

Carbon dioxide emissions and energy consumption in the UK

The UK is committed under the United Nations Framework Convention on Climate Change (UN-FCCC) and by agreement with the European Union to provide annual data on greenhouse gas emissions. This information is compiled by the National Environmental Technology Centre (NETCEN) under contract to Defra and the Devolved Administrations; data for the latest year (2004) was published by Defra on 23 January 2005. DTI is able to produce provisional estimates for 2005 based on energy consumption data that are published in this edition of Energy Trends. These provisional estimates will be subject to revision when final estimates are published next year, but they provide an indication of the emissions in the most recent calendar year. The majority of provisional estimates are within 1 per cent of the final figures. Emissions data are expressed in terms of millions of tonnes of carbon emitted per year (MtC/yr); they can be converted to million tonnes of carbon dioxide by multiplying by the relative molecular weights (44/12).

The key points to note are:

- Total UK CO₂ measured as emissions by sources minus removals by sinks¹ in 2005 were provisionally 153 MtC/yr, or 5½ per cent below 1990 levels. This is ½ MtC/yr (¼ per cent) higher than in 2004.
- Without accounting for removals by sinks, emissions were provisionally 157½ MtC/yr, or some 5 per cent below 1990 levels.
- The fall in emissions since 1990 is despite an overall increase of 10½ per cent in energy consumption over the same period. The increase in emissions between 2004 and 2005 resulted from an overall increase in energy consumption combined with fuel switching from natural gas to coal for electricity generation.
- CO₂ emissions from use of coal and other solid fuels rose by 4 per cent between 2004 and 2005 – resulting from increased demand for electricity generation due to high gas prices; emissions from gas fell by 2 per cent; emissions from oil were by ½ per cent higher mainly due to increased transport use.
- CO₂ emissions from power stations decreased by 16 per cent between 1990 and 2005. They increased by ½ per cent in 2005. Emissions from power stations are driven by changes in both the fuel mix used for generation and generation efficiency; more coal and oil but less gas was used to generate electricity in 2005 compared with 2004.
- Over the period 1990 to 2005 there were also falls in industrial emissions, in the commercial and public service sectors, and from land use change and agriculture. However emissions from fossil fuels delivered to both the domestic and transport sectors increased.

Why are CO₂ emissions important?

CO₂ emissions are important because, on a global basis, they contribute about 70 per cent of the potential global warming effect of anthropogenic emissions of greenhouse gases. Carbon dioxide is naturally emitted by living organisms and absorbed by plants during photosynthesis. However, the burning of fossil fuels releases CO₂ fixed by plants many millions of years ago, and increases its concentration in the atmosphere. The UK contributes about 2 per cent to global man-made emissions of CO₂; within the UK energy consumption accounts for about 95 per cent of all CO₂ emissions.

Policy targets

The UK met its commitment under the UN-FCCC to return emissions of CO₂ and other greenhouse gases to their 1990 level by the year 2000. The Kyoto Protocol to the Convention was agreed in December 1997. It committed the then 15 EU member states (including the UK) to a collective target of reducing EU emissions of a basket of 6 greenhouse gases, including CO₂, of 8 per cent relative to the 1990 level over the period 2008-2012. The UK undertook to reduce its emissions by 12½ per cent as its contribution to the target. The Kyoto Protocol became legally binding in February 2005 and to date has been ratified by 157 countries.

¹ Carbon sinks remove atmospheric carbon dioxide and store the carbon in wood, roots, leaves and the soil.

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The UK Government has also committed itself to moving towards a domestic goal of reducing UK CO₂ to 20 per cent below their 1990 level by 2010. This will be measured by total emissions by sources minus removals from sinks. The UK Climate Change Programme was published in November 2000. The Programme contained a package of measures aimed at meeting the UK's Kyoto target and move towards our domestic goal. A review has taken place to examine how existing policies were performing, and the range of policies that could be implemented to further reduce emissions.

The Energy White Paper², published in February 2003, defined four goals for energy policy, the first of which was to put ourselves on a long term path to reduce the UK's CO₂ emissions by 60 per cent by 2050. In reducing CO₂ emissions from the energy supply sector the priority is to increase the amount of energy generated from renewable energy sources and strengthen the contribution of energy efficiency; to support this "Energy Efficiency – The Government's Plan for Action" was published in April 2004³ – this sets out how improvements to energy efficiency can deliver a reduction of 12 million tonnes of carbon emissions by 2010. The EU Emissions Trading Scheme⁴ forms a key part of the "Plan for Action".

Estimates of CO₂ emissions

The measurement of CO₂ emissions presented in this article is based on the international methodology agreed by the Intergovernmental Panel on Climate Change, under which the UN-FCCC, and Kyoto Protocol commitments, and the UK's domestic targets for greenhouse gases are measured. This article refers to total emissions both with and without removals by sinks; annual figures since 1990 are shown in Table 1. Progress towards the 20 per cent domestic goal is measured using emissions by sources minus removals by sinks. The 2005 provisional estimates are based on provisional energy consumption data, contained in this edition of Energy Trends.

Total and net CO₂ emissions

CO₂ emissions by sources minus removals by sinks ("net emissions") fell provisionally by 5.3 per cent between 1990 and 2005; over the same period CO₂ emissions by sources ("total emissions") fell by 4.8 per cent. These falls in emissions occurred despite an overall increase of 10½ per cent in energy consumption. A number of factors explain these contrary movements, such as changes in efficiency in generation of electricity and switching to less carbon intensive fuels such as gas. Chart 1 shows total UK CO₂ emissions with the 20 per cent UK domestic goal. The Kyoto commitment is not shown because it relates to a basket of greenhouse gases, not just to CO₂.

Chart 1: CO₂ emissions

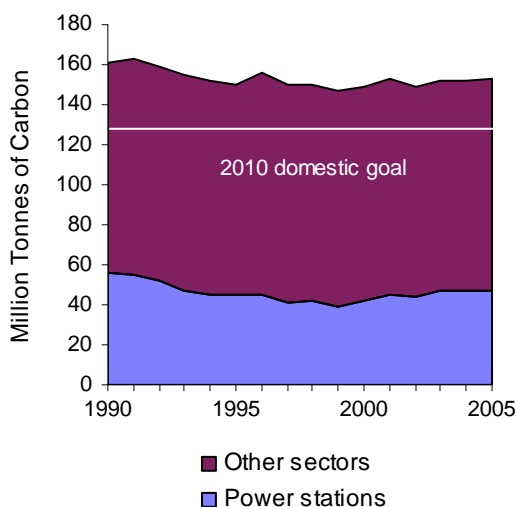
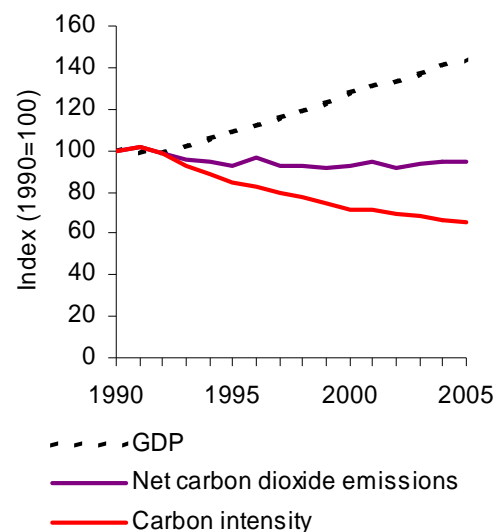


Chart 2: Carbon intensity



² "Our energy future – creating a low carbon economy". Available at www.dti.gov.uk/energy/whitepaper/index.shtml.

³ See www.defra.gov.uk/environment/energy/review/index.htm for more information.

⁴ See www.dti.gov.uk/energy/sepn/euets.shtml for more information.

CO₂ intensity

Chart 2 shows the trends in Gross Domestic Product (GDP) and CO₂ emissions since 1990 to show the relationship between carbon dioxide emissions and the economy. Overall, GDP has increased by around 43 per cent while CO₂ emissions have fallen. The ratio of CO₂ emissions to GDP is also shown in Chart 2. This ratio is known as the carbon intensity of the economy. The overall decline in carbon intensity of around 35 per cent has occurred because increased GDP has not resulted in overall increases in emissions of CO₂.

CO₂ emissions and removals by source

Chart 3 shows that between 1990 and 2005 emissions from services and agriculture have slowly declined, and emissions from industrial use have fallen since the late 1990s. The most substantial fall – in terms of reduced CO₂ emissions – occurred in the power stations sector, which fell by 16 per cent (9 MtC), despite rises during 5 of the last 6 years. The main sources are discussed in the following sections.

CO₂ emissions from electricity generation

CO₂ emissions from power stations currently account for 29½ per cent of total CO₂ emissions. Consumption of electricity increased between 1990 and 2005 by 25½ per cent but overall emissions from electricity generation have decreased by 16 per cent. Emissions from electricity generation rose by ½ per cent between 2004 and 2005 as a result of using less gas and more coal and oil during generation. Chart 4 illustrates the changing fuel mix in electricity generation between 1990 and 2005.

Chart 3: CO₂ emissions and removals by source

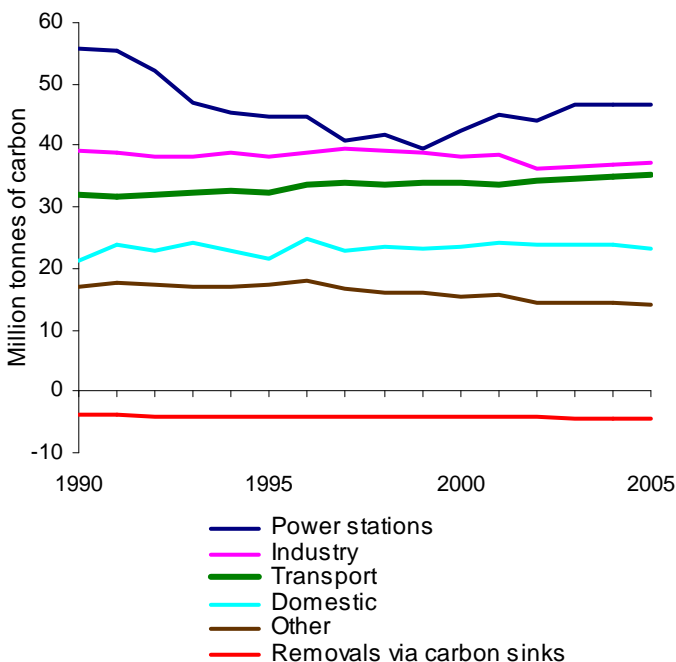


Chart 4: Fuel used in electricity generation

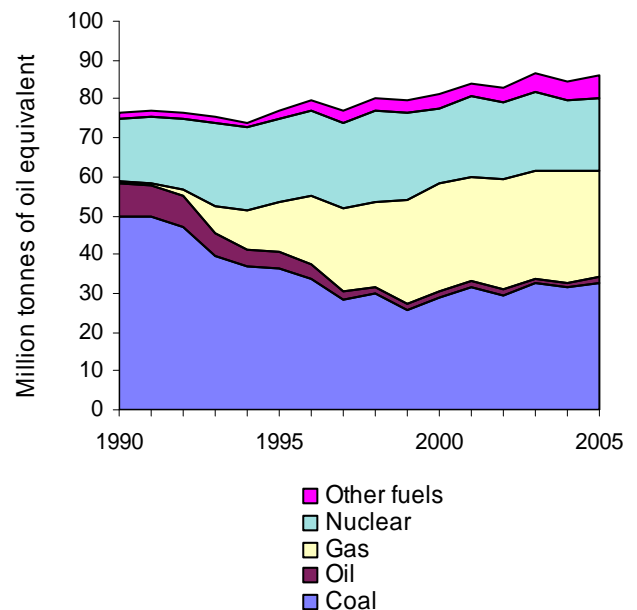


Chart 5 shows the actual level of CO₂ emissions from electricity generation. It also shows what emissions would have been had improvements in technology and changes in generating fuel mix not been made. Since 1990 savings due to increased efficiency and fuel switching have led to a reduction in CO₂ emissions of 33 per cent by 2005 compared with what they would have been (taking into account increased electricity demand). Of this 33 per cent saving, 19 per cent was due to fuel switching between 1990 and 2005 (a combination of an increased use of gas and nuclear energy). Improved efficiency was responsible for the remaining 14 per cent of the saving. The

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increase in the electricity supply over the period was not reflected in an equivalent increase in emissions due to this increased efficiency and fuel switching.

Chart 5: CO₂ emissions from electricity generation

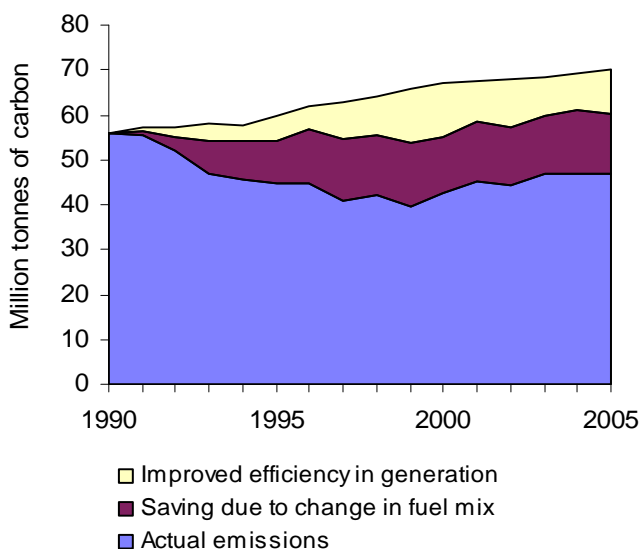
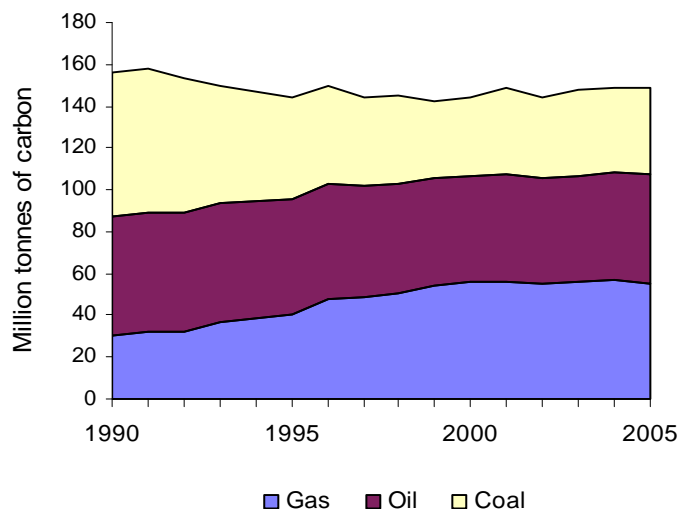


Chart 6: CO₂ emissions by fossil fuels



The emissions from power stations can be reallocated to the sector consuming the electricity. Around 29 per cent of electricity was consumed by the domestic sector in 2005, implying that 13½ MtC from the total of 47 MtC was attributable to that sector. Similarly 20 MtC can be allocated to the industrial sector, with 13½ MtC to the commercial and public service sector, and 1 MtC to the transport sector.

CO₂ emissions from the industrial sector

Emissions in the industrial sector remained unchanged in 2005 compared with a year earlier. Within this sectoral change emissions from the energy industry fell marginally, whilst other industries increased slightly. Overall industrial emissions were 5½ per cent lower than 1990 levels.

CO₂ emissions by transport

The transport sector accounted for 22½ per cent of CO₂ emissions in 2005, of which 93 per cent was road transport. Between 2004 and 2005, transport emissions rose by ½ per cent; emissions are now 10 per cent higher than during 1990. It is estimated that since 1990 emissions from vans and HGVs increased at a higher rate than emissions from cars, and that changes reflect traffic growth. Emissions from international aviation and shipping are excluded from the internationally agreed reporting framework.

CO₂ emissions from the domestic sector

CO₂ emissions from the domestic sector rose by ½ per cent between 2004 and 2005, resulting from increased (non-electricity) energy consumption in this sector. Since 1990 emissions have increased by 13 per cent, with non-electricity energy consumption for the domestic sector increasing by 19½ per cent over the same period. This is largely a result of the increase in the number of households - energy use per household is only slightly higher than in 1990. These emissions estimates do not include emissions from power stations as a result of domestic electricity consumption; domestic electricity consumption was 25 per cent higher in 2005 than during 1990.

CO₂ emissions by the commercial and public service sector

CO₂ emissions in these sectors fell by 10½ per cent between 1990 and 2005; there was a ½ per cent fall between 2004 and 2005.

CO₂ emissions from land use change & agriculture and removals from sinks

Emissions from land use change and agriculture are estimated to have been some 15 per cent (0.9MtC) lower than in 1990. Carbon sinks have removed 14 per cent (0.6MtC) more emissions over the same period.

CO₂ emissions by fuel

It is estimated that 149 MtC were emitted in 2005 from the use of fossil fuels. CO₂ emissions from fossil fuels, including fuel used for generating electricity, decreased by 4½ per cent over the period 1990 to 2005. Over the same period, overall inland consumption of fossil fuels increased by 8½ per cent. The increased use of gas (from 26 per cent of fossil fuels used in 1990 to 44 per cent in 2005) rather than coal and other solid fuels (whose share decreased from 34½ per cent to 19 per cent) resulted in a decrease in emissions. Oil accounted for 39½ per cent of fossil fuels used in 1990 and 37 per cent in 2005.

The amount of CO₂ released by the consumption of one unit of energy depends on the type of fuel consumed. For example, more CO₂ emissions are emitted from one unit of coal than from one unit of gas. Emissions per unit of electricity supplied from fossil fuels are estimated to have been 167 tonnes of carbon per GWh in 2005 overall. The figures for coal, oil and gas vary, with coal (238 tonnes per GWh) producing more carbon emissions per unit of electricity supplied than gas (99 tonnes per GWh) in 2005 and oil (207 tonnes per GWh of electricity supplied). For all sources (including nuclear and renewables) the overall amount of carbon emitted amounted to 124 tonnes per GWh of electricity generated.

Temperature correction

Temperature corrected figures show what emissions might have been if the average temperature during the year had been the same as the UK average for the years 1971 to 2000, which has been calculated at 9.5 degrees Celsius. Targets set at Kyoto are not based on temperature corrected data. Average temperatures in 2005 were very similar to 2004, but were 1.0 degree Celsius higher than the long-run average temperature. On a temperature corrected basis, total emissions of CO₂ for fuel combustion in 2005 was about ½ per cent lower than in 2004 and 6½ per cent less than in 1990.

Julian Prime

Energy Demand Analysis

Tel: 020 7215 6178

Email: julian.prime@dti.gsi.gov.uk

Chris Michaels

Tel: 020 7215 2710

Email: chris.michaels@dti.gsi.gov.uk

Shelley Milford

Tel: 020 7215 2703

Email: shelley.milford@dti.gsi.gov.uk

Special feature – Carbon dioxide emissions

Table 1: CO₂ emissions by source Million tonnes of carbon

	1990	1991	1992	1993	1994	1995	1996	1997
Power stations	55.6	55.3	52.1	46.8	45.5	44.6	44.6	40.7
Other energy industry	8.7	8.8	9.1	9.5	9.6	9.6	10.0	10.4
Other industrial	30.6	30.0	29.0	28.8	29.3	28.5	29.0	29.2
Domestic	21.4	23.7	23.0	24.1	22.9	21.7	24.8	22.8
Commercial and public service	6.9	7.7	7.5	7.4	7.3	7.3	7.8	7.3
Land use change and agriculture	6.1	6.1	6.1	5.9	5.9	5.9	5.9	5.8
Transport	32.0	31.8	32.1	32.5	32.5	32.2	33.6	34.0
Other sectors ¹	4.1	3.7	3.7	3.8	3.8	4.2	4.3	3.6
Total CO₂ emissions all sources	165.4	167.3	162.8	158.8	156.7	154.1	160.0	153.8
Total CO₂ removals all sinks	-3.9	-4.0	-4.1	-4.1	-4.2	-4.2	-4.2	-4.2
Net CO₂ emissions	161.5	163.3	158.7	154.6	152.5	149.9	155.8	149.6

<i>continued</i>	1998	1999	2000	2001	2002	2003	2004	2005p
Power stations	41.9	39.4	42.4	45.2	44.0	46.5	46.5	46.8
Other energy industry	10.2	9.9	9.7	9.6	10.3	10.1	10.0	9.9
Other industrial	28.8	29.1	28.4	28.9	25.8	26.5	27.1	27.1
Domestic	23.4	23.2	23.4	24.3	23.9	23.8	24.0	24.1
Commercial and public service	7.3	7.3	7.1	7.3	6.2	6.3	6.3	6.2
Land use change and agriculture	5.6	5.5	5.4	5.4	5.3	5.3	5.2	5.2
Transport	33.8	34.0	33.8	33.6	34.3	34.6	35.0	35.1
Other sectors ¹	3.3	3.2	3.0	3.0	3.1	2.9	2.9	2.9
Total CO₂ emissions all sources	154.2	151.7	153.2	157.3	152.9	156.1	156.9	157.4
Total CO₂ removals all sinks	-4.2	-4.2	-4.2	-4.2	-4.3	-4.4	-4.5	-4.5
Net CO₂ emissions	150.0	147.5	149.0	153.1	148.6	151.8	152.5	153.0

¹ Includes waste, fugitive emissions from fuels.

Table 2: CO₂ emissions by fuel Million tonnes of carbon

	1990	1991	1992	1993	1994	1995	1996	1997
Gas	30.0	32.2	32.5	36.6	38.7	40.8	47.3	48.8
Oil	57.1	57.1	56.7	56.8	55.6	54.2	55.6	53.4
Coal and other solid fuels	68.6	68.7	64.4	56.3	52.9	49.0	46.9	41.8
Non-fuel	9.6	9.3	9.2	9.1	9.6	10.1	10.2	9.7
Total	165.4	167.3	162.8	158.8	156.7	154.1	160.0	153.8

<i>continued</i>	1998	1999	2000	2001	2002	2003	2004	2005p
Gas	50.6	54.4	55.9	55.8	55.4	55.8	56.7	55.5
Oil	52.4	51.2	50.4	51.2	50.5	50.8	51.7	52.1
Coal and other solid fuels	41.7	37.0	38.1	41.7	38.5	41.0	40.1	41.7
Non-fuel	9.4	9.2	8.8	8.6	8.5	8.5	8.4	8.2
Total	154.2	151.7	153.2	157.3	152.9	156.1	156.9	157.4

Table 3: CO₂ emissions (unadjusted and temperature corrected)

	Million tonnes of carbon							
	1990	1991	1992	1993	1994	1995	1996	1997
Total CO₂ emissions	165.4	167.3	162.8	158.8	156.7	154.1	160.0	153.8
Percentage change (year on year)		1.2%	-2.7%	-2.4%	-1.3%	-1.6%	3.8%	-3.9%
Cumulative change since 1990		1.2%	-1.6%	-4.0%	-5.2%	-6.8%	-3.2%	-7.0%
Net CO₂ emissions	161.5	163.3	158.7	154.6	152.5	149.9	155.8	149.6
Percentage change (year on year)		1.1%	-2.8%	-2.6%	-1.4%	-1.7%	3.9%	-4.0%
Cumulative change since 1990		1.1%	-1.7%	-4.2%	-5.6%	-7.2%	-3.5%	-7.4%
Estimated total CO₂ emissions² (temperature corrected)	170.2	170.2	165.2	160.1	160.0	155.7	157.7	156.9
Percentage change (year on year)		-	-2.9%	-3.1%	-0.1%	-2.7%	1.3%	-0.6%
Cumulative change since 1990		-	-2.9%	-5.9%	-6.0%	-8.5%	-7.3%	-7.8%

<i>continued</i>	1998	1999	2000	2001	2002	2003	2004	2005p
Total CO₂ emissions	154.2	151.7	153.2	157.3	152.9	156.1	156.9	157.4
Percentage change (year on year)		0.3%	-1.6%	1.0%	2.7%	-2.8%	2.1%	0.5%
Cumulative change since 1990		-6.7%	-8.3%	-7.4%	-4.9%	-7.6%	-5.6%	-5.1%
Net CO₂ emissions	150.0	147.5	149.0	153.1	148.6	151.8	152.5	153.0
Percentage change (year on year)		0.3%	-1.7%	1.0%	2.8%	-3.0%	2.1%	0.5%
Cumulative change since 1990		-7.1%	-8.7%	-7.7%	-5.2%	-8.0%	-6.0%	-5.6%
Estimated total CO₂ emissions² (temperature corrected)	157.3	154.8	155.7	158.2	156.4	158.8	159.5	158.9
Percentage change (year on year)		0.3%	-1.6%	0.6%	1.6%	-1.1%	1.6%	0.4%
Cumulative change since 1990		-7.5%	-9.0%	-8.5%	-7.0%	-8.1%	-6.7%	-6.6%

² The energy component of total emissions has been temperature corrected and combined with unadjusted non-energy emissions. Targets are not based on temperature corrected figures.

Table 4: Fuel used in electricity generation

	Million tonnes of oil equivalent							
	1990	1991	1992	1993	1994	1995	1996	1997
Coal	49.8	50.0	46.9	39.6	37.1	36.3	33.6	28.3
Oil	8.4	7.6	8.1	5.8	4.1	4.2	4.0	2.0
Gas	0.6	0.6	1.5	7.0	10.1	13.3	17.4	21.7
Nuclear	16.3	17.4	18.5	21.6	21.2	21.3	22.2	22.0
Other fuels ³	1.3	1.3	1.6	1.4	1.5	2.2	2.5	2.7
Total	76.3	76.9	76.6	75.4	74.0	77.2	79.6	76.8

<i>continued</i>	1998	1999	2000	2001	2002	2003	2004	2005p
Coal	29.9	25.5	28.7	31.6	29.6	32.5	31.3	32.7
Oil	1.5	1.5	1.5	1.4	1.3	1.2	1.1	1.5
Gas	22.0	27.1	27.9	26.9	28.4	27.9	29.1	27.5
Nuclear	23.4	22.2	19.6	20.8	20.1	20.0	18.2	18.5
Other fuels ³	3.0	3.3	3.5	3.3	3.7	4.7	5.0	5.9
Total	80.0	79.7	81.2	84.0	83.0	86.4	84.7	86.1

³ Includes natural flow hydro, coke oven gas, blast furnace gas, waste products from chemical processes, sludge gas, refuse derived fuels and other renewable sources including wind