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POSTNOTE

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# Trends in Energy

Providing affordable, reliable and sustainable energy is a key issue in UK policy. Energy policy can be informed by current energy sector trends and projections into the future. This briefing outlines key trends in energy, the factors driving these changes and future projections. It also highlights the implications and challenges of these trends.

## Overview

- UK energy use fell by 18% from 2000 to 2014.
- Domestic energy bills almost doubled from 2004 to 2013, driven largely by gas prices.
- In 2014 UK greenhouse gas emissions were 36% lower than 1990 levels, meeting current targets. Emission targets for 2025 may not be met without further Government action.
- Since 1990, the proportion of the UK's electricity generated from renewables has increased rapidly to around 19% in 2014.
- Emerging energy technologies include electric vehicles, heat pumps and carbon capture and storage.
- The energy sector contributed 2.8% to GDP in 2014. This has fallen as a proportion of GDP from 10.4% in 1982.

## Background

The way individuals and businesses use and source energy affects a range of important policy issues including economic growth, the cost of living, air quality and health, the environment and the global climate. Policy across governments has aimed simultaneously to minimise energy costs, reduce pollution and promote economic growth, while maintaining reliable energy supplies.

Progress against these policy aims can be assessed using existing and emerging energy trends, such as changes to climate-change-inducing greenhouse gas (GHG) emissions (see Box 1). An understanding of some trends is also important for making projections, which can be used for identifying effective policy options. However, projections are only as reliable as the estimates and assumptions on which they are based.

This POSTnote outlines key trends and projections in six areas. The first covers energy use and fuel poverty. The next four cover the technologies and fuels used to generate and source energy in the UK: electricity generation technologies, heat generation technologies, transport technologies and coal, oil and gas production and imports; and how these affect GHG emissions and the cost and reliability of energy in the UK. The final area covers trends in jobs and GDP driven by the energy sector. All financial figures in this briefing are in real terms.

**Box 1. UK Greenhouse Gas Emission Trends and Targets**

The Climate Change Act commits the UK to reducing GHG emissions by 80% from 1990 levels by 2050[1] and requires that the Government set up interim five-yearly carbon budgets for GHG emissions (see Figure 1).[2] By 2014, UK GHG emissions had fallen by 36% since 1990,[3] meeting the second carbon budget (a 29% reduction on 1990 levels between 2013 and 2017). However, the Committee on Climate Change consider that the fourth carbon budget (a 50% reduction by 2023-2027) will be missed without further Government action.

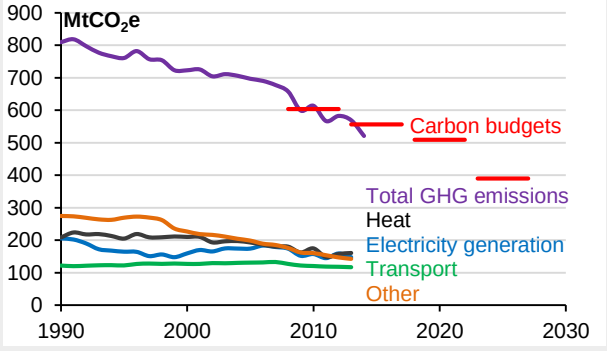


**Figure 1.** GHG emissions from energy use by sector in million metric tons of carbon dioxide equivalent ($MtCO_2e$).[4]

## Trends in Energy Use

Energy use includes electricity consumption and the burning of fuels for heating and transport. Between 2000 and 2014 energy demand fell by 32% in industry, 2% in transport, 12% in the service sector (including public administration, commerce and agriculture) and 19% in the domestic sector. Energy demand is predicted to continue declining in the UK until the mid-2020s.[5,6] However, electricity use is predicted to increase as heat and transport become electrified.[7,8] The following sections look at trends in the efficiency, price and flexibility of energy use.

### Increasing Energy Efficiency

Energy efficiency improvements (POSTnote 409) allow consumers to reduce energy use while still achieving the same outcome, such as keeping a room warm. Improved energy efficiency is a proven and cost-efficient way to lower emissions.[9-11] Domestic improvements also reduce bills and improve health, by helping homes retain heat. Analysis by the Department of Energy and Climate Change suggests that falls in UK energy demand were at least partly driven by energy efficiency improvements, such as increased fuel efficiency in cars and better insulation of homes.[12-15] Energy price rises and the shift of UK industry towards less energy intensive industries have also reduced consumption.

Some future energy efficiency improvements are expected to be stimulated by EU policy on the efficiency of appliances and the introduction of smart meters to all homes and small businesses in Great Britain (POSTnote 471).[16] However, the Committee on Climate Change (CCC) has raised concerns over recent and future energy efficiency policy and progress.[17] In 2013, two new Government incentive schemes were introduced (the Green Deal and Energy Company Obligation [ECO]). Since then, there has been a rapid decline in home insulation installation rates, following high rates encouraged by previous policies.[18,19] The Green Deal subsequently closed in July 2015, while support for ECO has yet to be set beyond 2017. The Government has also decided not to proceed with regulation to ensure that all new homes and non-residential buildings would be zero-carbon.[20]

### Energy Prices, Bills and Fuel Poverty

From 2004 to 2013 increases in energy prices led to higher bills for domestic, commercial and industrial customers, despite reductions in energy consumption.

- Industrial and commercial gas and electricity prices have both doubled.[21,22] Industry claim that this led to some factories being closed.[23]
- Domestic electricity prices increased by 80% while gas prices doubled, causing similar increases in domestic energy bills.[24-26] The average proportion of household income spent on energy increased from 3.3% in 2004 to 5.1% in 2012.[27]

Domestic price rises have been driven by increases in wholesale prices, network costs and environmental levies.

- Wholesale gas and electricity prices more than doubled between 2004 and 2013.[28] Wholesale prices make up 45-55% of a domestic energy bill.
- Costs for using the gas and electricity networks increased by over 40% from 2007 to 2014, in part to pay for network upgrades.[29,30] However, current costs are still lower than in 1990 as charges fell by almost 50% between 1990 and 2006, after privatisation.[31-33] Beyond 2014 charges are expected to remain stable.[34] Network costs make up 20-25% of a domestic energy bill.[35]
- Environmental levies increased from 2% of domestic dual fuel bills in 2004 to 7% in 2014, in part to support the development of low carbon electricity generation technologies.[36,37] However, these levies also supported energy efficiency policies, which helped to reduce bills for some homes.[38,39]

Increases in household energy bills have led to questions about energy market competition. In July 2015, the Competition and Markets Authority (CMA) reported that while companies offered competition, low switching rates were limiting the success of price-competitive firms or tariffs. Switching rates have been in decline since 2008.[40] This may be because of low awareness of deals, or real and perceived difficulties with switching. Consumers could save an average of 14% (£160) a year on their dual fuel bill by switching energy supplier.[41]

*Fuel Poverty*

Energy prices and bills affect levels of fuel poverty. A household is considered to be in fuel poverty in Scotland, Wales and Northern Ireland if 10% of income is spent on fuel. Between 2003 and 2013 the proportion of all UK households in fuel poverty (by the 10% measure) rose from around 7% to 17%.[42] In England, the measure for fuel poverty has recently changed and now takes into account both low income and high fuel costs.[43] Under this new measure fuel poverty in England decreased slightly (from 11.8 to 10.4%) but the depth of fuel poverty increased from £231 to £374.[44] Policy in Scotland and Wales aims to eradicate fuel poverty by 2016 and 2018 respectively, while the Fuel Poverty (England) Regulations 2014 aim to improve energy efficiency to a target level in as many fuel poor homes as possible by 2030.[45-47] However, it is unlikely Scotland or Wales will meet these targets and Policy Exchange estimates that annual spending in England is less than half of what is required to meet its target.[48-50]

Homes in fuel poverty are more likely to have prepayment meters (PPM) and PPM customers gain the least savings from switching,[51] are less likely to switch[52] and pay on average 22% more than the cheapest direct debit deal.[53] Between 1996 and 2014 the proportion of customers on prepayment meters doubled from 7% to 14%.[54]

### Flexibility to Use Energy at Different Times

There has been an increase in commercial and industrial consumers being more flexible about when they use energy when offered incentives (see Box 2). In future, smart meters may also enable domestic consumers to benefit from altering when they use energy (see POSTnote 471).

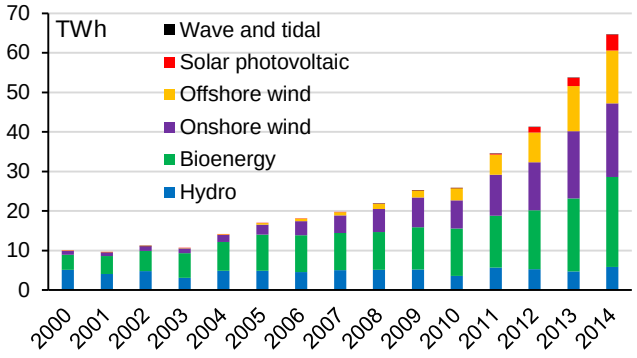


**Figure 2: Renewable electricity generation in Terawatt hours (TWh)**

## Trends in Electricity Generation

A binding EU target that 15% of UK energy consumption should be sourced from renewables by 2020 (which commentators agree will require at least 30% of electricity to be renewable, as renewable heat and transport contribute a smaller proportion) have helped drive the following changes in electricity sources.

- Renewable electricity generation increased from around 2% of the UK's total in 1990 to 19% in 2014. This included significant increases in wind, solar and bioenergy use (see Figure 2).[55,56]
- The proportion of electricity supplied by nuclear power has fallen from 28% in 1998 to 19% in 2014.[57,58]
- In the early 1990s, there was an increase in gas-fuelled electricity generation, with a decline in coal. Since the late 1990s coal and gas have had similar shares of electricity generation (25-40% each), varying depending on the relative prices of coal and gas.[59]

Changes in the source of electricity have reduced emissions and affected security of supply and who controls generation.

- $CO_2$ emissions from power generation have gradually fallen and in 2014 they were 40% below 1990 levels.[60]
- The margin of spare capacity at peak demand has fallen significantly since 2012 as a number of ageing 'backup' fossil fuel power plants have closed, partly because of EU (non-GHG) emissions limits.[61-63] However, security of electricity supply remains just within the Government's required level. The Government's Capacity Market plans to minimise the risk of a generation shortfall from 2018.[64]
- Increased amounts of small-scale (rooftop) solar and onshore wind generation are leading to a less centralised electricity system.[65,66] This can empower consumers to control their energy production.[67]

### Future Changes

Up to 2020 it is likely that the proportion of renewables will continue to increase because many projects are already being built in an attempt to meet the EU renewables target. However, recent reductions in UK support for solar farms, biomass and onshore wind may slow growth.[68-71] Another likely change would see gas power plants displace some coal power plants after the introduction of the EU Industrial Emissions Directive in 2016.[72] The first fossil fuel power plant fitted with carbon capture and storage (CCS, see POSTnote 335) is planned to open from 2019 with Government support.

**Box 2. Alternative Flexible Energy Options**

Fossil fuel power plants currently provide the flexibility to match consumer demands at all times. Variable renewables or nuclear plants (that cannot be easily turned off) cannot provide as much flexibility. In addition to biomass power stations and potential future fossil-fuelled plants with CCS, the following options could provide flexible energy.

- **Electricity from overseas networks,** which is transmitted to the UK through electricity interconnector wires, is making up an increasing proportion of UK electricity. The UK currently has four interconnectors providing 4% of supply capacity. A number of proposed interconnectors could almost triple current capacity.[73]
- **Energy Storage** (POSTnote 492) allows power and heat generated when supply is high (or demand is low) to be stored for release when supply is low (or demand is high).
- **Demand side response** (POSTnote 452) is used to manage energy demand instead of supply. Demand can be shifted away from peak times by offering incentives to consumers to change when they use electricity.

Beyond 2020, the electricity mix is more uncertain and will depend upon government policy and the future cost of the different electricity generation technologies.[74]

- Most commentators agree that there will be further increases in renewable generation.[75-79] In particular, the cost of solar generation has fallen quickly recently and the Solar Trade Association suggests that large-scale solar could be cheaper than gas power stations by as soon as 2018.[80] However, the future proportion of electricity generated by intermittent renewables (POSTnote 464) could be limited by the cost of providing flexible backup (Box 2). The amount of flexible biomass generation may also be limited by the availability and sustainability of biomass (POSTnote 410).[81]
- Many ageing nuclear plants are expected to close in the 2020s, but the Government expects new builds to increase nuclear generating capacity by 2030.[82,83] The Government also aspires to have significantly more nuclear capacity by 2050.[84]
- A second set of fossil-fuelled power plants with CCS is likely to depend upon further policy support. These may provide a cost competitive form of flexible low carbon electricity supply to complement inflexible nuclear and intermittent renewables.
- Fossil-fuelled power plants without CCS are expected to be used less to meet emissions targets, but many are likely remain open to help meet peak power demand.

## Trends in Heat Generation

Heating makes up a large proportion of average domestic energy bills and UK GHG emissions (see Figure 1).[85] Key trends in heating technologies relate to gas use, low carbon heating and heat networks.

### Gas for Heating

Natural gas began to replace coal for heating purposes in the early 1970s and by 2013 it provided 71% of heat (79% of domestic heat, 71% of service sector heat and 48% of industrial heat).[86,87] The number of natural-gas-fuelled Combined Heat and Power (CHP) plants (which generate

electricity then capture and use the waste heat) has also risen. CHP plant numbers increased from 266 in 1991 to 2,066 in 2014, with 67% of CHP fuelled by gas in 2014.[88]

### Emergence of Low Carbon Heating

Sales of heating technologies that can help to reduce UK GHG emissions have steadily increased, supported by subsidies from the Government's domestic and non-domestic Renewable Heat Incentive (RHI) schemes. By 2014, 4.9% of total heat came from the following sources:[89]

- **Bioenergy** (biomass and biogas) use for heat generation has more than tripled since 2005[90] and accounted for 94% of renewable heat in 2014.[91] The use of bioenergy to fuel CHP plants grew to 11% in 2014.[92]
- **Heat pumps** (POSTnote 426) capture heat from the air or the ground and transfer it inside a building. Electrifying heating through use of electric heat pumps can reduce emissions as the power sector is decarbonised. Over the last decade sales have grown and there are now around 120,000 electric heat pumps in the UK,[93] with over 19,000 accredited by the domestic RHI in its first year, 2014.[94]
- **Solar thermal** capacity rose by almost four times between 2003 and 2010. Since 2010, the rate of increase has been declining and the introduction of the domestic RHI in 2013 has not altered the trend.[95]
- **Electric storage heaters** have been used in 1-2 million households since the 1970s.[96] Electric storage heaters are not supported by the RHI.

The CCC highlights that this deployment of low carbon heating has been slow and it estimates that further Government policy will be required if the UK is to stay within the Government's fourth carbon budget (see Figure 1) and meet the EU 2020 renewables target.[97,98] The RHI budget has not been confirmed beyond 2016.

### Increasing Use of Heat Networks

Heat networks connect groups of buildings or homes to a central heat source and supply heat to them by transporting hot water in pipes. In areas of high heat demand density, heat networks can provide cost-efficient lower carbon heating by linking buildings to large CHP plants, heat pumps and geothermal.[99] There has been a growth in the number of heat networks, with around 2,000 installations in 2012 providing heat for about 210,000 dwellings. However, only about 2% of the UK's heat demand is provided via heat networks.[100] Currently the Government is supporting heat network feasibility studies for local authorities.[101] It is estimated that heat networks could provide 40% of the UK's heat demand in 2050.[102]

## Energy for Transport

Petroleum fuels accounted for 97% of transport fuel in 2014 and in the near future aviation and shipping are expected to remain petroleum-only.[103] However, there are emerging trends towards using low carbon fuels in road transport and to some extent in rail, through electrification (for further trends in transport see POSTnote 496). These have been partly driven by EU targets to reduce GHG emissions from transport by 10% from 2005 levels by 2020 and to increase the combined use of electricity, biofuels and hydrogen to 10% of transport fuel (excluding aviation and shipping).[104]

- Electrifying transport can reduce emissions as the power sector is decarbonised. The number of electric vehicles (including petrol-electric and diesel-electric hybrids) is increasing at an accelerating rate. By July 2015, 35,705 cars had been registered in the UK,[105] following the introduction of the Government's 'plug-in' grant[106] in 2011. There have also been increases in the number of hybrid buses, which made up 2% of the fleet in 2014,[107] and there are plans to electrify more railways.[108]
- Biofuels made up 3.3% of road fuels in April 2015[109], up from 2.7% in April 2009.[110] However, this fell short of an interim EU target for 2013/4 of 4.75%. The remaining third was made up by buying biofuel certificates.[111]
- Hydrogen use in transport has shown early signs of emerging with the Government set to invest £11m to establish 15 hydrogen refuelling stations by the end of 2015.[112] However, vehicles are not yet cost competitive.

Further increases in low carbon transport are likely as the UK looks to meet its EU 2020 target. However, the CCC estimates that further policies on low carbon transport will be needed if the UK is to meet future carbon budgets (see Box 1). This may be assisted by a further EU target for 2030, which the EU is considering.

## Trends in Coal, Oil and Gas Production

Domestic production of coal, oil and gas have seen steady declines since the 1990s[113-115] with operational and capital costs increasing.[116,117] The decline in oil and gas production is expected to continue in the long term,[118] leading to falling tax revenues.[119] Shale gas may reduce the rate of decline in the 2020s. Falling domestic production led the UK to become a net importer in 2004 and 46% of fossil fuels in the UK were imported in 2014.[120] Despite increasing import dependency, the diversity of the UK's fossil fuel supply is generally considered to be resilient to all but the most extreme combination of severe infrastructure failure or supply shocks.[121] However, imports mean energy prices are more vulnerable to international price fluctuations.[122]

## Trends in GDP and Energy Sector Jobs

The contribution of the energy industries to GDP fell from 10.4% in 1982 to 2.8% in 2014. Employment in the energy industries declined rapidly by around 75% between 1980 and 1995, predominantly because of coal mine closures. However, between 2005 and 2014 employment grew by 49% largely due to growth in the electricity sector.[123] Within the workforce there are growing skills shortages, in part due to global competition for skilled workers and low uptake of energy industry jobs among young people.[124] The proportion of employees aged 45-69 increased by 4% between 2002 and 2010, twice the rate seen across the economy.[125] The ageing energy sector workforce means that there is a risk that a high proportion of skilled employees could retire quickly. For instance, it is predicted that 70% of the existing nuclear workforce will have retired by 2025.[126]

POST is an office of both Houses of Parliament, charged with providing independent and balanced analysis of policy issues that have a basis in science and technology. POST is grateful to Abby Casey for researching this briefing, to the EPSRC for funding her parliamentary fellowship, and to all contributors and reviewers. For further information on this subject, please contact the co-author, Dr Aaron Goater. 

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