Chapter 6: Renewable sources of energy

Liz Waters 0747 135 8441 renewablesstatistics@energysecurity.gov.uk

Key headlines

Renewable generation in 2024 reached a new record of 143.7 GWh. Generation was up by 5.1 per cent on 2023, driven by new capacity and an increase in generation from plant biomass which had been dampened in 2022 and 2023 by reduced output at two major sites.

Renewable capacity increased by 7.3 per cent (4.1 GW). Half of the new capacity was in solar PV, the rest was mainly from onshore and offshore wind.

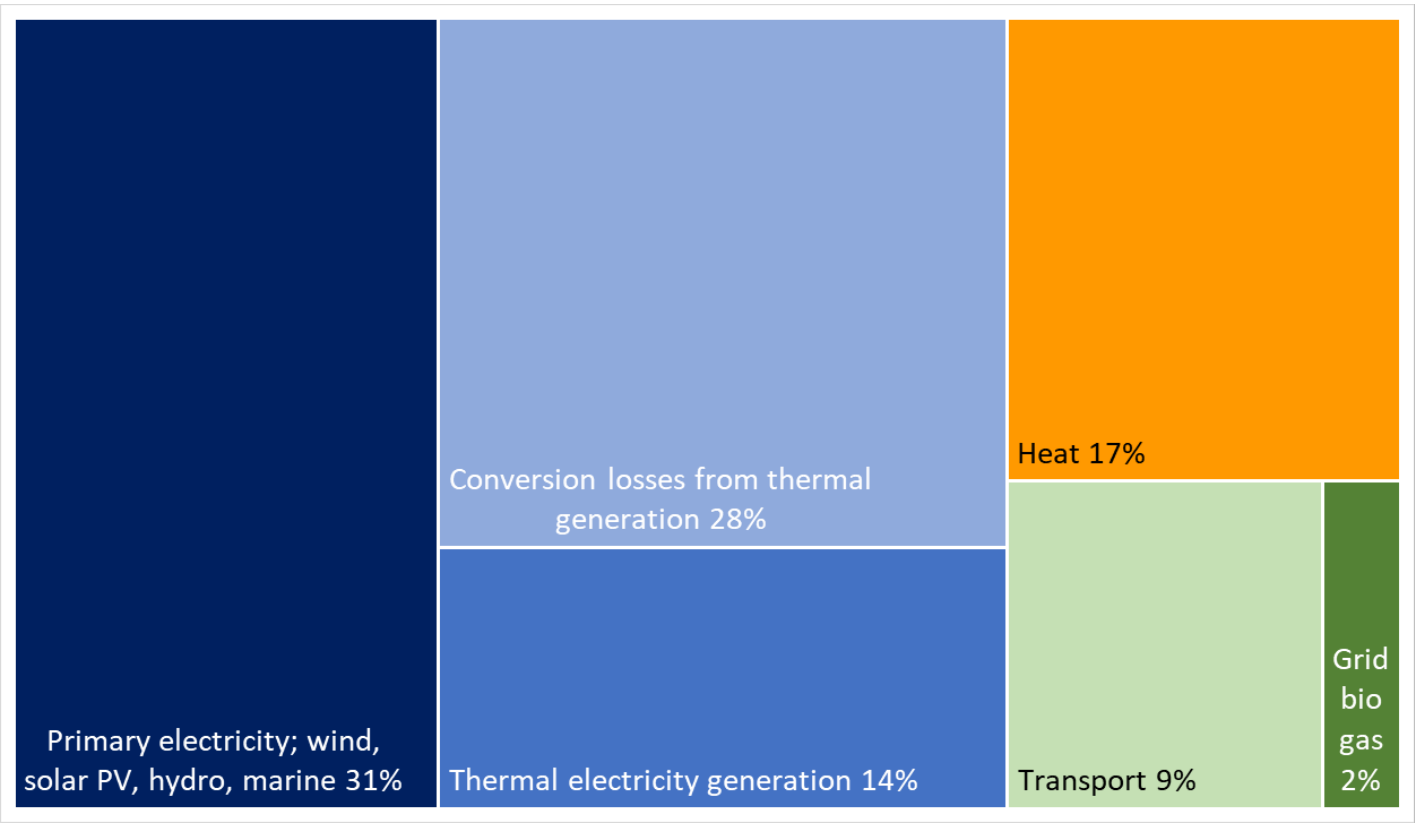
The share of renewable electricity generation in 2024 was 50.4 per cent, a new record and the first time that renewables had accounted for over half of total generation. The generation share was up by 3.9 percentage points on 2023 as a result of greater renewable generation and lower generation from other sources (see Chapter 5 for more details).

Renewable heat increased by just 1.6 per cent with higher heat from heat pumps and wood combustion being offset slightly by decreases in anaerobic digestion and bioliquids. Although heating degree days in 2024 were similar to 2023, higher levels of the stock of heat pumps and domestic wood appliances drove the increase.

As a share of gross final consumption, overall renewables accounted for 16.2 per cent, an increase of 0.5 percentage points on 2023 largely due to relatively higher increases in renewables' consumption compared with total consumption. The largest contribution was from renewable electricity generation.

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 73 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 9.4 per cent and 2.3 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, 2024 (DUKES Table 6.4)



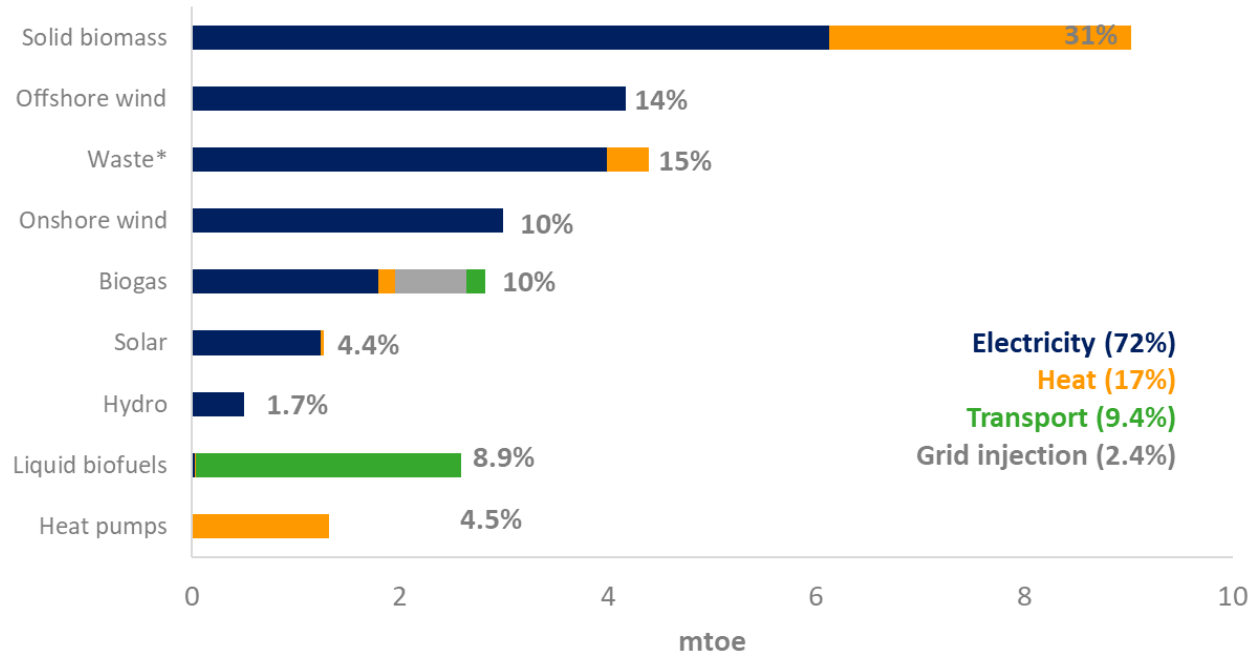
The chart replicates data included in Table 6.4; where this differs to Table 6.2 is the latter includes electricity generation only, i.e. primary generation and thermal generation after losses. The amount of conversion losses depends on the efficiencies of fuels which for renewables varies between around 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).

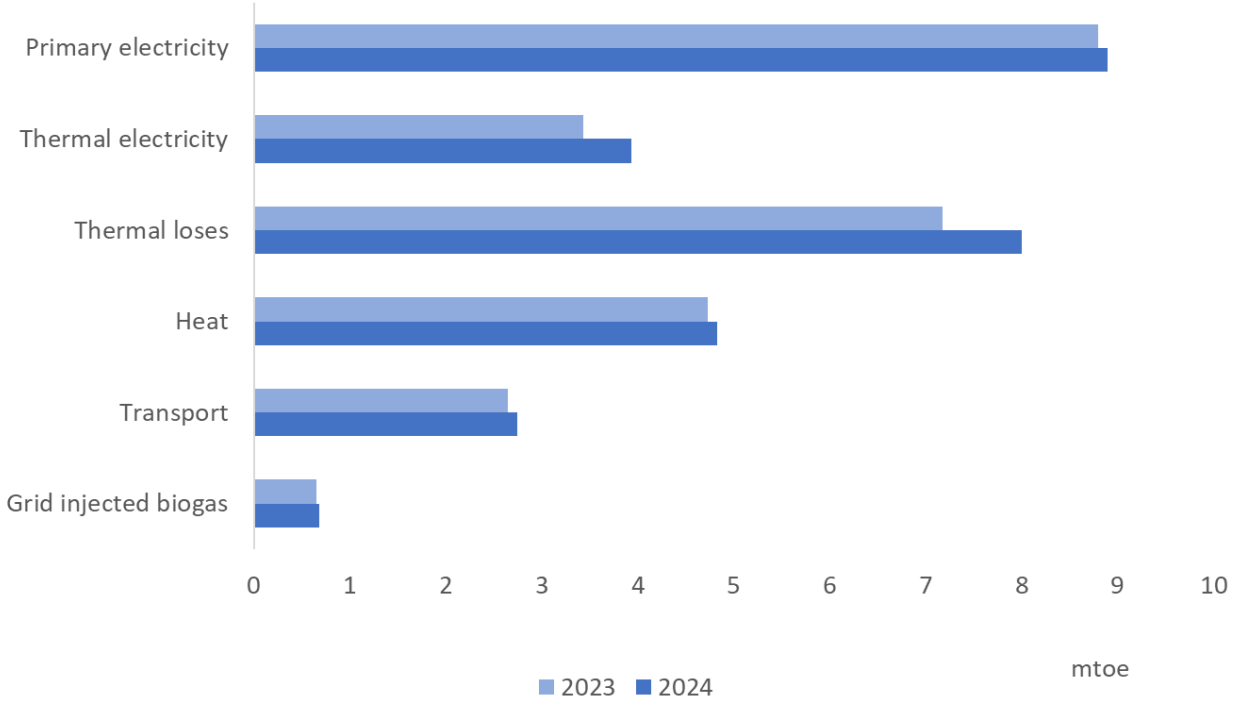
[1] Including non-biodegradable waste

Chart 6.2 Use of renewable fuels, 2024 (DUKES Table 6.4)



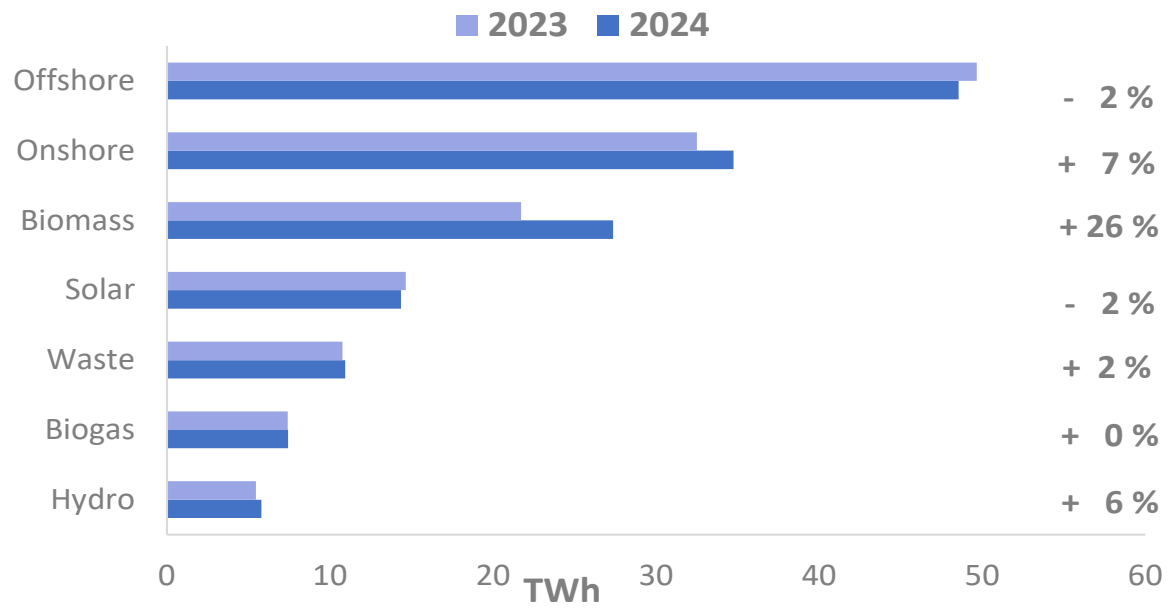
Between 2023 and 2024, overall renewable fuel demand increased by 6.0 per cent with the majority of the increase being from plant biomass as generation returned to more usual levels following reduced output at two major sites in 2022 and 2023. The increase in thermal renewables also drove up conversion losses. Renewable heat demand increased by 2.3 per cent driven by an increase in the stock of heat pumps and domestic wood appliances. Chart 6.3 shows how each component of fuel demand changed between 2023 and 2024.

Chart 6.3 Change in renewable fuel demand 2023 to 2024 (DUKES Table 6.4)



At 143.7 TWh, overall renewable generation exceeded the current record, set in 2023, by 5.1 per cent. The majority of the increase was plant biomass though onshore wind also saw an increase due to additional capacity. Chart 6.4 shows the change in generation between 2023 and 2024 across the technologies both in absolute and percentage terms.

Chart 6.4 Electricity generation by fuel, 2023 – 2024 (DUKES Table 6.2)



Offshore wind generation was down by 2.2 per cent on 2023 to 48.5 TWh. Generation from offshore wind reached record levels in 2023, the figure for 2024 was the next highest on record. Average wind speeds were up slightly in 2024 but offshore wind generation was hampered by planned maintenance, unplanned outages and curtailment. Over the course of the year, capacity increased by 8.1 per cent, this has included Moray West in Scotland (882 MW) as well as the first stages of Dogger Bank (England) and NNG (Scotland), both of which are due to expand in 2025. However, output has been limited at some of the new sites due to connection issues. Conversely, generation from onshore wind was up by 6.9 per cent to 34.7 TWh. Annual generation for onshore wind was the third highest on record after 2020 and 2022. Generation had been relatively low in 2023 due to outages and curtailment.

Solar PV generation was down by 1.9 per cent on 2023. The decrease was due to average sunlight hours being down on last year, 2024 was the least sunny year since our time series began in 2001. This was partly offset by new capacity which increased by nearly 13 per cent over the course of the year.

Hydro generation increased by 6.1 per cent in 2024 to 5.8 TWh, there was a small increase in average rainfall and new capacity (up 2.1 per cent on 2023). Hydro is an established technology and there has been little new capacity in recent years.

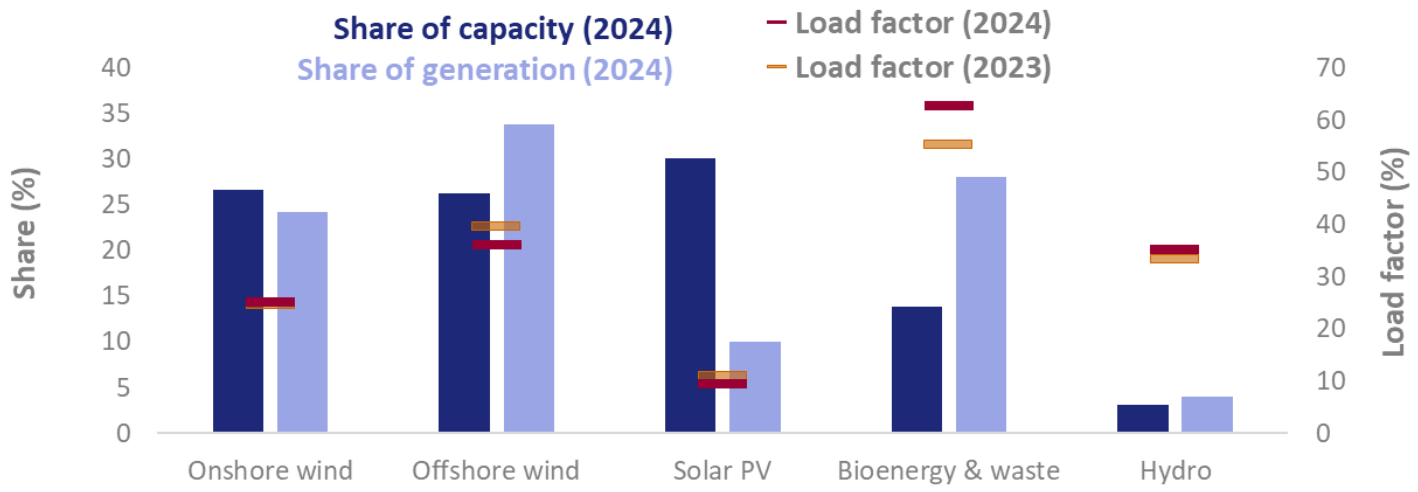
Bioenergy saw the largest increase on last year, being up by nearly 17 per cent. This was driven by an increase in plant biomass generation of 5.6 TWh (27 per cent). Generation had been particularly low in 2022 and 2023 due to reduced output at two major sites. Plant biomass generation was back to a similar level to that last seen in 2021. Elsewhere there were smaller increases for generation from animal biomass, sewage gas, municipal solid waste and anaerobic digestion, the latter two were records. Generation from landfill gas continues to fall in line with falling yields.

Despite a fall in generation this year**, offshore wind continues to be the leading renewable technology in 2024 for generation**, accounting for 58 per cent of all wind generation and 34 per cent of all renewable generation in 2024. Offshore first outstripped onshore generation in 2019, and although offshore capacity still lags onshore, the gap has continued to narrow. 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 2024.

Chart 6.5 Relative share of capacity and generation and load factors 2024 (DUKES Table 6.3)

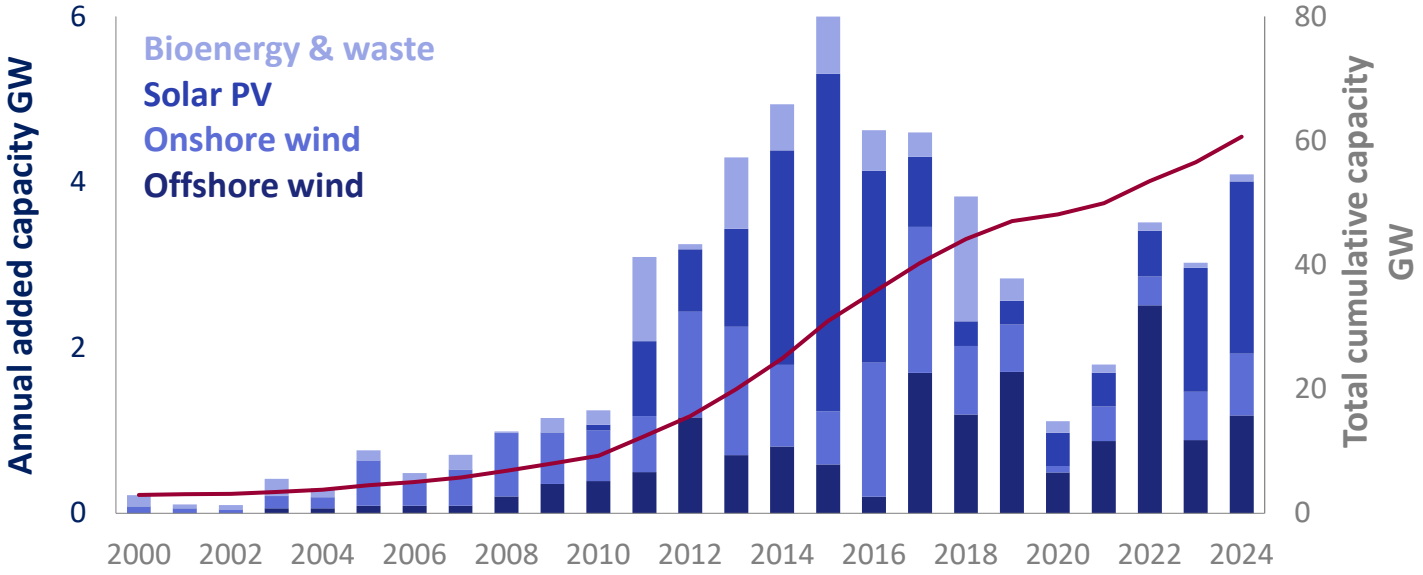


The overall load factor for renewables in 2024 was 28.0 per cent, down slightly from 28.7 per cent in 2023. The load factor was depressed by offshore wind generation which fell despite more capacity.

The load factor for bioenergy and waste was up on 2023, due to the recovery in generation from plant biomass. The average load factor for solar PV slipped below 10 per cent due to the low sunlight hours seen over the year.

Chart 6.6 shows the historic growth in capacity; new capacity recovered in 2024 after the stark slowdown over 2020 and 2021 (some projects may have been delayed in 2020 due to COVID-19 restrictions). 4.1 GW of capacity was added during 2024, the most in a calendar year since 2017. Around half of the new capacity was solar PV. New capacity peaked in 2015 when 6.0 GW was installed, 4.1 GW of which was in solar PV.

Chart 6.6 Annual added capacity 2000 to 2024 (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 2024, its share had increased to 30.1 per cent, with the majority (70 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 in the last two years; in 2023 there were more domestic solar panels installed than in any year since 2015[2]. In 2024, 2.1 GW of capacity was added, the most since 2016. The new capacity included nearly 150,000 domestic installations as well as large-scale sites such as Gorse Lane and Thaxted (roughly 50 MW each).

New capacity in onshore wind peaked in 2017 when 1.8 GW was added. Growth then slowed to a low of just 76 MW added in 2020, before picking up again to a recent high of 0.7 GW in 2024. Offshore wind has seen much higher levels of new capacity in recent years with 72 per cent of total capacity being installed over the last ten years. This has included several large sites supported by Contracts for Difference (CfD) such as Hornsea 1 and 2, Triton Knoll, Moray East and Seagreen. In 2024, 1.2 GW of offshore wind capacity was added, up from 2023 but down from the record 2.5 GW installed during 2022. 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 2000 to 2024 (DUKES Table 6.2)

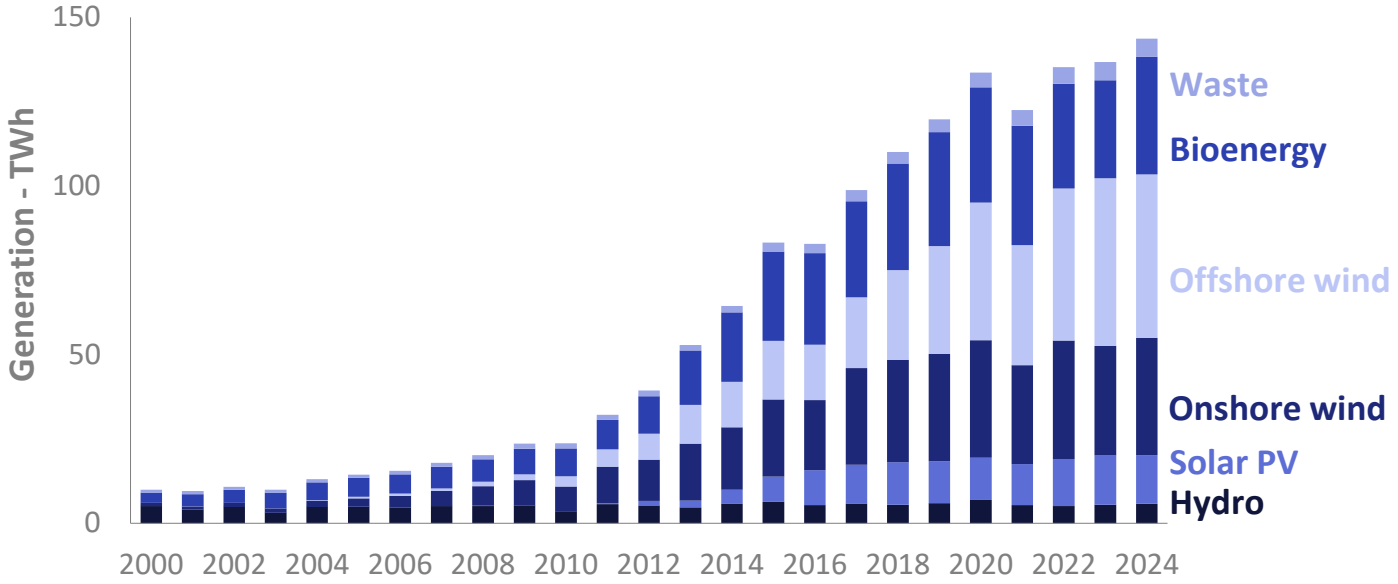


Chart 6.7 shows the overall upward trend in renewable generation and evolving fuel mix since 2000. The underlying trend is driven by increasing cumulative capacity, resulting in a record year for generation in 2024. Year-on-year fluctuations in generation due to weather effects can be observed in the chart, such as the drop in generation between 2020 (an unusually favourable year for wind speeds and rainfall) and 2021.

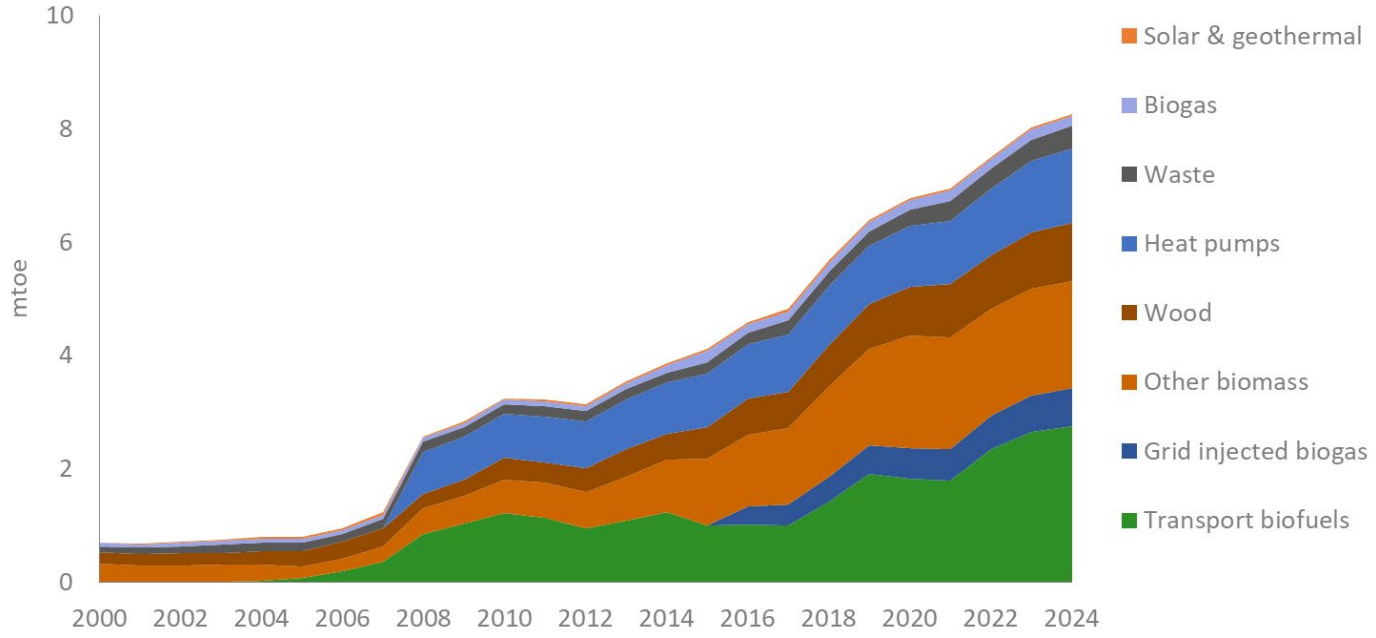
Hydro generation has been the most stable over the timeframe reflecting the maturity of the technology in the UK. With limited new capacity, generation tends to fluctuate in line with rainfall. In contrast, solar PV generation has increased rapidly since 2011 reflecting the surge in new capacity incentivised via the Feed in Tariff (FiT) support scheme. As a result, solar PV's share of renewable generation increased from just 0.2 per cent in 2010 to 10.7 per cent in 2023, this slipped to 10.0 in 2024 due to less favourable weather conditions.

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

Bioenergy has doubled over the last ten years as several large power stations converted from coal to plant biomass (mainly wood pellets). At 26.6 TWh, plant biomass generation was up 27 per cent on 2023, not far short of the record set in 2021 (27.0 TWh). Outages dampened generation in 2022 and 2023 but recovered in 2024. 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 has been offset by increases in generation from anaerobic digestion so that in total, generation from biogases has remained fairly stable since 2015.

Whilst electricity generation represents the largest share (72 per cent) of renewable fuel demand, heat also accounts for a sizable proportion (17 per cent), followed by transport biofuels (9.4 per cent) and biogas injected into the gas grid (2.3 per cent).

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



Renewable heat demand[4] is largely met by solid biomass, accounting for 60 per cent of fuel for heat in 2024, with the next largest share being heat pumps (27 per cent). The remainder is largely made up of wastes and biogases (8.3 per cent and 3.3 per cent respectively), with primary sources (such as active solar heating and geothermal) accounting for around 0.7 per cent. Renewable heat demand increased in 2024 by 1.6 per cent; although average heating degree days 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. Biogasoline and biodiesel dominate the fuel mix, together representing 82 per cent of renewable transport demand (down from 92 per cent in 2023). Since 2018, small but rapidly increasing amounts of new biofuels became available in the UK. In 2024, 6.9 per cent of renewable transport

[3] Including non-biodegradable waste
[4] Including non biodegradable waste
[5] DUKES 2024 included preliminary results of a new domestic wood survey undertaken by The Department for Environment, Food and Rural Affairs (Defra). Since then, Defra has published its final report available via the following link;
Evaluation of the Air Quality (Domestic Solid Fuels Standards) (England) Regulations 2020 and Monitoring of domestic burning practices in the UK - AQ1043
These final results have had no discernible impact on the baseline compared to 2024; any variations are down to weather effects and the stock of appliances. On this basis, no longer term revision has been undertaken.

fuels were biogases, up from less than 1 per cent in 2018, while bio-LPGs (bio propane and bio butane) accounted for 0.5 per cent, though supply is particularly volatile. Bio-jet fuel accounts for 10 per cent of all transport renewables (up from just 3.2 per cent in 2023) but only 2.1 per cent of total aviation demand.

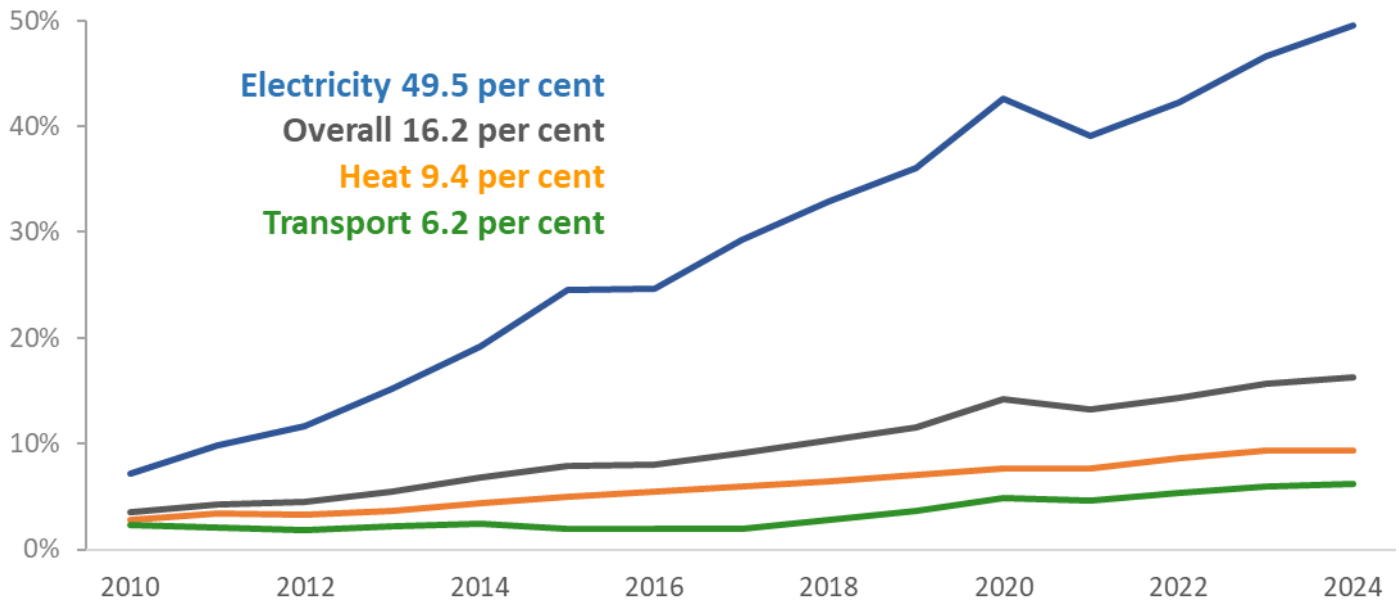
Demand for transport biofuels grew by 3.7 per cent to 2,744 ktoe; biodiesel fell by 15 per cent while biogasoline grew by 8.0 per cent, the latter being driven by the introduction of E10 petrol (i.e. up to 10 per cent bio content) at the pump as well as the general increase in transport fuel use.

Indigenous production of bioliquids decreased by 8.1 per cent in 2024, despite capacity remaining stable. Not all liquid biofuels are consumed in transport; use in autogeneration and non-mobile road machinery consume around 1.4 per cent of total consumption.

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).

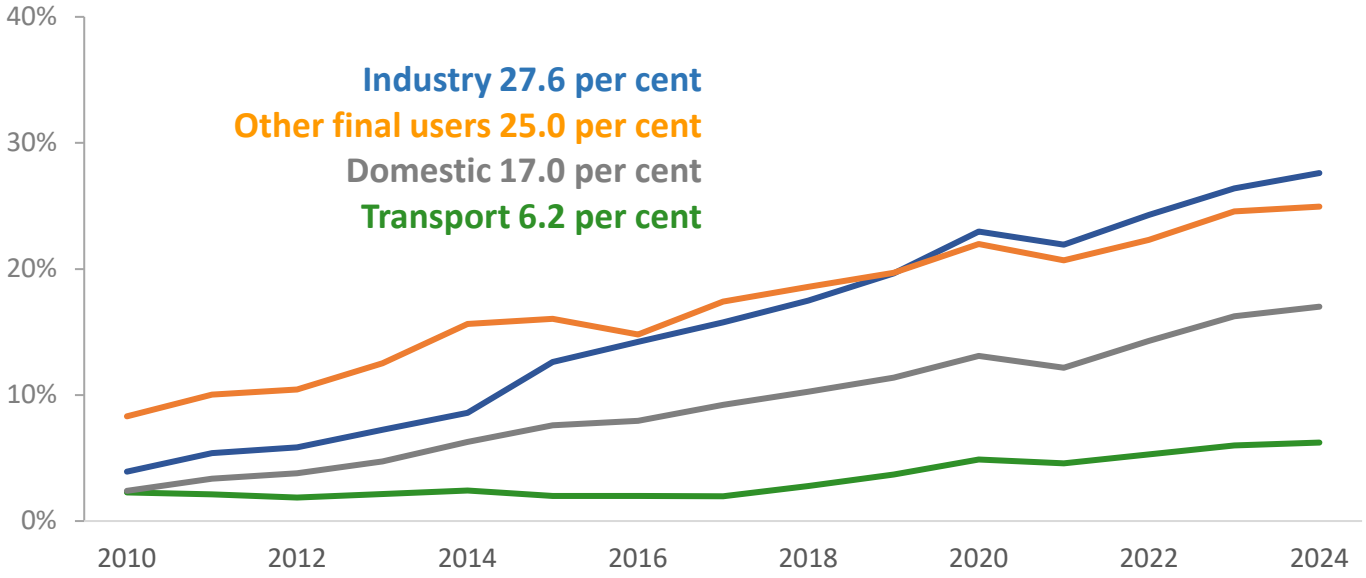
The proportion of electricity from renewables differs to that for generation and supply in that it excludes generation ultimately consumed in transport which is allocated to the transport measure. The underlying trend is however similar in that weather impacts are visible particularly between 2020 and 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.

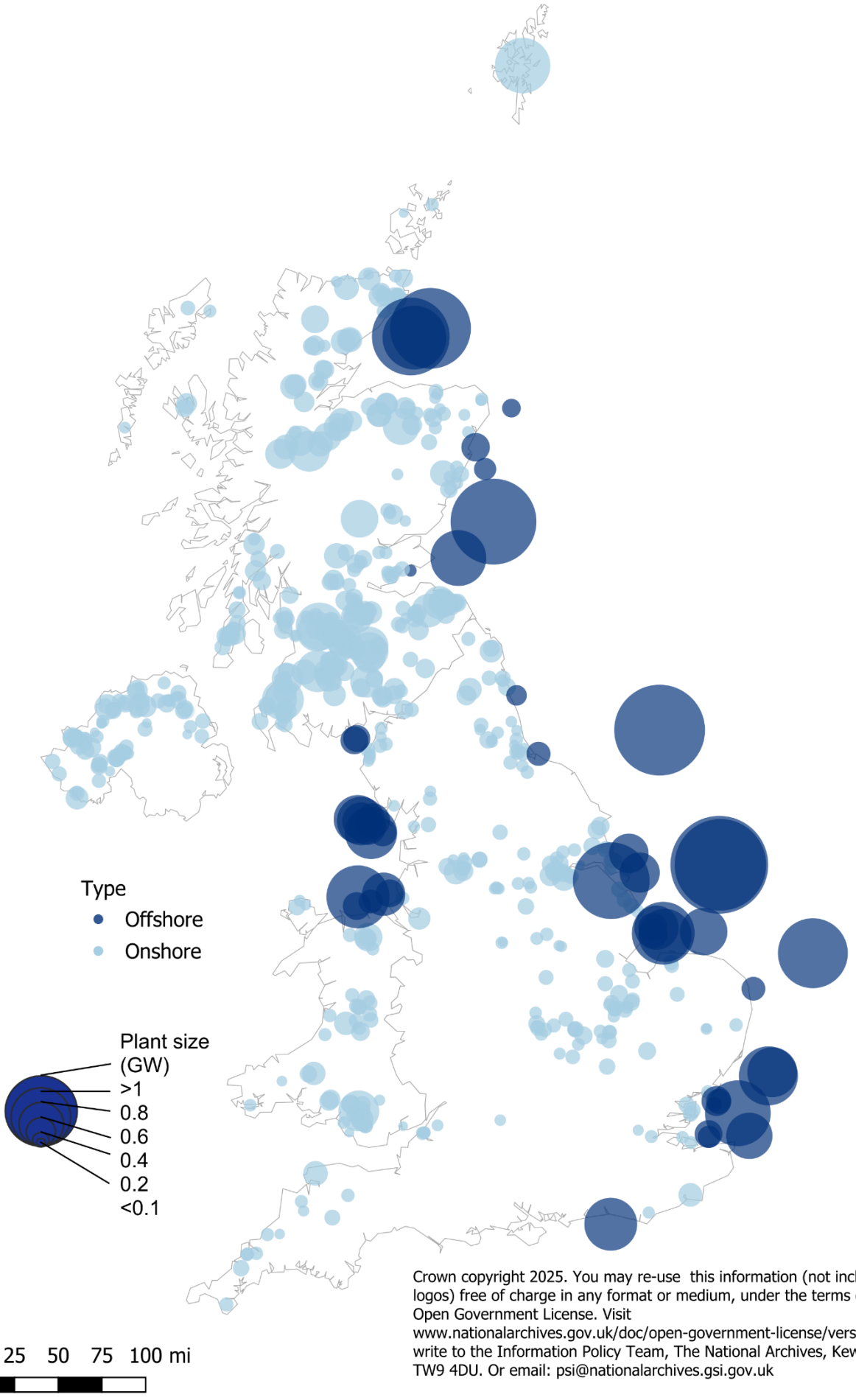
Chart 6.10 Renewables' share of final energy consumption by sector (DUKES Table 6.5b)



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 aligned 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. In 2024, industry continued its upward trend of its renewable share; by 1.2 percentage points. The domestic sector showed the next largest increase (0.7 percentage points) followed by other users and transport (0.4 and 0.2 percentage points respectively)

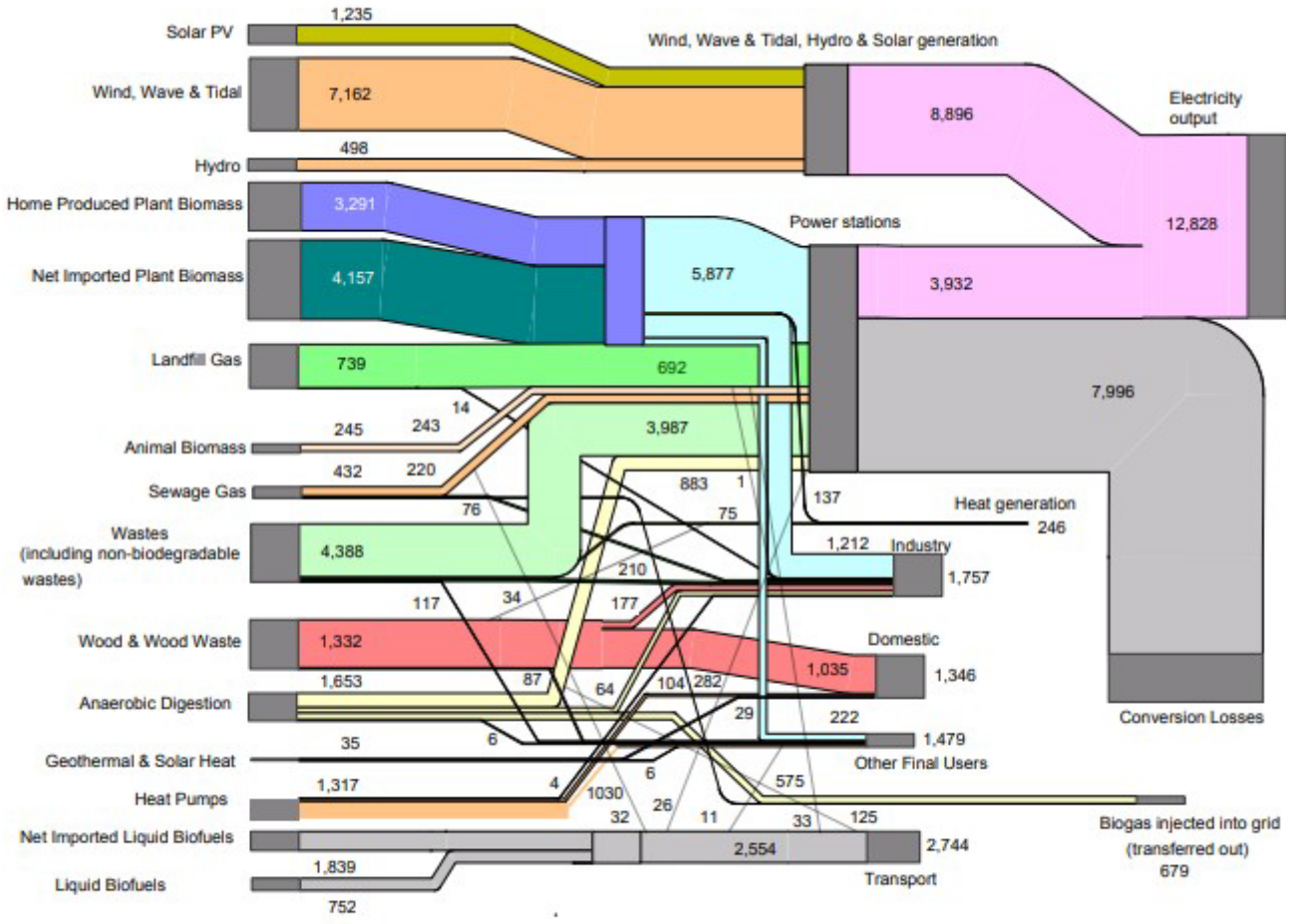
The map below shows UK wind farms that were operational at the end of 2024 with a capacity 5 MW or more; there are around 9,000 sites below this threshold and other sites are excluded due to a lack of precise location data. The locations are representative and not exact.

Map of UK wind capacity 2024



Renewable energy flow chart 2024 (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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