Annex E

Energy and the environment

Carbon dioxide emissions

Introduction

E.1 The UK is committed under the United Nations Framework Convention on Climate Change (UNFCCC) and by agreement with the European Union to provide annual data on greenhouse gas emissions. This information is compiled by AEA Energy and Environment under contract to Defra and the Devolved Administrations. Data for the latest year (2006) were published by Defra on 31 January 2008. BERR and Defra produced provisional carbon dioxide emissions estimates for 2007 based on provisional energy consumption data that are published in the March 2008 edition of Energy Trends. These estimates will be subject to revision when final estimates are published next year, but they provide an indication of the carbon dioxide 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 dioxide equivalent emitted per year (MtCO₂e/yr); this is in line with international emissions reporting. The figures can be converted to million tonnes of carbon by multiplying by the relative molecular weights (12/44). Carbon dioxide emissions are shown as net emissions, which equates to total emissions minus total removals from the atmosphere by carbon sinks. Carbon sinks are within the Land Use, Land Use Change and Forestry (LULUCF) sector, which covers afforestation, reforestation, deforestation and forest management; no emissions in this sector come from energy related activity.

E.2 The key points to note are:

- Net CO₂ emissions in 2007 were provisionally 544 MtCO₂e/yr, or 8 per cent below 1990 levels. This is 11 MtCO₂e/yr (2 per cent) lower than in 2006. Excluding the net contribution of LULUCF, emissions were provisionally 546 MtCO₂e/yr, or 7½ per cent below 1990 levels.
- The fall in emissions since 1990 occurred despite an overall increase of 6 per cent in gross inland energy consumption over the same period. The decrease in emissions between 2006 and 2007 resulted from fuel switching from coal to natural gas for electricity generation, combined with lower fossil fuel consumption by households and industry.
- CO₂ emissions from use of coal and other solid fuels fell by 6½ per cent between 2006 and 2007 resulting from reduced coal fired electricity generation; emissions from gas rose by 1½ per cent; whilst emissions from oil were 2 per cent lower.
- CO₂ emissions from power stations decreased by 11½ per cent between 1990 and 2007. Between 2006 and 2007 they fell by 2 per cent. Emissions from power stations are driven by changes in both the fuel mix used for generation and generation efficiency; less coal and oil but more gas was used to generate electricity in 2007 compared with 2006.
- Over the period 1990 to 2007 there were also falls in emissions from the industrial, household and the commercial and public service sectors; however emissions from the transport sector increased.
- These estimates do not include the effect of emissions trading. Installations covered by the EU Emissions Trading Scheme must buy allowances to cover emissions in excess of their allocations. In 2006, the latest year for which detailed figures are available, the UK was a net acquirer of allowances. This effectively means that the UK emission estimates can be reduced by the amount of allowances acquired during the year.
- Emissions implied by the production of goods and services imported by the UK are not included, since under the UN-FCCC agreement, these emissions are counted by the country in which they occur.

Why are CO₂ emissions important?

E.3 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; in the UK CO₂ emissions are far lower.

1 The 2006 EU-ETS results are reported in: www.defra.gov.uk/environment/climatechange/trading/eu/results/pdf/euets-ukresults-2006.pdf
accounts for about 85 per cent of total greenhouse gas emissions. 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 production and consumption accounts for about 95 per cent of all CO₂ emissions.

Policy targets

E.4 The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) was agreed in December 1997. The then 15 EU member states (including the UK) committed to a collective target of reducing EU emissions of a basket of 6 greenhouse gases, including CO₂, by 8 per cent relative to the base year level over the period 2008-2012. As part of an agreement between EU member states, the UK subsequently undertook to reduce its emissions by 12½ per cent as its contribution to the EU’s target. The Kyoto Protocol became legally binding in February 2005 and to date has been ratified by 176 countries. In the UK, the base year relates to 1990 for emissions of carbon dioxide, methane and nitrous oxide, and 1995 for fluorinated compounds. In July 2007, on completion of a review of the UK greenhouse gas inventory, the UK’s Kyoto base year figure was calculated to be 779.9MtCO₂e. This means that to meet the UK’s Kyoto commitment, greenhouse gas emissions must be below 682.4MtCO₂e on average per year over the first five year commitment period of the Protocol (2008-2012). In accordance with this average yearly target, the Kyoto Protocol target for the UK was then set at 3,412MtCO₂e over the full five year period. This is known as the UK’s assigned amount.

E.5 At the UN Climate Change Conference in Bali in December 2007, the Bali Action Plan was agreed. The Bali Action Plan establishes formal negotiations for developed and developing countries on a post-2012 framework, with a view to reaching agreement in December 2009. Negotiations will cover a number of key areas including a long-term goal, action on mitigation by both developed and developing countries, deforestation, adaptation, technology and financial resources.

E.6 In January 2008, the European Commission published its Climate Change and Energy Package. The package contains proposals to implement the decisions agreed by EU Heads of State and Government at the 2007 Spring European Council, including a 20 per cent reduction in EU greenhouse gas emissions by 2020, increasing to 30 per cent when there is an international climate agreement; 20 per cent of total EU energy consumption to come from renewables by 2020; and measures to support the development and demonstration of carbon capture and storage (CCS) and the inclusion of CCS in the emissions trading scheme (ETS). For the UK, the Commission’s proposals include a reduction of 16 per cent in UK greenhouse gas emissions from sectors not covered by the EU ETS by 2020 from 2005 levels, and 15 per cent of the energy consumed in the UK to come from renewable sources, subject to them being produced in a sustainable way.

E.7 Domestically, the 2007 Energy White Paper sets out the Government’s energy strategy based on a commitment to independently regulated competitive energy markets. Currently the UK has a domestic non-legally binding goal to reduce carbon dioxide emissions to 20 per cent below 1990 levels by 2010. In addition, the Climate Change, Energy, and Planning Bills form the legislative pillars of the Government’s strategy to tackle climate change by reducing emissions at home and abroad and ensuring we have clean, secure and affordable energy supplies. Amongst other things, the Climate Change Bill will set a comprehensive framework for managing our carbon emissions, including setting legally binding targets and a system of carbon budgeting to reduce carbon dioxide emissions by at least 60 per cent by 2050, with real progress (26-32 per cent) by 2020, set against the 1990 baseline. A new independent body (the Committee on Climate Change), will be set up to advise on the setting of carbon budgets and to report on progress. The Energy Bill will help achieve the targets by creating the right legislative framework to support investment in more low carbon sources of energy; and the Planning Bill will ensure that these, and other energy infrastructure projects which are key to security

2 See www.unfccc.int/meetings/cop_13/items/4049.php
3 See www.ec.europa.eu/environment/climat/climate_action.htm
4 See www.berr.gov.uk/energy/whitepaper/page39534.html
5 See www.defra.gov.uk/environment/climatechange/uk/legislation/index.htm
6 See www.communities.gov.uk/planningandbuilding/planning/planningpolicyimplementation/reformplanningsystem/planningbill
of energy supply, are dealt with by an efficient and fair planning process. All three Bills are currently being debated by the Houses of Parliament.

Estimates of CO₂ emissions

E.8 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 methodology excludes emissions from international aviation and shipping. This article generally refers to emissions including the net impact of emissions from land use, land use change and forestry (LULUCF). Selected annual figures since 1990 are shown in Table E.1.

Overall CO₂ emissions

E.9 Net CO₂ emissions fell provisionally by 8 per cent between 1990 and 2007; over the same period CO₂ emissions excluding LULUCF fell by 7½ per cent. These falls in emissions occurred despite an overall increase of 6 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 UK CO₂ emissions with the 20 per cent UK domestic goal. The Kyoto commitment target is not shown because it relates to a basket of greenhouse gases, not just to CO₂.

CO₂ intensity

E.10 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 52½ 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 40 per cent has occurred because increased GDP has not resulted in overall increases in emissions of CO₂.

CO₂ emissions by source

E.11 Chart 3 shows the key sources of emissions, and how they have changed since 1990. It can be seen that emissions from the transport sector have gradually increased throughout the period, and that since the late 1990s emissions from industrial use have fallen. The most substantial fall – in terms of reduced CO₂ emissions – occurred in the power stations sector, which fell by 11½ per cent (24 MtCO₂), despite rises during 5 of the last 8 years. The main sources are discussed in the following sections.

CO₂ emissions from electricity generation

E.12 CO₂ emissions from power stations currently account for one-third of total CO₂ emissions. Consumption of electricity increased between 1990 and 2007 by 24½ per cent but overall emissions from electricity generation have decreased by 11½ per cent. Emissions from electricity generation fell by 2 per cent between 2006 and 2007 as a result of using less coal and oil but more gas during
generation; the amount of electricity generated from nuclear sources fell. Chart 4 illustrates the changing fuel mix in electricity generation between 1990 and 2007.

E.13 Chart E.5 shows the actual level of CO₂ emissions from electricity generation at power stations. 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 29 per cent by 2007 compared with what they would have been (taking into account increased electricity demand). Of this 29 per cent saving, 16½ percentage points were due to fuel switching between 1990 and 2007 (mainly an increased use of gas). Improved generation efficiency was responsible for the remaining savings.

E.14 The emissions from power stations can be reallocated to the sector consuming the electricity. Around 31½ per cent of electricity was consumed by the domestic sector in 2007, implying that 56½ MtCO₂ from the total of 180 MtCO₂ was attributable to that sector. Similarly 70 MtCO₂ can be allocated to the industrial sector, with 49½ MtCO₂ to the commercial and public service sector, and 4 MtCO₂ to the transport sector.

CO₂ emissions from the industrial sector
E.15 Industrial sector emissions – which account for 23 per cent of the total - fell by 3 per cent in 2007 compared with a year earlier, continuing the trend in reduced emissions from industry shown over the previous two years. Overall industrial emissions were 15 per cent lower than 1990 levels.
CO₂ emissions by transport
E.16 The transport sector accounted for 24 per cent of CO₂ emissions in 2007, of which 92 per cent was from road transport. Between 2006 and 2007, transport emissions fell slightly (by ½ per cent); however emissions from this sector are 11½ 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; however the UK inventory contains memo items for these emissions based on refuelling of other UK and non-UK operators from bunkers at UK airports and ports.

CO₂ emissions from the domestic (household) sector
E.17 CO₂ emissions from the domestic sector fell by 5 per cent between 2006 and 2007, resulting from reduced gas and oil consumption in this sector. Since 1990 emissions have fallen by 3½ per cent, with non-electricity energy consumption in the domestic sector increasing by 3½ per cent over the same period. This is a combination of an increase in the number of households, but reduced energy consumption per household. The emissions estimates reported here for this sector do not include emissions from power stations as a result of domestic electricity consumption; domestic electricity consumption was 23 per cent higher in 2007 than during 1990.

CO₂ emissions by the commercial and public service sector
E.18 CO₂ emissions in these sectors fell by 11½ per cent between 1990 and 2007; however there was a 4 per cent rise between 2006 and 2007 due to increased gas consumption.

CO₂ emissions from agricultural and forestry fuel use and land use, land use change and forestry
E.19 Emissions from fuel used in the agricultural and forestry sectors are estimated to have been some 17 per cent (1 MtCO₂) lower than in 1990. Net land use, land use change and forestry emissions have changed from emitting 3 MtCO₂ in 1990 to removing 2 MtCO₂ in 2006; data are not yet available for 2007 so the 2006 estimate has been used for this component of these provisional estimates of total UK CO₂ emissions.

CO₂ emissions by fuel
E.20 It is estimated that 529 MtCO₂ were emitted in 2007 from the use of fossil fuels. CO₂ emissions from fossil fuels, including fuel used for generating electricity, decreased by 7½ per cent over the period 1990 to 2007. Over the same period, overall inland consumption of fossil fuels increased by 6 per cent. The increased use of gas (from 26 per cent of fossil fuels used in 1990 to 44 per cent in 2007) rather than coal and other solid fuels (whose share decreased from 34½ per cent to 19½ per cent) resulted in a decrease in emissions. Oil accounted for 39½ per cent of fossil fuels used in 1990 and 36½ per cent in 2007.

E.21 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 by major power producers from fossil fuels are estimated to have been 613 tonnes of carbon dioxide per GWh in 2007 overall; within this emissions from electricity generated from coal (914 tonnes of carbon dioxide per GWh electricity supplied) were around 2½ times higher than for electricity supplied by gas (365 tonnes of carbon dioxide per GWh). For all sources of electricity, (including nuclear, renewables and autogeneration) the average amount of carbon dioxide emitted amounted to 501 tonnes per GWh of electricity supplied.

Temperature correction
E.22 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 9.7 degrees Celsius. Targets set at Kyoto are not temperature corrected. Average temperatures in 2007 (at 10.5 degrees Celsius) were 0.2 degrees Celsius lower than in 2006, but 0.9 degrees Celsius higher than the long-run average temperature. On a temperature corrected basis, total emissions of CO₂ for fuel combustion in 2007 was about 7½ per cent lower than in 1990.
### Table E.1: CO₂ emissions by source

<table>
<thead>
<tr>
<th></th>
<th>Million tonnes of carbon dioxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power stations</td>
<td>204.0</td>
</tr>
<tr>
<td>Other energy industry</td>
<td>31.8</td>
</tr>
<tr>
<td>Other industrial</td>
<td>114.7</td>
</tr>
<tr>
<td>Domestic</td>
<td>78.5</td>
</tr>
<tr>
<td>Commercial and public services</td>
<td>25.5</td>
</tr>
<tr>
<td>Agriculture and forestry fuel use</td>
<td>5.1</td>
</tr>
<tr>
<td>Transport</td>
<td>116.7</td>
</tr>
<tr>
<td>Other sectors †</td>
<td>13.1</td>
</tr>
<tr>
<td>Total (excluding net LULUCF²)</td>
<td>589.5</td>
</tr>
<tr>
<td>Net LULUCF²</td>
<td>2.9</td>
</tr>
<tr>
<td>Total (including net LULUCF²)</td>
<td>592.4</td>
</tr>
<tr>
<td>Cumulative change since 1990</td>
<td>-7.2%</td>
</tr>
</tbody>
</table>

† Includes waste, fugitive emissions from fuels.
² Land Use, Land Use Change and Forestry

### Table E.2: CO₂ emissions by fuel

<table>
<thead>
<tr>
<th></th>
<th>Million tonnes of carbon dioxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td>110.2</td>
</tr>
<tr>
<td>Oil</td>
<td>209.5</td>
</tr>
<tr>
<td>Coal and other solid fuels</td>
<td>251.5</td>
</tr>
<tr>
<td>Non-fuel</td>
<td>21.2</td>
</tr>
<tr>
<td>Total</td>
<td>592.4</td>
</tr>
</tbody>
</table>

### Table E.3: Fuel used in electricity generation

<table>
<thead>
<tr>
<th></th>
<th>Million tonnes of oil equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>49.8</td>
</tr>
<tr>
<td>Oil</td>
<td>8.4</td>
</tr>
<tr>
<td>Gas</td>
<td>0.6</td>
</tr>
<tr>
<td>Nuclear</td>
<td>16.3</td>
</tr>
<tr>
<td>Other fuels³</td>
<td>1.3</td>
</tr>
<tr>
<td>Total</td>
<td>76.3</td>
</tr>
</tbody>
</table>

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
Other Greenhouse gases

E.23 Naturally-occurring greenhouse gases maintain the earth’s surface at a temperature 33°C warmer than it would be in their absence. Water vapour is by far the most abundant greenhouse gas but there are also significant natural sources of carbon dioxide, methane, ozone and nitrous oxide. At present overall greenhouse gas concentrations in the atmosphere are increasing as a result of human activities. There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.

E.24 Targets for emission reductions cover a basket of six greenhouse gases: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride. 95 per cent of emissions from energy use come from fuel combustion. The most important of these is carbon dioxide. Carbon dioxide emissions contribute around 70 per cent of the potential global warming effect of anthropogenic emissions of greenhouse gases. Although this gas is naturally emitted by living organisms, these emissions are balanced by the uptake of carbon dioxide by the biosphere during photosynthesis; they therefore tend to have no net effect on atmospheric concentrations. The burning of fossil fuels, however, releases carbon dioxide fixed by the biosphere over many millions of years, and thus increases its concentration in the atmosphere.

Air pollution

E.25 Air pollution has a wide range of environmental impacts, with excessively high levels potentially affecting soil, water, wildlife, crops, forests and buildings as well as damaging human health. The main air pollutants associated with fossil fuel combustion are sulphur dioxide, fine particles (measured as PM10), nitrogen oxides and carbon monoxide.

E.26 Sulphur dioxide is an acidic gas produced by the combustion of sulphur-containing fuels such as coal and oil. In 2006 there were 0.7 million tonnes of sulphur dioxide emitted, 82 per cent lower than 1990 and 89½ per cent lower than in 1970. The decrease is a result of lower coal and fuel oil consumption over the period, and introduction of flue gas desulphurisation at coal fired power stations, operational from 1994. Sulphur dioxide emissions from road transport have decreased by 88 per cent since 1998 following a reduction in the sulphur content of fuel.

E.27 “PM10” refers to fine, suspended particles in the air that come from a wide range of man-made and natural sources, including incomplete fuel combustion, wind-blown soil, and dust generated by activities such as quarrying. In 2006 there were 0.15 million tonnes of PM10 emitted; a fall of 70 per cent since 1970, largely as a result of a 90 per cent fall in emissions from the residential sector.

E.28 A number of nitrogen compounds including nitrogen dioxide, nitric oxide and nitrogen oxides are formed in combustion processes when nitrogen in the air or the fuel combines with oxygen. These compounds can add to the natural acidity of rainfall. The total level of emissions in 2006 (at 1.6 million tonnes) was 46 per cent lower than in 1990, with substantial falls from both road transport and power stations, the two largest contributing sectors. Emissions from power stations declined during the 1990s due to increased output from nuclear stations, and combined cycle gas turbine stations replacing coal-fired plant, together with the effect of the installation of low NOx burners at other coal fired power stations. A decline in output from nuclear power stations since 2000 has caused emission from the energy industry to rise, but they are still 45 per cent lower than in 1990. The fall in emissions from road transport is mainly due to tighter emissions standards for passenger and goods vehicles, including the introduction of catalytic converters on all new cars since 1993.

E.29 Carbon monoxide is derived from the incomplete combustion of fuel. In 2006, 2.3 million tonnes of carbon monoxide were emitted, a level 72 per cent lower than 1990 and 81 per cent lower than in 1970. 43 per cent of carbon monoxide emissions in the UK come from road transport, despite large reductions over the past thirty years due to tighter emission standards and the introduction of catalytic converters.

Oil pollution, oil spills and gas flaring

E.30 The amounts of oil spilled around the coasts of the United Kingdom and offshore (North Sea) are small in relation to total oil production, with the amounts discharged on drill cuttings, and with
produced water generally much larger than from offshore installation spills. The total amount of oil spilled offshore during 2006 was 27 tonnes.

E.31 The number of oil spills recorded rose from 392 in 1998 to 409 in 2006. The increase reflects the trend for reporting even the smallest of spills, 366 of those reported in 2006 were for spills of less than 1 tonne.

E.32 The Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (OPPC) came into effect in August 2005. Under OPPC installations a granted a permit for activities discharging oil-contaminated water to sea, but the oil content must not exceed 30 milligrams per litre. The average content of oil in produced water for 2005, for the UKCS as a whole, was 19.9 milligrams per litre. This is in line with previous years figures.

E.33 Under the terms of petroleum production licences, gas may be flared only with the consent of the Secretary of State. Flaring at onshore fields in 2006 was minimal, whilst 3.99 million cubic metres of gas a day was flared at offshore installations. Flaring at offshore installations in 2006 was 6 per cent lower than in 2005.

Data sources
E.34 Greenhouse gas emissions and air pollution statistics up to 2006 are published in the National Atmospheric Emissions Inventory which is compiled by the AEA Energy and Environment on behalf of Department for Environment, Food and Rural Affairs (Defra). Data and information on how the data have been compiled can be found:
• on the National Atmospheric Emissions Inventory web site at www.naei.org.uk;
• on the Defra web site, as part of the Digest of Environmental Statistics at www.defra.gov.uk/environment/statistics/index.htm;
• in the BERR Energy Sector Indicators publication at www.berr.gov.uk/energy/statistics/publications/indicators/page39558.html

E.35 Figures for the total number of oil spills reported are collected by the Advisory Committee on Protection of the Sea Annual Surveys of Oil Pollution around the Coasts of the United Kingdom.

E.36 Further information on oil spills and discharges is available on the BERR oil and gas website at www.og.berr.gov.uk/information/bb_updates/chapters/Table_chart3_1.htm www.og.berr.gov.uk/information/bb_updates/chapters/Table3_2.htm www.og.berr.gov.uk/information/bb_updates/appendices/Appendix12.htm

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