricity generating capacity.

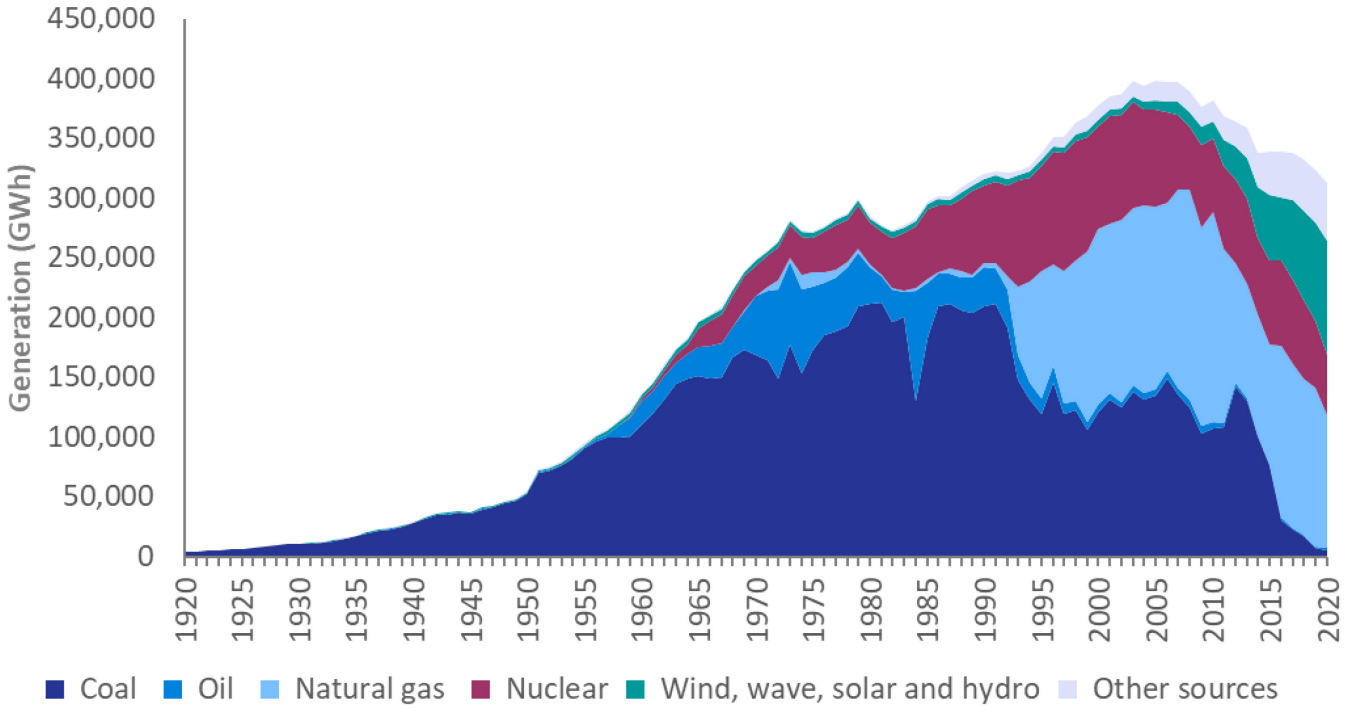
From 2000, and particularly from 2010 onwards, non-thermal renewables saw the largest increase in capacity. In 2000, capacity from wind, wave, solar, and hydro generators stood at just 1.9 GW. By 2010, this had increased to 7.0 GW, and by 2020 it had reached 41.3 GW. The substantial rise in non-thermal renewable capacity has primarily been driven by wind and solar projects, which have seen their combined capacity rise over 9000 per cent since the millennium. The growth of renewable capacity is covered further in a previous Energy Trends article '[Capacity of UK electricity generation assets in the 21st century, 2000 to 2019]'.

Whilst this century has seen gas-fired capacity remain consistently above a 30 per cent share, coal-fired and oil-fired capacity has declined considerably. Today, in 2023, total installed coal-fired capacity stands at just 4.2 GW across only 4 sites. Today, gas-fired capacity is the single largest fuel type.

Electricity generation by fuel

Electricity generation by fuel was not reported in the DUKES tables prior to 1996. With coal the dominant fuel for much of the time series, the historical data was broken down by power plant type rather than by fuel. In addition, much of the data was for electricity supplied rather than electricity generated, excluding electricity used in the process of generation. The section below presents estimates of electricity generation by fuel based on the historical electricity supplied and fuel input data as well as average efficiency proportions and average measures of electricity used in the process of generation. Further details of the approach to estimation are in the methodology note.

Chart 3: Estimated electricity generation by fuel, 1920 to 2020



Electricity generation followed a generally increasing trend throughout the period, and peaked in 2005, with increased efficiency since this point reducing the need for such high electricity generation. The estimated split by fuel highlights the dominance of coal, which represented more than 90 per cent of generation until 1957 and more than 75 per cent of generation until 1965. The estimates also show the effects of coal miners' strikes in 1972, 1974, and most noticeably 1984/85, where coal generation dipped below the usual trend and oil generation increased. Up until 2014, coal still provided over 100 TWh of electricity yearly, however since then generation has fallen dramatically. By 2020, coal provided just 0.55 TWh of generation, the lowest figure since 1922, and made up just 1.8 per cent of total generation.

Generation from oil began to make a substantial contribution in 1958 and was an important counterpart to coal through until 1992, when it was first overtaken by generation from gas during the 'Dash for Gas'. The 1990s saw a rapid expansion in gas generation, which was just 1.1 per cent of the total in 1990 but by 2000 gas generation represented a 39.3 per cent share. Generation from gas was higher than coal for the first time in 1996, providing 136.1 TWh of generation compared to 100.2 TWh from coal. Generation from gas peaked in 2010, when 175.7 TWh of generation provided 46.0 per cent of the UK's total output. Gas remains the single largest fuel source for generation in the UK, representing a 35.7 per cent share in 2020.

Nuclear generation began in 1956 with the opening of Calder Hall and represented around a tenth of generation from 1966 to 1980. The introduction of Advanced Gas-cooled Reactors (AGR) in the 1970s saw the UK's fleet of nuclear reactors expand by the 1980s, and this resulted in generation increasing substantially to a peak in 1998 at 99.5 TWh, 27.4 per cent of generation. Since then, nuclear generation has declined steadily, falling to 45.9 TWh in 2020, 14.9 per cent on generation.

Generation from other sources covers generation from coke oven gas, waste products from chemical processes, pumped storage generation and more recently, bioenergy and energy from municipal solid waste. It is not possible to separate these so a renewable total cannot be identified. Pumped storage generation has remained relatively consistent over time, so it is likely that most of the increased generation in this category comes from bioenergy and the non-renewable component of waste (reported under 'other fuels' in DUKES and

Energy Trends). The first bioenergy and waste plants were built in the 1970s but capacity did not increase substantially until after 2010.

Non-thermal renewable generation is present throughout the time series with a small amount of generation from hydro sources recorded from 1920 onwards. These non-thermal renewable generators accounted for between 1.0 and 2.0 per cent of total generation from 1930 onwards, largely providing the only alternative to coal generation in the early period. Most of the generation in this category came from hydro, with the first wind generators commissioned in the early 1990s, with wave and tidal capacity introduced in 2000 and solar generators from the mid-2000s. In 2020, 30.5 per cent of generation came from Wind, wave, solar and hydro generators. Further information on the growth of renewables is covered in the Energy Trends article 'Capacity of UK electricity generation assets in the 21st century, 2000 to 2019', whilst generation data for individual renewables from 1996 onwards can be found in DUKES 5.6.

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Methodology note

Data sources

The data in this article are taken from chapter 5 of the Digest of United Kingdom Energy Statistics (DUKES) 2022, historic copies of DUKES, DUKES long term trends tables (Electricity since 1920, DUKES 5.1.1, DUKES 5.1.3) and UK Energy in Brief, supplemented by desk and internet research.

Electricity capacity

Historically, a coherent timeseries of electricity capacity by fuel has not been recorded in the annual DUKES statistics. Capacity has been reported in several different ways, including installed capacity, grid export capacity, and declared net capability, as well as changing between measures for the whole UK, Great Britain only, and calendar years versus financial years. Historic tables also typically separated capacity by plant type rather than fuel.

These issues meant that constructing a timeseries based solely on existing DUKES data was not possible. To fill in the gaps, a combination of supplementary internet research and estimates have been used. This section explains the approach and assumptions made to do this.

General principles and assumptions

From 1996 onwards, generation by fuel is taken from DUKES 5.7. Prior to this point, the following assumptions were used to guide estimations for data that was not available:

- It is assumed that prior to 1991 the only non-thermal renewable capacity came from hydro plants.
- Pumped storage totals post 1984 have been taken from DUKES, and so are not true installed capacity.
- Nuclear data is sourced from 'Energy Trends: March 2019, special feature article - Nuclear electricity in the UK' for consistency.
- Where municipal solid waste (MSW) sites are concerned, capacity has been split 50/50 between bioenergy capacity and other fuels capacity, as is the standard treatment in DUKES publications.
- Where possible, UK total capacity was matched to the UK total capacity previously published in DUKES. Where this was not available, GB installed capacity was taken from DUKES with supplementary Northern Ireland data added produce a UK total.
- Where differences were identified between the supplementary research and published DUKES numbers, the missing/excess values were split between coal and oil, depending on the years under consideration. These splits are detailed below.

Time series differences

The following subheadings provide an overview of the methodology and assumptions applied in each time period, as different issues applied to the data depending on what had previously been published.

1920 to 1969

The total capacity figures are the sum of previously published GB installed capacity and supplementary research for Northern Ireland data. The split by fuel is sourced as follows:

- Capacity for hydro, oil, and other fuels is based on previously published DUKES totals and supplementary research.
- Pumped storage data is taken directly from previously published DUKES data.
- Coal data is based predominantly on supplementary research. This is due to previous editions of DUKES only reporting by plant type (e.g. conventional thermal), rather than splitting by fuel. Supplementary research was used to determine which sites were coal, and which were oil and other fuels.
- For this period, where the sum of research did not match the previously published total capacity, all missing capacity has been allocated to coal. This is due to coal being the dominant fuel during this

period. Percentage shares of any other fuel were too small to confidently allocate without artificially overinflating capacity data for that fuel type.

1970 to 1989

The total capacity figures are the sum of previously published GB installed capacity and supplementary research for Northern Ireland data. The split by fuel is sourced as follows:

- Hydro capacity is a combination of DUKES figures and supplementary research, with the additional data used to fill in gaps in the DUKES series.
- Gas capacity data has been sourced from supplementary research. In this period, the percentage share of gas capacity was too small to have any missing capacity allocated to it without the risk of overstating capacity.
- Coal and oil data comes predominantly from supplementary research, though again this was mainly to determine which sites were coal and which were oil.
- For this period, once again where the sum of research did not match the previously published total capacity, missing capacity has been allocated between coal and oil based on their percentage shares from the existing supplementary research. Oil has been included because the numbers in the supplementary research appeared too small initially.

1990 to 1995

This period has particular challenges as total capacity in DUKES was published for financial years rather than calendar years. In order to remain consistent with the rest of the time series, a scale factor was used in order to estimate total capacity for calendar years. The split by fuel is sourced as follows:

- Hydro capacity is a combination of DUKES figures and supplementary research, which was used to fill in gaps in the DUKES series.
- The ‘Other fuels’ category includes orimulsion in this period.
- Other renewable capacity is based on supplementary research, and includes the UK’s first onshore windfarm. Renewable capacity here is not derated.
- For this period, where the sum of research did not match the previously published total capacity, missing capacity has been allocated between coal and oil based on their percentage shares from the existing supplementary research. Missing capacity was not allocated to gas as it disrupted the time series too much.

1996 to 2000

For 1996 to 2000, all data is taken from the existing published DUKES 5.7 table. The only change is that renewable capacity is no longer derated. This has been done to stay consistent with the rest of the timeseries.

Site level capacity table

The site level capacity table reports a full list of sites identified in the DUKES dataset and from supplementary research for all sites of 5 MW or above. The table includes the site’s maximum installed capacity which is the highest installed capacity recorded at each site. This was chosen due to being a more robust measure than tracking changes over time, particularly due to data limitations in the earlier years of the timeseries.

This dataset is not exhaustive of the UK’s power generating capacity through time. Sites will be missing from this database, particularly in the early section of the timeseries where data is most limited. Capacities are reported based on the best available research and may be revised if new data becomes available.

Electricity generation by fuel

Generation by fuel was not recorded prior to the current layout of DUKES tables, which began in 1996. Up until this point, the published data focused on electricity supplied rather than electricity generated and the data was split by generator type (conventional thermal, CCGT etc.) rather than fuel. This reflected the dominance of coal for electricity generation which made the split by fuel less insightful. In order to show a full time series for generation by fuel, data prior to 1996 had to be estimated from the historic data. This section explains the approach and assumptions made.

Data sources

Electricity supplied data was taken from 'Historical electricity data: 1920 to 2021' and DUKES table 5.1.3. Fuel used data was taken from DUKES table 5.1.1.

Data on electricity supplied was scaled up to estimate total generation using data from DUKES table 5.6.

Efficiency was estimated using generation and fuel used data from DUKES table 5.6.

1920 to 1950

These years have generation from hydro and conventional thermal only so the calculations are relatively simple.

1. Hydro generation is estimated by scaling up from supply using a 20-year average of generation divided by supply from DUKES 5.6 (1996-2015).
2. The estimated hydro generation is subtracted from the published total generation to give estimated conventional thermal generation.
3. An efficiency factor by fuel is calculated using a 20-year average of generation divided by fuel use from DUKES 5.6 (1996-2015). This scales the total fuel used by the average efficiency for that fuel.
4. Estimated conventional thermal generation is apportioned to a fuel using the efficiency-scaled fuel used data.

1951 to 1989

These years include additional categories of supply for which estimated generation had to be calculated. These included 'Other generators' i.e. any generators that do not meet the criteria for Major Power Producers, nuclear generators and pumped storage. The estimated generation for these categories were calculated as follows:

- Thermal supply for other generators was calculated by subtracting non-thermal (wind, solar and hydro) supply from the total. Thermal generation was estimated using a 20-year average of generation / supply from DUKES 5.6 (1996-2015) for other generators. Since the historic data on other generators' supply was not fuel specific, the average for all thermal fuels was used.
- Non thermal supply from other generators refers to supply from hydro, wind, solar and tidal generators. It was assumed that generation was equal to supply for these technologies. This is always assumed to be the case for wind, solar and tidal generation and there was no data available to split out the supply from other hydro generators.
- Nuclear generation was scaled up from supply using a 20-year average of generation / supply from DUKES 5.6 (1996-2015).
- Pumped storage generation was scaled up from gross supply from pumped storage in the historical data series. Gross supply does not subtract the electricity used in pumping. This was scaled using a 20-year average of generation / supply from DUKES 5.6 (1996-2015).

The estimated thermal generation for Major Power Producers and other generators was then apportioned using efficiency-scaled fuel used values, as for the 1920-1950 data. Estimated generation from all other categories was reported without apportioning.

1990 to 1995

All the calculations above continued in this time period, with the addition of estimated generation from Combined Cycle Gas Turbines (CCGT). Supply from CCGT was included in the historic time series from 1990 when these plants were introduced.

Generation from CCGT was scaled up from supply using a 20-year average of generation / supply from DUKES 5.6 (1996-2015). CCGT supply from Major Power Producers and other generators was scaled up using the same factor.

It was assumed that generation from CCGT was all attributable to gas. The split between gas input to CCGT compared to gas input to other forms of generation was estimated using a 20-year average taken from DUKES 5.3 (1996 –2015). The fuel used in CCGT plants was subtracted from the total gas used to give estimated gas used in non-CCGT plants.

The estimated thermal generation for Major Power Producers and other generators was then apportioned using efficiency-scaled fuel used values, as for the 1920-1950 data. The non-CCGT gas used was used in apportioning conventional thermal generation along with the other fuels. Estimated generation from all other categories was reported without apportioning. Generation from non-CCGT plants apportioned to gas was added to the estimated generation from CCGT to give an estimated total generation from gas.

Assumptions

Data is not available prior to 1996 to determine fuel used in the process of generation. This has been estimated using a 20-year average from DUKES table 5.6 for 1996-2015. This assumes that there has not been any material change in the amount of electricity used in generation for specific fuels.

Data is not available prior to 1996 to determine the efficiency of generation from specific fuels. This has been estimated using a 20-year average from DUKES table 5. 6 for 1996-2015. This assumes that there has not been any material change in the efficiency of generation.

References

Digest of UK Energy Statistics 2022 (DUKES) – Electricity (Chapter 5):
https://www.gov.uk/government/statistics/electricity-chapter-5-digest-of-united-kingdom-energy-statistics-dukes

Historical electricity data: 1920 to 2021:
https://www.gov.uk/government/statistical-data-sets/historical-electricity-data

Electricity Statistics: data sources and methodologies
https://www.gov.uk/government/publications/electricity-statistics-data-sources-and-methodologies

Energy Trends: March 2021, special feature article - Capacity of UK electricity generation assets in the 21st century, 2000 to 2019:
https://www.gov.uk/government/publications/energy-trends-march-2021-special-feature-article-capacity-of-uk-electricity-generation-assets-in-the-21st-century-2000-to-2019

Energy Trends: March 2019, special feature article - Nuclear electricity in the UK:

https://www.gov.uk/government/publications/energy-trends-march-2019-special-feature-article-nuclear-electricity-in-the-uk

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