Chapter 6: Renewable sources of energy

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Key headlines

Renewable generation in 2023 exceeded the current 2022 record marginally (by 0.3 per cent) to 135.8 TWh. The effect of less favourable weather conditions for wind and solar PV was more than offset by an increase in capacity for both technologies. Within the technologies, records were set for offshore wind, solar PV, energy from renewable waste, and anaerobic digestion.

Renewable capacity increased by 5.2 per cent (2.8 GW). Although this is higher than during the slowdown in new capacity observed between 2019 and 2021, it is lower than 2022 and the years prior to 2019 (the average growth in capacity between 2012 and 2018 was 20 per cent). Half the new capacity installed in 2023 was accounted for by wind (0.8 GW offshore and 0.6 GW onshore) with the remainder being mostly accounted for by solar PV (1.3 GW) and a small addition for energy from waste (less than 0.1 GW).

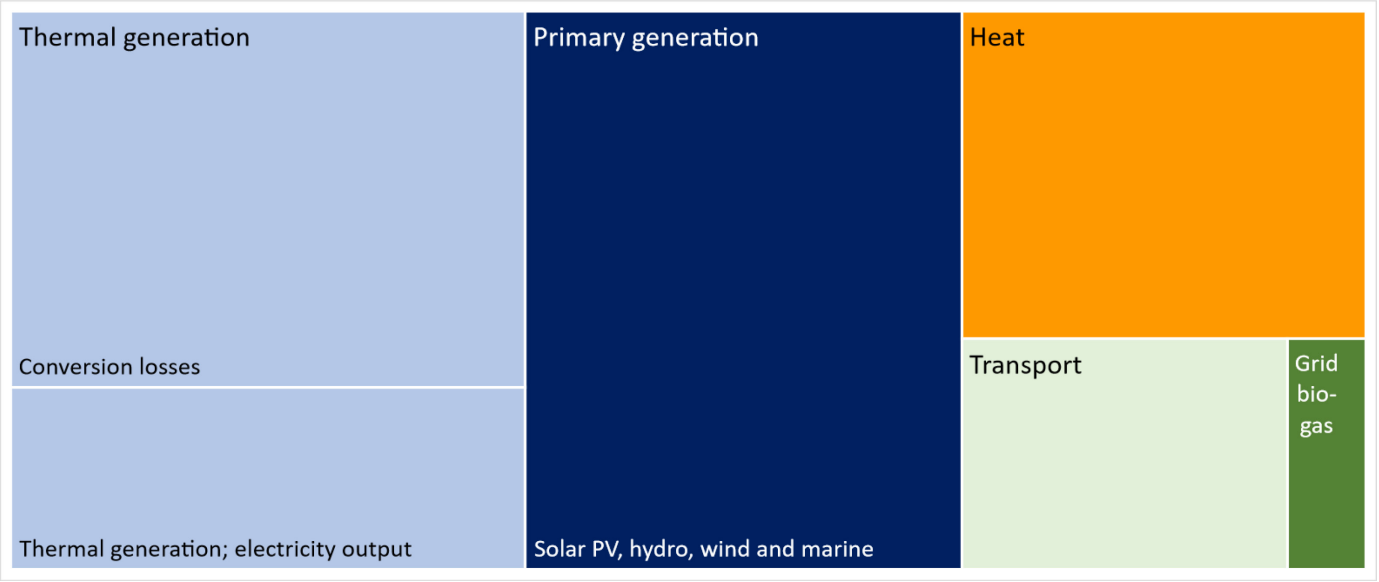
The share of renewable electricity generation in 2023 was 46.4 per cent, a new record. Despite a small increase in renewable generation, this was 4.7 percentage points up on 2022 and 3.4 percentage points up on the previous record set in 2020. The increase was driven by a fall in total electricity generation, see Chapter 5 for more details.

Renewable heat increased by 2.9 per cent; with almost two thirds of the increase being accounted for by domestic wood consumption and a third by heat pumps. With average temperatures in 2023 only marginally lower than in 2022, the increase is due to an increase in the stock of domestic wood appliances and heat pumps.

As a share of gross final consumption, overall renewables accounted for 15.5 per cent, an increase of 1.3 percentage points on 2022, a combination of increases in renewable electricity generation and renewable heat, combined with a slight fall in total gross final consumption.

Renewable fuels include primary energy such as wind, solar, and hydro, and thermal fuels (solid biomass, biogases, and liquids). Thermal fuels are combusted to produce energy and in the case of electricity generation, some is lost during this conversion process. Around 70 per cent of renewable fuels are used for electricity generation, a third of which is lost in the conversion process. Heat accounts for 17 per cent with transport and grid injected biogas accounting for 9.9 per cent and 2.4 per cent. Chart 6.1 below shows the demand for all renewable fuels including losses from the conversion process.

Chart 6.1 Renewable fuel[1] demand, 2023 (DUKES Table 6.4)



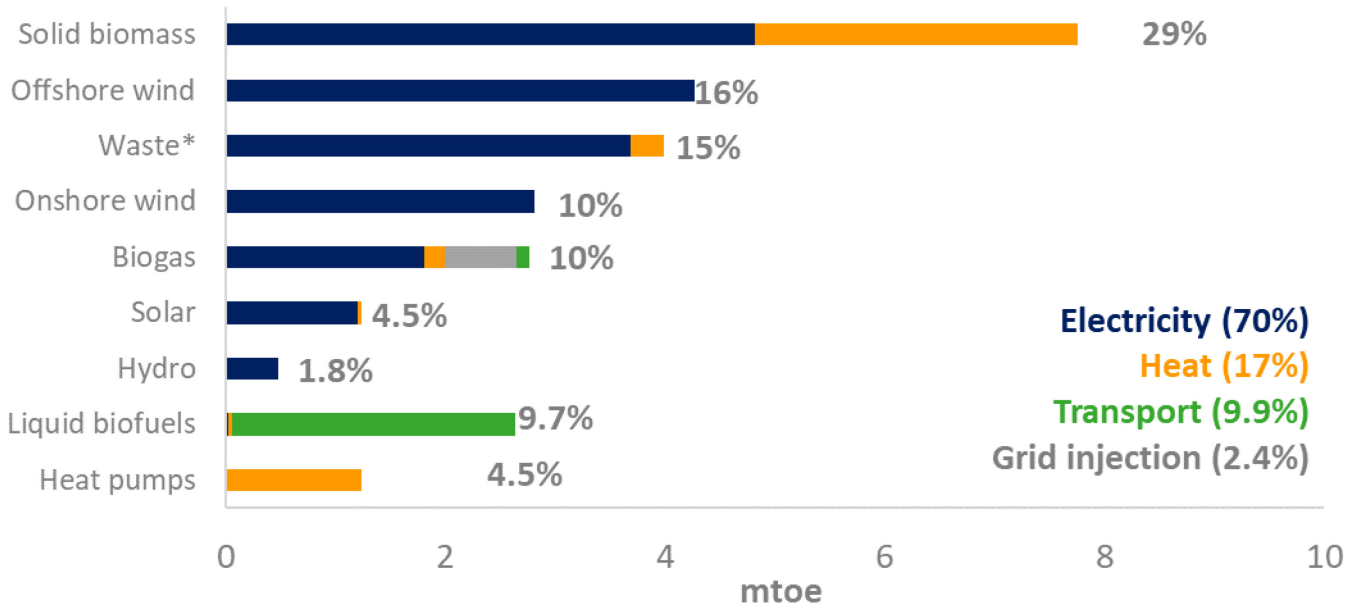
The chart replicates data included in Table 6.4; where this differs to Table 6.2 is the latter includes electricity generation only, i.e. primary generation and thermal generation after losses. The amount of conversion losses depends on the efficiencies of fuels which for renewables varies between around 35 to 40 per cent, with the remainder being lost in conversion. This compares with an efficiency of around 48 per cent for natural gas and around 34 per cent for coal and oil generation.

Some renewable fuels are more versatile than others such as biogases; historically demand had been dominated by electricity generation, but it is now increasingly used for heat generation, injection into the National Grid, and most recently small amounts are consumed within the transport sector. Conversely, primary energy sources such as wind and hydro are consumed solely by the electricity sector and although solar is primarily used in generation, small amounts of solar thermal are used for space and water heating.

Chart 6.2 shows how the individual fuels and technologies are consumed across the end uses (note: thermal fuels include losses incurred during conversion).

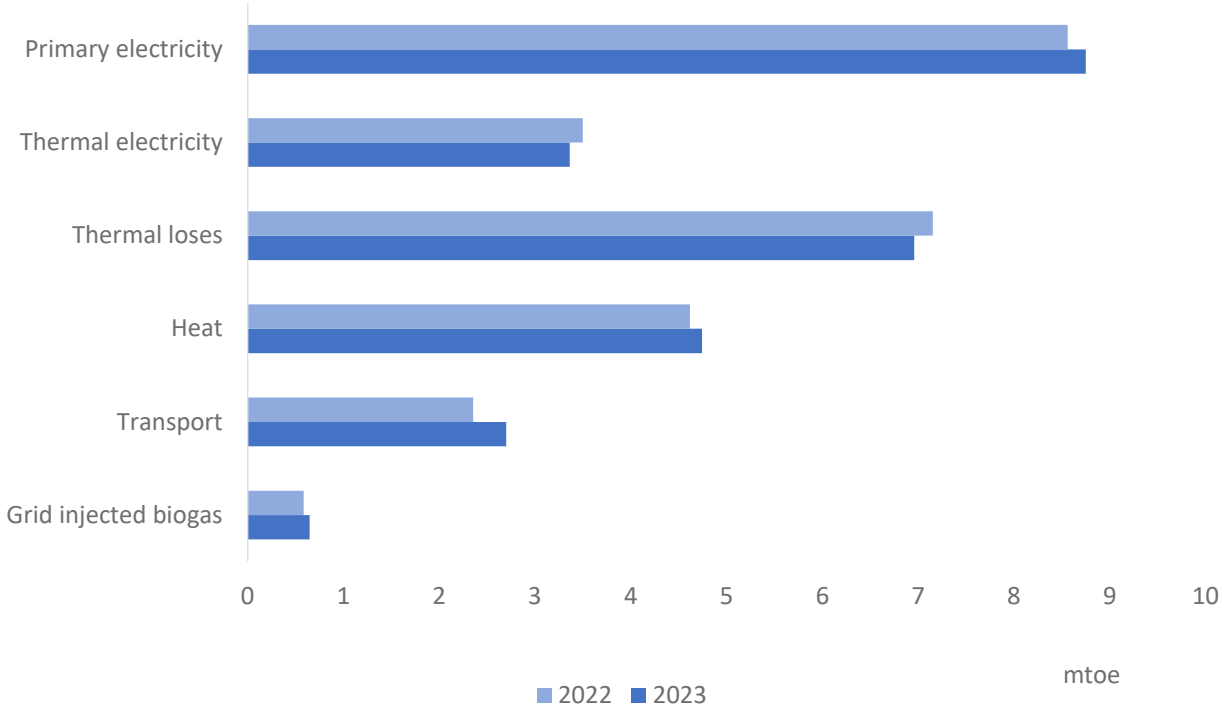
[1] Including non-biodegradable waste

Chart 6.2 Use of renewable fuels, 2023 (DUKES Table 6.4)



Between 2022 and 2023, overall renewable fuel demand increased by 1.5 per cent with the majority of the increase being from offshore wind generation, transport fuels, and energy from waste. Generation from thermal renewables fell along with the associated conversion loses. Renewable heat demand increased by 2.7 per cent due to strong growth in heat pumps and domestic wood consumption. Chart 6.3 shows how each component of fuel demand changed between 2022 and 2023.

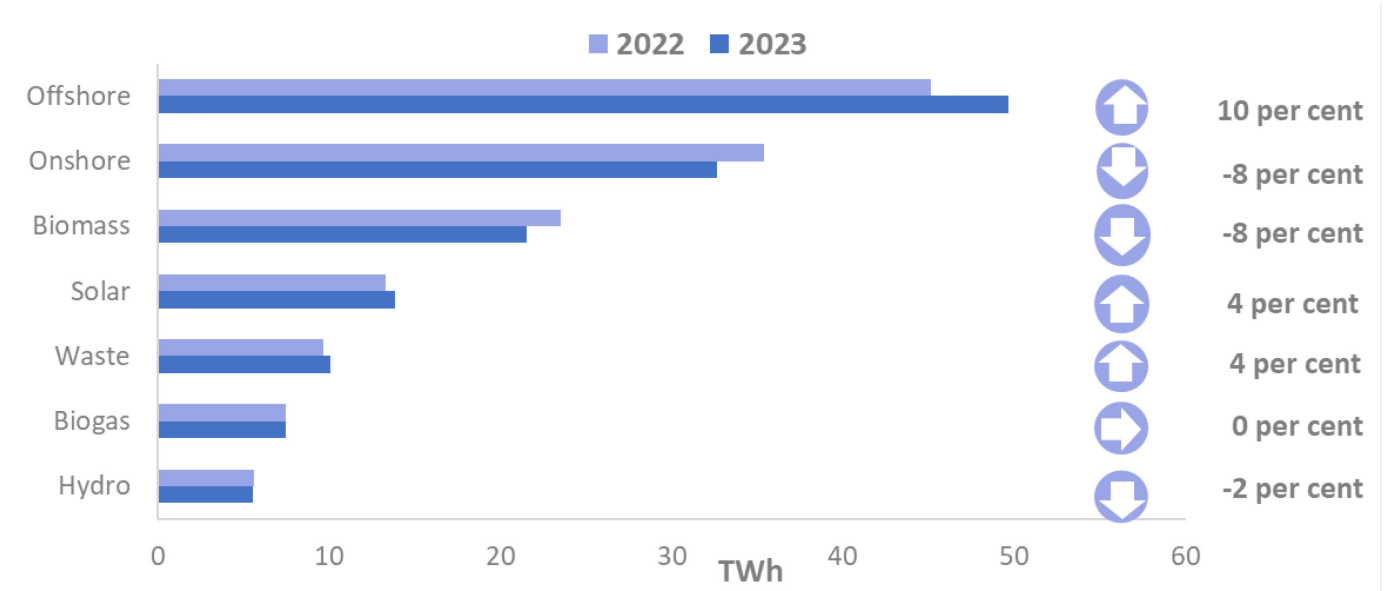
Chart 6.3 Change in renewable fuel demand 2022 to 2023 (DUKES Table 6.4)



At 135.8 TWh, overall renewable generation marginally exceeded the current record, set in 2022, by just 0.3 per cent. With less favourable weather conditions in 2023 (lower wind speeds and fewer sun hours), generation was boosted by new capacity for onshore and offshore wind, and solar PV.

Chart 6.4 shows the change in generation between 2022 and 2023 across the technologies both in absolute and percentage terms.

Chart 6.4 Electricity generation by fuel, 2022 – 2023 (DUKES Table 6.2)



Offshore wind reached a new record in 2023, increasing by 10 per cent on 2022**.** Average wind speeds were down on the previous year but generation was boosted by 0.8 GW of added capacity, including new capacity at Seagreen in Scotland where the first phase is now complete, totalling 1.1 GW. Conversely, onshore wind generation fell in 2023, by 7.9 per cent, with the impact of additional capacity being subdued by outages, in combination with lower wind speeds.

Similarly solar PV exceeded its previous record from 2022. As with offshore wind generation, new capacity contributed to the new record despite average sun hours being lower in 2023 compared to 2022. This resulted in a 4.1 per cent increase in generation on 2022.

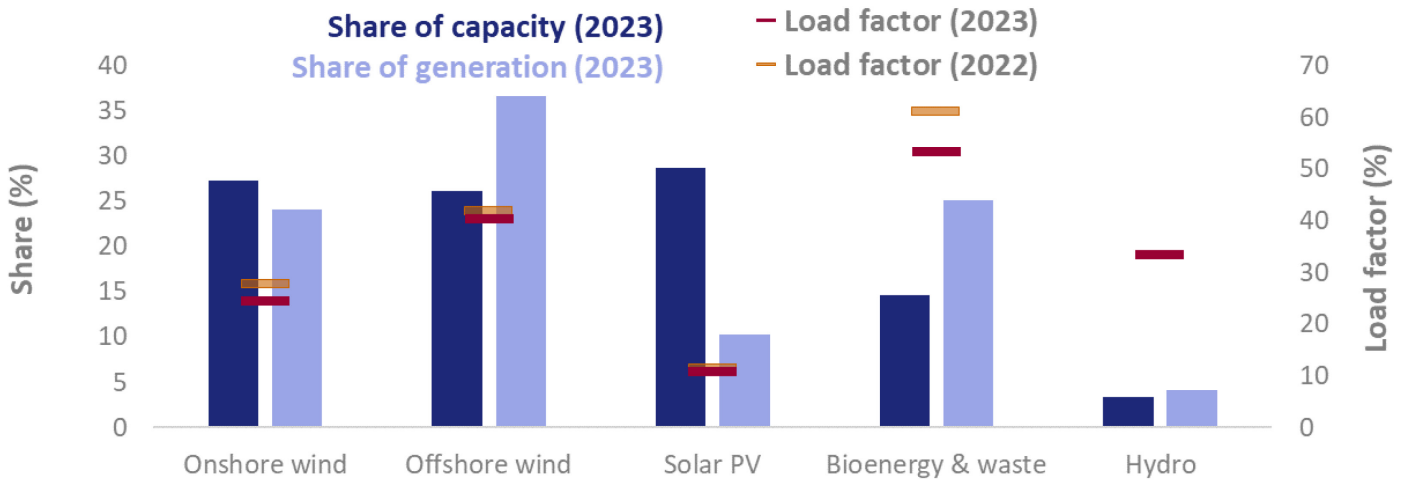
Hydro generation decreased by 2.2 per cent in 2023 to 5.5 TWh, average rainfall was at a similar level to 2022 and there was no new capacity. Hydro is an established technology and there has been little new capacity in recent years.

Overall, bioenergy generation fell by 4.9 per cent to 34.1 TWh, the lowest since 2017. This is largely due to outages at two large power stations supressing demand for plant biomass (mostly wood pellets). Generation from landfill gas continues to decrease, by 3.5 per cent, in line with falling yields. **Only anaerobic digestion and energy from waste saw increases in 2023**, with both reaching new records in 2023; 3.5 TWh for anaerobic digestion and 5.0 TWh for energy from waste.

Offshore wind continues to be the leading renewable technology in 2023 for generation, accounting for 60 per cent of all wind generation and 37 per cent of all renewable generation in 2023. Offshore first outstripped onshore generation in 2019, and although offshore capacity still lags onshore, the gap has closed. The discrepancy between capacity and generation can be explained by a combination of stronger and more consistent coastal wind speeds, and offshore turbines tend to be newer and larger than onshore, often yielding a higher load factor.

Technologies with a high share of capacity do not necessarily have the highest share of generation because **generation is dependent on the load factor**. Load factors are the ratio of how much electricity was generated as a proportion of the total generating capacity**.** Within renewables, load factors can be heavily influenced by weather conditions: such as wind speeds, sun hours and, to a lesser extent, rainfall. Chart 6.5 compares the key technologies' share of capacity and generation for 2023. The load factors for both 2022 and 2023 have been added where the impact of less favourable weather in 2023 can be seen in the lower load factors.

Chart 6.5 Relative share of capacity and generation and load factors 2023 (DUKES Table 6.3)



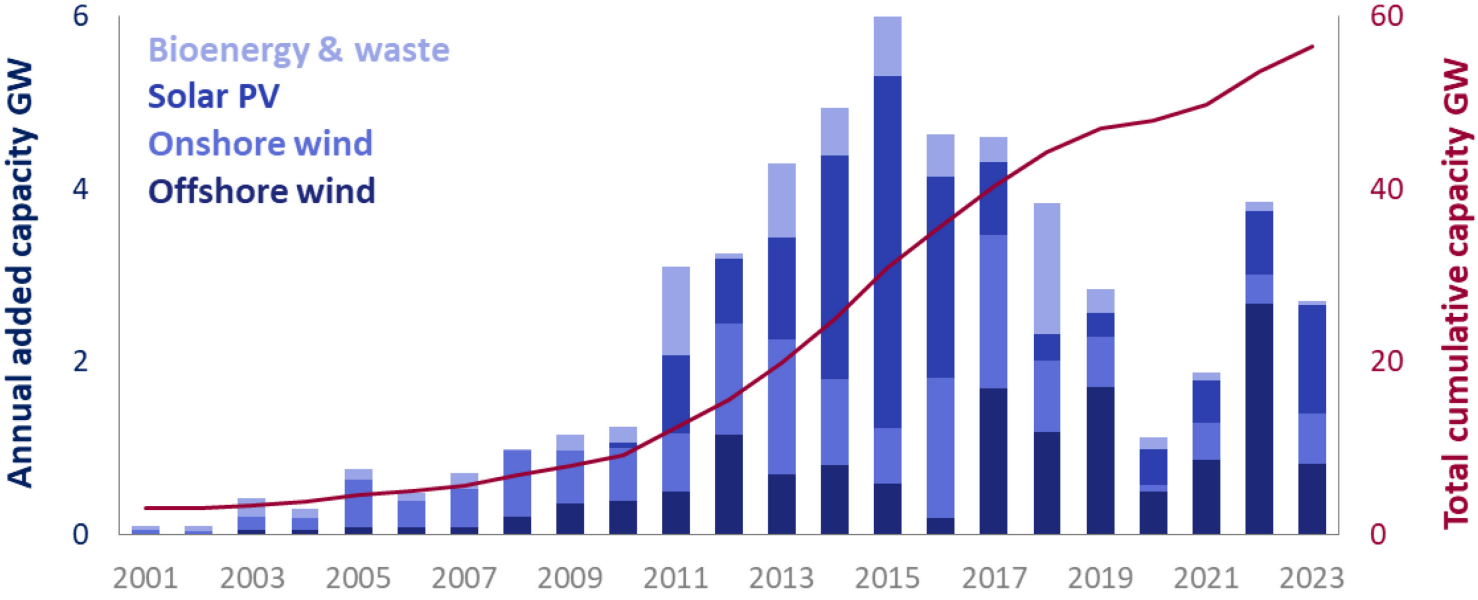
Thermal generation such as bioenergy and waste tend to have high, stable load factors varying only when outages occur at major power plants. Conversely, solar PV has a very low load factor due to limited hours of sunlight in the UK.

On an unchanged configuration basis, where only sites operating for the full year are included, the load factor for overall renewables in 2023 was 32.0 per cent. This was 6.0 percentage points lower than in 2022 and the lowest since 2019. The load factors were depressed by lower average wind speeds, shorter average sun hours and relatively low output at major biomass plants. Load factors for landfill gas continue to decline as extraction rates decrease.

Chart 6.6 shows the historic growth in capacity highlighting the stark slowdown over 2020 and 2021 (some projects may have been delayed in 2020 due to Covid-19 restrictions). New capacity was much higher in 2022 (3.8 GW) but was lower in 2023 (2.7 GW). Capacity growth was driven by the expansion at Seagreen in Scotland (offshore wind), which added around 0.8 GW.

New capacity peaked in 2015 when 6.0 GW was installed, 4.1 GW of which was in solar PV. New installations began to tail off during 2018 (3.8 GW), reaching a recent low of 1.1 GW in 2020.

Chart 6.6 Annual added capacity 2001 to 2023 (DUKES Table 6.2)



Prior to the launch of the Feed-in Tariff (FiT) in 2010, solar PV represented just 1.0 per cent of renewable generation capacity, but by the end of 2023, its share had increased to 28.7 per cent, with the majority (78 per cent) being installed between 2011 and 2017. Following the closure of The Renewable Obligation to new entrants in 2016, growth began to slow in 2017 further exacerbated by the FiT closure in April 2019. Growth has since improved and during 2023 there were more domestic solar panels installed than in any year since 2015[2].

Growth in new wind sites has been more stable, particularly onshore wind, though it has slowed over recent years with just 0.6 GW added in 2023 (an increase of 3.9 per cent) and 0.3 GW added in 2022. Offshore wind has seen much higher levels of new capacity in recent years with 64 per cent of total capacity being installed since 2016. This has included several large plants supported by Contracts for Difference (CfD) such as Hornsea 1 and 2, Triton Knoll, Moray East and Seagreen. Wind now represents around 53 per cent of installed renewable capacity (see wind map at the end of this chapter showing location by capacity).

Chart 6.7 Trends in generation by technology 2001 to 2023 (DUKES Table 6.2)

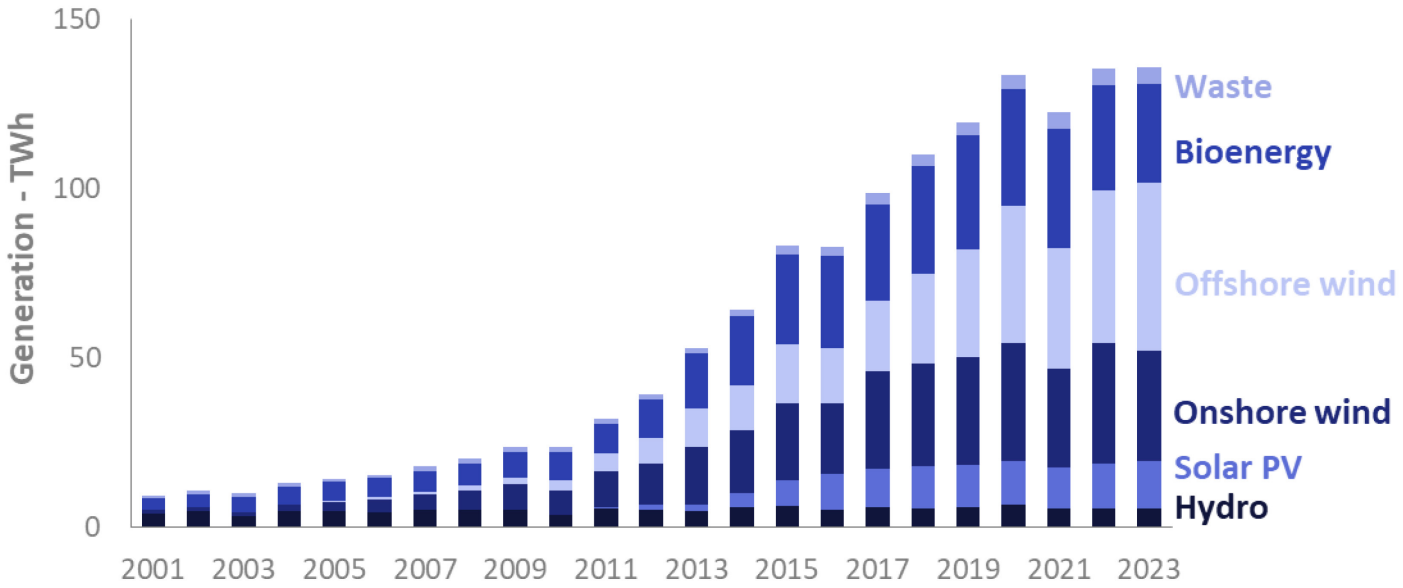


Chart 6.7 shows the changes in electricity generation fuel mix since 2001. The overall upward trend in generation is driven by increasing cumulative capacity. However, there are year-on-year fluctuations due to weather conditions. For example, despite the record capacity installed in 2015, generation for 2016 remained similar to 2015. This can also be seen with a fall in generation in 2021. Generation in 2023 is the highest on record but only marginally higher than in 2020 and 2022.

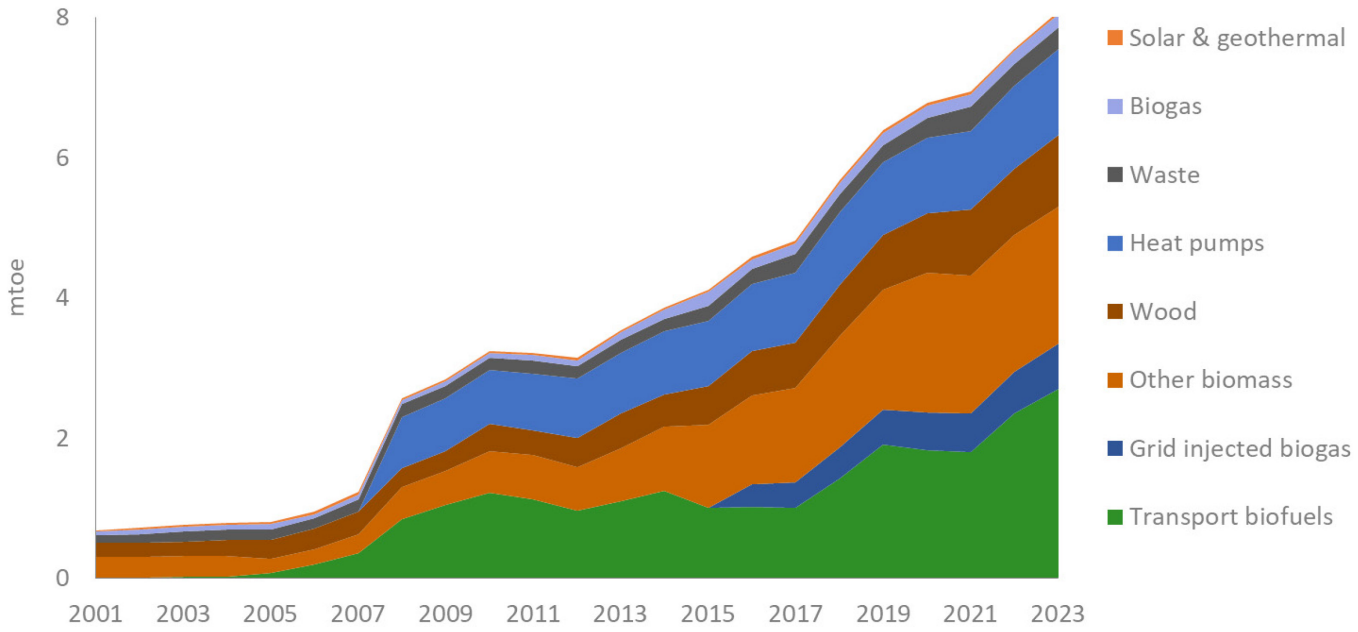
Hydro is a mature technology and generation tends to fluctuate from year-on-year in line with rainfall. In contrast, solar PV generation has increased rapidly since 2011 reflecting the surge in new capacity incentivised via the Feed in Tariff (FiT) support scheme. As a result, solar PV's share of renewable generation increased from just 0.7 per cent in 2011 to 10.2 per cent in 2023.

[2] For more information see the solar deployment tables at: https://www.gov.uk/government/statistics/solar-photovoltaics-deployment

Bioenergy has seen rapid growth over the last ten years as several large power stations converted from coal to plant biomass (mainly wood pellets). Generation has roughly doubled during this time. However, outages have dampened generation over the last two years. At 20.8 TWh, plant biomass generation remains lower than the record seen in 2021 (27.0 TWh). Generation from landfill gas peaked at 5.3 TWh in 2011 but has fallen in each year since then as extraction rates have declined at landfill sites. This fall was more than offset increases in anaerobic digestion since 2011.

Whilst electricity generation represents the largest share (70 per cent) of renewable fuel demand, heat also accounts for a sizable proportion (17 per cent), followed by transport biofuels (9.6 per cent) and biogas injected into the gas grid (2.4 per cent).

Chart 6.8 Other renewable fuel uses[3]; heat, transport, and grid injected biogas (DUKES Table 6.4)



[3] Including non-biodegradable waste

Renewable heat demand[4] is largely met by solid biomass, accounting for 62 per cent of fuel for heat in 2023, with the next largest share being heat pumps (26 per cent). The remainder is largely made up of wastes and biogases (6.6 per cent and 4.0 per cent respectively), with primary sources (such as active solar heating and geothermal) accounting for around 0.8 per cent. Renewable heat demand increased in 2023 by 2.7 per cent; although average temperatures were fairly similar, an increase in heat pump installations and domestic wood stoves boosted renewable heat[5].

Renewables used in transport are liquid and gaseous biofuels, supplied either as additives or as a replacement ("drop-in") for fossil fuels. Among liquid biofuels, biogasoline and biodiesel dominate the fuel mix, together representing 91 per cent of renewable transport demand. Since 2018, small but rapidly increasing amounts of new biofuels became available in the UK. In 2023, 4.6 per cent of renewable transport fuels were biogases, up from less than 1 per cent in 2018, while bio-LPGs (bio propane and bio butane) accounted for 0.3 per cent, though supply is particularly volatile. Bio-jet fuel accounts for 4.5 per cent of all transport renewables but only 1.0 per cent of aviation demand.

When compared to 2022, demand for transport biofuels grew by 15 per cent to 2,697 ktoe; biodiesel increased by 14 per cent while biogasoline grew by 9.6 per cent, the latter being driven by the introduction of E10 petrol (i.e. up to 10 per cent bio content) at the pump as well as the general increase in transport fuel use.

[4] Including non biodegradable waste

[5] Preliminary results of a new domestic wood survey undertaken by The Department for Environment, Food and Rural Affairs (Defra) have been incorporated this year. Field work for the survey took place between July 2022 and June 2023 with the results being seasonally adjusted to achieve calendar year estimates for 2022 and 2023. A similar adjustment was undertaken with further allowances for changes in the stock of appliances to produce a historic series. This produced no discernible step change in the series confirming the results are in line with Defra's previous survey undertaken in 2018 therefore the series published in DUKES 6.4 has been revised back to just 2020. Defra intend to publish the results on Defra Search Science in due course at which stage this will be reviewed and a longer-term revision will be considered.

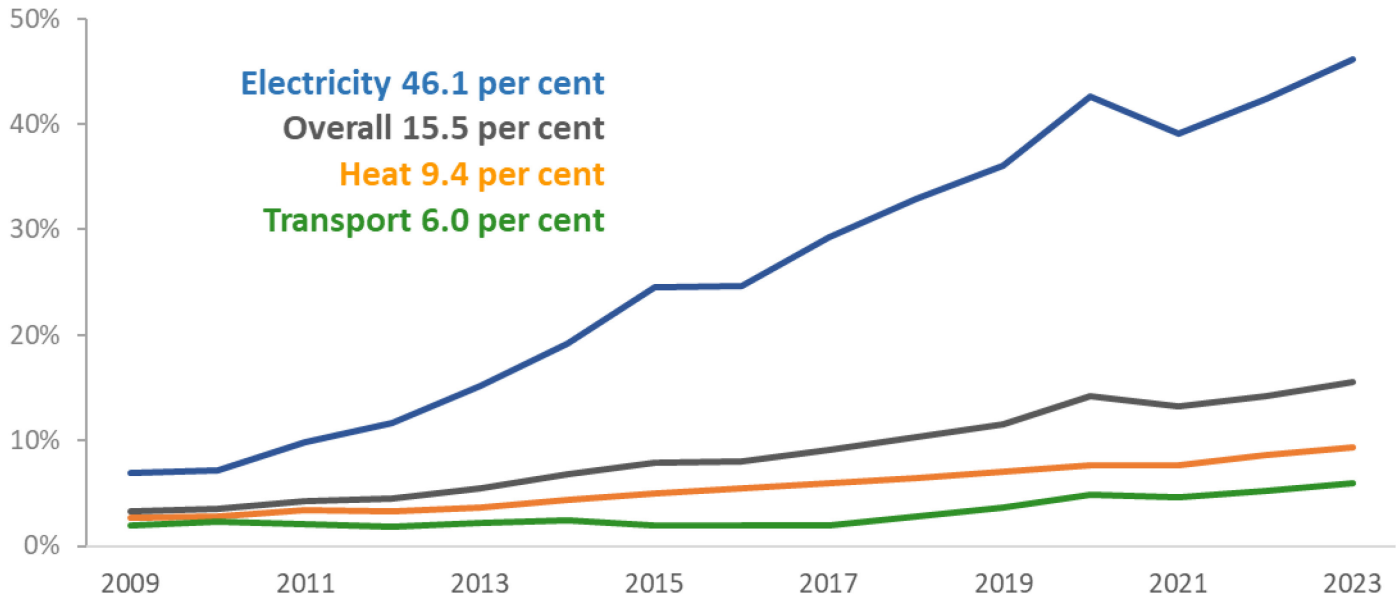
Indigenous production of bioliquids increased by 7.9 per cent in 2023. Overall capacity increased by 3.7 per cent due to biodiesel capacity; bioethanol capacity has remained stable at 504 ktoe per annum for the most recent three years.

Biogas injected into the National Grid increased by 11 per cent in 2023 driven by sewage gas which has almost doubled since 2022 due to several new sites coming online. Biogas from anaerobic digestion, however, still dominates grid injected biogas representing 85 per cent of the total.

To place renewable energy in context, DUKES Table 6.5 provides a measure for the share of renewables across the various energy flows, as well as estimates for the renewable proportion of **Gross Final Consumption (i.e. before losses) for electricity and heat.** The renewable share of transport fuels is on an actual basis as presented in the final consumption by sector chart (Chart 6.9).

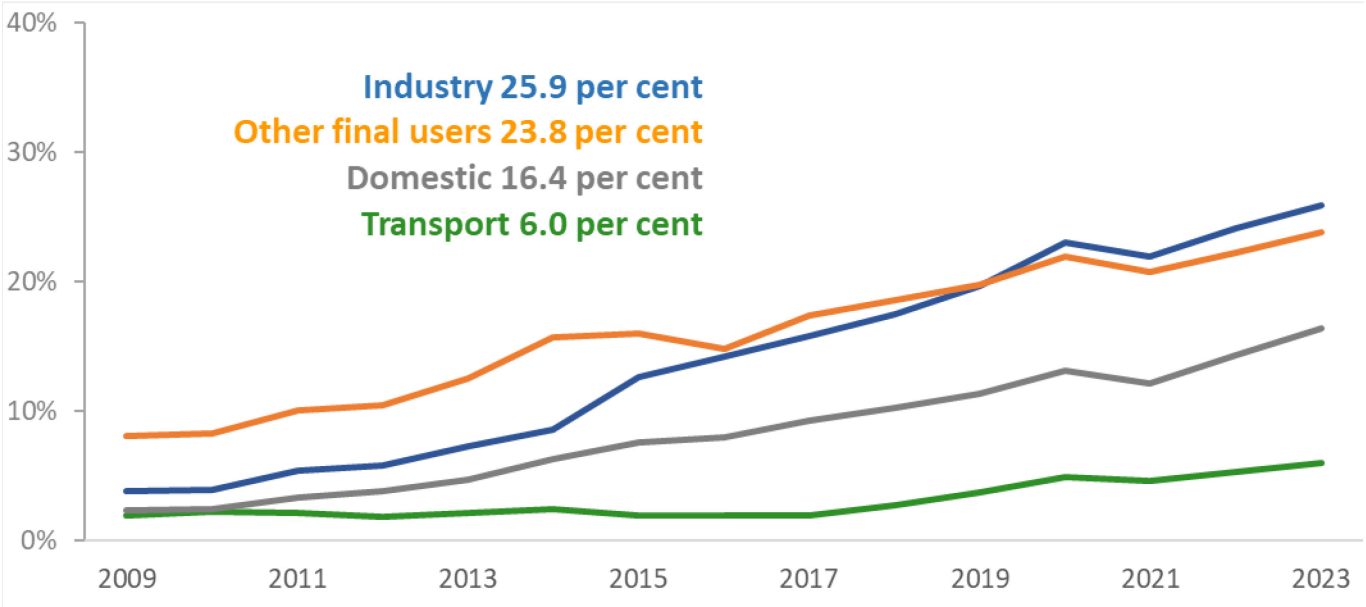
The proportion of electricity from renewables differs to that for generation and supply in that it excludes generation ultimately consumed in transport which is allocated to the transport measure. The underlying trend is however similar in that weather impacts are visible particularly between 2020 and 2021. Weather influences can also be seen between 2015 and 2016; despite this being a period of strong renewable capacity growth, generation was flat for the year with lower wind speeds, sun hours and rainfall. The heat measure is based on renewable fuels allocated to heat in Table 6.4; although some electricity will be consumed for heating purposes, this is allocated to electricity. Although over time, renewable fuels used in transport and heat have increased, both remain modest when compared with renewable electricity.

Chart 6.9 Renewable energy as a proportion of total gross final consumption (DUKES Table 6.5a)



The renewable proportion of fuels consumed by sectors, regardless of end use, varies depending not only on the proportion of thermal fossil fuels and bioenergy, but also on the share of electricity consumption which has seen its renewable proportion dramatically increase over the time period. Chart 6.10 below shows the changing proportion of renewables for each consuming sector.

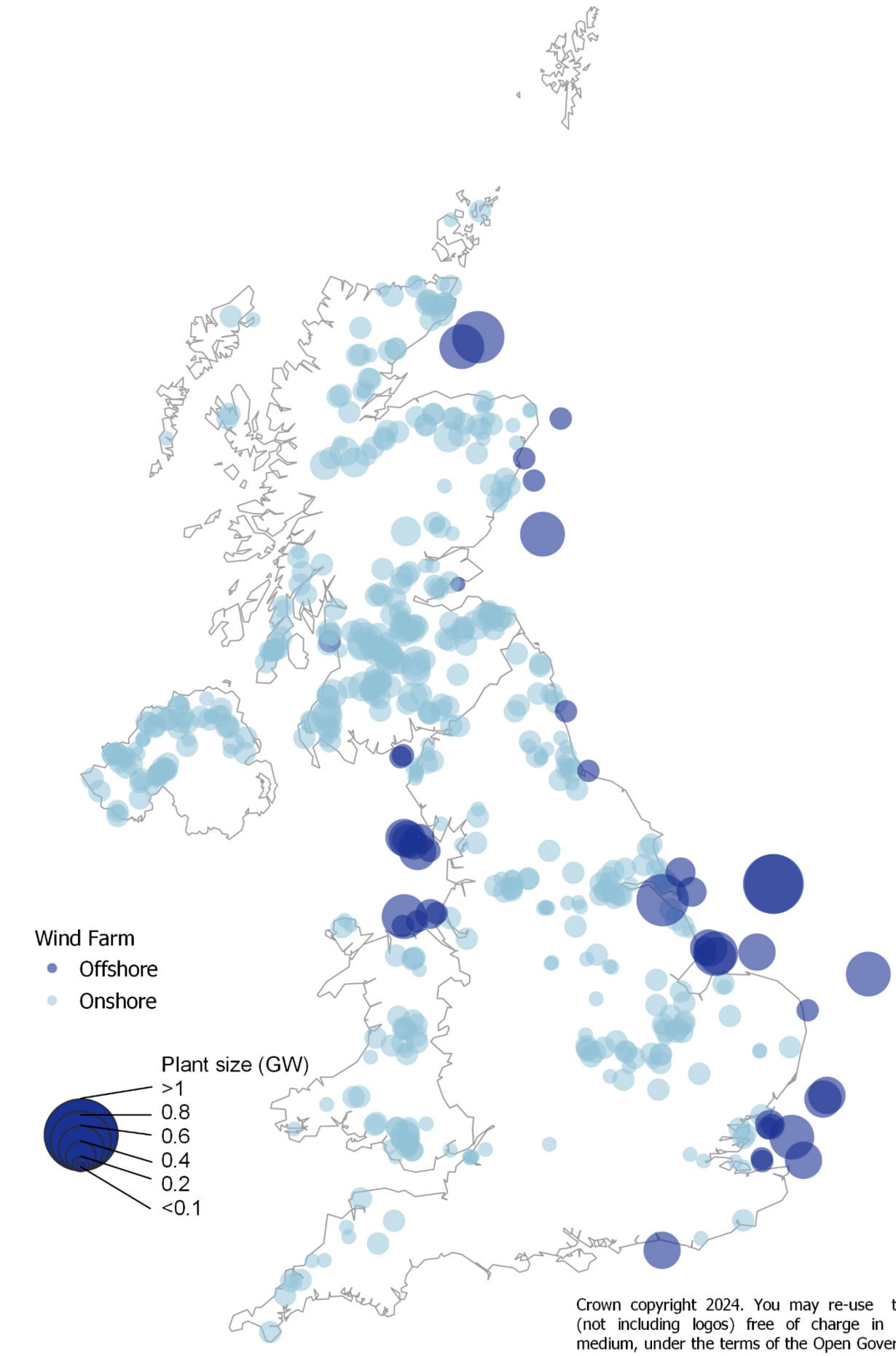
Chart 6.10 Renewables' share of final energy consumption by sector (DUKES Table 6.5b)



All sectors show an increase in their share of renewable consumption, in line with an increase in renewable electricity supply. Between 2016 and 2019, the proportion of renewables consumed by industry fell in line with that for other final consumers, though remained slightly lower. This historic trend was driven by the shift from the high-grade heat requirements of heavy industry to lighter, less energy intensive industries. In 2019, industry's share of renewables exceeded other users' share for the first time. Although the fuel switching within sectors over this period is subtle, it has largely been driven by a relatively higher increase in the share of bioenergy and electricity consumption in industry combined with a fall in the share of natural gas, compared to an increase for other sectors. The domestic sector also saw a notable increase in 2023 due higher levels of wood and plant biomass consumption combined with an increase in heat pump usage.

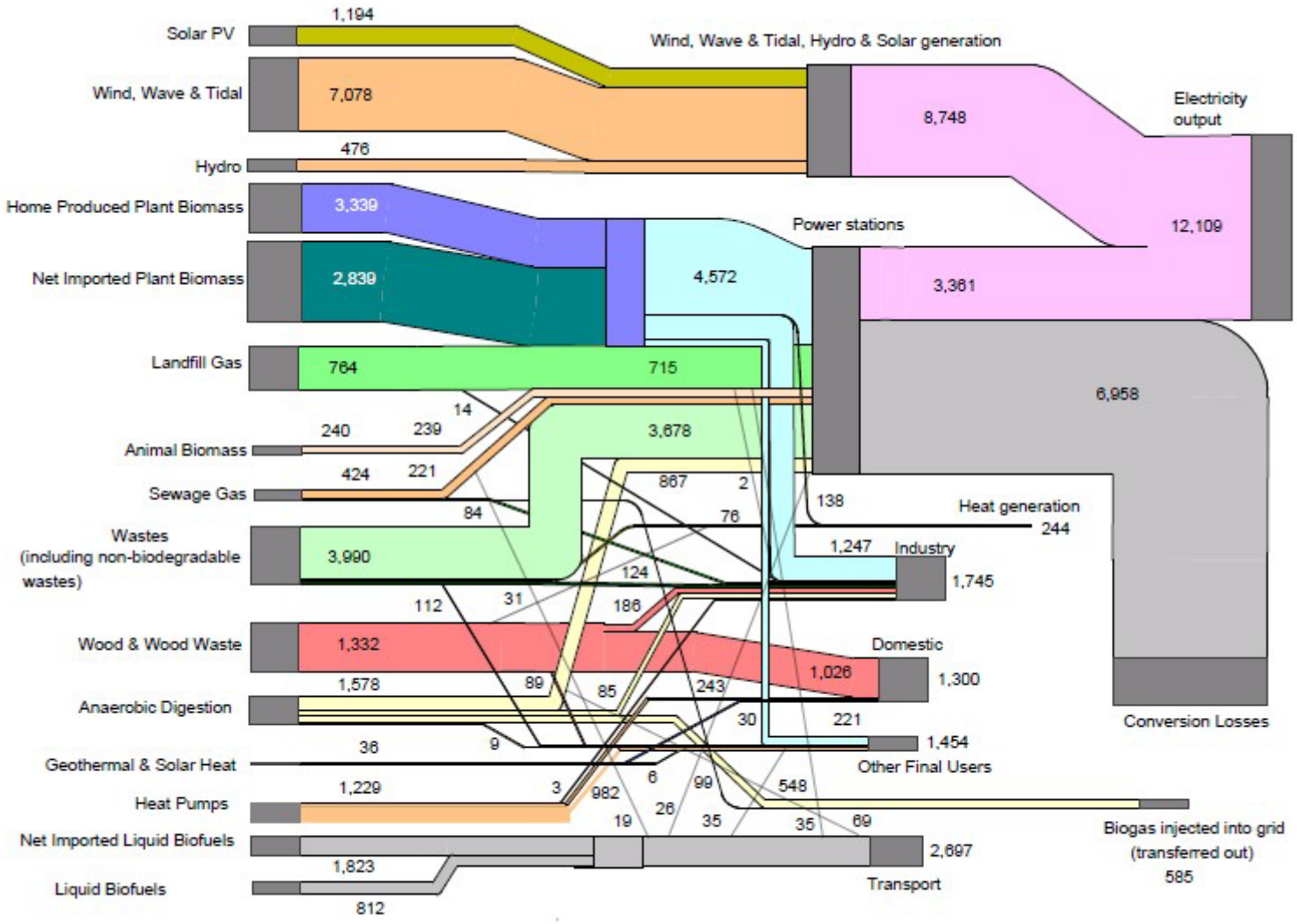
The map below shows UK wind farms that were operational at the end of 2023 with a capacity 5 MW or more; there are around 9,000 sites below this threshold and other sites are excluded due to a lack of precise location data. The locations are representative and not exact.

Map of UK wind capacity 2023



Renewable energy flow chart 2023 (DUKES Tables 6.1 and 6.2)

The renewable energy flow chart overleaf summarises the flows of renewables including production, net imports through to final outputs by sector. It also shows the conversion losses associated with thermal renewable generation. The data are sourced from the commodity balance Table 6.1, and Table 6.2 for electricity outputs.



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