Chapter 6
Renewable sources of energy

Key points

Progress against the Renewable Energy Directive (RED) target

- **In 2016, 8.9 per cent of total energy consumption came from renewable sources;** up from 8.2 per cent in 2015. Renewable electricity represented 24.6 per cent of total generation; renewable heat 6.2 per cent of overall heat; and renewables in transport, 4.5 per cent.
- **The UK has now exceeded its third interim target;** averaged over 2015 and 2016, renewables achieved 8.5 per cent against its target of 7.5 per cent

Trends in generation

- **Electricity generation (table 6.4) in the UK from renewable sources fell marginally by 0.2 per cent between 2015 and 2016, to 83.2 TWh.** Lower rainfall and wind speeds resulted in lower hydro and wind generation, more than offsetting a 16 per cent increase in total capacity, to 35.7 GW in 2016 (table 6.4).
- For the second year running, **solar photovoltaics were the leading technology in capacity** terms at 11.9 GW, representing a third of total electricity capacity. This resulted in a 38 per cent increase in generation (table 6.4).
- **Onshore wind generation fell by 8.4 per cent to 21.0 TWh and offshore fell by 5.8 per cent to 16.4 GWh.** Wind speeds were lower than in 2015 which had been the highest in fifteen years, more than offsetting additional capacity for both onshore and offshore winds (table 6.4).
- **Generation from hydro sources fell by 14 per cent to 5.4 TWh in 2016**, although 2015 had seen the second highest rainfall during the preceding 15 years (table 6.4).

Renewable Heat

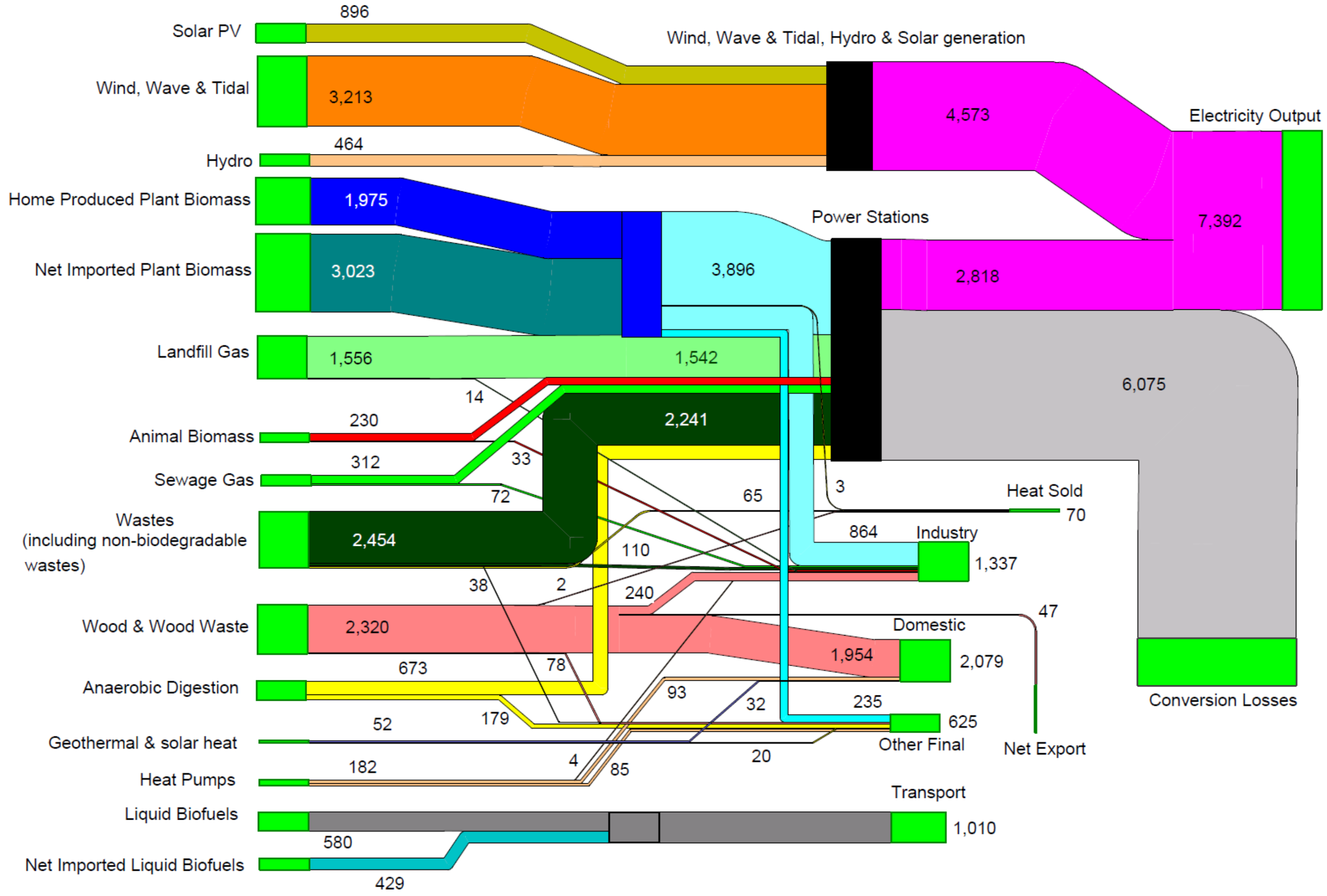
- **Renewable heat increased by 12 per cent** due to increases in plant biomass and anaerobic digestion schemes supported by the Renewable Heat Incentive (RHI)
- **The RHI supported 15 per cent of renewable heat in 2016**, an increase of 4.0 percentage points on 2015

Introduction

6.1 Energy from renewable sources has been steadily increasing since 2000 as a result of national and international incentives including the EU Renewable Energy Directive which requires the EU as a whole to achieve 20 per cent of its energy from renewable sources by 2020 (the UK's target is set at 15 per cent) (see the technical annex for a description of the policy context). The UK has a varied mix of renewable technologies including biomass which is a key fuel source in both electricity generation and heat. Wind, solar photovoltaics, hydro and shoreline wave and tidal also contribute to electricity generation and active solar, heat pumps and deep geothermal are used in heat generation (see the technical annex for descriptions of the sources of renewable energy). Liquid biofuels in transport also contribute to the separate RED transport target (for the UK, this is set at 10 per cent). Although solar photovoltaics was the leading technology in 2016 (a third of total capacity), in generation terms, bioenergy accounted for the largest proportion (36 per cent) followed by onshore wind (25 per cent) and offshore wind (20 per cent).

6.2 The renewable energy flow chart on page 154 summarises the flows of renewables from fuel inputs through to consumption for 2016 and includes energy lost in conversion; the data are sourced from the commodity balance table 6.1 and table 6.4 for electricity outputs.

Renewables flow chart 2016 (thousand tonnes of oil equivalent)



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

Renewable fuel demand (Tables 6.1 and 6.6)

6.3 The commodity balances tables for renewables (tables 6.1 to 6.3) show that a large proportion (83 per cent) of renewable fuel sources are produced domestically, largely due to the local nature of utilising natural resources such as wind, solar and hydro. However, bio energy fuels are transportable and a significant proportion is imported (27 per cent in 2016, including wood and liquid biofuels). Plant biomass showed the largest proportion of imports at 61 per cent, mainly wood pellets for electricity generation.

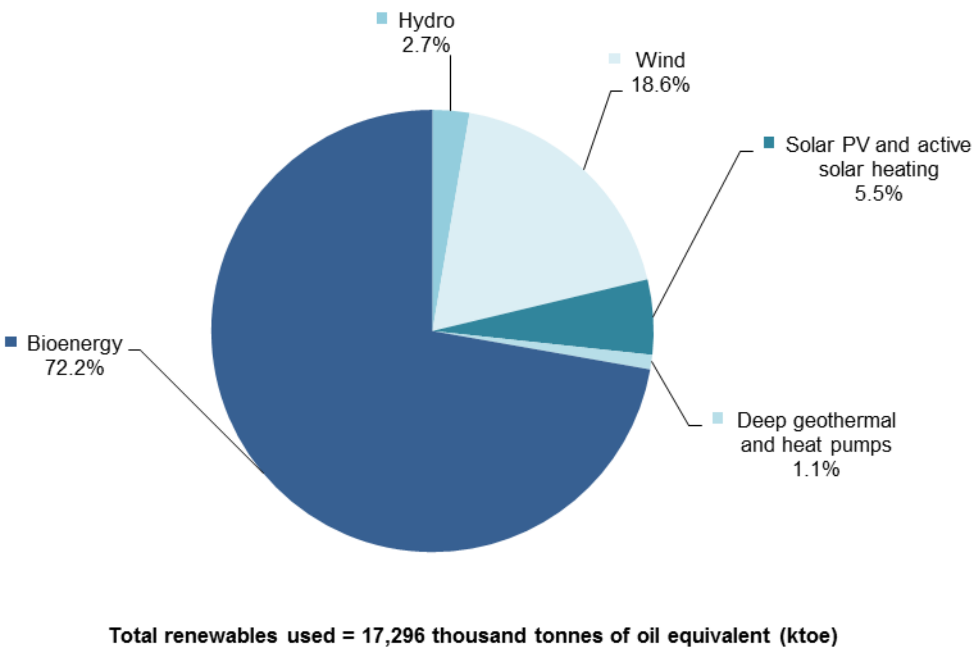
6.4 The balances also show for the first time, a transfer out from bioenergy. This represents biogas generated from farm waste digestion and injected into the gas grid. This has also been included for 2014 and 2015 as a revision (see paragraph 6.51). The amount transferred is then included as a positive transfer in the natural gas balance of chapter 4 (table 4.1).

6.5 Unlike other fuel sources, the renewables energy balances have zero statistical differences as the data are mostly taken from a single source where there is less likelihood of differences due to timing, measurement, or differences between supply and demand.

6.6 Table 6.6 shows how renewable fuel demand (excluding non-biodegradable waste) by source (i.e. on an input basis[1]) is split between electricity generation, heat and as a fuel in transport. Excluding non-biodegradable energy from waste, total demand in 2016 increased by 4.3 per cent, to 17,296 ktoe. This growth was due to an increase in bio energy demand, particularly in biodegradable energy from waste and anaerobic digestion used for electricity generation and also plant biomass used for heating purposes.

6.7 In 2016, 72 per cent of renewable energy demand was accounted for by bioenergy with wind accounting for 19 per cent. Chart 6.1 shows a comparison for the key renewables sources;

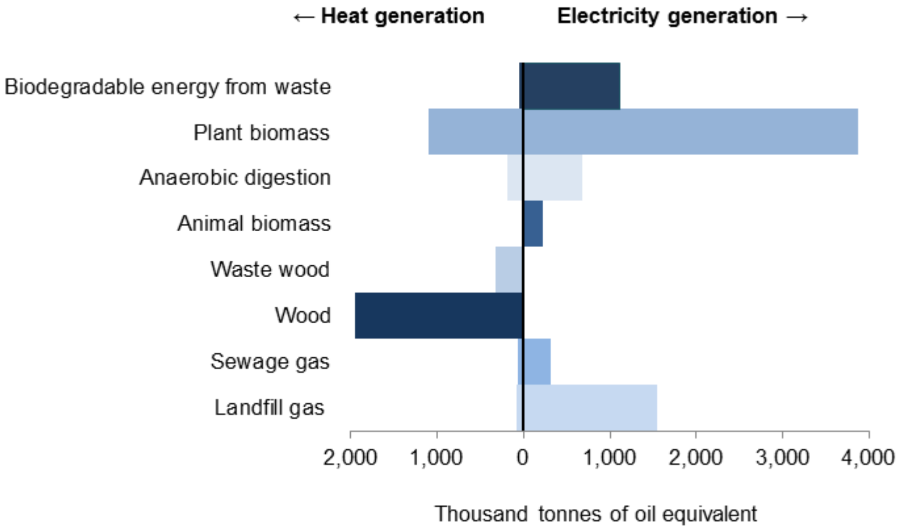
Chart 6.1: Renewable fuel use 2016



[1] For combustible fuels used to generate electricity, this refers to the energy value of the fuel source rather than the actual electricity generated. For heat generation and primary electricity sources (solar photovoltaics, wind, hydro, and wave and tidal), the output energy is deemed to be equal to the fuel inputs.

6.8 Whilst several renewable technologies are specific to either electricity generation or heat production, combustible fuels are used for both purposes. In 2016, 68 per cent of biomass was used in electricity generation. Chart 6.2 below shows a further breakdown of biomass by source and also how its use is split between heating and electricity generation.

Chart 6.2: Biomass fuel use 2016

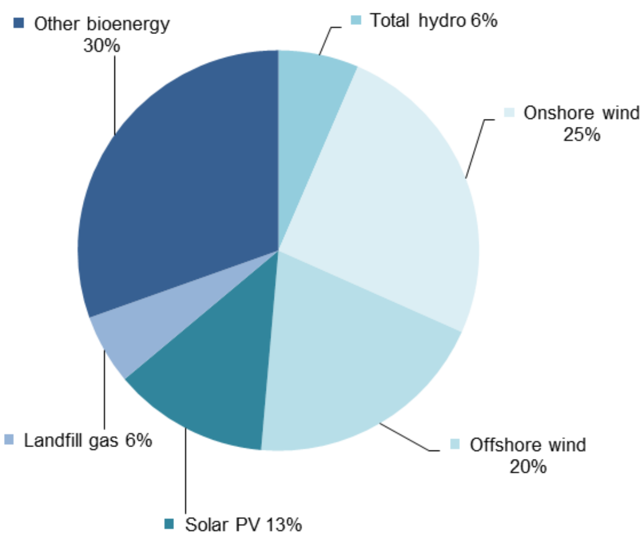


6.9 Where biofuels are used for generation, a comparison is made in the electricity generation section (paragraph 6.11) between the fuel input split and actual output generation.

Comparison of fuel use in heat consumption and electricity generation (Tables 6.6 and 6.4)

6.10 While bioenergy dominates on a fuel input basis (chart 6.1), hydroelectricity, wind power and solar together provide a larger contribution when the **output** of electricity is being measured as chart 6.3 shows;

Chart 6.3: Electricity generation by fuel source 2016



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, i.e. are deemed to be 100 per cent efficient (see Chapter 5, paragraph 5.71). 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 (6,075 ktoe in 2016), as the renewables flow chart (page 154) illustrates.

6.11 Generally growth in bioenergy fuels used in electricity generation will be similar to the growth in output generation unless there is a change in thermal efficiency (the amount of fuel required to produce a unit of electricity). Table 6.1 below shows the comparative growth rates between 2015 and 2016 for bioenergy fuel inputs and generation outputs;

Table 6A: Growth in fuel inputs versus generation for bioenergy

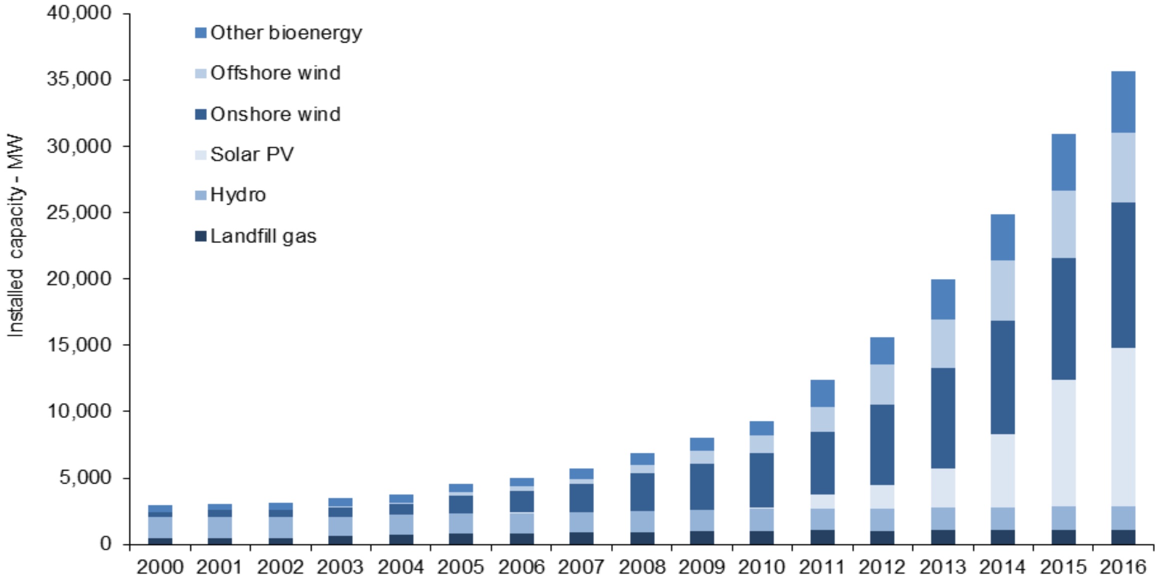
Growth between 2015 and 2016	**Fuel use** (table 6.6)	**Generation** (table 6.4)
Bioenergy:		
Landfill gas	-3.5%	-3.5%
Sewage sludge digestion	6.3%	6.3%
Biodegradable energy from waste	23.4%	6.0%
Co-firing with fossil fuels	-34.8%	-35.9%
Animal Biomass	-2.2%	0.4%
Anaerobic digestion	39.5%	39.5%
Plant Biomass	0.6%	1.3%
Total bioenergy	**5.0%**	**2.7%**

6.12 For the majority of biofuels, growth in fuel use is similar to generation growth with the exception of energy from waste. This is due to a drop in efficiency between 2015 and 2016.

Trends in Overall Electricity Generation and Capacity (table 6.4)

6.13 Although total generation capacity increased between 2015 and 2016 (by 16 per cent to 35.7 MW), generation actually fell (by 0.2 per cent to 83.2 GWh). Charts 6.4 and 6.5 below show the long term trends, highlighting 2016 as the first year to show a decrease (although generation supported by the Renewables Obligation showed an increase, by 0.8 per cent, table 6.4);

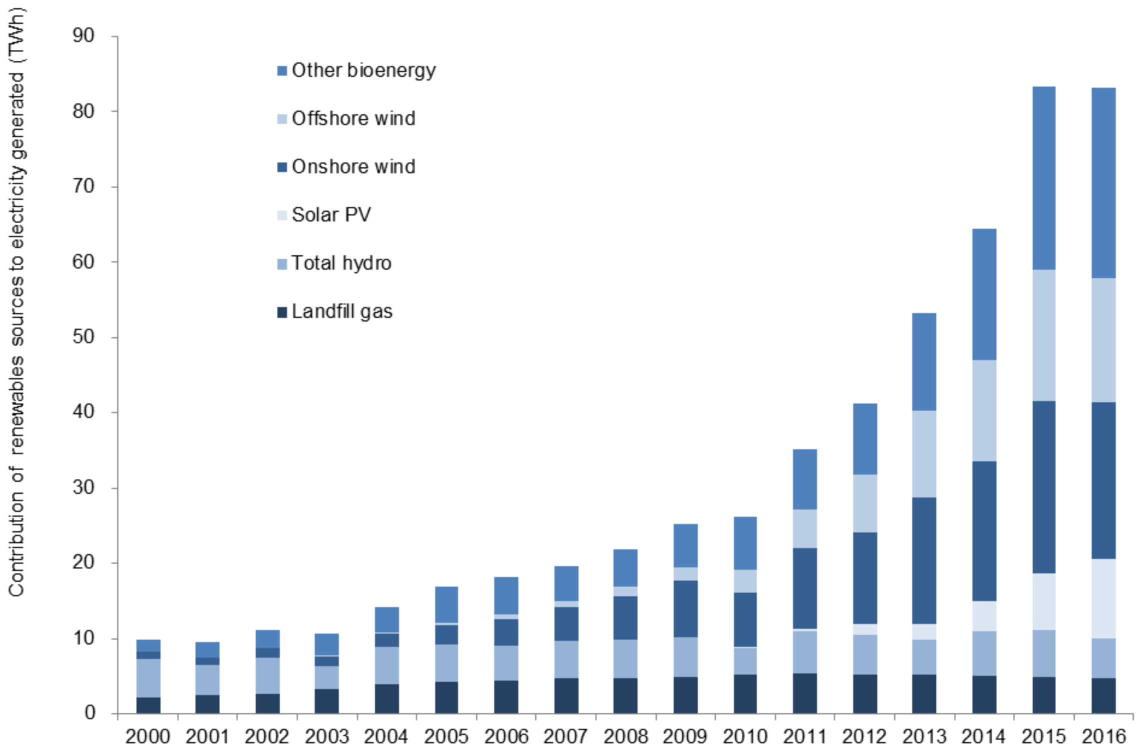
Chart 6.4: Electrical generating capacity of renewable energy plant



(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 (13.5 MW in 2016).

Chart 6.5: Electricity generation by main renewable sources



Note: Hydro bar includes shoreline wave/tidal (0.0007TWh in 2016)

6.14 The fall in generation in 2016 is due to lower wind and hydro generation; wind speeds were considerably lower than in 2015 and rainfall (in the main catchment areas) was also comparatively low. This is despite an increase in wind generation capacity, mostly in onshore wind which increased by 18 per cent to 10.9 GW, ahead of closure of the Renewables Obligation (RO) on 31 March 2017 (see para 6.57). Hydro generating capacity also increased; although large scale capacity is fairly stable, small scale increased by 20 per cent though from a small base (0.3 GW).

6.15 The decrease in wind and hydro generation was almost offset by a large increase in solar photovoltaic generation (by 38 per cent to 10.4 TWh, a record). This is the result of a large increase in capacity from both smaller installations supported by the Feed in Tariff (FiT) and particularly larger schemes supported by the Renewables Obligation. Although this increase in capacity has resulted in solar photovoltaics being the leading technology by capacity, its share of generation is fourth after onshore wind, offshore wind, and bioenergy. This is due to solar photovoltaics having a low load factor compared to other technologies [2] Table 6.B below shows the share of total generation and capacity and also their load factors for 2016;

Table 6B Share of generation and capacity by leading technologies

	Share of total capacity	Share of total generation	Load factor
Solar photovoltaics	33.3%	12.5%	11.1%
Onshore wind	30.6%	25.2%	23.7%
Bioenergy	16.1%	36.1%	62.0%
Offshore wind	14.8%	19.7%	36.0%
Hydro	5.1%	6.5%	34.0%
Total	100%	100%	

6.16 The table shows that the technologies with highest capacity do not necessarily have the highest share of generation, since this depends on the load factor (a high load factor giving a relatively higher share of generation).

Different measures of electricity generation (tables 6.4 and 6.7)

6.17 **Renewable sources provided 24.5 per cent of the electricity generated in the UK in 2016** compared to 24.6 per cent 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).

6.18 Generation from **renewable sources claiming Renewable Obligation Certificates (ROCs)** in 2016, at 76.1 TWh, was 0.8 per cent greater than in 2015 and a record. RO supported generation has increased by over 70 TWh since its introduction in 2002, a thirteen fold increase[3]. As a proportion of total electricity sales, RO supported generation actually increased (by 0.2 percentage points) to 26.2 per cent, compared to a fall in the share on the international basis. Table 6A and chart 6.6 show the three measures. Chart 6.6 illustrates the steady growth until this year, but shows the impact of weather conditions on generation this year, despite an increase in capacity.

[2] A measure of actual generation compared to maximum output. See individual technology sections and the methodology note for more details of drivers of load factors and how they are calculated.
[3] 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.

Table 6C: Percentages of electricity derived from renewable sources

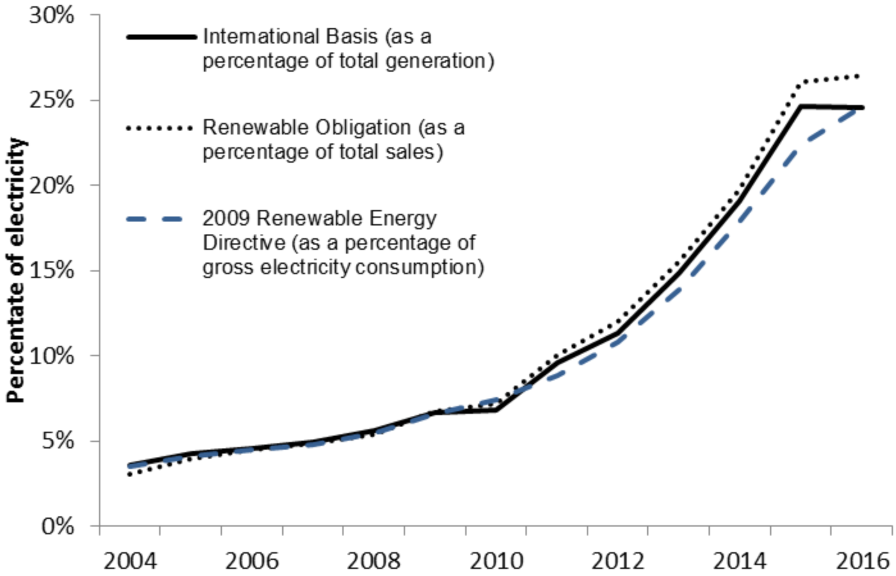
	2012	2013	2014	2015	2016
International Basis *(1)*	11.3	14.9	19.1	24.6	24.5
Renewable Obligation *(2)*	12	15.5	19.8	26.1	26.2
2009 Renewable Energy Directive *(3)*	10.8	13.8	17.8	22.3	24.6

[1] All renewable electricity as a percentage of total UK electricity generation

[2] Measured as a percentage of UK electricity sales

[3] 2009 Renewable Energy Directive measured as a percentage of gross electricity consumption

Chart 6.6: Growth in electricity generation from renewable sources since 2004



Electricity Generation, Capacity, and Load Factors by technology (tables 6.4 and 6.5)

6.19 This section discusses trends in generation, capacity (table 6.4),and load factors (table 6.5), for the key technologies. Within renewables, load factors[4] can be heavily influenced by weather conditions; wind speeds affect the load factors for onshore and offshore wind, rainfall similarly impacts the load factor for hydro and, to a lesser extent, hours of sunshine impact the load factor for solar pv. The load factor calculation assumes that capacity is added evenly throughout the year which may not always be the case; for example, a large generator could add a high capacity installation towards the end of the year but may only generate for a very short period. To remove this, the second part of table 6.5 shows load factors on an "unchanged configuration basis". This calculation includes only those generators who are producing at the start and end of the year providing a more reflective picture of the underlying trend.

6.20 **Chart 6.7 at the end of this section shows trends in load factors for wind, hydro, and bioenergy**. The impacts of new capacity and changes in weather conditions can be observed in this time series.

Solar Photovoltaics[5]

6.21 **Solar photovoltaic generation showed the largest absolute increase of the renewable technologies, rising by 2.9 TWh (38 per cent) to 10.4 TWh in 2016, a record**. This is due to

[4] For further details of how load factors are calculated, refer to the methodology note

[5] See paragraphs 6.73 to 6.75 for a description of solar photovoltaics.

increases in capacity in both larger schemes supported by the RO and smaller schemes under the FiT programme; capacity increased by 25 per cent to 11.9 GW in 2016. For the second year, solar PV is the leading technology in capacity terms, representing a third of total capacity, though in generation terms, it accounts for just 13 per cent.

6.22 The load factor for solar pv decreased slightly in 2016, by 0.4 percentage points to 11.1. On an unchanged configuration, it fell by 0.5 percentage points to 10.8. The slightly lower load factor on the unchanged configuration basis is mainly due to the large amount of capacity that came online earlier in the year, largely in March (ahead of the closure of the RO to grace period large-solar and non-grace period small solar – see para 6.57).

6.23 The decrease in load factors (on both bases) could be explained by shorter average hours of sunshine in 2016; average hours in 2015 were in line with the ten year mean of 4.4 hours per day compared to 4.2 in 2016. June in particular showed particularly short hours of sun hours at 4.4 hours compared with the ten year mean of 6.8 hours per day and 7.5 for the month in 2015.

Wind[6]

6.24 **Total wind generation fell by 7.3 per cent to 37.4 TWh, despite an increase in capacity of 1.9 GW (13 per cent), mostly in onshore wind**. The reduction in generation is due to lower wind speeds in 2016 compared to 2015, though wind speeds for that year had been the highest for the preceding 15 years. In 2016, average wind speeds were 8.3 Knots, compared with 9.4 for 2015 and a ten year mean of 8.4 Knots. Wind speeds were particularly low for the months of November and December when compared to 2015, with November's wind speeds 3.4 knots lower and December's 4.6 knots lower.

6.25 **Onshore wind saw the largest fall in generation, by 8.4 per cent to 21.0 GWh in 2016**, despite a record 1.7 GW (18 per cent) increase in capacity, including Dunmaglass (94 MW) and Dersalloch (69 MW) in Scotland, and the first 156 MW of Wales's largest onshore wind farm, Pen y Cymoedd (256 MW on completion). The standard load factor fell by 5.7 percentage points to 23.7. On an unchanged configuration basis, the load factor was slightly higher (24.2 per cent), reflecting the higher levels of deployment towards the end of the year (76 per cent in the second half of the year) on this basis, the fall was 5.2 percentage points, as a result of the low wind speeds for the year.

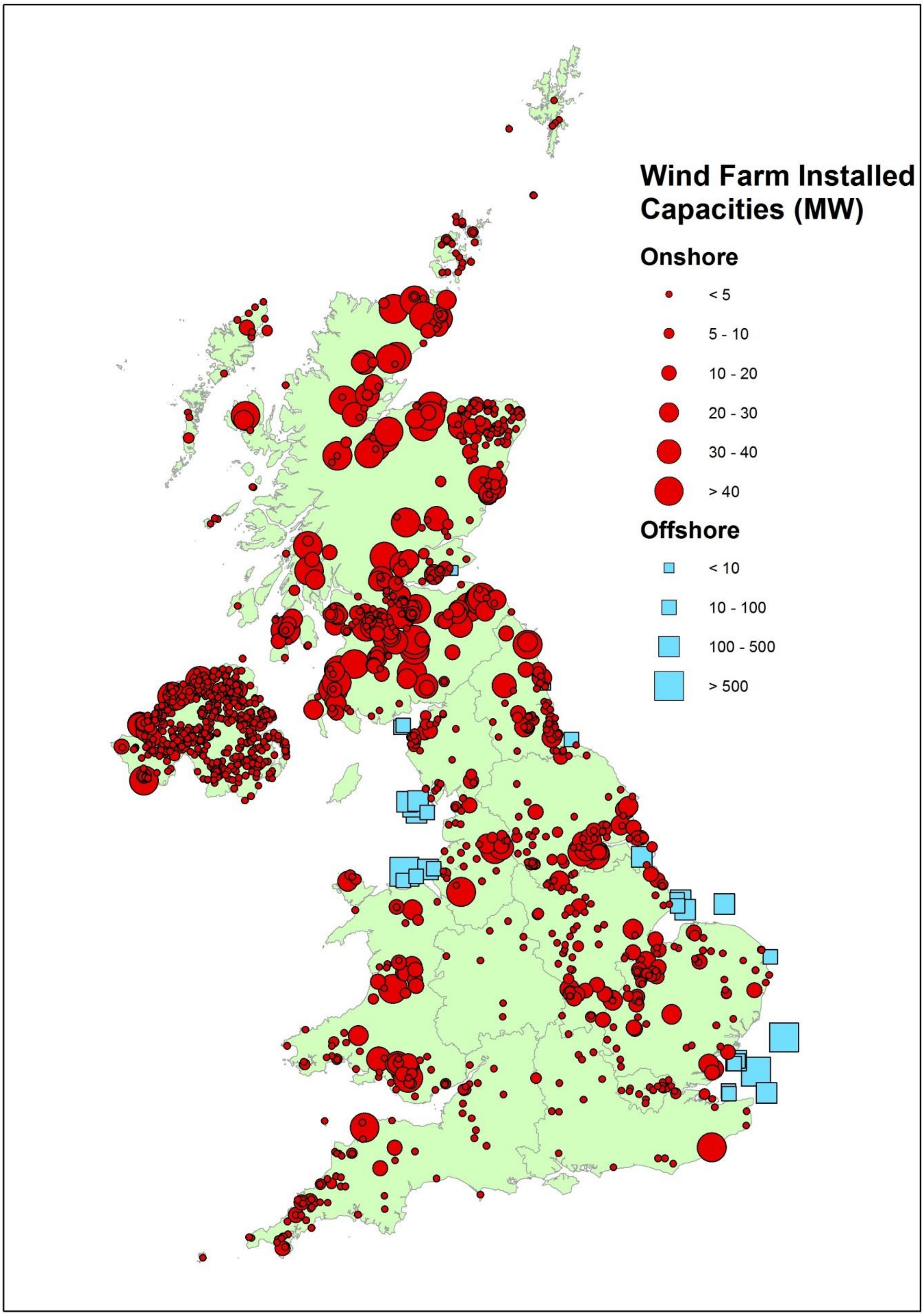
6.26 **Offshore wind generation fell by 1.0 GWh (5.8 per cent),** less than for onshore wind but with a much smaller increase in capacity. Capacity is now at 5.3 GW, an increase of 3.9 per cent (200 MW) on 2015, due to the installation of the first 200 MW (25 turbines) at the extension to Burbo Bank offshore wind farm in late 2016. This late installation resulted in the standard load factor being 0.5 percentage points lower than the unchanged configuration measure. The load factor fell on both bases, by 5.5 percentage points (standard) and by 3.1 percentage points (unchanged configuration) to 36.0 and 36.7 respectively.

Table 6C: Number of operational wind turbines split by FiTs and non FiTs accredited sites, as at end of December 2016

	FiTs confirmed	Other sites	Total
Onshore Wind	7,414	5,686	13,100
Offshore Wind	-	1,465	1,465
Total	**7,414**	**7,151**	**14,565**

The map on the following page shows the location of wind farms operational at the end of 2016 along with an indication of capacity;

[6] See paragraphs 6.76 to 6.6.82 for a description of onshore and offshore wind capacity and generation.


Wind Farm Installed Capacities (MW)
Onshore
< 5
5 - 10
10 - 20
20 - 30
30 - 40
> 40
Offshore
< 10
10 - 100
100 - 500
> 500

Hydro generation[7]

6.27 **Generation from hydro fell, by 14 per cent to 5.4 TWh in 2016**, partly due to 2015 being a record year, the result of high rainfall (in the main hydro catchment areas). Average rainfall in 2016 was 1,386 mm compared to 1,723 mm in 2015, the wettest year in the preceding fifteen years. Rainfall in 2015 was particularly high in December and was twice the ten year mean for that month. In comparison, rainfall in December 2016 was less than the ten year mean. Whilst large-scale hydro capacity remained unchanged, an increase in schemes supported by FiTs increased small-scale hydro by a record 59 MW (20 per cent). On a standard basis, the load factor fell, also the result of lower rainfall; by 5.5 percentage points for small scale hydro to 35.2 (34.6 per cent on an unchanged configuration basis), and by 7.3 percentage points for large scale, to 33.8.

Bioenergy[8]

6.28 **Generation from bioenergy increased by 2.7 per cent to 30.0 TWh, whilst capacity increased by 9.1 per cent to 5.7 GW**. The majority of the increase in generation was from anaerobic digestion with plant biomass accounting for most of the increase in capacity. Changes in load factors between 2015 and 2016 account for the differences in these trends; the load factor for anaerobic digestion increased in contrast to a decrease for plant biomass.

6.29 **Anaerobic digestion generation increased by 40 per cent to 2.1 TWh, a record**. Largely driven by installations supported by FiTs, capacity increased by 30 per cent to 0.4 GW. The differences in trends can be explained by the load factors; on an actual basis, the load factor increased by 3.5 percentage points to 62.8 per cent. On an unchanged configuration basis, the load factor increased by just 1.9 percentage points to 59.4[9].

6.30 **Generation from plant biomass increased by 1.3 per cent to 18.8 TWh compared to 9.3 per cent growth in capacity (to 2.9 GW in 2016**), the second highest absolute growth in capacity (after solar PV). Of the 244 MW of new plant biomass capacity, the Brigg and Snetterton straw–fired plants accounted for around 100 MW, with the remainder smaller plants. The actual load factor for plant biomass was 78.6 per cent for 2016, 8.7 percentage points less than for 2015, in part reflecting outages at Drax in the second half of the year (though the 2015 figure had been inflated due to the conversion of a third unit at Drax early in the first half of the year). On an unchanged configuration basis, the load factor actually increased in 2016 from 74.3 per cent to 78.9 per cent

6.31 **There were several new sites in 2016, generating using energy from waste**, including the 50 MW scheme at the Wilton complex at Redcar. This new capacity resulted in growth of 10 per cent to 1.0 GW in 2016, and prompted growth in generation from non-biodegradable waste of 6 per cent, to 2.7 TWh. The standard load factor fell from 36.8 in 2015 to 32.1 in 2016; on an unchanged configuration basis, the load factor fell by 1.7 percentage points to 34.6, with over 90 per cent of capacity being installed in the second half of the year.

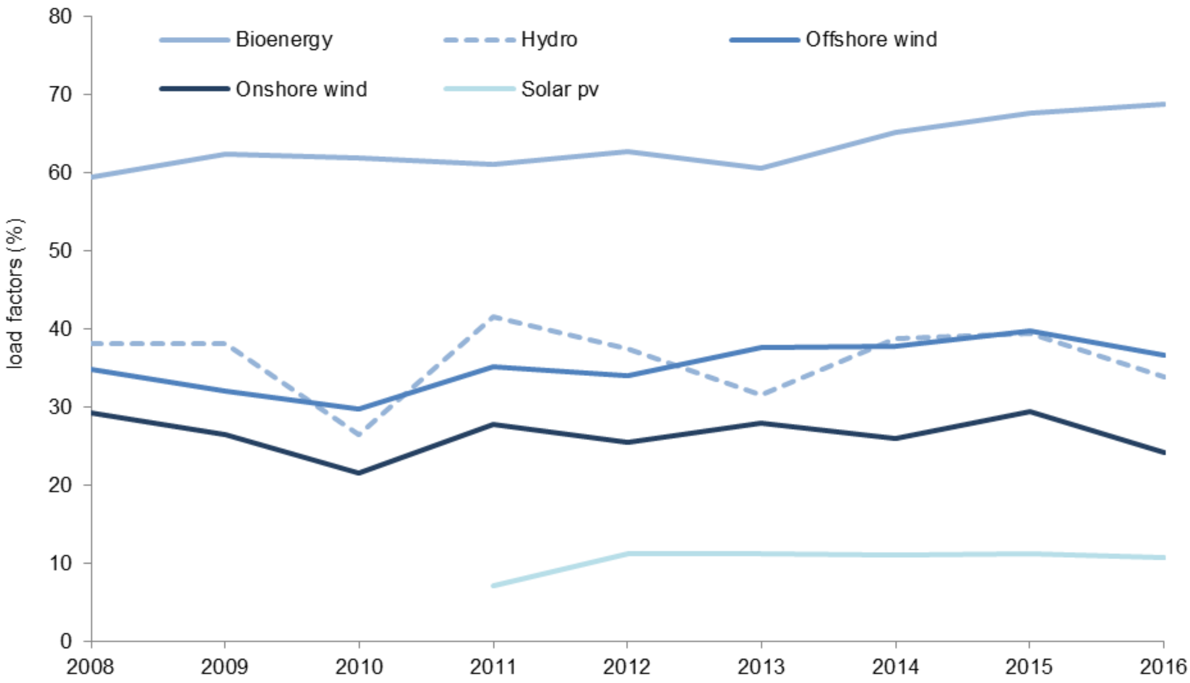
6.32 Generation from landfill gas fell for the fifth year in a row, as sites continue to become exhausted, and increasing quantities of waste are being recycled. Generation peaked in 2011 at 5.3 TWh and was 4.7 TWh in 2016, a decrease of 12 per cent. Generation fell by 3.5 per cent between 2015 and 2016. Over the same period, generation capacity for landfill gas (2011 to 2016) increased by 8.4 GW (0.8 per cent). On an unchanged configuration basis, the load factor for landfill gas has been falling since 2011; from 59.8 to 49.9 in 2016.

6.33 **Animal biomass generation increased by 0.4 per cent to 0.7 TWh with an increase in capacity of 17 per cent to 0.1 GW.** The load factor fell by 5.2 percentage points to 61.7 per cent in 2016 and by 9.7 percentage points to 57.2 per cent on an unchanged configuration basis). **Growth in sewage gas generation was 6.3 per cent, achieving 1.0 TWh in 2016**, due to an 11 per cent growth in capacity (to 0.3 GW). Although the load factor remained stable between 2015 (44.2) and 2016 (44.3), on an unchanged configuration basis, it fell by 5.1 percentage points to 43.1.

[7] See paragraphs 6.87 to 6.88 for a description of large and small scale hydro capacity and generation.
[8] See paragraphs 6.95 to 6.113 for a description of the various bio energy technologies.
[9] Generation from the majority of FiT schemes is estimated at an aggregate level; therefore, these schemes are not included in the unchanged configuration measure, which will largely be sites accredited on the RO.

6.34 Chart 6.7 below shows the load factors for the key renewable technologies since 2000. Although bioenergy has been grouped into one category, it is mostly influenced by plant biomass which represents 63 per cent of all generation from bioenergy. The chart shows that for weather dependent technologies, the load factors have fluctuated from year to year though there is no evidence of an underlying trend. However, for bioenergy, there has been a steady increase since 2011 representing an improvement in generation load factors, largely driven by the three Drax unit conversions, which tend to operate at high load factors, with a large share of bioenergy capacity.

Chart 6.7: Load factors[10] for renewable electricity generation since 2008



[10] On an unchanged configuration basis

Renewable heat (table 6.6)

6.35 **Renewable heat generation increased by 12 per cent in 2016 to 3,943 ktoe.** Of this increase (413 ktoe) 68 per cent was plant biomass. The largest increase in percentage terms was anaerobic digestion which increased 88 per cent. **Renewable energy from heat pumps increased by 17 per cent in 2016, from 156 ktoe to 182 ktoe,** due to an increase in capacity. Apart from a very small decrease in heat from sewage gas (by 1.4 per cent), heat from animal biomass was the only fuel source to see a decline in 2016; from 31 ktoe to 23 ktoe (25 per cent).

6.36 **Around 15 per cent of renewable heat was supported by the Renewable Heat Incentive (RHI) or Renewable Heat Premium Payment (RHPP) in 2016, compared to 11 per cent in 2015**. This increase is largely due to growth in RHI supported heat; from 379 ktoe (4,412 GWh) in 2015 to 589 ktoe, (6,583 GWh) in 2016[11]. The majority of the increase can be accounted for by bio methane injected into the gas grid, and also demand for biomass driven by the increase in small and medium biomass boilers in the non-domestic sector. Further information on the RHI and RHPP schemes can be found in paragraphs 6.70 to 6.72.

6.37 **Around 23 per cent of renewable sources were used to generate heat in 2016**, 2.0 percentage points higher than in 2015.

6.38 **Domestic wood combustion retained the largest share of renewable heat at 50 per cent**, followed by 28 per cent for plant biomass. Non-bioenergy renewable heat sources include solar thermal, deep geothermal and heat pumps, and combined these accounted for 5.9 per cent of total renewable heat, the same level as in 2015.

Liquid biofuels for transport (tables 6.1 and 6.6)[12]

6.39 Biofuels are made from recently-living biological material[13] and can be waste products, non-agricultural residue, or sourced from crops. The petrol substitutes are biomethanol and MTBE (methyl tern-butyl ether), and the diesel substitutes are FAME (fatty acid methyl ester), HVO (hydrogenated vegetable oil), pure plant oil.

6.40 **In 2016, 708 million litres of biodiesel[14] were consumed, 5.8 per cent higher than in 2015.** 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 385 million litres of biodiesel were produced in the UK in 2016, more than double the volume produced in 2015. Of this, about 96 million litres are known to have been used for non-transport applications or exported. Therefore, at least 420 million litres of biodiesel were imported in 2016. The total annual capacity for biodiesel production in the UK in 2016 is estimated to be around 541 million litres.

6.41 **Consumption of bioethanol fell in 2016, by 4.5 per cent to 759 million litres**. The UK capacity for bioethanol production at the end of 2016 was estimated to be around 910 million litres, although actual production was estimated to be 468 million litres, around half actual capacity. Of UK production, 219 million litres was known to be used for non-transport applications, or exported, so at least 509 million litres was imported.

6.42 During 2016, biodiesel accounted for 2.4 per cent of diesel, and bioethanol 4.4 per cent of motor spirit. The combined contribution of liquid biofuels for transport was 3.1 per cent, a decrease of 0.1 percentage points on 2015.

6.43 Volume data have been converted from litres to tonnes of oil equivalent and 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

[11] 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.
[12] See paragraphs 6.114 to 6.115 for a description of liquid biofuels.
[13] Department for Transport Renewable Transport Fuel Obligation statistics, notes and definitions;
www.gov.uk/government/uploads/system/uploads/attachment_data/file/519910/notes-and-definitions.pdf
[14] The most usual way for biodiesel to be sold is for it to be blended with ultra-low sulphur diesel fuel.

increased by 1.2 per cent (to 1,010 ktoe) between 2015 and 2016 with the majority of the increase being due to biodiesel (bioethanol consumption actually fell in 2016). In 2016, liquid biofuels for transport comprised 5.8 per cent of total renewable sources, 0.2 percentage points less than 2015.

6.44 When measuring the contribution of transport biofuels for the Renewable Energy Directive, only those meeting sustainability criteria count. The data referred to above do not contain sustainability information, including which fuels carry a higher reward (mostly sourced from waste), and the table which does, is not yet a complete data set for 2016. 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 the Department for Transport 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 compliant and also the proportion meeting the double credited criteria (mostly those from waste sources). 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)

6.45 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 the methodology document.

6.46 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[15], and also shows the proportions of electricity, heat and transport energy coming from renewable sources. It is an update of the provisional figure published in the June 2017 edition of Energy Trends. D**uring 2016, 8.9 per cent of final energy consumption was from renewable sources**. **The third interim target, averaged across 2015 and 2016, was set at 7.5 per cent, and was exceeded at 8.5 per cent**. The fourth interim target is 10.2 per cent averaged across 2017 and 2018.

6.47 Overall renewable sources, excluding non-biodegradable wastes, provided 9.2 per cent of the UK's total primary energy requirements in 2016 (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 9.4 per cent, the final consumption denominator increased by just 0.8 per cent. Table 6D shows both measures.

[15] This is an update of the first estimate of the UK progress published in the June 2017 edition of Energy Trends. It includes a member state comparison for 2015 and progress for the EU as a whole
www.gov.uk/government/statistics/energy-trends-june-2017-special-feature-article-renewable-energy-in-2016

Table 6D: Percentages of energy derived from renewable sources since 2012

	2012	2013	2014	2015	2016
Eligible renewable energy sources as a percentage of capped gross final energy consumption (i.e. the basis for the Renewable Energy Directive)	4.7%	5.7%	7.0%	8.2%	8.9%
Renewable energy as a percentage of primary energy demand	4.9%	5.9%	7.3%	8.8%	9.2%

Revisions to published data and new reporting

6.48 Renewables data have been revised back to 2010, with the most recent years seeing the largest revisions; mostly the result of more up to date information. There were also some reclassifications and also new reporting. Where revisions have been made, the values in the excel versions of the tables have been suffixed with an "r" to indicate the value has been changed since last published.

6.49 Some revisions have also been made to installed generating capacities (table 6.4) following an exercise to replace previously estimated data points with actual data, for 2010 to 2014, and including a reconciliation of different sources of survey and administrative data sources.

6.50 New data have enabled consumption in the industrial sector to be allocated to the relevant subgroup whereas previously it was all reported under "unclassified". This has also been included for 2015 data (tables 6.1 and 6.2).

6.51 For the first time biomethane injected into the gas grid has been reported for 2014, 2015, and 2016; previously there were so few sites, including it would have disclosed individual sites. This is shown in the energy balances tables (6.1 to 6.3) as a transfer out, and a corresponding transfer in is included in the natural gas commodity balance table.

6.52 RHI supported biomass has been reclassified (table 6.6, heat generation); this was included in industrial wood but is now reported under plant biomass with the negative revision for industrial wood combustion offsetting the positive revision for biomass.

6.53 Updated assumptions used in the calculation of heat generated by heat pumps have resulted in revisions (tables 6.1 and 6.6); previous research undertaken by University College London (UCL) in to the performance of heat pumps in situ has been updated and republished[16].

[16] www.gov.uk/government/publications/detailed-analysis-of-data-from-heat-pumps-installed-via-the-renewable-heat-premium-payment-scheme-rhpp

Technical Notes

European and UK Renewable Energy Policy Context

EU Renewable Energy Directive

6.54 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,

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

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

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

UK Renewables Policy

6.55 The UK's low carbon policies have seen renewable electricity capacity increase by more than three times since 2010. In 2016, renewables provided nearly one quarter of the UK's electricity generation, and we are on track to comfortably exceed our ambition of delivering 30% of the UK's electricity from renewables in 2020-21.

Renewables Obligation (RO)

6.56 The Renewables Obligation (RO) came into effect in April 2002[17]. 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 to traders. Suppliers present ROCs to Ofgem to demonstrate their compliance with the obligation.

[17] 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.

6.57 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. In Great Britain, 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 closed to all capacities of onshore wind in Great Britain on 12 May 2016. In Northern Ireland, it closed to large-scale onshore wind (over 5MW) on 31 March 2016 and to small-scale onshore wind (up to 5MW) on 30 June 2016. The scheme closed to all other technologies on 31 March 2017, although existing generating stations will continue to receive support for 20 years, up to 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 at:
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 at:
www.gov.uk/guidance/calculating-renewable-obligation-certificates-rocs

6.58 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)

6.59 Contracts for Difference has replaced the RO for new renewable energy stations. 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.

6.60 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 are available at:
www.gov.uk/government/publications/contracts-for-difference/contract-for-difference

Feed-in Tariffs (FiTs)

6.61 The Feed-in Tariff (FiT) scheme is a policy mechanism designed to support investment in small-scale renewable and low carbon electricity generation projects up to 5MW capacity. It offers long term support to projects and provides tariffs based on the costs of generation for each technology. The technologies supported are: solar PV, onshore wind power, hydropower, anaerobic digestion (AD), and micro (<2kW) combined heat and power (micro-CHP). Under the scheme, generators receive three sources of income/savings:

- A Generation tariff - a payment for every kWh generated, dependent on the technology and capacity of the installation, and date installed;
- An Export tariff - an additional payment for every kWh exported to the local electricity network; and
- Bill savings - additional benefit from usage of electricity "onsite" as opposed to paying the retail price for importing that energy from the grid.

Provisionally, overall Feed-in Tariff (FIT)-scale deployment at the end of May 2017 was 6,091 MW (902,560 installations). This represented an 8% increase in total FIT installed capacity and a 4% increase in the number of installations compared to the same period in 2016. Around 99% are solar PV installations (82% of capacity). Statistical reports are available at:
www.gov.uk/government/statistics/monthly-small-scale-renewable-deployment

6.62 The scheme has been hugely successful in attracting investment. A review of the scheme took place in 2015 and new measures were introduced in early 2016 to ensure the scheme's costs are effectively controlled and it provides value for money for the consumers that fund it through their bills. A review of support for AD and mCHP concluded in February 2017 with similar measures introduced. Details are available at:

www.gov.uk/government/consultations/review-of-support-for-anaerobic-digestion-and-micro-combined-heat-and-power-under-the-feed-in-tariffs-scheme

Feed in Tariff Supported Capacity

6.63 Much small scale (up to 5 MW capacity) renewable electricity 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 71 MW of renewable capacity was installed and subsequently confirmed on it. During 2011, a further 976 MW of FiT supported renewable capacity was installed. For 2012, 892 MW of capacity was added and in 2013, 624 MW. In 2014, 996 MW of capacity was added, while in 2015, a further 1,726 MW of FiT capacity was installed, with 84 per cent of this new capacity coming from solar photovoltaics (PV). A further 676 MW of solar PV capacity was installed in 2016.

6.64 **The greatest increase in FiT capacity in percentage terms in 2016 was from solar photovoltaics**, from 4,368 MW at the end of 2015 to 4,856 MW at the end of 2016. Onshore wind increased from 608 MW at the end of 2015 to 695 MW at the end of 2016, while hydro capacity increased from 124 MW to 181 MW, and anaerobic digestion from 229 MW to 274 MW. At the end of 2016, solar PV represented 81 per cent of commissioned FiTs capacity (down from 82 per cent at the end of 2015), with onshore wind 12 per cent (up from 11 per cent), and anaerobic digestion 4.6 per cent (up from 4.3 per cent) and hydro increased from 2.3 to 3.0 per cent. It should be noted that, due to administrative lags of around three months, much capacity installed towards the end of 2016 was not confirmed until the first quarter of 2017 (so the amount of capacity installed under FiTs at the end of 2016 will not equal the amount actually confirmed on the Central FiTs Register).[18]

6.65 Table 6B shows the number of sites generating renewable electricity at the end of 2016. There were 917,488 sites, although this figure is dominated by small-scale solar PV installations confirmed on FiTs.

Table 6E: Number of sites generating renewable electricity, as at end of December 2016 (excluding co-firing)[19]

	FiTs confirmed	Other sites	Total
Onshore Wind	7,414	5,686	13,100
Offshore Wind	-	1,465	1,465
Marine energy	-	14	14
Solar PV	786,502	113,643	900,145
Hydro	971	344	1,315
Landfill gas	-	450	450
Sewage sludge digestion	-	192	192
Energy from waste	-	51	51
Animal biomass (non-AD)	-	6	6
Anaerobic digestion	366	160	526
Plant biomass	-	224	224
Total	**795,253**	**122,235**	**917,488**

[18] At the end of 2016, 5,421 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.
[19] 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.

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 were 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/collections/renewable-transport-fuels-obligation-rtfo-orders#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 consulted in 2016 on a range of proposals to increase the supply and sustainability of renewable transport fuels, including proposals to increase the obligation from 2017 and to set a trajectory to 2020 and beyond. Other proposals included increasing the supply of waste derived fuels, encouraging the production of advanced, or 'development', fuels, and renewable fuels of non-biological origin and setting a maximum level for the supply of fuels made from crops. The consultation closed in January 2017 and the department aims to publish its response in due course.

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 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.

6.72 Table 6E below shows the breakdown of technologies accredited to the domestic scheme, over the period 9 April 2014 (launch date) to 31 December 2016, with average installed capacity and heat paid out for under the scheme. In total there were 52,971 accreditations, with 1,408,656 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 6F: Domestic Renewable Heat Incentive accreditations, average capacity installed and estimated heat generation to December 2016

Technology	Number of accreditations	Average (mean) capacity installed (kW)	Heat paid out under the scheme (MWh)
Air source heat pump	25,031	9.8	338,336
Ground source heat pump	7,738	12.3	213,054
Biomass systems	12,164	24	784,787
Solar thermal	8,038	-	22,478
Total	**52,971**	**-**	**1,408,656**

Sources of Renewable Energy

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.

Solar photovoltaics (PV)

6.74 Photovoltaics (PV) 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. Within the UK, PV installations are primarily either ground-mounted solar farms, usually built on low-grade farmland and disused facilities (e.g., airfields) or rooftop devices mostly retrofitted to existing buildings. The installation costs associated with these has fallen dramatically in recent years. Since April 2010 support for small scale (less than 5 MW) solar PV and other micro-generation technologies in Great Britain had 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 were supported by the Renewables Obligation (RO) (see paragraph 6.57)[1]. As of 31 March 2017, the Renewables Obligation is now closed to all new generating capacity which was replaced by the FiT Contracts for Difference (CFD) scheme but only for the first round.

6.75 The small Scale Feed In Tariff Scheme has seen significant cuts in support through both revisions to the scheme, and uptake-based degression, and will in any case end in 2019. There are indications the market is seeking to develop schemes without subsidy, though these are likely to seek other ways of ensuring cost effectiveness, e.g., through private wire, or combining with storage to sell at other times of day, or simply being very large (several tens of MW).

6.76 On Saturday 25 March 2017, demand on the National Transmission System was, for the first time ever, lower during the afternoon, than it was overnight. This was due to very high levels of PV generation, even in March. This will become common place in future summer days with implications for management of the grid and for operation of fossil fuelled plant.

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 suitable 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 For larger scale installations, turbine size has increased steadily over the years. The average new turbine size for operational schemes over the last 5 years was around 2.5 MW. For those schemes under construction, however, this is moving towards 3 MW. A small number of the early projects which were installed around 20 years ago have re-powered. This involves replacing ageing turbines with larger, more efficient ones and increasing tower height to take advantage of the higher wind speeds found at increased height above ground level. Multiple turbines are often sited together in ‘wind farms’ and the electricity generated is supplied to the electricity grid. In England and Wales, planning applications for large-scale (>50MW) wind farms are now handled by local authorities. In addition, the Renewables Obligation is now closed to all new generating capacity which is replaced by the Contracts for Difference (CFD) scheme administered by National Grid.

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

6.79 In the small-medium wind market (1.5–100 kW), generated energy is often 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[20] 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, Round 2 in July 2003 and Round 3 in January 2010. Construction of some Round 3 capacity (Rampion) has already begun. The Crown estate published a detailed account of progress with operational offshore wind in 2016[21].

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

[20] www.gov.uk/government/collections/uk-renewable-energy-roadmap
[21] www.thecrownestate.co.uk/media/1050888/operationalwindreport2017_final.pdf

leasing calls. This provides greater opportunities for tidal turbines of 100kW or less to be deployed, with a large number of developers successfully commissioning small scale prototype turbines.

6.86 Atlantis and Andritz both commissioned turbines in 2017 and are currently completing operational trials. Scotrenewables report having generating 18MWh over a 24-hour period with their 2MW device, subject to losses, this equates to an offshore wind competitive 37.5% capacity factor. Conversely Sustainable Marine Energy moved their prototype testing overseas reducing the potential for installed capacity in UK waters this year, whilst Delta Stream went into administration.

6.87 Wave Energy Scotland continue to provide research and development funding to a number of wave developers to look at ways of improving the performance and reliability of wave device subsystems and components. Innovate UK have also opened a call to support wave and tidal projects. Wave energy deployment in the UK is still limited to early prototypes. The UK Government review of tidal lagoons was published at the end of 2016. This concluded that tidal lagoons can play a cost effective role in the UK's energy mix. The review recommends a less than 500MW pathfinder project is identified to take forward as tidal lagoons would help deliver security of supply; they would assist in delivering our decarbonisation commitments; and they would bring real and substantial opportunities for the UK supply chain.

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 cover plants with a capacity of 5 MW and over and most of these are located in Scotland and Wales where they mainly draw their water from high-level reservoirs with their own natural catchment areas. The data in this Chapter excludes pumped storage stations. 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, with those less than 50kW referred to as micro-scale. These are schemes for either domestic/farm purposes or for local sale to electricity supply companies. The majority of new development will fall into this category and will remain eligible for FITs support following the closure of the RO on 31st March 2017.

Deep geothermal energy

6.90 There are two broad types of deep geothermal technology; for direct heat use (where temperatures are above 60^{o}C) and for power generation (though normally for combined heat and power) usually where the resource temperature is above 120^{o}C. 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 The Government has provided grant support for this sector. Deep geothermal electricity generation was also supported under the RO and is now eligible for support under the Contracts for Difference. Deep geothermal energy for direct heat use, defined as coming from a drilling depth of at least 500m, is eligible for support under the Renewable Heat Incentive. The tariff is currently set at 5.22p/kWh (commissioned on or after 4 December 2013) from 1 April 2015.

6.92 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.

Heat pumps

6.93 Heat pumps extract heat from the local surroundings, either from the air (ASHP), the ground (GSHP) or water (WSHP). Only heat extracted from ambient surroundings is eligible as renewable heat, i.e. exhaust heat from other processes is not included. Heat pumps can be dedicated to heat production or reversible, such that they can be operated in either a heating or cooling mode. Currently only heat from dedicated heat pumps is included in the statistics. Dedicated ASHP and GSHP are eligible technologies in both the domestic and non-domestic RHI.

6.94 Heat pumps require an energy source to operate. The majority use electricity to operate a compression cycle. The seasonal performance factor (SPF) estimates the ratio of the heating output of the heat pump to the electricity input over the whole heating season and so 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. 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, based on an average pan-European electricity efficiency. Recent analysis of performance of a sample of the domestic heat pumps installed in the UK under the Renewable Heat Premium Payment Scheme (RHPP)[22] showed that about 62% of ASHP and 80% of GSHP achieved the minimum SPF.

6.95 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.

Bioenergy and wastes

(a) Landfill gas

6.96 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. The load factor continues to steadily decrease, as the gas producing resource becomes depleted. Landfill operators respond to reducing gas yields by removing modular generating sets when it is no longer economic to run.

(b) Sewage sludge digestion

6.97 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. Some sites also co-digest other feedstocks (e.g., food waste) with sewage sludge.

(c) Domestic wood combustion

6.98 Wood has been used for home heating, cooking and hot water for many years. Traditionally, wood has been used in the form of logs in multi-fuel stoves and open fires. It is difficult to obtain information on domestic wood fuel use as wood is sourced from a wide range of sources, many of them informal.

6.99 Domestic wood consumption represents a sizeable contribution to UK renewable heat production. In 2015, BEIS commissioned a large scale survey of households in the UK to provide an updated baseline estimate. The results suggested that wood fuel use had previously been

[22] Final report on analysis of heat pump data from the RHPP scheme. UCL energy institute, March 2017.

underestimated by a factor of three[23]. The survey confirmed that closed stoves and open fires remain the most common wood fuel appliances installed. These appliances are usually used to supply some of the home heating, although about 12% of wood fuel users use wood as their main fuel. Logs remain the most common form of wood fuel (90% of wood fuel users). The survey indicated a substantial contribution to domestic wood fuel supply from the informal sector including from farmers, garden contractors, self-supply, foraging, and use of discarded wood.

6.100 Wood fired boilers and wood pellet stoves are eligible for the domestic RHI. These appliances utilise mainly wood pellets and wood chips. Currently the proportion of wood pellets and wood chips fuelling these appliances remains a small proportion (about 4%) of the total domestic wood fuel use.

(d) Non-domestic wood combustion

6.101 Use of sawmill residues, furniture manufacturing offcuts etc.as wood fuel (Industrial wood fuel use) has been included as a separate category since 1997. This wood is either used for heat or CHP in house, or is sold as wood fuel. Surveys in 2000 and 2006 showed that the in-house use of wood residues had declined due to the imposition of more stringent emissions controls. Since the introduction of the Renewable Heat Incentive (RHI) in 2011, there has been increased interest in the use of wood fuel. The wood fuel is sourced both from forestry and woodland management (Plant Biomass), and from in-house and recycled by-products (Industrial wood fuel). Typically wood fuel is 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. The non-domestic RHI has supported some 9,365 GWh of heat from biomass, mostly wood, to December 2016 since its inception in November 2011. This is equivalent to some 1.5 million oven dried tonnes of commercial wood pellets.

(e) Energy crops and forestry residues

6.102 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[24]. These show that only small areas of these crops are currently planted in England, with estimates of about 6,900ha of Miscanthus and 2,900ha of SRC in 2015. Based on Renewables Obligation sustainability reporting data, Defra estimate that about 33,000 tonnes of UK Miscanthus and 15,000 tonnes of UK SRC was used in UK power stations in 2014/15. Data for 2016 are not yet available but are unlikely to be too dissimilar.

(f) Straw combustion

6.103 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.

6.104 There has also been a rapid growth in the number of straw-fired power stations, with schemes in the high straw production areas of the eastern parts of England at Ely, Cambridgeshire (40MW), Sleaford (45MW), Brigg (54.6MW) and Snetterton (45MW).

(g) Waste combustion

6.105 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.

[23] Summary Results of the Domestic Wood Fuel survey. BEIS. Published in Energy Trends March 2016. www.gov.uk/government/publications/summary-results-of-the-domestic-wood-use-survey
[24] www.gov.uk/government/statistics/area-of-crops-grown-for-bioenergy-in-england-and-the-uk-2008-2015

6.106 **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. Since 2014, approximately 50% of these feedstocks is considered to be biodegradable and therefore only this is taken into account when calculating the renewable statistics from this resource. These wastes are primarily burnt in purpose-built combustion facilities fitted with enhanced flue gas treatment. There is considerable interest in the use of Advanced Conversion Technologies (ACT) as an alternative treatment technology but there are known to be technical issues with several of the facilities.

6.107 **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.

6.108 **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.

6.109 **Specialist non-biodegradable waste**. Although a dedicated 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, this small biodegradable content has currently been included under non-biodegradable wastes in this chapter.

6.110 **Hospital waste**. The combustion of clinical waste has been used to produce both heat and electricity. The results of the survey showed an ongoing process of centralisation and consolidation, in response to changes in pollution emissions and clinical waste regulations. Generation has now focused on larger plants with many smaller facilities closing as the cost of compliance with regulations made them no longer viable.

6.111 **Animal biomass**. The first small-scale CHP poultry litter combustion project began generating towards the end of 1990 but was subsequently closed due to new emissions regulations. It provided useful data which resulted in the World's first poultry litter-fired power station in 1992 closely followed by a second in 1993. Further schemes started generating in 1998, 2000 and 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)

6.112 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 by removal of the carbon dioxide and cleaning/ conditioning the gas for use in transport applications or injection into the gas grid. Increasingly the energy requirements for the biomethane production are provided by an on-site CHP powered by biogas. The CHP unit may also export excess electricity to the grid.

6.113 The indigestible material left after the AD process is called digestate. This is rich in nutrients and can be used as a fertilizer. 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, used as a compost product.

(i) Co-firing of biomass with fossil fuels

6.114 Compared with dedicated renewable facilities, 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. Interest in co-firing has now waned as this will no longer be supported under the RO and has encouraged some stations to undergo conversion to dedicated biomass firing.

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

6.115 Biodiesel is a liquid fuel produced from biological sources of oils and fats by trans-esterification. The ester content of biodiesel is not less than 96.5 per cent by weight and the sulphur content must not exceed 0.005 per cent by weight[25] Biodiesel can be blended in low proportions with fossil diesel for use in diesel engines. Diesel fuel currently sold at retail outlets in the UK can contain up to 7 per cent biodiesel. Biodiesel can be produced from oil crops, such as rapeseed and soy or from waste fats and oils. In 2015/16 the feedstock for biodiesel consumed in the UK for transport was almost entirely waste fats and oils[26].

6.116 Bioethanol a liquid fuel consisting of ethanol produced from biomass. Bioethanol can be blended with petrol at low proportions for use in petrol engines. 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[27]. Bioethanol can be produced from sugar or starch from purpose grown crops such as corn (maize), wheat and sugar beet. It can also be produced from waste feedstocks such as sugar/ starch residues. In 2015/16 about 20% of bioethanol consumed in the UK was supplied from waste feedstocks.

Combined Heat and Power (CHP)

6.117 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.

6.118 Chapter 7 of this Digest summarises information on the contribution made by CHP to the UK's energy requirements in 2010 to 2016 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 2016. 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

6.119 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

[25] www.gov.uk/government/publications/excise-notice-179e-biofuels-and-other-fuel-substitutes/excise-notice-179e-biofuels-and-other-fuel-substitutes

[26] RTFO year 8 report. www.gov.uk/government/statistics/biofuel-statistics-year-8-2015-to-2016-report-6

[27] www.gov.uk/government/uploads/system/uploads/attachment_data/file/232126/petrol-protection-extention-ia.pdf

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 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.

6.120 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.

6.121 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 2016

Renewables and waste

Thousand tonnes of oil equivalent

	Waste wood	Wood	Animal biomass and anaerobic digestion *(4)*	Plant biomass *(5)*	Sewage gas	Landfill gas
Supply						
Production	298	2,022	1,271	1,975	384	1,556
Other sources	-	-	-	-	-	-
Imports	38	41	-	3,032	-	-
Exports	-17	-109	-	-9	-	-
Marine bunkers	-	-	-	-	-	-
Stock change *(1)*	-	-	-	-	-	-
Transfers	-	-	-165	-	-	-
Total supply (2)	**319**	**1,954**	**1,106**	**4,998**	**384**	**1,556**
Statistical difference *(3)*	-	-	-	-	-	-
Total demand	**319**	**1,954**	**1,106**	**4,998**	**384**	**1,556**
Transformation	**2**	**-**	**903**	**3,899**	**312**	**1,542**
Electricity generation	-	-	903	3,896	312	1,542
Major power producers	-	-	210	3,233	-	-
Autogenerators	-	-	693	663	312	1,542
Heat generation	2	-	-	3	-	-
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	**317**	**1,954**	**202**	**1,099**	**72**	**14**
Industry	**240**	**-**	**33**	**864**	**72**	**14**
Unclassified	-	-	12	40	-	-
Iron and steel	-	-	-	-	-	-
Non-ferrous metals	-	-	-	-	-	-
Mineral products	13	-	11	147	-	14
Chemicals	-	-	-	26	-	-
Mechanical engineering, etc	-	-	-	-	-	-
Electrical engineering, etc	-	-	-	-	-	-
Vehicles	-	-	-	-	-	-
Food, beverages, etc	-	-	7	30	-	-
Textiles, leather, etc	-	-	-	-	-	-
Paper, printing, etc	-	-	3	596	-	-
Other industries	227	-	-	26	72	-
Construction	-	-	-	-	-	-
Transport	**-**	**-**	**-**	**-**	**-**	**-**
Air	-	-	-	-	-	-
Rail	-	-	-	-	-	-
Road	-	-	-	-	-	-
National navigation	-	-	-	-	-	-
Pipelines	-	-	-	-	-	-
Other	**78**	**1,954**	**169**	**235**	**0**	**-**
Domestic	-	1,954	-	-	-	-
Public administration	-	-	-	-	0	-
Commercial	38	-	-	156	-	-
Agriculture	40	-	169	79	-	-
Miscellaneous	-	-	-	-	-	-
Non energy use	**-**	**-**	**-**	**-**	**-**	**-**

(1) Stock fall (+), stock rise (-).
(2) Including non-biodegradable wastes, which accounted for 1,291 ktoe.
(3) Total supply minus total demand.
(4) Includes poultry litter, meat and bone and farm waste
(5) Includes straw, short rotation coppice (SRC), and other plant based biomass
(6) Municipal solid waste, tyres, general industrial waste and hospital waste.
(7) The amount of marine energy was very small.

6.1 Commodity balances 2016 (continued)

Renewables and waste

Thousand tonnes of oil equivalent

Waste *(6)*	Solar photovoltaics, active solar heating, and deep geothermal	Heat pumps	Hydro	Wind and marine energy *(7)*	Liquid biofuels	Total renewables	
							Supply
2,454	948	182	464	3,213	580	15,347	Production
-	-	-	-	-	-	-	Other sources
-	-	-	-	-	632	3,743	Imports
-	-	-	-	-	-203	-338	Exports
-	-	-	-	-	-	-	Marine bunkers
-	-	-	-	-	-	-	Stock change *(1)*
-	-	-	-	-	-	-165	Transfers
2,454	**948**	**182**	**464**	**3,213**	**1,010**	**18,587**	**Total supply** *(2)*
-	-	-	-	-	-	-	**Statistical difference** *(3)*
2,454	**948**	**182**	**464**	**3,213**	**1,010**	**18,587**	**Total demand**
2,307	**896**	**-**	**464**	**3,213**	**-**	**13,537**	**Transformation**
2,241	896	-	464	3,213	-	13,467	Electricity generation
790	175	-	340	2,641	-	7,389	Major power producers
1,451	721	-	124	572	-	6,078	Autogenerators
65	-	-	-	-	-	70	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**
148	**52**	**182**	**-**	**-**	**1,010**	**5,050**	**Final consumption**
110	**-**	**4**	**-**	**-**	**-**	**1,337**	**Industry**
78	-	4	-	-	-	134	Unclassified
-	-	-	-	-	-	-	Iron and steel
-	-	-	-	-	-	-	Non-ferrous metals
-	-	-	-	-	-	185	Mineral products
-	-	-	-	-	-	26	Chemicals
2	-	-	-	-	-	2	Mechanical engineering, etc
-	-	-	-	-	-	-	Electrical engineering, etc
-	-	-	-	-	-	-	Vehicles
-	-	-	-	-	-	37	Food, beverages, etc
-	-	-	-	-	-	-	Textiles, leather, etc
-	-	-	-	-	-	599	Paper, printing, etc
31	-	-	-	-	-	355	Other industries
-	-	-	-	-	-	-	Construction
-	-	-	-	-	**1,010**	**1,010**	**Transport**
-	-	-	-	-	-	-	Air
-	-	-	-	-	-	-	Rail
-	-	-	-	-	1,010	1,010	Road
-	-	-	-	-	-	-	National navigation
-	-	-	-	-	-	-	Pipelines
38	**52**	**178**	**-**	**-**	**-**	**2,704**	**Other**
-	32	93	-	-	-	2,079	Domestic
37	0	-	-	-	-	38	Public administration
1	20	85	-	-	-	299	Commercial
-	-	-	-	-	-	288	Agriculture
-	-	-	-	-	-	-	Miscellaneous
-	**-**	**-**	**-**	**-**	**-**	**-**	

6.2 Commodity balances 2015

Renewables and waste

Thousand tonnes of oil equivalent

	Waste wood	Wood	Animal biomass and anaerobic digestion *(4)*	Plant biomass *(5)*	Sewage gas	Landfill gas
Supply						
Production	342r	2,011r	928r	1,924r	366r	1,612
Other sources	-	-	-	-	-	-
Imports	50r	35	-	2,836r	-	-
Exports	-73	-138	-	-37r	-	-
Marine bunkers	-	-	-	-	-	-
Stock change *(1)*	-	-	-	-	-	-
Transfers	-	-	-84r	-	-	-
Total supply (2)	**319r**	**1,908r**	**844r**	**4,723r**	**366r**	**1,612**
Statistical difference *(3)*	-	-	-	-	-	-
Total demand	**319r**	**1,908r**	**844r**	**4,723r**	**366r**	**1,612**
Transformation	**2r**	**-**	**718r**	**3,892r**	**293r**	**1,598**
Electricity generation	-	-	718r	3,885r	293r	1,598
Major power producers	-	-	209	3,381	-	-
Autogenerators	-	-	509r	505r	293r	1,598
Heat generation	2r	-	-	6r	-	-
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	-	-	-	-r	-	-
Other	-	-	-	-	-	-
Losses	**-**	**-**	-	-	**-**	**-**
Final consumption	**317r**	**1,908r**	**126r**	**831r**	**73**	**14**
Industry	**239r**	**-**	**39r**	**648r**	**73r**	**14**
Unclassified	-r	-	14r	11r	-	-r
Iron and steel	-	-	-	-	-	-
Non-ferrous metals	-	-	-	-	-	-
Mineral products	12r	-	17r	159r	-	14r
Chemicals	-	-	-	16r	-	-
Mechanical engineering, etc	-	-	-	-	-	-
Electrical engineering, etc	-	-	-	-	-	-
Vehicles	-	-	-	-	-	-
Food, beverages, etc	-	-	5r	22r	-	-
Textiles, leather, etc	-	-	-	-	-	-
Paper, printing, etc	-	-	3r	408r	-	-
Other industries	227r	-	-	32r	73r	-
Construction	-	-	-	-	-	-
Transport	**-**	**-**	**-**	**-**	**-**	**-**
Air	-	-	-	-	-	-
Rail	-	-	-	-	-	-
Road	-	-	-	-	-	-
National navigation	-	-	-	-	-	-
Pipelines	-	-	-	-	-	-
Other	**78r**	**1,908r**	**87r**	**183r**	**0r**	**-**
Domestic	-	1,908r	-	-	-	-
Public administration	-	-	-	-	0r	-
Commercial	38r	-	-	104r	-	-
Agriculture	40r	-	87r	78r	-	-
Miscellaneous	-	-	-	-	-	-
Non energy use	**-**	**-**	**-**	**-**	**-**	**-**

(1) Stock fall (+), stock rise (-).
(2) Including non-biodegradable wastes, which accounted for 1,070 ktoe.
(3) Total supply minus total demand.
(4) Includes poultry litter, meat and bone and farm waste
(5) Includes straw, short rotation coppice (SRC), and other plant based biomass
(6) Municipal solid waste, tyres, general industrial waste and hospital waste.
(7) Marine energy was 0.2 ktoe.

6.2 Commodity balances 2015 (continued)

Renewables and waste

Thousand tonnes of oil equivalent

Waste *(6)*	Solar photovoltaics, active solar heating, and deep geothermal	Heat pumps	Hydro	Wind and marine energy *(7)*	Liquid biofuels	Total renewables	
							Supply
2,020r	700r	182r	542r	3,467r	325r	14,419r	Production
-	-	-	-	-	-	-	Other sources
-	-	-	-	-	790r	3,712r	Imports
-	-	-	-	-	-117	-366r	Exports
-	-	-	-	-	-	-	Marine bunkers
-	-	-	-	-	-	-	Stock change *(1)*
-	-	-	-	-	-	-84r	Transfers
2,020r	**700r**	**182r**	**542r**	**3,467r**	**998r**	**17,681r**	**Total supply** *(2)*
-	-	-	-	-	-	-	**Statistical difference** *(3)*
2,020r	**700r**	**182r**	**542r**	**3,467r**	**998r**	**17,681r**	**Total demand**
1,880r	**649r**	**-**	**542r**	**3,467r**	**-**	**13,040r**	**Transformation**
1,817r	649r	-	542r	3,467r	-	12,968r	Electricity generation
471	121r	-	422	2,860r	-	7,463r	Major power producers
1,346r	528r	-	120r	607r	-	5,506r	Autogenerators
63r	-	-	-	-	-	71r	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
-r	-	-	-	-	-	-	Pumped storage
-	-	-	-	-	-	-	Other
-	-	-	-	-	-	-	**Losses**
140r	**52r**	**182r**	**-**	**-**	**998r**	**4,641r**	**Final consumption**
103r	**-**	**4r**	**-**	**-**	**-**	**1,121r**	**Industry**
69r	-	4r	-	-	-	99r	Unclassified
-	-	-	-	-	-	-	Iron and steel
-	-	-	-	-	-	-	Non-ferrous metals
-	-	-	-	-	-	202r	Mineral products
-	-	-	-	-	-	16r	Chemicals
2r	-	-	-	-	-	2r	Mechanical engineering, etc
-	-	-	-	-	-	-	Electrical engineering, etc
-	-	-	-	-	-	-	Vehicles
-	-	-	-	-	-	27r	Food, beverages, etc
-	-	-	-	-	-	-	Textiles, leather, etc
-	-	-	-	-	-	411r	Paper, printing, etc
33r	-	-	-	-	-	365r	Other industries
-	-	-	-	-	-	-	Construction
-	-	-	-	-	**998r**	**998r**	**Transport**
-	-	-	-	-	-	-	Air
-	-	-	-	-	-	-	Rail
-	-	-	-	-	998r	998r	Road
-	-	-	-	-	-	-	National navigation
-	-	-	-	-	-	-	Pipelines
37r	**52r**	**178r**	**-**	**-**	**-**	**2,523r**	**Other**
-r	32r	93r	-	-	-	2,033r	Domestic
37r	0	-	-	-	-	38r	Public administration
-r	19r	85r	-	-	-	246r	Commercial
-	-	-	-	-	-	205r	Agriculture
-	-	-	-	-	-	-	Miscellaneous
-	**-**	**-**	**-**	**-**	**-**	**-**	

6.3 Commodity balances 2014

Renewables and waste

Thousand tonnes of oil equivalent

	Waste wood	Wood	Animal biomass and anaerobic digestion *(4)*	Plant biomass *(5)*	Sewage gas	Landfill gas
Supply						
Production	374r	1,767	638r	1,354r	343r	1,664r
Other sources	-	-	-	-	-	-
Imports	24	14	-	2,190	-	-
Exports	-79	-83	-	-44	-	-
Marine bunkers	-	-	-	-	-	-
Stock change *(1)*	-	-	-	-	-	-
Transfers	-	-	-12r	-	-	-
Total supply (2)	**319r**	**1,698**	**626r**	**3,499r**	**343r**	**1,664r**
Statistical difference *(3)*	-	-	-	-	-	-
Total demand	**319r**	**1,698**	**626r**	**3,499r**	**343r**	**1,664r**
Transformation	**-**	**-**	**560r**	**2,943r**	**276r**	**1,651r**
Electricity generation	-	-	560r	2,938r	276r	1,651r
Major power producers	-	-	195	2,583	-	-
Autogenerators	-	-	366r	355r	276r	1,651r
Heat generation	-	-	-	5r	-	-
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	**319r**	**1,698**	**66r**	**556r**	**68**	**14**
Industry	**319r**	**-**	**35**	**128r**	**-**	**14**
Unclassified	319r	-	35	128r	-	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	**-**	**1,698**	**31r**	**428r**	**68**	**-**
Domestic	-	1,698	-	-	-	-
Public administration	-	-	-	-	68	-
Commercial	-	-	-	-	-	-
Agriculture	-	-	31r	428r	-	-
Miscellaneous	-	-	-	-	-	-
Non energy use	**-**	**-**	**-**	**-**	**-**	**-**

(1) Stock fall (+), stock rise (-).
(2) Including non-biodegradable wastes, which accounted for 847 ktoe.
(3) Total supply minus total demand.
(4) Includes poultry litter, meat and bone and farm waste
(5) Includes straw, short rotation coppice (SRC), and other plant based biomass
(6) Municipal solid waste, tyres, general industrial waste and hospital waste.

(7) Marine energy was 0.2 ktoe.

6.3 Commodity balances 2014 (continued)

Renewables and waste

Thousand tonnes of oil equivalent

Waste *(6)*	Solar photovoltaics, active solar heating, and deep geothermal	Heat pumps	Hydro	Wind and marine energy *(7)*	Liquid biofuels	Total renewables	
							Supply
1,605r	399r	107r	506r	2,748r	423r	11,927r	Production
-	-	-	-	-	-	-	Other sources
-	-	-	-	-	975	3,203	Imports
-	-	-	-	-	-155	-361	Exports
-	-	-	-	-	-	-	Marine bunkers
-	-	-	-	-	-	-	Stock change *(1)*
-	-	-	-	-	-	-12r	Transfers
1,605r	**399r**	**107r**	**506r**	**2,748r**	**1,243r**	**14,757r**	**Total supply** *(2)*
-	-	-	-	-	-	-	**Statistical difference** *(3)*
1,605r	**399r**	**107r**	**506r**	**2,748r**	**1,243r**	**14,757r**	**Total demand**
1,426r	**349r**	**-**	**506r**	**2,748r**	**-**	**10,458r**	**Transformation**
1,371r	349r	-	506r	2,748r	-	10,398r	Electricity generation
379	-	-	399	2,301r	-	5,856r	Major power producers
992r	349r	-	108r	447r	-	4,542r	Autogenerators
55r	-	-	-	-	-	60r	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**
179r	**50**	**107r**	**-**	**-**	**1,243r**	**4,299r**	**Final consumption**
97r	**-**	**2r**	**-**	**-**	**-**	**594r**	**Industry**
97r	-	2r	-	-	-	594r	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
-	-	-	-	-	**1,243r**	**1,243r**	**Transport**
-	-	-	-	-	-	-	Air
-	-	-	-	-	-	-	Rail
-	-	-	-	-	1,243r	1,243r	Road
-	-	-	-	-	-	-	National navigation
-	-	-	-	-	-	-	Pipelines
82r	**50**	**105r**	**-**	**-**	**-**	**2,462r**	**Other**
20r	50	70r	-	-	-	1,837r	Domestic
51r	0	-	-	-	-	119r	Public administration
11r	0	35r	-	-	-	47r	Commercial
-	-	-	-	-	-	459r	Agriculture
-	-	-	-	-	-	-	Miscellaneous
-	**-**	**-**	**-**	**-**	**-**	**-**	**Non energy use**

6.4 Capacity of, and electricity generated from, renewable sources

	2012	2013	2014	2015	2016
Installed Capacity (MW) *(1)*					
Wind:					
Onshore	6,035	7,586	8,573	9,222	10,923
Offshore	2,995	3,696	4,501	5,093	5,293
Marine energy (wave and tidal stream)	9	8	9	9	13
Solar photovoltaics	1,753	2,937	5,528	9,535	11,899
Hydro:					
Small scale	216	232	253	300	358
Large scale *(2)*	1,477	1,477	1,477	1,477	1,477
Bioenergy:					
Landfill gas	1,042	1,050	1,058	1,061	1,062
Sewage gas	212	201	230	231	257
Energy from waste *(3)*	513	545	680	925	1,017
Animal biomass *(4)*	111	111	111	111	129
Anaerobic digestion	121	163	243	323	420
	1,166	1,955	2,258	2,607	2,850
Total bioenergy and wastes	3,163	4,025	4,579	5,258	5,736
Total	15,649	19,961	24,920	30,893	35,700
Co-firing (6)	208	39	14	21	13
Generation (GWh)					
Wind:					
Onshore *(7)*	12,244	16,925	18,555	22,895	20,962
Offshore	7,603	11,472	13,405	17,423	16,406
Marine energy (wave and tidal stream)(8)	4	5	2	2	0
Solarphotovoltaics	1,354	2,010	4,054	7,546	10,420
Hydro:					
Small scale(7)	678	675	835	984	1,016
Large scale(2)	4,632	4,026	5,053	5,314	4,379
Bioenergy:					
Landfill gas	5,208	5,175	5,033	4,872	4,703
Sewage gas	739	766	840	894	950
Biodegradable energy from waste(9)	1,773	1,648	1,900	2,585	2,741
Co-firing with fossil fuels	1,829	337	124	183	117
Animal biomass(4)	643	628	614	648	650
Anaerobic digestion	495	713	1,023	1,471	2,052
Plant biomass(5)	4,048	8,832	13,086	18,587	18,829
Total bioenergy	14,734	18,100	22,619	29,240	30,043
Total generation	41,249	53,213	64,522	83,403	83,225
Non-biodegradable wastes *(10)*	1,428	1,480	1,901	2,586	2,742
Total generation from sources eligible for the Renewable Obligation *(11)*	36,967	47,539r	57,569r	75,505	76,106

(1) Capacity on a DNC basis is shown in Long Term Trends Table 6.1.1 available on the BEIS website.
(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 6.57 for definition and coverage.

6.5 Load factors for renewable electricity generation

	2012	2013	2014	2015	2016
					Per cent
Load factors - based on average beginning and end of year capacity (1)					
Wind	28.9	31.9	30.0	33.6	27.9
Onshore	25.8	28.4	26.2	29.4	23.7
Offshore	35.8	39.1	37.3	41.5	36.0
Marine energy (wave and tidal stream)	7.7	6.5	3.0	2.6	0.0
Solar photovoltaics	11.2	9.8	10.9	11.4	11.1
Hydro	35.9	31.6	39.1	41.0	34.0
Small scale	37.0	34.4	39.3	40.7	35.2
Large scale	35.7	31.1	39.1	41.1	33.8
Bioenergy (excludes cofiring and non-biodegradable wastes)	46.9	56.4	59.7	67.4	62.0
Landfill gas	56.6	56.5	54.5	52.5	50.4
Sewage sludge digestion	40.9	42.3	44.4	44.2	44.3
Energy from waste (3)	39.8	35.6	35.4	36.8	32.1
Animal biomass (4)	66.2	64.9	63.4	66.9	61.7
Anaerobic digestion	57.9	57.5	57.6	59.3	62.8
Plant Biomass (5)	39.6	64.6	70.9	87.2	78.6
All renewable technologies (excluding cofiring and non-biodegradable wastes)	32.0	33.9	32.8	34.0	28.4
Load factors - for schemes operating on an unchanged configuration basis (2)					
Wind	27.7	31.0	29.8	33.3	28.8
Onshore	25.5	27.9	25.9	29.4	24.2
Offshore	34.1	37.6	37.8	39.7	36.7
Solar photovoltaics	11.2	11.3	11.1	11.2	10.8
Hydro	37.5	31.6	38.8	39.5	33.9
Small scale	39.5	36.1	39.7	41.8	34.6
Large scale	37.3	31.2	38.8	39.2	33.8
Bioenergy (excludes cofiring and non-biodegradable wastes)	62.7	60.5	65.1	67.6	68.9
Landfill gas	58.4	57.5	55.2	52.6	49.9
Sewage sludge digestion	45.4	49.8	48.0	48.2	43.1
Energy from waste (3)	40.4	35.3	35.5	36.3	34.6
Animal biomass (4)	66.2	70.4	63.4	66.9	57.2
Anaerobic digestion	59.2	61.5	57.5	57.6	59.4
Plant biomass (5)	69.9	60.6	70.5	74.3	78.9
All renewable technologies (excluding cofiring and non-biodegradable wastes)	36.0	36.1	37.8	38.2	33.0

(1) See methodology note for details of the calculation.

(2) See methodology note 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

	2012	2013	2014	2015	2016
Used to generate electricity *(3)*					
Wind:					
Onshore	1,052.8	1,455.3	1,595.4	1,968.6	1,802.4
Offshore	653.8	986.4	1,152.6	1,498.1	1,410.6
Marine energy (4)	0.4	0.4	0.2	0.2	0.0
Solar photovoltaics	116.4	172.8	348.6	648.8	896.0
Hydro:					
Small scale	58.3	58.0	71.8	84.6	87.4
Large scale *(5)*	398.2	346.2	434.5	456.9	376.5
Bioenergy:					
Landfill gas	1,708.3	1,697.2	1,650.8	1,598.0	1,542.4
Sewage gas	242.2	251.2	275.5	293.3	311.7
Biodegradable energy from waste	638.5	564.7	682.1	905.2	1,117.4
Co-firing with fossil fuels	400.5	53.7	25.1	37.8	24.6
Animal biomass *(6)*	225.0	226.4	224.8	235.3	230.1
Anaerobic digestion	162.2	233.9	335.4	482.4	673.1
Plant biomass *(7)*	1,062.3	2,008.3	2,912.9	3,847.6	3,871.0
Total bioenergy	4,439.1	5,035.3	6,106.6	7,399.6	7,770.4
Total	6,718.9	8,054.5	9,709.7	12,056.9	12,343.3
Non-biodegradable wastes *(8)*	520.3	513.1	688.4	911.5	1,123.7
Used to generate heat					
Active solar heating	45.9	47.9	49.6	50.7	51.2
Bioenergy:					
Landfill gas	13.6	13.6	13.6	13.6	13.6
Sewage gas	63.7	68.3	67.7	73.1	72.1
Wood	1,518.5	1,787.7	1,698.1	1,908.5	1,954.0
Waste wood	309.1	315.4	319.1	318.7	319.1
Animal biomass *(9)*	31.5	29.1	34.5	30.7	23.0
Anaerobic digestion	14.5	18.5	42.9	95.5	179.4
Plant biomass *(10)*	285.4	418.8	561.2	837.7	1,102.2
Biodegradable energy from waste *(6)*	29.8	29.7	22.4	45.6	45.7
Total bioenergy	2,266.2	2,681.1	2,759.6	3,323.3	3,709.1
Deep geothermal	0.8	0.8	0.8	0.8	0.8
Heat Pumps	54.8	96.5	106.7	155.8	182.2
Total	2,367.8	2,826.3	2,916.6	3,530.6	3,943.3
Non-biodegradable wastes *(8)*	144.1	154.7	158.4	158.5	167.6
Renewable sources used as transport fuels					
Bioethanol	436.9	462.2	458.8	449.1	427.8
Biodiesel	520.9	629.4	783.8	554.1	581.7
Total	957.8	1,091.6	1,242.7	1,003.1	1,009.5
Total use of renewable sources and wastes					
Solar heating and photovoltaics	162.3	220.7	398.1	699.5	947.2
Onshore wind	1,052.8	1,455.3	1,595.4	1,968.6	1,802.4
Offshore wind	653.8	986.4	1,152.6	1,498.1	1,410.6
Marine energy (wave and tidal stream)	0.4	0.4	0.2	0.2	0.0
Hydro	456.6	404.3	506.3	541.6	463.9
Bioenergy	6,705.3	7,716.4	8,866.2	10,722.9	11,479.4
Deep geothermal	0.8	0.8	0.8	0.8	0.8
Heat pumps	54.8	96.5	106.7	155.8	182.2
Transport biofuels	957.8	1,091.6	1,242.7	1,003.1	1,009.5
Total	10,044.5	11,972.4	13,869.0	16,590.6	17,296.1
Non-biodegradable wastes *(8)*	664.4	667.8	846.8	1,070.0	1,291.3
All renewables and wastes *(11)*	10,708.9	12,640.2	14,715.8	17,660.6	18,587.5

(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) Wave and tidal stream; 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

	2012	2013	2014	2015	2016
Electricity generation component:					
Normalised hydro generation *(1) (2)*	448	445	448	461	481
Normalised wind generation *(3)*	1,638	2,228	2,714	3,224	3,506
Electricity generation from renewables other than wind, hydro, and compliant biofuels	1,383	1,730	2,295	3,174	3,506
Electricity generation from compliant biofuels	-	-	-	1	2
Total renewable generation from all compliant sources	3,468	4,402	5,457	6,859	7,493
Total Gross Electricity Consumption *(2)*	32,046	31,798	30,587	30,706	30,437
Percentage of electricity from renewable sources	10.8%	13.8%	17.8%	22.3%	24.6%
Heat component:					
Renewable energy for heating and cooling	1,993	2,387	2,468	3,020	3,408
Total Gross energy consumption for heating and cooling	57,733	59,180	52,997	54,791	55,266
Percentage of heating and cooling energy from renewable sources	3.5%	4.0%	4.7%	5.5%	6.2%
Transport component (excluding air transport):					
Road transport renewable electricity	0	1	1	2	3
Non-road transport renewable electricity	75	81	90	96	107
Biofuels (restricted to those meeting sustainability criteria from 2011) *(4)*	896	1,045	1,176	943	936
Total electricity consumption in transport	385	374	387	388	401
Total petrol and diesel consumption in transport	37,065	36,777	37,270	37,960	38,816
Total transport component numerator (including weighted components) *(5)*	1,539	1,824	2,090	1,780	1,823
Total transport component denominator (including weighted components) (5)	38,913	38,894	39,653	40,022	40,919
Percentage of transport energy from renewable sources *(5)*	4.0%	4.7%	5.3%	4.4%	4.5%
Overall directive target:					
Renewables used for:					
Electricity generation	3,392	4,321	5,366	6,761	7,383
Heating and Cooling	1,993	2,387	2,468	3,020	3,408
Transport biofuels (restricted to those meeting sustainability criteria from 2011)	971	1,127	1,267	1,041	1,046
Total Final Consumption of Renewable Energy ["Row A"]	6,356	7,835	9,101	10,822	11,837
Final Electricity Consumption *(6)*	26,981	26,820	25,648	25,704	25,720
Transport Final Energy Consumption (including air transport) *(7)*	50,316	50,107	50,720	51,282	52,231
Heating and Cooling Final Energy Consumption	57,722	59,170	52,988	54,782	55,255
Total Final Energy Consumption *(8)*	135,019	136,097	129,356	131,767	133,207
plus Distribution losses for electricity	2,425	2,283	2,360	2,452	2,280
plus Distribution losses for heat	-	-	-	-	-
plus Consumption of electricity in the electricity and heat generation sectors	1,548	1,535	1,417	1,432	1,313
plus Consumption of heat in the electricity and heat generation sectors	-	-	-	-	-
Gross Final Energy Consumption (GFEC)	138,992	139,915	133,133	135,651	136,800
of which Air transport	11,788	11,812	11,798	11,903	12,003
Air transport as a proportion of GFEC	8.48%	8.44%	8.86%	8.77%	8.77%
Air transport cap specificed in Directive	6.18%	6.18%	6.18%	6.18%	6.18%
Capped air transport	8,590	8,647	8,228	8,383	8,454
Capped Gross Final Energy Consumption (CGFEC) ["Row B"] *(9)*	135,794	136,750	129,562	132,131	133,251
Headline Directive percentage : Renewable Energy Consumption as a percentage of Capped Gross Final Energy Consumption ["Row A" divided by "Row B"]	4.7%	5.7%	7.0%	8.2%	8.9%

(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 BEIS 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.