Chapter 6
Renewable sources of energy

Key points

- Electricity generation in the UK from renewable sources increased by 29 per cent between 2014 and 2015, to reach 83.6 TWh. Capacity grew by 23 per cent (to 30.5 GW) over the same period (table 6.4).

- Generation from bioenergy sources was 30 per cent higher in 2015 compared to 2014 due to the conversion of a third unit at Drax Power Station to high-range co-firing (greater than 85 per cent biomass but less than 100 per cent).

- Offshore wind generation was 30 per cent higher than in 2014, with capacity up 13 per cent. Onshore wind generation was 23 per cent higher, with capacity up 7.6 per cent. Overall wind generation was 26 per cent higher and capacity 7.0 per cent higher (table 6.4).

- Solar photovoltaic generation increased by 87 per cent in 2015 to 7.6 TWh due to an increase in capacity, particularly from schemes accredited through the Renewables Obligation on energy suppliers. Capacity is now 9.2 GW, up from 5.4 GW in 2014, an increase of 69 per cent (table 6.4).

- Generation from hydro sources also increased by 6.7 per cent to 6.3 TWh, a record, due to high rainfall (table 6.4).

- 909 MW of renewable electricity capacity was added by energy producers qualifying for the Feed-in Tariffs (FiT) scheme during 2015. Following the introduction of the FiT scheme in April 2010, total commissioned FiT capacity amounts to 4,367 MW.

- The contribution of all renewables to UK electricity generation was 24.6 per cent in 2015, 5.5 percentage points higher than in 2014. However, using normalised load factors to take account of fluctuations in wind and hydro, the contribution of renewables to gross electricity consumption was 22.4 per cent, up 4.5 percentage points on 2014 (table 6A).

- Heat from renewable sources increased by 20 per cent during 2015 (to 3,535 ktoe). Renewable biofuels for transport decreased by 19 per cent (to 1,003 ktoe) (table 6.6).

- Progress has been made against the UK’s 15 per cent target introduced in the 2009 EU Renewable Directive. Using the methodology set out in the Directive, provisional calculations show that 8.3 per cent of energy consumption in 2015 came from renewable sources; this is up from 7.1 per cent in 2014. There was a significant growth in the contribution of renewable electricity, while the renewable heating contributions also rose.

Introduction

6.1 This chapter provides information on the contribution of renewable energy sources to the United Kingdom's energy requirements. It covers:

- the use of renewables to generate electricity,
- heat obtained from renewable fuels and from other renewable sources, and
- the use of liquid biofuels for transport.

The chapter includes some sources that under international definitions are not counted as renewable sources or are counted only in part. This is to ensure that this Digest covers all sources of energy available in the UK. However, within this chapter the international definition of total renewables is used and this excludes non-biodegradable wastes. The energy uses of these wastes are still shown in the tables of this chapter but as "below the line" items.

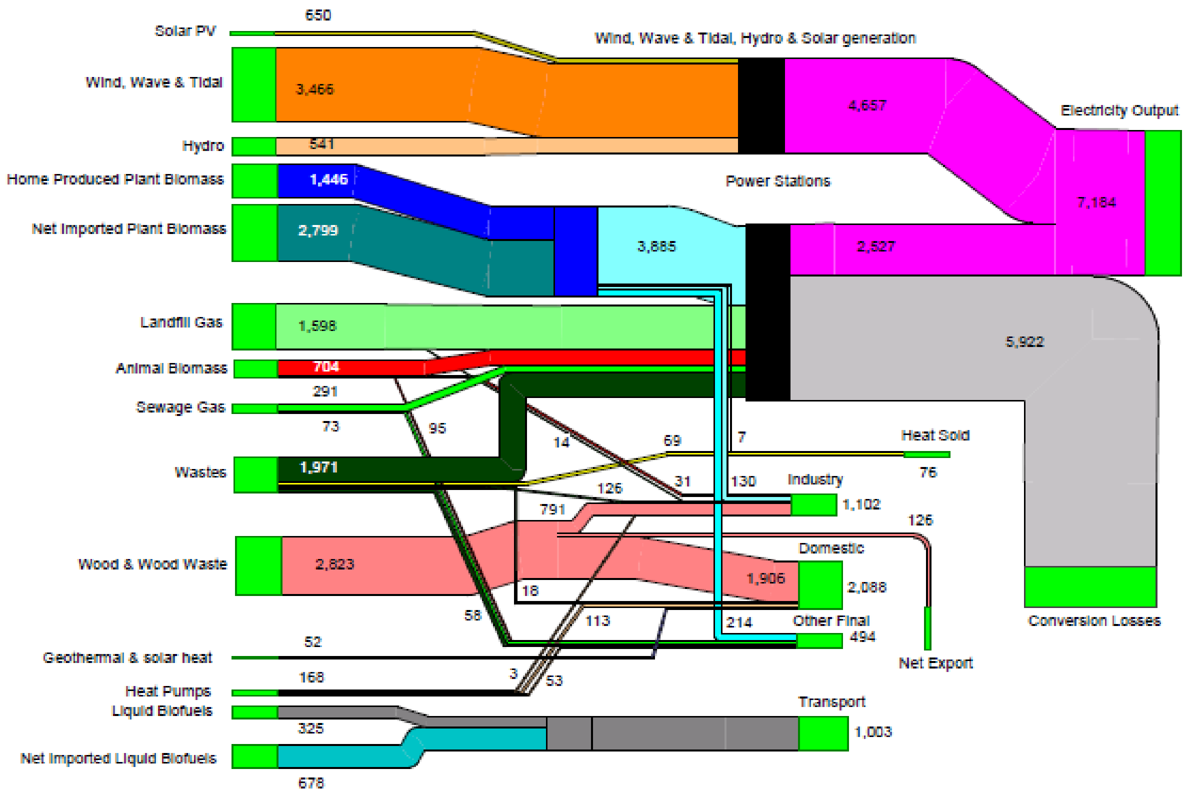
6.2 The data presented in this Chapter is drawn from the results of BEIS surveys of electricity generators, information from Combined Heat and Power (CHP) schemes, and The Renewable Energy STATisticS database (RESTATS) which is an on-going study undertaken by Ricardo Energy and Environment on behalf of BEIS to update a database containing information on all relevant renewable energy sources in the UK.

6.3 The renewable energy flow chart on page 157 summarises the flows of renewables from fuel inputs through to consumption for 2015. This is a way of simplifying the figures that can be found in the commodity balance for renewable energy sources in Table 6.1 and the renewable electricity output that can be derived from Table 6.4. The flow diagram illustrates the flow of primary fuels from the point at which they become available from home production or imports (on the left) to their eventual final uses (on the right) as well as the energy lost in conversion.

6.4 Commodity balances for renewable energy sources covering each of the last three years form the first three tables in this chapter (Tables 6.1 to 6.3). Unlike the commodity balance tables in other chapters of the Digest, Tables 6.1 to 6.3 have zero statistical differences. This is because the data for each category of fuel are, in the main, taken from a single source where there is less likelihood of differences due to timing, measurement, or differences between supply and demand. These balance tables are followed by five-year tables showing capacity of, and electricity generation from, renewable sources (Table 6.4). Table 6.5 focuses on load factors for electricity generation. Table 6.6 shows renewable sources used to generate electricity, to generate heat, and for transport purposes in each of the last five years. Finally, Table 6.7 shows the UK's progress against the 2009 EU Renewable Energy Directive target.

6.5 In addition to the tables and commentary contained within this Digest, a long-term trends commentary and table (Table 6.1.1) covering the use of renewables to generate electricity, to generate heat, and as a transport fuel is available on the BEIS section of the GOV.UK website, accessible from the Digest of UK Energy Statistics home page:
www.gov.uk/government/collections/digest-of-uk-energy-statistics-dukes.
Quarterly table ET 6.1, showing renewable electricity generation and capacity by UK country, can be found at: www.gov.uk/government/statistics/energy-trends-section-6-renewables

Renewables flow chart 2015 (thousand tonnes of oil equivalent)



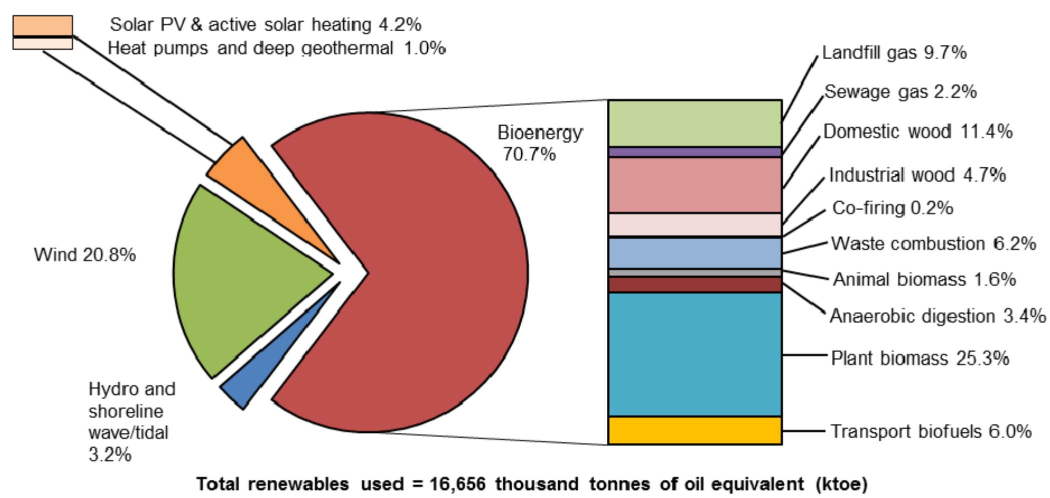
Note: This flow chart is based on data that appear in Tables 6.1 and 6.4

Commodity balances for renewables and waste in 2015 (Table 6.1), 2014 (Table 6.2) and 2013 (Table 6.3)

6.6 Twelve different categories of renewable fuels are identified in the commodity balances. Some of these categories are themselves groups of renewables because a more detailed disaggregation could disclose data for individual companies. In the commodity balance tables the distinction between biodegradable and non-biodegradable wastes cannot be maintained for this reason. The largest contribution to renewables and waste energy in input terms (around 71 per cent) is from bioenergy (excluding non-biodegradable wastes), with wind and solar photovoltaic generation contributing the majority of the remainder, as Chart 6.1 shows. Just 4.2 per cent of renewable energy comes from renewable sources other than biomass, wind and solar photovoltaic. These include hydro, heat pumps, and deep geothermal.

6.7 **Of the 16,656 ktoe of renewable energy (excluding non-biodegradable wastes) consumed in 2015, 73 per cent was transformed into electricity**. While bioenergy appears to dominate the picture when fuel inputs are being measured, hydroelectricity, wind power and solar together provide a larger contribution when the **output** of electricity is being measured as Table 6.4 shows. This is because on an energy supplied basis the inputs are deemed to be equal to the electricity produced for hydro, wind, wave and solar (see Chapter 5, paragraph 5.75). However for landfill gas, sewage sludge, municipal solid waste and other bioenergy sources a substantial proportion of the energy content of the input is lost in the process of conversion to electricity, as the renewables flow chart (page 157) illustrates.

Chart 6.1: Renewable energy fuel use 2015 (1)



(1) Excludes all passive use of solar energy and all non-biodegradable wastes (1,147 ktoe). In this chart renewables are measured in primary input terms.
(2) Biomass co-fired with fossil fuels in power stations.
(3) 'Animal biomass' includes farm waste, poultry litter, and meat and bone combustion.
(4) 'Plant biomass' includes straw and energy crops.

Capacity of, and electricity generated from, renewable sources (Table 6.4)

6.8 Table 6.4 shows the capacity of, and the amounts of electricity generated from, each renewable source. **Total electricity generation from renewables in 2015 amounted to 83,550 GWh, an increase of 18,965 GWh (29 per cent) on 2014**. The largest absolute increase in generation came from wind, which was up by 8,344 GWh compared to 2014. Bioenergy saw the second largest absolute increase, rising by 6,704 GWh to 29,338 GWh, largely due to an increase in plant biomass generation.

6.9 **Generation from plant biomass rose 42 per cent to 18,587 GWh**, although this was a smaller increase in percentage terms than the previous year (47 per cent). This was largely due to the conversion of a third unit at Drax Power Station from coal to high-range co-firing (greater than 85 per cent biomass but less than 100 per cent) in July 2015, and a small number of new generators.

6.10 **Total wind generation increased by 26 per cent to 40,310 GWh**, from 31,966 GWh in 2014. This was due to a combination of an increase in capacity, particularly for offshore wind, and higher than average wind speeds. 2015 saw average wind speeds of around 9.3 knots, 0.4 knots higher than the ten year mean and the highest in the last 15 years. Onshore wind saw a larger increase in absolute terms, from 18,562 GWh in 2014 to 22,887 in 2015, however, offshore's increase was more significant in percentage terms; 30 per cent compared to 23 per cent for onshore.

6.11 **Greater uptake of solar photovoltaics led to an increase in generation of 87 per cent**, from 4,040 GWh in 2014 to 7,561 GWh in 2015. These increases were seen in both larger schemes supported by the Renewables Obligation (RO and smaller schemes under the Feed in Tariff (FiT) programme. **Generation from hydro increased by 6.7 per cent to a record 6,289 GWh due to higher than average rainfall** (in the main hydro catchment areas) - the highest since 2011. **There were also large increases in municipal solid waste combustion up by 45 per cent and anaerobic digestion by 40 per cent**. Animal biomass increased 5.6 per cent, sewage sludge by 4.9 per cent and generation from landfill gas fell slightly, by 173 (3.4 per cent).

6.12 **Onshore wind continued to be the leading individual technology for the generation of electricity from renewable sources during 2015**, although its share of renewables generation decreased from 32 percent in 2013 to 29 per cent in 2014 and is now 27 per cent. This is despite a 7.6 per cent increase in capacity. Offshore wind's share of renewables generation remained the same as in 2014 at 21 percent. Solar photovoltaic generation's share increased from 6.3 per cent to 9.0 per cent. Hydro generation represented 7.5 per cent of renewable generation, mostly large scale. The combined generation from the variety of different bioenergy sources accounted for 35 per cent of renewable generation, the same as in 2014, with plant biomass accounting for 63 per cent of bioenergy generation and landfill gas accounting for 17 per cent.

6.13 **Renewable sources provided 24.6 per cent of the electricity generated in the UK in 2015** (measured using the "international basis", i.e. electricity generated from all renewables except non-biodegradable wastes as a percentage of all electricity generated in the UK). This was 5.5 percentage points higher than the proportion recorded during 2014. Table 6A and Chart 6.2 show the growth in the proportion of electricity produced from renewable sources. The table also includes the progress towards the electricity renewables target set under the RO (see paragraphs 6.57 to 6.59), and progress towards the 2009 Renewable Energy Directive (see paragraph 6.53).

Table 6A: Percentages of electricity derived from renewable sources

	2011	2012	2013	2014	2015
Overall renewables percentage (international basis)	9.4	11.3	14.9	19.1	24.6
Percentage on a Renewables Obligation basis	9.8	11.9	15.5	19.8	26.1
Percentage on a 2009 Renewable Energy Directive basis (normalised)	8.8	10.7	13.8	17.9	22.3

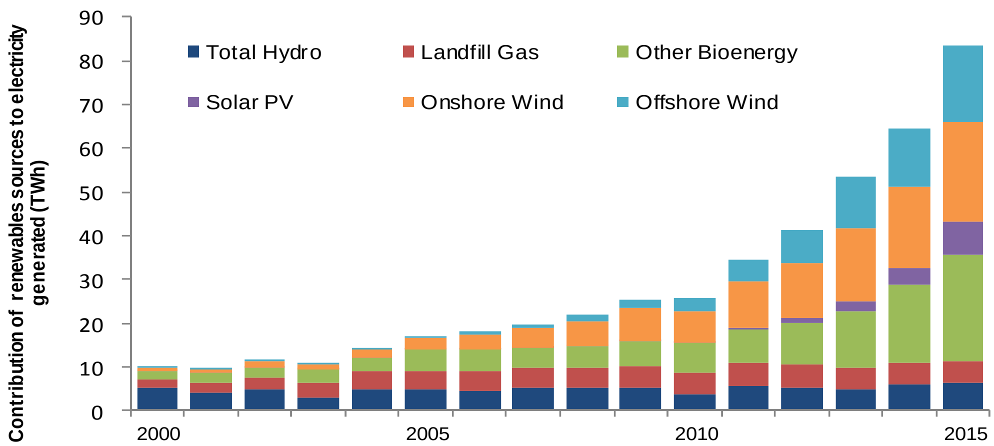
6.14 **Installed generation capacity reached 30,465 MW at the end of 2015, an increase of 5,718 MW (23 per cent) during the year**; this excludes the capacity within conventional generation stations that was used for co-firing (a further 21 MW). The largest contributor towards the increase was 3,763 MW from solar photovoltaics with a further 671 from bioenergy, and 652 MW and 602 MW increases from onshore and offshore wind respectively.

6.15 Onshore wind capacity grew from 8,536 MW in 2014 to 9,198 MW in 2015, with the biggest contributors being the new Strathy North (68 MW) (in North Sutherland), Clashindarroch (37 MW) (in Aberdeenshire) and Crook Hill (36 MW) (in East Lancashire) sites. Offshore wind capacity increased from 4,501 MW in 2014 to 5,103 in 2015. This was largely due to the new Humber Gateway (219 MW) (in the North Sea) and Kentish Flats Extension (49.5 MW) (outer Thames Estuary) schemes as well as the completion of Westermost Rough (North Sea) and Gwynt y Mor (Irish Sea). Solar PV capacity increased from 5,424 MW to 9,187 MW (69 per cent), with the majority from large scale sites accredited on or awaiting accreditation on, the RO.

6.16 Capacity from the variety of bioenergy technologies increased from 4,548 MW in 2014 to 5,219 MW in 2015. This resulted from the extra capacity from an additional unit conversion to high-range co-firing at Drax Power Station (following two earlier unit conversions to dedicated plant biomass) and also several small scale new installations. These increases more than compensated for the fact that Ironbridge ceased generation in late 2015 (following a fire in 2014 which had already reduced capacity).

6.17 In capacity terms, onshore wind and solar photovoltaics were the leading technologies, each with a 30 per cent share of capacity at the end of 2015. Offshore wind had a 17 per cent share of total capacity, and hydro a 5.8 share. Bioenergy represented 17 per cent of capacity, with the main components being plant biomass (8.6 per cent) and landfill gas (3.5 per cent).

Chart 6.2: Electricity generation by main renewable sources since 2000



Note: Hydro bar includes shoreline wave/tidal (0.002TWh in 2015)

6.18 Much small-scale (up to 5 MW) renewable electricity capacity in Great Britain is supported by, and has increased as a result of, the Feed in Tariff (FiT) scheme. During the first nine months (April and December 2010) of the FiT scheme, a total of 69 MW of renewable capacity was installed and subsequently confirmed on it. During 2011, a further 953 MW of FiT supported renewable capacity was installed. For 2012, 849 MW of capacity was added and in 2013, 609 MW. In 2014, 940 MW of capacity was added, while in 2015, a further 909 MW of FiT capacity was installed, with 85 per cent of this new capacity coming from solar photovoltaics (PV). A further 274 MW of solar PV capacity was installed in 2015.

6.19 **The greatest increase in FiT capacity in percentage terms in 2015 was from solar photovoltaics**, from 2,802 MW at the end of 2014 to 3,574 MW at the end of 2015. Onshore wind increased from 433 MW at the end of 2014 to 514 MW at the end of 2015, while hydro capacity increased from 77 MW to 104 MW, and anaerobic digestion from 147 MW to 177 MW. At the end of 2015, solar PV represented 82 per cent of commissioned FiTs capacity (up from 81 per cent at the end of 2014), with onshore wind 12 per cent (down from 13 per cent), and anaerobic digestion 4.0 per cent (down from 4.3 per cent) and hydro increased slightly from 2.2 to 2.4 per cent. It should be noted that, due to administrative lags of around three months, much capacity installed towards the end of

2015 was not confirmed until the first quarter of 2016 (so the amount of capacity installed under FiTs at the end of 2015 will not equal the amount actually confirmed on the Central FiTs Register).[1]

6.20 Table 6B shows the number of sites generating renewable electricity at the end of 2015. There were 853,711 sites, although this figure is dominated by small-scale solar PV installations confirmed on FiTs. Table 6C shows the number of turbines in operation at these sites at the end of December 2015.

6.21 Chart 6.3 illustrates the continuing increase in the electricity generation capacity from all significant renewable sources since 2000. This upward trend in the capacity of renewable sources should continue as recently consented onshore and offshore wind farms and other projects come on stream. The map, shown below, shows the location of wind farms in operation at the end of December 2014, together with an indication of the capacity.

[1] At the end of 2015, 4,367 MW of renewable capacity was commissioned (and subsequently confirmed) on the Central FiTs Register. This includes 37 MW commissioned prior to the start of FiTs on 1 April 2010.

Map 6.1: The Location of Wind Farms in the United Kingdom as at 31 December 2015

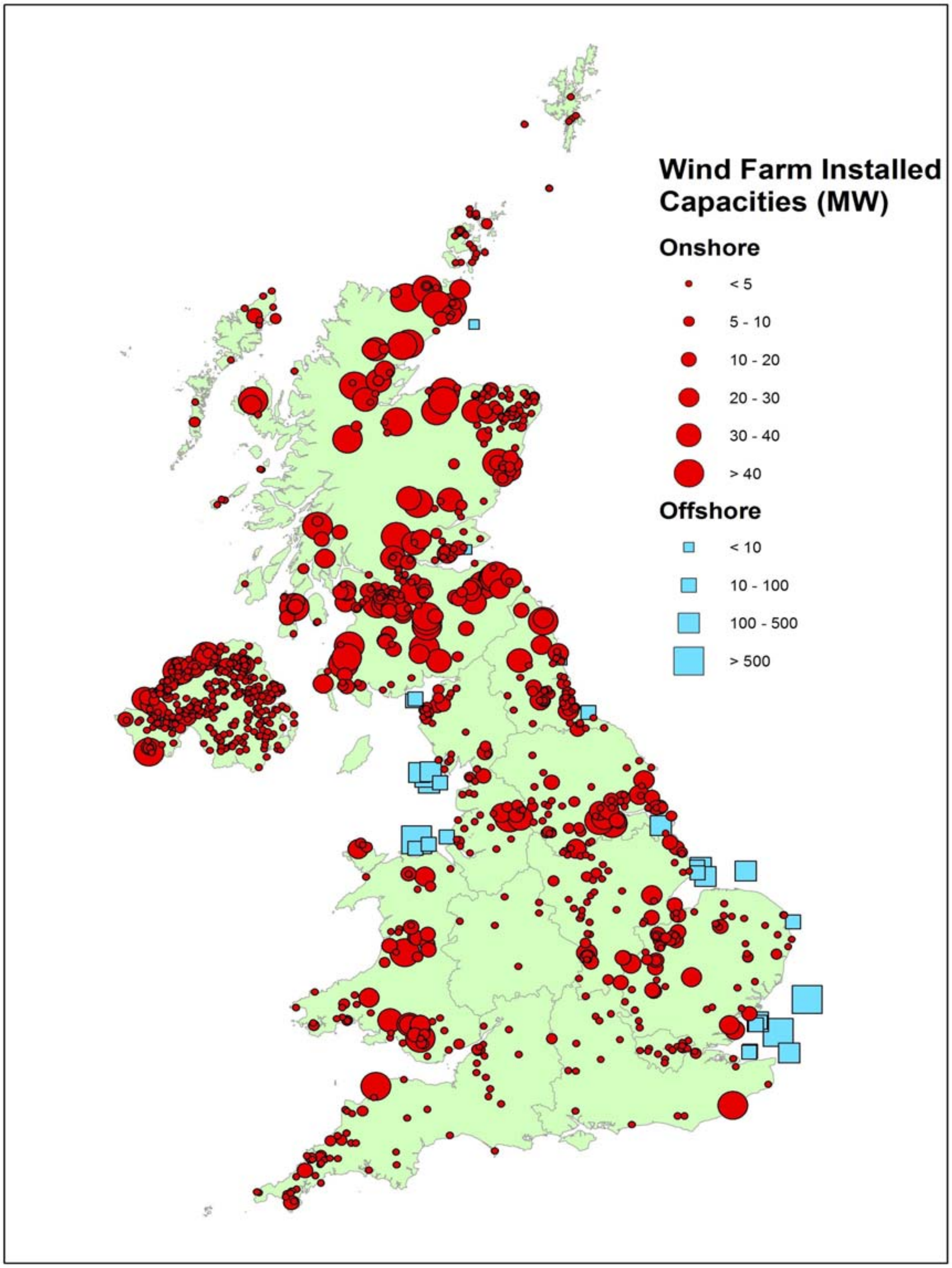


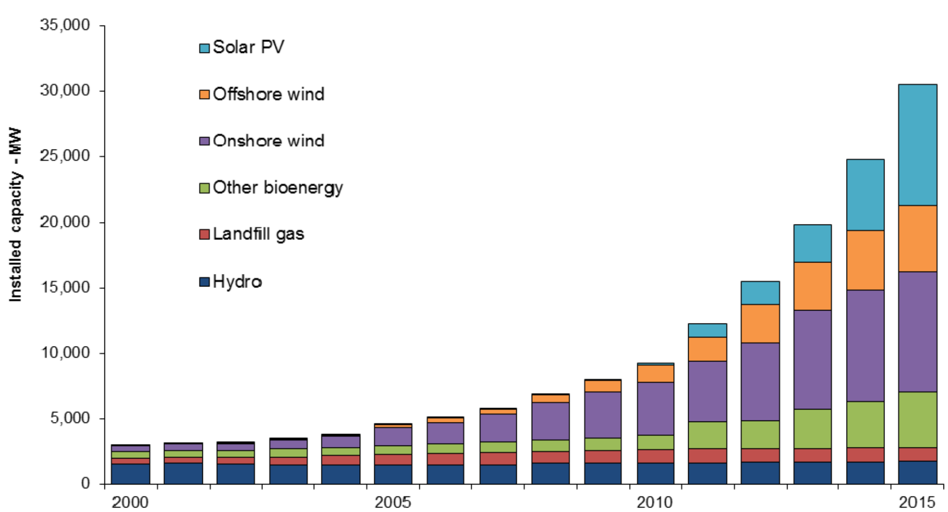
Table 6B: Number of sites generating renewable electricity, as at end of December 2015 (excluding co-firing)[2]

	FiTs confirmed	Other sites	TOTAL
Onshore Wind	6,898	1,671	8,569
Offshore Wind	-	30	30
Marine energy	-	13	13
Solar PV	740,077	102,760	842,837
Hydro	715	350	1,065
Landfill gas	-	446	446
Sewage sludge digestion	-	187	187
Energy from waste	-	47	47
Animal biomass (non-AD)	-	6	6
Anaerobic digestion	250	101	351
Plant biomass	-	160	160
TOTAL	747,940	105,771	853,711

Table 6C: Number of operational wind turbines split by FiTs and non FiTs accredited sites, as at end of December 2015[3]

	FiTs confirmed	Other sites	TOTAL
Onshore Wind	6,898	4,734	11,632
Offshore Wind	-	1,465	1,465
TOTAL	6,359	5,705	13,097

Chart 6.3: Electrical generating capacity of renewable energy plant since 2000



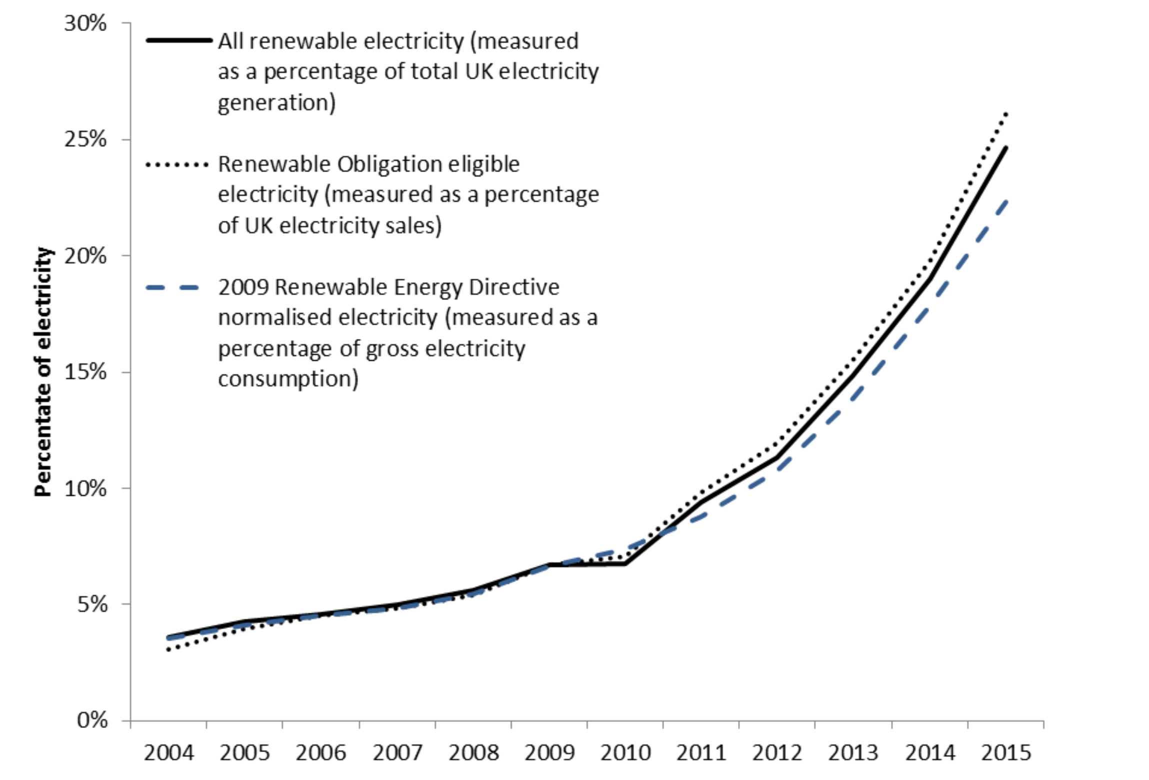
(1) All waste combustion plant is included because both biodegradable and non-biodegradable wastes are burned together in the same plant.
(2) Hydro includes both large scale and small scale, and shoreline wave and tidal (8.9 MW in 2015).

[2] The number of sites (as with overall capacity) is subject to revision, due to lags in data sources. This particularly affects solar PV, where more sites may have come online since compiling this edition of DUKES.
[3] For FiTs schemes, turbine information is not available, so it is assumed that each site consists of one turbine. For other sites, any sites that *could* be eligible for FiTs have been excluded, to avoid any double-counting; therefore, this may be an under-estimate. Additionally, the number of turbines for other sites is that given in the site's planning application, which may vary from the outturn.

6.22 Electricity generated in the UK from renewable sources claiming Renewable Obligation Certificates (ROCs) in 2015, at 67.8 TWh, was 28 per cent greater than in 2014. The growth in 2015 is mainly due to the increased capacity at Drax following the conversion of a third unit (to high-range co-firing) and also increased wind and solar photovoltaic capacity. Chart 6.4 shows the growth in the proportion of electricity produced from renewable sources claiming ROCs compared to the proportion calculated on the International basis and also using the 2009 Renewable Energy Directive methodology. Table 6A shows electricity eligible for and claiming ROCs as a percentage of electricity sales. RO supported generation has increased by over 60 TWh since its introduction in 2002, an increase of over 11 times[4]. This compares with an all-renewable electricity generation figure that has increased by 72 TWh, over seven times the same period, but from a higher starting level.

6.23 As shown in Table 6A, during 2015 renewable generation measured using the RO basis (i.e. as a proportion of electricity sales by licensed suppliers) increased to 26 per cent. Since the introduction of the RO in 2002, generation from wind has increased on average by around one-third each year, with year-on-year increases ranging from 2 per cent to 53 per cent.

Chart 6.4: Growth in electricity generation from renewable sources since 2000



Load factors for electricity generated from renewable sources (Table 6.5)

6.24 Plant load factors in Table 6.5 have been calculated in terms of installed capacity and express the average hourly quantity of electricity generated as a percentage of the average capacity at the beginning and end of the year. The method can be expressed as:

$$\frac{E}{\frac{(C_b + C_e)}{2} \times h}$$

Where;

E Electricity generated during the year (kWh)

[4] A small amount is due to existing hydro stations being refurbished and thus becoming within the scope of the RO definition, as opposed to new capacity being installed.

C_b Installed capacity at the beginning of the year (kW)
C_e Installed capacity at the end of the year (kW)
h Hours in year

6.25 A key influence on load factors of renewable technologies is the weather, with rainfall being the key driver behind the availability of hydro. **In 2015, average rainfall (in hydro catchment areas) was 13 per cent higher than in 2014; as a consequence, the load factor of hydro schemes increased to 41.2 per cent, the highest in the last 19 years.**

6.26 **Average wind speeds during 2015 (at 9.3 knots) were 0.6 knots higher than in 2014, the highest in the last 15 years.** Wind speeds were particularly strong at the start and end of the year; wind speeds in January were the highest for that month since 2007, while December saw wind speeds averaging 13.3 knots, the highest for December in the last 15 years, and 0.4 knots higher than the long term mean. However, it was the least windy October in the last 15 years, and 2.4 knots lower than the 10 year mean. **As a result of the higher wind speeds, the load factor for total wind generation was 33.7, the highest in the last 19 years**; the next highest was seen in 2013. Other factors, such as improved design can also impact on load factors. Load factors for all non-renewable generating plant in the UK are shown in Chapter 5, Table 5.9.

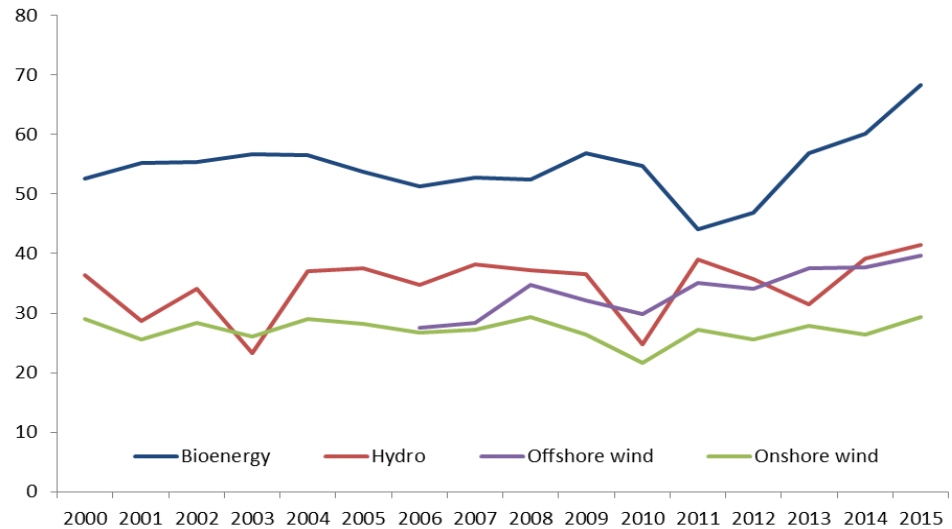
6.27 Changes in capacity during the year can also affect load factors calculated using this methodology; removing Ironbridge from the plant biomass load factor calculation resulted in a 1.8 percentage point reduction in the load factor. This is because Ironbridge ceased operating during the year but generated for the bulk of the year, contributing to the numerator in a bigger proportion compared to the capacity in the denominator which is averaged.

6.28 To compensate for these factors, a second "unchanged configuration" set of statistics have been calculated for many technologies and included in Table 6.5. These statistics use the same methodology as the other load factor statistics, but are restricted to those schemes that have operated continuously throughout the year without a change in capacity. One of the inputs to the unchanged configuration calculation is data on issued ROCs, and a site is included in the calculation only if it has been issued ROCs for each month during the calendar year. The formula for calculating the unchanged configuration load factors is:

$$\frac{\text{Electricity generated during the year (kWh)}}{\text{Installed capacity operating throughout the year with unchanged configuration (kW) x hours in year}}$$

6.29 Chart 6.5 shows load factors for wind and hydro. The impacts of new capacity and changes in weather conditions – referred to in the preceding paragraphs - can be identified.

Chart 6.5: Load factors for renewable electricity generation since 2000



Renewable sources used to generate electricity, heat, and for transport fuels (Table 6.6)

Renewable electricity

6.30 **Between 2014 and 2015, there was an increase of 25 per cent in the *input* of renewable sources into electricity generation, to 12,118 ktoe.** Solar photovoltaics increased by 87 per cent, and anaerobic digestion by 40 per cent, and plant biomass by 32 per cent. Onshore and offshore wind increased by 23 per cent and 30 per cent respectively, while hydro increased by 6.7 per cent. Shoreline, wave and tidal (Marine Energy) fell by 10 per cent although its overall contribution to renewable electricity is very small and generation intermittent due to test rigs not being continuously on line. Co-firing with fossil fuels increased by 50 per cent; the reduction in capacity due to the conversion of a third unit at Drax Power Station to high-range co-firing was offset by an increase in capacity at other sites.

Renewable heat

6.31 DUKES 2015 saw some significant revisions to domestic wood consumption following a survey conducted in 2015 (see paragraphs 6.100 to 6.108). This year's Digest has seen more modest revisions to renewable heat, mostly within domestic and industrial wood use where the calorific values and moisture contents being standardised. Industrial wood was revised up by 42 ktoe (9.1 per cent) and domestic by 144 ktoe (9.2 per cent).

6.32 **Around 21 per cent of renewable sources were used to generate heat in 2015, the same proportion as in 2014**. **Energy used for all renewable heat sources increased by 20 per cent during 2015, from 2,954 ktoe to 3,535 ktoe**. Around 11 per cent of renewable heat was supported by The Renewable Heat Incentive (RHI) or Renewable Heat Premium Payment (RHPP) in 2015, compared to 4.6 per cent in 2014. This increase is largely due to growth in RHI supported heat; from 127 ktoe (1,460 GWh) in 2014 to 372 ktoe, (4,326 GWh) in 2015[5]. Further information on the RHI and RHPP schemes can be found in paragraphs 6.71 to 6.72.

6.33 **Of the 581 ktoe increase in renewables used for heat in 2015, 86 per cent was wood combustion** (208 domestic and 289 industrial). In percentage terms, industrial wood increased by 58 per cent, compared to 12 per cent for domestic wood; the average number of heating degree days was higher in 2015 (5.3) compared to 2014 (4.9) though remained below the long term mean (6.0). **The largest percentage growth component of renewable heat was anaerobic digestion** which almost doubled to 46 ktoe in 2015. This was largely driven by the RHI and Feed in Tariff mechanisms.

[5] Note RHI and RHPP data is by date of payment as opposed to when the heat was generated
Source; www.gov.uk/government/collections/renewable-heat-incentive-statistics

6.34 Plant biomass used for heat decreased by 5.2 per cent in 2015 from 379 ktoe to 359 ktoe due to a reduction in heat generation at some CHP plants.

6.35 **Renewable energy from heat pumps increased by 26 per cent in 2015, from 143 ktoe to 168 ktoe.** In DUKES 2015, only those heat pumps performing at the seasonal performance factor (SPF) required to meet the Renewable Energy Directive were included. However, following discussions with Eurostat, this year's Digest includes all heat pumps (with the exception of Table 6.7 which measures progress against the Directive). This change in methodology together with a review of heat pump properties has resulted in an upward revision for 2014 from 108 ktoe to 143 ktoe. The total installed capacity of ground source heat pumps, ambient air to water heat pumps, and exhaust air heat pumps was estimated to be 1,369 MW at the end of 2015. The capacity installed during 2014 was assumed to be installed at a steady rate throughout the year. Note that only the net gain in energy from heat pumps (i.e. total heat energy minus the electricity used to power the pump) is counted as renewable energy (see paragraph 6.93 for details on the methods used).

6.36 Over half of renewable heat is from domestic wood combustion (54 per cent), followed by industrial wood consumption (22 per cent). Plant biomass' share has fallen from 13 per cent in 2014 to 10 per cent in 2015. Non-bioenergy renewable heat sources include solar thermal, deep geothermal and heat pumps, and combined these accounted for 6.2 per cent of renewable heat in 2015.

Liquid biofuels for transport

6.37 Biodiesel and bioethanol consumption figures, previously sourced from The HMRC Hydrocarbon Oils Bulletin, have this year been obtained from data published by The Department for Transport, derived from The Renewable Transport Fuel Obligation (RTFO) statistics (see paragraphs 6.66 to 69 for more details),
www.gov.uk/government/collections/biofuels-statistics

6.38 The RTFO figures show that **674 million litres of biodiesel[6] were consumed in 2015, 29 per cent lower than in 2014.** Biodiesel is considered the 'marginal fuel' supplied under the RTFO and therefore the supply of biodiesel fluctuates in response to changing market conditions. It is estimated that 167 million litres of biodiesel were produced in the UK in 2015, 4.1 per cent less than in 2014. Of this, about 6 million litres are known to have been used for non-transport applications or exported. Therefore, at least 514 million litres of biodiesel were imported in 2015. The total annual capacity for biodiesel production in the UK in 2015 is estimated to be around 327 million litres.

6.39 RTFO data also shows that **797 million litres of bioethanol were consumed in the UK in 2015, a decrease of 2.1 per cent on 2014**. The UK capacity for bioethanol production at the end of 2015 was estimated to be around 900 million litres, although actual production was estimated to be 333 million litres, 37 per cent of capacity. Of UK production, 199 million litres was known to be used for non-transport applications, or exported, so at least 663 million litres was imported.

6.40 During 2015, biodiesel accounted for 2.4 per cent of diesel, and bioethanol 4.8 per cent of motor spirit. The combined contribution of liquid biofuels for transport was 3.3 per cent, a decrease of 0.6 percentage points on 2014.

6.41 The RTFO data have been converted from litres to tonnes of oil equivalent and the data are shown in both the commodity balances (Tables 6.1 to 6.3) and in Table 6.6. In addition these data are also included in the aggregate energy balances (Tables 1.1 to 1.3). The tables show the contribution that liquid biofuels are making towards total renewable sourced energy. Renewable biofuels used for transport fell by 19 per cent (to 1,003 ktoe) between 2014 and 2015 with the majority of the decrease due to biodiesel. In 2014, liquid biofuels for transport comprised around 6.0 per cent of total renewable sources, 2.9 percentage points less than 2014, and less than half the high reached in 2010 of 14.8 per cent.

6.42 When measuring the contribution of transport biofuels for the Renewable Energy Directive, only those meeting sustainability criteria count. The RTFO tables referred to above do not contain

[6] The most usual way for biodiesel to be sold is for it to be blended with ultra-low sulphur diesel fuel.

sustainability information, including those which carry a higher weighting (mostly sourced from waste), and the table which does, is not yet a complete data set for 2015. This is due to the RTFO allowing suppliers to make claims for RTFCs up to August after the obligation period (in order to allow suppliers to optimise their supply chain verification processes), as well as, allowing sufficient time for DfT to make necessary compliance checks before applications are processed. Table 6.7 records progress against the directive and includes an estimate of the proportion of bio liquids being complaint and also the proportion meeting the double credited criteria (mostly those from waste sources). During RTFO obligation period 7, from April 2014 to April 2015, **almost 100 percent of transport biofuel consumption was demonstrated to be sustainable**. Under the RTFO, 1,177 million litres of transport biofuels were consumed in 2015, although, as at June 2015, only 62 per cent of this had been awarded with Renewable Transport Fuel Certificates (RTFCs) as suppliers have until August to apply for them. Further information on the RTFO is given in paragraphs 6.66 to 6.69.

Renewable sources data used to indicate progress under the 2009 EU Renewable Energy Directive (RED) (Table 6.7)

6.43 The 2009 Renewable Energy Directive (RED) has a target for the UK to obtain 15 per cent of its energy from renewable sources by 2020. The target uses a slightly different definition of renewable and total energy than is used in the rest of the Digest, including the use of 'normalised' wind and hydro generated electricity. Further details on the RED methodology can be found in paragraphs 6.53 and 6.54.

6.44 Table 6.7 brings together the relevant renewable energy and final energy consumption data to show progress towards the target of 15 per cent of UK energy consumption to be sourced from renewables by 2020, and also shows the proportions of electricity, heat and transport energy coming from renewable sources. These provisional figures indicate that **during 2015, 8.3 per cent of final energy consumption was from renewable sources**. The RED introduced interim targets for member states to achieve on their route to attaining the 2020 proportion. The second interim target, averaged across 2013 and 2014, was set at 5.4 per cent, and was exceeded at 6.3 per cent. The third interim target is 7.5 per cent averaged across 2015 and 2016.

6.45 Overall renewable sources, excluding non-biodegradable wastes and passive solar design (see paragraph 6.73), provided 8.8 per cent of the UK's total primary energy requirements in 2015 (excluding energy products used for non-energy purposes). This is a different measure to that reported in the RED. The primary energy demand basis typically produces higher percentages because thermal renewables are measured including the energy that is lost in transformation. The thermal renewables used in the UK are less efficient in transformation than fossil fuels, so as non-thermal renewables such as wind (which by convention are 100 per cent efficient in transformation) grow as a proportion of UK renewables use, then the gross final energy consumption percentage will overtake the primary energy demand percentage. Both of these percentage measures are directly influenced by overall energy use: for instance, whilst the renewable energy component (the numerator in the RED calculation) increased by 18 per cent, the final consumption denominator increased by just 1.3 per cent. Table 6D shows both measures.

Table 6D: Percentages of energy derived from renewable sources since 2011

	2011	2012	2013	2014	2015
Eligible renewable energy sources as a percentage of capped gross final energy consumption (i.e. the basis for the Renewable Energy Directive)	4.2%	4.6%	5.8%	7.1%	8.3%
Renewable energy as a percentage of primary energy demand	4.5%	4.9%	5.9%	7.3%	8.8%

6.46 Eurostat publishes data on how all countries are progressing towards their RED (final and interim) targets. The latest comparative data relates to 2014. The 2014 RED percentage for all EU countries combined was 16.0 per cent, an increase of 1.0 percentage point compared to 2014. Sweden achieved the highest proportion of renewable energy at 53 per cent.

6.47 Most member states' share of renewable energy increased from 2013 to 2014 with the highest increase being Finland with a 2.0 percentage point increase. **The UK increased its share of renewable energy by 1.4 percentage points, the sixth highest increase across member states**. The UK has the fourth lowest proportion of renewable energy in 2014, though it has managed to increase its share of renewable energy more than seven-fold since 2004. Since 2004, Denmark has seen the highest increase in its share of renewable energy at 14.3 percentage points.

6.48 A third of the member states have now exceeded their 2020 targets; Bulgaria, the Czech Republic, Estonia, Croatia, Italy, Lithuania, Romania, Finland and Sweden. Denmark and Austria are less than one percentage point from meeting theirs. Taking into account the UK's 2015 result it is now challenged to increase its share of renewable energy by a further 6.7 per cent to meet its 2020 target of 15 per cent. Further details of progress for all member states can be found at:
http://ec.europa.eu/eurostat/en/web/products-press-releases/-/8-10022016-AP

Technical notes, definitions, and policy context

6.49 The Renewable Energy STATisticS database (RESTATS) study started in 1989 and, where possible, information was collected on the amounts of energy derived from each renewable source. Additional technologies have been included for more recent years, such as the inclusion of energy from heat pumps from 2008 onwards and the recording of technology types such as anaerobic digestion. This technical notes section defines these renewable energy sources. The database now contains 27 years of data from 1989 to 2015. Information within RESTATS is also combined with supplementary data obtained from monitoring the planning process for new renewable electricity and heat installations to ensure that it is more comprehensive.

6.50 The information contained in the database is collected by a number of methods. For larger projects, an annual survey is carried out in which questionnaires are sent to project managers. For technologies in which there are large numbers of small projects, the values given in this chapter are estimates based on information collected from a sub-sample of the projects. Some data are also collected via other methods, such as desk research and data from the administration of renewable energy policies. Further details about the data collection methodologies used in RESTATS are also contained in a guidance note on the BEIS section of the GOV.UK website at:
www.gov.uk/government/collections/renewables-statistics#methodology

6.51 Energy derived from renewable sources is included in the aggregate energy tables in Chapter 1 of this Digest. The main commodity balance tables (Tables 6.1 to 6.3) present figures in the common unit of energy, the tonne of oil equivalent, which is defined in Chapter 1 paragraph 1.29. The gross calorific values and conversion factors used to convert the data from original units are given in Annex A. The statistical methodologies and conversion factors are in line with those used by the International Energy Agency and the Statistical Office of the European Communities (Eurostat). Primary electricity contributions from hydro and wind are expressed in terms of an electricity supplied model (see Chapter 5, paragraph 5.75). Electrical capacities in this chapter are quoted as Installed capacities. However, in Chapter 5, Declared Net Capacity (DNC) or Transmission Entry Capacity of renewables are used when calculating the overall UK generating capacity. These measures take into account the intermittent nature of the power output from some renewable sources (see paragraph 6.129).

6.52 The various renewable energy Directives, policies and technologies are described in the following paragraphs. This section also provides details of the quality of information provided within each renewables area, and the methods used to collect and improve the quality of this information. While the data in the printed and bound copy of this Digest cover only the most recent five years, these notes also cover data for earlier years that are available on the BEIS section of the gov.uk website.

European and UK Renewable Energy Policy Context

EU Renewable Energy Directive

6.53 In March 2007 the European Council agreed to a common strategy for energy security and tackling climate change. An element of this was establishing a target of 20 per cent of EU's energy to come from renewable sources. In 2009 a new Renewable Energy Directive (Directive 2009/29/EC) ('RED') was implemented on this basis and resulted in agreement of country "shares" of this target. For the UK, its share is that 15 per cent of final energy consumption - calculated on a net calorific value basis, and with a cap on fuel used for air transport - should be accounted for by energy from renewable sources by 2020. The RED included interim targets, and required each Member State to produce a National Renewable Energy Action Plan (which contains a progress trajectory and identifies measures which will enable countries to meet their targets). The Directive also requires each Member State to submit a report to the Commission on progress in the promotion and use of energy sources every two years. The UK's action plan and the first three progress reports (covering performance during 2009-2010, 2011-12, and 2013-14) are available at:
www.gov.uk/government/uploads/system/uploads/attachment_data/file/47871/25-nat-ren-energy-action-plan.pdf, www.gov.uk/government/publications/first-progress-report-on-the-promotion-and-use-of-energy-from-renewable-sources-for-the-uk, and

www.gov.uk/government/publications/second-progress-report-on-the-promotion-and-use-of-energy-from-renewable-sources-for-the-united-kingdom

The third progress report will cover 2015-16 and will be published in January 2018.

6.54 The RED uses different measures of both renewables and overall energy from those elsewhere in the Digest. The renewable numerator in the calculation uses 'normalised' wind and hydro generated electricity – combined with other actual electricity generated from other sources, energy for heating and cooling by final consumers, as well as the use of energy for transport purposes. Gross final energy consumption (which is calculated on a net calorific value basis) also includes consumption of electricity by electricity generators, consumption of heat by heat generators, transmission and distribution losses for electricity, and transmission and distribution losses for distributed heat. The normalisation process is carried out by calculating generation by applying an average load factor to current capacity. For wind, the load factor is calculated as the average of the past five years (including the present one), with current capacity taken as an average of the start and end of year capacity. For hydro, the load factor is the average of the past 15 years, applied to capacity at the end of the current year. The generation figures obtained from this procedure replace the actual generation figures for wind and hydro in the Directive calculation. The energy generated by heat pumps is also calculated differently; only heat pumps which meet a minimum Seasonal Performance Factor (SPF) of 2.5 are included as prescribed by the Commission's guidance for calculating renewable energy from heat pumps which is set out at;

http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013D0114

Additionally, the Directive includes a cap on the proportion that air transport can contribute to the total; this cap is currently 6.18 per cent; certain fuels also receive a higher weighting in the calculation, with full details being set out in the Directive, which is available at:

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF.

6.55 In the UK, energy balances are usually published on a gross calorific value basis, but in order to facilitate comparisons with EU statistics the balances for 2004 to 2015 have been calculated on a net calorific value basis and are available in Table I.1 at:
www.gov.uk/government/statistics/energy-chapter-1-digest-of-united-kingdom-energy-statistics-dukes

UK Renewables Policy

6.56 The UK's progress report details the key policies and measures undertaken or in planning, to further increase renewables deployment. These include:

- Putting in place appropriate financial incentives to bring forward and support the take-up of renewable energy, including the "banded" Renewables Obligation (closing on 31st March 2017, although extensions are available in certain situations), Feed-in Tariffs (FiTs) for small scale (under 5 MW) electricity generation, the Renewable Transport Fuel Obligation, the Renewable Heat Incentive tariff scheme (for industry, commercial premises, the public sector, and, since April 2014, households), and the (now closed) Renewable Heat Premium Payment Scheme (for households); and, Contracts for Differences under Electricity Market Reform.
- Identifying and removing the most significant non-financial barriers to renewables deployment, including measures to improve existing grid connection arrangements; and
- Overcoming supply chain blockages and promoting business opportunities in the renewables sector in the UK.

More details of the main renewable technologies that either have the greatest potential to help the UK meet the 2020 RED target in a cost effective and sustainable way, or offer the greatest potential for the decades that follow, can be found in the UK Renewable Energy Roadmap, which was first published in July 2011, and updated in 2012 and 2013, available at:

www.gov.uk/government/publications/renewable-energy-roadmap
www.gov.uk/government/publications/uk-renewable-energy-roadmap-update
www.gov.uk/government/publications/uk-renewable-energy-roadmap-second-update

Renewables Obligation (RO)

6.57 In April 2002 the Renewables Obligation (RO) came into effect[7]. It is an obligation on electricity suppliers to source a specific proportion of electricity from eligible renewable sources or pay a penalty. The proportion is measured against total electricity sales (as shown in Table 5.5 contained in the electricity chapter of this Digest). The Obligation is intended to incentivise an increase in the level of renewable generating capacity and so contribute to our climate change targets. Examples of RO eligible sources include wind energy, bioenergy (including landfill gas, sewage gas, biomass, anaerobic digestion and energy from waste), hydro, photovoltaics, wave and tidal energy and deep geothermal. Ofgem (which administers the RO) issues Renewables Obligation Certificates (ROCs) to qualifying renewable generators. These certificates may be sold by generators directly to licensed electricity suppliers or traders. Suppliers present ROCs to Ofgem to demonstrate their compliance with the obligation.

6.58 When the Obligation was first introduced, 1 ROC was awarded for each MWh of renewable electricity generated. In 2009, 'banding' was introduced into the RO, meaning different technologies now receive different numbers of ROCs depending on their costs and potential for large scale deployment; for example new offshore wind in Great Britain receives 1.8 ROCs/MWh while onshore wind receives 0.9 ROCs/MWh. The more established renewable technologies such as sewage gas receive 0.5 ROCs/MWh. A review of the bands across the UK concluded in 2012 and set the level of support under the RO from 1 April 2013 – 31 March 2017. Banding reviews ensure that, as market conditions and innovation within sectors change and evolve; renewables developers continue to receive the appropriate level of support necessary to maintain investments within available resources. The RO closed to large-scale solar PV (over 5MW) on 31 March 2015 and to small-scale solar (up to 5MW) on 31 March 2016. It also closed to all capacities of onshore wind in Great Britain on 12 May 2016 and to onshore wind over 5MW in Northern Ireland on 31 March 2016. The scheme will close to all other technologies on 31 March 2017, although existing generating stations will continue to receive support until 2037. Various grace periods are available which extend the closure date in certain specified situations. Details of the grace periods are available on Ofgem's website: www.ofgem.gov.uk/environmental-programmes/renewables-obligation-ro/information-generators/closure-renewables-obligation-ro . A list of technologies eligible for the RO, details of the RO banding review, and the level of ROCs received, is available: Calculating Renewable Obligation Certificates (ROCs) - Detailed guidance - GOV.UK

6.59 Table 6.4 contains a row showing the total electricity eligible for the RO. Prior to 2002 the main instruments for pursuing the development of renewables capacity were the Non Fossil Fuel Obligation (NFFO) Orders.

Electricity Market Reform (EMR)

6.60 Contracts for Difference will replace the RO for new renewable energy stations from April 2017 (although new stations have a choice between support mechanisms until the RO's closure at the end of March 2017). Contracts for Difference tackle the risks and uncertainties of the underlying economics of different forms of electricity generation by offering long term contracts for low carbon energy.

6.61 In effect, companies will get a fixed and secure price at which they can sell their electricity to consumers. This will allow investors to be confident about the returns of their capital in advance of investing billions into new infrastructure schemes. It will also encourage banks to lend at cheaper rates because the projects are less risky. Further details of the reforms are available at:
www.gov.uk/government/policies/maintaining-uk-energy-security--2/supporting-pages/electricity-market-reform

[7] Parliamentary approval of the Renewables Obligation Orders under The Utilities Act 2000 was given in March 2002. The Renewables Obligation covering England and Wales and the analogous Renewables (Scotland) Obligation came into effect in April 2002. Northern Ireland introduced a similar Renewables Obligation in April 2005. Strictly speaking until 2005, the RO covers only Great Britain, but in these UK based statistics Northern Ireland renewable sources have been treated as if they were also part of the RO.

Feed-in Tariffs (FiTs)

6.62 Feed-in tariffs are a financial support scheme for eligible low-carbon electricity technologies, aimed at small-scale installations with a capacity of less than 5 Megawatts (MW). FiTs support new anaerobic digestion (AD), solar photovoltaic (PV), small hydro and wind, by requiring electricity suppliers to make payments (generation tariffs) to these generators based on the number of kilowatt hours (kWh) they generate. An additional guaranteed export tariff is paid for electricity generated that is not used on site and exported to the grid. The scheme also supports micro-combined heat and power (micro-CHP) installations with an electrical capacity of 2kW or less, as a pilot programme.

6.63 The number of PV installations, particularly on domestic properties, increased rapidly at the start of the FIT scheme. The rate of increase slowed significantly after August 2012 following tariff reductions introduced to reflect the rapidly falling costs of solar modules. A cost control mechanism (contingent degression) was also introduced, following a comprehensive review in 2011/12. A further review of the scheme occurred in 2015 covering all technologies except micro-CHP. This implemented a deployment cap of up to £100m for new expenditure by 2018/19. The budget is split across technologies and sub-divided into quarterly caps. If a quarterly cap is hit, tariffs are reduced through contingent degression. Tariffs are also reduced automatically every quarter (default degression). Similar proposals for micro-CHP installations regarding a deployment cap and contingent degression are being consulted on in 2016.

6.64 Tariff changes implemented as a result of the reviews only affect new entrants to the scheme. Policy information and statistical reports relating to FiTs can be found at:
www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/feed-in-tariffs-scheme and www.gov.uk/government/organisations/department-of-energy-climate-change/series/feed-in-tariff-statistics

6.65 In the first five years of FITs (April 2010 – March 2015) over 680,000 installations, totalling over 3.5GW of installed capacity has been registered under the scheme. This is significantly ahead of original projections (750,000 installations by 2020), and has resulted in an annual spend considerably above the original budget estimates.

Renewable Transport Fuel Obligation (RTFO)

6.66 The Renewable Transport Fuel Obligation, introduced in April 2008, placed a legal requirement on road transport fuel suppliers (who supply more than 450,000 litres of fossil petrol, diesel or renewable fuel per annum to the UK market) to ensure that 4.75 per cent (by volume) of their overall fuel sales are from a renewable source by 2013/14 and all subsequent years, with incremental levels of 2.5 per cent (by volume) for 2008/09, 3.25 per cent (by volume) in 2009/10, 3.5 per cent (by volume) in 2010/11, 4.0 per cent (by volume) in 2011/12, and 4.5 per cent (by volume) in 2012/13. Under the RTFO all obligated companies are required to submit data to the RTFO administrator on volumes of fossil and renewable fuels they supply. Renewable Transport Fuel certificates are issued in proportion to the quantity of biofuels registered.

6.67 The RTFO (amendment) Order, made in 2011, introduced mandatory carbon and sustainability criteria for all renewable fuels and double rewards for some fuel types, including those made from waste and residue materials. From April 2013 the end uses covered by the RTFO were amended to include non-road mobile machinery, agriculture and forestry tractors and recreational craft when not at sea. Further information on the RTFO policy can be found at:
www.gov.uk/government/publications/rtfo-guidance

6.68 The verified RTFO biofuels statistics, including information on origin and sustainability from 2008 onwards can be found at: www.gov.uk/government/collections/biofuels-statistics.

6.69 The Department for Transport will be consulting in 2016 on proposals to increase the obligation from 2017 and set a trajectory to 2020 and beyond.

Renewable Heat Incentive and Premium Payment

6.70 The Renewable Heat Incentive (RHI) scheme is a government financial incentive scheme introduced to encourage a switch to renewable heating systems in place of fossil fuels. The tariff based scheme is split into two parts:

- The non-domestic RHI scheme which has been open to commercial, industrial, public sector, not for profit and community generators of renewable heat since November 2011.
- The domestic RHI scheme which opened on 9 April 2014 and is available to homeowners, private and social landlords and people who build their own homes.

Further information on this scheme, including details of the technologies, can be found at: www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/renewable-heat-incentive-rhi.

6.71 The Renewable Heat Premium Payment (RHPP) voucher scheme, launched in August 2011, made one-off payments to householders to help them buy renewable heating technologies. This scheme closed on the 31 March 2014 prior to the introduction of the domestic RHI scheme. Further information on the RHPP can be found at: www.gov.uk/renewable-heat-premium-payment-scheme, with further data available at www.gov.uk/government/collections/renewable-heat-incentive-renewable-heat-premium-payment-statistics.

Table 6E below shows the breakdown of technologies accredited to the domestic scheme, over the period 9 April 2014 (launch date) to 31 December 2015, with average installed capacity and heat paid out for under the scheme. In total there were 26,628 installations, with 597,909 MWh of heat generated and paid for. Further data and information relating to the RHI can be found at: www.gov.uk/government/collections/renewable-heat-incentive-statistics.

Table 6E: Domestic Renewable Heat Incentive accreditations, average capacity installed and estimated heat generation to December 2015

Technology	Number of accreditations	Average (mean) capacity installed (kW)	Heat paid out under the scheme (MWh)
Air source heat pump	19,921	10.0	163,276
Ground source heat pump	6,522	12.2	91,582
Biomass systems	11,223	25.9	332,348
Solar thermal	7,445	-	10,705
Total	**45,111**	**-**	597,909

Sources of Renewable Energy

Use of passive solar energy

6.72 Nearly all buildings make use of some existing (passive) solar energy because they have windows or roof lights, which allow in natural light and provide a view of the surroundings. This existing use of passive solar energy is making a substantial contribution to the energy demand in the UK building stock. Passive solar design (PSD), in which buildings are designed to enhance solar energy use, results in additional energy savings. The installed capacity of PSD in the UK and other countries can only be estimated and is dependent on how the technology is defined. The unplanned benefit of solar energy for heating and lighting in UK buildings is estimated to be 145 TWh per year. The figure is very approximate and, as in previous years, has therefore not been included in the tables in this chapter. Only a few thousand buildings have been deliberately designed to exploit solar energy – a very small proportion of the total UK building stock. It has been estimated that the benefit of deploying PSD in these buildings is equivalent to a saving of about 10 GWh per year.

Active solar heating

6.73 Active solar heating employs solar collectors to heat water mainly for domestic hot water systems but also for swimming pools and other applications. There are primarily two key designs: flat-plate, comprising a dark absorbing material with a cover to reduce heat loss and a liquid – usually water with antifreeze – to extract the heat from the absorber, and evacuated-tube collectors that use heat pipes for their core to extract the energy instead of passing liquid directly through them. Planning permission is required for free-standing domestic solar panels of more than $9m^2$, but the more common form of installation is the roof mounted scheme which does not require planning permission.

6.74 Updated figures on the contribution of active solar heating have been calculated by Ricardo Energy and Environment (on behalf of BEIS) based on sales figures from the Solar Trade Association (STA) and the European Solar Thermal Industry Foundation (ESTIF) and using a conversion methodology recommended by the IEA Solar Heat and Cooling Programme and ESTIF which can be found at:
http://www.estif.org/no_cache/st_energy/area_to_energy_conversion_method/?sword_list[]=method

The figures reported are currently made up of two inputs:

- STA sales data, recently revised by applying a scaling factor of 1.2, (as done by ESTIF) to take into account that not the whole market is reported by the STA.
- An estimate of active solar for some designs of swimming pools not covered by the STA.

The model was updated in 2015 to correct the fact that the growth rates applied to swimming pools had been too high previously. This year, the model was further improved by allowing for equipment replacement after 20 years of operation and also for a small reduction in efficiency with age of the system.

6.75 For 2015, active solar heating replaced an estimated 262 GWh of gas (80 per cent) and electricity (20 per cent) for domestic hot water generation and an estimated 141 GWh of gas (45 per cent), oil (45 per cent) and electricity (10 per cent) for swimming pool heating.

Solar photovoltaics (PV)

6.76 Photovoltaics is the direct conversion of solar radiation into direct current electricity by the interaction of light with the electrons in a semiconductor device or cell. Since April 2010 support for small scale (less than 5 MW) solar PV and other micro-generation technologies in Great Britain has been provided by FiTs (see paragraph 6.62), resulting in a rapid expansion in solar PV capacity. Larger-scale (> 50 kW) solar PV and all installations in Northern Ireland are supported by the Renewables Obligation (RO) (see paragraph 6.57)[8]. Generation data are available for sites accredited under the RO (via ROCs issued), but are not currently available for other schemes, including those supported by FiTs. Where generation data are not available, this has been estimated using the methodology to be found at: www.gov.uk/government/statistics/energy-trends-december-2013-special-feature-article-estimating-generation-from-feed-in-tariff-installations

Onshore wind power

6.77 Onshore wind is one of the most mature renewable energy technologies. The UK has a good onshore wind resource, with wind speeds particularly good in Scotland, Northern Ireland and Wales but less good in England, particularly in the South East. A wind turbine extracts energy from the wind by means of a rotor (usually a three-bladed horizontal-axis rotor) that can be pitched to control the rotational speed of a shaft linked via a gearbox to a generator.

6.78 The rate of installation of new wind farms slowed down in 2015 after increasing year on year with the introduction of the Renewables Obligation (RO) in April 2002 and FiT in 2010. Turbine size has continued to steadily increase over the years and the average new turbine size for operational schemes over the last 5 years is around 2.5 MW. For those schemes under construction, however, this is moving towards 3 MW. Some of the early projects which were installed around 20 years ago have re-powered (replaced ageing turbines with more efficient ones) as increased tower height

[8] Eligible GB schemes between 50 kW and 5 MW capacity can currently choose between the RO and FiTs.

associated with increased turbine size has increased wind capture (wind speed generally increases with height above ground level) and turbine design has improved and become more sophisticated leading to improvements in efficiency. The figures included for generation from wind turbines are based on actual metered exports from the turbines and, where these data are unavailable, are based on estimates using regional load factors (see paragraphs 6.24 to 6.29 regarding load factors) and the wind farm installed capacity.

6.79 In the small-medium wind market (15–100 kW), generated energy is used to satisfy on-site demand. Small-scale wind system technology can be subdivided into three categories: micro wind turbines (0–1.5 kW), small wind turbines (1.5–15 kW) and small–medium wind turbines (15–100 kW). The two main designs are the horizontal axis wind turbines (HAWT) and vertical axis wind turbines (VAWT).

6.80 In terms of operational characteristics, siting considerations and the value and nature of the market, small-scale wind systems vary markedly from large-scale units. Small-scale wind systems can be off-grid or on-grid; mobile or fixed; free-standing or building-mounted; or they can form part of combined installations, most commonly with photovoltaic systems. As a result, they have a greater range of applications, compared to large-scale wind turbines and can be used in commercial, public or domestic settings and as single or multiple installations providing power to communities.

Offshore wind power

6.81 The UK has some of the best offshore wind resource in Europe, with relatively shallow waters and strong winds. The Renewable Energy Roadmap (referred to in paragraph 6.56) highlights offshore wind as a key technology that will help the UK meet the 2020 RED target, with a potential deployment by 2020 of up to 18 GW subject to cost reduction. This would correspond to around 17 per cent of the UK's net electricity production.

6.82 Offshore winds tend to blow at higher speeds and are more consistent than on land, thus allowing turbines to produce more electricity (because the potential energy produced from the wind is directly proportional to the cube of the wind speed, increased wind speeds of only a few miles per hour can produce a significantly larger amount of electricity) but it is more costly to implement than onshore wind. However, onshore constraints such as planning, noise effects, visual impact and the effects of transportation of large components are reduced offshore. As a result, offshore turbines are generally larger than their onshore counterparts, with the current commercially available turbines having a rated capacity of between 3 and 6 MW; a number of larger, offshore specific turbines, however, are currently being developed. Floating concepts are also being developed as they are considered by many to be more viable (both economically and environmentally) in deeper waters.

6.83 In the development of the UK's offshore wind capacity, the Crown Estate have run a number of leasing rounds under which areas of the seabed have been made available for the development of offshore wind farms. Round 1 started in December 2000 and Round 2 in July 2003 and 7.2 GW have already been enabled from these two rounds. In January 2010, the Crown Estate announced the successful development partners for each of nine new Round 3 offshore wind zones, with a potential installed capacity of up to 33 GW. The Round 3 zones were identified using the Crown Estate's marine asset planning expertise and by consultation with key national stakeholders. Construction of the Round 3 capacity is expected to begin in the next few years, though not all projects will be constructed and all projects will be subject to the relevant planning process.

Marine energy (wave and tidal stream power)

6.84 Ocean waves are created by the interaction of winds with the surface of the sea. Because of the UK's position on the north eastern rim of the Atlantic it has some of the highest wave power levels in the world. Tidal currents are created by the movement of the tides, often magnified by local topographical features such as headlands and channels. Tidal current energy is the extraction of energy from this flow, analogous to the extraction of energy from moving air by wind turbines. Tidal range power can be extracted from tidal barrage and tidal lagoon systems. With a tidal barrage across an estuary, water is collected during the flood tide, creating a head of water. During the ebb tide the water flows out of the pool through low-head hydro turbines thus generating electricity. Some technologies also allow generation on ebb and flood. A tidal lagoon works in a similar manner, but an artificial pool is used to collect the water. The UK is still seen as the world leader in wave and tidal stream technology, however a number of other countries are rapidly developing sites for wave and tidal installations with the associated supply chain such as Canada, France, South Korea and Australia.

6.85 In 2015, The Crown Estate announced a new programme of leasing for small scale wave and tidal current test and demonstration projects under 3MW. This allows developers to apply for leases when their technology is ready and they have raised sufficient finance rather than being restricted to leasing calls. This also provides greater opportunities for turbines of 100kW or less to be deployed, with a large number of developers successfully commissioning small scale prototype turbines. This will continue in 2016, which will also see Atlantis, Andritz Hydro, Hammerfest Hydro, Open Hydro and ScotRenewables commission multi MW devices.

6.86 Wave power devices continue to be developed at a slower rate than tidal devices. Aquamarine Power with its Oyster device joined Pelamis falling into administration. Conversely, newly formed Wave Energy Scotland is now playing a leading role in the UK in supporting the development of wave energy technologies.

6.87 The Swansea Bay tidal barrage project continued development through 2015, however in early 2016 this was put on hold whilst a review is carried out by the UK Government to determine, amongst other things, in what circumstances, tidal lagoons could play a cost effective role as part of the UK energy mix. The review is expected to be completed by autumn 2016.

Large scale hydro

6.88 In hydro schemes the turbines that drive the electricity generators are powered by the direct action of water either from a reservoir or from the run of the river. Large-scale hydro covers plants with a capacity of 5 MW and over and most of the plants are located in Scotland and Wales and mainly draw their water from high-level reservoirs with their own natural catchment areas. Major Power Producers (MPPs) report their output to BEIS in regular electricity surveys. Prior to 2004 these data were submitted in aggregate form and not split down by size of scheme. This meant that some small-scale schemes were hidden within the generation data for the large-scale schemes. Since 2004 MPPs have provided a more detailed breakdown of their data and some smaller sites included under “large scale” before 2004 are now under “small scale”. The data in this Chapter excludes pumped storage stations (see paragraph 5.74). The UK has one mixed pump storage and natural flow hydro station, at Foyers in Scotland. Whilst it is primarily a pumped storage site, the generation attributed to the natural flow component of this station can be calculated, and is included in the large-scale hydro generation figures in this Chapter. However, the natural flow share of the capacity cannot be separated, and is therefore not included.

Small scale hydro

6.89 Hydro electricity generation schemes with a capacity below 5 MW are classified as small scale. These are schemes for either domestic/farm purposes or for local sale to electricity supply companies. Currently there are 281.9 MW of installed small-scale hydro schemes. Of this, 68 per cent is owned by small-scale energy producers with the remainder owned by major power producers. There are 715 FiTs and 270 non-FiTs schemes in operation; 86 per cent of these non-FiTs schemes claim ROCs and 7 schemes have current NFFO contracts.

Deep geothermal energy

6.90 There are two broad types of deep geothermal technology, for direct heat use (where temperatures are above 60^oC) and for power generation (though normally for combined heat and power) usually where the resource temperature is above 120^oC. The UK’s deep geothermal resources include hot aquifers (i.e. subterranean bodies of water) in the North East, Wessex and Cheshire and the ‘hot dry rocks’ in Cornwall which are likely to have the greatest potential (at 5km depth) for power generation. There are two simple models for deep geothermal projects. Where a hot aquifer has been identified, it is possible to simply pump the hot water to the surface and use it directly, for example in a heat network. The water then needs to be either disposed of or re-injected into the ground via a second borehole. An alternative model is to pump cold water from the surface down into a volume of hot rock, exploiting existing fractures in the rock or creating these through Enhanced Geothermal System techniques, and then recovering it to the surface once it has been heated.

6.91 Deep geothermal electricity generation is eligible for support under the Renewables Obligation. Deep geothermal energy for direct heat use is eligible for support under the Renewable Heat Incentive. The Government has also provided grant support for the sector. At present there are no deep geothermal power plants in the UK. The UK's only existing geothermal heat generating station is at Southampton, where an 1800m borehole taps into the edge of the aquifer under Wessex and provides heat to the Southampton district heat network, although this borehole is currently being refurbished.

6.92 Up to December 2013 geothermal was supported in the non-domestic RHI under the ground source heat pump tariff but a separate bespoke tariff for deep geothermal heat was introduced after this. The tariff is set at 5.08p/kWh from 1 April 2015, and deep geothermal heat is defined as coming from a drilling depth of a minimum of 500m.

Heat pumps

6.93 A ground source heat pump (GSHP) uses electricity to power a vapour compression cycle to pump heat from underground heat exchange coils and boreholes to a target heating system. An air source heat pump (ASHP) uses a vapour compression cycle to pump heat from ambient air to the target heating system. The ASHP data included in the Digest are air to water heat pumps extracting heat from external air only, and the renewable energy component of exhaust air systems, extracting heat from the exhaust air of a building.

6.94 Heat pumps use electricity to operate the compression cycle. The ratio of the heating output of a heat pump over the amount of electricity it uses gives the coefficient of performance (COP) of the heat pump. The seasonal performance factor (SPF), is the average COP for a heat pump over a whole year and reflects the efficiency a heat pump achieves when installed. The Renewable Energy Directive (Annex VII) sets out the equation for calculating how much of the energy generated by heat pumps should be considered renewable and a minimum SPF is part of that equation. The SPF is dependent on pan-EU average electricity generation efficiency. Heat pumps which do not meet the minimum SPF are not counted as renewable under the Directive. The latest available guidance from the European Commission gives a minimum SPF of 2.5. Guidance on measuring the contribution of heat pumps for the RED was produced by the European Commission in March 2013, and data in the 2014 edition of the Digest used this methodology. Eurostat now requires that renewable heat statistics should include renewable heat from all heat pumps, including those with an SPF lower than the minimum required under RED. This edition of DUKES follows the Eurostat methodology.

6.95 There have been a number of changes to values used in calculation of the renewable heat contribution this year. This is due to the availability of updated information on locations and capacities of heat pumps installed under the RHI and actual performance of domestic heat pumps installed in the UK under the RHPP. This is in line with advice from the European Commission to utilise country specific information where available and to opt for conservative estimates.

6.96 Estimates on number of heat pumps installed since 2008 continue to be based on sales information from BSRIA, a research organisation. It is assumed that there was no significant contribution from heat pumps installed before 2008. . All heat pumps installed after 2008 are assumed to contribute to renewable heat production in the UK. Average SPF values for all UK heat pumps are currently based on EU default values.

6.97 The contribution of energy from heat pumps is included in the Digest for 2008 onwards, in tables 6.1-6.3 and 6.6. For example, the output (less the electricity used to run the pump) is included in the production line in table 6.1, with the amount of this consumed by sector detailed within the final consumption sector below.

Bioenergy and wastes

(a) Landfill gas

6.98 Landfill gas is a methane-rich gas formed from the natural decomposition of organic material in landfill sites. The gas can be used to fuel reciprocating engines or turbines to generate electricity or used directly in kilns and boilers. In other countries, the gas is cleaned to pipeline quality or used as a vehicle fuel. Landfill gas exploitation benefited considerably from NFFO and this resulted in a large rise in electricity generation from 1992. Information on generation comes from Renewables Obligation Certificates (ROCs), supplemented by a RESTATS survey carried out by Ricardo Energy & Environment in 2008 on behalf of BEIS.

(b) Sewage sludge digestion

6.99 Sewage sludge digestion is the break down of the solid part of sewage by natural bacteria in a sealed tank in the absence of oxygen to produce a methane rich sewage gas. Some plants only use the sewage gas to generate heat but many use combined heat and power (CHP) systems, with the electricity generated being used on site or sold. Information on the projects was provided from the CHPSTATS Database, which is compiled and maintained by Ricardo Energy & Environment on behalf of BEIS (see Chapter 7). The majority of the information in the database is gathered through the CHP Quality Assurance (CHPQA) Programme. However, many sewage treatment works are not part of the CHPQA Programme and information on these plants comes from ROCs data. Estimates of electrical efficiencies and heat to power ratios typical of the technology and capacity are used to determine fuel inputs and heat outputs. In this year's statistics, data for 89 per cent of the schemes (98 per cent of the capacity) were from RESTATS (i.e. ROCs) with the remainder from CHPQA; all schemes, however, were vetted by CHPQA before being accepted by RESTATS.

(c) Domestic wood combustion

6.100 Domestic wood use includes the use of wood fuel in open fires, "AGA"-type cooker boilers, modern biomass boilers and other wood burning stoves. Domestic wood use was for a long time estimated based on the historic survey results of 1989.

6.101 During the survey of 2003, Ricardo Energy & Environment were asked to examine an accumulating body of anecdotal evidence that implied that there was considerable growth in this area, suggesting that the use of this resource might be being underestimated. This was based on the amount that was being burnt on open fires rather than dedicated wood-burning stoves, which had previously been overlooked. A revision in 2003 to subsequent domestic wood use figures was based on a 50 per cent growth rate in sales/installations of wood-burning stoves for each 2-3 year period since 2000, supported with anecdotal information from the sources listed below:

- HETAS, the official body recognised by Government to approve solid fuel domestic heating appliances, fuels and services;
- the National Association of Chimney Sweeps; and
- Discussions with a risk assessor acting on behalf of insurance companies.

6.102 Estimates from 2003 to 2013 were based on 2002 baseline data that were then extrapolated forward using information from annual discussions with representatives of the associations listed above. The estimates were then peer reviewed by the Forestry Commission prior to publication. Degree-day corrections were added, based on those used for seasonally adjusted and temperature corrected final energy consumption figures for gas, to model increased fuel use during colder weather[9]. These degree-day normalisation factors are based on monthly correction data and are weighted differently to those calculated using annual degree days. A degree day change in winter is likely to result in increased use of fuel for heating whereas this is unlikely in summer. The accuracy of these estimates was, however, dependent on the accuracy of the baseline figures for domestic wood use in 2002.

6.103 In 2014 BEIS commissioned a one-off, large scale, user survey of domestic wood fuel consumption in the UK. The purpose of the survey was to provide a new baseline for domestic wood fuel use in the UK. The survey was part of a weekly face to face omnibus survey and was conducted in England, Wales and Scotland. A separate dedicated survey was commissioned in Northern Ireland. A total of 16,046 households were surveyed, with 1,206 (7.5 per cent) confirmed as wood fuel users,

[9] www.gov.uk/government/uploads/system/uploads/attachment_data/file/295406/et1_3.xls

which is lower than the recent estimate of 12 per cent from the smaller scale Forestry Commission Public Opinion of Forestry 2013 survey. Information was collected on number, type and frequency of use of domestic wood fuel appliances and on types and quantities of wood fuels purchased over the previous year.

6.104 Wood fuel use was estimated by two independent methods. Firstly the appliance data was used to estimate total hours of operation in the year and wood fuel use was then calculated using standard data for appliance wood fuel use per hour. Secondly, the total wood fuel use was calculated from respondent estimates of quantities of wood fuel they had purchased in the past year.

6.105 There are uncertainties associated with each method. The appliance method is indirect in that respondents had to estimate how many hours per week they operated their appliances in winter and summer, and a standard factor for wood use per hour for each appliance type was required. For the second method respondents had to estimate the amount of wood fuel that was delivered in the past year, which many found challenging. It was also assumed that the wood used equalled the delivered wood.

6.106 Although both methodologies confirmed the anecdotal evidence that domestic wood fuel use has been consistently underestimated, the two estimates differed by a factor of almost two, with the estimate from wood fuel purchased being higher. This can be partially explained by timing issues; wood is purchased in anticipation of a heating season and if winter proves warmer than expected, then not all wood purchased would necessarily be burned. Average heating degree days[10] for 2014 were 21 per cent lower than in 2013, and 19 per cent lower than the long term mean (1981 to 2010). This compares to questions relating to appliance usage where the responses relate directly to the period being considered.

6.107 The lower estimate of 1,554 ktoe has been used in the current statistics as feedback from the survey confirmed that providing an accurate response to the appliance usage approach proved to be considerably less challenging than estimating actual wood fuel use. In addition, previous surveys have also indicated that the appliance method is more reliable because it is notoriously difficult to obtain reliable estimates from the general public for energy derived from burning wood which can vary depending on the species, quantity and moisture content of the wood. The survey data were further analysed this year and a special feature article was published in the March 2016 edition of Energy Trends[11] , but the new baseline figure has remained unchanged for the 2015 statistics as the more detailed analysis of the higher estimate has proved to be more time consuming that first envisaged and is still ongoing.

6.108 This new baseline was used with an uplift based on industry sales figures, and applying a weather correction methodology. In addition, this year the model has been modified to allow for a replacement rate for existing installation of 2 per cent based on the views of the Renewable Energy Association and Delta EE. Calorific values were also revised upwards following research into current typical values.

(d) Non-domestic wood combustion

6.109 In 1997, the industrial wood figure (which includes sawmill residues, furniture manufacturing waste etc.) was included as a separate category for the first time. Surveys in 2000 and 2006 highlighted that the in-house use of wood wastes had declined due to the imposition of more stringent emissions controls. Since these surveys, there has been increased interest in the use of wood, usually from forestry and woodland management but also in-house and recycled by-products. Typically these are being used for space heating and hot water in commercial and public sector properties such as hotels, schools, hospitals, nursing homes, poultry farms, horticulture, and government buildings. This has been almost exclusively in response to incentives, most notably the Renewable Heat Incentive which has supported some 5,031 GWh of heat from biomass, mostly wood, to December 2015 since its inception in November 2011. This is equivalent to some 1,184 thousand tonnes of commercial wood pellets.

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[11] www.gov.uk/government/publications/energy-trends-march-2016-special-feature-article-summary-results-of-the-domestic-wood-use-survey

(e) Energy crops and forestry residues

6.110 Miscanthus and Short Rotation Coppice (SRC) are grown in the UK as energy crops intended for the heat and electricity energy markets. To date they have been burnt in power stations, CHP units and heating systems. Official area estimates of Miscanthus and SRC grown in England are available from 2008 in the Defra June survey of Agricultural statistics, and have been summarised by Defra[12]. These show that only small areas of these crops are currently planted in England, with estimates of about 7,000ha of Miscanthus and 2,900ha of SRC in 2014. Based on Renewables Obligation sustainability reporting data, Defra estimate that about 22,000 tonnes of UK Miscanthus and 6,700 tonnes of UK SRC was used in UK power stations in 2013/14. Data for 2015 are not yet available but are unlikely to be too dissimilar.

(f) Straw combustion

6.111 Straw can be burnt in high temperature boilers, designed for the efficient and controlled combustion of solid fuels and biomass to supply heat, hot water and hot air systems. There are large numbers of these small-scale batch-fed whole bale boilers.

6.112 Historically, the figures used were estimates based partly on 1990 information and partly on a survey of straw-fired boilers carried out in 1993-94 but these were always considered to be a particularly weak estimate. A BEIS/Defra initiative to investigate opportunities to improve these data resulted in questions on the end use of straw being introduced to the Cereal and Oilseed Production survey in 2014[13]. The total straw used for energy in 2014 was estimated to be 551.2 ktoe. Excluding straw that was used for co-firing and in dedicated straw power stations, this leaves a remainder of 206.5 kt (77.8 ktoe) assumed to have been used for heat production in 2014, not dissimilar to 200 ktoe (75.3 ktoe) reported in previous editions of the Digest. As no time series data are available to amend historic time series data or estimate growth rates, a linear growth rate has been assumed to back-correct to 2008. The same value for 2014 has been used for 2015 data.

6.113 A 40 MW straw-fired power station near Ely, Cambridgeshire and the 45MW Sleaford straw-fired power station are currently the only electricity generation schemes in operation.

(g) Waste combustion

6.114 Domestic, industrial and commercial wastes represent a significant resource for materials and energy recovery. Unprocessed wastes may be combusted in purpose built incinerators or the waste can be processed into a range of refuse derived fuels (RDF) for both on-site and off-site use. RDF can be partially processed to produce coarse RDF that can then be burnt in a variety of ways. By further processing the refuse, including separating off the fuel fraction, compacting, drying and densifying, it is possible to produce an RDF pellet. This pellet has around 60 per cent of the gross calorific value of British coal. Only the biodegradable portion of waste is counted in renewables statistics although non-biodegradable wastes are included in this chapter as “below the line” items. The paragraphs below describe various categories of waste combustion in greater detail.

6.115 **Municipal solid waste (MSW) combustion:** MSW comprises domestic waste plus other feedstocks, such as, general industrial waste, building demolition waste and tree clippings from civil amenities. Sample areas for the analysis of household collected waste are selected using ACORN socio-economic profiles (ACORN stands for A Classification Of Residential Neighbourhoods). This is based on the premise that households of similar socio-economic characteristics are likely to have similar behavioural, purchasing and lifestyle characteristics; this will be reflected in the quantity and composition of waste that those households produce. For several years, the analysis calculated that UK domestic waste had a biodegradable content of 67.5 per cent $\pm$ 1 per cent and this accounted for about 62.5 per cent of the energy generated from its combustion but work in 2009 revised this upwards to 63.5 per cent. The success of recycling strategies, however, has gradually changed the composition of waste available for combustion and the biodegradable content is now considered to be about 50 per cent which has been used since the 2014 survey but will continue to be reviewed periodically. As no time series data are available to amend historic time series data, a linear change in composition over this period has been assumed to back-correct to 2009. Information on the direct combustion of unprocessed MSW and the combustion of RDF was provided via a RESTATS questionnaire.

[12] www.gov.uk/government/uploads/system/uploads/attachment_data/file/483812/nonfood-statsnotice2014-10dec15.pdf

[13] www.gov.uk/government/uploads/system/uploads/attachment_data/file/483812/nonfood-statsnotice2014-10dec15.pdf

6.116 **General industrial waste (GIW) combustion:** Certain wastes produced by industry and commerce can be used as a source of energy for industrial processes or space heating. These wastes include general waste from factories such as paper, cardboard, wood and plastics. A survey conducted in 2001 noted that GIW was now burnt in MSW waste-to-energy facilities. As no sites are solely burning GIW for heat or electricity generation, this feedstock is being handled under the MSW category.

6.117 In 2015, 47 energy from waste plants were in operation, burning municipal solid waste (MSW), refuse derived fuel (RDF) and general industrial waste (GIW).

6.118 **Specialised waste combustion:** Specialised wastes arise as a result of a particular activity or process. Materials in this category include scrap tyres, hospital wastes, poultry litter, meal and bone and farm waste digestion.

6.119 **Specialist non-biodegradable waste**. Although the large tyre incineration plant with energy recovery has not generated since 2000, the cement industry has burned some waste tyres in its cement and lime kilns. Although part of waste tyre combustion is of biodegradable waste, because there is no agreed method of calculating the small biodegradable content, all of the generation from waste tyres has been included under non-biodegradable wastes in this chapter.

6.120 **Hospital waste**. Information is based on a RESTATS survey undertaken in 2007, repeated in 2010 and reviewed again in 2013. Additional information on sites that reclaim energy was obtained from the Environment Agency's clinical waste incineration database. The results continue to show an ongoing process of centralisation and consolidation, in response to changes in pollution emissions and clinical waste regulations. Generation is focusing on larger plants and many smaller facilities have closed as they were no longer viable due to the cost of compliance with regulations. One heat producing scheme was found to have closed.

6.121 **Animal biomass**. One poultry litter combustion project started generating electricity in 1992; a second began in 1993. Both of these are NFFO projects. In addition, a small-scale CHP scheme began generating towards the end of 1990. However, this has now closed due to new emissions regulations. A further NFFO scheme started generating in 1998, and during 2000 a SRO scheme began to generate. A further poultry litter scheme became fully operational in 2001. One of the earlier poultry litter projects was modified to be fuelled mainly by meat and bone; two additional schemes fuelled primarily by meat and bone have also been built.

(h) Anaerobic digestion (AD)

6.122 Anaerobic Digestion uses natural bacteria to break down biomass in a sealed tank in the absence of oxygen to produce a methane rich biogas. The biomass fuel includes wet wastes such as animal manures and slurries, crop residues and food waste and/ or purpose grown crops such as maize. The biogas can be used for process heat, or for heat and electricity generation using a combined heat and power unit. Alternatively, the biogas can be upgraded to biomethane for use in transport applications or injection into the gas grid. The leftover indigestible material is called digestate; this is rich in nutrients and can be used as a fertiliser. Digestate can be used whole and spread on land. Alternatively, it can be separated into liquor and fibres. Separated fibre can be used fresh as a soil conditioner or, after further aerobic composting to stabilise it, the material is suitable for making into a compost product.

6.123 Information on operational AD sites in the UK was obtained from a number of sources including; the CHPSTATS database, information from previous AD surveys conducted for RESTATS, the AD portal run by the National Non-Food Crops Centre (NNFCC), the Renewable Energy Association (REA), the Renewable Energy Planning Database, Waste & Resources Action Programme (WRAP), ROC, FiT and RHI returns and Ricardo Energy & Environment internal information. Electricity and heat production was estimated using survey information, where available, or information from ROC, FiT and RHI if no survey information existed. Where neither of these sources was available, the energy production was calculated from the capacity using an estimated load factor. The load factor was based on ROC data from operating schemes and date of commissioning where applicable for electricity schemes, and on historic load factors for heat only schemes. Of the 351 electricity-generating AD plants operating at the end of 2015, 67 (72.1 MW) qualified as CHP plant under CHPSTATS. An additional 20 were heat only and 23 were producing bio-methane for grid injection. The majority of the heat-only schemes were small on-farm installations.

(i) Co-firing of biomass with fossil fuels

6.124 Compared with some other renewables, co-firing has a relatively low capital cost and is quick to implement. Biomass fuel is usually fed into a conventional power station boiler by means of the existing firing mechanism as a partial substitute for fossil fuel. The pulverised fuel preparation, transport and combustion system of a modern power plant may cope with approximately 5 - 10 per cent substitution without any major mechanical changes. The boiler design and airflows however may permit much higher percentages if the burner systems are modified. Specially designed burners have been introduced on some installations in the UK.

(j) Biodiesel and bioethanol (Liquid Biofuels for Transport)

6.125 In the UK biodiesel is defined for taxation purposes as diesel quality liquid fuel produced from biomass or waste vegetable and animal oils and fats, the ester content of which is not less than 96.5 per cent by weight and the sulphur content of which does not exceed 0.005 per cent by weight or is nil. Bioethanol is defined for taxation purposes as a liquid fuel consisting of ethanol produced from biomass and capable of being used for the same purposes as light oil. For further information, see HMRC Notice 179E: Biofuels and other fuel substitutes, available at:
www.gov.uk/government/publications/excise-notice-179e-biofuels-and-other-fuel-substitutes/excise-notice-179e-biofuels-and-other-fuel-substitutes

6.126 Diesel fuel currently sold at retail outlets in the UK can contain up to 7 per cent biodiesel. Petrol currently sold in at retail outlets in the UK can contain up to 5% bioethanol. Since March 2013 a revised petrol standard (EN228) allows retailers to sell petrol containing up to 10% ethanol by volume (E10), if appropriately labelled[14]. Quantities of biodiesel and bioethanol consumed in the UK in Calendar Year 2015 are based on information available from RTFO statistics[15] reports, specifically Y7 report 6 and Y8 report 3.

Combined Heat and Power (CHP)

6.127 A CHP plant is an installation where useful heat and power (usually electricity) are supplied from a single generation process. Some CHP installations are fuelled either wholly or partially by renewable fuels. The main renewable fuel currently used in CHP is sewage gas, closely followed by other biomass.

6.128 Chapter 7 of this Digest summarises information on the contribution made by CHP to the UK's energy requirements in 2010 to 2015 using the results of annual studies undertaken to identify all CHP schemes (CHPSTATS). Included in Tables 7.1 to 7.9 of that chapter is information on the contribution of renewable sources to CHP generation in each year from 2010 to 2015. Corresponding data for 1996 to 2008 are available on the BEIS section of the gov.uk website. The information contained in those tables is therefore a subset of the data contained within the tables presented in this chapter. There are occasionally differences in the numbers reported by CHPSTATS compared with RESTATS that are primarily attributed to whether the electricity is considered to come from 'good quality' CHP (further details on 'good quality' CHP are provided in Chapter 7). In addition, there are oddities with some CHP facilities where both biomass and fossil fuels are burnt (though not always as co-firing). The total installed capacity recorded for the site under CHPSTATS can cover multiple generators, some of which only handle fossil fuels (e.g. gas turbines). As it would be misleading to record the entire capacity reported in RESTATS as being potentially available for renewables generation, only the appropriate capacity figures are recorded.

Generating capacity and load factor

6.129 The electrical capacities are given in Table 6.4 as installed capacities i.e. the maximum continuous rating of the generating sets in the stations. In Chapter 5 Declared Net Capacity (DNC) is used, i.e. the maximum continuous rating of the generating sets in the stations, less the power consumed by the plant itself, and reduced by a specified factor to take into account the intermittent nature of the energy source e.g. 0.43 for wind, 0.365 for small hydro, 0.33 for shoreline wave, and

[14] www.gov.uk/government/uploads/system/uploads/attachment_data/file/232126/petrol-protection-extention-ia.pdf
[15] www.gov.uk/government/collections/biofuels-statistics

0.17 for solar photovoltaics. DNC represents the nominal maximum capability of a generating set to supply electricity to consumers. For electrical capacities of generation using renewables in DNC terms see Table 6.1.1 on the BEIS section of the gov.uk website.

6.130 Plant load factors shown in Table 6.5 have been calculated in terms of installed capacity (i.e. the maximum continuous rating of the generating sets in the stations) and express the average hourly quantity of electricity generated as a percentage of the average of the capacities at the beginning and end of the year. Additionally, the unchanged configuration load factor has now been used for a number of years, which calculates the amount of electricity generated from wind farms compared with the amount that such turbines would have generated had they been available for the whole of the calendar year and running continually and at maximum output throughout the calendar year.

6.131 It is recognised that one of the shortcomings of the data contained in the Digest (end of calendar year) is that finalised ROCs data are often not available for several months following the compilation process for the Digest. In particular this can have an impact on the schemes included in the unchanged configuration definition as new data could include or remove particular schemes. This should be kept in mind if users wish to reanalyse these results.

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6.1 Commodity balances 2015

Renewables and waste

Thousand tonnes of oil equivalent

	Wood waste	Wood	Poultry litter, meat and bone, and farm waste	Straw, SRC, and other plant-based biomass (4)	Sewage gas	Landfill gas
Supply						
Production	814	2,009	830	1,446	364	1,612
Other sources	-	-	-	-	-	-
Imports	50	35	-	2,836	-	-
Exports	-73	-138	-	-37	-	-
Marine bunkers	-	-	-	-	-	-
Stock change *(1)*	-	-	-	-	-	-
Transfers	-	-	-	-	-	-
Total supply (2)	**791**	**1,906**	**830**	**4,245**	**364**	**1,612**
Statistical difference *(3)*	-	-	-	-	-	-
Total demand	**791**	**1,906**	**830**	**4,245**	**364**	**1,612**
Transformation	**-**	**-**	**704**	**3,892**	**291**	**1,598**
Electricity generation	-	-	704	3,885	291	1,598
Major power producers	-	-	209	3,381	-	-
Autogenerators	-	-	495	505	291	1,598
Heat generation	-	-	-	7	-	-
Petroleum refineries	-	-	-	-	-	-
Coke manufacture	-	-	-	-	-	-
Blast furnaces	-	-	-	-	-	-
Patent fuel manufacture	-	-	-	-	-	-
Other	-	-	-	-	-	-
Energy industry use	**-**	**-**	**-**	**-**	**-**	**-**
Electricity generation	-	-	-	-	-	-
Oil and gas extraction	-	-	-	-	-	-
Petroleum refineries	-	-	-	-	-	-
Coal extraction	-	-	-	-	-	-
Coke manufacture	-	-	-	-	-	-
Blast furnaces	-	-	-	-	-	-
Patent fuel manufacture	-	-	-	-	-	-
Pumped storage	-	-	-	-7	-	-
Other	-	-	-	-	-	-
Losses	**-**	**-**	**-**	**-**	**-**	**-**
Final consumption	**791**	**1,906**	**126**	**352**	**73**	**14**
Industry	**791**	**-**	**31**	**138**	**-**	**14**
Unclassified	791	-	31	138	-	14
Iron and steel	-	-	-	-	-	-
Non-ferrous metals	-	-	-	-	-	-
Mineral products	-	-	-	-	-	-
Chemicals	-	-	-	-	-	-
Mechanical engineering, etc	-	-	-	-	-	-
Electrical engineering, etc	-	-	-	-	-	-
Vehicles	-	-	-	-	-	-
Food, beverages, etc	-	-	-	-	-	-
Textiles, leather, etc	-	-	-	-	-	-
Paper, printing, etc	-	-	-	-	-	-
Other industries	-	-	-	-	-	-
Construction	-	-	-	-	-	-
Transport	**-**	**-**	**-**	**-**	**-**	**-**
Air	-	-	-	-	-	-
Rail	-	-	-	-	-	-
Road	-	-	-	-	-	-
National navigation	-	-	-	-	-	-
Pipelines	-	-	-	-	-	-
Other	**-**	**1,906**	**95**	**214**	**73**	**-**
Domestic	-	1,906	-	-	-	-
Public administration	-	-	-	-	73	-
Commercial	-	-	-	-	-	-
Agriculture	-	-	95	214	-	-
Miscellaneous	-	-	-	-	-	-
Non energy use						

(1) Stock fall (+), stock rise (-).
(2) Including non-biodegradable wastes, which accounted for 1,147 ktoe.
(3) Total supply minus total demand.
(4) SRC is short rotation coppice.
(5) Municipal solid waste, general industrial waste and hospital waste.
(6) The amount of marine energy included is 0.2 ktoe.

6.1 Commodity balances 2015 (continued)

Renewables and waste

Thousand tonnes of oil equivalent

	Waste *(5)* and tyres	Geothermal, active solar heat and PV	Heat pumps	Hydro	Wind and marine energy *(6)*	Liquid biofuels	Total renewables
Supply							
Production	2,243	702	168	541	3,466	325	14,519
Other sources	-	-	-	-	-	-	-
Imports	-	-	-	-	-	796	3,717
Exports	-	-	-	-	-	-117	-366
Marine bunkers	-	-	-	-	-	-	-
Stock change *(1)*	-	-	-	-	-	-	-
Transfers	-	-	-	-	-	-	-
Total supply *(2)*	**2,243**	**702**	**168**	**541**	**3,466**	**1,003**	**17,870**
Statistical difference *(3)*	-	-	-	-	-	-	-
Total demand	**2,243**	**702**	**168**	**541**	**3,466**	**1,003**	**17,870**
Transformation	**2,041**	**650**	**-**	**541**	**3,466**	**-**	**13,183**
Electricity generation	1,971	650	-	541	3,466	-	13,106
Major power producers	471	121	-	422	2,860	-	7,463
Autogenerators	1,500	529	-	119	607	-	5,644
Heat generation	69	-	-	-	-	-	76
Petroleum refineries	-	-	-	-	-	-	-
Coke manufacture	-	-	-	-	-	-	-
Blast furnaces	-	-	-	-	-	-	-
Patent fuel manufacture	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-
Energy industry use	-	-	-	-	-	-	-
Electricity generation	-	-	-	-	-	-	-
Oil and gas extraction	-	-	-	-	-	-	-
Petroleum refineries	-	-	-	-	-	-	-
Coal extraction	-	-	-	-	-	-	-
Coke manufacture	-	-	-	-	-	-	-
Blast furnaces	-	-	-	-	-	-	-
Patent fuel manufacture	-	-	-	-	-	-	-
Pumped storage	-2	-	-	-	-	-	-
Other	-	-	-	-	-	-	-
Losses	-	-	-	-	-	-	-
Final consumption	**202**	**52**	**168**	**-**	**-**	**1,003**	**4,688**
Industry	**126**	**-**	**3**	**-**	**-**	**-**	**1,102**
Unclassified	126	-	3	-	-	-	1,102
Iron and steel	-	-	-	-	-	-	-
Non-ferrous metals	-	-	-	-	-	-	-
Mineral products	-	-	-	-	-	-	-
Chemicals	-	-	-	-	-	-	-
Mechanical engineering, etc	-	-	-	-	-	-	-
Electrical engineering, etc	-	-	-	-	-	-	-
Vehicles	-	-	-	-	-	-	-
Food, beverages, etc	-	-	-	-	-	-	-
Textiles, leather, etc	-	-	-	-	-	-	-
Paper, printing, etc	-	-	-	-	-	-	-
Other industries	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-
Transport	-	-	-	-	-	**1,003**	**1,003**
Air	-	-	-	-	-	-	-
Rail	-	-	-	-	-	-	-
Road	-	-	-	-	-	1,003	1,003
National navigation	-	-	-	-	-	-	-
Pipelines	-	-	-	-	-	-	-
Other	**76**	**52**	**166**	**-**	**-**	**-**	**2,582**
Domestic	18	51	113	-	-	-	2,088
Public administration	47	0	-	-	-	-	121
Commercial	10	0	53	-	-	-	64
Agriculture	-	-	-	-	-	-	310
Miscellaneous	-	-	-	-	-	-	-

6.2 Commodity balances 2014

Renewables and waste

Thousand tonnes of oil equivalent

	Wood waste	Wood	Poultry litter, meat and bone, and farm waste	Straw, SRC, and other plant-based biomass (4)	Sewage gas	Landfill gas
Supply						
Production	556r	1,767r	636r	1,171r	345	1,668
Other sources	-	-	-	-	-	-
Imports	24	14	-	2,190r	-	-
Exports	-79	-83	-	-44	-	-
Marine bunkers	-	-	-	-	-	-
Stock change *(1)*	-	-	-	-	-	-
Transfers	-	-	-	-	-	-
Total supply (2)	**501r**	**1,698r**	**636r**	**3,317r**	**345**	**1,668**
Statistical difference *(3)*	-	-	-	-	-	-
Total demand	**501r**	**1,698r**	**636r**	**3,317r**	**345**	**1,668**
Transformation	**-**	**-**	**559r**	**2,944**	**277**	**1,655**
Electricity generation	-	-	559r	2,938	277	1,655
Major power producers	-	-	195	2,583	-	-
Autogenerators	-	-	364r	355	277	1,655
Heat generation	-	-	-	6	-	-
Petroleum refineries	-	-	-	-	-	-
Coke manufacture	-	-	-	-	-	-
Blast furnaces	-	-	-	-	-	-
Patent fuel manufacture	-	-	-	-	-	-
Other	-	-	-	-	-	-
Energy industry use	**-**	**-**	**-**	**-**	**-**	**-**
Electricity generation	-	-	-	-	-	-
Oil and gas extraction	-	-	-	-	-	-
Petroleum refineries	-	-	-	-	-	-
Coal extraction	-	-	-	-	-	-
Coke manufacture	-	-	-	-	-	-
Blast furnaces	-	-	-	-	-	-
Patent fuel manufacture	-	-	-	-	-	-
Pumped storage	-	-	-	-	-	-
Other	-	-	-	-	-	-
Losses	**-**	**-**	**-**	**-**	**-**	**-**
Final consumption	**501r**	**1,698r**	**77r**	**373r**	**68**	**14**
Industry	**501r**	**-**	**35**	**127**	**-**	**14**
Unclassified	501r	-	35	127	-	14
Iron and steel	-	-	-	-	-	-
Non-ferrous metals	-	-	-	-	-	-
Mineral products	-	-	-	-	-	-
Chemicals	-	-	-	-	-	-
Mechanical engineering, etc	-	-	-	-	-	-
Electrical engineering, etc	-	-	-	-	-	-
Vehicles	-	-	-	-	-	-
Food, beverages, etc	-	-	-	-	-	-
Textiles, leather, etc	-	-	-	-	-	-
Paper, printing, etc	-	-	-	-	-	-
Other industries	-	-	-	-	-	-
Construction	-	-	-	-	-	-
Transport	**-**	**-**	**-**	**-**	**-**	**-**
Air	-	-	-	-	-	-
Rail	-	-	-	-	-	-
Road	-	-	-	-	-	-
National navigation	-	-	-	-	-	-
Pipelines	-	-	-	-	-	-
Other	**-**	**1,698r**	**43**	**246r**	**68**	**-**
Domestic	-	1,698r	-	-	-	-
Public administration	-	-	-	-	68	-
Commercial	-	-	-	-	-	-
Agriculture	-	-	43	246r	-	-
Miscellaneous	-	-	-	-	-	-
Non energy use	**-**	**-**	**-**	**-**	**-**	**-**

(1) Stock fall (+), stock rise (-).
(2) Including non-biodegradable wastes, which accounted for 856 ktoe.
(3) Total supply minus total demand.
(4) SRC is short rotation coppice.
(5) Municipal solid waste, general industrial waste and hospital waste.
(6) The amount of marine energy included is 0.2 ktoe.

6.2 Commodity balances 2014 (continued)

Renewables and waste

Thousand tonnes of oil equivalent

Waste *(5)* **and tyres**	**Geothermal, active solar heat and PV**	**Heat pumps**	**Hydro**	**Wind and marine energy** *(6)*	**Liquid biofuels**	**Total renewables**	
							Supply
1,622r	398r	108	507r	2,749r	423	11,950r	Production
-	-	-	-	-	-	-	Other sources
-	-	-	-	-	975	3,203r	Imports
-	-	-	-	-	-155	-361	Exports
-	-	-	-	-	-	-	Marine bunkers
-	-	-	-	-	-	-	Stock change *(1)*
-	-	-	-	-	-	-	Transfers
1,622r	**398r**	**108**	**507r**	**2,749r**	**1,243**	**14,792r**	**Total supply** *(2)*
-	-	-	-	-	-	-	**Statistical difference** *(3)*
1,622r	**398r**	**108**	**507r**	**2,749r**	**1,243**	**14,792r**	**Total demand**
1,441r	**347r**	**-**	**507r**	**2,749r**	**-**	**10,480r**	**Transformation**
1,386r	347r	-	507r	2,749r	-	10,418r	Electricity generation
379	-	-	398	2,301	-	5,856	Major power producers
1,007r	347r	-	108	448r	-	4,562r	Autogenerators
55r	-	-	-	-	-	62r	Heat generation
-	-	-	-	-	-	-	Petroleum refineries
-	-	-	-	-	-	-	Coke manufacture
-	-	-	-	-	-	-	Blast furnaces
-	-	-	-	-	-	-	Patent fuel manufacture
-	-	-	-	-	-	-	Other
-	-	-	-	-	-	-	**Energy industry use**
-	-	-	-	-	-	-	Electricity generation
-	-	-	-	-	-	-	Oil and gas extraction
-	-	-	-	-	-	-	Petroleum refineries
-	-	-	-	-	-	-	Coal extraction
-	-	-	-	-	-	-	Coke manufacture
-	-	-	-	-	-	-	Blast furnaces
-	-	-	-	-	-	-	Patent fuel manufacture
-	-	-	-	-	-	-	Pumped storage
-	-	-	-	-	-	-	Other
-	-	-	-	-	-	-	**Losses**
181r	**50r**	**108**	**-**	**-**	**1,243**	**4,312r**	**Final consumption**
97r	**-**	**2**	**-**	**-**	**-**	**776r**	**Industry**
97r	-	2	-	-	-	776r	Unclassified
-	-	-	-	-	-	-	Iron and steel
-	-	-	-	-	-	-	Non-ferrous metals
-	-	-	-	-	-	-	Mineral products
-	-	-	-	-	-	-	Chemicals
-	-	-	-	-	-	-	Mechanical engineering, etc
-	-	-	-	-	-	-	Electrical engineering, etc
-	-	-	-	-	-	-	Vehicles
-	-	-	-	-	-	-	Food, beverages, etc
-	-	-	-	-	-	-	Textiles, leather, etc
-	-	-	-	-	-	-	Paper, printing, etc
-	-	-	-	-	-	-	Other industries
-	-	-	-	-	-	-	Construction
-	-	-	-	-	**1,243**	**1,243**	**Transport**
-	-	-	-	-	-	-	Air
-	-	-	-	-	-	-	Rail
-	-	-	-	-	1,243	1,243	Road
-	-	-	-	-	-	-	National navigation
-	-	-	-	-	-	-	Pipelines
84r	**50r**	**105**	**-**	**-**	**-**	**2,294r**	**Other**
21	50r	61	-	-	-	1,829r	Domestic
51r	0	-	-	-	-	120r	Public administration
12	0	45	-	-	-	57	Commercial
-	-	-	-	-	-	289r	Agriculture
-	-	-	-	-	-	-	Miscellaneous
-	**-**	**-**	**-**	**-**	**-**	-	**Non energy use**

6.3 Commodity balances 2013

Renewables and waste

Thousand tonnes of oil equivalent

	Wood waste	Wood	Poultry litter, meat and bone, and farm waste	Straw, SRC, and other plant-based biomass (4)	Sewage gas	Landfill gas
Supply						
Production	399r	1,890r	512r	879r	318	1,706
Other sources	-	-	-	-	-	-
Imports	32	5	-	1,576r	-	-
Exports	-56	-104	-	-46	-	-
Marine bunkers	-	-	-	-	-	-
Stock change *(1)*	-	-	-	-	-	-
Transfers	-	-	-	-	-	-
Total supply (2)	**374r**	**1,790r**	**512r**	**2,409r**	**318**	**1,706**
Statistical difference *(3)*	-	-	-	-	-	-
Total demand	**374r**	**1,790r**	**512r**	**2,409r**	**318**	**1,706**
Transformation	**1**	**-**	**465r**	**2,070**	**250**	**1,692**
Electricity generation	-	-	465r	2,063	250	1,692
Major power producers	-	-	199	1,819	-	-
Autogenerators	-	-	265r	244	250	1,692
Heat generation	1	-	-	8	-	-
Petroleum refineries	-	-	-	-	-	-
Coke manufacture	-	-	-	-	-	-
Blast furnaces	-	-	-	-	-	-
Patent fuel manufacture	-	-	-	-	-	-
Other	-	-	-	-	-	-
Energy industry use	**-**	**-**	**-**	**-**	**-**	**-**
Electricity generation	-	-	-	-	-	-
Oil and gas extraction	-	-	-	-	-	-
Petroleum refineries	-	-	-	-	-	-
Coal extraction	-	-	-	-	-	-
Coke manufacture	-	-	-	-	-	-
Blast furnaces	-	-	-	-	-	-
Patent fuel manufacture	-	-	-	-	-	-
Pumped storage	-	-	-	-	-	-
Other	-	-	-	-	-	-
Losses	**-**	**-**	**-**	**-**	**-**	**-**
Final consumption	**374r**	**1,790r**	**48**	**338r**	**68**	**14**
Industry	**374r**	**-**	**29**	**127**	**-**	**14**
Unclassified	374r	-	29	127	-	14
Iron and steel	-	-	-	-	-	-
Non-ferrous metals	-	-	-	-	-	-
Mineral products	-	-	-	-	-	-
Chemicals	-	-	-	-	-	-
Mechanical engineering, etc	-	-	-	-	-	-
Electrical engineering, etc	-	-	-	-	-	-
Vehicles	-	-	-	-	-	-
Food, beverages, etc	-	-	-	-	-	-
Textiles, leather, etc	-	-	-	-	-	-
Paper, printing, etc	-	-	-	-	-	-
Other industries	-	-	-	-	-	-
Construction	-	-	-	-	-	-
Transport	**-**	**-**	**-**	**-**	**-**	**-**
Air	-	-	-	-	-	-
Rail	-	-	-	-	-	-
Road	-	-	-	-	-	-
National navigation	-	-	-	-	-	-
Pipelines	-	-	-	-	-	-
Other	**-**	**1,790r**	**19**	**211r**	**68**	**-**
Domestic	-	1,790r	-	-	-	-
Public administration	-	-	-	-	68	-
Commercial	-	-	-	-	-	-
Agriculture	-	-	19	211r	-	-
Miscellaneous	-	-	-	-	-	-
Non energy use	**-**	**-**	**-**	**-**	**-**	**-**

(1) Stock fall (+), stock rise (-).
(2) Including non-biodegradable wastes, which accounted for 668 ktoe.
(3) Total supply minus total demand.
(4) SRC is short rotation coppice.
(5) Municipal solid waste, general industrial waste and hospital waste.
(6) The amount of marine energy included is 0.5 ktoe.

6.3 Commodity balances 2013 (continued)

Renewables and waste

Thousand tonnes of oil equivalent

Waste*(5)* **and tyres**	**Geothermal, active solar heat and PV**	**Heat pumps**	**Hydro**	**Wind and marine** *energy (6)*	**Liquid biofuels**	**Total renewables**	
							Supply
1,283r	221r	88	404	2,442r	542r	10,684r	Production
-	-	-	-	-	-	-	Other sources
-	-	-	-	-	591r	2,203r	Imports
-	-	-	-	-	-41	-247	Exports
-	-	-	-	-	-	-	Marine bunkers
-	-	-	-	-	-	-	Stock change *(1)*
-	-	-	-	-	-	-	Transfers
1,283r	**221r**	**88**	**404**	**2,442r**	**1,092**	**12,640r**	**Total supply** *(2)*
-	-	-	-	-	-	-	**Statistical difference** *(3)*
1,283r	**221r**	**88**	**404**	**2,442r**	**1,092**	**12,640r**	**Total demand**
1,099r	**173r**	**-**	**404**	**2,442r**	**-**	**8,596r**	**Transformation**
1,078	173r	-	404	2,442r	-	8,566r	Electricity generation
385	-	-	310	2,060	-	4,774	Major power producers
693	173r	-	94	382r	-	3,793r	Autogenerators
21r	-	-	-	-	-	30r	Heat generation
-	-	-	-	-	-	-	Petroleum refineries
-	-	-	-	-	-	-	Coke manufacture
-	-	-	-	-	-	-	Blast furnaces
-	-	-	-	-	-	-	Patent fuel manufacture
-	-	-	-	-	-	-	Other
-	-	-	-	-	-	-	**Energy industry use**
-	-	-	-	-	-	-	Electricity generation
-	-	-	-	-	-	-	Oil and gas extraction
-	-	-	-	-	-	-	Petroleum refineries
-	-	-	-	-	-	-	Coal extraction
-	-	-	-	-	-	-	Coke manufacture
-	-	-	-	-	-	-	Blast furnaces
-	-	-	-	-	-	-	Patent fuel manufacture
-	-	-	-	-	-	-	Pumped storage
-	-	-	-	-	-	-	Other
-	-	-	-	-	-	-	**Losses**
184r	**49r**	**88**	**-**	**-**	**1,092**	**4,044r**	**Final consumption**
90r	**-**	**2**	**-**	**-**	**-**	**636r**	**Industry**
90r	-	2	-	-	-	636r	Unclassified
-	-	-	-	-	-	-	Iron and steel
-	-	-	-	-	-	-	Non-ferrous metals
-	-	-	-	-	-	-	Mineral products
-	-	-	-	-	-	-	Chemicals
-	-	-	-	-	-	-	Mechanical engineering, etc
-	-	-	-	-	-	-	Electrical engineering, etc
-	-	-	-	-	-	-	Vehicles
-	-	-	-	-	-	-	Food, beverages, etc
-	-	-	-	-	-	-	Textiles, leather, etc
-	-	-	-	-	-	-	Paper, printing, etc
-	-	-	-	-	-	-	Other industries
-	-	-	-	-	-	-	Construction
-	-	-	-	-	**1,092**	**1,092**	**Transport**
-	-	-	-	-	-	-	Air
-	-	-	-	-	-	-	Rail
-	-	-	-	-	1,092	1,092	Road
-	-	-	-	-	-	-	National navigation
-	-	-	-	-	-	-	Pipelines
93r	**49r**	**86**	**-**	**-**	**-**	**2,317r**	**Other**
22	48r	49	-	-	-	1,909r	Domestic
55r	0	-	-	-	-	124r	Public administration
16	0	37	-	-	-	53	Commercial
-	-	-	-	-	-	230r	Agriculture
-	-	-	-	-	-	-	Miscellaneous
-	**-**	**-**	**-**	**-**	**-**	-	**Non energy use**

6.4 Capacity of, and electricity generated from, renewable sources

	2011	2012	2013	2014	2015
Installed Capacity (MW) *(1)*					
Wind:					
Onshore	4,629	5,904	7,516r	8,536r	9,188
Offshore	1,838	2,995	3,696	4,501	5,103
Marine energy (wave and tidal stream)	3	7	7	9	9
Solar photovoltaics	995	1,756	2,873r	5,424r	9,187
Hydro:					
Small scale	202	218	232r	252r	282
Large scale *(2)*	1,477	1,477	1,477	1,477	1,477
Bioenergy:					
Landfill gas	1,052	1,037	1,046r	1,058r	1,061
Sewage sludge digestion	198	204	199r	215r	216
Energy from waste *(3)*	505	517	545r	681r	925
Animal Biomass (non-AD)*(4)*	111	111	111	111	111
Anaerobic digestion	71	119	163r	238r	286
Plant Biomass *(5)*	1,149	1,171	1,955	2,245r	2,619
Total bioenergy and wastes	3,085	3,159	4,019r	4,548r	5,219
Total	12,230	15,515	19,820r	24,747r	30,465
Co-firing (6)	338	204	35	16	21
Generation (GWh)					
Wind:					
Onshore *(7)*	10,503	12,232	16,924r	18,562r	22,887
Offshore	5,149	7,603	11,472	13,404	17,423
Marine energy (wave and tidal stream) *(8)*	1	4	6	2	2
Solar photovoltaics	244	1,352	2,008r	4,040r	7,561
Hydro:					
Small scale *(7)*	691	654	678r	839r	975
Large scale *(2)*	4,989	4,631	4,026	5,053	5,314
Bioenergy:					
Landfill gas	5,085	5,145	5,160	5,045	4,872
Sewage sludge digestion	764	719	761	846	888
Biodegradable energy from waste *(9)*	1,503	1,774	1,649	1,923r	2,782
Co-firing with fossil fuels	2,964	1,783	309	133	183
Animal Biomass *(4)*	615	643	628	614	648
Anaerobic digestion	273	501	726r	1,019r	1,429
Plant Biomass *(5)*	1,749	4,083	8,929	13,105	18,587
Total bioenergy	12,953	14,648	18,163r	22,684r	29,388
Total generation	34,529	41,124	53,278r	64,584r	83,550
Non-biodegradable wastes *(10)*	1,085	1,429	1,481	1,923r	2,784
Total generation from sources eligible for the Renewable Obligation *(11)*	28,919	33,406	44,958r	53,157r	67,813

(1) Capacity on a DNC basis is shown in Long Term Trends Table 6.1.1 available on the DECC web site - see paragraph 6.5.
(2) Excluding pumped storage stations. Capacities are as at the end of December.
(3) Includes waste tyres and hospital waste.
(4) Includes the use of poultry litter and meat & bone.
(5) Includes the use of straw combustion and short rotation coppice energy crops.
(6) This is the proportion of fossil fuelled capacity used for co-firing of renewables based on the proportion of generation accounted for by the renewable source.
(7) Actual generation figures are given where available, but otherwise are estimated using a typical load factor or the design load factor, where known.
(8) Includes electricity from the EMEC test facility.
(9) Biodegradable part only.
(10) Non-biodegradable part of municipal solid waste plus waste tyres, hosptal waste and general industrial waste.
(11) See paragraphs 6.56 to 6.58 for definition and coverage.

6.5 Load factors for renewable electricity generation

					Per cent
	2011	2012	2013	2014	2015
Load factors - based on average beginning and end of year capacity (1)					
Wind	30.1	29.4	32.2	30.1	33.7
Onshore wind	27.6	26.4	28.8	26.4	29.5
Offshore wind	37.0	35.8	39.1	37.3	41.4
Marine energy (wave and tidal stream)	3.8	8.3	9.6	3.2	2.6
Solar photovoltaics	5.1	11.2	9.9	11.1	11.8
Hydro	39.0	35.7	31.6	39.1	41.2
Hydro (small scale)	40.9	35.5	34.4	39.6	41.7
Hydro (large scale)	38.8	35.7	31.1	39.1	41.1
Bioenergy (excludes cofiring and non-biodegradable wastes)	44.1	46.9	56.8	60.1	68.3
Landfill gas	56.3	56.1	56.6	54.8	52.5
Sewage sludge digestion	44.6	40.7	43.1	46.6	46.9
Energy from waste (3)	36.9	39.5	35.4	35.8	39.6
Animal Biomass (4)	63.5	66.2	64.9	63.4	66.9
Anaerobic Digestion	61.6	60.3	59.0	58.0	62.2
Plant Biomass (5)	27.3	40.1	65.2	71.2	87.2
All renewable technologies (excluding cofiring and non-biodegradable wastes)	33.6	32.3	34.2	33.0	34.5
Load factors - for schemes operating on an unchanged configuration basis (2)					
Wind	29.4	28.1	31.0	30.2	33.3
Onshore wind	27.2	25.6	27.9	26.4	29.4
Offshore wind	35.1	34.1	37.6	37.8	39.7
Solar photovoltaics				11.3	11.2
Hydro	41.5	35.3	31.5	38.8	39.5
Hydro (small scale)	43.2	36.7	35.2	39.6	41.8
Hydro (large scale)	41.4	35.1	31.2	38.8	39.2
Bioenergy (excludes cofiring and non-biodegradable wastes)	60.9	63.5	59.9	65.1	67.7
Landfill gas	59.4	58.8	56.9	55.1	52.6
Sewage sludge digestion	53.5	48.0	49.7	47.9	48.2
Energy from waste (3)	36.5	40.1	35.1	35.1	36.8
Animal Biomass (4)	69.0	66.2	70.4	63.4	66.9
Anaerobic Digestion	57.6	60.6	60.7	58.3	57.6
Plant Biomass (5)	60.9	67.2	61.6	70.5	74.3
All renewable technologies (excluding cofiring and non-biodegradable wastes)	37.2	36.2	35.5	38.1	38.2

(1) See paragraph 6.24 for details of the calculation.

(2) See paragraph 6.28 for details of the calculation.

(3) Calculation is based on biodegradable waste generation but all waste capacity; this reduces the load factor.

(4) Includes the use of poultry litter and meat & bone.

(5) Includes the use of straw combustion and short rotation coppice energy crops.

6.6 Renewable sources used to generate electricity and heat and for transport fuels*(1)(2)*

Thousand tonnes of oil equivalent

	2011	2012	2013	2014	2015
Used to generate electricity *(3)*					
Wind:					
Onshore	903.1	1,051.8	1,455.2r	1,596.0r	1,967.9
Offshore	442.7	653.8	986.4	1,152.6	1,498.1
Marine energy (wave and tidal stream) (4)	0.1	0.3	0.5	0.2	0.2
Solar photovoltaics	20.9	116.3	172.7r	347.4r	650.1
Hydro:					
Small scale	59.4	56.2	58.3r	72.2r	83.8
Large scale *(5)*	429.0	398.2	346.2	434.5	456.9
Bioenergy:					
Landfill gas	1,667.9	1,687.6	1,692.4	1,654.6	1,598.0
Sewage sludge digestion	250.4	235.9	249.6	277.4	291.1
Biodegradable energy from waste	567.4	638.5	564.7	689.9r	982.4
Co-firing with fossil fuels	763.5	400.5	53.7	25.1	37.8
Animal Biomass *(6)*	224.0	225.0	226.4	224.8	235.3
Anaerobic digestion	89.4	164.3	238.2r	334.1r	468.6
Plant Biomass *(7)*	553.7	1,062.3	2,009.1	2,912.9	3,847.6
Total bioenergy	4,116.4	4,414.1	5,034.1r	6,118.9r	7,460.7
Total	5,971.7	6,690.6	8,053.4r	9,721.8r	12,117.8
Non-biodegradable wastes *(8)*	415.5	520.3	513.1	696.2r	988.7
Used to generate heat					
Active solar heating	44.4	47.8	47.9r	49.6r	50.7
Bioenergy:					
Landfill gas	13.6	13.6	13.6	13.6	13.6
Sewage sludge digestion	64.3	63.7	68.3	67.7	73.1
Wood combustion - domestic	1,096.7	1,392.3	1,790.3r	1,698.1r	1,906.2
Wood combustion - industrial	281.9	289.5	374.2r	501.4r	790.8
Animal Biomass *(9)*	35.8	31.5	29.1	34.5	30.7
Anaerobic digestion	9.7	14.5	18.5r	42.9r	95.5
Plant Biomass *(10)*	289.6	276.6	346.0r	379.0r	359.4
Biodegradable energy from waste *(6)*	33.1	29.8	30.1	23.3	45.7
Total bioenergy	1,824.6	2,111.5	2,670.1r	2,760.6r	3,315.0
Deep geothermal	0.8	0.8	0.8	0.8	0.8
Heat Pumps	48.6	68.4	116.5r	142.5r	168.3
Total	1,918.4	2,228.4	2,835.3r	2,953.5r	3,534.8
Non-biodegradable wastes *(8)*	152.6	144.1	155.0	159.3	158.6
Renewable sources used as transport fuels					
as Bioethanol	367.5	436.9	462.2	458.8	449.1
as Biodiesel	760.0	520.9	629.4	783.8	554.1
Total	1,127.5	957.8	1,091.6	1,242.7	1,003.1
Total use of renewable sources and wastes					
Solar heating and photovoltaics	65.3	164.0	220.6r	396.9r	700.8
Onshore wind	903.1	1,051.8	1,455.2r	1,596.0r	1,967.9
Offshore wind	442.7	653.8	986.4	1,152.6	1,498.1
Marine energy (wave and tidal stream)	0.1	0.3	0.5	0.2	0.2
Hydro	488.4	454.4	404.5r	506.7r	540.7
Bioenergy	5,941.1	6,525.6	7,704.2r	8,879.6r	10,775.7
Deep geothermal	0.8	0.8	0.8	0.8	0.8
Heat Pumps	48.6	68.4	116.5r	142.5r	168.3
Transport biofuels	1,127.5	957.8	1,091.6	1,242.7	1,003.1
Total	9,017.6	9,876.9	11,980.3r	13,917.9r	16,655.7
Non-biodegradable wastes *(8)*	568.1	664.4	668.1	855.5r	1,147.3
All renewables and wastes *(11)*	9,585.8	10,541.2	12,648.4r	14,773.4r	17,803.0

(1) Includes some waste of fossil fuel origin.
(2) See the Digest of UK Energy Statistics for technical notes and definitions of the categories used in this table.
(3) For wind, solar PV and hydro, the figures represent the energy content of the electricity supplied but for bioenergy the figures represent the energy content of the fuel used.
(4) Includes the EMEC test facility.
(5) Excluding pumped storage stations.
(6) Includes electricity from poultry litter combustion and meat & bone combustion.
(7) Includes electricity from straw and energy crops.
(8) Non-biodegradable part of municipal solid waste plus waste tyres, hospital waste, and general industrial waste.
(9) Includes heat from farm waste digestion, and meat and bone combustion.
(10) Includes heat from straw, energy crops, paper and packaging.
(11) The figures in this row correspond to the total demand and total supply figures in Tables 6.1, 6.2 and 6.3.

6.7 Renewable sources data used to indicate progress under the 2009 EU Renewable Energy Directive (measured using net calorific values)

Thousand tonnes of oil equivalent

	2011	2012	2013	2014	2015
Electricity generation component:					
Normalised hydro generation *(1) (2)*	440	448r	444	447r	457
Normalised wind generation *(3)*	1,217	1,615	2,218r	2,717r	3,234
Electricity generation from renewables other than wind, hydro, and compliant biofuels	1,135	1,376	1,740r	2,298r	3,163
Electricity generation from compliant biofuels	-	-	-	-	1
Total renewable generation from all compliant sources	2,792r	3,438	4,402r	5,463r	6,854
Total Gross Electricity Consumption *(2)*	31,878	32,028	31,806r	30,594r	30,722
Percentage of electricity from renewable sources	8.8%	10.7%	13.8%	17.9%r	22.3%
Heat component:					
Renewable energy for heating and cooling	1,674r	1,925r	2,433r	2,536r	3,037
Total Gross energy consumption for heating and cooling	53,569r	57,988r	59,262r	52,689r	53,867
Percentage of heating and cooling energy from renewable sources	3.1%r	3.3%r	4.1%	4.8%	5.6%
Transport component (excluding air transport):					
Road transport renewable electricity	0	0	1	1	2
Non-road transport renewable electricity	69r	72r	81r	90r	96
Biofuels (restricted to those meeting sustainability criteria from 2011) *(4)*	1,063r	880r	1,048r	1,173r	1,004
Total electricity consumption in transport	366	367	374r	387r	385
Total petrol and diesel consumption in transport	37,217r	37,065r	36,777r	37,251r	37,974
Total transport component numerator (including weighted components) *(5)*	1,133r	1,406r	1,712r	1,948r	1,688
Total transport component denominator (including weighted components) (5)	38,647r	38,782r	38,782r	39,496r	39,949
Percentage of transport energy from renewable sources *(5)*	2.9%r	3.6%r	4.4%	4.9%r	4.2%
Overall directive target:					
Renewables used for:					
Electricity generation	2,722r	3,366r	4,321r	5,372r	6,757
Heating and Cooling	1,674r	1,925r	2,433r	2,536r	3,037
Transport biofuels (restricted to those meeting sustainability criteria from 2011)	1,132r	952r	1,129r	1,264r	1,102
Total Final Consumption of Renewable Energy ["Row A"]	5,529r	6,244r	7,883r	9,172r	10,896
Final Electricity Consumption *(6)*	26,962r	26,973r	26,817r	25,655r	25,647
Transport Final Energy Consumption (including air transport) *(7)*	51,001r	50,297r	50,107r	50,696r	51,394
Heating and Cooling Final Energy Consumption	53,558r	57,976r	59,252r	52,680r	53,857
Total Final Energy Consumption *(8)*	131,522r	135,247r	136,176r	129,031r	130,898
plus Distribution losses for electricity	2,419r	2,485r	2,379r	2,464r	2,361
plus Distribution losses for heat	-	-	-	-	-
plus Consumption of electricity in the electricity and heat generation sectors	1,413	1,545	1,535r	1,417r	1,434
plus Consumption of heat in the electricity and heat generation sectors	-	-	-	-	-
Gross Final Energy Consumption (GFEC)	135,353r	139,277r	140,090r	132,911r	134,692
of which Air transport	12,163r	11,786r	11,813r	11,779r	11,932
Air transport as a proportion of GFEC	8.99%r	8.46%r	8.43%r	8.86%r	8.86%
Air transport cap specificed in Directive	6.18%	6.18%	6.18%	6.18%	6.18%
Capped air transport	8,365r	8,607r	8,658r	8,214r	8,324
Capped Gross Final Energy Consumption (CGFEC) ["Row B"] *(9)*	131,555r	136,098r	136,935r	129,347r	131,084
Headline Directive percentage : Renewable Energy Consumption as a percentage of Capped Gross Final Energy Consumption ["Row A" divided by "Row B"]	4.2%	4.6%r	5.8%r	7.1%r	8.3%

(1) Based on a 15 year average hydro load factor.
(2) Excludes generation from pumped storage.
(3) Based on a 5 year average wind load factor.
(4) For the current year, an estimate has been made for the proportion of biofuels meeting the sustainability criteria
(5) Some sustainable biofuels are double weighted in the numerator of this calculation, as specified by the Directive.
(5) Final Electricity Consumption is Gross Electricity Consumption minus generators' own use of electricity and losses.
(7) Includes consumption of petrol and diesel, biofuels, other oil products, and coal.
(8) Total final consumption less non-energy use, as shown in Annex I, Table I.1, available on the DECC website.
(9) This row includes adjustments for loses, and generators own use of electricity, combined with the capping mechanism for air transport as specified in the Directive.