# 4NC

The UK's Fourth National Communication under the United Nations Framework Convention On Climate Change

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Department for Environment Food and Rural Affairs

The UK's Fourth National Communication under the United Nations Framework Convention On Climate Change

Department for Environment, Food and Rural Affairs
Nobel House
17 Smith Square
London SW1P 3JR
Telephone 020 7238 6000
Website: www.defra.gov.uk



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# Contents

# Foreword

**By the Secretary of State for Environment, Food and Rural Affairs**

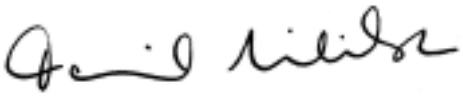
I am pleased to present the UK's Fourth National Communication under the UN Framework Convention on Climate Change.

This Communication reports in detail the action the UK is taking to fulfil its commitments under the UN Framework Convention on Climate Change and the Kyoto Protocol, taking into account the additional policies and measures included in the 2006 Climate Change Programme.

Our 2000 Climate Change Programme has already helped put us on track to meet our Kyoto greenhouse gas emissions reduction commitment. Indeed we are projected to go significantly beyond our Kyoto commitment and reduce our greenhouse gas emissions by 23–25 per cent by 2010. Our 2006 Climate Change Programme, which we published in March, contains further policies and measures to help towards the achievement of our national goal of reducing carbon dioxide emissions by 20 per cent below 1990 levels by 2010 and, in the long-term, reduce emissions by some 60 per cent by 2050, with real progress by 2020.

The UK's Fourth National Communication outlines how the UK is planning to adapt to the predicted impacts of climate change, provides details of the UK's programme for research and systematic observation and gives information about the assistance that the UK is providing to developing countries.

It also highlights the UK's significant contribution to global action to fight climate change. We will continue our efforts to tackle climate change throughout 2006 and beyond through the European Union, G8 and UN Framework Convention processes, and find ways to reach global agreement to action on the scale needed to avert dangerous climate change.



**The Rt Hon David Miliband MP**

May 2006

# Executive Summary

UK greenhouse gas emissions were 14.6 per cent below base year levels in 2004 and, with current policies and measures, are projected to be about 19.4 per cent below base year levels in 2010. Under the Kyoto Protocol the UK agreed to ensure that emissions of greenhouse gases were at least 12.5 per cent lower than base year levels, on average, over the period 2008 to 2012. The UK is therefore on track to meet this commitment.

Additional polices and measures to reduce emissions, announced in the UK's revised Climate Change Programme published in March 2006[1], will ensure that the UK goes even further in reducing greenhouse gas emissions and moves towards its more challenging domestic goals.

## Background

The threats posed by climate change demand serious, concerted action by the international community. Though no country can solve the problem on its own, all countries must show what they can achieve by their own actions, which should be consistent with their national circumstances. They can also help the international process to secure future agreements. These precepts are the core of the UK's strategy in tackling climate change.

This communication sets out the progress that the UK has made in implementing its commitments under the UNFCCC and the Kyoto Protocol. Some of these commitments have been driven by national policy initiatives and some have been implemented following measures adopted at European Union (EU) level. The latter are described in the EU's report on Demonstrable Progress and the EU's Fourth National Communication.

The UK has a legally binding commitment under the Kyoto Protocol to reduce greenhouse gas emissions by 12.5 per cent below base-year levels, on average, over the first commitment period, 2008-2012[2]. The UK has also adopted a domestic goal to reduce carbon dioxide emissions to 20 per cent below 1990 levels by 2010. The 2003 UK Energy White Paper, *Our energy future – creating a low carbon economy*, introduced a further, long-term aim of achieving a carbon dioxide emissions reduction of some 60 per cent by 2050, with real progress by 2020. The UK has set these ambitious goals because it recognises that if climate change is not tackled, the consequences will be very damaging for the global environment, the economy and security.

## The UK's progress to date

The UK's emissions of the basket of six greenhouse gases fell by 14.6 per cent between the base year and 2004. This reduction has been driven by the restructuring of the energy supply industry; energy efficiency and energy intensity improvements; pollution control measures in the industrial sector and other policies that reduced emissions of non-carbon dioxide greenhouse gases.

The UK is well on track to meet its target for the first commitment period with current policies and measures. Without introducing any additional measures the UK's greenhouse gas emissions are expected to be about 19.4 per cent below base year levels in 2010.

The UK Government and UK Devolved Administrations published a new Climate Change Programme in March 2006 which sets out the package of policies and measures needed to move towards our more challenging domestic goal by 2010, and pave the way for further carbon reductions to 2020 and beyond.

It is estimated that the new programme could reduce the UK's emissions of the basket of greenhouse gases on which the Kyoto target is based to 23–25 per cent below base year levels, and reduced the UK's carbon dioxide emissions to 15–18 per cent below 1990 levels by 2010.

In addition to putting itself on track towards meeting its emissions reduction commitments through its National Climate Change Programme and other national policies, the UK has also put in place institutional structures and other provisions to enable delivery of its wider Kyoto commitments. These include:

- Establishment of a national registry for holding, transferring, and acquiring EU allowances and Kyoto units
- Implementation of the EU Emissions Trading Scheme. The scheme started on 1 January 2005. The first phase runs from 2005–2007 and the second phase will run from 2008–2012 to coincide with the first Kyoto Commitment Period. The Scheme will continue beyond 2012 with further five year phases

1 http://www.defra.gov.uk/environment/climatechange/uk/ukccp/pdf/ukccp06-all.pdf

2 The Kyoto commitment is monitored against a basket of emissions of carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluororcarbons and sulphur hexafluoride. The base year emissions level is derived using 1990 emissions for the first three gases and 1995 for the fluorinated compounds.

3 Details available at: http://www.defra.gov.uk/environment/climatechange/trading/eu/kyoto/index.htm

- Cooperation with interested Member States to develop EU/United Nations compliant registry software in order to facilitate the start of the EU Emissions Trading Scheme – a project known as the Greenhouse gas Registry for Emissions Trading Arrangements or GRETA
- Transposition of the EU linking directive[3] into UK law which specifies use of project credits in Phase I (2005–2007) of the EU Emissions Trading Scheme, as well as project approval processes and authorisation to participate in the flexible mechanisms

Private sector interest in emissions trading and the Kyoto Mechanisms is considerable and the establishment of the City of London as a substantial centre for carbon trading with an estimated €1bn available in private finance funds is to be warmly welcomed.

Further actions include:

- Development of a national system for greenhouse gas inventory estimation, reporting and archiving, which includes new legal powers for national inventory purposes
- Establishment of the UK's Adaptation Policy Framework which will provide the structure in which climate change considerations can be integrated into policies developed at every level across a range of sectors of the economy
- Contribution to the United Nations Global Climate Observing System via meteorological and atmospheric observations made across the UK and its Overseas Territories, together with scientific participation on the Global Climate Observing System international steering committee
- The continued funding of world-class climate research at the Hadley Centre and other UK research centres
- Establishment of a £12 million Climate Change Communications Initiative to inform the British public about climate change issues, and to give them the tools to make individual actions to reduce it
- Making a financial contribution to the Global Environment Facility, including a sum of £320 million between 1997 and 2004, and to bilateral development projects across the world
- Promotion of technological development in developing countries, including participation in the Climate Technology Initiative

The UK has appointed Kyoto authorities required under the Marrakesh Accords. The Department for Environment, Food and Rural Affairs has been appointed as the Single National Entity for the UK national system, the Designated Focal Point for Joint Implementation projects and the Designated National Authority for Clean Development Mechanism projects.

# 1

# National Circumstances

# National Circumstances

## Key developments

- The fall in energy intensity reported in the 3rd National Communication has continued, with a decrease of 30% relative to 1990
- The percentage of urban and other land has increased to 14%.
- The UK experienced its fourteenth consecutive year of positive economic growth in 2005.
- The growth in new gas fired electricity generation has slowed and nuclear generation is being replaced largely by coal leading to increased carbon emissions per unit of electricity.
- The average emissions from new cars in the UK decreased by 10% between 1995 and 2004
- Renewable energy sources currently account for 4% of UK electricity generation, this is up from 2.8% in 2000. Around 2% of the total UK energy supply currently comes from renewable sources.
- The UK emissions trading scheme was introduced in 2002. To date, the scheme has delivered emissions reductions of over 1.6 MtC. The UK went on to enter the EU emissions trading scheme in January 2005.
- UK greenhouse gas emissions in 2004 and 2005 were around 14.5% below the base year level, compared with the 12.5% reduction required to meet the UK's Kyoto commitment
- The UK has introduced additional measures to move towards meeting the domestic goal to reduce $CO_2$ emissions by 20% below the 1990 level by 2010, and the 2003 Energy White Paper introduced the aim for a 60% reduction by 2050, with real progress by 2020.

## Government Profile

1.1 The United Kingdom (UK) consists of England, Scotland, Wales and Northern Ireland. The Devolved Administrations consisting of the Scottish Parliament, the National Assembly for Wales and the Northern Ireland Assembly were established in 1999. However, the Northern Ireland Assembly was suspended in 2000. The UK Government has overall responsibility for ensuring that a programme is put in place to deliver the UK's Kyoto target and to move towards the domestic policy goals, although a range of policies are the responsibility of the devolved administrations.

The Department for Environment, Food and Rural Affairs (Defra) is responsible for overall policy coordination. Fiscal matters are the responsibility of Her Majesty's Treasury (HMT) and many of the policies are the responsibility of other government departments including the Department for Trade and Industry (DTI), the Department for Transport (DfT), the Office of the Deputy Prime Minister (ODPM) (renamed Department of Communities and Local Government in May 2006) and the Department for International Development (DfID). Local government implements policies through relevant responsibilities at the local level, e.g. as planning and waste authorities, and as housing and local transport providers.

## Geographic Profile

1.2 Table 1.1 shows recent land-use data for the UK and constituent countries in 2004.

**Table 1.1 Land use in the UK 2004[4]**

| Country | Percentage of country[5] | | | | | | Area ('000 hectares) |
|---|---|---|---|---|---|---|---|
| | Agricultural land | | | | | | |
| | Crops and bare fallow | Grasses and rough grazing | Other | Forest and woodland | Urban land and land not otherwise specified | Inland water | Total land |
| England | 30 | 37 | 5 | 9 | 19 | 0.5 | 13,028 |
| Wales | 3 | 72 | 1 | 14 | 9 | 0.6 | 2,073 |
| Scotland | 7 | 66 | 2 | 17 | 8 | 2 | 7 792 |
| Northern Ireland | 4 | 75 | 1 | 7 | 13 | 4.7 | 1,358 |
| UK | 19 | 51 | 3 | 12 | 14 | 1 | 24,251 |

4 Land by Agricultural and Other Uses: 2004, http://www.defra.gov.uk/environment/statistics/land/lduse.htm#ldtb1

5 Percentages may not total 100%, due to rounding.

The UK covers about 24 million hectares of land. Most land is used for agriculture and forestry, though the proportion of urban land has been increasing. In more detail:

- About 73 per cent of the land is in agricultural use. Of this, the majority is made up of grasses and rough grazing. The remainder consists of crops, bare fallow and other agricultural land, including farm roads, yards, buildings and agricultural set-aside.
- Forest and woodland make up around 12 per cent of the total UK land use, this includes both private and state-owned land.
- Around 14 per cent of land is used for urban (which includes transport infrastructure and recreational land) and other purposes (semi natural environments such as sand dunes and non agricultural grasslands).
- Inland water accounts for about 1 per cent of UK land use. The main use of the waterways is recreational, there is little commercial traffic.

## Climate Profile

1.3 The UK's climate is maritime: variably cool, moist, temperate and within a moderate annual temperature and limited ranges. Average annual precipitation ranges from less than one metre to more than three metres. Space heating is required in buildings throughout the winter months and the use of air conditioning in the summer months is increasing. Recent climate change scenarios suggest that average annual UK temperatures could rise by between 2.5 and 3°C by the 2080s[6].

## Population Profile

1.4 Table 1.2 shows the estimated population and population density for the UK in 2004 and the projected population in 2031.

In mid-2004 the population of the UK was 59.8 million; 83.7 per cent of whom lived in England. The UK population is expected to reach 65.7 million by 2031, representing an average annual rate of growth of 0.35 per cent from 2003. Longer-term projections suggest that this population growth will peak in around 2050, at nearly 67 million people and fall gradually thereafter[8].

The population density is around three times higher in England than in Wales and Northern Ireland, and is nearly six times higher than in Scotland. This has implications for transport demand and the development of energy supply infrastructure.

## Economic Profile and Industry

1.5 The UK is the world's eighth largest exporter of goods (£191 billion in 2004) and the second largest exporter of services (£96 billion in 2004). Exports are currently equivalent in value to about 25 per cent of UK GDP. Over 50 per cent of UK trade (imports and exports) is with the EU 15. The remainder is made up of the USA, Asia, the Middle East and Australasia, the rest of Europe, the Americas (less USA) and Africa[9]. The labour market is stable with an employment rate of 74.5 per cent for people of working age in 2005[10].

**Table 1.2 Population in the UK in mid 2004[7]**

| Country | Population (000's) | 2004 population density (persons per km$^2$) | % of total UK population (2004) | Predicted 2031 population (000's) |
|---|---|---|---|---|
| England | 50,093 | 384 | 83.7 | 55,881 |
| Wales | 2,953 | 142 | 4.9 | 3,153 |
| Scotland | 5,078 | 65 | 8.5 | 4,825 |
| Northern Ireland | 1,710 | 126 | 2.9 | 1,840 |
| UK total | 59,834 | 246 | 100 | 65,700 |

6 Office for National Statistics.

7 Office for National Statistics, Mid Year Population Estimates, 2004, http://www.statistics.gov.uk/cci/nugget.asp?id=6

8 Interim 2003 Based National Population Projections for the United Kingdom and Constituent Countries, Office for National Statistics, http://www.statistics.gov.uk/STATBASE/Product.asp?vlnk=13928

9 http://www.dti.gov.uk/ewt/

10 Office for National Statistics Economic Update, 2005.

The UK experienced its fourteenth consecutive year of economic growth in 2005, representing the longest period of stable and sustainable economic growth since records began 50 years ago. The rate of growth fell temporarily in mid-2004, due largely to high oil prices. UK gross domestic product (GDP) at current market prices totalled £1,164,439 million in 2004.

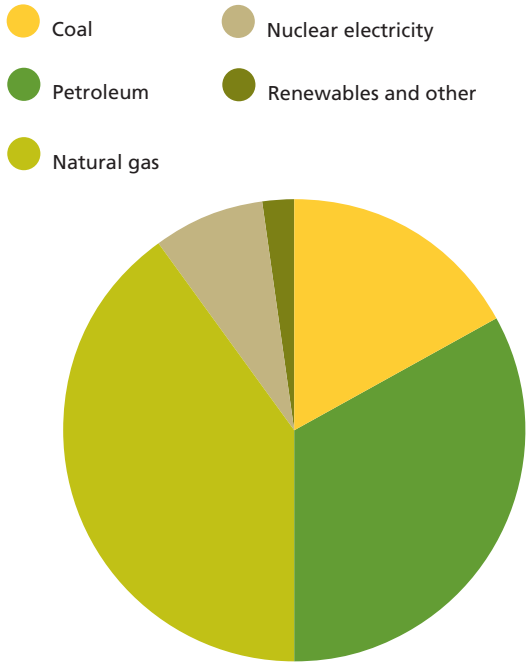
In 2003 the financial and other business services sector provided the largest UK sector contribution to gross value added (GVA) (32 per cent). Other significant contributions included the wholesale and retailing sector (16 per cent) and the manufacturing sector (15 per cent). Manufacturing contributes a smaller share of GVA than in 1990 though output has increased in absolute terms and is projected to continue to do so.

## Energy

1.6 The UK's energy supply incorporates coal, petroleum, natural gas, nuclear power and renewable energy. Over the next two decades much of the nuclear and coal powered electricity generation capacity of the UK is scheduled for closure. The majority of new build in the 1990s was in gas-fired generation. This slowed after 2000, with no further significant increase in capacity, but in the medium term new build is expected to be in gas.

The UK is currently one of the top ten global producers of oil and gas and is expected to remain an important producer for many years; however production of oil and gas is gradually declining and the UK was a net importer of gas on an annual basis in 2004 and 2005 and, based on current trends is expected to become a net importer of oil by about 2010.

**Figure 1.1 Breakdown of UK Energy Supply 2005[11]**

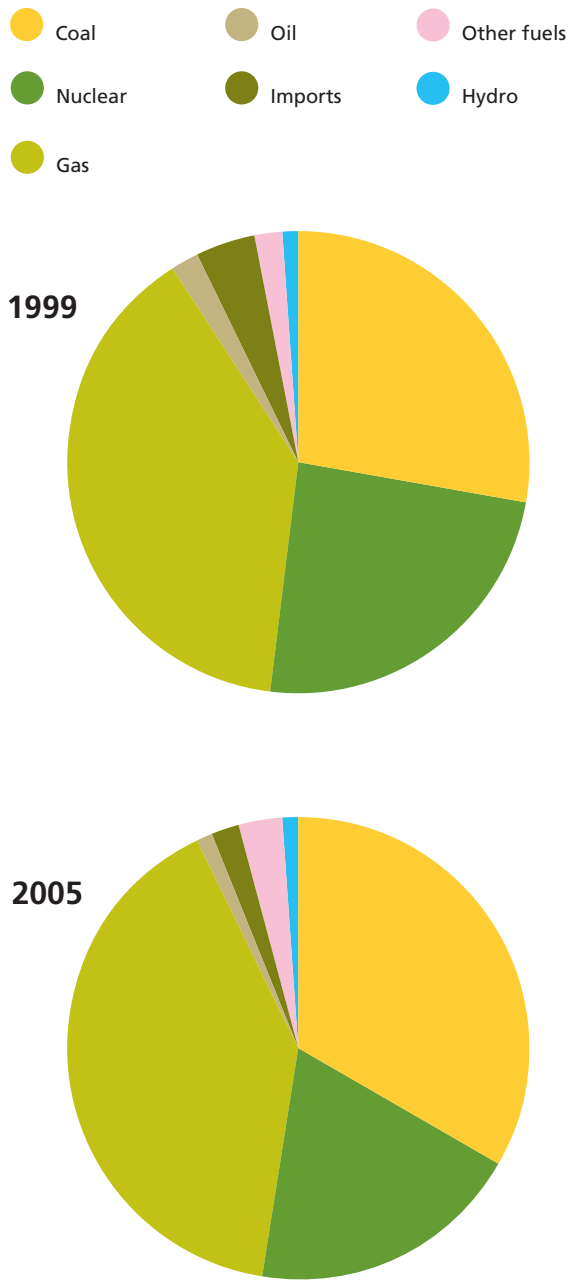



In 2005, most of the UK's energy supply was from natural gas (40 per cent), followed by petroleum (33 per cent), coal (17 per cent), nuclear electricity (8 per cent) and renewable energy sources (2 per cent). The renewable energy sources currently used in the UK are largely hydropower, wind, biomass and landfill gas. The Government's current policy on renewable energy includes a target to generate10 per cent of electricity from renewable sources by 2010, with an aspirational target of 20 per cent by 2020.

Since 1999, the share of gas has remained approximately constant. Other fuels, mainly renewables, have increased by 1.5 per cent, but nuclear generation has been replaced largely by coal, which increases the carbon emissions per unit of generation.

11 DTI, DUKES 2005

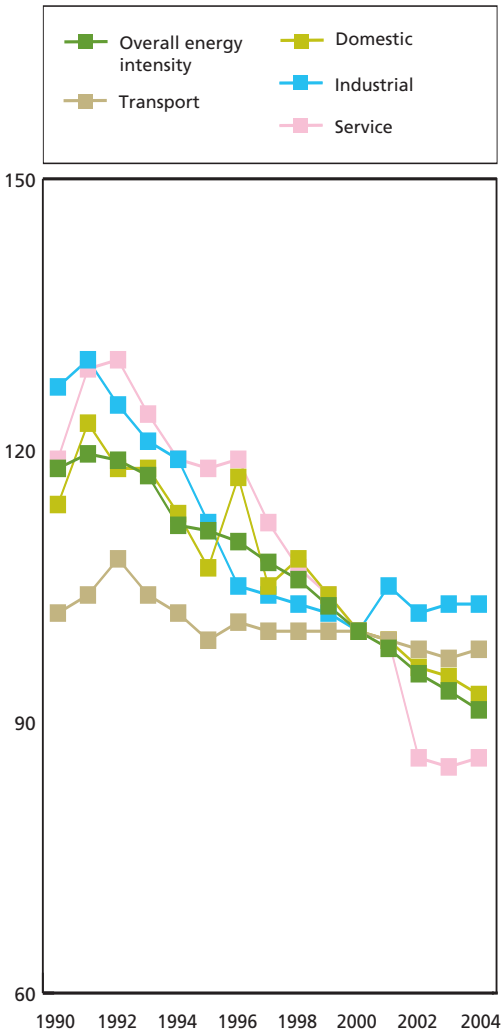
**Figure 1.2 Share of fuels on electricity supplied basis[12]**




Consumers, businesses and households are all able to choose between competing suppliers of electricity and gas. This exerts a downward pressure on energy prices and the UK's gas and electricity prices for households have been lower than other major European countries. Electricity and gas networks are privately owned, but are regulated in Great Britain by the Independent Office for Gas and Electricity Markets (Ofgem) and in Northern Ireland by the Office for Regulation of Electricity and Gas (Ofreg).

Since 1990, the energy intensity of the UK economy has fallen by 30 per cent. This results from energy efficiency improvements in the sectors and the shift of the economy from heavy industry towards the commercial and services sectors. Intensity in the transport sector has decreased slightly but less significantly than the other sectors. There are some signs of a levelling-off in these trends, which if continued, could exert upward pressure on emissions.

**Figure 1.3 Energy intensity in the UK (indexed 2000=100)[13]**




12 DTI, DUKES 2005

13 Our Energy Challenge, Securing Clean, Affordable Energy for the Long Term, DTI Energy Review Consultation Document January 2006.

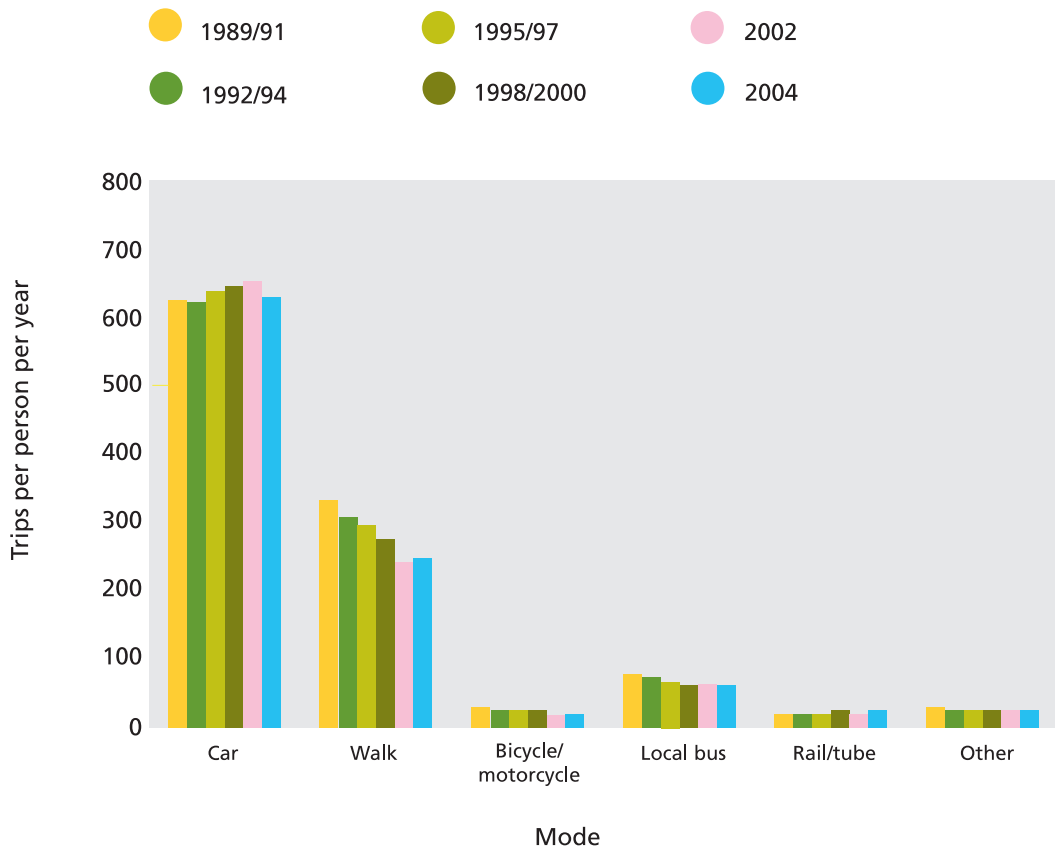
## Transport

1.7 Transport currently accounts for 24 per cent of the UK's greenhouse gas emissions. Demand for transport and transport fuels is increasing, leading to an increase in transport emissions as a result. For example, forecasts indicate that road transport emissions will grow by 7 per cent from 2000 by 2010[14].

The average annual distance travelled by residents in Great Britain rose by 5 per cent between 1992/94 and 2004, but the number of walking trips fell by a fifth[15].

Both Vehicle Excise Duty and the Company Car Tax System now reward motorists for selecting fuel-efficient cars. Due to the increased manufacture of more fuel efficient cars, the average emissions from new cars in the UK decreased by 10 per cent between 1995 and 2004, however the rate of improvement may have started to fall[17]. The UK's long term strategy to reduce transport emissions includes the Renewable Transport Fuels Obligation, which requires 5 per cent of transport fuel sold in the UK to come from renewable sources by 2010.

**Figure 1.4 Average annual trips made by mode[16]**




14 $CO_2$ projections published in UEP21: http://www.dti.gov.uk/energy/sepn/UEP_Feb 2006.pdf

15 Department for Transport, National Travel Survey, 2004.

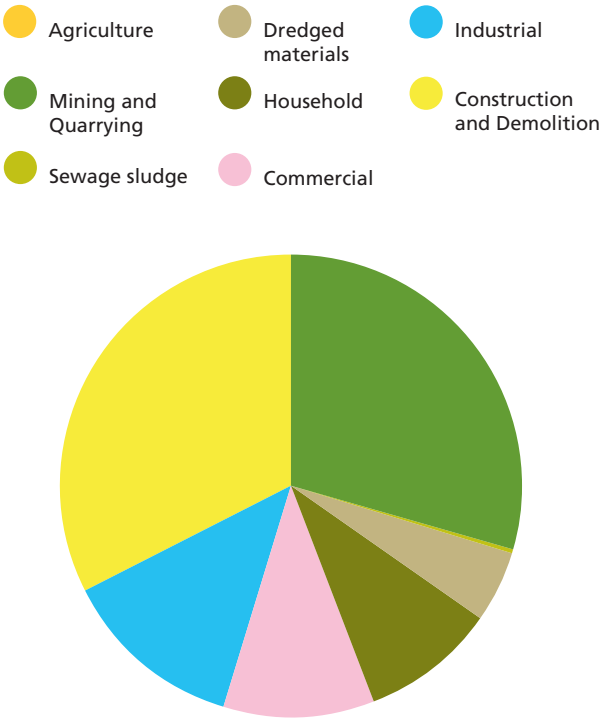
16 Transport Trends 2005, Department for Transport

17 Our Energy Challenge, Securing Clean, Affordable Energy for the Long Term, DTI Energy Review Consultation Document January 2006.

## Waste

1.8 In 2005, 330 million tonnes of waste were produced in the UK, of which most (32 per cent) came from the construction and demolition industries. Less than 10 per cent of the waste produced in 2005 came from households. Waste production is projected to grow at a rate of around 3 per cent per year[18]

**Figure 1.5 UK Waste arisings 2002/03[19]**




Most waste produced in the UK is currently disposed of at landfill sites. The remainder is treated by other means, including waste-to-energy, recycling and composting. In 2004/2005 households in England recycled nearly 23 per cent of their waste[18].

Consistent with the EU Landfill Directive the Government and the devolved administrations have published waste strategies aiming to reduce the quantity of waste produced and to increasingly recover value from it. The strategies also set targets for reducing the amount of waste sent to landfill and to increase the amount of recycling or composting. These targets will further reduce the level of methane emissions from the waste sector in the UK.

## Building Stock and Urban Structure

1.9 Although the UK has a long history of urbanisation, some areas are sparsely populated, including the Highlands of Scotland, parts of Wales and northern England.

In 2003 there were around 26 million dwellings in the UK. Most common are semi-detached houses (31 per cent), followed by terraced houses (27 per cent), detached houses (22 per cent), and purpose built flats (16 per cent). The number of households in England is projected to increase by 19 per cent between 1996 and 2021. This reflects, amongst other things, the increasing number of people living on their own. This trend shows some large regional variations, with increases of about 25 per cent in the south but only 10 per cent in the north. In Scotland the housing stock is projected to increase by around 12 per cent between 1998 and 2012. Improvements in energy efficiency standards of new build homes are beginning to offset the energy use increases that would otherwise occur[20].

## Agriculture

1.10 The total area of agricultural land in the UK is currently around 18.4 million hectares. About 5.8 million hectares of this is arable mainly cereal production. 11.5 million hectares is currently under grass, including rough grazing. The remainder is in set-aside or farm woodland.

18 Defra: www.defra.gov.uk/environment/waste

19 Defra, Environment Agency, Water UK: http://www.defra.gov.uk/environment/statistics/waste/kf/wrkf02.htm

20 Blue Book, 2005 Edition.

The total number of livestock in the UK in 2004 was 210 million. Of this, there were 10.6 million cattle, 35.9 million sheep, 5.2 million pigs and 157.9 million fowl. This represents a slight decrease from the 2000 levels. The dairy herd continues a long-term trend to reducing numbers and emissions from agriculture are decreasing[21].

During 2000, the Common Agricultural Policy was reformed. This involved the creation of an integrated EU Rural Development Policy, which provided the basis for a shift of emphasis from production support towards environmental and rural development.

## Forestry

1.11 The total area of woodland in the UK is currently 2.8 million hectares. Of this total, 47 per cent is in Scotland, 40 per cent in England, 10 per cent in Wales and 3 per cent in Northern Ireland.

Around 1.6 million hectares of the total UK woodland is made up of conifers, the remainder being broadleaved species. There is a shift towards broadleaves which accounted for the majority (82 per cent) of new planting in 2004.

In 2003, more than 11 million cubic meters of timber (overbark standing volume) were harvested in the UK. This is projected to increase to over 16 million cubic meters by 2021 as a number of large plantations from the 1960s and 1970s reach maturity[22].

The UK Forestry Standard (2004) provides criteria and standards for the sustainable management of UK forests and woodlands. This is used by the Forestry Commission for Great Britain and the Forestry Service for Northern Ireland, and its implementation is also required in those areas of private forestry receiving grants.

A high proportion of UK forests have also now been certified under the UK Woodland Assurance Standard. This standard allows the certified forests to be recognised by consumers as a sustainable resource.

**Table 1.3 Woodland activity 2004–5[23]**

| Country | Area (kha) of woodland | Area (kha) of new planting | Area (kha) of restocking | Harvested timber (thousands of cubic meters) |
|---|---|---|---|---|
| England | 1119 | 5.3 | 2.5 | 10,040 |
| Wales | 286 | 0.5 | 1.6 | |
| Scotland | 1334 | 5.7 | 9.5 | |
| Northern Ireland | 85 | 0.4 | 1.0 | 480 |
| UK total | 2825 | 11.9 | 14.6 | 11,150 |

21 Defra 2004, E Digest Statistics.

22 Blue Book, 2005 Edition.

23 Forestry Commission, Department of Agriculture and Rural Development, Northern Ireland.

# 2

# Greenhouse Gas Inventory

## Key Developments

- The UK's greenhouse gas emissions were about 14.6 per cent below Kyoto Protocol base-year levels in 2004.
- Between 1990 and 2004 net carbon dioxide emissions fell by 5.6 per cent; methane emissions fell by 50.1 per cent; and nitrous oxide emissions fell by 40.4 per cent.
- Between 1995 and 2004, hydrofluorocarbon emissions fell by 42.8 per cent; perfluorocarbon emissions fell by 25.2 per cent; and sulphur hexafluoride emissions fell by 9.0 per cent.
- The reduction in the basket of six greenhouse gas emissions since 1990 has been mainly driven by restructuring especially in the energy supply industry; energy efficiency; pollution control measures in the industrial sector and other policies that reduced emissions of non-$CO_2$ greenhouse gases.

## Introduction

2.1 This chapter provides information on the national system for the UK greenhouse gas inventory, taken from the UK's greenhouse gas inventory submitted to the UNFCCC in April 2006[24]. It shows trends in UK greenhouse gas emissions between 1990 and 2004, disaggregating overall emissions by gas, and by source and end-use sector. The by-source basis reports emissions from the energy supply industry separately and the end-user basis reallocates these emissions to the sectors that make use of the energy supplied.

The UK's Kyoto Protocol target is to reduce emissions of the basket of six greenhouse gases by 12.5 per cent compared to base-year levels. This was agreed by the EU in 1998 and represents the UK's share of the agreement under the Kyoto Protocol by the fifteen States which were members of the EU in 1997 to reduce emissions collectively by 8 per cent relative to base year levels during the first commitment period. The UK also has a domestic goal to reduce $CO_2$ emissions only by 20 per cent below the 1990 level in 2010, and a long term aim, introduced in the 2010 Energy White Paper, to reduce $CO_2$ emissions by 60 per cent below the 1990 level by 2050, with real progress by 2020. These more ambitious goals show commitment to the long term emissions reduction needed to stabilise atmospheric concentrations of greenhouse gases, and help ensure that the UK meets its Kyoto commitments.

The UK's base year for assessing emissions of carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$) is 1990. In line with most other EU Member States, and in accordance with Article 3.8 of the Kyoto Protocol, the UK the has chosen, for the purposes of accounting under the Kyoto Protocol, to use 1995 as the base year for emissions of the fluorinated gases: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride ($SF_6$). The Common Reporting Format Tables are included as Annex A.

Land use, land-use change and forestry (LULUCF) emissions and removals are reported in the UK's greenhouse gas inventory in accordance with the rules for reporting this sector under the UNFCCC. The UNFCCC reporting basis includes all an estimate of all anthropogenic sources minus sinks from the LULUCF sector. It is on this basis that the national goal to reduce $CO_2$ emissions by 20 per cent relative to the 1990 level by 2010 is assessed. A narrower definition of LULUCF emissions and removals is used to assess progress against the Kyoto target which includes only mandatory activities under Article 3.3 of the Kyoto Protocol, and forest management, which the UK has chosen as an activity under Article 3.4 of the Kyoto Protocol. The UK has decided not to account for cropland or grazing land management or revegetation which are other choices under Article 3.4 because of the additional uncertainties associated with the detailed monitoring of these activities required under the Protocol. A small allowance related to deforestation emissions in 1990 is included in the base year estimate, as required by Article 3.7 of the Kyoto Protocol and subsequent decisions of the COP.

The geographical coverage of the inventory for assessing progress towards the UK's goal to reduce $CO_2$ emissions by 20 per cent below the 1990 level in 2010 is the UK including the Crown Dependencies of Jersey, Guernsey and the Isle of Man. The coverage for assessing progress on the 12.5 per cent reduction in emissions below base year levels for the first commitment period under the Kyoto Protocol also includes emissions from the Overseas Territories that have associated themselves with the UK's instrument of ratification, namely Bermuda, the Cayman Islands, the Falkland Islands and Montserrat. Appendix C shows the relationship between these bases.

24 UK Greenhouse Gas Inventory, 1990–2004, Annual report for submission under the UN Framework Convention on Climate Change, April 2006.

## National system for preparing the UK greenhouse gas inventory

2.2 The UK's greenhouse gas inventory is compiled under contract to Defra by the National Environmental Technology Centre (NETCEN), which is part of AEA Technology. NETCEN also compiles the UK's National Atmospheric Emissions Inventory, used for reporting emissions to other international agreements, including the Geneva Protocol and the UNECE Convention on Long Range Trans-boundary Air Pollution. Most of the underlying information is held on common databases and this helps ensure consistency between the inventories.

Emissions from the agricultural sector are provided by the Institute of Grassland and Environmental Research (IGER) under contract to Defra, and estimates for LULUCF are produced on behalf of Defra by the UK Centre for Ecology and Hydrology (CEH). Defra also funds research contracts to provide improved emissions estimates for certain sources such as fluorinated gases, landfill methane, and to provide estimates for previously unreported sub-sectors such as methane from abandoned coal mines, included for the first time in the UK's inventory submitted in 2005.

The greenhouse gas inventory is compiled annually according to Intergovernmental Panel on Climate Change (IPCC) Good Practice Guidance (IPCC, 2000 and 2003). Methodological improvements take account of new data sources, updated guidance from IPCC, relevant work by organisations such as CORINAIR (the European inventory system certain for air pollutants) and specific research programmes sponsored by Defra. All methodological improvements are applied back to 1990 to ensure a consistent time series.

The UK has implemented Kyoto Protocol guidelines for setting up its national system for greenhouse gas emissions estimation, reporting and archiving. Defra has been appointed as the Single National Entity with responsibility for the overall management and strategic development of the UK's greenhouse gas inventory. Defra has set up an inter-departmental steering committee to consider and approve the national inventory prior to submission to the EU and the UNFCCC each year.

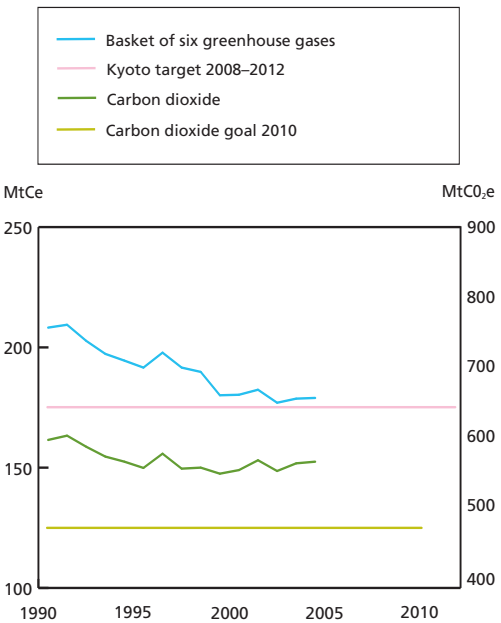
A detailed description of the UK's national system was provided in the most recent annual inventory report submitted in April 2006 to the UNFCCC and the EU. The annual inventory report provides some of the additional reporting required under Article 7, paragraph 2 of the Kyoto Protocol. Other sources of information required under Article 7, paragraph 2 are summarised in Annex E

## Greenhouse gas emissions trends

2.3 The UK's base-year emissions of the basket of six greenhouse gases covered by the Kyoto Protocol was about 209.5 million tonnes of carbon (MtC)[25]. As a result of policy action and trends in the UK, annual greenhouse gas emissions fell by about 14.6 per cent between the base year and 2004. Figure 2.1 shows the trend in emissions of the basket of six greenhouse gases between 1990 and 2004. The trend in $CO_2$ emissions is also shown, together with the levels of emission reduction corresponding to the reduction commitment for the first commitment period under the Kyoto Protocol and the 20 per cent domestic $CO_2$ reduction goal identified above.

Information on individual gases is contained in sections below and Annex A contains the common reporting format (CRF) tables summarising the UK's greenhouse gas emissions. More details can be found in the UK's annual greenhouse gas inventory, published in April 2006[24].

**Figure 2.1 UK emissions of greenhouse gases, 1990–2004.**




25 Greenhouse gas emissions are expressed throughout this document as million tonnes of carbon equivalent (MtC). One tonne of carbon is contained in 3.67 tonnes of carbon dioxide which is the ratio of the molecular weight of carbon dioxide to the atomic weight of carbon (i.e. 44/12). Other gases are expressed in terms of carbon equivalent by multiplying their emissions by their global warming potential (GWP) and dividing by 3.67.

## Greenhouse gas emissions inventory by gas

**Table 2.2 UK Greenhouse gas emissions, MtC**

| Gas | Base Year | 1990 | 1995 | 2000 | 2004 |
|---|---|---|---|---|---|
| Total carbon dioxide[26] | 161.5 | 161.5 | 149.9 | 149.0 | 152.5 |
| Methane | 25.1 | 25.1 | 21.8 | 16.3 | 12.5 |
| Nitrous oxide | 18.6 | 18.6 | 15.5 | 12.1 | 11.1 |
| HFCs | 4.2 | 3.1 | 4.2 | 2.5 | 2.4 |
| PFCs | 0.1 | 0.4 | 0.1 | 0.1 | 0.1 |
| Sulphur hexafluoride | 0.3 | 0.3 | 0.3 | 0.5 | 0.3 |
| Total greenhouse gas emissions by sources minus removals by sinks[27] | 209.9 | 209.0 | 191.9 | 180.5 | 178.9 |
| Total greenhouse gas emissions including only mandatory Article 3.3 LULUCF activities and forest management cap under Article 3.4 LULUCF[28] | 209.5 | 208.2 | 191.6 | 180.3 | 179.0 |
| Change from base year levels (for row above) | | -0.6% | -8.5% | -13.9% | -14.6% |

*Percentage changes and emission estimates may differ slightly due to rounding*

2.4. Table 2.2 shows historical data for $CO_2$ and the other greenhouse gases. The sections that follow summarise the main factors affecting the historical trend by gas.

### 2.4.1 Carbon dioxide

Carbon dioxide is the main greenhouse gas in the UK. Net CO2 emissions (all anthropogenic sources minus removals by sinks) in 1990 were estimated to be 161.5 MtC[29], or around 77% of the UK's total emissions of greenhouse gases. In 2004 $CO_2$ emissions had been reduced by 5.6% to 152.5 MtC, contributing around 85% of UK greenhouse gas emissions in that year.

The main source of $CO_2$ is from combustion of fossil fuels. Power consumption and structural changes in power generation provided the main drivers behind the reduction in emissions between 1990 and 2004. Although electricity consumption increased by 17% between 1990 and 2004, $CO_2$ emissions from power stations per fell by 16%.

The reduced carbon intensity was mainly due to switching from coal to gas in electricity generation, but also because of improved performance from nuclear generation and an increased use of renewable energy and combined heat and power.

The $CO_2$ estimate takes account of changes in carbon stocks in forests and soils produced by CEH, based on land use and soil survey data, and on annual planting data from the Forestry Commission. CEH also uses the inventories of woodlands in Great Britain, which the Forestry Commission has undertaken at 15–20 year intervals since 1924. The most recent woodland inventory was carried out between 1995–2000. Further woodland inventories are being planned on a ten year rolling programme.

26 As shown in the $CO_2$ line in fig 2.1. Includes total emissions by sources minus total removals by sinks.

27 UNFCCC reporting basis: totals include all anthropogenic sources and sinks for assessing progress against national $CO_2$ goal. Totals do not include emissions from UK Overseas Territories associated with UK's ratifications of UNFCCC and Kyoto Protocol.

28 As shown in the Kyoto basket line in fig 2.1. LULUCF component includes mandatory Article 3.3 LULUCF afforestation plus reforestation minus deforestation since 1990 and the forest management cap of 0.37MtC agreed for the UK under Article 3.4 LULUCF of the Kyoto Protocol. Totals also include emissions from UK Overseas Territories associated with the UK's ratifications of the UNFCCC and Kyoto Protocol.

29 Total emissions by sources minus total removals by sinks.

### 2.4.2 Methane

Methane provides the second largest share of the UK's greenhouse gas emissions. Emissions in 1990 were 25.1 MtC, contributing around 12 per cent of the UK's total emissions of greenhouse gases. In 2004 $CH_4$ emissions had been reduced by 50 per cent to 12.5 MtC, contributing around 7 per cent of UK greenhouse gas emissions in that year.

The major sources of $CH_4$ were landfill waste, agriculture, natural gas distribution and coal mining. Emissions from all the main sources of methane in the UK have fallen since 1990. This takes account of trends in energy production, replacement of gas distribution infrastructure, utilisation of methane from working and abandoned coal mines, waste policies introduced to meet the requirements of the EU Landfill Directive as well as previous policy goals, and livestock numbers and agricultural waste disposal. The reduction in methane from landfill takes account of the recent upward revision in the level of emissions due to a revaluation of gas collection and oxidation efficiencies[30]. This has affected the historical time series as well as future projections.

For the first time in 2005 the UK greenhouse gas inventory contained emissions estimates for abandoned mine methane.

### 2.4.3 Nitrous oxide

Nitrous oxide emissions contributed 18.6 MtC or 9 per cent of the UK's total greenhouse gas emissions in 1990. $N_2O$ emissions had been reduced by 40.4 per cent to 11.1 MtC in 2004, contributing around 6 per cent of UK greenhouse gas emissions in that year.

The major sources were agricultural soils and industrial processes, particularly fugitive emissions from adipic acid manufacture. Emissions of $N_2O$ from industrial processes fell from an estimated 8.0 MtC in 1990 to 1.1 MtC in 2004, largely from the introduction of abatement technology in adipic acid manufacture in 1998.

$N_2O$ emissions from road transport increased from 0.4 MtC in 1990 to 1.5 MtC in 2004, because of the rise in the number of petrol-fuelled motor vehicles fitted with three-way catalytic converters to reduce emissions of hydrocarbons, carbon monoxide and other nitrogen oxides (NO and $NO_2$), and because of growth in traffic.

### 2.4.4 Fluorinated gases (HFCs, PFCs and $SF_6$)

Emissions of the fluorinated or industrial gases are small in absolute terms but their significance is increased by high GWP values. For the purpose of accounting under the Kyoto Protocol, the UK has chosen to use 1995 as the base year for HFCs, PFCs and $SF_6$. This is in line with the approach that most other EU Member States are adopting. In 1995 emissions of all fluorinated gases from the UK amounted to about 4.7 MtC or 2.4 per cent of UK total greenhouse gas emissions; by 2004 emissions had fallen by 46.4 per cent to 2.5 MtC, contributing 1.6 per cent of UK greenhouse gas emissions in that year.

Emissions of HFCs fell by 42.8 per cent, from 4.2 MtC in 1995 to 2.4 MtC in 2004, mainly due to the introduction of thermal oxidiser pollution abatement equipment at the two UK plants where HCFC-22 is manufactured. Other sources of HFC emissions include refrigeration/air-conditioning, foam blowing, general aerosols, metered dose inhalers, solvent cleaning and fire-fighting. HFCs were virtually unused in many of these sectors before 1990 but since then, consumption has risen in response to the phase out of chlorofluorocarbons (CFCs) and HCFCs under the Montreal Protocol.

Emissions of PFCs fell by 25.2 per cent between 1995 and 2004. This is mainly due to the introduction of improved technology in the aluminium production sector that has led to lower process emissions.

$SF_6$ is used in four main markets: electrical insulation, magnesium smelting, electronics and training shoes. Total use of $SF_6$ from these end use markets fell by 9 per cent between 1995 and 2004.

[30] UK Landfill Methane Emissions: Evaluation and Appraisal of Waste Policies and Projections to 2050, Golder Associates, November 2005.

## Sectoral emissions – by source

**Table 2.3 Greenhouse gas emissions by source, MtC**

| Sector | Base year | 1990 | 1995 | 2000 | 2004 |
|---|---|---|---|---|---|
| Energy supply | 74.4 | 74.4 | 63.1 | 58.2 | 61.4 |
| Business | 30.7 | 30.4 | 29.4 | 30.3 | 29.2 |
| Industrial processes | 16.4 | 15.9 | 13.2 | 6.7 | 5.1 |
| Transport | 34.1 | 34.1 | 34.3 | 36.0 | 37.4 |
| Residential | 22.3 | 22.2 | 22.5 | 24.6 | 25.3 |
| Public | 3.7 | 3.7 | 3.6 | 3.2 | 2.9 |
| Agriculture | 16.2 | 16.2 | 15.6 | 14.8 | 13.8 |
| LULUCF (net) | 0.8 | 0.8 | 0.3 | -0.1 | -0.5 |
| Waste management | 11.3 | 11.3 | 10.0 | 6.8 | 4.5 |
| Total GHG emissions by sources minus removals by sinks | 209.9 | 209.0 | 191.9 | 180.5 | 178.9 |

*Note: the percentage changes and emission estimates may differ slightly due to rounding*

Table 2.3 shows the contribution to UK greenhouse gas emissions of different sectors by emissions source. By-source reporting shows emissions from the energy supply industry separately to the other sectors.

Figures 2.4 to 2.9 below show the contribution of each relevant sector to the emissions of each of the basket of six greenhouse gases between 1990 and 2004.

**Figure 2.4 Carbon Dioxide Emissions by Source, 1990–2004, MtC**

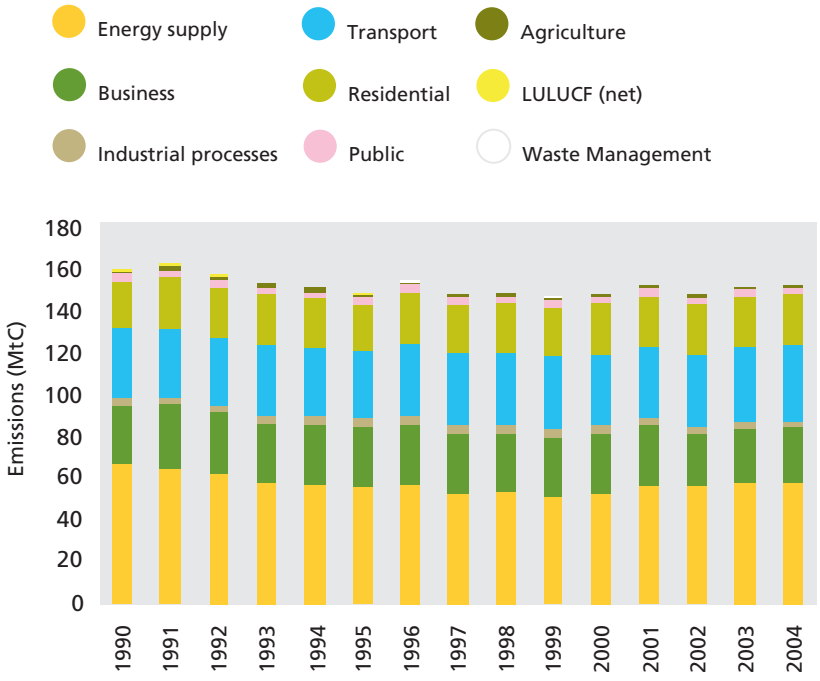


**Figure 2.5 Methane Emissions by Source, 1990–2004, MtC**

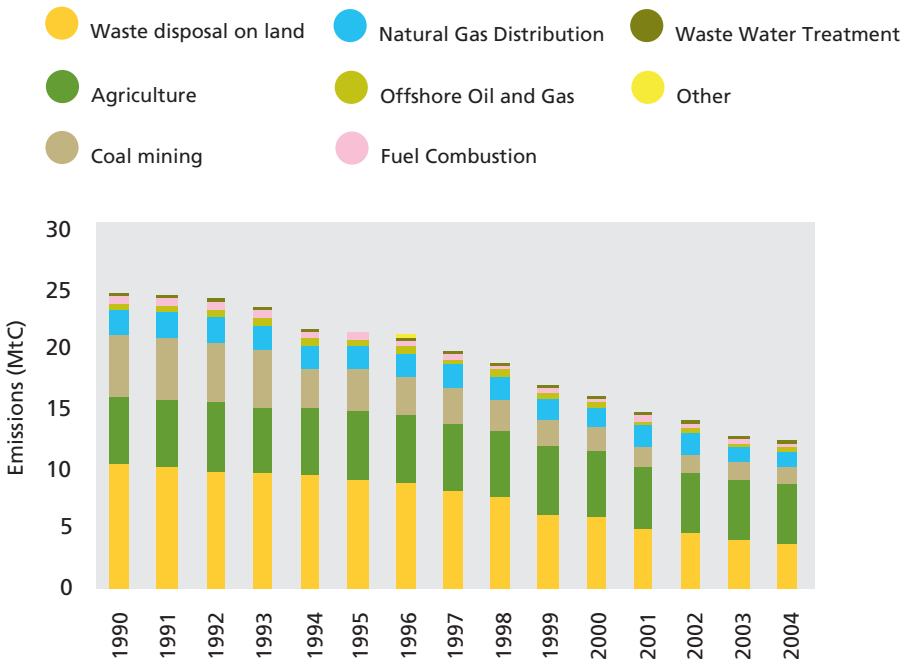



**Figure 2.6 Nitrous Oxide Emissions by Source, 1990–2004, MtC**

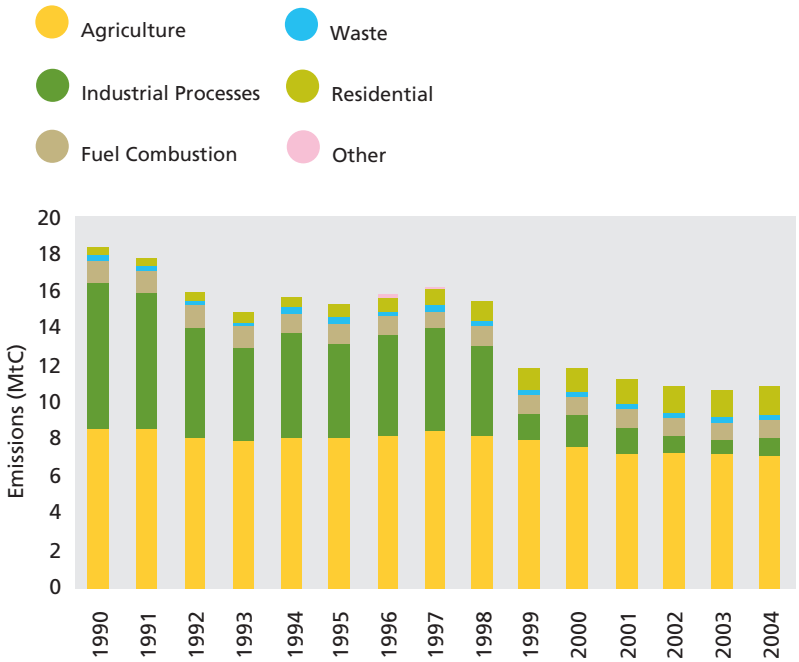


**Figure 2.7 HFC Emissions by Source, 1990–2004, MtC**

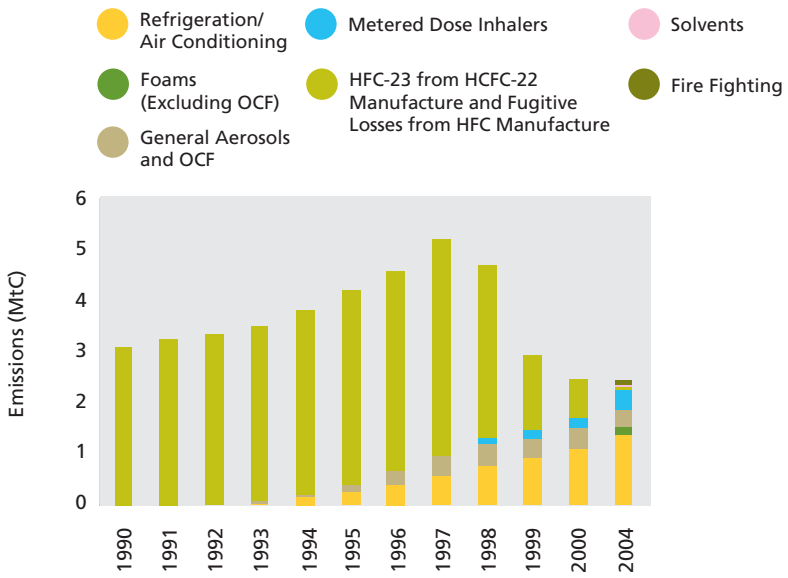



**Figure 2.8 PFC Emissions by Source, 1990–2004, MtC**

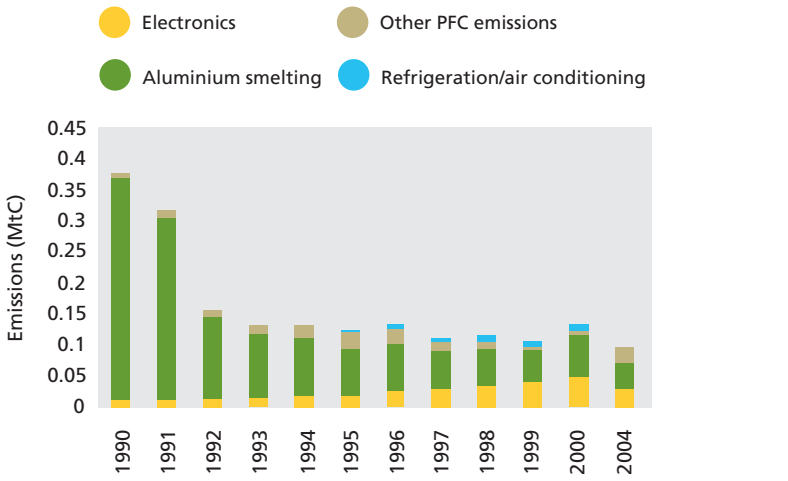
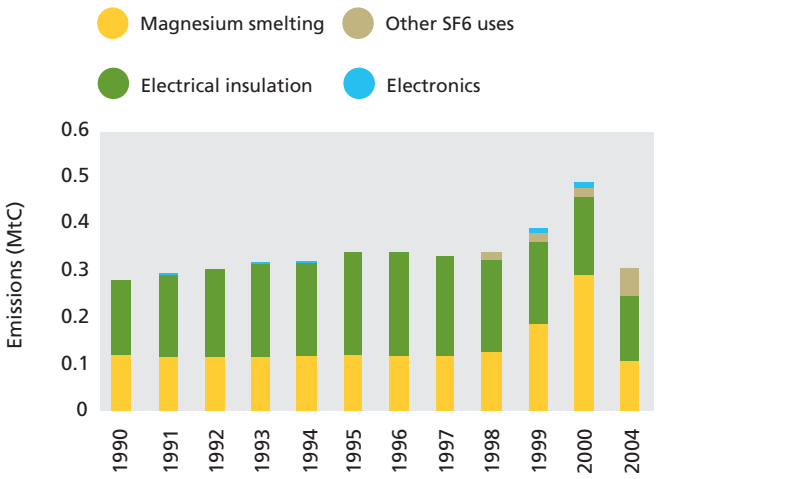



**Table 2.9 SF6 Emissions by Source, 1990–2004, MtC**



### 2.5.1 Energy supply

The energy supply sector is the biggest single contributor to the UK's carbon dioxide emissions and was responsible for about 58 MtC or 38 per cent of net $CO_2$ emissions in 2004. The restructuring of the energy supply industry in the mid-1990s led to a significant decrease in emissions to 2000. Since then the volatile and high gas price, and the corresponding switching from gas to coal and oil generation increased emissions with estimated 2004 emissions being 1 per cent higher than 2003.

## Sectoral emissions – by end-user

2.6 Table 2.10 shows greenhouse gas emissions on an end-user basis. Emissions from the energy supply industry are reallocated to the sectors, which make use of the energy supplied.

### 2.6.1 Energy use

The trend in the business sector is for decreasing emissions. In 2004, emissions from this sector were about 22 per cent below 1990 levels and represented 34 per cent of total emissions. A number of factors contributed to this decrease: fuel switching and a decline in energy intensity arising from structural changes and policy actions.

In 2004, residential sector emissions had fallen to 43.7 MtC, compared to base year emissions of 45.9 MtC. This small net change was the result of interactions between several much larger individual contributions over the decade. Three factors had a major influence:

- growth in demand for underlying energy services (such as warmer homes, hot water and home entertainment)
- background improvement in energy efficiency, over 1 per cent per annum
- reduction in the carbon intensity of grid electricity

Transport accounted for about 25 per cent of UK greenhouse gas emissions in 2004, representing a growth of some 12 per cent since 1990. This growth is driven by increasing demand, which offsets improvements in new car fuel efficiency of 10 per cent since 1997.

Public sector emissions fell from 8.5 MtC in 1990 to 5.9 MtC in 2004 and represent 3 per cent of total emissions.

### 2.6.2 Agriculture, forestry and land use

In 1990, greenhouse gas emissions from agriculture, forestry and land use were 14.5 MtC or about 8 per cent of the UK total. This includes net emissions and removals from LULUCF. Annual emissions from this sector have fallen around 16 per cent between 1990 and 2004. The fall in emissions is the result of decreasing animal numbers and fertiliser use, plus expanded forest area and a tendency to less intensive agriculture

### 2.6.3 Waste

Emissions from disposal of waste have decreased by over 60 per cent since 1990, which contributes to the decline in methane emissions. This decrease has been realised mainly through fitting of methane recovery systems on landfills and increasing diversion of biodegradable waste from landfill, plus more diversion away from landfills in response to the UK landfill tax and policies to meet the requirements of the EU Landfill Directive.

**Table 2.10 Greenhouse gas emissions by end user, MtC**

| Sector | Base year | 1990 | 1995 | 2000 | 2004 |
|---|---|---|---|---|---|
| Business | 68.7 | 68.3 | 60.8 | 59.9 | 60.4 |
| Industrial processes | 17.3 | 16.8 | 13.9 | 7.3 | 5.4 |
| Transport | 40.2 | 40.2 | 41.2 | 42.6 | 45.0 |
| Residential | 45.9 | 45.8 | 41.7 | 42.1 | 43.7 |
| Public | 8.5 | 8.5 | 7.7 | 6.3 | 5.9 |
| Agriculture | 17.2 | 17.2 | 16.5 | 15.5 | 14.5 |
| LULUCF (net) | 0.8 | 0.8 | 0.3 | -0.1 | -0.5 |
| Waste management | 11.3 | 11.3 | 10.0 | 6.8 | 4.5 |
| Total GHG emissions by sources minus removals by sinks | 209.9 | 209.0 | 191.9 | 180.5 | 178.9 |

### 2.6.4 Industrial processes

Industrial process emissions have decreased by nearly 70 per cent since 1990. The largest reductions are from the chemicals industry and a significant contribution to this is the introduction of abatement technology in adipic acid manufacture, in response to Integrated Pollution Prevention Control and the UK Emissions Trading Scheme.

# 3

# Policies and Measures

## Key developments

- The Government and the devolved administrations published a new Climate Change Programme in March 2006.
- The UK is on track to meet our commitment under the Kyoto Protocol to reduce emissions of greenhouse gases by 12.5 per cent below 1990 levels by 2008–12.
- Higher than anticipated levels of economic growth and the recent rise in global energy prices, which has altered the relative prices of coal and gas, have made the achievement of the UK's domestic target of a reduction 20 per cent in carbon dioxide more challenging.
- The measures announced in new Climate Change Programme are projected to take the UK close to the domestic target and ensure that real progress can be made by 2020 towards the long-term goal to reduce carbon dioxide emissions by some 60 per cent by about 2050.

**Key policies include:**

- A national allocation plan for the second phase of the EU Emissions Trading Scheme to achieve carbon savings of between 3 and 8 MtC.
- Spend of £80m in the next three years to support microgeneration technologies, with the aim of encouraging manufacture at higher scale leading to low costs.
- Introduce the Renewable Transport Fuel Obligation from 2008 to increase the uptake of biofuels.
- Building on substantial progress to date, seek to achieve substantially higher carbon savings from the Energy Efficiency Commitment in 2008–11.
- Encouragement of personal action by consumers.

## Introduction

3.1 The UK plays a leading role in the fight against climate change and made it a priority for the UK Presidencies of the G8 and EU during 2005. Action taken since the 1990s has significantly reduced emissions and the UK is on track to meet its share of the EU target under the Kyoto Protocol. This target, a 12.5 per cent reduction, was agreed with other Member States during the 1998 UK Presidency of the EU.

The Government's priority is to deliver the Kyoto target, but it believes greater reductions in emissions are feasible, and that there are real advantages to the UK in aiming to achieve them. That is why the Government and devolved administrations agreed a separate domestic goal of reducing carbon dioxide emissions to 20 per cent below 1990 levels by 2010.

In 2000, the UK Government launched a Climate Change Programme[31] designed to enable the UK to meet, and go beyond, its commitment under the Kyoto Protocol. The programme took a balanced approach, with all sectors and all parts of the UK playing their part. The policies and measures in that programme were reported to the UNFCCC by means of the 3rd National Communication.

A major review of this programme was launched in 2004 and a revised programme published in March 2006[32]. More details of the policies and measures described in this chapter can be found in the UK programme. A summary can also be found in Annex B.

## Policy development process

3.1 Defra coordinates policy on climate change at the official level through inter-departmental committees chaired at Defra. A Cabinet Committee chaired by the Prime Minister makes decisions at the political level.

Some policies are the responsibility of Defra directly, while others are the responsibility of Her Majesty's Treasury (HMT), Department of Trade and Industry (DTI), the Department for Transport (DfT), the Office of the Deputy Prime Minister (ODPM), the Foreign and Commonwealth Office (FCO) and the Department for International Development (DFID). The UK's programme is supported by action taken by the Devolved Administrations in Scotland, Wales and Northern Ireland.

31 *Climate Change: The UK Programme* was published in November 2000. Available from http://www.defra.gov.uk

32 *Climate Change: The UK Programme 2006* was published in March 2006. Available from http://www.defra.gov.uk/environment/climatechange/uk/ukccp/pdf/ukccp06-all.pdf

The process for developing the new programme was launched in 2004 with a public consultation. The development of the programme was underpinned by analysis of the costs and benefits of each of the policies and measures using a common framework. The analytical work has been published[33]. In line with the review of the Air Quality Strategy, this analysis included quantification of air quality benefits ensuring that in the long term the two policies will work together synergistically.

The principles underlying the Climate Change Programme are:

- the need to take a balanced approach with all sectors and all parts of the UK playing their part;
- the need to safeguard, and where possible enhance, the UK's competitiveness, encourage technological innovation, promote social inclusion and reduce harm to health;
- the need to focus on flexible and cost effective policy options which will work together to form an integrated package;
- the need to take a long-term view, looking to targets beyond the first commitment period and considering the need for the UK to adapt to the impacts of climate change; and
- the need for the Programme to be kept under review.

In the 2003 Energy White Paper[34], the UK Government announced an ambitious long-term goal for climate change policy, to put the UK on a path to cut its carbon dioxide emissions by 60 per cent by about 2050, with real progress by 2020.

The UK Government announced a Review of UK Energy Policy in November 2005. The review is taking place during 2006 against a background of more evidence on the nature and extent of climate change and increasing concerns about the future of UK energy supplies. The review is not re-examining the goals set out in the 2003 White Paper, rather it recognises that further measures might be necessary to make significant progress.

The UK has undertaken research to determine the extent of impacts of its response measures to climate change and to minimise any adverse effects. The UK has also ensured that response measures are as diverse as possible, and include

- measures to reduce emissions of GHG other than $CO_2$ from fossil fuels
- emissions trading
- measures to enhance carbon sinks
- action to encourage carbon capture and storage.

## The Kyoto mechanisms

3.3 The baseline with measures projections set out in Chapter 4 indicate that the UK is on track to meet its 12.5 per cent emissions reduction commitment under the Kyoto Protocol on the basis of domestic measures alone.

The UK in common with the EU as a whole recognises that the Kyoto Mechanisms play an essential role in meeting commitments under the Protocol and has put in place the necessary institutions and accounting framework to facilitate their use, including development of a registry which has been licensed to date for use in sixteen countries as well as the UK.

Through the EU Linking Directive, companies with obligations under the EU Emissions Trading Scheme can now make use of the Kyoto mechanisms. The UK is a leading investor country in the CDM. By the end of February 2006, the UK was ranked second investor country in terms of registered projects with UK approval of participation. The UK designated national authority for CDM had issued 60 letters of approval of participation for 46 projects[35].

UK Government will be purchasing CDM credits to offset emissions attributable to a variety of central government activities. These credits will then be unilaterally cancelled to offset emissions.

33 Synthesis of Climate Change Policy Evaluations, Defra April 2006, available at http://www.defra.gov.uk/environment/climatechange/uk/ukccp/pdf/synthesisccpolicy-evaluations.pdf. This covers evaluation of currently implemented policies. Appraisal of additional policies will be published in Synthesis of Climate Change Policy Appraisals, to be available at www.defra.gov.uk The methodological approach set out in Greenhouse Gas Policy Evaluation and Appraisal in Government Departments, available at: http://www.defra.gov.uk/environment/climatGreenhouse Gas policyechange/uk/ukccp/pdf/greengas-policyevaluation.pdf

34 The Energy White Paper, *Our energy future – creating a low carbon economy* was published in February 2003. Available from http://www.dti.gov.uk

35 http://www.defra.gov.uk/environment/climatechange/internat/kyotomech/documents/cdm-dna-approvals.pdf

## Cross cutting measures

### 3.4.1 EU Emissions trading scheme

The European Emissions Trading Scheme (EU ETS) was established in 2003 by Directive 2003/87/EC and is the largest emissions trading scheme in the world. In the UK, the scheme covers 1,000 installations, responsible for approximately 50 per cent of the UK's carbon emissions.

The Government believes that, by providing for emissions savings to be made at the point of least cost, emissions trading is a cost effective mechanism for reducing greenhouse gas emissions. The National Allocation Plan for the UK in the first phase of the scheme, running from 2005 to 2007, sets the total quantity of allowances to be issued and the number of allowances each installation will receive. Since 1st January 2005, operators of installations have been required to monitor their emissions and to ensure that they surrender allowances equivalent to their emissions in any calendar year.

The UK Government has played an active role in the development of emissions trading registries, which track the ownership and transfer of allowances and the UK has licensed its GRETA software to 16 other states.

The second phase runs from 2008 to 2012. Key priorities for the second phase are:

1. **Contribution to the UK emissions reduction targets:** The total quantity of allowances allocated should be consistent with ensuring that the trading sector makes an appropriate contribution to the domestic goal to reduce carbon dioxide emissions by 20 per cent below 1990 levels by 2010 and to the long-term targets set out in the Energy White Paper[36].
2. **Maintain the competitive position of UK industry.** The UK has been working with other Member States and the European Commission to improve consistency of implementation of the Directive. Further clarification has been provided in the Commissions guidance for the second phase, which should minimise distortions.
3. **Facilitate development of an economically efficient EU-wide trading market.** A key consideration has been to look for ways in which to improve the scheme for the second phase by providing appropriate messages to industry and signalling the long term direction of UK policy.

Installations in the EU ETS can meet their obligations by purchasing allowances, which might come from installations in other EU countries and credits from the Kyoto Protocol project mechanisms. This means that the emissions reductions from the second phase of the scheme will not necessarily take place in the UK, nor will they necessarily be of carbon dioxide. Nevertheless, as explained in Chapter 4, the Government will include allowances or project credits surrendered by installations in its assessment of progress towards the 2010 domestic carbon dioxide goal.

The overall cap for the second phase will be set within a range that would achieve **3.0 to 8.0 MtC by 2010.** It is proposed that the reductions in allowances against business as usual will be borne entirely by the electricity supply industry, which is less subject to international competition and in a better position to pass on costs.

The EU ETS will continue after 2012 and the UK recognises the need for more certainty about the future shape of the scheme to encourage investments in the technologies needed to deliver deeper cuts in emissions. There is a strong case for strengthening the scheme beyond 2012 and for developing a robust scheme that maintains the competitiveness of European firms, supports investment in developing countries through the continuation of the Clean Development Mechanism, and provides early certainty for industry.

36 The Energy White Paper, Our energy future – creating a low carbon economy was published in February 2003. Available from http://www.dti.gov.uk

## Energy supply

### 3.5.1. Policy framework

The Government set out the long-term framework for energy policy in the 2003 White Paper "Our Energy Future – Creating a Low Carbon Economy". The White Paper brought climate change to the heart of energy policy, as one of four key goals. It made it clear that, in reducing carbon dioxide emissions, the priority is to strengthen the contribution of energy efficiency and renewable energy sources, and to put the EU Emissions Trading Scheme at the centre of the future market and policy framework.

Liberalised and competitive markets continue to be a cornerstone of UK energy policy, improving efficiency and helping keep prices down for domestic customers and industrial users. The Government believes that the market framework, reinforced by long-term policy measures, is the best way of delivering energy security and encouraging investment.

On 1st April 2005, the British Electricity Trading and Transmission Arrangements (BETTA) introduced a single GB-wide wholesale electricity market. This extended the market arrangements previously operational in England and Wales to Scotland, enabling competitive markets in the generation and supply of electricity to develop further.

In January 2006[37], the Government launched a public consultation on the Energy Review. The Review is looking at whether the Government needs to take further steps to meet its goals for energy policy. It is also considering whether the UK should do more to improve the conditions for the introduction of low carbon technologies, and it is reconsidering the potential role of nuclear power. It will also examine what role carbon capture and storage might play in ensuring that the UK can continue to use fossil fuels, while reducing emissions.

### 3.5.2 Electricity from renewables

In January 2000, the UK set a target to increase the proportion of electricity provided by renewables sources to 10 per cent of electricity supplied by 2010, subject to the cost to the consumer being acceptable.

The main policy mechanism through which the Government supports the development of new renewables capacity is the Renewables Obligation on licensed electricity suppliers in England and Wales and its equivalents in Scotland and Northern Ireland. The Renewables Obligation requires suppliers to source a specific and annually increasing percentage of electricity they supply from renewable sources. To provide a stable and long-term market for renewable electricity, the Obligation will remain in place until 2027.

**Renewables Obligation**

For each megawatt hour of renewable electricity generated, Ofgem who administers the scheme issues a tradable certificate called a Renewables Obligation Certificate (ROC). Suppliers can meet their obligation either by acquiring ROCs or by paying a buy-out price, set at £33.23/MWh in 2006/7 and indexed by inflation, or by a combination of both. Money paid into the buy-out fund is recycled to ROC holders at the end of the 12-month Obligation period.

The level of the Obligation in England, Wales and Scotland is 6.7 per cent for 2006/7 rising to 15.4 per cent by 2015/16.

Since the introduction of the Obligation in April 2002, there has been a step change in the number of renewables projects that have been built in the UK; almost 450 MWe of wind capacity was installed in 2005, double that in 2004. There is expected to be another record year for growth in 2006, with over 500 MWe planned for construction in Scotland alone. **The Renewables Obligation is expected to save 2.5 MtC by 2010, included in the with measures projection.**

Unlike some other renewable technologies, biomass has the advantage that it can be used to generate electricity when required. A strong biomass supply chain can also offer diversification opportunities for farmers and foresters as well as job opportunities, building and operating the generating plant. In addition to the Renewables Obligation, £66m of capital grant funding has been allocated from the DTI/Big Lottery Fund to bring forward additional capacity.

Co-firing of biomass with fossil fuels is eligible for ROCs, with certain restrictions and a requirement for a minimum use of purpose-grown energy crops from 2009. These rules are being reviewed as part of the Energy Review.

37 http://www.dti.gov.uk/energy/review/energy_review_consultation.pdf

Recent projections indicate that generation may not reach the 10 per cent target until some time after 2010. The Government is continuing with a range of work to address barriers to progress and has recently laid a new Renewables Obligation Order before Parliament, which includes a number of small modifications aimed at improving its effectiveness over time.

As well as the Renewables Obligation, support is provided through R&D funding and capital grants worth about £500m between 2002 and 2008, including grants for offshore wind, biomass, solar PV and R&D.

Scottish Ministers are committed to promoting energy from a wide range of renewable sources, and have a target that 40 per cent of electricity generated in Scotland as a proportion of demand should come from renewable sources by 2020. Much of the developer activity at present, driven by the Renewables Obligation Scotland/ROS, is focused on onshore wind. The Scottish Executive continues to provide additional support to small and micro scale renewables through its Scottish Community and Household Renewables Initiative.

The main driver for increasing the use of renewable energy in Northern Ireland is the Renewables Obligation (NIRO), which was introduced on 1st April 2005. The NIRO operates alongside the Renewables Obligation. In February 2006, a £59m Environment and Renewable Energy funding package was launched to enhance and accelerate the development and deployment of renewables over the next two years.

### 3.5.3 Wave and tidal stream

Wave and tidal stream technologies will only make a small contribution in 2010, but if they can be developed successfully on a commercial scale, they could make a significant contribution in 2020 and beyond. Since 1999, around £25m has been committed to R&D on these technologies by the DTI's Technology Programme. In August 2004, a Marine Renewables Deployment Fund (MRDF) was set up to support visionary businesses to take R&D on wave and tidal stream technologies to market. The centrepiece of the MRDF is a Wave and Tidal Stream Energy Demonstration Scheme, which will provide up to £42m to support the deployment of a small number of multi-device wave or tidal stream electricity generating facilities connected to the UK electricity grid.

### 3.5.3 Network infrastructure for renewables

The development of distributed generation including renewables will require the upgrade or reinforcement of parts of the transmission or distribution system. The Government is working with the electricity regulator Ofgem to ensure that these upgrades happen in a timely manner. In December 2004, Ofgem approved additional investment of £560m to strengthen electricity transmission networks in Scotland and the North of England.

### 3.5.5 Biomass heat

Developing a strong biomass heat sector supplied from indigenous sources will contribute to security of supply, as well as reducing emissions. One of the barriers to the development of a biomass heat sector is the higher infrastructure cost compared to conventional systems. Accordingly a support scheme for biomass heat in the industrial, commercial and community sectors are to be introduced. **The scheme will run for five years and will be worth at least £10–15m in England over the next two years. This scheme is expected to save 0.1 MtC by 2010 as an additional measure.**

### 3.5.5 Combined Heat and Power

The environmental benefits of combined heat and power (CHP) have been recognised in the setting, in 2000, of a target to achieve at least 10 GWe of Good Quality CHP capacity[38] by 2010. In recent years, the CHP industry has faced adverse economic conditions, largely due to the difference between the price received for electricity and the cost of generation. Measures to support CHP were reported in the 3rd National Communication. Despite these measures, modelling estimates suggest that the installed capacity will not reach 10 GWe until some time after 2010.

Two new measures will be introduced:

- A consultation will be held on proposals to create a separate sector for the EU ETS for existing Good Quality CHP and for these installations to receive an equitable allocation based on historic emissions. Additionally, there are proposals for new entrant CHP to receive favourable allocation arrangements relative to non-CHP.
- Eligibility for ROCs will be extended to include mixed waste plants, which use Good Quality CHP.

38 Good Quality CHP ensures significant energy efficiency and environmental benefits compared to separate generation of heat and power.

39 Our Energy Challenge: Microgeneration Strategy: Power from the People, DTI, March 2006 can be obtained at http://www.dti.gov.uk/files/file27575.pdf

### 3.5.7 Microgeneration

Microgeneration is the production of heat or electricity on a small-scale from low carbon sources, including air source or ground source heat pumps, fuel cells, micro-CHP and solar. A strategy to promote microgeneration was published on 28th March 2006[39]. This strategy outlines measures, including an £80m capital grant programme, to tackle the barriers currently preventing widespread take-up of microgeneration technologies.

### 3.5.8 Carbon abatement technologies

Carbon abatement technologies (CATs) cover a range of generic options for reducing the carbon dioxide emissions from fossil fuel combustion, including higher efficiency conversion processes and carbon capture and storage. The Government published a Strategy for CATs in June 2005[40]. Capital grants of £35m have been made available to support demonstration of these technologies, including capture ready plant and storage. A consultation document on the barriers to the commercial deployment of carbon capture and storage was published in March 2006[41]. The responses will be fed into the Energy Review.

### 3.5.9 Coal mine methane

The production of electricity from coal mine methane was exempted from the climate change levy in November 2003. The Government is working with the Coal Authority to develop a competitive grant scheme to support projects aimed at controlling coal mine methane emissions. Funding, however, is not presently available for such a scheme.

### 3.5.10 Hydrogen

The Government announced in June 2005 a £15m demonstration programme for hydrogen and fuel cell technologies. State Aids approval for the programme is being sought currently from the European Commission. The Government intends to establish a Hydrogen Coordination Unit to enable the development and deployment of low carbon, low cost and secure hydrogen energy chains for transport, and to ensure that the UK contributes to and benefits from international collaboration on hydrogen with partners such as the International Energy Agency and the International Partnership for the Hydrogen Economy.

## Business

### 3.6.1 Framework for action

The Government is committed to a clear, flexible and stable policy framework for business (comprising the industry and service sectors). This framework draws together a range of instruments and measures including:

- Economic instruments
- Technology deployment
- Regulation
- Measures to make the market work better
- Improving public and company information

The introduction of the EU ETS means that overlapping policy measures now cover some business sector emissions. The Government will explore the medium-term regulatory framework in the light of developments in the EU ETS.

### 3.6.2 Climate change levy and agreements

The climate change levy and climate change agreements were described in detail in the 3rd National Communication. The levy is a tax on the use of energy in industry, commerce and the public sector. Since it was introduced in 2001, the levy rates have not been increased. In Budget 2006[42], it was announced that CCL rates would increase in line with current inflation, starting on 1st April 2007.

Climate change agreements provide an 80 per cent discount from the levy for those sectors that agree to meet challenging targets for improving energy efficiency or reducing greenhouse gas emissions. At the first and second target period, sectors performed well against their targets. **Climate change agreements are an existing measure and expected to save 2.9 MtC by 2010.**

Around 500 installations, in the first phase of the EU ETS are also at least partially covered by CCAs. The UK has obtained temporary exclusion for 331 of these, with the remainder opting to go into the scheme.

40 40 http://www.dti.gov.uk/energy/energy-sources/sustainable/carbon-abatement-tech/Carbon%20abatement%20technology%20strategy/page19434.html

41 http://www.hm-treasury.gov.uk/budget/budget_06/other_documents/bud_bud06_odcarbob.cfm

42 http://www.hm-treasury.gov.uk/budget/budget_06/bud_bud06_index.cfm

### 3.6.3 Carbon Trust

The Carbon Trust is an independent company funded by the Government, to help the UK move towards a low carbon economy. It helps business and the public sector save energy, reduce carbon emissions and capture the commercial opportunities of low carbon technologies. It provides information and impartial advice on energy saving and carbon management, through site visits, events and case studies. It also promotes the Enhanced Capital Allowance Scheme, through which companies can claim 100 per cent first year allowances against investment in qualifying technologies. **Carbon Trust activities are estimated to save 1.1 MtC in the with measures projection.**

### 3.6.4 UK Emissions Trading Scheme

In April 2002, the Government established the first economy-wide greenhouse gas emissions trading scheme. Thirty-three direct participants bid annual, cumulative greenhouse gas emissions reductions targets set against a 1998-2000 baseline, in return for a share of the incentive money of £215 million. The voluntary UK ETS was established as a 5-year pilot scheme and is set to end in December 2006. Installations temporarily excluded from the EU ETS due to UK ETS participation will then move into the EU ETS. **Emissions savings at 2010 of 0.3 MtC from the UK ETS are included in the with measures projection.**

As part of the Energy Efficiency Innovation Review, the Carbon Trust published a detailed, independent report to Government looking at future policy options[43]. The report concluded that there is significant scope for cost-effective energy efficiency and emissions reductions in large non-energy intensive businesses and public sector organisations. It put forward a proposal for a new,mandatory auction based UK emissions trading scheme, which would not be linked to the existing voluntary market, and that would target energy use by large non-energy intensive businesses and public sector organisations.

The Government is considering the proposal, which raises some important issues, and will decide in due course whether to take it forward. As well as exploring the potential environmental benefits of such a scheme, we will also examine the impact of such a scheme on different sectors, including implications for regulatory burden and competitiveness. We will also consider whether it would be consistent with the Government's Better Regulation principles.

### 3.6.5 Small and medium-sized businesses

The pilot Energy Efficiency Loan Scheme for SMEs provides interest free loans of between £5,000 and £100,000 for up to four years for qualifying energy efficiency projects. Additional funding of £15m has been provided to support the role out of a full scheme building on the pilot. **The Government estimates that this additional measure could save up to 0.1 MtC by 2010.**

The Government will introduce other measures to encourage and assist SMEs to take up energy saving opportunities. **Initial analysis suggest that these measures could save a further 0.1 MtC by 2010.**

### 3.6.6 Building Regulations

Building Regulations (described in more detail in the domestic section) also deliver more efficient non-domestic buildings. The 2002 standard Building Regulations are expected to deliver **0.4 MtC in the business sector in the with measures scenario** and the 2006 Building Regulations **0.2 MtC.**

Scottish building regulations are devolved. The current energy standards for buildings in Scotland came into effect in May 2005. There is review of the energy standards currently out for public consultation. It is intended to implement these standards in May 2007 and that they will deliver a carbon saving in the region of 23–28 per cent for new non-domestic buildings when compared with current elemental measures. In most cases these new build proposals have the capability to deliver the best carbon savings of any standards in the UK

### 3.6.7 EU Regulation and Directive on F-gases

Final agreement on a European Regulation on certain fluorinated greenhouse gases and a Directive relating to emissions from Mobile Air Conditioning systems in cars was reached in January 2006. The Regulation will enter into force in mid–2006, with the main body of the provisions in the regulation set to apply from one or two years after that date. The Government will work with stakeholders to ensure that the key information is targeted to those who need it in a timely way.

43 http://www.carbontrust.co.uk/NR/rdonlyres/914BDFBB-627F-4DAE-A70D-2F176944B2F7/0/Quantifying_UK_investment_incentives.pdf

## Transport

### 3.7.1 Policy framework

The task of tackling emissions growth in this sector is challenging and a range of approaches will be used:

- reducing the fossil carbon content of road transport fuels;
- improving the fuel efficiency of vehicles;
- encouraging a move towards more environmentally friendly means of transport; and
- promoting the inclusion of aviation in emissions trading schemes and developing the evidence base for the possibility of including surface transport in emissions trading schemes in the future.

In Scotland the National Transport Strategy (NTS) will be launched in 2006. The NTS will offer the opportunity to start a wider debate on environmental issues. In the meantime, the Executive is addressing the issue of transport impacts on the environment in a number of ways ranging from initiatives aimed at promoting modal shift such as the funding of StepChange[44] location specific pilot projects.

An integral feature of Northern Ireland's Regional Development Strategy is the Regional Transportation Strategy 2002–2012. A major aim of the RTS is to start a strategic move towards a balanced transport system.

The Transport (Wales) Act 2006 sets out the context for the development of a Wales Transport Strategy to cover the period up to 2030.

### 3.7.2 Reducing the fossil carbon content

The Government published the Alternative Fuels Framework as part of the Pre-Budget Report[45] in 2003. This set out the Government's commitment to promoting sustainable alternatives for fossil fuel and affirmed the need for fiscal incentives to reflect environmental benefits. The framework committed the Government to a three-year rolling guarantee for biofuels and road fuel gas duty rates, offering certainty to support investment. The UK Government's Budget[46] in 2006 announced that the 20 pence per litre duty incentive for bioethanol and biodiesel will be maintained to 2008–09.

A Renewable Transport Fuel Obligation (RTFO) was announced in November 2005. The RTFO requires transport fuel suppliers to ensure a set percentage of their sales are from a renewable source. It will be introduced in 2008–09, with the obligation set at 2.5 per cent in 2008–09 and 5 per cent in 2010–11. **It is estimated that the RTFO will lead to additional reductions of 1.6 MtC by 2010.** This figure uses the international agreed methodology to avoid global double counting of emissions and does not take into account emissions from the production of those biofuels that are produced abroad and used in the UK.

The Government is considering how best to use the RTFO to encourage development of advanced biofuel production techniques. The cleanest biofuel production plants will be eligible for Enhanced Capital Allowances from 2007 (subject to State Aid agreement).

The use of clean low carbon fuels is also supported through:

- the Hydrogen and Fuel Cells Demonstration Programme, providing £15m of support as described in the energy section
- a grant programme for alternative refuelling infrastructure.

The Scottish Executive has encouraged and supported the construction of Scotland's first large-scale biodiesel plant by the Argent Group near Motherwell.

### 3.7.3 Improving the fuel efficiency of vehicles

The Government is committed to the Voluntary Agreements on new car fuel efficiency between the European Commission and the automotive industry, which aim to improve fuel efficiency of new cars sold in the EU by 25 per cent by 2008–09 against a 1995 baseline. These have already led to improvements in average new fuel car efficiency across the EU. But indications are that the target is unlikely to be met in full. The target has been set at EU level, and, as such, not all countries need individually to meet the target in order for it to be reached on average. However, by 2003 average new car carbon dioxide emissions had been reduced by only 12 per cent across the EU. The Government is pressing for new targets beyond 140g/km after 2008 to be finalised as soon as possible. **This might lead to additional savings of 0.1 MtC by 2010**

44 www.stepchangescotland.org.uk

45 A summary of the UK Government's 2003 Pre-Budget Report is available from http://prebudget2003.treasury.gov.uk/ . The full report is available from http://www.hm-treasury.gov.uk

46 A summary of the UK Government's 2006 Budget is available from http://budget2006.treasury.gov.uk/. The full report is available from http://www.hm-treasury.gov.uk

Further reforms to VED were introduced in the UK Government's Budget 2006, to sharpen incentives to choose fuel-efficient cars. To further promote environmentally friendly vehicles, changes to company car tax benefit were also announced.

Most car showrooms now display colour-coded fuel efficiency labels, which are directly linked to the VED bands and which will be familiar to consumers used to similar labels for their household appliances. The UK strongly supports the development of a mandatory system of such labels across the EU, provided sufficient flexibility is built into the system.

### 3.7.4 Encouraging a move towards environmentally means of transport

The UK now has the fastest growing railway in Europe and it is expected to continue to grow. The Government will consider how new technologies can improve energy efficiency and reduce fuel consumption to get even more environmental benefits from rail.

The Future of Transport White Paper[47] in 2004 gave local authorities greater power to determine the bus network. Greatly increased funding is also available for local authority expenditure on infrastructure schemes such as bus lanes and through rural bus grants and the urban bus challenge.

The Government has also been encouraging local authorities to make smarter choices an integral part of their transport plans and have three headline projects:

- with the Department for Education and Skills, the Travelling to School initiative aims to have active travel plans in every school in England by the end of the decade.
- The Sustainable Travel Towns initiative aims to create three showcase towns to act as models for other local authorities. Over five years, the Department for Transport is providing funding for Darlington, Peterborough and Worcester.
- Cycling England, with an annual budget of £5m for three years, has been set up as an expert advisory body. Its work programme includes £2.8m per year for six cycle demonstration towns to provide investment for an increase in cycling.

The Government is examining how pricing could be used to manage congestion and reduce emissions. Together with complementary public transport and travel information, pricing could be an important part of demand management. It is prepared to invest up to £200m per annum between 2008/9 and 2014/15 from the Transport Innovation Fund to support schemes involving road pricing.

### 3.7.5 Aviation

During the UK's Presidency of the European Union in 2005, the inclusion of aviation in the EU ETS scheme by 2008 or as soon as possible thereafter was made a priority. The European Commission is taking forward work through an Aviation Working Group in the European Climate Change Programme and aim to bring forward a legislative proposal by the end of 2006.

The Government is also continuing to press for the development and implementation, through the International Civil Aviation Organisation, of emissions trading at the international level. It is also pressing for other ways of tackling aviation emissions including:

- the adoption of working practices that minimise the impact of the activities airports, airlines and air traffic controllers;
- R&D by aerospace manufacturers to reduce the climate impact of future aircraft; and
- voluntary action by the aviation sector to control greenhouse gas emissions and develop sustainability strategies.

Carbon offsetting of emissions from air travel is also being encouraged, through a Government Carbon Offsetting fund for central Government air travel. Voluntary initiatives by airlines are also welcomed.

47 *The Future of Transport* White Paper was published in July 2004, and is available from www.dft.gov.uk

## Domestic

### 3.8.1 Policy framework

A range of different approaches is required to tackle domestic energy efficiency effectively. These include the provision of advice to consumers, financial incentives, building standards and voluntary agreements. The Government recognise that a step change in consumer attitudes and behaviour will be needed to tackle the trend towards rising energy demand.

### 3.8.2 Energy Efficiency Commitment (EEC)

EEC is the principal policy mechanism driving increases in efficiency of existing homes. Under EEC, electricity and gas suppliers are required to achieve targets for the promotion of energy efficiency improvements in the domestic sector. Suppliers can fulfil their obligations by carrying out any combination of approved measures including installing insulation or supplying high efficiency appliances or boilers. The only constraint on the suppliers' activity is that they must achieve at least half of their energy savings in households on income-related benefits and tax credits.

The first phase of EEC ran from April 2002 to March 2005 and is expected to save **0.37 MtC annually by 2010**. The current phase of EEC running from April 2005 to March 2008 will deliver roughly double the level of activity and is expected to save **0.62 MtC annually by 2010.** The next phase of EEC, running from April 2008 – March 2011 will deliver at least the same amount of savings (see below). The total delivery from EEC in the **with measures projection is 1.6 MtC annually by 2010.**

The assumed average cost of the current phase of EEC to energy suppliers is estimated at less than £9 per fuel per customer per year. Taken against an average for yearly energy bills in Great Britain of £340 for electricity and £530 for gas, this contribution is around 2 per cent of household bills[48]. On average, these costs will be more than outweighed by the end of the second phase of EEC, by the benefits householders enjoy in the form or reduced fuel bills or increase comfort.

An increasing share of the activity in the future phases of EEC is likely to come from the installation of insulation in privately owned homes. To encourage consumers to take up energy efficiency measures, the Government is launching a major new initiative, working closely with local authorities, energy suppliers and others to help overcome consumers' reluctance to invest in these measures. Funding for this initiative will be £20m over the next two years.

The third phase of EEC has the potential to offer more options for delivery of carbon savings, with a larger range of eligible measures and more scope for innovation and competition among companies. **It is estimated that this increased scope could give additional savings of 0.5 MtC per year.**

The Government intends to consider with all stakeholders how to provide as much flexibility as possible in the range of measures that can be employed to meet EEC targets, for example microgeneration, renewables, smart metering and behavioural measures.

Budget 2006 announced that suppliers will be able to count extra work carried out in this EEC period towards their targets in the next.

### 3.8.3 Building regulations

Building regulations[49] are steadily driving up the energy standards of new and refurbished buildings. Since 1990, the energy efficiency of new buildings has increased by 70per cent. **The 2002 Building Regulations are expected to deliver reductions in carbon dioxide emissions in 2010 of 0.7 MtC in the domestic sector.**

In September 2005, further changes to the Building Regulations were announced coming into force in April 2006 to make buildings more energy efficient. The average energy efficiency improvement in dwellings will be 20 per cent. One provision of the revised Building Regulations came into force in April 2005, requiring all new boilers to be at least B-rated condensing boilers, subject to some exemptions. **This measure together with the 2006 Building Regulations is expected to provide 0.75 MtC savings per year**.

48 Assessment of EEC 2002–05 Carbon, Energy and Cost Savings (Defra 2006) http://www.defra.gov.uk/environment/energy/eec/pdf/eec-assessment.pdf

49 England and Wales share Building Regulations, Northern Ireland and Scotland have separate ones.

The Building Regulations do not address the fabric of a significant proportion of the existing building stock. The Government is currently undertaking a wide-ranging review to identify measures to improve the sustainability of the existing building stock, including energy efficiency and will put recommendations to ministers in 2006.

As part of the 2006 revisions, the Government has engaged in an unprecedented dissemination programme aimed at ensuring that all stakeholders can acquaint themselves with the changes. This programme aims at achieving greater compliance with the Regulations. A requirement for random sample air leakage testing of buildings has also been introduced to help secure better compliance.

Scottish building regulations are devolved. The current energy standards for buildings in Scotland came into effect in May 2005. There is review of the energy standards currently out for public consultation. It is intended to implement these standards in May 2007 and that they will deliver a carbon saving in the region of 18-25 per cent for new dwellings when compared with current elemental measures. In most cases these new build proposals have the capability to deliver the best carbon savings of any standards in the UK

### 3.8.4 Code for sustainable homes

The Code for Sustainable Homes will set out voluntary standards beyond those required by the Building Regulations. It will cover a range of environmental impacts including energy, water and waste, with minimum standards of energy and water efficiency at every level of the code. This will ensure that builders cannot trade energy and water efficiency for other kinds of improvements. To encourage on site energy generation, new homes that use micro-renewable technologies such as wind turbines will gain extra Code points. Once the Code is launched, all new homes funded by the Government or its agencies will have to meet Code level 3.

The Scottish Building Standards Agency has published a document on Sustainable Development Policy into Practice – New Buildings.

The report describes progress in work by Scottish Executive to further the sustainable development of new buildings, both domestic and non-domestic. This work is a continuing, practical response to the Scottish Executive's sustainability policy introduced by "Meeting the Needs in 2002, A partnership for a better Scotland" in 2003, and "Choosing Our Future" in 2005. It is Scottish Executive policy to continue to embed the principles of sustainable development in building regulations, planning policy, and procurement guidance.

### 3.8.5 Energy Performance of Buildings Directive

The UK will also be implementing elements of the EU Energy Performance of Buildings Directive (EPBD) from April 2006[50]. The Directive lays down requirements on the application of minimum standards for the energy performance of new buildings and on the performance of large existing buildings undergoing major renovation. It also requires the provision of energy performance certificates when buildings are constructed, sold or rented out and the display of these certificates in public buildings over 1000m$^2$.

One of the provisions of the Directive is the regular inspections of boilers, or an equivalent national advice system, and the inspection of air conditioning systems in buildings. It is estimated that the effect of this, including the early replacement of boilers brought about by advice **could deliver additional savings of up to 0.2 MtC in 2010.**

The Government is exploring what more can be done to implement the EPBD in ways to encourage greater carbon savings. Better communication and advice is highlighted as one way of tackling the failure to recognise the economic case for energy-saving measures. One means through which this will be delivered is the requirement of the EPBD for an energy performance certificate to be made available to prospective owner or tenant when buildings are constructed, sold or rented out. Home Information Packs, being introduced in June 2007 under the Housing Act 2004, will deliver this for residential properties on market sale. The Packs will include a Home Condition Report, part of which will be an energy survey, together with information on possible energy efficiency measures.

50 http://www.europa.eu.int/eur-lex/pri/en/oj/dat/2003/l_001/l_00120030104en00650071.pdf

In Scotland it is intended that energy certificates will be part of the Single Survey that is proposed for marketed dwellings.

The Government estimates that the Sustainable Buildings Code, the Energy Performance in Buildings Directive, the commitment on procuring public buildings and further measures coming out of the review of existing building stock together could **deliver additional carbon savings of 0.1MtC in 2010.**

### 3.8.6 Encouraging consumer choice and raising standards

Government targets for saving energy in households depend on a policy package which, over time, removes the inefficient products from use, and builds markets for the most resource efficient goods and services. Consumer education is important but there is also the need to work with industry to set and to drive up product performance standards.

The Market Transformation Programme (MTP)[51] works with industry and other stakeholders to drive and underpin sustainable improvements in the energy efficiency and other environmental characteristics of products.

The Government committed in 2005 to promote an international 1-Watt Initiative to reduce emissions from the use of products. Budget 2006 introduced a new initiative in partnership with major retailers and the Energy Saving Trust (EST), to introduce voluntary schemes in the retail sector that encourage the purchase of more energy efficient alternatives in consumer electronics.

The Eco-design of Energy Using Products (EUP) framework Directive now provides a formal mechanism for establishing product standards. Although the focus of the Directive is on setting mandatory standards, a clear intention is to encourage voluntary action by manufacturers. The Government would prefer voluntary agreements where they are effective and is already following this approach through MTP.

The first implementation measures under EUP will be introduced at the earliest in 2008 and therefore the Government is pursuing other measures. These include:

- industry voluntary agreements such as the Code of Conduct on Digital TV Services;
- embedding product standards in Building Regulations;
- product endorsements via schemes such as the EST's 'Energy Saving Recommended' logo;
- procurement policy. The UK Procurement Task Force is due to publish an action plan in April 2006; and
- the International Task Force on Sustainable Products – a UK initiative to promote co-operation.

Statutory labels[52] provide relative performance information for traded goods and are established at the EU level, but supported by national schemes.

The MTP and appliance standards and labelling are expected to contribute savings of **0.2MtC annually by 2010 to the with measures projections.**

### 3.8.7 Consumer engagement

The EST's activities are designed to underpin and complement the work of other actors in energy efficiency markets. It is grant-funded by Defra and receives funding from the Scottish Executive, from the Department of Transport and from the Department of Trade and Industry to run specific programmes.

The EST is piloting the development of a Sustainable Energy Network (SEN) a network of regional delivery agencies that aims to support national awareness-raising of sustainable energy and to translate that awareness into practical action. Defra has provided additional funding of £10m over three years for the pilot.

51 http://www.mtprog.com/

52 The mandatory EU Energy label currently covers domestic refrigeration, washing machines, electric tumble dryers, washer dryers, dishwashers, lamps, electric ovens and air conditioners

3.8.8 **Billing and metering**

The Government is committed to seeking measures to **achieve additional savings of 0.2MtC by 2010** through better billing and metering in the UK. One way of doing this might be to provide better consumption feedback through information on bills, or via smart meters or display devices linked to existing meters. At Budget 2006, the Government announced a £5m fund to co-finance with energy suppliers a pilot study of feedback devices.

The recently agreed Energy End-Use Efficiency and Energy Services Directive requires, subject to a range of tests, the use of individual meters that can provide among other things, time of use information. The Government is considering its approach to implementing this and other parts of the Directive.

3.8.9 **Economic instruments**

Reduced VAT rates for certain energy-saving materials have been applied for some time. Since Budget 2000, reduced VAT rates were also introduced for solar panels; micro wind and water turbine; ground source and air source heat pumps, micro-CHP and wood fuelled boilers.

In 2004, the Government introduced the Landlords Energy Saving Allowance to offer up-front relief (up to £1500) for capital expenditure on investment in cavity wall and loft insulation. This was extended in 2005 to include solid wall insulation, and again in 2006 to include draught proofing and hot water system insulation.

In the 2005 Pre-Budget Report, the Government also announced that it intended to implement a Green Landlord Scheme by reforming existing Wear and Tear Allowance and making it conditional on the energy efficiency level of the property. The Government continues to explore how the Allowance should be reformed, with a view to introducing the new allowance structure alongside the forthcoming Energy Performance Certificates.

3.8.10 **Tackling fuel poverty**

Fuel poverty is caused by a combination of poorly insulated, energy inefficient housing and low incomes. The latest available figures indicate that the number of fuel poor households has fallen between 1996 and 2003. However, recent energy price rises are expected to begin to reverse the trend. In *Fuel Poverty in England: The Government's Plan for Action,* November 2004, the Government announced extra funding of £140m between 2005-08 to tackle fuel poverty. This has since been boosted by the announcement in the 2005 Pre-Budget Report of an additional £300m over the same period. **Carbon savings from Warm Front and other fuel poverty programmes are expected to be 0.4MtC by 2010 (this is included in the with measures projection).**

The Energy Review will consider whether there are any further steps that could be taken to ensure that the UK's goal of eradicating fuel poverty by 2016–18 will be met.

Northern Ireland has the highest level of fuel poverty in the UK. In November 2004, the Department for Social Development launched the Ending Fuel Poverty, A Strategy for Northern Ireland[53]. A Fuel Poverty Advisory Group was established in Northern Ireland in April 2005 to monitor and review the strategy and to promote a partnership approach to tackling fuel poverty.

The introduction of the Welsh Housing Quality Standard in May 2002 provides a common target standard for the physical condition of all existing social housing within Wales to be achieved by 2012. Welsh Housing Quality Standard provides for the annual energy consumption for space and water heating to be estimated using the SAP (Standard Assessment Procedure) method and specifies the minimum ratings to be achieved.

Through the Development Quality Requirements, the Welsh Assembly Government requires that all new build social housing that it funds meets a minimum standard above that of Building Regulations. Development Quality Requirements are the published design standards for all new housing built by Registered Social Landlords in Wales receiving Social Housing Grant. All general needs schemes and housing for the elderly must be built so as to achieve a British Research Establishment (BRE) 'ECOHomes' rating level of 'GOOD'.

53 www.dsdni.gov.uk/ending_fuel_poverty_-_a_strategy_for_ni.pdf

## Agriculture, forestry and land management

### 3.9.1 Policy framework

Action to address climate change issues in the land management sector forms a key part of the Strategy for Sustainable Farming and Food. The priority is to facilitate a farming and food industry in the UK, which makes a major contribution to sustainable development. This means a partnership to:

- help UK farming and food industries compete successfully both at home and abroad;
- produce quality products that the market will buy;
- ensure an appropriate reward structure for the positive contribution our farmed landscape makes to the natural environment; and
- play an increasing part in tackling the biggest threat, climate change.

To date, most UK and EU, policies in this sector have not included greenhouse gas mitigation or climate change adaptation as specific goals. In future more explicit recognition of their contribution will be needed.

The Government believes that it is vital that land managers change their behaviour to help to deliver emission reductions, to allow them to take advantage of the opportunities to their businesses of adopting a resource efficiency approach, contribute to the shift to a low carbon economy, and to provide incentives for innovation of all kinds.

The Rural Climate Change Forum is a high level forum for discussion, input into policy development, and communication with land managers on climate change mitigation and adaptation.

In September 2005, the UK hosted the first ever *Joint Informal Meeting of EU Agriculture and Environment Councils.* International experts underlined that sustainable agriculture and land-use can play a significant role in addressing climate change and still provide the economic and social benefits rural areas need.

The Scottish Executive has funded a range of research projects to understand the role of agriculture on greenhouse gas emissions, for example fertiliser use in Scotland. A commitment has already been made in the Rural Implementation Plan of the Scottish Biodiversity Strategy to develop soil management strategies to promote conservation and enhance biodiversity.

The recently updated Forward Strategy for Scottish Agriculture recognises the need for Scottish agriculture to adapt and manage the risks associated with climate change and to make its contribution to mitigation in a range of ways. It specifically aims at improving the evaluation of agriculture's contribution to climate change and at developing a comprehensive action plan to bring about further improvement. A Forward Strategy for Scottish Agriculture: Next Steps has an agreed action to establish a stakeholder group to evaluate and monitor agriculture's response to climate change through mitigation and adaptation (including the potential for related business opportunities).

The current Northern Ireland Rural Development Programme comprises a range of agri-environment schemes including the Countryside Management Scheme, the Environmentally Sensitive Area Scheme and the Organic Farming Scheme.

The Rural Development Plan for Wales covering the 2007–13 period will be published at the end of the year and will be a key tool to support the agri-environmental agenda within the farming community.

### 3.9.2 Common Agricultural Policy

Over the past thirty years, the European Common Agricultural Policy (CAP) has had a dominant influence on UK agriculture. The CAP reform agreement reached in June 2003 broke the link between production and direct payments. This is likely to lead to a reduction in livestock numbers and an associated decrease in methane **estimated at 0.68MtC per annum in 2010.** The cross-compliance regime puts requirements on all farmers in receipt of the single farm payment to preserve and enhance soil organic matter. A clear action to benefit the storage of carbon in soils.

### 3.9.3 Reducing nitrous oxide emissions

The use of inorganic nitrogen as a fertiliser is a major source of nitrous oxide, which can also arise from manures during storage. The practices needed to reduce these emissions are, in many cases, similar to those required to address other negative impacts of the use of nutrients. The Government's aim is to encourage action that will maximise the multiple benefits, and to simplify the messages to land managers about the change in behaviour required.

The range of policy measures is being examined as part of the Catchment Sensitive Farming (CSF) Programme aimed at tackling water pollution to help meet the objectives of the EU Water Framework Directive. The Government will encourage agricultural practice changes that deliver both water quality outcomes and at the same time reduce greenhouse gas emissions.

### 3.9.4 Reducing methane emissions

Emissions of methane result from diffuse sources and through variable biological processes. Defra's research portfolio is examining a range of options for decreasing emissions from dairy cows in a programme costing some £5.5m in 2005–06. Potential options will be assessed for compatibility with the wider goals for sustainable agriculture.

### 3.9.5 Anaerobic digestion

Anaerobic digestion is widely used in treatment of waste waters, and can be applied to the treatment of animal manures. The Government views this an important area for further work, and the Biomass Taskforce recently recommended that options to pursue anaerobic digestion technology and biogas production were explored. The UK is also committed to identifying solutions as part of the G8 inspired international Methane to Markets Partnership and co-chairs the new Agriculture Sub-committee of the Partnership. The Government will convene a high level international seminar of experts before the end of 2006.

### 3.9.6 Rural Development Regulation and Environmental Stewardship

A new strategy for England is being prepared for expenditure under the new EU Rural Development Regulation for 2007–13, of which Environmental Stewardship will be a key part. The Government will review progress in 2007–08 to ensure that expenditure is effectively directed to policy priorities, including the potential for Environmental Stewardship to contribute to climate change objectives.

Scotland is currently developing the Rural Development Programme for Scotland 2007–2013, in which Land Management Contracts are seen as a primary vehicle for supporting land management. One of the National Priorities is Climate Change.

A new Rural Development Plan for Wales is being prepared under the new EU Rural Development Regulation for 2007–13, addressing climate change will be a key element in the Plan.

### 3.9.7 Energy efficiency

The intensive pig and poultry farming sectors have been involved in climate change agreements since 2001, and the horticulture sector is now eligible and has agreed challenging energy reduction targets.

### 3.9.8 Non-food crops

The Strategy for Non-Food Crops and Uses, launched in November 2004[54], aims to promote and develop the use of renewable raw materials as energy crops or to replace other fossil fuel based products. Funding of around £2m per year is provided for research into this area. The Biomass Taskforce, which was established to help Government and industry to optimise the development of biomass energy in support of renewable energy targets and sustainable farming, forestry and rural objectives, published its final report in October 2005[55]. In its formal response issued on 27 April 2006, the Government recognised that biomass is an important contributor to renewable energy with potential applications in heat, electricity, combined heat and power and transport. As noted in section 3.6.5, the Government plans to stimulate biomass heat through a series of measures including new five-year capital grant scheme for biomass boilers and a second round of the Bio-energy Infrastructure scheme.

The Energy Crops Scheme introduced in 2000 supports farmers growing energy crops. The Government is consulting on further measures to apply from 2007. Plantings to 2006 under the existing Energy Crops Scheme are expected to lead to carbon savings of around 11ktC by 2010.

### 3.9.9 Sustainable forestry policy

The practical framework for the delivery of sustainable forestry in the UK is the UK Forestry Standard, which has been endorsed by the administrations of England, Scotland, Wales and Northern Ireland and built into their separate forestry policies.

54 www.defra.gov.uk/farm/acu/pdf/nfc-strategy.pdf

55 www.defra.gov.uk/farm/acu/energy/biomass-taskforce/btf-finalreport.pdf

Woodland established under the England Woodland Grant Scheme will remove 3.5MtC between 2006 and 2020, assuming planting continues at current levels. The dynamics of tree growth mean that any increase in woodland creation now will have maximum carbon savings achieved beyond 2010.

The Government will ensure that the current and future reviews of the England Forestry Strategy will take full account of the opportunities and risks for forestry from climate change.

The Northern Ireland Department of Agriculture and Rural Development's consultation paper Options for Forestry, recognised the value of trees in removing carbon dioxide from the atmosphere and indicated that the Forest Service would work with others to pursue opportunities for carbon sequestration. The Forest Service has operated a Challenge Fund for Short Rotation Coppice Energy Crops since 2004 to encourage the establishment of short rotation willow coppice for renewable energy generation.

## Public sector

3.10. The public sector is in a key position to lead on carbon emission reduction by setting a behavioural and strategic example to the private sector.

### 3.10.1 The role of local government

Local authorities are uniquely placed to provide vision and leadership to local communities, raise awareness and help change behaviours. In addition, through their powers and responsibilities (housing, planning, local transport) they can have significant influence over emissions in their local areas. During the review of the Climate Change Programme, examples of exemplary activities by local authorities were identified, including the Sustainable Energy Beacon Councils. However, it was clear that much local action depends critically on interested, committed individuals within local government to succeed.

The Government wants to see a significant increase in the level of engagement by local government in climate change issues. The Government will consider how to ensure that the local government performance framework will include an appropriate focus on action on climate change.

A report on the ways in which local authorities can reduce greenhouse gas emissions and alleviate fuel poverty will be published within 18 months of the Climate Change and Sustainable Energy Bills commencement

The Government will also:

- fund a new £4m local government best practice support programme, to be launched in 2006–7. This programme will benchmark the performance of local authorities on climate change and sustainable energy and target those who need to raise their performance;
- provide further resources to local authorities to invest in energy saving on their own estate through the Carbon Trust's Local Authority Energy Financing Scheme;
- provide £20m over the next two years to help local authorities and others to work in partnership with energy companies to promote energy efficiency measures to households; and
- work with the Local Government Associations and others to review existing guidance to local authorities.

**These measures together can deliver additional savings of 0.2 MtC in 2010.**

In Wales, policy agreements between an individual local authority and the Welsh Assembly Government set out what the local authority aims to achieve as its key contributions towards shared strategic priorities, over a three year period, currently 2004–05 to 2006–07. In return for making and delivering upon the agreement, the Welsh Assembly Government makes a Performance Incentive Grant to the authority, which the authority can deploy as it sees fit.

Each policy agreement consists of 16 measures; eight prescribed which are the same for each local authority and allow for comparative analysis and eight local measures which are unique to each authority. Of the eight prescribed measures one is linked to energy efficiency. The energy efficiency measure is made up of two targets, which are:

- Percentage reduction in carbon dioxide emissions in the non-domestic public stock.
- Percentage reduction in energy use and carbon dioxide emissions in the housing stock.

The non-domestic stock target is set individually for each local authority. The domestic stock target is a national one, which states that all local authorities in Wales must achieve a 12 per cent reduction by the end of the Policy Agreement.

### 3.10.2 Planning

Statements of planning policy issued by the Government and the devolved administrations set out a national planning policy framework. Planning Policy Statement (PPS) 22 sets out policies for the promotion of renewable energy in England. The Government now intends to prepare and consult on a new PPS setting out how it expects participants in the planning process to work towards the reduction of carbon emissions in the location, siting and design of new development.

In Scotland, the integration of climate change considerations into land use planning is dealt with in a wide range of planning publications. The Scottish Planning Policy (SPP) 1 – the Planning System[56] recognises the Executive's wider commitment to tackling climate change. More specific references are included in SPP3 Housing, National Planning Policy Guideline (NPPG)6 Renewable Energy (under review) SPP7 Flooding.

Part F of the Northern Ireland Building Regulations is being amended and the revisions will have the effect of reducing carbon dioxide emissions from those buildings to which the regulations apply by up to 40 per cent.

Planning Policy Wales, published in March 2002, sets out the Welsh Assembly Government's planning policies and climate change is fully integrated into it. It is supplemented by a series of technical advice notes (TANs) particularly relevant ones include: TAN 15: Flood risk and TAN 8 Renewable Energy.

### 3.10.3 Funding schemes for public sector organisations

In the 2005 Pre-Budget report, an increase of funding of £20m was announced for the Carbon Trust to establish a revolving fund for energy efficiency work in the public sector, building on the pilot Local Authority Energy Financing (LAEF) Scheme. With the additional funding, Salix Finance, which was set up by the Carbon Trust to administer the fund, will seek proposals from local authorities with the aim of increasing the size of existing the LAEF programme by around 60 authorities. **The scheme is expected to deliver additional carbon savings of 0.1MtC by 2010.**

### 3.10.4 Public sector procurement

Sustainable procurement is a key lever to build markets for new and improved products and services, and with a budget of over £125bn the public sector can play a large role. In 2003, the Government implemented a range of measures to encourage central government departments to apply minimum environmental standards across a wide range of commonly purchased products. The Sustainable Procurement Group identified 19 energy consumption-focused Quick Wins which are off-the-shelf procurement specifications57. An action plan to bring a step change in sustainable public procurement will be developed in 2006.

The Public Sector Efficiency Review for Energy is a project to generate £200m energy savings, through developed innovation in energy procurement, improving the management of energy through better metering and clear billing and increasing conservation activity.

### 3.10.5 Central Government

Targets for Government Estates are being reviewed as part of the UK Sustainable Development Strategy commitment to improve the Government's performance and ensure it leads by example. Progress is being made in many areas. Overall, the combined average total of the amount of electricity source from renewable sources is 19 per cent, suggesting that central government has met its renewable electricity target of 10 per cent.

As well as reviewing the targets, new annual reporting procedures are being developed and larger public sector organisations are being encouraged to sign up to the Carbon Trust's Carbon Management programme and for energy audits. In future, each Secretary of State will be required to sign-off their department's annual progress report.

### 3.10.6 Schools

Building on the Sustainable Development Action Plan for Education and Skills launched in 2003, the Government will emphasise the sustainability and energy efficiency requirements for school buildings through a Sustainable Schools launch and consultation in 2006. To support work on school

56 www.scotland.gov.uk/library5/planning/spp1-00.asp

performance, during 2006 the Government will collect energy and consumption data from 2003–4 and 2005–6 to benchmark school energy consumption and set targets for the sector. New guidance on the design of sustainable schools will also be published.

To date, nearly £3m has been committed to projects in 186 schools to develop the use of renewable energy technologies. The Budget 2006 announcement to provide a further £50m for the installation of microgeneration technology will benefit schools further. The Government is developing a strategy on renewable energy generation and carbon reduction for schools. This will include a whole life costs toolkit to help decision makers prioritise expenditure on energy efficiency measures and low and zero carbon energy systems.

3.10.7 **Higher and further education**

The Higher Education Funding Council for England published a strategy and action plan in 2005 setting out how, within the next ten years, the Higher education sector in England will achieve sustainability and tackle climate change.

3.10.8 **The NHS Estate**

The National Health Service (NHS) has the largest property portfolio in Europe and the biggest capital spend programme with an annual budget of over £76bn. The NHS has two targets in England:

- to reduce the level of primary energy consumption by 15 per cent or 0.15MtC from a base year of 2000 by March 2010; and
- to achieve a target of 35-55 GJ/100m$^3$ energy efficiency performance for the healthcare estate for all new capital developments and major redevelopments or refurbishments; and that all existing facilities should achieve 55–65 GJ/100m$^3$.

If the trend demonstrated in the 2004–5 data continues, the 15 per cent target is likely to be achieved.

Planning Policy Wales, published in March 2002, sets out the Welsh Assembly Government's planning policies and climate change is fully integrated. It is supplemented by a series of technical advice notes (TANs) particularly relevant ones include: TAN 15: Flood risk and TAN 8 Renewable Energy.

## Policies no longer in place

3.11 In January 2002, the Government launched Community Energy, a £50m UK-wide capital programme for installing and refurbishing community heating. Schemes are mainly based on CHP with innovative approaches also encouraged. In December 2004, Defra announced an extra £10m to extend the programme. This was based on the initial strong demand and a number of large schemes with significant outputs. However, experience has shown that many larger schemes under the initial programme could not complete with the 31st March 2007 spend deadline. Without these large schemes, the programme falls short of delivering its objective and other programmes would deliver the objectives more cost effectively. There will therefore be no extension in time nor will the Government continue with the £10m extension.

## Monitoring and evaluation

3.12 Progress on emission reductions is monitored through the Sustainable Energy Policy Network (SEPN), which operates through a Ministerial Committee, an Advisory Board Strategy Group, working-level group and Interdepartmental Analysts' Group (IAG). The IAG provides cross-cutting analytical support to SEPN including: reviewing analytical requirements feeding into work streams; advising on potential gaps; identifying cross-cutting requirements and drawing links between analytical work conducted in support of work streams; and providing a measure of peer review.

The Government will introduce a new annual report to Parliament on the level of greenhouse gas emissions in the UK and the steps taken to reduce these. It will set out an indicative work plan for the following year.

# 4

# Projections of Emissions and Total Effects of Policies

## Key Developments

- Even without the additional measures included in the recently published UK Climate Change Programme (CCP), the UK's emissions of greenhouse gases are expected to fall to about 19.4 per cent below base year levels by 2010. The UK is therefore on track to meet its Kyoto Protocol target.
- Without any additional measures, emissions by sources minus the removals by sinks of carbon dioxide are projected to be about 10.6 per cent below 1990 levels by 2010. This means that further effort will be required for the UK to achieve its domestic goal to reduce carbon dioxide emissions by 20 per cent below 1990 levels by 2010.
- The new measures outlined in the 2006 CCP are expected to take the UK further beyond its international target and move the UK closer to its 2010 domestic carbon dioxide goal.
- It is estimated that the new programme could reduce the UK's emissions of the basket of greenhouse gases on which the Kyoto target is based to 23–25 per cent below base year levels; and reduce the UK's carbon dioxide emissions to 15–18 per cent below 1990 levels by 2010.

## Projections of Greenhouse Gas Emissions

The UK prepared new projections of $CO_2$[58] and Non-$CO_2$[59] greenhouse gas emissions alongside the CCP 2006. These projections provide the basis for this communication.

Table 4.1 sets out the UK's base year and historic emissions and baseline with measures projections, presented by greenhouse gas. The historic emissions set out in this communication are based on the UK greenhouse gas inventory published in 2006[60]. The non-$CO_2$ and the LULUCF projections have been updated to be consistent with this inventory. The $CO_2$ energy projections are based on the UK inventory published in 2005, which agrees with the inventory published in 2006 to about 0.01 per cent for total $CO_2$ emissions on average over the period 1990 to 2003, with individual years differing by up to about 0.4 per cent. The energy projections will be updated to be based on the 2006 inventory. In place of 2005 projections, inventory data for 2004 are used in all the tables below.

**Table 4.1 UK greenhouse gas emissions, MtC**

| Gas | Base Year | 1990 | 1995 | 2000 | 2004 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|
| Total carbon dioxide[61] | 161.5 | 161.5 | 149.9 | 149.0 | 152.5 | 144.3 | 149.0 | 146.6 |
| Methane | 25.1 | 25.1 | 21.8 | 16.3 | 12.5 | 10.8 | 10.0 | 9.5 |
| Nitrous oxide | 18.6 | 18.6 | 15.5 | 12.1 | 11.1 | 11.0 | 11.0 | 11.0 |
| HFCs | 4.2 | 3.1 | 4.2 | 2.5 | 2.4 | 2.7 | 2.6 | 2.5 |
| PFCs | 0.1 | 0.4 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Sulphur hexafluoride | 0.3 | 0.3 | 0.3 | 0.5 | 0.3 | 0.4 | 0.3 | 0.3 |
| Total greenhouse gas emissions by sources minus removals by sinks[62] | 209.9 | 209.0 | 191.9 | 180.5 | 178.9 | 169.2 | 173.0 | 170.0 |
| Total greenhouse gas emissions including only mandatory Article 3.3 LULUCF activities and forest management cap under Article 3.4 LULUCF[63] | 209.5 | 208.2 | 191.6 | 180.3 | 179.0 | 168.9 | 172.1 | 168.5 |
| Change from base year levels (for row above) | | -0.6% | -8.5% | -13.9% | -14.6% | -19.4% | -17.9% | -19.6% |

*Percentage changes and emission estimates may differ slightly due to rounding*

58 $CO_2$ projections published in UEP21: http://www.dti.gov.uk/energy/sepn/UEP_Feb 2006.pdf

59 Technical report will be made available on Defra website at: www.defra.gov.uk

60 UK Greenhouse Gas Inventory, 1990 to 2004, available at: http://www.airquality.co.uk/archive/reports/reports.php?report_id=400

61 Total emissions by sources minus total removals by sinks.

62 UNFCCC reporting basis: totals include all anthropogenic sources and sinks for assessing progress against national CO2 goal. Totals do not include emissions from UK Overseas Territories associated with UK's ratifications of UNFCCC and Kyoto Protocol.

63 Kyoto Protocol reporting basis: totals include only mandatory Article 3.3 LULUCF afforestation plus reforestation minus deforestation since 1990 and the forest management cap of 0.37MtC agreed for the UK under Article 3.4 LULUCF of the Kyoto Protocol. Totals also include emissions from UK Overseas Territories associated with the UK's ratifications of the UNFCCC and Kyoto Protocol.

The base year chosen for the purposes of assessing progress towards the Kyoto Protocol target uses 1990 data for emissions of carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$) and 1995 data for emissions of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride ($SF_6$). The calculation of the UK's base year for reporting under the Kyoto Protocol includes a small allowance (0.1 MtC) representing emissions from deforestation in 1990. This allowance is calculated in accordance with rules associated with Article 3.7 of the Kyoto Protocol. Annex C provides a table comparing the UNFCCC and Kyoto Protocol coverage.

Without the additional measures included in the recently published UK CCP, the UK's emissions of greenhouse gases are expected to fall to about 19.4 per cent below base year levels by 2010. The UK is therefore on track to meet its Kyoto Protocol target.

Without any additional measures, emissions by sources minus the removals by sinks of carbon dioxide are projected to be about 10.6 per cent below 1990 levels by 2010. This means that further effort will be required for the UK to achieve its domestic goal to reduce carbon dioxide emissions by 20 per cent below 1990 levels by 2010.

The baseline with measures projections in **Table 4.1** include the emission reductions expected from existing measures such as the climate change levy. They also include the effect of policies introduced since the 2000 CCP was published, such as the climate change agreements, the UK emissions trading scheme and the Energy Efficiency Commitment. The impact of these policies on projections has been re-evaluated wherever possible[64].

## Baseline 'With Measures' Projections by Sector

The following tables set out the base year and projected with measures emissions by sector. **Table 4.2** shows how historical and projected greenhouse gas emissions are distributed across the UK economy. In this classification, emissions from the energy supply sector, which includes emissions from power stations, refineries and other energy supply industries are shown separately.

**Table 4.3** shows another way of looking at the economic profile of UK emissions. In this classification, emissions from power stations, refineries and other energy supply industries are re-allocated to the end users of electricity, petroleum products and other fuels. There is therefore no separate line for the energy supply industry. This 'end-user' classification gives the most complete account of the relationship between emissions and the production of goods and services. Emissions presented in all the tables below exclude the UK's Overseas Territories associated with the UK's ratifications of the UNFCCC and the Kyoto Protocol.

**Table 4.2 Greenhouse gas emissions by source, MtC**

| Sector | Base year | 1990 | 1995 | 2000 | 2004 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|
| Energy supply | 74.4 | 74.4 | 63.1 | 58.2 | 61.4 | 56.2 | 56.0 | 51.1 |
| Business | 30.7 | 30.4 | 29.4 | 30.3 | 29.2 | 28.5 | 30.4 | 31.0 |
| Industrial processes | 16.4 | 15.9 | 13.2 | 6.71 | 5.1 | 5.4 | 5.6 | 5.8 |
| Transport | 34.1 | 34.1 | 34.3 | 36.0 | 37.4 | 38.6 | 40.1 | 40.7 |
| Residential | 22.3 | 22.2 | 22.5 | 24.6 | 25.3 | 21.7 | 22.0 | 22.2 |
| Public | 3.7 | 3.7 | 3.6 | 3.24 | 2.9 | 3.0 | 3.1 | 3.2 |
| Agriculture | 16.2 | 16.2 | 15.6 | 14.8 | 13.8 | 12.0 | 11.9 | 11.9 |
| LULUCF (net) | 0.8 | 0.8 | 0.29 | -0.11 | -0.5 | -0.5 | 0.1 | 0.7 |
| Waste management | 11.3 | 11.3 | 10.0 | 6.8 | 4.5 | 4.2 | 3.9 | 3.6 |
| Total GHG emissions by sources minus removals by sinks | 209.9 | 209.0 | 191.9 | 180.5 | 178.9 | 169.2 | 173.1 | 170.0 |

*Percentage changes and emission estimates may differ slightly due to rounding*

64 http://www.defra.gov.uk/environment/climatechange/uk/ukccp/pdf/synthesisccpolicy-evaluations.pdf

Baseline with measures projections from the energy supply industry, which include estimated savings from the UK's 10 per cent renewables target, show that emissions are expected to be 24.5 per cent lower than 1990 levels by 2010 **(Table 4.4)**.

Baseline with measures projections from the business sector, which include emissions from the manufacturing and commercial sectors and business' use of energy, show that emissions are expected to fall to 19.8 per cent below 1990 levels by 2010. This can largely be attributed to fuel switching in the electricity supply industry. The overall energy intensity of businesses has also reduced, together with a general move to gas from oil for direct usage **(Table 4.5)**.

**Table 4.3 Greenhouse gas emissions by end user, MtC**

| Sector | Base year | 1990 | 1995 | 2000 | 2004 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|
| Business | 68.7 | 68.3 | 56.9 | 56.2 | 60.4 | 55.1 | 56.4 | 56.1 |
| Industrial processes | 17.3 | 16.8 | 13.9 | 7.3 | 5.4 | 6.0 | 6.2 | 6.4 |
| Transport | 40.2 | 40.2 | 41.1 | 42.6 | 45.0 | 46.5 | 47.5 | 47.2 |
| Residential | 45.9 | 45.8 | 41.7 | 42.1 | 43.7 | 38.6 | 39.8 | 37.6 |
| Public | 8.5 | 8.5 | 7.7 | 6.35 | 5.9 | 6.5 | 6.5 | 6.0 |
| Agriculture | 17.2 | 17.2 | 16.5 | 15.5 | 14.5 | 12.7 | 12.6 | 12.5 |
| LULUCF (net) | 0.8 | 0.8 | 0.00 | 0.00 | -0.5 | -0.5 | 0.1 | 0.7 |
| Waste management | 11.3 | 11.3 | 3.8 | 3.8 | 4.5 | 4.2 | 3.9 | 3.6 |
| Total GHG emissions by sources minus removals by sinks | 209.9 | 209.0 | 0.29 | -0.11 | 178.9 | 169.2 | 173.1 | 170.0 |

**Table 4.4 Greenhouse gas emissions from energy supply industry by source, MtC**

| Gas | 1990 | 1995 | 2000 | 2004 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|
| Carbon dioxide | 66.1 | 56.6 | 53.7 | 58.0 | 53.4 | 53.7 | 49.1 |
| Methane | 7.8 | 6.1 | 4.1 | 3.0 | 2.4 | 2.0 | 1.7 |
| Nitrous oxide | 0.5 | 0.4 | 0.3 | 0.4 | 0.4 | 0.3 | 0.3 |
| Total GHG emissions | 74.4 | 63.1 | 58.2 | 61.4 | 56.2 | 56.0 | 51.1 |
| Change from 1990 levels for row above | | -15.2% | -21.8% | -17.6% | -24.5% | -24.8% | -31.4% |
| *Percentage changes and emission estimates may differ slightly due to rounding* | | | | | | | |

**Table 4.5 Greenhouse gas emissions from business[65] by end user, MtC**

| Gas | Base year | 1990 | 1995 | 2000 | 2004 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|
| Carbon dioxide | 63.7 | 63.7 | 56.7 | 56.0 | 56.5 | 52.2 | 53.7 | 53.5 |
| Methane | 3.7 | 3.7 | 2.9 | 2.0 | 1.5 | 0.6 | 0.5 | 0.5 |
| Nitrous oxide | 0.7 | 0.7 | 0.6 | 0.5 | 0.5 | 0.5 | 0.5 | 0.4 |
| HFCs | 0.3 | 0.0 | 0.3 | 1.2 | 1.6 | 1.6 | 1.6 | 1.4 |
| PFCs | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| SF6 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 |
| Total GHG emissions | 68.7 | 68.3 | 60.8 | 59.9 | 60.4 | 55.1 | 56.4 | 56.1 |
| Change from base year levels for row above | | | -11.6% | -12.8% | -12.1% | -19.8% | -17.9% | -18.4% |
| *Percentage changes and emission estimates may differ slightly due to rounding* | | | | | | | | |

[65] Business includes the category 'exports' representing emissions occurring within the UK from producing fuels (for example from a refinery or coal mine), which are subsequently exported or sent to bunkers for use outside the UK. These emissions are properly part of the UK inventory but emissions from the use of the fuel outside the UK are not.

Baseline with measures projections for emissions from the industrial process sector are expected to fall to about 65 per cent below 1990 levels by 2010. This reflects both fuel switching in the electricity supply industry and a more general shift of the UK economy away from heavy industry and towards less energy intensive sectors. Large reductions in emissions of nitrous oxide and HFCs were achieved through introduction of abatement equipment to control fugitive emissions from adipic acid manufacture and HFC–23 emissions from HCFC–22 manufacture respectively **(Table 4.6).**

Annual emissions from the transport sector are projected to rise to 15.6 per cent above 1990 levels by 2010 unless action is taken. This can be directly linked to the overall growth of the UK economy, which has lead to a general rise in travel and an increased demand for goods and services. The UK Government plans to introduce a Renewable Transport Fuel Obligation in 2008-2009 and will also continue to support the development, introduction and uptake of new vehicle technologies to help to reduce these emissions **(Table 4.7).**

Emissions related to fuel combustion from ships and aircraft engaged in international transport are reported separately in the common reporting format (see Annex A), and in accordance with the UNFCCC's reporting guidelines are not included in the UK's historic or projected emissions. Emissions from aviation fuel loaded in the UK onto international flights have increased at an average rate of between 5 and 6 per cent per annum since 1990. The UK is working to establish an international method for allocating these emissions to national inventories and is working through the International Civil Aviation Organisation to encourage development and implementation of emissions trading at the international level.

**Table 4.6 Greenhouse gas emissions from industrial processes by end user, MtC**

| Gas | Base year | 1990 | 1995 | 2000 | 2004 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|
| Carbon dioxide | 4.8 | 4.8 | 4.3 | 4.2 | 3.9 | 4.1 | 4.3 | 4.5 |
| Methane | 0.5 | 0.5 | 0.4 | 0.3 | 0.1 | 0.3 | 0.2 | 0.3 |
| Nitrous oxide | 8.0 | 8.0 | 5.2 | 1.7 | 1.1 | 1.1 | 1.1 | 1.1 |
| HFCs | 3.8 | 3.1 | 3.8 | 0.7 | 0.1 | 0.3 | 0.3 | 0.3 |
| PFCs | 0.1 | 0.4 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| SF6 | 0.1 | 0.1 | 0.1 | 0.3 | 0.1 | 0.2 | 0.2 | 0.2 |
| Total GHG emissions | 17.3 | 16.8 | 13.9 | 7.3 | 5.4 | 6.0 | 6.2 | 6.4 |
| Change from base year levels for row above | | | -19.3% | -57.5% | -68.7% | -65.1% | -64.2% | -62.9% |

*Percentage changes and emission estimates may differ slightly due to rounding*

**Table 4.7 Greenhouse gas emissions from transport by end user, MtC**

| Gas | 1990 | 1995 | 2000 | 2004 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|
| Carbon dioxide | 39.2 | 39.8 | 40.9 | 43.1 | 44.8 | 45.6 | 45.3 |
| Methane | 0.6 | 0.6 | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 |
| Nitrous oxide | 0.4 | 0.8 | 1.3 | 1.6 | 1.7 | 1.8 | 1.9 |
| Total GHG emissions | 40.2 | 41.2 | 42.6 | 45.0 | 46.5 | 47.5 | 47.2 |
| Change from 1990 levels for row above | | 2.3% | 5.8% | 11.8% | 15.6% | 18.0% | 17.4% |

*Percentage changes and emission estimates may differ slightly due to rounding*

Baseline with measures projections for the residential sector show that emissions are expected to fall to about 16 per cent below 1990 levels by 2010. This can be largely attributed to fuel switching in the electricity supply sector as well as improvements in the energy efficiency of housing **(Table 4.8)**.

Baseline with measures projections for the public sector show that annual emissions are expected to fall to about 23 per cent below 1990 levels by 2010. This results from both fuel switching in the electricity supply industry and improvements in energy efficiency within the public sector **(Table 4.9)**.

Emissions projections from the agriculture sector show that emissions are expected to fall to 26.3 per cent below 1990 levels by 2010. This is due to fuel switching in the energy supply industry, reductions in methane emissions from livestock and reductions in nitrous oxide emissions from fertiliser use **(Table 4.10)**.

**Table 4.8 Greenhouse gas emissions from the residential sector by end user, MtC**

| Gas | Base year | 1990 | 1995 | 2000 | 2004 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|
| Carbon dioxide | 42.4 | 42.4 | 39.1 | 39.8 | 41.7 | 36.4 | 37.9 | 35.9 |
| Methane | 3.2 | 3.2 | 2.3 | 1.6 | 1.2 | 1.2 | 1.0 | 0.8 |
| Nitrous oxide | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 | 0.2 | 0.2 | 0.1 |
| HFCs | 0.1 | 0.0 | 0.1 | 0.6 | 0.7 | 0.8 | 0.8 | 0.8 |
| Total GHG emissions | 45.9 | 45.8 | 41.7 | 42.1 | 43.7 | 38.6 | 39.8 | 37.6 |
| Change from base year levels for row above | | | -9.2% | -8.3% | -4.7% | -16.0% | -13.3% | -18.1% |
| *Percentage changes and emission estimates may differ slightly due to rounding* | | | | | | | | |

**Table 4.9 Greenhouse gas emissions from the public sector by end user, MtC**

| Gas | 1990 | 1995 | 2000 | 2004 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|
| Carbon dioxide | 7.9 | 7.2 | 6.1 | 5.7 | 5.9 | 6.0 | 5.5 |
| Methane | 0.5 | 0.4 | 0.2 | 0.2 | 0.5 | 0.4 | 0.4 |
| Nitrous oxide | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 |
| Total GHG emissions | 8.5 | 7.7 | 6.3 | 5.9 | 6.5 | 6.5 | 6.0 |
| Change from 1990 levels for row above | | -9.5% | -25.0% | -30.1% | -22.9% | -22.8% | -29.6% |
| *Percentage changes and emission estimates may differ slightly due to rounding* | | | | | | | |

**Table 4.10 Greenhouse gas emissions from agriculture by end user, MtC**

| Gas | 1990 | 1995 | 2000 | 2004 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|
| Carbon dioxide | 2.4 | 2.2 | 2.0 | 2.0 | 1.2 | 1.2 | 1.0 |
| Methane | 5.9 | 5.8 | 5.5 | 5.2 | 4.4 | 4.4 | 4.4 |
| Nitrous oxide | 8.9 | 8.5 | 8.0 | 7.4 | 7.1 | 7.1 | 7.0 |
| Total GHG emissions | 17.2 | 16.5 | 15.5 | 14.5 | 12.7 | 12.6 | 12.5 |
| Change from 1990 levels for row above | | -4.4% | -10.1% | -15.7% | -26.3% | -26.6% | -27.6% |
| *Percentage changes and emission estimates may differ slightly due to rounding* | | | | | | | |

The main trends in UK sources and sinks from the land use, land use change and forestry (LULUCF) sector are presented in **Table 4.11**. The UNFCCC basis includes all human-induced changes to land-based carbon stocks i.e. all anthropogenic sources and sinks, and is used for assessing progress against the national $CO_2$ goal. The Kyoto Protocol basis includes LULUCF emissions and removals associated with mandatory activities under Article 3.3 of the Kyoto Protocol – afforestation plus reforestation minus deforestation or ARD – since 1990. In addition since the UK has chosen to account for forest management under Article 3.4 of the Kyoto Protocol, the Kyoto basis also indicates removals up to the level of the cap agreed for the UK as part of the Marrakesh Accords, since the actual uptake by forests is projected to exceed the cap in all years. A small base year allowance of 0.1 MtC related to deforestation emissions in 1990 is added to the UK base year because LULUCF was a net source of emissions in 1990. This is in accordance with the provisions of the second sentence of Article 3.7 of the Kyoto Protocol, and subsequent COP decisions.

**Table 4.11 Greenhouse gas emissions and removals from land use, land use change and forestry, on a) Convention and b) Kyoto Protocol basis, MtC**

| a) UNFCCC basis | 1990 | 1995 | 2000 | 2004 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|
| Carbon dioxide | 0.795 | 0.282 | -0.12 | -0.53 | -0.455 | 0.124 | 0.653 |
| Methane | 0.004 | 0.003 | 0.005 | 0.005 | 0.004 | 0.003 | 0.003 |
| Nitrous oxide | 0.0004 | 0.0003 | 0.0005 | 0.0005 | 0.0004 | 0.0003 | 0.0003 |
| Total GHG emissions by sources minus removals by sinks | 0.799 | 0.285 | -0.114 | -0.524 | -0.451 | 0.128 | 0.656 |

| b) Kyoto Protocol basis | 1990 | 1995 | 2000 | 2004 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|
| Carbon dioxide Afforestation & Reforestation | 0.008 | -0.076 | -0.388 | -0.586 | -0.843 | -0.978 | -1.179 |
| Carbon dioxide Deforestation | 0.046 | 0.061 | 0.1 | 0.102 | 0.104 | 0.106 | 0.104 |
| Methane | 0.004 | 0.003 | 0.005 | 0.005 | 0.004 | 0.003 | 0.003 |
| Nitrous oxide | 0.0004 | 0.0003 | 0.0005 | 0.0005 | 0.0004 | 0.0003 | 0.0003 |
| Total GHG removals by Afforestation and Reforestation less emissions by Deforestation mandatory under Art 3.3 of the KP. (-ve is net removal). | 0.058 | -0.011 | -0.282 | -0.479 | -0.735 | -0.869 | -1.072 |
| Removals associated with forest management under Article 3.4 of the Kyoto Protocol | | | | 0.37 | 0.37 | 0.37 | 0.2 |
| Under Kyoto Protocol Article 3.7, Total Emissions in 1990 due to Deforestation (added to base year emissions for KP reporting) | 0.1 | | | | | | |

**Table 4.12 Greenhouse gas emissions from waste management by end user, MtC**

| Gas | 1990 | 1995 | 2000 | 2004 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|
| Carbon dioxide | 0.3 | 0.2 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 |
| Methane | 10.6 | 9.5 | 6.3 | 4.0 | 3.6 | 3.3 | 3.1 |
| Nitrous oxide | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 |
| Total GHG emissions | 11.3 | 10.0 | 6.8 | 4.5 | 4.2 | 3.9 | 3.6 |
| Change from 1990 levels for row above | | -11.2% | -39.7% | -59.9% | -62.8% | -65.6% | -67.8% |

*Percentage changes and emission estimates may differ slightly due to rounding*

Annual emissions from waste management are expected to fall to 62.8 per cent below 1990 levels by 2010. This can largely be attributed to a reduction in methane emissions from landfill sites due to increased collection of landfill gas for energy recovery and environmental control **(Table 4.12).**

## Supplementary Projections by Gas

The following tables summarise projections organised by gas. Projections are broken down by source and end-user.

**Table 4.13 Carbon dioxide emissions by source, MtC**

| Sector | 1990 | 1995 | 2000 | 2004 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|
| Energy supply | 66.1 | 56.6 | 53.7 | 58.0 | 53.4 | 53.7 | 49.1 |
| Business | 29.7 | 28.3 | 28.4 | 26.9 | 26.2 | 28.1 | 28.9 |
| Industrial processes | 4.3 | 3.9 | 3.9 | 3.7 | 3.7 | 3.9 | 4.1 |
| Transport | 33.5 | 33.4 | 34.7 | 35.8 | 37.0 | 38.3 | 38.8 |
| Residential | 21.7 | 22.1 | 23.8 | 24.4 | 20.8 | 21.0 | 21.2 |
| Public | 3.7 | 3.6 | 3.2 | 2.9 | 3.0 | 3.1 | 3.1 |
| Agriculture | 1.4 | 1.4 | 1.3 | 1.3 | 0.5 | 0.5 | 0.5 |
| LULUCF (net) | 0.8 | 0.3 | -0.1 | -0.5 | -0.5 | 0.1 | 0.7 |
| Waste management | 0.3 | 0.2 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 |
| Total $CO_2$ emissions by sources minus removals by sinks[66] | 161.5 | 149.9 | 149.0 | 152.5 | 144.3 | 149.0 | 146.6 |
| Change from 1990 levels for row above | | -7.2% | -7.7% | -5.6% | -10.6% | -7.8% | -9.2% |

*Percentage changes and emission estimates may differ slightly due to rounding*

**Table 4.14 Carbon dioxide emissions by end user, MtC**

| Sector | 1990 | 1995 | 2000 | 2004 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|
| Business | 63.7 | 56.7 | 56.0 | 56.5 | 52.2 | 53.7 | 53.5 |
| Industrial processes | 4.8 | 4.3 | 4.2 | 3.9 | 4.1 | 4.3 | 4.5 |
| Transport | 39.2 | 39.8 | 40.9 | 43.1 | 44.8 | 45.6 | 45.3 |
| Residential | 42.4 | 39.1 | 39.8 | 41.7 | 36.4 | 37.9 | 35.9 |
| Public | 7.9 | 7.2 | 6.1 | 5.7 | 5.9 | 6.0 | 5.5 |
| Agriculture | 2.4 | 2.2 | 2.0 | 2.0 | 1.2 | 1.2 | 1.0 |
| LULUCF (net) | 0.8 | 0.3 | -0.1 | -0.5 | -0.5 | 0.1 | 0.7 |
| Waste management | 0.3 | 0.2 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 |
| Total $CO_2$ emissions by sources minus removals by sinks | 161.5 | 149.9 | 149.0 | 152.5 | 144.3 | 149.0 | 146.6 |

*Percentage changes and emission estimates may differ slightly due to rounding*

66 Totals exclude emissions from the UK's Overseas Territories associated with the UK's ratifications.

**Table 4.15 Methane emissions by source, MtC**

| Sector | 1990 | 1995 | 2000 | 2004 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|
| Waste disposal on land | 10.4 | 9.25 | 6.12 | 3.82 | 3.39 | 3.09 | 2.85 |
| Agriculture | 5.86 | 5.69 | 5.46 | 5.12 | 4.41 | 4.41 | 4.41 |
| Coal mining | 4.98 | 3.43 | 1.91 | 1.34 | 0.99 | 0.79 | 0.69 |
| Natural gas distribution | 2.17 | 2.03 | 1.80 | 1.32 | 1.14 | 1.02 | 0.90 |
| Offshore oil and gas | 0.64 | 0.62 | 0.37 | 0.32 | 0.25 | 0.13 | 0.06 |
| Fuel combustion | 0.72 | 0.50 | 0.44 | 0.36 | 0.34 | 0.33 | 0.33 |
| Wastewater treatment | 0.19 | 0.19 | 0.21 | 0.22 | 0.23 | 0.23 | 0.24 |
| Other | 0.09 | 0.06 | 0.03 | 0.02 | 0.020 | 0.02 | 0.02 |
| Total | 25.07 | 21.8 | 16.3 | 12.5 | 10.8 | 10.0 | 9.50 |
| Change from 1990 levels for row above | | -13.1% | -34.9% | -50.1% | -57.0% | -60.0% | -62.1% |

**Table 4.16 Nitrous oxide emissions by source, MtC**

| Sector | 1990 | 1995 | 2000 | 2004 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|
| Agriculture | 8.74 | 8.31 | 7.87 | 7.24 | 6.96 | 6.91 | 6.86 |
| Industrial processes | 7.98 | 5.18 | 1.71 | 1.09 | 1.09 | 1.09 | 1.09 |
| Fuel combustion | 1.22 | 1.03 | 0.91 | 0.91 | 0.93 | 0.91 | 0.85 |
| Waste | 0.29 | 0.29 | 0.34 | 0.34 | 0.35 | 0.36 | 0.36 |
| Transport | 0.39 | 0.71 | 1.22 | 1.50 | 1.62 | 1.72 | 1.82 |
| Other | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 |
| Total | 18.6 | 15.5 | 12.1 | 11.1 | 10.9 | 11.0 | 11.0 |
| Change from 1990 levels for row above | 0.00% | -16.6% | -35.3% | -40.4% | -41.2% | -40.9% | -41.0% |

**Table 4.17 Fluorinated gas emissions by market sector, MtC**

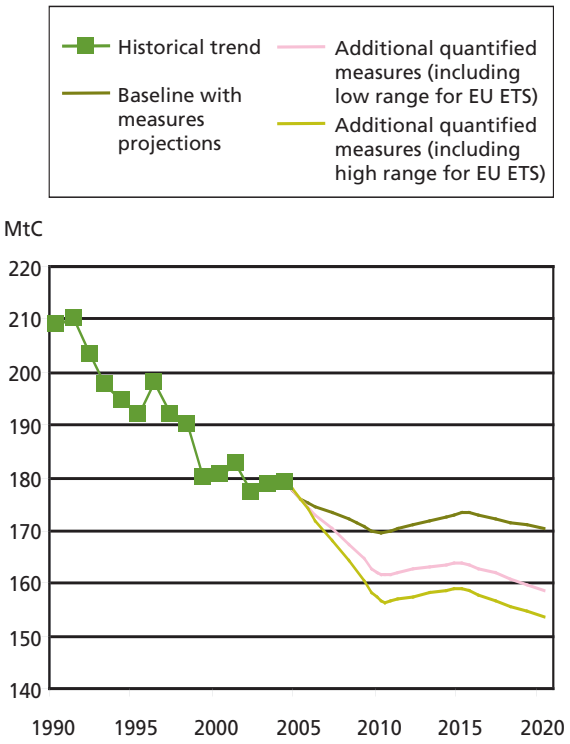
| Sector | 1990 | 1995 (base year) | 2000 | 2004 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|
| **HFCs** | | | | | | | |
| Refrigeration/ air conditioning | 0.00 | 0.25 | 1.10 | 1.38 | 1.23 | 1.12 | 0.91 |
| Foams (excluding OCF) | 0.00 | 0.00 | 0.02 | 0.14 | 0.24 | 0.28 | 0.32 |
| General aerosols and OCF | 0.00 | 0.16 | 0.37 | 0.34 | 0.45 | 0.47 | 0.49 |
| Metered dose inhalers | 0.00 | 0.00 | 0.24 | 0.39 | 0.38 | 0.34 | 0.32 |
| HFC–23 from HCFC–22 manufacture and fugitive losses from HFC manufacture | 3.10 | 3.81 | 0.73 | 0.08 | 0.27 | 0.27 | 0.27 |
| Solvents | 0.00 | 0.00 | 0.00 | 0.01 | 0.03 | 0.03 | 0.03 |
| Fire fighting | 0.00 | 0.00 | 0.02 | 0.08 | 0.10 | 0.11 | 0.13 |
| **Total HFC emissions** | **3.10** | **4.23** | **2.48** | **2.42** | **2.70** | **2.63** | **2.47** |
| **PFCs** | | | | | | | |
| Electronics | 0.01 | 0.02 | 0.05 | 0.03 | 0.02 | 0.02 | 0.03 |
| Aluminium smelting | 0.36 | 0.08 | 0.07 | 0.04 | 0.03 | 0.03 | 0.03 |
| Other PFC emissions | 0.01 | 0.03 | 0.01 | 0.03 | 0.02 | 0.02 | 0.03 |
| Refrigeration/ air conditioning | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total PFC emissions | 0.38 | 0.13 | 0.14 | 0.09 | 0.07 | 0.08 | 0.09 |
| **SF6** | | | | | | | |
| Magnesium smelting | 0.12 | 0.12 | 0.29 | 0.11 | 0.20 | 0.20 | 0.20 |
| Electrical insulation | 0.16 | 0.22 | 0.17 | 0.14 | 0.14 | 0.14 | 0.14 |
| Other SF6 uses | 0.00 | 0.00 | 0.02 | 0.06 | 0.01 | 0.00 | 0.00 |
| Electronics | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 | 0.01 |
| Total SF6 emissions | 0.28 | 0.34 | 0.49 | 0.31 | 0.35 | 0.35 | 0.34 |
| **Total UK emissions of HFCs, PFCs and SF6** | **3.77** | **4.69** | **3.10** | **2.52** | **3.13** | **3.05** | **2.90** |
| Change from 1995 levels for row above | | | -33.8% | -46.4% | -33.3% | -34.9% | -38.1% |

## Assessment of Total Effect of Policies and Measures

This section presents the estimated total effect of implemented and adopted policies and measures as well as quantified additional policies and measures that the UK is introducing following publication of its CCP. The new measures outlined in the 2006 CCP are expected to take the UK further beyond its target for the first commitment period under the Kyoto Protocol and move the UK closer to its 2010 domestic carbon dioxide goal.

It is estimated that the new programme could reduce the UK's emissions of the basket of greenhouse gases on which the Kyoto target is based to 23–25 per cent below base year levels; and reduce the UK's carbon dioxide emissions to 15–18 per cent below 1990 levels by 2010. The carbon savings associated with existing policies and measures included in the baseline projections presented above, and additional quantified policies and measures that the UK is introducing are detailed in Annex B. **Figure 4.1** shows the overall estimated effect of quantified implemented and planned policies and measures on total UK greenhouse gas emissions to 2020. Savings from existing measures are conservatively assumed to be constant beyond 2010, unless there is particular evidence for increased savings, for example associated with vehicle fuel efficiency.

**Figure 4.1 Projections of greenhouse gas emissions and estimated effect of quantified additional measures.**




## Methodology

### 4.51 Carbon Dioxide

Projections of the UK's emissions of carbon dioxide have been largely derived from the DTI Energy Model. This is made up of a set of interlocking sub-models of the UK energy market including final user energy sectors and the electricity supply sector. It is a top down demand model, based on econometrically estimated relationships between energy demand, energy supply, economic activity and energy prices and a bottom–up supply side model. The sector classification source, and the principal source of energy statistics, is the Digest of UK Energy Statistics (DUKES)[67]. The DTI model makes projections based on prospects for fossil fuel prices, economic growth and demographics.

Energy and emissions projections which informed the CCP 2000 were published in November 2000 in Energy Paper 68. Updated Energy Projections (UEP) are now published periodically. The UEP exercise includes significant improvements to the DTI model in several sectors. Key assumptions have been updated and revised and have been incorporated in the baseline. It also now includes all current Government environmental policy measures as most recently evaluated. Baseline with measures projections underpinning the CCP review were published in UEP, in February 2006[68].

Four variants of the projections were presented:

- A high fossil fuel price
- A central fossil fuel price, but with the assumed prices somewhat favouring gas in generation;
- A central fossil fuel price, but with the assumed prices somewhat favouring coal in generation;
- A low fossil fuel price.

**Table 4.18 Projections of carbon dioxide emissions in the with measures and with additional measures scenarios MtC**

| Gas | Base Year | 1990 | 1995 | 2000 | 2004 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|
| Total carbon dioxide [1] with measures | 161.5 | 161.5 | 149.9 | 149 | 152.5 | 144.3 | 149 | 146.6 |
| Total carbon dioxide [1] with additional measures (low ETS) | | | | | | 137 | 141 | 137 |
| Total carbon dioxide [1] with additional measures (high ETS) | | | | | | 132 | 136 | 130 |

[1] Total emissions by sources minus total removals by sinks.

67 See www.dti.gov.uk/energy/inform/dukes/dukes2005/index.shtml

68 www.dti.gov.uk/energy/sepn/UEP_Feb2006.pdf

The projections presented in this chapter are an average of the central fossil fuel price scenarios.

The UEP projections provide two central scenarios based on HM Treasury projections of economic growth combined with two variations on assumptions of world fossil fuel price projections. The two central price variations provide relative price situations that would indicate either gas or coal as more economic within the electricity-generating sector.

$CO_2$ projections from LULUCF are made by the Centre for Ecology and Hydrology (CEH) using methods consistent with the inventory estimates. The projections[69] take account of the dynamics of carbon stocks in the relevant pools and assume that current trends in land use as summarised by the land use change matrix will continue.

### 4.5.2 Other Greenhouse Gas Emissions

The emissions projections of the other greenhouse gases covered by the Kyoto Protocol, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride, were produced by ENTEC[70] and are broadly consistent with the assumptions underlying the projections of carbon dioxide emissions published by the DTI. The projections have been developed for thirteen different sectors and sub-sectors based on a range of different sources, including consultation with experts and stakeholders from UK Government departments, industry and other organisations; technical literature; and incorporating results of studies undertaken for Defra.

Projections have been calculated using spreadsheet models that calculate emissions based on forecast activity statistics, emissions factors and various other sector specific assumptions for each of the main sources of emissions. Greenhouse gas emission projections are disaggregated by sector and are calculated for each year from 2005 to 2020. These are then aggregated to provide an estimate of total projected emissions. The spreadsheets have been constructed so as to provide transparency in the assumptions and approaches used and also for ease of updating. Probabilistic modelling of the range of uncertainty associated with the total emissions for each gas has also been undertaken to calculate the confidence range for the projections.

As with the projections for carbon dioxide, the non-$CO_2$ projections are based on a 'with measures' scenario, which takes into account currently adopted and implemented policies and measures. Central estimates for sector projections are aggregated to calculate the best estimate for the total emissions.

Projections are verified by comparing trends in actual historic emissions against future emission estimates. If there is a significant deviation between the trend in historic data and future emission estimates, projection methodologies and assumptions are revised accordingly.

In certain sectors, projection methodologies are verified by using a combination of bottom up and top down information. For example, the methodology that derives estimates of future emissions of hydrofluorocarbons is based on detailed disaggregated projections on a sector by sector basis. This is a bottom up approach. The outputs from this model have been checked against historic sales information for hydrofluorocarbons, where available – a top down approach. Consequently, the model has been verified by comparing projected emissions to actual sales information for the fluids concerned.

69 The approach used is described in the UK Emissions by Sources and Removals by Sinks due to Land Use, Land Use Change and Forestry Activities, CEH, April 2006. **Available at http://www.edinburgh.ceh.ac.uk/ukcarbon/docs/Defra Report 2006 Section2.pdf**

70 This technical report will be available following publication of the National Communication. The non-CO2 projections have been updated for consistency with the greenhouse gas inventory published in 2006.

### 4.5.3 Key Assumptions

Key assumptions for the projections are given in this section, further details of the assumptions can be found in the February 06 publication of UEP projections[68].

Economic growth assumptions are from the December Pre-Budget Report (up to 2008). Longer-term growth is assumed close to the long-term average.

**Table 4.19 Growth assumptions**

| | 2006 | 2007 | 2008 | 2009-2020 |
|---|---|---|---|---|
| Growth assumption | 2.25% | 3% | 3% | 2.5% |

Fossil fuel price assumptions are set out below.

In the central price scenarios, it is assumed that oil prices ease as new production capacity is built and demand growth moderates. However, prices are assumed to remain higher than the historic average. Additional investment in coal production capacity is assumed to lead to coal prices falling to long-run marginal costs.

**Table 4.20 Central fuel prices favouring gas**

| | Oil ($/bbl) | Gas (p/therm) | Coal ($/GJ) |
|---|---|---|---|
| 2005 | 55 | 36 | 2.5 |
| 2010 | 35 | 23 | 1.5 |
| 2015 | 35 | 23 | 1.43 |
| 2020 | 35 | 23 | 1.35 |

**Table 4.21 Central fuel prices favouring coal**

| | Oil ($/bbl) | Gas (p/therm) | Coal ($/GJ) |
|---|---|---|---|
| 2005 | 55 | 36 | 2.5 |
| 2010 | 35 | 28 | 1.5 |
| 2015 | 35 | 28 | 1.43 |
| 2020 | 35 | 28 | 1.35 |

In the high price scenario, global economic growth is assumed to remain strong, and demand elasticity for oil remains low. The UK gas supply/demand balance is assumed to remain tight for the next year or so, and despite EU market liberalisation, increased competition in gas markets is limited. Coal demand is assumed to remain strong.

**Table 4.22 High fuel prices**

| | Oil ($/bbl) | Gas (p/therm) | Coal ($/GJ) |
|---|---|---|---|
| 2005 | 60 | 36 | 2.6 |
| 2010 | 50 | 38 | 1.7 |
| 2015 | 50 | 38 | 1.7 |
| 2020 | 50 | 38 | 1.7 |

In the low price scenario, it is assumed that oil producers invest in new production capacity and technological development minimises the costs of oil production. In the gas market, increased competition drives gas prices towards the long run marginal. Coal demand is assumed to continue to decline due to the competitiveness of gas.

**Table 4.23 Low fuel prices**

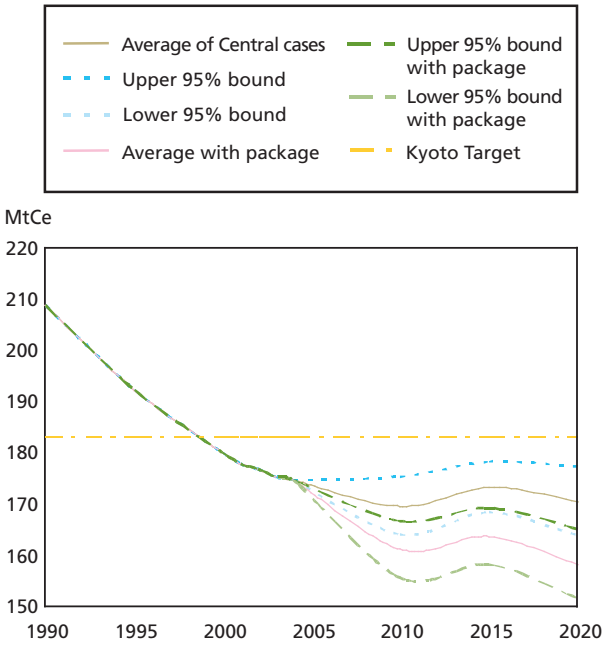
| | Oil ($/bbl) | Gas (p/therm) | Coal ($/GJ) |
|---|---|---|---|
| 2005 | 50 | 36 | 2.4 |
| 2010 | 20 | 18 | 1.3 |
| 2015 | 20 | 18 | 1.15 |
| 2020 | 20 | 18 | 1.0 |

### 4.5.4 Overall Uncertainty

Uncertainty ranges for each greenhouse gas, including carbon dioxide, were combined probabilistically to determine the overall uncertainty range for total greenhouse gas emissions and projections presented in the Programme. For this exercise, the probabilistic range of baseline emissions from energy use was consistent with the Average of central projections scenario. **Figure 4.2** shows the results of the probabilistic analysis, which is described in the report on the appraisal of policy options[71]

[71] To be published in Synthesis of Climate Change Policy Appraisals, which will be available at www.defra.gov.uk

**Figure 4.2 Results of the probabilistic analysis**




This analysis suggests that in 2010, UK emissions of greenhouse gases will be between 16 per cent and 22 per cent below 1990 levels, with the central scenario about 19 per cent below. The range takes into account macroeconomic, sectoral and modelling uncertainties. Overall therefore, the Kyoto target would be delivered on the basis of the policies included in the projections. The additional policies set out in this Programme could further reduce UK emissions of greenhouse gases to between 20 per cent and 26 per cent below 1990 levels by 2010, with the central scenario about 23 per cent below.

### 4.5.5 Sensitivity Analysis

Projections for the four price scenarios suggest a relatively narrow range of $CO_2$ emissions in 2010 from 144 MtC to 145 MtC. The small sensitivity reflects a number of counteracting influences.

- In the central case favouring gas, more gas is used in generation but energy demands are also greater.
- In the high fossil fuel price scenario, emissions are higher than in the central cases. Coal is relatively more competitive with gas and is consequently more heavily used in generation. This effect outweighs the impact of high energy prices in reducing energy demand.
- In the low fossil fuel price scenario, emissions are also higher than the central case because increasing energy demand outweighs the effects from fuel switching towards gas in the generation sector.

Sensitivity to other key assumptions was also considered and is summarised below.

**Table 4.24 Summary of impact on carbon emissions in 2010 of alternative key assumptions**

| Key assumptions | Alternative | Emissions in 2010 (MtC) |
|---|---|---|
| Further voluntary agreements with vehicle manufacturers | | -0.1 |
| Number of households | Higher growth in number of households | +1.2 |
| Car ownership levels | Higher growth in number of households | +1.0 |
| Higher coal generation | 5 TWh higher | +0.7 |
| Nuclear output | 1 TWh higher<br>1 TWh lower | -0.1<br>+0.1 |
| Different electricity demand | 1 TWh higher | +0.1 |
| Higher electricity imports | 1 TWh higher | -0.1 |
| Renewables at various levels | 7% generation<br>9% generation | +0.3<br>-0.3 |
| Temperature | Level trend | +0.7 |

**Table 4.25 Differences in baseline with measures projections between the third and fourth national communications, MtC**

| Gas | Third National Communication | | | Fourth National Communication | | |
|---|---|---|---|---|---|---|
| | Baseline | 2010 | Projected Change | Baseline | 2010 | Projected Change |
| Carbon Dioxide | 164.4 | 150.9 | -8.21% | 161.5 | 144.3 | -10.7% |
| Methane | 21.0 | 11.6 | -44.8% | 25.1 | 10.8 | -56.9% |
| Nitrous Oxide | 18.3 | 11.8 | -35.5% | 18.6 | 11.0 | -40.9% |
| HFCs | 4.1 | 2.9 | -29.3% | 4.2 | 2.7 | -35.7% |
| PFCs | 0.3 | 0.1 | -66.7% | 0.1 | 0.1 | 0.00% |
| $SF_6$ | 0.3 | 0.3 | 0.00% | 0.3 | 0.4 | 133% |

### 4.5.6 Differences from the 3rd National Communication

The table above summarises the differences between the projections in the third and fourth National Communications. The main difference between the two projections is the implementation of the measures in the climate change programme, moving them from the with additional measures to the with measures projection.

Table 4.25 Differences in baseline with measures projections between the third and fourth national communications, MtC.

# 5

# Impacts, Vulnerability and Adaptation

## Key developments

- The UK Climate Impacts Programme (UKCIP) has continued to provide a focus for stakeholder-led research on the impacts of climate change. Alongside assessments, UKCIP has developed a stronger emphasis on equipping stakeholders to start to adapt to the impacts of climate change. New resources, guidance and tools, including new climate change scenarios, a risk, uncertainty and decision-making framework and a method for costing the impacts of climate change have been produced. A report integrating the results from UKCIP studies was published in 2005.
- The UK government and devolved administrations launched a consultation on the UK Adaptation Policy Framework in 2005. This framework aims to provide a consistent approach to building adaptation into policies, a coherent way to identify crosscutting risks and opportunities and is intended to assist in defining priorities for action across government.
- The UK has continued to support research and capacity-building on adaptation at an international level. Bilateral collaborative research projects on the impacts of climate change in China and India have been completed, and further research is underway or planned.

## Introduction

This chapter describes how the UK is developing adaptation strategies. It looks at how climate change is likely to be experienced in the UK, provides an overview of impacts assessments from the UK Climate Impacts Programme and other research, and outlines the actions and policies that the Government and the devolved administrations are taking to prepare for climate change.

The UK has a well-established foundation for assessing impacts from climate change, and, increasingly, progressing understanding, guidance and action on adaptation. The UK Climate Impacts Programme was set up in 1997 to advance stakeholder-led assessments of climate impacts, and adaptation has been incorporated in the UK's Climate Change Programme since 2000.

Both bottom-up and top-down approaches to impacts assessments and adaptation have been developed. The stakeholder-led approach pioneered by UKCIP is an example of the former, complemented more recently by impacts audits carried out by government departments, and the ongoing work to develop an adaptation policy framework.

## Observed changes in the UK

The UK's climate has changed over the last century, with central England average annual temperature rising by around 1°C. The 1990s was the warmest decade in central England since records began. Winters have been getting wetter, with a larger proportion of precipitation falling on heavy rainfall days. Sea level has risen by about 1 mm per year on average, though this has varied around the coast.

The impacts of climate change in the UK are already being felt, particularly in the natural environment. In the long term, climate change may have significant impacts on the economy and people's daily lives, but within the next decade or so, subtle changes in the behaviour of plants and animals are likely to give the strongest indicators of impacts. Yearly changes in the timing of natural events, including appearance, activity and abundance of insects, arrival dates of migratory birds, and plant leafing and flowering continue to reflect warmer temperatures in the UK.

The Government published a review of UK climate change indicators in 2004. The average annual growing season in Europe lengthened by about 10 days between 1962 and 1995. The date at which leaves appear on oak trees in Surrey has advanced by about two weeks compared with the 1950s. On average, butterflies are appearing nearly a month earlier than in the 1940s, and the Red Admiral, normally a summer migrant, now appears to be successfully over-wintering in Britain. These kinds of trends look set to continue.

The economic consequences of some of these changes are beginning to be felt. For example, damage related to the European heat wave in 2003 left insurers with almost £400 million in subsidence claims in the UK – more than double the cost of the previous year. Claims for storm and flood damages in the UK totalled more than £6 billion over 1998–2003, which was twice the amount for the previous six-year period.

## Impacts Assessments

The impacts of climate change in the UK are assessed in a co-ordinated way through the UK Climate Impacts Programme, with additional assessments for a variety of specific purposes provided through other research projects and programmes.

### 5.3.1 UK Climate Impacts Programme

In 1997, the Government established the UK Climate Impacts Programme (UKCIP) to provide a co-ordinated framework for assessing climate change impacts and identifying potential adaptation strategies in the UK. UKCIP has put stakeholders at the heart of the research process, in a pioneering approach for producing relevant information on climate change. Through the use of common tools and resources in climate impacts studies UKCIP has achieved a degree of coherence within and between studies. From an initial focus on impacts research studies, there has been a progression towards developing stakeholder partnerships that share information, identify research needs and pursue work on climate impacts and adaptation in the regions and in different sectors[72].

In 2004, an independent review[73] of UKCIP indicated that the Programme had performed very effectively, establishing a valuable body of work on UK climate impacts and increasingly adaptation, through its stakeholder network. The review also noted that there is still much for the UKCIP to achieve, and that its work should be continued in a similar form.

In 2005, the Government established a new five-year contract for the UKCIP, with the twin aims of improving knowledge and understanding of the impacts of climate change among stakeholders and helping stakeholders be equipped better to undertake adaptation to climate change. The programme has five objectives:

- To improve knowledge and understanding of the impacts of climate change at a regional and national level among stakeholders, through the co-ordination, integration and communication of research.
- To help stakeholders to be better equipped to undertake adaptation to climate change through the provision of tools and methods, and supporting training and guidance.
- To promote a consistent programme of work on impacts and adaptation across the UK, working through partnerships with stakeholders and other researchers in regional, national, and sectoral contexts.
- To provide a focal point for information on climate change impacts in the UK, through the UKCIP Programme Office and strategic communications activities.
- To learn from the research and experience of other countries, through appropriate links with international partners engaged in work on climate change impacts and adaptation.

UKCIP is modular in structure, with individual studies funded by stakeholder partnerships. Two main categories of study are conducted. **Regional** studies consider multiple sectors within a given region and deliver information that is relevant to local decision-making, facilitate the inclusion of climate risks into spatial planning, and help develop climate adaptation strategies. **Sectoral** studies are typically undertaken at the national level, tend to be quantitative in nature, and inform decision-making on climate impacts and adaptation at the local, regional and national scale for given sectors. More recently UKCIP has played an increasing role in helping stakeholders to build adaptive capacity, that is, strengthening their ability to adapt to climate change.

The UKCIP Office team helps others to commission and fund research and actively supports all studies and partnerships. It also provides common tools and resources to ensure a consistent approach is adopted between studies. Stakeholders steer research projects to ensure their relevance for decision-making on adaptation.

The UKCIP provides tools to equip stakeholders to develop their own adaptation responses (see Table 1). They provide a common framework for integrating activities on impacts and adaptation, providing comparability across studies, sectors and regions. All of the tools have been funded by the Department for Environment, Food and Rural Affairs and are available free of charge from the UKCIP website **www.ukcip.org.uk.**

72 A comprehensive synthesis of the work achieved under the UK Climate Impacts Programme is provided in Measuring Progress: Preparing for climate change through the UK Climate Impacts Programme, UKCIP, 2005, available from **www.ukcip.org.uk**

73 Review of UKCIP, ESYS, 2004. Available from **www.defra.gov.uk**

**Table 1: Tools provided by the UK Climate Impacts Programme**

| Title of Tool | Purpose | Short Description |
|---|---|---|
| Climate Change Scenarios for the United Kingdom | To provide information at a regional scale on possible changes in the UK's climate and extreme weather events over the 21st century. | UKCIP02 scenarios are based on four different emissions scenarios (Low, Medium-Low, Medium-High and High) published by the Intergovernmental Panel on Climate Change (IPCC). Information on future changes is reported on a 50km square grid across the UK. Data includes temperature, precipitation and wind provided over seasonal and annual time periods. A briefing report provides an accessible introduction to the main climate changes expected in the UK in the 21st Century. A technical report provides more comprehensive information. Full data sets (for all reported climate variables for each 50km grid square) are available electronically. |
| Socio-economic scenarios for climate change impact assessment | To provide four alternative 'storylines' for the future world in which climate changes will be experienced. | Four national socio-economic scenarios (National Enterprises, Local Stewardship, World Markets and Global Sustainability) have been developed to provide a consistent set of information for UKCIP studies. Whilst the scenarios do not claim to predict the future, they provide useful 'storylines' that can be used for thinking about the different types of futures in which climate change might occur. |
| Climate adap tation: Risk, uncertainty and decision-making framework | To help assess climate risks and uncertainties and incorporate suitable adaptation measures into a risk based decision | Provides a step-by-step decision-making framework to help organisations assess the risk posed by climate change and work out how best to respond. It helps users to answer questions such as the following. What climate change risks could affect my decision? What adaptation measures are required? When should they be implemented? How can I deal with uncertainty? |
| Costing the Impacts of Climate Change in the UK | To provide a method for calculating the cost of climate impacts, adaptation and non-adaptation. | The UKCIP costings report explains how to calculate and compare the costs of climate impacts to the costs of adaptation measures. The methodology is designed to be used in conjunction with the UKCIP decision-making framework. |
| UKCIP Adaptation Wizard | To help decision-makers move through a process from simple understanding of climate change to integration of climate risks into decision-making. | The UKCIP Adaptation Wizard is a web-based tool that helps users move through a process from simple understanding of climate change to integration of climate change into decision-making, by making use of a number of resources – all signposted from the Wizard. It identifies four steps in a project management and decision-making process: scoping climate change impacts; quantifying risks; making decisions and planning action; and reviewing adaptation strategies. The Wizard draws heavily on the UKCIP Risk Framework (see above) |
| UKCIP Adaptation Case Study Database | To provide a searchable database of adaptation options implemented in the UK. | The adaptation case study database will be web-based and searchable by a variety of parameters including region, activity or sector. |

*Continued*

**Table 1: Tools provided by the UK Climate Impacts Programme**

| Title of Tool | Purpose | Short Description |
|---|---|---|
| UKCIP's ten principles for good adaptation | To assist in the process of making good adaptation decisions | UKCIP's ten good adaptation principles are simple principles to help in making proper choices for adapting to climate change. The principles are generic so that they can be widely applied and are designed to be used in conjunction with the Adaptation Wizard. |
| A Changing Climate For Business: Business planning for the impacts of climate change (Metcalf and Jenkinson, 2005) | To help businesses (and other organisations) begin to assess the climate risks for their own organisation. | 'A changing climate for business' helps businesses and other organisations to assess the impact that climate change will have across the full range of business activities. It uses a simple checklist of generic business areas (such as markets, premises, logistics, etc) as the basis for identifying the threats and opportunities presented by a changing climate. |

The climate change and socio-economic scenarios provide a commonly accepted set of projections that have allowed for consistent assessments of impacts and adaptation in the UK. A summary of the climate projections is provided below. The Risk, Uncertainty and Decision-making Framework has been used widely, as a means for developing a process through which adaptation can be started, despite uncertainties and lack of complete information at the outset.

**Climate Change Scenarios for the UK.**

The UKCIP02 climate change scenarios for the United Kingdom were produced by the Hadley Centre and the Tyndall Centre, with funding from Defra, in 2002. They describe expected climate changes in the UK over the 21st century for four different greenhouse gas emissions scenarios and three time slices centred around the 2020s, 2050s and 2080s. In summary, the scenarios suggest that higher temperatures, combined with changing patterns of precipitation, will lead to hotter, possibly drier summers and milder, wetter winters. Rising sea levels and changes in storm surge height are expected, as is an increase in extreme weather. In future we may expect:

*Higher temperatures, with regional and seasonal variation:*

- by the 2020s: an increase in annual average temperature of between 0.5° and 1.5° C depending on region and scenario;
- by the 2050s: an increase in annual average temperature of between 0.5° and 3.0° C depending on region and scenario;
- greater summer warming in the south east than the north west of the UK;
- greater warming in summer and autumn than in winter and spring.

*Changing patterns of precipitation:*

- wetter winters, by up to 15 per cent by the 2020s (up to 25 per cent by the 2050s) for some regions and scenarios;
- possibly drier summers, by up to 20 per cent by the 2020s (up to 40 per cent by the 2050s) for some regions;
- significant decreases in snowfall.

*Changes in extreme events:*

- an increase in frequency and intensity of extreme weather conditions, such as very high temperatures, or heavy downpours of rain.

*Changes in sea level:*

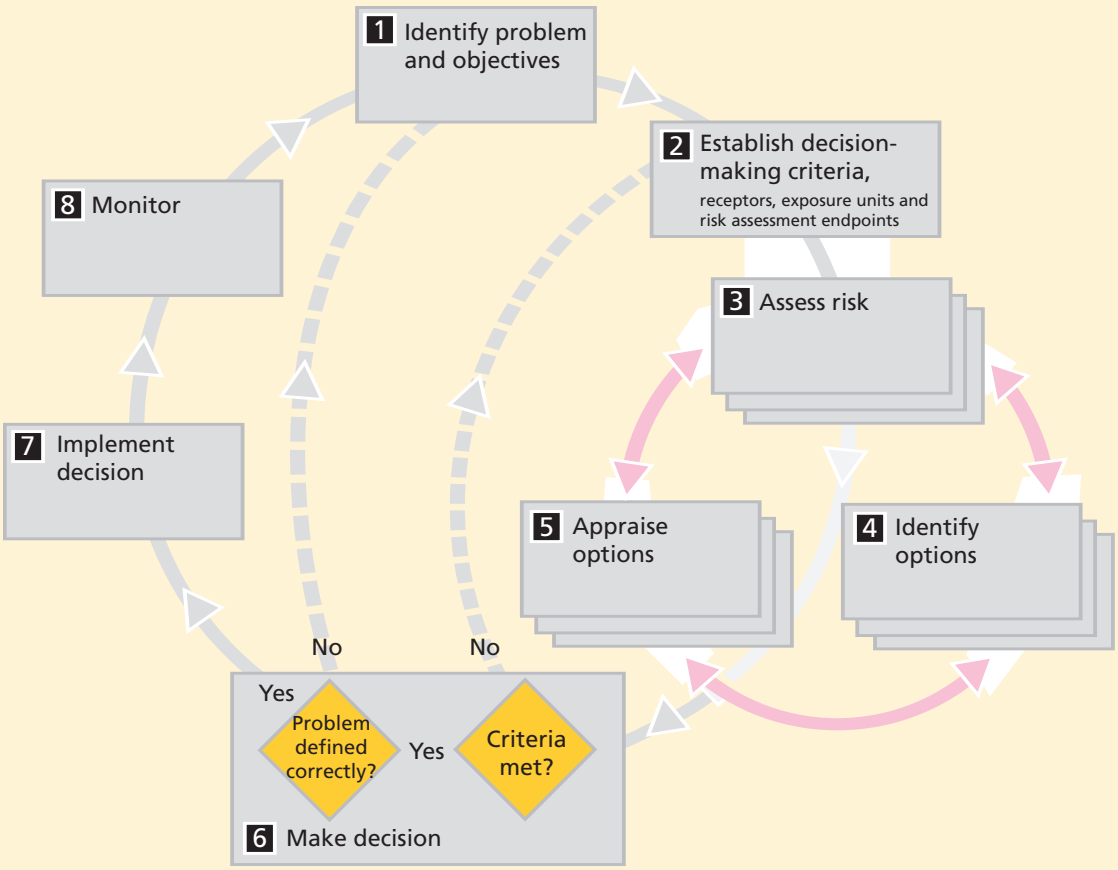
- a rise in global average sea level, due mainly to thermal expansion of ocean water and melting of mountain glaciers, in the range of 4 to 14cm by the 2020s and 7 to 36cm by the 2050s, depending on the emissions scenario;
- historic trends in vertical land movements will introduce significant regional differences in relative sea level rise around the UK, with much of southern Britain sinking and much of northern Britain rising relative to the sea;
- in addition, extremes of sea level – storm surges and large waves – are expected to increase in height and frequency.

### Risk, Uncertainty and Decision-making framework

The UKCIP report Climate adaptation: Risk, uncertainty and decision-making (Willows and Connell, 2003) was developed with the Environment Agency. It provides an 8-stage decision-making framework with accompanying guidance, to help assess climate risks and uncertainties and incorporate suitable adaptation measures into a decision. For each stage of the framework, there are questions to answer, and recommended tools to help.

The framework:

- directs decision-makers to undertake rapid risk characterisation and screening exercises, before moving on to more detailed assessments;
- helps refine the problem and objectives and modify adaptation options, before making a decision; and
- guides the decision-maker to review the decision, for instance to see if it delivered the expected benefits.



Findings from studies carried out for the UK Climate Impacts Programme indicate that changes in climate are likely to have far-reaching effects on the UK's environment, economy and society and in some cases these are already being felt. A full synthesis[74] of results from the UKCIP was published in 2005, and launched by the UK's Environment Minister. Without effective action to tackle the causes of climate change, climate-related risks and damages are expected to increase. Some of the most widely -expected impacts in the UK include an increased risk of flooding and coastal erosion, increased pressure on drainage systems, possible winter storm damage, habitat loss, summer water shortages and low stream flows, increased subsidence risk in subsidence-prone areas, increasing thermal discomfort in buildings, and health issues in summer. Commonly-perceived benefits include longer growing seasons, less winter transport disruption, reduced demand for winter heating, less cold-related illness. Some opportunities from climate change are anticipated, including agricultural diversification, an increase in tourism and leisure pursuits, and a shift to more outdoor-oriented lifestyles.

The phase of scoping impacts for all UK regions is now complete. Further quantification is now required, and particular attention is needed on cross-sectoral impacts and on socio-economic drivers of change as they relate to impacts and adaptation decisions. The focus for research is moving away from single sector topics towards more integrated issues such as spatial planning, and from the natural environment to the built environment.

### 5.3.2 Other research on impacts and adaptation

The Government has several research programmes ongoing to continue to build the evidence base on the impacts of climate change and adaptation. Climate model data and observational datasets are made available for researchers through Defra's LINK Programme[75], located at the University of East Anglia.

*Cross-regional research programme*

Following on from initial scoping work carried out in the English regions and devolved administrations through the UKCIP, Defra commissioned a major programme of cross-regional research[76] on impacts and adaptation. This focused on six priority topics (planning and the built environment, business, water resources, countryside and the rural economy, quantifying the cost of impacts and adaptation, linking adaptation research and practice). A seventh project focused on climate change and the visitor economy in England's northwest. These projects will complete in 2006.

*Flooding and coastal erosion*

Defra and the Environment Agency fund a collaborative research programme on flood and coastal erosion risk management. Climate change has featured in the work of a number of the themes and recently this has been based on analysis of the UKCIP02 scenarios to provide guidance for design and appraisal. Future work is likely to consider the impacts of climate change on sea levels, surges and waves and how the next generation of UKCIP climate change scenarios can best be used in flood and coastal erosion risk management design and analysis activities.

The Foresight Future Flooding study[77] was commissioned by the Office of Science and Technology to provide an independent vision of flood and coastal erosion risk management in the UK between 2030 and 2100 to inform long-term policy. In undertaking the study there was a recognition that decisions taken today will have a profound impact on the flood and coastal erosion risks which future generations will need to manage. It was also recognised that the options available for managing risks in the long term will be strongly influenced by short-term actions.

The study used four Foresight socio-economic futures paired with UKCIP climate change scenarios to allow responses to be tested against different outcomes. In this way it was possible to identify policies and responses capable of coping with a range of possible futures, allowing flexible adaptation as the situation evolves. Under the baseline assumption of current levels of expenditure and approaches to flood and coastal management remaining unchanged, it was found that all scenarios would result in a substantial increase in risk. An integrated approach combining a portfolio of responses would provide significant cost savings over conventional defences and also enable a much more sustainable approach to be realised.

74 Measuring Progress: Preparing for climate change through the UK Climate Impacts Programme available from www.ukcip.org.uk/resources/assessment/ . Additional tables of impacts in different sectors and regions of the UK are also available from this website.

75 Further information about LINK is provided in Chapter 7.

76 Further information on Defra's cross-regional research programme is available from **www.defra.gov.uk**

77 Full details of the study are available from **www.foresight.gov.uk**

*Agriculture*

Agriculture is inherently sensitive to climate. The Government has a long-standing programme of research on climate change impacts and adaptation in agriculture. This has covered issues such as the scale and rate of impacts of climate change on agriculture and identifying adaptation options to help industry and policy makers plan for the uncertainties ahead. This includes work at all levels – from impacts on individual plants, to farm scale planning, and catchments or regional based approaches. Complementing this research is a programme of work, which aims to raise awareness and promote uptake of sustainable adaptation strategies in the industry. The programme has recently been reviewed and future objectives for research are currently being set.

*Biodiversity*

The changing climate brings particular challenges for the management of biodiversity and protected sites. Defra funds a research programme on biodiversity and climate change undertaken in partnership with the devolved administrations, the statutory nature conservation agencies and other interested non-governmental organisations. This programme has three main objectives: (1) to improve understanding of impacts of climate change on biodiversity in terrestrial and marine environments, including through application of modelling techniques to assess vulnerability of priority species and habitats; (2) to review and develop options for adaptation of policy and management, including improved transfer of knowledge between researchers and practitioners; and (3) to ensure that long-term monitoring systems are in place to detect changes in biodiversity and discriminate the effects of climate change from other factors. Defra recently published a review of climate change impacts on migratory species[78]. As part of the UK Presidency of the EU, the UK Government hosted a meeting of the European Platform for Biodiversity Research Strategy in 2005 to review the status of knowledge on impacts of climate change and to identify knowledge gaps that hinder implementation of adaptation strategies.

*Marine*

The Government and the UKCIP are establishing a Marine Climate Change Impact Partnership (MCCIP) to develop a long-term, multidisciplinary approach to understanding the implications of climate change for the marine ecosystem. The main purpose of MCCIP is to provide a national co-ordinating framework that will facilitate transfer of high-quality evidence on the impacts of marine climate change to the public, politicians, policy advisors and decision-makers. Within the UK Marine Monitoring Strategy, relevant indicators will be identified to monitor and evaluate the effects of climate change on marine ecosystems.

*Insurance*

The Association of British Insurers[79] has developed a work programme over the last three years on the impacts of climate change for insurance and the wider financial services sector. A recent report on the financial risks of climate change was launched in 2005 at an international conference hosted by the ABI on insurance and climate change. It outlined how climate change could increase the financial costs of extreme weather around the world, based on the best-available scientific assessment of climate change. Even quite small increases in the intensity of major storms (hurricanes, typhoons, windstorms), as predicted by the latest climate change science, could increase damage costs by at least two-thirds by the end of the century. The most extreme storms could become even more destructive, making insurance markets more volatile, as the cost of capital required to cover such events increases.

78 Review available from **http://www.defra.gov.uk/wildlife-countryside/resprog/findings/climatechange-migratory/index.htm**

79 Further information about the ABI's work on climate change, including a scoping study entitled "A changing climate for insurance" is available from **www.abi.org.uk/climatechange**

80 The presentations made at the conference are still available from the website at **www.stabilisation2005.com** . The conference book was published in January 2006 by Cambridge University Press.

81 Further information on the climate change research agendas of the UK Research Councils is provided in Chapter 7.

82 Further information on the Tyndall Centre is provided in Chapter 7.

*International conference*

The Government hosted the International Symposium on Stabilisation of Greenhouse Gas Concentrations – Avoiding Dangerous Climate Change in February 2005[80]. The conference provided new scientific evidence on the impacts of climate change on human and natural systems from work sponsored by the UK Government at the Hadley Centre. The message from the conference was that climate change looks set to be worse than expected, that urgent global action is needed to avoid considerable risks and that the long-term costs of mitigation are less than previously stated. The scientific findings presented at the conference were published in a book on 'Avoiding Dangerous Climate Change'. The book presents a global picture of the impacts of climate change on natural and human systems, reflects on emission pathways that can lead to the stabilisation of greenhouse gas concentrations in the atmosphere and identifies technological options that can be deployed to achieve significant emission reductions.

*UK Research Councils*

The Government's Science Budget provides funding to UK Research Councils[81] to support basic, strategic and applied research and related postgraduate training, including in the fields of climate change and energy. This budget provides funding for a variety of research work addressing aspects of adaptation to climate change and which has the potential to impact a broad range of sectors. It includes support for the Tyndall Centre for Climate Change Research; for research programmes on flood risk and management, for research to support the adaptation of UK buildings and infrastructure (built environment, transport and utilities) to changing climate patterns, and aspects of research in energy, crops, soils, biodiversity and water management; as well as scientific expertise contributed to the Natural Hazard Working Group. The Tyndall Centre[82] has established a worldwide reputation for high quality research into climate change response options, tackled from an inter-disciplinary perspective (see Chapter 7).

The Engineering and Physical Sciences Research Council (EPSRC) are working with UKCIP on a £3m portfolio of research projects addressing climate impacts and adaptation for the built environment. The projects are investigating climate impacts and adaptation for urban planning and design, urban drainage, historic buildings, transport operations and infrastructure, and the electricity supply industry. All of the projects involve partnerships of researchers with decision-makers who plan to use the research outputs to inform their own organisations' adaptation strategies.

*Devolved Administrations*

The Department of the Environment (DOE) in Northern Ireland has taken forward a number of initiatives to promote understanding and awareness of climate change impacts. Much of this work has been developed in co-ordination with the UKCIP. A comprehensive report on *Implications of Climate Change for Northern Ireland: Informing Strategy Development*, published in 2002 by the Scotland and Northern Ireland Forum for Environmental Research (SNIFFER), examined the likely impacts of climate change across a wide range of sectors. The key impacts identified include potentially adverse effects on public health, the likelihood of more accidents and damage from extreme weather events and threats to vulnerable eco-systems. The DOE has recently commissioned SNIFFER to provide an updated report on the implications of climate change for Northern Ireland. This study will incorporate a risk assessment and will recommend adaptation strategies for the key impacts.

**European Spatial Planning: Adapting to Climate Events** (ESPACE)

ESPACE is a four-year European project[83], running from 2003 to 2007, that aims to promote awareness of the importance of adapting to climate change and to recommend that it is incorporated within spatial planning mechanisms at local, regional, national and European levels. It is funded by the INTERREG IIIB North West Europe Programme and ESPACE Partners, and is supported by the UK Office of the Deputy Prime Minister, with Hampshire County Council acting as lead partner and co-ordinator. Focussing on North West Europe, the project is looking into how water resources are managed and planned in the face of a changing climate. ESPACE is also raising awareness amongst a wide range of stakeholders including policy makers and planning practitioners to ensure that climate change is acknowledged as a major influence on spatial planning processes.

**Biodiversity Requires Adaptation in Northwest under a Changing climate** (BRANCH)

BRANCH is a three-year European project[84], running from 2004 to 2007, bringing together spatial planners, policy makers and scientists across North West Europe. It has received European Regional Development Funding through the INTERREG IIIB Community Initiative. The project is advocating change to the spatial planning and land use systems to allow wildlife to adapt to climate change. BRANCH aims to demonstrate the need for change based on science, and recommend policies and tools that will be developed in collaboration with planners. UK partners in this project include English Nature (lead partner and co-ordinator), the Environment Agency, Hampshire County Council and Kent County Council.

## Actions, Policies and Programmes for Adaptation

The UK Climate Change Programme was revised and published in 2006. It sets out the UK Government's approach to tackling climate change, including policy on the UK successfully adapting to the impacts of future unavoidable climate change. It provides the rationale for taking action to adapt, gives some general principles for adaptation, shows the different roles played by government and others, and indicates where research, tools and guidance can be found.

**Climate Change: The UK Programme 2006**

- In its revised Climate Change Programme[85], the UK Government has committed to:
- set out our adaptation plan for the UK, informed by additional research on the impacts of climate change;
- help poorer developing countries to adapt to changes in climate already occurring and to make their economies more resilient to future changes.
- The UK Government has outlined the following specific activities for adaptation:
- We will analyse stakeholder responses to the public consultation and will publish the first phase of the adaptation policy framework during 2006.
- We will launch the second phase of consultation during 2007 and a third phase in 2008.
- We will develop a process for reviewing and assessing existing and new policies for their vulnerability to climate change impacts and their contribution to adaptation.
- We will initiate a study of the potential role of regulation and standards in accelerating action.
- We will work with UKCIP to continue to raise awareness of climate change impacts and adaptation at strategic levels within private sector organisations and the business community.
- We will publish revised and expanded climate change scenario datasets and information for the UK in 2008.
- We will commission a programme of research to investigate cross-sectoral issues in adapting to the impacts of climate change in the UK.
- We will review and update UK indicators of climate change, and provide guidance for the development of regional indicators of climate change.

83 Further information about the ESPACE project is available from **www.espace-project.org**

84 Further information about the BRANCH project is available from **www.branchproject.org**

85 Climate Change: The UK Programme 2006, published in March 2006. Available from **www.defra.gov.uk**

- We will commission a study of the business costs and benefits of adapting to climate change impacts.
- We will assess the role and status of regional stakeholder climate change partnerships including future funding options.
- We will produce revised guidance, with the Environment Agency, on implementing flood and coastal erosion risk management measures, to ensure that adaptability to climate change becomes an integral part of all flood and coastal erosion management decisions.
- We will publish the results of collaborative research on the effects of climate change on UK priority species and habitats (MONARCH3) and on the establishment of a long term monitoring network.
- We will review the implications of climate change for biodiversity in England and integrate adaptation within the England Biodiversity Strategy.
- Adaptation to climate change as an impact will be built into the development of integrated policy for the Natural Environment.
- We will conduct a review of current activities to assess the impacts of climate change in the marine environment.
- We will commission an assessment of the changes in the distribution and abundance of marine species in relation to changes in hydrodynamics and sea temperature.
- We will combine knowledge and expertise on the impacts of climate change in the marine environment through the Marine Climate Change Impacts Partnership.
- We will commission an academic "Climate Change Impacts Review Group" to produce a review of the impacts of climate change and adaptation in the UK.

The UK Government also highlights adaptation to climate change as a key issue in its Sustainable Development Strategy[86]. As this strategy is worked out through policies and plans at national, regional and local levels, a consideration of potential impacts from climate change, and appropriate adaptation measures should be incorporated across all relevant policy areas. There are already a range of adaptation activities taking place within different sectors and across different agencies and regions.

*National action on adaptation*

The Government is currently developing a climate change Adaptation Policy Framework (APF), which will set out in more detail the appropriate responsibilities and activities by a range of organisations in a sector by sector approach. This work contributes to the strategic outcome in Defra's Five Year Strategy[87] under its climate change and energy strategic priority on the "UK successfully adapting to unavoidable climate change". This framework aims to provide a consistent approach to building adaptation into policies, a coherent way to identify cross-cutting risks and opportunities, and is intended to assist in prioritisation of action across Government.

This first stage, which was launched with a consultation period in November 2005, aims to capture the national picture of climate change adaptation as it currently stands across the UK. It will focus on priority sectors where climate change will have a significant impact, or where considerable co-ordination between Departments or with other bodies will be needed to make progress on adaptation. During stage 2, there will be an analysis of activities taking place and an assessment made of the reasons why some sectors are adapting more successfully than others. Stage 3 will identify those areas where adaptation is not occurring and what incentives and assistance may be required to ensure that it is considered appropriately in future planning and development.

The APF distinguishes between two kinds of adaptation activity, "building adaptive capacity" and "delivering adaptation actions". These are illustrated in Tables 5.1 and 5.2.

86 Securing the future. UK Government Sustainable Development Strategy, 2005. Available from www.sustainable-development.gov.uk

87 Delivering the Essentials of Life: Defra's Five Year Strategy, Defra, 2004. Available from www.defra.gov.uk

**Table 5.1 Explanation and examples of building adaptive capacity**

| Type | Generic activity | Case examples |
|---|---|---|
| Research | • Scoping studies<br>• Technical/quantitative impact and adaptation assessments<br>• Climate scenarios development<br>• Use of risk-based appraisals to evaluate current and future climate and non-climate risks | Association of British Insurers has conducted research on how climate change could increase the financial costs of extreme weather around the world, based on the best available scientific assessment of climate change. |
| Data collection and monitoring | • Phenology<br>• Monitoring climate impacts and learning lessons<br>• Monitoring effectiveness of adaptation and learning lessons | Indicator studies for Northern Ireland and Wales<br><br>Ongoing climate trends study for Scotland |
| Changing or developing regulations, standards, codes, plans, policy or programmes | • National and international regulation and statute<br>• National codes and standards, best practice guidelines<br>• National, regional and local policy and plans<br>• Resource allocation<br>• Enforcement of standards | Scottish Planning Policy 7: Planning and Flooding (Feb 2004) notes that climate change must be taken into account by developers and planning authorities |
| Internal organisational development | • Training and staff development programmes<br>• Senior management buy-in<br>• Identify climate change champion(s)<br>• Make the business case in all business areas<br>• Capacity building programmes | Network Rail has introduced a civil engineering post to lead the company on understanding the effects of long-term changes in climate on its assets. |
| Awareness-raising | • Education and training<br>• Capacity building programmes<br>• Conferences, events and publications | UKCIP risk training workshops, costing training workshops and programmes with local authorities and businesses |
| Working in partnership | • Work in sectoral partnerships<br>• Work in locality-based partnerships<br>• Linked projects<br>• Work in cross-disciplinary partnerships | Regional climate change partnerships |

**Table 5.2 Explanation and examples of delivering adaptation actions**

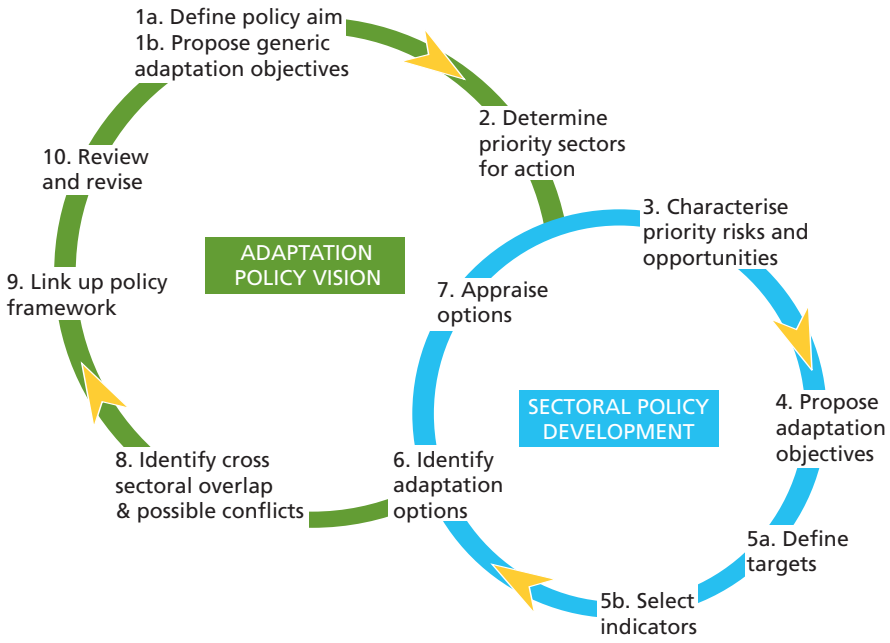
| Type | Generic activity | Case examples |
|---|---|---|
| Accept impacts and bear (some) loss | • Accept that some habitats or species may disappear from UK<br>• Accept loss of some coastal land to sea level rise and coastal erosion<br>• Insurance companies accept some losses and set premiums accordingly<br>• Make conscious decision to do nothing to adapt | Evolving practice in UK by nature conservation agencies |
| Spread/share impacts | • Take out insurance to cover risks<br>• Use other financial products that lay-off risk<br>• Diversify business activity, market, location, etc to spread risk | Insurance companies "risk price", charging more in high flood risk areas |
| Avoid negative impacts | • Technical or structural change<br>• Geographical change<br>• Behavioural or activity change | School design project in Worcester using UKCIP "Adaptation Wizard"<br><br>Emergency, contingency and disaster planning |
| Exploit opportunities | • Exploit new markets emerging as a consequence of climate change both locally and globally<br>• Cultivate new agricultural crop/ develop alternative land use | Change ski-centre to walking centre in Scotland<br><br>Introduce new crops in South West England |

### Objective-setting for climate change adaptation policy

Analytical work in support of adaptation policy development in Defra included a study[88] to recommend approaches for defining policy objectives, targets and indicators for adaptation. A new policy-setting method was proposed. The method is circular and iterative. It is initiated from a central lead, providing the overarching aim of adaptation policy, which needs to define "successful" adaptation. Defra has already started to develop this adaptation policy vision. The policy cycle allows for input from individual sectors to occur concurrently and almost independently, and requires engagement with different stakeholders at several stages. Without ownership of this process by the sectors themselves, the evolving policy is unlikely to have the impact required for effective, co-ordinated and comprehensive adaptation.

Example policy objectives were developed in each sector using a risk-based approach. Risk prioritisation should ideally take into account agreed levels of risks, information on economic costs, and considerations of existing adaptive capacity, thus linking characterisation of risks and opportunities with the options appraisal stage. It should also take into account knock-on effects in other sectors.

Whilst adaptation remains at an early stage of development, it is inevitable that policy objectives, targets and indicators will focus on building capacity. The study suggested that a balanced mix of process-based and outcome-based targets and indicators would be needed. As the policy area matures, a shift towards outcome-based indicators that focus on measuring the delivery of actual adaptation would be expected.




The study applied the method in six priority sectors (transport, energy, agriculture, tourism, water resources and flood risk management). These sectors were selected on the basis of criteria including the economic importance of the sector to the UK, the potential significance of climate impacts and adaptation measures within the sector in economic, social and environmental terms, and the immediacy of potential climate change impacts on the sector.

*Information from Defra-funded study carried out by AEA Technology Environment, 2005.*

88 Final report from study on Obective-setting for adaptation policy available from **www.defra.gov.uk**

A central theme of the UK's adaptation agenda is the need for climate change to be taken into account across Government's policies, responsibilities and activities. Many Government departments are already addressing adaptation. In 2003, Defra published a scoping study investigating the implications of climate change across its policy responsibilities in the natural environment, food and farming, and rural affairs. In those policy areas where climate change has been identified as a priority (e.g. water resources, water quality, biodiversity and flood management) good progress in relevant research was being made, but in other areas further research was required, or improved awareness of research was needed. In terms of integrating an understanding of climate impacts into policy development, the areas of flood management and water resources had begun to incorporate allowances for climate changes, but few policy areas had reached the point of practical decision-making in adaptation. Most other Government departments have also carried out initial assessments of the implications of climate change across policy agendas.

Climate change adaptation is a key theme in the Welsh Assembly Government's Environment Strategy for Wales. Work is underway to develop a climate change adaptation action plan for Wales.

*Regional and local action on adaptation*

Local Authorities in the UK are increasingly aware of potential climate change impacts on the services they provide. To make public their commitment to address climate change, 100 councils (about one-quarter of all the local councils in the UK) have signed the Nottingham Declaration on Climate Change[89]. Signing the declaration requires councils to work with local stakeholders to address the causes and effects of climate change. The declaration was relaunched at a conference in Nottingham in December 2005 and the revised Declaration expands on the role of adaptation. It will also provide signatories with a tool kit and support to help them achieve their targets. In Wales, work on the Welsh Declaration on Climate Change was launched by the Welsh Assembly Government and the Welsh Local Government Association in April 2006.

The Government supports a range of stakeholder-led adaptation programmes and actions through the UKCIP. These include regional and sectoral partnerships, a local authorities network, and a programme focused on the private sector. Climate change partnerships have been set up in eight of the nine English regions and in Scotland, and they have established a network, the UK Inter-Regional Climate Change Group, to help foster co-ordination and share common experiences. Memberships of the regional partnerships are diverse and cross-sectoral. The status of activity in the regional climate change partnerships is summarised in **Table 5.3.**

The UKCIP local authorities network consists of English local councils and other related stakeholders, such as Local Government Association (LGA) and the Office of the Deputy Prime Minister (ODPM). This group is currently exploring how to make best use of UKCIP tools such as the Adaptation Wizard. Work initiated by UKCIP on establishing a local authority network in Scotland is being developed by the Scottish and Northern Ireland Forum for Environmental Research (SNIFFER). UKCIP's work with councils in Wales and Northern Ireland is at an earlier stage of development.

The UKCIP business network, known as Changing Climate for Business (CCFB), was initiated as a pilot project in 2004. Eight trade associations and professional bodies are developing resources that will help prepare their sector for the impacts of climate change. Each organisation is preparing one or more adaptation-related outputs and these include: workshops for staff and members, business planning documents, technical guidance notes, magazine and journal articles and sector-specific networks.

A recent project[91] for Defra provided an inventory of adaptation occurring in four priority sectors (water, construction, rural land use, and transport) in the UK (see box). The project found many more examples of "building adaptive capacity" than of "implementing adaptation actions" indicating that adaptation is still at an early stage. Most adaptation is occurring through the public sector (e.g., government Ministries, devolved administrations, government agencies and local authorities). In addition to adaptation in the individual sectors, the research also found evidence of a number of cross-sectoral initiatives occurring mainly at national government or regional level, including, reports, strategy and policy development at various scales, toolkits, etc.

89 Further information about the Nottingham Declaration and the councils' Climate Action Pack is available from **www.est.org.uk/nottinghamdeclaration**

91 Tompkins et al. 2005 Linking adaptation research and practice. Final project report for Defra, science project number GA01077. Available from **www.defra.gov.uk**

**Table 5.3 Status of regional climate change activities supported through the UKCIP[90]**

| Region | Partnership established? | Focus | Example Activities |
|---|---|---|---|
| South West | Yes, through Environment Agency | Adaptation | • Develop work programme based on priority themes<br>• Establish thematic working groups<br>• Prepare to appoint full-time officer |
| South East | Yes, South East Climate Change Partnership | Adaptation | • Implement work programme<br>• Publish South East Climate Threats and Opportunities Research Study (SECTORS)<br>• Input into ESPACE (European Spatial Planning: Adapting to Climate Events) |
| London | Yes, London Climate Change Partnership | Adaptation | • Work on growth areas<br>• Project on risks and costs to transport systems<br>• Development of website |
| East of England | No, pending | | • Publication of scoping report<br>• Launch of scoping report<br>• Establishment of regional partnership |
| East Midlands | Yes, through the Regional Assembly with the Environment Agency | Adaptation & mitigation | • Reformation of regional partnership<br>• Gather support<br>• Propose and adopt work plan |
| West Midlands | Yes, led by Sustainability West Midlands | Adaptation | • Publication of scoping report<br>• Launch of scoping report<br>• Establishment of regional partnership |
| North West | Yes, North West Climate Group | Adaptation & mitigation | • Deliver pilot second stage climate impacts project, Climate change and the visitor economy in England's Northwest |
| Yorkshire & Humber | Yes, through Government Office for Yorkshire and Humber | Adaptation & mitigation | • Draft climate change action plan published<br>• Appointment of full-time co-ordinator |
| North East | Yes, but informal | Adaptation | • Host UKCIP User Forum<br>• Review of regional activity by local authorities |
| **Devolved Administrations** | | | |
| Scotland | Yes, Scottish Climate Change Impacts partnership | | • Continued partnership development through SNIFFER<br>• Programme of work confirmed |
| Northern Ireland | Preliminary work to establish partnership underway | | • Progress partnership development process<br>• Event held for central government officers across all departments |
| Wales | Partnership to be developed | | • Commitment to partnership development in Environment Strategy for Wales Action Plan |

[90] Table adapted from Measuring Progress: Preparing for climate change through the UK Climate Impacts Programme, UKCIP, 2005, available from www.ukcip.org.uk

**Examples of adaptation in the UK**

There are numerous examples of adaptation in practice in the UK. This box illustrates a few, and highlights some of the issues for adaptation in key sectors, but it is not an exhaustive overview of adaptation across the UK. More detailed information is available in the original report[92], and also from the UKCIP[93].

*Water supply*

Both public institutions and private organisations in the water supply sector are taking climate change seriously, but efforts to respond are still at an early stage. The legislative framework appears to be in place for firms to adapt. The majority of adaptation outputs are in the form of building adaptive capacity and few companies have yet begun to implement adaptation actions. Legislation, such as the Water Act 2003 and the EU Water Directive at the national and international scale are important drivers of adaptation in this sector in the UK. Some companies are investing financial resources into infrastructure improvements (such as sewage services) driven in part by climate-related events, but more generally by UK and EU legislative requirements. This investment is a function of the high level of awareness of climate change in the water supply industry, and potentially high susceptibility.

*Flood management*

There are many different kinds of adaptation outputs in this sector, ranging from planning policy guidance to flood risk maps and local activities. Adaptation is occurring both in terms of implementing adaptation actions and building adaptive capacity. Most of the examples of adaptation in this sector are planned, i.e. deliberately initiated in response to the need to adapt to the impacts of climate change. However, it is clear that there are many drivers of adaptation in the inland and coastal flooding management sector, aside from climate change. Defra's "Making Space for Water: Developing a New Government Strategy for Flood and Coastal Erosion and Risk Management in England" was reviewed in 2005 in light of drivers for change, including the latest predictions on climate change.

Other actions include for example, the Environment Agency's efforts to build further flood defences in Carlisle and Lower Eden (on the River Eden). The Environment Agency is also involved in the maintenance and operation of the Thames Barrier in London, through the Thames Estuary 2100 project that addresses flooding linked to the impacts of climate change. A further example of adaptation in practice is the Essex Wildlife Trust, which has undertaken the largest coastal realignment project in Europe, converting over 84 hectares of arable farmland into salt marsh and grassland, to provide sustainable sea defences. Local actions include the activities by 21 flood appraisal groups across Scotland. The Association of British Insurers has produced guidance both to policy makers and chief executives, and to parliament on climate change and the insurance sector.

*Construction*

In the planning and construction sector, adaptive capacity is being built, but there are far fewer adaptation actions being undertaken. Policy-related adaptations are occurring within the planning system, with revised Planning Policy Statements including the need to take long term climate change into account in new developments. ODPM produced a guidance report entitled 'The Planning Response to Climate Change: Advice on Better Practice' to provide planning professionals with advice on how to respond to climate change. Regional Planning Guidance and spatial strategies are also starting to include adaptation: RPG 6 (East Anglia) notes the number of climate change impacts and necessary responses including that development proposals should be resisted on flood plains and that development plans should promote the use of sustainable urban drainage solutions. While guidance is emerging to drive adaptation considerations in new development at a broad level, there is, as yet, no clear policy on issues relating to the maintenance of the existing built environment.

92 Tompkins et al. 2005 Linking adaptation research and practice. Final project report for Defra, science project number GA01077. Available from **www.defra.gov.uk**

93 Measuring Progress: Preparing for climate change through the UK Climate Impacts Programme available from **www.ukcip.org.uk/resources/assessment/ .**

The uncertainty involved in adapting to climate change may be a reason why institutions, particularly in the private sector and operating at local scales, appear to be reluctant to engage in anticipatory action. The New Construction Research and Innovation Strategy Panel (nCRISP) is one example of planned adaptation in the construction sector: nCRISP has links with government, industry and the research community, and considers the impact of climate change on the built environment and vice versa. There are a large number of drivers for adaptation in this sector, including climate change itself, through extreme weather, heatwaves, flooding, wind and storm damage and subsidence. Regulations, policies and standards, particularly the UK planning policy guidance and statements, are powerful drivers. Sustainable development is another important driver, particularly among the private sector, associations and networks where it is firmly on the construction agenda. The evidence suggests that in the planning and construction sector, little change is undertaken in response to environmental issues on a voluntary basis and that legislation is necessary to push organisations to act.

*Biodiversity and conservation*

This sector is at an early stage in implementing adaptation actions, although there is considerable effort in building adaptive capacity. A range of outputs have been generated, such as recommendations and advice, including improvements to the permeability of landscapes to facilitate rainwater dispersal, minimization of further loss of semi-natural habitats; identification and safeguarding of areas with good existing adaptive capacity, supporting new habitat creation, securing more effective targeting of agri-environment schemes, and translocation of species where necessary. These outputs largely fall within existing policy and legislative frameworks, and climate change is considered as one of many pressures on wildlife conservation and habitat protection. Examples of actions include a habitat restoration project in the Fenlands through a partnership of public sector bodies and NGOs, which aims to restore 3000 hectares of fenland over 50 years. The majority of actions seem to be occurring at national levels

*Agriculture and Forestry*

There are a large number of research projects and studies on climate change impacts and adaptation that are generating reports, guidelines, and advice, and these are beginning to impact on policies, regulations, and grant schemes. Although there are relatively few published examples of implemented actions, adaptation may be occurring more widely as an ancillary benefit of various other environmental schemes and regulations (such as the Countryside Stewardship Scheme). The Rural Climate Change Forum was set up by Defra to address climate change issues in rural areas. The Scottish Executive has also taken steps to address climate impacts in the Scottish Forestry Strategy. In some cases there may have been a reluctance to consider climate change adaptation at the individual level due to greater pressures from shorter-term issues, and a perception that farmers can adapt in step with the changing climate.

*Transport*

Most of adaptation to climate change in the transport sector is occurring in public institutions. However, there are also some private sector adaptations underway connected with both the rail and road networks. The sector demonstrates a wide variety of adaptation outputs including management plans, various actions, workshops and research into the potential impacts of climate change and adaptation options. Most of the examples are of building adaptive capacity, with a very small minority of examples demonstrating the implementation of adaptation actions: these are occurring in both the public and private sector. Most of the examples are organisational examples of adaptation, rather than policy or behavioural indicating that much adaptation is taking place within the operation of the industry rather than at a national policy scale. Many adaptations in this sector are planned in response to climate change, and most of the drivers of adaptation are directly related to climate change and its impacts (both experienced and projected for the future): institutions in the transport sector are responding directly to the risks that climate change poses for the industry. Examples include: the Highways Agency's 2005-6 business plan includes a programme of work connected with climate change – including the responses required for adaptation to the climate over the next 30 to 40 years. Network Rail's Safety and Environment Plan (2003) notes adverse weather as a hazard for the rail network and indicates that Network Rail will introduce a strategy to increase the resilience of the railway infrastructure to high winds, flooding and extreme temperatures, including research into the long-term impacts of climate change and recommendations to address it.

*Information from Defra-funded research project carried out by Tyndall Centre, 2005, under the Climate Change Impacts and Adaptation: Cross-regional Research Programme.*

### 5.4.1 International co-operation on adaptation

The UK is giving increasing attention to the need to understand the impacts of climate change on developing countries to help them assess their vulnerability to these impacts. As well as supporting the development of a regional climate model (PRECIS[94]) that can be applied to any part of the world to generate detailed climate change predictions, it also contributed to the Global Environment Facility and funds research programmes to investigate the impacts of climate change in India, China and Bangladesh. Details of individual projects can be found in the chapter on finance.

*Other international co-operation*

DFID's Central Research Department has officially committed £15 million over three years for a collaborative research and capacity development programme on climate adaptation, and is considering extending the research programme for an additional two years.

DFID is preparing its policy and implementation plan on reducing the risks of disasters, the majority of which are climate-related. The goal of the policy is to contribute to sustainable development through reducing the burden of disasters on the poor and most vulnerable. It aims to better integrate disaster risk reduction into development policy and programming. DFID is also developing a framework for assessing climate change and disaster risks across DFID programmes. The framework will be used to assess, manage and reduce the risks to the programme portfolio from climate change and disasters. This will involve a preliminary screening to determine broad risk profiles and highlight areas where more detailed risk assessment and integration of risk reduction are appropriate.

Mindful of the need to address capacity needs in relation to climate monitoring in Africa, an outcome of the UK's Presidency of the G8 in 2005 was an allocation of £5 million over 5 years to support the integration of climate risk information in decision-making processes and to increase the long-term availability of climate observations in Africa. This is dependent upon similar contributions from other G8 partners.

The UK was fully supportive of the developments under the UNFCCC Buenos Aires programme of work on adaptation and response measures. The UK has continued to support the development of a structured five-year programme of work on the scientific, technical and socio-economic aspects of impacts, vulnerability and adaptation by the Subsidiary Body for Scientific and Technological Advice through workshops and the Conference of Parties in 2005.

Under GEF 3 (2003/4 – 2006/07), DFID has committed to a core contribution of £103 million and an additional £15 million as a signal of the UKs commitment to addressing global environmental problems, making the UK the fourth largest donor to the facility. Negotiations for the fourth replenishment were underway during 2005.

DFID has committed £10 million over 3 years to the UNFCCC Special Climate Change Fund (aimed at developing countries) to mainstream climate change responses into development planning, policies and implementation. DFID is intending to contribute to the Least Developed Countries Fund, to support the implementation of National Adaptation Programmes of Action (NAPAs), pending adoption of agreed Decision text by the Conference of Parties.

Over the last three years, DFID has also funded negotiation preparation workshops for Least Developed Countries, prior to the Conference of Parties.

Through the Global Opportunities Fund (GOF), the FCO has contributed almost £5 million for 2005–06 to fund climate change or energy-related projects in key countries (particularly the emerging economies). The purpose of GOF is to promote action on global issues in areas of strategic importance to the UK. Climate change and energy is one of six thematic programmes supported by GOF; the programme includes a focus on increased high-level attention to, or understanding of, impacts of climate change and costs of inaction.

94 See longer description of PRECIS in Chapter 7

In January 2005 Defra, NERC and FCO launched a 5 year partnership in scientific co-operation on climate modelling between the Hadley Centre, the Centre for Global Atmospheric Modelling and the Earth Simulator Centre of the Japan Agency for Marine-Earth Science and Technology. The use of the Japanese supercomputer in Yokohama allows climate change scenarios to be run at an unprecedented level of detail and provides improved estimates of key societal and economic vulnerabilities. The UK is investing £1.4 million in this initiative.

The government supports the research and assessments of the Intergovernmental Panel on Climate Change (IPCC), and UK scientists involved in them, both directly and through the provision of a Technical Support Unit (TSU) hosted by the Met Office. Since 2002, the UK has supported Professor Martin Parry as the co-chair of Working Group II[95], and the TSU, which serves this working group. Since being set up, WGII TSU activities have focused on expert meetings, discussions and decisions leading towards the IPCC's Fourth Assessment Report (AR4), to be published in 2007.

95 IPCC Working Group II (WG2) – Impacts, Adaptation and Vulnerability

# 6

# Financial Assistance and Technology Transfer

## Key Developments

- In 2005 the UK held the Presidency of the G8 and focused on climate change, along with Africa, as the two main themes. During the G8 Summit at Gleneagles in July 2005, the heads of Government of Brazil, China, India, Mexico and South Africa were involved in climate change discussions, which resulted in a new Dialogue between the developed and developing world to link clean energy, climate change and sustainable development goals.
- The UK used its Presidency of the European Union (EU), during the second half of 2005, to continue to engage with key international partners. Climate change was an important element of the EU summits with China and India, which resulted in the successful agreement of the EU-China Partnership on climate change and the EU-India Initiative on clean development and climate change.
- At the UNFCCC COP11/CMP1 in Montreal, the UK used its presidency of the EU to help strengthen the Clean Development Mechanism (CDM) institutions, and procedures at UN level, establishing the framework for Joint Implementation (JI) and the timetable for the deployment and linking of the UN registry system.
- In February 2005 the UK hosted the International Symposium on Stabilisation of Greenhouse Gas Concentrations, 'Avoiding Dangerous Climate Change'. The conference provided new scientific evidence on the impacts of climate change on human and natural systems from work sponsored by the UK Government and at the Hadley Centre. The findings were published in a book of the same name, which presents a global picture of the impacts of climate change and identifies the technological options that can be deployed in order to achieve significant emissions reductions.
- The UK is currently the fourth largest contributor to the Global Environment Facility (GEF). The UK supports an increase in GEF funding in the fourth replenishment.

## New and Additional Financial Resources

6.1 The UK's development assistance programme is increasing. New and additional resources are available to deal with global environmental problems such as climate change. The UK intends to meet its share of the commitment made by donors in Bonn in July 2001[96].

As a result of the UK's presidency of the G8 in 2005, DFID allocated £5 million over five years to support the integration of climate risk information in decision making processes and to increase the long-term availability of climate observations in Africa.

The G8 also agreed to put climate risk management procedures in place for donor-funded development investments, to increase their resilience to the impacts of climate change. The UK will put these procedures in place by 2008. Before then a pilot phase will be implemented, working with the World Bank and other donors.

DFID has committed £10 million over 3 years to the UNFCCC Special Climate Change Fund, available to all developing countries, to mainstream climate change responses into development planning, policies and implementation, and pledged £10 million over 3 years to the least developed countires fund for the same purpose.

DFID's Central Research Department has officially committed £24 million over 5 years for a collaborative research and capacity development programme on climate adaptation, and is considering extending the research programme for an additional 2 years.

DFID Bangladesh is providing £6 million over 5 years to support UNDP and the Government of Bangladesh to establish the Comprehensive Disaster Management Programme. This programme aims to enable the transition of disaster management from relief to a risk reduction focus, including longer-term climate risks.

DFID is preparing its policy and implementation plan on reducing the risks of disasters, the majority of which are climate related. The policy's goal is to contribute to sustainable development through reducing the burden of disasters on the poor and most vulnerable. DFID has allocated around £18 million for the next two years to disaster risk reduction.

96 Sixth Conference of Parties to the UNFCCC – resumed session Bonn, July 2001.

At the G8 Environment and Development Ministers' meeting in March 2005, the UK announced funding of £100k towards regional predictions of climate change for Africa and £400k over the next three years towards a new multi-country initiative on advancing knowledge, capacity and networks in support of climate change in Africa. The UK has recently announced funding of around £6 million to the Renewable Energy and Energy Efficiency Partnership (REEEP) between 2006 and 2008. The funding will, amongst other activities, help increase the uptake of energy efficiency and renewable energy technologies through capacity building, tackling barriers to the up take of these new technologies and though supporting innovative financial instruments.

## Multilateral Activities

6.2 The UK makes a major contribution to the aid programmes of the UN development agencies and other international financial institutions, which are funding projects in developing countries related to the implementation of the UNFCCC.

The UK believes that it is vital for developing countries to participate in the UNFCCC and the Intergovernmental Panel on Climate Change (IPCC). The Government therefore makes an annual contribution to UNFCCC and IPCC Trust Funds that enable developing country participants to attend meetings.

**Table 6.1** gives details of financial contributions to the Global Environment Facility and other multilateral institutions.

**Table 6.1 Financial Contribution to the Global Environment Facility and other Multilateral Institutions and Programmes**

| Institution or programme | Contribution (£millions) | | |
|---|---|---|---|
| | 2002–2003 | 2003–2004 | 2004–2005 |
| **Global Environment Facility** | | 29.5[97] | |
| **Multilateral Institutions** | | | |
| 1 World bank | | | |
| 2 International Finance Corporation | | | |
| 3 African Development Bank | | 1.0 | |
| 4 Asian Development Bank | | | |
| 5 EBRD | | | |
| 6 Inter-American Development Programme | | | |
| 7 UNDP | | 82.6[98] | |
| 8 UNEP | | 4.2 | |
| 9 UNFCCC | 0.1 | 0.1 | 0.1 |
| 10 World Meteorological Organisation | | 1.7 | |
| *Details of other multilateral contributions on climate change are not available. Bilateral activities are summarised in Annex D.* | | | |

97 http://www.dfid.gov.uk/pubs/files/reportdesertificationoct2004.pdf

98 'The United Kingdom in the United Nations', October 2004 http://www.fco.gov.uk/Files/kfile/Cm6325.pdf

## Global Environment Facility

6.3 The GEF finances the incremental costs to developing countries of protecting the global environment in five focal areas: climate change, biodiversity, depletion of the ozone layer, persistent organic pollutants and the pollution of international waters. It supplements the funds provided for sustainable national development from national resources and by aid donors and international development agencies. The UK is the fourth-largest contributor to the GEF with a commitment of over £320 million between 1997 and 2004[99].

## Bilateral Activities

6.4 The UK works bilaterally in partnership with a number of countries on both mitigation and adaptation measures in order to build understanding of the urgency of tackling climate change and the possible solutions to the problem. The bilateral activities are summarised in Annex D.

In 2004, the UK and China agreed to establish a bilateral working group on climate change[100]. Defra has been working with the Chinese Ministry of Science and Technology since 2001 on projects investigating the impacts on agriculture in China. The UK also supports activities to accelerate the deployment of renewable energy and improve energy efficiency in China, primarily through REEEP. In 2005 the UK and India announced their intention for a structured dialogue on climate change. A number of activities have since been taken forward. In November 2005, the UK and India announced the launch of a joint study on how to reinforce co-operation on energy technology between developed and developing countries. Defra also funded a collaborative project with the Indian Ministry of Environment and Forests involving eight Indian research institutions that looked into the impacts of climate change in India.

Through REEEP the UK is funding initiatives to promote the acceleration of renewable energy and improvement of energy efficiency in India[101]. March 2006 saw the launch of the UK-Brazil working group on climate change, which focuses on the promotion of low-carbon technology globally, improved scientific collaboration on assessing the impacts of climate change and the further development of Brazil's leading role in the emerging Latin American carbon market. The working group will also examine the links between climate change, poverty eradication and social development.

These, and other bilateral activities, are described in the adaptation and technology transfer sections below.

## Emissions Reduction

6.5 In January 2005 the UK entered the EU Emissions Trading Scheme (EU ETS). The UK Government has been active in promoting the development of domestic Emissions Trading Schemes in countries outside of Europe, and in looking to establish links between those schemes and the EU ETS. The UK continues to exchange information with those countries that are developing ETSs outside of the EU. This included a successful session on emissions trading at the Montreal UN Climate Change conference in 2005.

## Adaptation

6.6 The UK supports a number of projects, which aim to help developing countries adapt to the impacts of climate change. Examples of these projects are given below and in the chapter on adaptation.

Defra and DFID commissioned a study on climate change in Africa in 2004. The aim of the study was to review the information available on climate change in Africa and to evaluate the adequacy of existing data to inform policy decisions. The study identified the knowledge gaps and suggested ways in which they could be filled[102].

Defra is supporting a new project, Advancing capacity to Support Climate Change Adaptation. This project aims to bring together the stakeholder and scientific communities of the developing world, to enable and support effective adaptation decisions that would reduce vulnerability to climate and environmental change while also promoting sustainable development. The project will support nine pilot projects in Asia and Africa. The UK Government has pledged €0.3m for a start-up phase and another €0.3m for implementation of the pilot actions.

99 The United Kingdom's Report on Demonstrable Progress Under the Kyoto Protocol, 2006.

100 UK Climate Change Programme 2006.

101 The UK Climate Change Programme, 2006.

102 http://www.defra.gov.uk/environment/climatechange/internat/devcountry/africa.htm

*India*

In India, Defra funded a collaborative project[103] with the Indian Ministry of Environment and Forests, involving eight Indian research institutes assessing the impacts of climate change on sea level variability, water resources, forests, agriculture, health, energy, industry and transport infrastructure through the development of climate change and socio-economic scenarios. Key results were that temperatures are likely to rise in the next few decades, leading to a reduction in wheat and rice yields in India; rainfall is predicted to rise, while periods of drought are expected to become longer in others, leading to changes in forestry and vegetation; incidents of malaria could increase in areas that are already prone to the disease, with the disease also entering new regions. The study also looked at the impact of climate change on a coastal railway system in South West India and showed that rising sea levels could cause severe disruption of services.

DFID is funding a study by the World Bank addressing vulnerability to climate variability and climate change in India through an assessment of adaptation issues and options. Key components of the project include a review of the current coping strategies of populations already affected by climate variability, an assessment of the likely impacts of increased climate variability and climate change on the agriculture and water sectors, and the elaboration of approaches to reduce vulnerability and enhance adaptation to climate related developments and events. Outcomes sought include a common understanding of issues and options for an informed dialogue between and within the Bank and the Government of India and better integration and mainstreaming of climate issues into the Bank's activities and into India's development efforts.

*China*

Between 2001 and 2004, the UK funded a bilateral research project in partnership with the Chinese government, investigating the impacts of climate change on Chinese agriculture[104]. A second phase has now begun, funded by both Defra and DFID. This programme, entitled "Integrated Assessment of Impacts of Climate Change on Chinese Agriculture and options for adaptation", combines cutting-edge scientific advice with practical policy recommendations. As well as integrating development aspects with scientific research, the programme is focusing on institutional and policy mapping in order to translate the scientific findings into provincial policies that support poor people's livelihoods. The initiative will look at the implications of climate change in one province in central China, and then examine how best to disseminate the approach nationally. This project is one of the first of its kind to combine scientific analysis of climate change impacts in a sub-region with the policy and planning process.

*Bangladesh*

DFID is providing £6 million over 5 years to support the UNDP and Government of Bangladesh in the establishment of the Comprehensive Disaster Management Programme (CDMP) for Bangladesh. This programme aims to enable the transition of disaster management from relief to a risk reduction focus, including longer-term climate risks. A significant component of CDMP specifically addresses climate change, with the aim of facilitating the management of long term climate risks and uncertainties as an integral part of national development planning. A Climate Change Cell has been established to build government capacity to coordinate and integrate climate change issues in mainstream development activities and across government. The cell's work will focus on awareness raising, advocacy and coordination to promote climate change adaptation and risk reduction in development activities, as well as strengthening existing knowledge and information accessibility on impact prediction and adaptation to climate change. Another part of CDMP is piloting a livelihood adaptation strategy approach for drought-related climate risks. This will develop a methodology to translate climate change impact data into agricultural response options and livelihood adaptation practices, with a view facilitating replication elsewhere.

103 Key sheets summarising results from the Indo-UK impacts project are available at www.defra.gov.uk/environment/climatechange/internat/devcountry/india2.htm

104 A research summary from the China-UK impacts project is available at www.defra.gov.uk/environment/climatechange/internat/devcountry/china2.htm

## Technology Transfer

6.7 The UK provides support on climate change related technology transfer in a number of different ways. This is mainly through its bilateral and multilateral activities, as mentioned elsewhere in this chapter, as well as a range of different programmes and funding undertaken by Government departments and agencies. Some of the key elements are outlined here and further details on specific projects in the format suggested by the UNFCCC reporting guidelines will be made available[105].

As part of the EU-China Partnership (signed in 2005), the UK is supporting a new initiative on near zero emissions coal (nZEC) with carbon capture and storage (CCS) in China. The overall aim is to bring forward the time when Chinese coal plants are built with CCS. The first phase of the project is a three-year feasibility study, which the UK is leading and is also supporting with £3.5M of funding (Defra £3M and DTI £0.5M). It is hoped that a demonstration project will have been set up in China by 2020[106].

The UK Technology Partnership Initiative was launched in 1993. Through its information network it aims to encourage the transfer of environmental technology and knowledge to developing countries on a commercial basis. It facilitates access to UK sources of environmental technology in the areas of energy management, renewable energy, cleaner technology and environmental monitoring and analysis. It also provides regular information through training and support as well as the production of a quarterly newsletter and case studies.

The UK launched the Climate Change Projects Office (CCPO) in 2001 to facilitate and promote the UK's participation in JI and CDM projects. The CCPO is jointly funded by Defra and the DTI. It also aims to enhance the UK's ability to capitalise on other significant anticipated climate change opportunities. It has developed a database of country specific information, relating to both host and investor countries, to allow understanding of the position of a country with respect to climate change.

The UK supported the development of, and continues to participate in, the implementation of the International Energy Agency's Greenhouse Gas Technology Information Exchange (GREENTIE). The database is intended to help developing countries to locate information on new technologies and identify equipment suppliers and centres of excellence.

The UK participates in the Climate Technology Initiative. The aim of the initiative is to promote the objectives of the UNFCCC by speeding up the development and dissemination of cost effective, environmentally friendly technologies, reducing barriers to existing technologies and encouraging the development of medium to long term technologies. The Initiative also works closely with the Secretariat to the UNFCCC with the aim of accelerating technology transfer.

As a member of the EU, the UK also participates in a wide range of European environmental programmes, which have relevance to climate change and technology transfer. For example, the UK Meteorological Office participates in a range of EU framework programmes, which have led to advances in the science of meteorology and the development of numerical weather prediction and climate simulation modelling. This has included the development of an ensemble prediction system for climate change.

## Science

6.8 The UK has developed PRECIS, a regional climate modelling system. PRECIS is described in more detail in Chapter 7. The UK Government currently funds the application of PRECIS in developing countries. Defra has contributed approximately £200,000 per annum to this project since 2000.

105 http://www.defra.gov.uk/Environment/climatechange/internat/

106 http://www.defra.gov.uk/Environment/climatechange/internat/devcountry/china.htm

# 7

# Research and Systematic Observations

## Key developments

- The Hadley Centre has developed a new climate model, called the Hadley Global Environment Model (HadGEM1). It has higher vertical and horizontal resolution, over both land and oceans, compared with its predecessors. It also incorporates improvements to the representation of the dynamics of the atmosphere, and of many processes in the atmosphere and oceans. Results from this model will be assessed in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.
- The Tyndall Centre for Climate Change Research was set up in 2000 and has established a worldwide reputation for high quality research into climate change response options, tackled from an inter-disciplinary perspective. Pioneering work has been carried out in a number of areas, including energy-economic modelling, adaptation in the water sector and decision-support tools for coastal zone management, flooding and public health, linking air quality and climate change mitigation, and perceptions of dangerous climate change.
- The Advanced Along-Track Scanning Radiometer (AATSR) instrument, procured by Defra in conjunction with NERC and the Australian Government, was successfully launched on the satellite ENVISAT in 2002. Validation of the data has demonstrated the accuracy of the satellite instrument, and its ability to detect climatic trends in the ocean. Preliminary analyses of the data indicate an observed warming trend between 0.1–0.2 °C per decade. The AATSR data will be added to measurements from previous satellite instruments, ATSR-1 and ATSR-2, to provide a sea surface temperature record covering approximately 15 years.
- The International Science Conference on "Stabilisation of Greenhouse Gases – Avoiding Dangerous Climate Change" took place, at the invitation of the British Prime Minister Tony Blair and under the sponsorship of the UK Department of Environment, Food and Rural Affairs (Defra), at the Met Office, Exeter, United Kingdom, on 1–3 February 2005. The conclusion of the meeting was that climate change looks to be worse than expected, that urgent action is needed to avoid considerable risks, and that the long term costs of mitigation are small and less than previously stated.

## Introduction

7.1 This chapter describes some of the UK's activities in the area of climate change research and systematic climate-related observations. It covers the UK's policy on promoting and funding climate-related scientific research and observations. It provides an overview of research activities funded by Government departments and Research Councils, and the UK's contribution to international research and capacity-building in research. It includes a summary of the UK's activities in information and data exchange, and some of the highlights of UK research. The report on Systematic Observations is provided in Section 5 of this chapter.

Climate research has a long history in the UK, and the Government continues to sponsor a wide range of research on climate change to improve our understanding of the climate system, the impacts of climate change on society and the human responses to climate change.

## General policy on and funding of research and observations

7.2 Climate research and procurement of climate-related observations are highly devolved activities in the UK. They are sponsored by various government departments to support a range of responsibilities and policy requirements. In addition, some research is increasingly being funded from a wider stakeholder base in both public and private sectors, particularly in the area of climate impacts and adaptation. The UK does not therefore have set national plans for climate research and observations. UK activities in the science and technology of climate change are co-ordinated through the Global Environmental Change Committee (GECC), an inter-agency Committee chaired by the Chief Scientist of Defra. Defra has the lead on climate change policy and provides funds of about £12 million each year for climate research and observations to advise the UK's policy and its impacts and response strategies. The UK's Environment Research Funders' Forum[107] (ERFF) brings together the UK's major public sector sponsors of environmental science, aiming to make best possible use of funding. The ERFF

107 Further information about the UK's Environmental Research Funders' Forum is available from www.erff.org.uk

provides broader co-ordination for funding of climate change related research for activities that clearly add value, could not be done by a single member acting alone, and have the potential to advance environmental research in the UK and internationally.

DTI funds work on new technologies and provide funding for the Research Councils. The Councils are responsible for maintaining the science base and operate at a distance from Government. They are responsible for basic research on climate prediction and processes and for some monitoring activities. The Met Office, as the national meteorological agency, also has a strong involvement in climate research and observation.

Systematic observations in the UK and its overseas territories are made by a number of national agencies and organizations. The UK Met Office is the lead agency for making and collecting meteorological and atmospheric observations and observations are also made by others including the Natural Environment Research Council's (NERC) Centres and Surveys. Collection of oceanographic (and marine) observations is widely distributed throughout the UK with many government departments and laboratories, universities and commercial companies involved. Terrestrial observations are made or coordinated by NERC, the Forestry Commission and others. The UK also contributes to space-based observations through the European agencies; the European Space Agency and the European Organisation for the Exploitation of Meteorological Satellites.

## Research

### 7.3.1 Policy-driven research funded by Government Departments

The Government funds a wide range of climate change research directly to inform UK policy development and to support international action on climate change through the UNFCCC and the IPCC.

The key aims of Defra's climate change research programme[108] are to:

- improve understanding of uncertainty in climate predictions;
- improve climate impact assessments and adaptation strategies;
- meet the UK's national and international commitments for assessing trends in greenhouse gas emissions and future projections;
- improve assessment of mitigation options and costs;
- help to build internationally acceptable approaches to responding to climate change in the long term; and
- continue long-term measurement of changes occurring in the ocean and the atmosphere.

The scope of this research broadly reflects the areas covered by the three Working Groups of the Intergovernmental Panel on Climate Change (IPCC), namely the scientific basis of climate change; impacts, adaptation and vulnerability; and mitigation (i.e. the reduction of greenhouse gas emissions).

The Ministry of Defence and Defra commission research from the Met Office's **Hadley Centre** for Climate Prediction and Research[109]. The Hadley Centre monitors global and national climate trends, and develops state of the art ocean-atmosphere coupled climate models. It uses them to assess the causes of climate change and to provide long-term global and regional projections. The Hadley Centre now employs 150 scientists and support staff, and much of its research involves international collaboration. The aims of the Hadley Centre's research continue to be:

1. To monitor climate variability and change on global and national scales;
2. To attribute recent changes in climate to specific natural and man-made factors;
3. To understand the processes within the climate system and develop comprehensive climate models which represent them;
4. To use climate models to simulate global and regional climate change over the last 100 years, and to predict changes over the next 100 years and beyond;
5. To predict the impacts caused by climate change such as the availability of water resources and capacity for food production.

108 Defra's climate change research programme is part of a larger Evidence and Innovation Strategy, which is described at www.defra.gov.uk/science/default.htm

109 Further information about the Hadley Centre can be found from www.metoffice.gov.uk/research/hadleycentre

As reported in the Third National Communication, an independent scientific review of the Hadley Centre's climate prediction work was carried out during 2000. The review assessed the merit of the scientific work carried out by the Hadley Centre, and wider questions about funding. It concluded that the Hadley Centre was "second to no other climate modelling centre world wide". This review exercise could not be repeated in 2005 (according to the established 5-year cycle) due to the pressures of the UK's simultaneous presidencies of the G8 and EU. An independent review will be commissioned in 2006.

In recent years the Hadley Centre's leading position amongst climate modelling centres has been maintained. A new model, HadGEM1, has been developed, and extensively tested. The value of the programme has increased significantly, to £11 million in 2005/06, and the overall driver continues to be to address policy relevant questions concerning future climate. Thus the programme now includes significant components aimed at understanding extremes of climate (as it is through extremes that the impacts of climate change will largely be felt), and understanding and quantifying uncertainties in predictions of future climate. Detection and attribution continues to be an important area of work.

Defra sponsors the Advanced Along Track Scanning Radiometer (AATSR) satellite instrument, which monitors sea surface temperatures to within an accuracy of 0.3K. It was launched in 2002 on the European Space Agency ENVISAT satellite platform and continues to operate successfully, extending the record of highly accurate sea surface temperature measurements from its precursor instruments ATSR and ATSR-2. Validation and data processing activities have also been supported by Defra to promote the use of these new datasets in climate studies.

Defra funds the **UK Climate Impacts Programme**[110] (UKCIP) on behalf of the UK government and devolved administrations, to provide a co-ordinated framework for assessing climate change impacts and identifying potential adaptation strategies in the UK. This is described in more detail in Chapter 5.

The Defra-funded "Fast Track" projects[111] were completed in 2004, and provided estimates of the implications of climate change at the global scale. Five linked projects assessed the effect of climate change and population growth on human health, natural vegetation, agriculture, the coastal zone, and water resources. The projects used socio-economic scenarios and climate projections made using the HadCM3 climate model driven by IPCC SRES emissions scenarios.

Defra also supports research to ensure that the UK meets its legal international reporting requirements to the EU Monitoring Mechanism, the UNFCCC and the Kyoto Protocol. This research includes the preparation of estimates of UK greenhouse gas emissions and removals, including research in specific sectors (e.g. emission estimates for abandoned mine methane, landfill methane, fluorinated gases etc); the preparation of estimates of baseline emissions projections for the non-carbon dioxide gases and for carbon dioxide emissions in the LULUCF sector; development of technologically disaggregated models of building and industrial sector carbon emissions and associated costs; emissions inventory verification through a long term measurement programme combined with inverse modelling techniques; and reviews of technological options capable of delivering deep cuts in emissions in the medium to long term including carbon capture and storage. The results of this research are reflected in the policies and measures included in the UK Climate Change Programme, and details and applications of some of this research are provided in Chapters 3, 4 and the Annexes of this Communication.

The Department for Trade and Industry funds the **Foresight** programme[112] to produce challenging visions of the future to ensure effective strategies now. (see Chapter 5).

The **Carbon Trust** is an independent company funded by the Government. It works with UK business and the public sector to cut carbon emissions and develop commercial low carbon technologies. The Carbon Trust's Applied Research Programme is open to UK businesses and research institutions and aims to support the development and commercialisation of technology with the potential to reduce UK carbon dioxide emissions. The Carbon Trust also supports Carbon Vision (see below).

110 More information about the UKCIP was provided in Chapter 5, and is available at www.ukcip.org.uk

111 Results from the "Fast Track" research projects were reported in a special edition of Global Environmental Change, volume 14, April 2004.

112 Foresight programme website at www.foresight.gov.uk

The Energy Saving Trust (EST) manages research into the health impacts of living in inefficiently heated homes and into ways of helping people who live in homes where conventional methods of cutting fuel bills cannot be applied.

A considerable amount of climate-related research is also funded by other Government bodies, including the Scottish Executive, the Welsh Assembly, the Department of Environment (Northern Ireland), the Forestry Commission, the Environment Agency, the Scottish Environment Protection Agency and the statutory conservation agencies.

### 7.3.2 Research Councils programmes

The Science Budget administered by the DTI provides funding to UK Research Councils to support basic, strategic and applied research and related postgraduate training. Research Council expenditure on climate change and energy-related research in 2004–5 was over £130 million. Included within this budget is funding for a variety of research work addressing aspects of adaptation to climate change with the potential to impact a broad range of sectors. This funding includes support for the Tyndall Centre for Climate Change Research.

The **Tyndall Centre** was set up in 2000 with a purpose "to research, assess and communicate from a distinct trans-disciplinary perspective, the options to mitigate, and the necessities to adapt to, climate change, and to integrate these into the global, UK and local contexts of sustainable development". It is core-funded by a partnership of three of the UK's Research Councils (NERC, EPSRC and ESRC) and also received support from the UK Department of Trade and Industry (DTI). The Centre comprises a selection of researchers from a consortium[113] of ten UK research institutions.

The Tyndall Centre has established a worldwide reputation for high quality research into climate change response options, tackled from an inter-disciplinary perspective. Much of the Tyndall Centre's work is agenda-setting and becomes research questions for other centres.

UK Research Councils commissioned an independent review of the Tyndall Centre in 2004. The review said "no comparable programme in its initial years has come further, faster or produced more exciting results than the Tyndall Centre." The review recommended that the Centre be supported in a manner that would allow it to expand the substantial benefits it is already providing. Following the review, the Tyndall Centre submitted a proposal for Phase 2 funding and NERC, ESRC and EPSRC have committed to a further three years' support for the Centre.

The Tyndall Centre has progressed pioneering work in energy-economic modelling, adaptation in the water sector and decision-support tools for coastal zone management, and has opened up new work on flooding and public health, linking air quality and climate change mitigation, and on perceptions of dangerous climate change. Some specific policy achievements include facilitating a more sustainable and participatory approach to coastal adaptation to climate change; a Handbook on Climate Change and Small Islands; work to produce the UKCIP02 climate change scenarios; highlighting the policy conflict between planned growth in aviation and climate change targets. Tyndall Centre work on Domestic Tradeable Quotas led to a Bill and Parliamentary debate.

The Government and Research Councils established the UK Energy Research Centre (UKERC) in 2004, based on the Tyndall experimental model, which is also being taken up by other institutes overseas.

The Natural Environment Research Council (NERC) identifies climate change (predicting and mitigating the impacts) as one of three science priority areas in their Strategic Plan[114] (2002–2007). This plan indicated that the environmental science community will seek to understand the integrated physical, chemical, geological and biological response to climate variability, and the consequent feedback on the climate system, at a range of temporal and spatial scales. It also set out fundamental research questions to be addressed by the scientific community. All of NERC's research centres and most of NERC's collaborative centres[115] have particular research focuses in climate change.

113 The Tyndall Consortium consists of groups drawn from departments within the following academic institutions: University of East Anglia, University of Southampton, University of Manchester, University of Cambridge, Centre for ecology and Hydrology, University of Sussex, University of Leeds, CLRC Rutherford Appleton Laboratory, Cranfield University, University of Sheffield.

114 NERC's Strategic Plan available from http://www.nerc.ac.uk/publications/strategicplan/

115 The NERC owns four research centres (British Antarctic Survey, British Geological Survey, Centre for Ecology and Hydrology, and Proudman Oceanographic Laboratory), and sponsors 15 collaborative centres. See www.nerc.ac.uk for further information.

The **Engineering and Physical Sciences Research Council** (EPSRC) 2005–08 Delivery Plan[116] includes several strands, which contribute to climate change research. Energy technologies for the *21st century* is a vibrant and diverse UK energy research programme to expand support for the research and associated training necessary to underpin all future energy options. This encompasses renewables, improved and cleaner use of fossil fuels, keeping the nuclear option open and addressing fusion for the longer term. A key focus will be the engineering and scientific aspects of the technologies that will reduce or remove the reliance on fossil fuels. Examples include improvements in clean coal technologies, materials for hydrogen storage providing a basis for a viable hydrogen economy, and improved catalysts for fuel cells. The EPSRC has funded a joint initiative with the UK Climate Impacts Programme to draw industry stakeholders alongside academic researchers to address the impacts of climate change in the built environment through the programme "Building Knowledge for a Changing Climate".

The **Economic and Social Research Council** (ESRC) includes 'Energy, the environment and climate change' as one of seven key research challenges in their Strategic Plan[117] for 2005-2010. ESRC's work in this field involves research on a variety of scales, using many different approaches to social science research. It includes looking at human behaviour and how it changes, and at how a fully sustainable economy would differ from the fossil-fuelled one of today. Working with the NERC and the EPSRC, ESRC aims to support further research as a part of the Research Councils' Energy Programme addressing the key goals of reducing carbon emissions, promoting competitive energy markets, tackling fuel poverty and maintaining reliability of energy supplies as outlined in the Government's Energy White Paper; support, in collaboration with other Research Councils, a new phase of research addressing the social, economic and political challenges of mitigating and adapting to climate change; build capacity for environmental research through enhanced support for inter-disciplinary studentships and fellowships.

The **Biotechnology and Biological Sciences Research Council** (BBSRC) supports climate change related research in response to proposals for individual projects under its seven science programmes, covering Agri-food, Animal Sciences, Biochemistry and Cell Biology, Biomolecular Sciences, Engineering and Biological Systems, Genes and Developmental Biology, and Plant and Microbial Sciences. Several of BBSRC's sponsored institutes have been particularly active in research into impacts of climate change on the function and behaviour of plants, animals and soils.

## International research and capacity building

7.4 The government supports the research and assessments of the IPCC, and UK scientists are involved in them, both directly and through the provision of a Technical Support Unit (TSU) hosted by the Met Office. Until mid-2002, the TSU supported IPCC Working Group I[118] activities while UK-based Sir John Houghton was co-chair of the Working Group. Since 2002, the UK has supported Professor Martin Parry as the co-chair of Working Group II[119], and the TSU now serves this working group. Since being set up, WGII TSU activities have focused on expert meetings, discussions and decisions leading towards the IPCC's Fourth Assessment Report (AR4), to be published in 2007. The UK has taken a leading role, on the steering committee, and providing lead authors and contributing authors, in the preparation of revised IPCC inventory guidelines, which will go forward for consideration and adoption at the next UNFCCC Conference of Parties.

The Hadley Centre has undertaken internationally renowned research, expected to be reviewed and assessed by the IPCC Fourth Assessment Report (AR4). Several of its scientists are authors of the AR4. The Hadley Centre has the only non-U.S. authors within the U.S. Climate Change Science Program (CCSP) and hosted a CCSP workshop in September 2004.

The government has funded the development of a portable regional climate model. The "Providing REgional Climates for Impact Studies" (PRECIS) model[120] is a regional climate modelling system developed at the Hadley Centre. It is designed to run on a PC and can be applied easily to any area of the globe to generate detailed climate change predictions. PRECIS should enable developing countries to generate their own local climate predictions without the need for supercomputers or individually developed modelling software.

116 EPSRC's Delivery Plan available at http://www.epsrc.ac.uk/publications/corporate/deliveryplan.htm

117 ESRC Strategic Plan available at http://www.esrcsocietytoday.ac.uk/ESRCInfoCentre/Images/Strategic_Plan_2005-10_tcm6-12995.pdf

118 IPCC Working Group I (WG1) – investigating the scientific basis of climate change

119 IPCC Working Group II (WG2) – impacts, adaptation and vulnerability

120 Further information on the PRECIS model is available at http://www.metoffice.gov.uk/research/hadleycentre/models/PRECIS.html

PRECIS is always released in conjunction with a workshop[121] to give scientific advice on designing model experiments and how to interpret results. Scientists at the Hadley Centre also provide post workshop support to users.

Defra funds the development of the Hadley Centre's regional climate model, and specific collaborations have focused on its application to India, southern Africa and China. DFID funds the PC version of the Hadley Centre's regional climate model. The United Nations Development Programme (UNDP) funds support for training materials relevant to PRECIS, for experts in developing countries. The PRECIS model is now used in numerous government and academic institutions around the world. The period 2004–2005 saw a focus on collaboration among countries in neighbouring regions of the world. Such collaborations now exist in South America and south Asia and scientists are working towards a similar collaboration in central Asia.

Since 2003, PRECIS workshops have been held in the UK, Cuba, Bhutan, Brazil, India, Turkey and Argentina. Delegates from fifty countries have been trained through PRECIS workshops. Workshops planned for 2006 will be held in Ghana, the UK and Malaysia.

A three-year collaborative project between Defra and the Chinese Ministry of Science and Technology investigated the impacts of climate change on Chinese agriculture[122] and concluded in 2004. Final outputs included calibration of the Hadley Centre's regional climate model for China, climate projections for the 21st century, socio-economic scenarios and national assessments of the impacts of climate change on key agricultural crops (wheat, rice, cotton, maize). In order to develop and apply climate and socio-economic scenarios for China, a scientist from the Chinese Academy of Sciences spending a year at the Hadley Centre learning how to set up, use and analyse results from the PRECIS model. A second three-year phase of this research was launched 2005. Alongside a more detailed national assessment of impacts, the project will produce a regional level scoping study, to identify effects on society, those most at risk from climate change (such as poorest population groups) and possible adaptation measures.

Defra funded a collaborative project[123] with the Indian Ministry of Environment and Forests (MOEF). This project involved eight Indian institutes in research to assess the impacts of climate change on sea level variability, water resources, forests, agriculture, health, energy, industry and transport infrastructure. The project was completed in 2005 and indicated that India was likely to face significant adverse effects in many sectors. Key sheets for each of the sectors were produced. The research programme included the sharing of knowledge through technology transfer and capacity building, including through scientists from Indian institutes working with UK research institutes, such as the Hadley Centre.

The UK government funds Hadley Centre international collaboration for the International Geosphere-Biosphere Programme (IGBP)[124]. The IGBP studies the interactions between biological, chemical and physical processes and human systems and collaborates with other programmes to develop and impart the understanding necessary to respond to global change.

The UK also contributes to the "Ensemble-based prediction of climate changes and their impacts" (ENSEMBLES) programme. ENSEMBLES[125] is half EU-funded and half funded through Hadley Centre funding streams. The research is coordinated by the Hadley Centre and aims to quantify the uncertainty in long-term predictions of climate change. It also considers climate change impacts on time frames ranging from seasonal to decadal and longer at global, regional, and local spatial scales. Other climate change-related EU research projects in which the Hadley Centre participates include PRUDENCE[126], CarboEurope[127], CarboOcean[128], SCOUT-3[129], DYNAMITE[130] and NitroEurope[131] and EURORISK.

121 Further information on PRECIS workshops is available at http://precis.metoffice.gov.uk/Training_courses_and_workshops.html

122 Further information on the China-UK climate impacts projects is available from www.defra.gov.uk or from the project website at www.ami.ac.cn/sino_uk

123 Further information on the Indo-UK climate impacts project, including the key sheets on each of the sectors, is available from www.defra.gov.uk

124 www.igbp.kva.se

125 http://www.ensembles-eu.org

126 http://prudence.dmi.dk/

127 http://www.carboeurope.org

128 http://www.carboocean.org/

129 http://www.ozone-sec.ch.cam.ac.uk/scout_o3/index.html

130 http://dynamite.nersc.no

131 http://www.neu.ceh.ac.uk/about.html

### 7.4.1 Information exchange (within UK and internationally)

Since 1991, the government-funded Climate Impacts LINK project has acted as the interface between the Hadley Centre and the national and international climate change impacts communities. LINK's main purpose is to facilitate the exchange of climate impacts-related ideas and information in several ways. Staff at the University of East Anglia's Climatic Research Unit provide scientific and technical advice. The LINK website[132] hosts the Hadley Centre's climate model results, a climate change research community database, including details of data users, projects and publications, and a database of observed climate data, including global and regional datasets.

The LINK Project is jointly responsible for the IPCC Data Distribution Centre[133] (DDC) along with organisations in Germany and the US. The DDC has been functioning since early 1998 and supports the activities of the Technical Support Units of IPCC Working Groups I (scientific basis), II (impacts and adaptation) and III (mitigation). DDC activities include collating new climate model datasets meeting the criteria of the IPCC's Task Group on Scenarios for Climate Impact Assessment (TGCIA), enhancing and extending Guidance Material, widening the range of available climate, environmental and socio-economic datasets, and encouraging climate modelling centres to make daily data available.

The UKCIP is an established link between stakeholders and researchers, and helps to make connections between partners and between researchers to stimulate climate change impacts studies. UKCIP facilitates the sharing of information, provides core data sets (such as the UKCIP02 climate change scenarios), and other tools for impacts assessments and adaptation studies. The UKCIP website is a key means of data and information exchange.

In February 2005, the UK hosted the **International Symposium on Stabilization of Greenhouse Gas Concentrations** – *Avoiding Dangerous Climate Change.* The conference provided new scientific evidence on the impacts of climate change on human and natural systems from work sponsored by the UK Government at the Hadley Centre. The message of the conference was that climate change looks set to be worse than expected, that we need to act urgently to avoid considerable risks and that the long term costs of mitigation are less than previously stated.

The scientific findings presented at the conference were published in January 2006 in a book on 'Avoiding Dangerous Climate Change'. The book presents a global picture of the impacts of climate change on natural and human systems, reflects on emission pathways that can lead to the stabilisation of greenhouse gas concentrations in the atmosphere and identifies technological options that can be deployed to achieve significant emission reductions. The book underlines the need for urgent action. It provides essential underlying science for the forthcoming international debate and will contribute to the IPCC's Fourth Assessment Report.

Government-funded regional climate modelling work also provides opportunities for data exchange. Two scientists, from ACMAD 'African Centre for Meteorological Applications to Development' and the Algerian Meteorological Service spent two weeks at the Hadley Centre in May 2003 learning about and working with PRECIS, with the aim of becoming contact points and eventually a local training/coordination centre for PRECIS work in the region. Since 2001, the Hadley Centre has also hosted visiting scientists from China, Japan, Australia and Russia.

### 7.4.2 Research highlights

The Hadley Centre has continued to make considerable progress in climate prediction and research. A paper by Stott et al.[134] on the unusually hot European summer of 2003 concluded that human activity has at least doubled the risk of such a summer occurring, and that by the middle of this century, such summers could be commonplace. A paper by Murphy et al.[135] used many different, but plausible, variants of the Hadley Centre model to investigate uncertainty in climate predictions. This involved generating probabilistic climate predictions, which it is hoped, will be useful for planning adaptation measures. The work suggests that climate sensitivity could be greater than that reported in the IPCC's Third Assessment Report. A paper by Gedney et al.[136]

132 http://www.cru.uea.ac.uk/link

133 The IPCC Data Distribution Centre is at http://ddcweb1.cru.uea.ac.uk

134 Stott, P. A., Stone, D. A., Allen, M. R. (2004). Human contribution to the European heatwave 2003. Nature, 432, 610–614.

135 Murphy J M, D M H Sexton, D N Barnett, G S Jones, M J Webb, M Collins and D A Stainforth (2004). Quantification of modelling uncertainties in a large ensemble of climate change simulations. Nature, 430, 768–772.

136 Gedney, N., P. M. Cox, R. Betts, O. Boucher, C. Huntingford, P. A. Stott (2006). Detection and attribution of changes in 20th century continental runoff. Nature, 439, 835-838.

has shown that a reason for increased river flows could be the effect of increasing atmospheric carbon dioxide on plants. The carbon dioxide causes the plants to take up less water, leaving more in the soil and enhancing run-off.

For the UK's Presidency of the G8 group of industrialised nations in 2005, the Tyndall Centre presented eight key findings from their research.

**Tyndall Centre "Key 8 for G8", 2005**

Climate change solutions should be fair and just

A low carbon economy will cost less than we thought

UK carbon reduction can be achieved

Crashing coral reefs are making Caribbean islands vulnerable to climate change

Shift from emergency flood response to health care preparedness

Climate scenarios help prepare for the UK's future

Involve communities in decisions about coastal planning

People won't care about climate change until it hits them

## Systematic Observations

### 7.5.1 Introduction

The Global Climate Observing System (GCOS) was established in 1992 to ensure that the observations and information needed to address climate-related issues are obtained and made available to all potential users. It is co-sponsored by the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organisation (UNESCO), the United Nations Environment Programme (UNEP) and the International Council for Science (ICSU). GCOS is intended to be a long-term, user-driven operational system capable of providing the comprehensive observations required for monitoring the climate system, for detecting and attributing climate change, for assessing the impacts of climate variability and change, and for supporting research toward improved understanding, modelling and prediction of the climate system. It addresses the total climate system including physical, chemical and biological properties, and atmospheric, oceanic, hydrologic, cryospheric and terrestrial processes. The GCOS will form the climate component of the Global Earth Observation System of Systems (GEOSS) and the GCOS Implementation Plan[137] (GIP) forms the basis of the GEOSS 10-year Implementation Plan[138], which has been formally endorsed by the UK Government, implying endorsement of the GIP. The UK has provided additional support to GCOS by funding Professor Paul Mason in his role as GCOS chairman, and now as vice-chair.

Systematic observations in the UK and its overseas territories are made by a number of national agencies and organizations. For making and collecting meteorological and atmospheric observations the lead agency is the Met Office, but observations are also made by the Natural Environment Research Council's (NERC) Centres and Surveys among others. Collection of oceanographic (and marine) observations is widely distributed throughout the UK with many government departments and laboratories, universities and commercial companies involved. Terrestrial observations are made or coordinated by NERC, the Forestry Commission and others. The UK also contributes to space-based observations through the European agencies ESA (European Space Agency) and EUMETSAT (the European Organization for the Exploitation of Meteorological Satellites).

The GECC sub-group on Observations coordinates observational activities, which are contributions to GEOSS, GCOS, GMES (Global Monitoring for Environment and Security) etc. and various satellite programmes. The Inter Agency Committee on Marine Science and Technology (IACMST) maintains an overview of marine activities across government and its GOOS (Global Ocean Observing System) Action Group acts as the UK national GOOS coordinating committee. Close liaison is maintained between the groups to ensure activities are coordinated.

This report focuses on those UK observations that relate to the designated GCOS networks (i.e. are relevant to global climate needs) as defined in the GIP and, as a result, need to be sustained in the longer-term, with data provided to the appropriate international data centres. Additional measurements from national networks are only noted briefly as these are supplementary and not necessarily essential (although may be useful) to GCOS. It is

137 Implementation Plan for the Global Observing Systems for Climate in Support of the UNFCCC. GCOS – 92, October 2004. (http://www.wmo.ch/web/gcos/Implementation_Plan_(GCOS).pdf)

138 GEOSS 10-Year Implementation Plan Reference Document. Ad hoc Group on Earth Observations (GEO), GEO-204, February 2005. Conference, September 2005. (http://earthobservations.org/docs/GEOSS%2010-Year%20Implementation%20Plan%20(GEO%201000).pdf)

planned that a further, more comprehensive report similar to that provided as part of the third national communication[139] will be prepared later during 2006.

### 7.5.2 Meteorological and atmospheric observations

The GCOS networks for surface and upper air observations (overland) are the GCOS Surface Network (GSN) and the GCOS Upper Air Network (GUAN). The Global Atmospheric Watch (GAW) provides the atmospheric chemistry component of GCOS. For making and collecting meteorological and atmospheric observations the lead agency is the Met Office but the NERC's Centres and Surveys also make observations among others. Met Office funding for these observations is provided through the National Meteorological Programme (NMP).

UK participation in the global atmospheric observing systems is as summarised in Table 7.1.

*Surface climate stations*

The Met Office is responsible for 6 GCOS Surface Network (GSN) stations in the UK (Lerwick, Stornoway, Eskdalemuir, Valley, Waddington and Camborne) and 2 stations overseas (St. Helena and Ascension Island). The NERC British Antarctic Survey (BAS) runs 3 GSN stations in the Antarctic (Halley, Rothera and Fossil Bluff). In addition 3 other GSN stations are operated in UK Overseas Territories (Gough Island, Bermuda and Pitcairn) for which UK is not responsible, although funding is provided through the NMP for the station on Pitcairn. BAS have just upgraded the AWS at Grytviken, South Georgia and will investigate whether this station (which has a record back to 1910) can be designated as a GSN station.

The 6 GCOS stations are a subset of the 20 stations within the UK's Regional Basic Climate Network (RBCN) and the 34 stations within the UK's Reference Climate Network. Overall, there are ~450 climatological stations in the UK made up from ~110 Principal Stations (which make hourly observations), ~285 Ordinary Stations (where observations are made at least once daily), ~35 Climate Data Logger sites and ~20 Health Resort stations. A large number of Ordinary Climatological Stations are voluntary, co-operating stations operated by other organisations or private individuals. The operation of these stations depends on the goodwill of authorities and individuals to provide the information, often free of charge. Gaps in the network occur when volunteers are not available and these may be filled by installing automatic equipment (Climate Data Loggers) to record the basic data. There are ~170 synoptic stations (reporting hourly) and around 3,000 rainfall stations.

*Upper air stations*

The Met Office runs 2 GCOS Upper Air (GUAN) stations in the UK (Lerwick and Camborne) and 3 GUAN stations overseas (Gibraltar, St. Helena and Mt. Pleasant), in addition BAS run the GUAN station at Halley. At present these stations meet the minimum requirement for profiles to at least 100 hPa (although 30 hPa generally appears to be the minimum expectation), but do not achieve the target requirement of 5 hPa. 3 other GUAN stations are operated by other countries in UK Overseas Territories (Ascension, Gough Island and Bermuda).

In addition BAS have commenced a regular upper air programme at Rothera and there is a long-term commitment to maintain the programme. They have been asked by GCOS to designate it as a GCOS Upper Air Network (GUAN) station, but it may be premature to do so. Support is provided by the Met Office for the BAS upper air programmes at Halley and Rothera.

**Table 7.1 Participation in the global atmospheric observing systems**

| | GSN | GUAN | GAW |
|---|---|---|---|
| How many stations are the responsibility of the Party | 11 | 6 | See Table 71.a |
| How many of those are operating now | 11 | 6 | |
| How many of those are operating to GCOS standards now | 11 | 6 | |
| How many are expected to be operating in 2009 | 11 | 6 | |
| How many are providing data to international data centres now | 11 | 6 | |

139 United Kingdom report on systematic observations for climate for the Global Climate Observation System (GCOS). Defra, October 2001. Available from http://www.defra.gov.uk/

Through the NMP the Met Office provides support to the GUAN station on Gough Island which is run by the South African Weather Service (SAWS) and also provides support to the GUAN stations at Seychelles, Penrhyn, Tarawa and Funafuti. Support is largely for consumables (sondes), although a technician is supported for Penrhyn. Support has also been provided towards setting up GUAN stations in Gan, Dar-es-Salaam and Yerevan.

In addition the Met Office is responsible for one of the two GUAN Data Analysis Centres and routinely monitors and quality controls monthly CLIMAT TEMP radiosonde data and develops upper air datasets for use in climate research.

In the UK the Met Office operates an upper air network of 6 stations; this includes the 2 manned GCOS stations (Lerwick and Camborne) plus 4 autosonde sites at Albemarle, Castor Bay, Herstmonceaux and Watnall.

*Global Atmospheric Watch (GAW)*

GAW provides the atmospheric chemistry component of GCOS and includes the Baseline Surface Radiation Network (BSRN). The GIP calls for the establishment of baseline networks for ozone, carbon dioxide and methane (these networks have still to be formally defined). Although the GAW Information System lists 28 stations registered for UK, including overseas sites, not all of these are active and not all are relevant to GCOS, (e.g. the list includes air quality monitoring sites).

Defra provides support for the Irish global GAW station at Mace Head on the west coast of Ireland.

The Met Office stations at Lerwick and Camborne are BSRN stations contributing to GCOS.

Column ozone measurements (funded by Defra) are made by the Met Office at Lerwick (record extending to 1957) and by Reading University. A limited number of ozonesonde ascents funded through the NMP are also made from Lerwick in support of satellite calibration. Column ozone measurements are also made by BAS at Halley (long term record to 1956) and Rothera. BAS also provide support to the Ukraine station at Vernadsky/Faraday and one of the Met Office instruments (the Dobson previously operated at Camborne) has been loaned to the SAWS for use at Gough Island.

In the UK, Lerwick is listed as a station in the GAW networks for $CO_2$ and $CH_4$. Met Office involvement ceased in 1996, although sampling continued to March 2004 (data for 1993 to 2001 have been submitted to the World Data Centre for Greenhouse Gases, WDCGG). Overseas the BAS station at Halley is a regional GAW station making greenhouse gas measurements and these are submitted through the NOAA CMDL (Climate Monitoring and Diagnostics Laboratory).

*Key climatological datasets*

The Hadley Centre receives, quality controls, and archives large amounts of observed climate data. These are used for monitoring the climate, in studies of the causes of climate change, and in climate modelling. On the national scale, the Central England Temperature[140] (CET) and the England and Wales (total) Precipitation[141] (EWP) are used as indicators of historical and present changes in climate. CET is representative of a roughly triangular area of the UK enclosed by Bristol, Lancashire and London. The monthly series begins in 1659, and to date is the longest available instrumental record of temperature in the world. The monthly time series of EWP begins in 1766

**Table 7.1.a Participation in the Global Atmospheric Watch**

| | BSRN | $O_3$ | GHG |
|---|---|---|---|
| How many stations are the responsibility of the Party | 2 | 4 | 2 |
| How many of those are operating now | 2 | 4 | 1 |
| How many of those are operating to GCOS standards now | 2 | * | * |
| How many are expected to be operating in 2009 | 2 | 4 | 1 |
| How many are providing data to international data centres now | 2 | 4 | 1 |

** not applicable - network yet to be defined by GCOS.*

140 Available from www.metoffice.gov.uk/research/hadleycentre/obsdata/cet.html

141 Available from www.metoffice.gov.uk/research/hadleycentre/obsdata/HadEWP.html

and the series is currently based on weighted averages of daily observations from a network of stations in five regions. It is the longest instrumental series of this kind in the world.

On the global scale, the Hadley Centre monitors the global average temperature[142] on land and over the sea, and the sea surface temperature in the tropical Pacific, which is an indicator of variations associated with El NiÉo. Key datasets are for global annual surface air temperature (HadCRUG prepared in collaboration with the Climatic Research Unit (CRU) of the University of East Anglia); for global sea ice and SST analyses (HadISST and MOHSST); quasi-global night marine air temperature analyses (HadMAT1and MOHMAT) and for global sea level pressure (GMSLP).

### 7.5.3 Oceanographic observations

For oceanographic observations the GCOS is based upon the open ocean (climate) module of the GOOS. Through IACMST a UK GOOS Strategic Plan[143] is being prepared and will be published in early 2006.

A significant portion of the UK's ocean observations capability lies within the NERC marine centres and is funded through research budgets. The NERC marine centres, together with the Marine Biological Association and Sir Alister Hardy Foundation for Ocean Science (SAHFOS) have jointly prepared a strategic research bid for the period 2007–2012 which includes support for 18 long-term monitoring activities, a number of which are relevant to GCOS. Surface marine meteorological observations are managed by the Met Office and funded through the NMP.

The components of the ocean observing system for climate are: Voluntary Observing Ships (VOS), the tropical moored buoy network, the global reference mooring network, the global drifter array (including ice buoys), the Global Sea Level Observing System (GLOSS) core sea level network, the Argo profiling float array, repeat XBT (expendable bathythermograph) lines from Ships of Opportunity (SOOP), and repeat hydrographic sections.

**Table 7.2 Participation in the global ocean observing system**

| | VOS | SOOP | TIDE GAUGES (GLOSS) | SFC DRIFTERS (DBCP)[1] | SUB-SFC FLOATS (Argo) | MOORED BUOYS[2] | ASAP[3] |
|---|---|---|---|---|---|---|---|
| For how many platforms is the Party responsible | 385 | 0 | 13 | 9 | 89 (end 2005) | 1 | 1 |
| How many are providing data to international data centres | 385 | 0 | 12[4] | 5[5] | all | 1 | 1 |
| How many are expected to be operating in 2009 | ~350 | 0 | 13 | Not known | ~150 (subject to funding) | 1 | |

*1 Excludes drifting buoys managed through E-SURFMAR.*
*2 Includes NOCS PAP mooring but excludes Met Office moored buoys that are not part of the designated GCOS system.*
*3 ASAP is no longer regarded as a GCOS network. UK currently runs one ASAP ship which in time will be integrated into the EUCOS ASAP (EASAP) programme.*
*4 The non-reporting station is "Signy" (in the Antarctic) where upgrade is difficult and it has been agreed amongst UK parties that this is not a top priority.*
*5 4 of the 9 are research buoys not reporting in real-time. Their data will, however, be made available in due course.*

142 Available from www.metoffice.gov.uk/research/hadleycentre/obsdata/globaltemperature.html
143 UK GOOS Strategic Plan. To be published by IACMST in 2006.

*Voluntary Observing Ships (VOS)*

The UK Voluntary Observing Fleet (VOF), which currently comprises around 385 vessels, is managed by the Met Office and contributes to the international VOS programme. Fleet numbers are expected to reduce during 2006, as non- or poorly performing ships will be deselected. Data from VOS provide the main source of information on air temperature and humidity over the ocean. This includes 55 vessels contributing to VOSClim (a subset of the VOS fleet reporting to higher standards), this number is expected to increase to ~80 by end 2006.

The Met Office also provides one of the two Global Collecting Centres for VOS data, with responsibility for basic quality control of ship data and collection of those data not available in real-time (e.g. ship's logbooks). These data are ultimately made available through the International Comprehensive Ocean Atmosphere Data Set (ICOADS) maintained by the US National Oceanic and Atmospheric Administration (NOAA). In addition the Met Office runs the Real Time Monitoring Centre for VOSClim data and provides the project leader for the VOSClim project, while the National Oceanography Centre, Southampton (NOCS) provides scientific advice to the project and carry out fundamental research into the application of VOS data and metadata for climate science.

*Ship of Opportunity Programme (SOOP)*

MoD funding, through the UK Hydrographic Office, for XBTs for the SOOP has ceased. These XBTs were deployed in low-density areal mode and this mode of deployment is being phased out and Argo floats (see below) now provide global areal coverage. The UK does not have responsibility for any of the high density or frequently repeated lines that SOOP is now focusing on. However, BAS carry out a series of XBT stations in the Weddell Sea.

*Tide gauges (GLOSS)*

The National Tidal and Sea Level Facility (NTSLF) was established in 2002 to reflect the importance of national sea level monitoring to the public and government, as well as to the academic community. It comprises the UK National Tide Gauge Network (of 44 gauges around the UK), geodetic networks for monitoring vertical land movements, and gauges in the British Dependent Territories of the South Atlantic and Gibraltar. Responsibility for funding the UK National Tide Gauge Network lies with the Environment Agency. The South Atlantic gauges are funded through NERC as part of its science programme, and future support for the South Atlantic network is included in the NERC strategic marine research bid. The Government of Gibraltar partly supports the gauge in Gibraltar. These gauges contribute to the GLOSS network, which in turn has a GCOS sub-set of gauges.

NERC Proudman Oceanographic Laboratory (POL) is responsible for 3 UK gauges (Lerwick, Stornoway and Newlyn) and 7 South Atlantic gauges (Bermuda, Diego Garcia, Vernadsky/Faraday, Gibraltar, Rothera, Signy (inactive), St Helena and Stanley) that contribute to the GCOS GLOSS sub-set. Bermuda and Diego Garcia are operated jointly with NOAA and Vernadsky/Faraday with the Ukraine Antarctic Expedition. BAS also operate a GCOS gauge at Rothera. A further 4 stations operated by POL (Ascension, Tristan da Cunha, South Caicos and South Georgia (not presently operating)) are part of the GLOSS network. POL are also involved in providing support for the GLOSS GCOS gauges for Pemba (Mozambique) and Cananeia (Brazil).

The Permanent Service for Mean Sea Level (PSMSL) is hosted by POL and holds the global databank for sea level data from over 1,800 tide gauges and so is an important data centre contributing to GCOS. Funding for the PSMSL is almost entirely provided through the NERC science budget, and future support is included in the NERC strategic marine research bid.

*Drifting buoys*

The global drifter network of 1,250 drifters has been adopted by GCOS as a baseline network. Over the last 5 years the Met Office has typically deployed around 20 to 30 drifting buoys per year in the North Atlantic as part of its contribution to EGOS (European Group on Ocean Stations), which was an Action Group of the WMO/IOC Data Buoy Cooperation Panel (DBCP). In 2005 EGOS responsibilities were transferred to the EUMETNET Composite Observing System (EUCOS) Surface Marine programme (E-SURFMAR) and the drifters are now procured and managed through E-SURFMAR, although the Met Office are likely to arrange an increasing number of deployments for the programme. In the longer-term, proposals (subject to approval by EUCOS) are to increase the number of drifting buoys deployed (with pressure sensors) in the North Atlantic and Mediterranean to as many as 175. This would more than meet the coverage required by GCOS in the North Atlantic.

With the transfer of funding for drifter operations to E-SURFMAR, there is currently no assured regular NMP funding for drifters to be deployed in other ocean areas in support of the baseline global array required by GCOS (and GOOS). Nonetheless, 5 Southern Ocean drifters were deployed in late 2005 and it is hoped to continue this contribution to the Southern Ocean/South Atlantic.

A few drifting buoys (including ice buoys) have in the past been deployed by research organisations (e.g. BAS, SAMS (Scottish Association for Marine Science) and SPRI (Scott Polar Research Institute)) and SAMS presently (March 2006) have 4 ice buoys operating on the Arctic ice north of Greenland.

*Global reference mooring network and tropical moored buoys*

A sparse global network of 29 moorings for surface reference measurements is called for by the GCOS IP to provide essential air-sea flux information for testing models and evaluating climate change projections. These sites are coordinated through the OceanSITES (OCEAN Sustained Interdisciplinary Timeseries Environment observation System) programme. This network includes the Porcupine Abyssal Plane (PAP) mooring run by NOCS. The PAP mooring is listed as one of the NERC long-term monitoring activities in the NERC strategic marine research bid.

The tropical moored buoy arrays in the Pacific (TAO/TRITON) and the Atlantic (PIRATA) are designated as GCOS networks. The UK does not contribute to these networks, although a network of moored buoys is maintained by the Met Office in the north-east Atlantic as part of its Marine Automatic Weather Station (MAWS) network. The MAWS network provides a number of time-series now extending over 10-years, which have becoming increasingly valuable for climate studies and provided a valuable contribution to the recent 'State of UK Seas' assessment[144].

*Sub-surface profiling floats (Argo)*

The UK has made a substantial contribution to the Argo programme, with its first Argo deployments in January 2001. Since then, around 180 floats have been deployed by the UK in a wide range of ocean areas (North and South Atlantic, Arctic Ocean, Southern Ocean and the Indian Ocean) in support of building the global Argo array. Over the last few years 3 floats have been donated to Mauritius who have deployed them in regions of specific interest to them.

Funding for UK Argo is being provided by Defra, Ministry of Defence (MoD) and NERC. The MoD funding stream ends in March 2006, but Defra expect to continue funding Argo into 2007 and NERC funding (for data processing and science, but not floats) is in place to March 2007. Efforts to identify sustained funding are ongoing and longer term NERC funding is included in their funding bid for 2007-2012.

*Repeat hydrographic surveys*

High quality hydrographic surveys are made as part of research funded programmes. The GIP recommends a system of around 30 hydrographic sections, repeated on a 10-year cycle (but more frequently where conditions are more variable). A number of these sections are (or have been) occupied by the UK. These include the Drake Passage (section A21/S1 – carried out by NOCS on an annual basis, has been occupied most years since 1993); Indian Ocean 30S section (I5 – occupied in 1987, 1995 and in 2002 by NOCS); Atlantic Ocean 24.5N section (A5 – occupied by NOCS in 2004); Atlantic Meridional Transect (AMT – cruises funded 2002-2005). Ongoing funding for the Drake Passage section and for AMT cruises is included in the NERC strategic marine research bid.

A number of other repeat hydrographic sections are also occupied by UK agencies: Ellett Line and the extended line to Iceland – by NOCS, SAMS and FRS (Scottish Fisheries Research Services); Faroes to Shetland sections and east of Orkney (JONSIS – Joint North Sea Information System) by FRS. These are not part of the GCOS network, although the Faroes/Shetland time-series extend back to 1903 and are the longest time-series of oceanographic parameters in UK waters, so are important in defining the climate of UK seas.

*Ocean carbon measurements*

The oceans are the largest long-term sink for anthropogenic carbon and hold some 95 per cent of the carbon that circulates in the biosphere. Ocean carbon measurements are made from fixed (time-series) sites, certain SOOP vessels and during repeat hydrography surveys. Key UK contributions are the two regular ship programmes of surface water measurements of $CO_2$ using SOOP that are operated by UK scientists: (i) Portsmouth to

144 Charting Progress: An Integrated Assessment of the State of UK Seas. 2: Marine Processes and Climate. Defra, March 2005. Available from **http://www.defra.gov.uk/**

Martinique in the Caribbean (M/V Santa Maria), return trip approximately 4 weeks; (ii) Southampton to Bilbao (M/V Pride of Bilbao), 3 day round trip (2+ trips per week) – year round late January to early January except for 3 week refit period; Atlantic Meridional Transect (AMT) (see above).

*Continuous Plankton Recorder (CPR) survey*

While not specifically identified as a GCOS baseline network the GIP states that phytoplankton records from analyses of the CPR data provide the only basin-scale multi-decadal records of ocean ecosystem variables and that sustained repeat CPR sections should be developed and implemented. The CPR survey is operated by the Sir Alister Hardy Foundation for Ocean Science (SAHFOS), a Charity and Company limited by guarantee, funded from UK and international sources in open competition with other institutions for contracts and tenders. SAHFOS has been collecting data from the North Atlantic and the North Sea on biogeography and ecology of plankton since 1931. The CPR survey provides many ecological indicators of use to marine management, including indicators of zooplankton and phytoplankton biomass, biodiversity and climate change. The survey produces an annual assessment of the 'ecological status of the North Atlantic', utilising these and other indicators to provide a large-scale status report on the region. These data are a valuable and relevant contribution to GOOS/GCOS.

### 7.5.4 Terrestrial observations

For terrestrial observations GCOS works with the Global Terrestrial Observing System (GTOS) – which is a programme for observations, modelling, and analysis of terrestrial ecosystems to support sustainable development – through the TOPC (Terrestrial Observations Panel for Climate). However the terrestrial domain is the least well-developed component of the GCOS. The Global Terrestrial Network (GT-Net) of the GTOS is a system of observation networks that includes those for ecology (GTN-E), glaciers (GTN-G), hydrology (GTN-H) and permafrost (GTN-P). The GTN-R (rivers) and GTN-L (lakes) networks being newly established components of the GTN-H.

*Hydrological monitoring*

The GTN-R, which has recently been established as a GCOS baseline river discharge network, includes around 380 gauging stations near the downstream end of the world's largest rivers. These stations should capture about 70 per cent of the global freshwater (runoff) to the oceans. Following discussions with the Centre for Ecology and Hydrology (CEH) Wallingford six gauging stations have been confirmed as contributions to the network, these are the stations at Blairston (Clyde), Ballathie (Tay), Colwick (Trent), Kingston (Thames), Norham (Tweed) and Redbrook (Wye).

The UK National River Flow Archive provides stewardship for, and access to over 50,000 years of daily and monthly flow data deriving from over 1,300 gauging stations. Responsibility for the gauging station networks rests principally with the Environment Agency in England and Wales, the Scottish Environment Protection Agency and in Northern Ireland, the Rivers Agency. The National River Flow Archive (NRFA) is maintained by CEH Wallingford and its utility is increased by close co-operation with the National Groundwater Level Archive (NGLA) maintained by the British Geological Survey (BGS), both are major components of the National Water Archive.

Groundwater is also an essential climate variable, the wells and boreholes with the greatest utility are those where the impact of groundwater abstractions is least. The NGLA is maintained by the BGS and holds water level data for around 170 wells and boreholes throughout the UK. One borehole (Chilgrove) has a continuous record extending back to 1837 and a UK network of around half a dozen representative monitoring sites could be designated.

**Table 7.3 Participation in the global terrestrial observing systems**

| | GTN-P and GTN-G | FLUXNET | GTN-R | GTN-E |
|---|---|---|---|---|
| How many sites are the responsibility of the Party | 0 | 15 | 6 | 56 |
| How many of those are operating now | 0 | 15 | 6 | 56 |
| How many are providing data to international data centres now | 0 | 15 | 6 | 56 |
| How many are expected to be operating in 2009 | 0 | | 6 | |

*Carbon flux monitoring*

15 sites in the UK are presently contributing to the global FLUXNET network, 10 of these are operated by CEH. Most of these sites are part of the EC-funded CarboEurope Integrated Project (which started in January 2004).

*Ecological monitoring*

The UK Environmental Change Network (ECN) is the UK's long-term, integrated environmental monitoring and research programme. ECN gathers information about the pressures on and responses to environmental change in physical, chemical and biological systems. It is supported by a consortium of fourteen sponsoring organisations and seven research organisations. The programme operates a network of 12 terrestrial and 44 freshwater sites throughout the UK ranging from upland to lowland, moor land to chalk grassland, small ponds and streams to large rivers and lakes. The ECN is a member of the GT-E network.

Tree health is a matter of great public interest and concern and Britain participates in a pan-European annual survey of forest condition. The survey monitors crown density in some 370 plots distributed throughout Britain. Five species are surveyed – Sitka spruce, Norway spruce, Scots pine, oak and beech. Assessments were started in 1987. Since 1995, 10 permanent intensive monitoring Level II plots have been installed in Britain in accordance with EU protocols and an additional 10 plots were added in 2002.

### 7.5.5 Space-based Observations

UK makes important contributions to space-based observing programmes through ESA (European Space Agency) and EUMETSAT.

The UK makes a varying annual contribution to the infrastructure and programmes of EUMETSAT via contributions mainly from the Met Office (through the NMP). The UK share is ~17 per cent on a GNI basis. Although the operational programmes of EUMETSAT are predominantly intended to deliver near real-time data for meteorology, the observations, following further quality control and made available through archiving, underpin the GCOS.

The British National Space Centre (BNSC) represents the UK in ESA, and acts on behalf of Government and the Research Councils. BNSC is located in the Department of Trade and Industry and its membership includes a number of organisations including Defra, MoD, the Met Office and NERC.

#### EUMETSAT geostationary observations

*Meteosat Second Generation*

The main instrument on the Meteosat Second Generation (MSG) satellites is the Spinning Enhanced Visible and Infrared Imager (SEVIRI). SEVIRI data is largely used for imagery, but there are a number of products derived from SEVIRI data which are assimilated into Numerical Weather Prediction (NWP) models.

The UK developed Geostationary Earth Radiation Budget (GERB) instrument aboard all the MSG satellites contributes important data to climate studies, being the first instrument designed specifically to measure ERB parameters to fly on a geostationary platform.

To ensure continuity of observations from a geostationary orbit, the third generation of Meteosat satellites (MTG) is currently being designed, with an anticipated need date of 2015. Additional requirements for MTG, some of them serving climate applications, are being considered in defining the user requirements, although affordability will influence what can be achieved.

#### EUMETSAT low earth orbit observations

*EPS/MetOp*

The EUMETSAT Polar System (EPS) programme will launch the first of three MetOp polar orbiting satellites in a low earth orbit (LEO) in June 2006. This series of satellites will complement the global overview received through the geostationary service. The task of covering polar orbits will be shared between EUMETSAT and its US counterpart NOAA under the Initial Joint Polar System Agreement (IJPS).

The MetOp satellites will provide improved data in several areas including temperature and moisture soundings in all weather conditions, imagery of clouds, land and ocean surfaces, air-sea interactions and ozone mapping and monitoring. This data is very useful to both NWP and climate applications.

The IJPS agreement will need to be reviewed in the coming few years to ensure continuity of the LEO service.

Having established the first European polar meteorological satellite system with MetOp, EUMETSAT is already looking towards the requirements for the follow-on system which should become available from around 2020 or a little later. The user consultation process has started. Instrument concepts, including those for climate purposes, will be subsequently analysed within the constraints of affordability and technical feasibility.

*Jason-2*

The Jason-2 ocean altimetry programme is the first optional programme of EUMETSAT and will mark the transition of oceanography into the operational domain. Jason-2 will complement the Argo observations and it will enable an enhanced ocean monitoring and prediction capability. Its mission will be to continuously monitor the oceans by measuring sea levels and wave heights and to support marine weather and ocean forecasting. The programme costs will be shared by the US National Aeronautics and Space Administration (NASA), NOAA, French Centre National d'Etudes spatiales (CNES) and EUMETSAT.

Without Jason-2 data, it would not be possible to continue to monitor global or regional scale changes in sea-level with 1 mm/year accuracy and consequently there would be a break in the record of a critical environmental parameter. Uncertainty in the regional patterns of sea level rise would have a significant impact on investment planning for future coastal flood defences.

Altimeter data are important in climate model validation, as model predictions of future sea level rise in response to global warming vary greatly in their regional patterns. For wider climate modelling applications, high precision data are important but not critical.

Continuity of Jason-2 data needs to be addressed. This may be covered by the EU/ESA GMES missions.

**GMES**

The UK (through Defra) continues to have discussions regarding where prediction products and services for climate change and its impacts lies within GMES. The Met Office is the leader of a work package to scope the global climate change area as an additional dimension to GMES in an ESA submitted bid entitled: GMES Service Evolution (submitted mid-December 2005).

**ESA Earth Explorers**

The ESA Earth Explorer missions yield much interest for Climate monitoring:

*GOCE*

Expected to provide an order of magnitude improvement in the determination of the marine geoid, and hence lead to improved knowledge of the ocean circulation. It will also enable better use of altimeter data in ocean forecasting and improved modelling of the cryosphere.

*CRYOSAT–2*

Cryosat 2 will make a unique contribution to understanding how Arctic sea ice is thinning due to global warming, and the extent to which the Antarctic and Greenland ice sheets are contributing to global sea level rise.

In parallel with the space-based mission there will be extensive complementary modelling and ground-based experiments to maximise the scientific return from the mission. This will lead to improved predictions of future sea-ice extent and sea-level rise.

*SMOS*

Soil moisture and ocean salinity mission. If this mission achieves its stated accuracy, the soil moisture data will potentially be very useful for NWP and climate, as this is an important variable for which there are no current global observations. Likewise, ocean surface salinity is potentially very useful for climate, since no other global observations are available.

*EarthCare*

Earth, clouds, aerosol and radiation mission – to study atmospheric processes currently causing uncertainties in climate models. Uncertainties in the realism of clouds in climate models are currently a major source of uncertainty in climate predictions. This mission should provide valuable new information to advance understanding and modelling in this area.

# 8

# Education, Training and Public Awareness

## Key developments

- In 2005, the UK contributed 30,000 Euros to support the development of an internet-based Information Clearing House.
- The Sustainable *Development Action Plan for Education and Skills* was launched in September 2003
- "Tomorrow's climate, today's challenge". In 2006, Defra launched a three year cross-Government climate change communications initiative to raise awareness of the issue and inspire collective action.

## Support for Article 6 of the UN Framework Convention on Climate Change

8.1 The EU as a block supports activities organised by the UNFCCC Secretariat related to Article 6 of the Convention, which deals with education, training and public awareness. The EU, including the UK has endorsed the New Delhi Work Programme, which is a non-binding work programme agreed at COP8 in New Delhi (2002). This programme relates to the promotion of international cooperation, education, training, public awareness, public participation and public access to information. The UK submitted information on national activities undertaken to promote education, training and public awareness of climate change to the UN as part of an intermediate review of the New Delhi Work Programme in 2004. The UK also contributed 30,000 Euros in 2005 to support the development of an internet-based Information Clearing House designed to disseminate information on education, training and public awareness to the public.

## Training

8.2 The UK government funds the Hadley Centre for Climate Prediction and Research at the Met Office, which is at the forefront of training scientists from developing countries. The programme, called PRECIS (Providing Regional Climates for Impact Studies), trains scientists to use a regional climate modelling system that can run on a PC and generate detailed climate change predictions. Hadley Centre scientists have run training workshops in Cuba, Butan, Brazil and India as well as the UK. Scientists attended these workshops from 27 developing countries including Jamaica, Mexico, Nepal, Sri Lanka, India, Pakistan, Argentina and Uruguay. More workshops are being planned in Asia, South America, Africa and the UK. Scientists from China, India and Africa have also visited the UK to learn from scientists at the Hadley Centre.

In addition, the Met Office has a budget for capacity building in developing countries, which is part of the WMO (World Met Office) Voluntary Cooperation Programme. Students from Jamaica, Guyana and Ethiopia are currently being funded to study in the UK and there are fellowships in Uganda and Barbados. The Met Office supports a number of short courses; this year, a Reading University short course on Statistics in Applied Climatology (SIAC) is being run in Kenya, Algeria and Botswana.

## Education

### 8.3.1 Information for Young People

Much of the work relating to the education of children and young people in England about climate change is being taken forward under the wider banner of sustainable development. The Sustainable Development Action Plan for Education and Skills was launched in September 2003. Education for sustainable development is an approach to the whole curriculum and management of a school, not a new subject. It permeates teaching across the curriculum at all ages but is a teaching requirement in Science, Citizenship/ PSHE, Design and Technology, and Geography. The Government has developed web-based support material (http://www.nc.uk.net/esd/ index.html) to assist teachers to fulfil their enhanced responsibilities to cover sustainable development.

In Science, pupils learn about the benefits and drawbacks of scientific and technological developments on the environment, health and quality of life. They learn about the ways in which living things and the environment can be protected, and the importance of sustainable development. They also learn about the possible effects of burning fossil fuels on the environment, how these effects can be minimised and the distinction between renewable and non-renewable energy resources.

In Citizenship, pupils learn about the world as a global community, and the political, economic, environmental and social implications of this. They should develop skills of participation and responsible action.

In Personal, Social and Health Education (PSHE),

pupils are taught to consider social and moral dilemmas, for example, how the choices they make as consumers affect other people's economies and environments.

In Wales, Personal and Social Education (PSE) teaches pupils about how environmental issues affect the future quality of life. They are helped to understand the principles of stewardship and sustainability and to develop an informed concern for and responsible use of the environment. PSE also aims to empower pupils to develop a global perspective, and to encourage positive attitudes and behaviours towards the environment and the principles of sustainable development locally, nationally and globally.

In Design and Technology, pupils are taught to evaluate whether resources have been used appropriately, and the global, environmental impact of products. They should be able to assess their sustainability.

In Geography, pupils are taught to explore the idea of sustainable development and recognise its implications for people, places and environments, and for their own lives. They learn about physical and human processes, and their impact on places and environments, how and why weather and climate vary, the effects of resource use on the environment and the reasons for environmental change (for example, deforestation, the water cycle and ecosystems) and how to manage it.

In studying Geography in Wales, the theme of environmental change is introduced at primary school level. Pupils are taught to investigate ways in which people attempt to look after the present and safeguard the future environment through sustainable development, to understand the individual's responsibility and to recognise that people have different views about changes to the environment. At secondary school level this is developed further. Pupils learn about weather and climate, ecosystems, and resource issues. The programme of study also requires pupils to be taught about global environmental change, and in particular, about the nature, possible consequences and potential effects, and how considerations of sustainable development affect international responses to this change.

In Scotland there is no statutory national curriculum. Learning and Teaching Scotland **(www.ltscotland.org.uk)** is funded by the Scottish Executive to provide guidance on the curriculum for Scottish schools. The 5–14 national guidelines are non-statutory guidelines for Scottish local authorities and schools. One of the five broad curricular areas covered by the 5–14 curriculum is Environmental Studies. Pupils are taught to understand their environment, their place within it, and the factors, past and present, that have shaped it. They learn to develop informed attitudes and values relating to the care and conservation of the environment and should also gain an unde standing of issues relating to the use of resources and sustainable global development. A major review of the school curriculum in Scotland is currently being undertaken. A key purpose of the curriculum review will be to strengthen the contribution that cross-cutting and interdisciplinary elements, such as education for citizenship, for sustainable development, and for the global perspective, can make to subject learning.

The Government runs an interactive website for children and young people between seven and sixteen which explains the causes of climate change, why it is causing concern and what they can do to help reduce emissions **(http://www.defra.gov.uk/environment/climatechange/schools/index.htm)**. An information and activity pack is also available for children between seven and eleven years old. The pack includes activities that children can do at home and at school, games and a poster. It is available through the website.

ENCAMS **(http://www.encams.org)** is an environmental charity which works closely with the Government in running a number of campaigns and programmes, many of which are aimed at schools and young people. Eco-Schools is a European environmental award programme for schools. The scheme is designed to fit in with the curriculum and guides schools through a programme to involve pupils in decision making regarding the environmental management of the school.

Through the Environmental Action Fund, the Government funds the Atmospheric, Climate & Environment (ACE) Information Programme at Manchester Metropolitan University to disseminate information on the causes, effects of and controls on air pollution and climate change, within the framework of national legislation and international discussion.

The Government and the devolved administrations are keen for schools to adopt a 'whole school approach' to energy efficiency, incorporating both sound energy management and the education of

pupils and through them, the wider community. The National Curriculum is supported by a range of other projects aimed at schools, some of which are funded by Government and some which involve private sector companies working in partnership. An example is the Energy Certification for Schools programme **(http://www.est.org.uk/schools/)**, run by the Energy Saving Trust. The programme offers schools lower energy bills and help with finding curriculum resources for use in the classroom. The Centre for Research Education and training in Energy (CREATE) is a not-for-profit body which is partly funded by the Government. CREATE develops, manages and delivers school-based education programmes relating to climate change, renewable energy, energy efficiency, recycling and sustainable transport.

### 8.3.2 Educating the Public about the Impact of Climate Change in Developing Countries

The Department for International Development (DFID) provided support to the interactive exhibition run by London's Science Museum, *Climate Change: The Burning Issue*, which ran from March to September 2002. It demonstrated what is being done to model, measure and manage the effects and implications of climate change. The exhibition included displays on the potential implications for developing countries and what researchers and communities are doing not only to reduce emissions but also to cope with the changing climate.

DFID also supported a Schools Initiative for the exhibition in conjunction with six UK schools. The schools linked up with partner institutions in the developing world and developed questions to pose to a panel of "experts"/"key players". These were put to panellists, including the DFID Parliamentary Under Secretary of State, in a panel discussion held in February 2003.

As a follow up to this work, between the end of March and early May 2004, the Dana Centre (part of London's Science Museum) ran a series of three DFID-sponsored events on climate change. These raised awareness of and focused attention on the effects of the UK public's lifestyle choices on people in the developing world, and involved college and university institutions and a local Bangladeshi community.

This project took the form of an innovative combination of brainstorming sessions and interactive forum theatre. In each case, experts on a range of aspects of climate change put forward the case for a particular radical solution, and the audience voted (as groups) for their favourite.

## The Carbon Trust Campaign

8.4 In January 2005 the government-support Carbon Trust ran an integrated multi-media campaign to raise awareness of climate change – and the need to do something about it – among business audiences. The twin themes of responsibility and action were designed to place carbon emission reduction on the business agenda, to explain the services available from the Carbon Trust and to signpost the opportunities for business in the development of the low carbon economy. The campaign was a notable success –meeting or exceeding all of its key performance goals including:

- a significant increase in awareness of climate change and carbon emission reduction as business issues.
- Over 30,000 new and unique visitors to the business advice website.
- Over 3,000 business action packs ordered.
- hundreds of businesses attending briefing events across the UK.

The total campaign spend of £4 million; including heavyweight TV, outdoor and press advertising, meant this was the largest business campaign on climate change of its kind in the world to date. Further developments of the campaign are planned for 2006.

For more information contact the Carbon Trust on 0800 085 2005 or **www.carbontrust.co.uk**.

## The Energy Saving Trust

8.5 The Energy Saving Trust is a Government-supported body, which works with households, businesses and the public sector to increase awareness of how to reduce greenhouse gas emissions through energy efficiency and the promotion of renewable technologies. Information on their campaigns can be found through their website at **http://www.est.org.uk**.

## Climate Change Communications Initiative

8.6 Defra has launched a new three year cross Government climate change communications initiative to raise awareness of the issue and inspire collective action. The initiative includes a new £6m fund, spread over the next two years, to support local communicators and a new slogan, "Tomorrow's climate, today's challenge", which will help unite climate change communicators across Government and beyond.

A new website, **www.climatechallenge.gov.uk** has been launched carrying easy-to-access information about climate change and how best to communicate it. The site provides free-to-use resources, including a short film about climate change, a series of radio adverts and a downloadable written guide about communicating climate change. A series of initiatives is being planned during 2006, including a youth competition designed to create nine regional climate change young champions across England. A similar competition, aiming to select a group of young people for each local authority area, is being launched in Wales on 17 May 2006.

Defra is working with its key delivery partners – the Carbon Trust, Energy Saving Trust, Environment Agency, Sustainable Development Commission and UK Climate Impacts Programme, and other Government departments. It follows a detailed report by consultants Futerra.

## Sustainable Development

8.7 The Government's Sustainable Development Strategy *Securing the Future – delivering UK sustainable development strategy*[145], introduced a new approach to delivering long-term behaviour change based on the latest research and evidence, and gave greater recognition to some of the social and practical factors that influence and limit behaviour. Implementation of the strategy is supported by a range of communications activities, including the **www.sustainable-development.co.uk** website, the 'SD-Scene' e-newsletter, podcasts, stakeholder events and awards sponsorship. As part of this strategy it is recognised that the public need clear and reliable advice about the environmental impact of different products and services and how they can make the most sustainable consumption choices. The Government believes that the best way of making this available is through the internet; and is planning a new online information service.

Community Action 2020 is a specific programme within the voluntary and community sector to deliver Sustainable Development[146]. It includes the Community resource bank, which aims to improve community access to ideas, advice, toolkits and information which can help community groups make a difference on sustainable development. In November 2005 Defra commissioned an independent researcher to review some of the existing written materials, which help community groups to tackle sustai able development[147].

The Academy for Sustainable Communities (ASC) is a new national and international centre of excellence for the skills and knowledge needed to create communities fit for the 21st century[148]. The focus is on increasing skills and learning, targeting skills shortages and sharing knowledge and expertise.

145 http://www.sustainable-development.gov.uk/index.asp
146 http://www.sustainable-development.gov.uk/advice/community/index.htm#Community
147 http://www.sustainable-development.gov.uk/advice/community/documents/andrew-darnton-action2020-reportupdate-111105.pdf
148 http://www.ascskills.org.uk/what_we_do/index.cfm

# Annexes

# Annex A

## Inventory Tables

### SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A)

Submission 2006

1990

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | | CO2 net | CH4 | N2O | HFCs | | PFCs | | SF6 | | NOx | CO | NMVOC | SO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | A | P | A | P | A | | | | |
| | | (Gg) | | | CO2 equivalent (Gg) | | | | | | (Gg) | | | |
| **Total National Emissions and Removals** | | **592117** | **-4376** | **220** | **12** | **11375** | **74** | **1481** | **0.08** | **0.04** | **2932** | **8280** | **2304** | **2699** |
| **1. Energy** | | **573856** | **1487** | **19** | | | | | | | **2906** | **7714** | **1415** | **2640** |
| A. Fuel Combustion | Reference Approach | 564095 | | | | | | | | | | | | |
| | Sectoral Approach | 566439 | 125 | 19 | | | | | | | 2892 | 7655 | 1034 | 2611 |
| 1. Energy Industries | | 235829 | 7 | 6 | | | | | | | 852.5 | 131.3 | 8.1 | 2888.1 |
| 2. Manufacturing Industries and Construction | | 99023 | 15 | 5 | | | | | | | 389.3 | 734.3 | 36.5 | 416.8 |
| 3. Transport | | 117227 | 30 | 4 | | | | | | | 1420.3 | 5525.3 | 875.1 | 94.8 |
| 4. Other Sectors | | 109079 | 73 | 3 | | | | | | | 214.4 | 1250.3 | 114.8 | 203.0 |
| 5. Other | a | 5285 | 0 | 0 | | | | | | | 35.5 | 13.4 | 2.3 | 9.2 |
| B. Fugitive Emissions from Fuels | | 6817 | 1362 | 0 | | | | | | | 1.0 | 60 | 381 | 29 |
| 1. Solid Fuels | | 856 | 871 | 0 | | | | | | | 0.6 | 38.5 | 0.3 | 20.7 |
| 2. Oil and Natural Gas | | 5760 | 491 | 0 | | | | | | | 13.3 | 21.5 | 380.7 | 7.8 |
| **2. Industrial Processes** | | **13102** | **8** | **94** | **12** | **11375** | **74** | **1481** | **0.08** | **0.04** | **10.94** | **270.08** | **258.44** | **52.22** |
| A. Mineral Products | | 9478 | 1 | 0 | | 0.00 | | 0.00 | | 0.00 | 0.0 | 5.0 | 12.9 | 4.3 |
| B. Chemical Industry | | 1323 | 6 | 94 | | 0.00 | | 0.00 | | 0.00 | 8.5 | 80.9 | 165.7 | 39.0 |
| C. Metal Production | | 2310 | 1 | 0 | 0.00 | 0.00 | 0.00 | 1332.75 | 0.00 | 0.02 | 2.5 | 183.2 | 2.1 | 8.9 |
| D. Other Production | | 0 | 0 | 0 | | 0.00 | | 0.00 | | 0.00 | 0.0 | 0.0 | 77.7 | 0.0 |
| E. Production of Halocarbons and SF6 | | 0 | 0 | 0 | 0.00 | 1137.4 | 0.00 | 10.90 | | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 |
| F. Consumption of Halocarbons and SF6 | b | 0 | 0 | 0 | 12 | 2 | 73.65 | 57.80 | 0.08 | 0.02 | 0.0 | 0.0 | 0.0 | 0.0 |
| G. Other | | 0 | 0 | 0 | | 0.00 | | 0.00 | | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 |
| **3. Solvent and Other Product Use** | | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0.0** | **0.0** | **469.6** | **0.0** |
| **4. Agriculture** | | **0** | **1023** | **103** | | | | | | | **9** | **266** | **26** | **8** |
| A. Enteric Fermentation | | 0 | 871 | 0 | | | | | | | 0.0 | 0.0 | 0.0 | |
| B. Manure Management | | 0 | 130 | 5 | | | | | | | 0.0 | 0.0 | 0.0 | |
| C. Rice Cultivation | | 0 | 0 | 0 | | | | | | | 0.0 | 0.0 | 0.0 | |
| D. Agricultural Soils | | 0 | 0 | 98 | | | | | | | 0.0 | 0.0 | 0.0 | |
| E. Prescribed Burning of Savannas | | 0 | 0 | 0 | | | | | | | 0.0 | 0.0 | 0.0 | |
| F. Field Burning of Agricultural Residues | c | 0 | 13 | 0 | | | | | | | 9.1 | 266.0 | 26.1 | |
| G. Other | | 0 | 0 | 0 | | | | | | | 0.0 | 0.0 | 0.0 | |
| **5. Land-Use Change and Forestry** | | **2515** | **1** | **0.005** | **0** | **0** | **0** | **0** | **0** | **0** | **0.2** | **5.8** | **0** | **0** |
| 5A Forest Land | | -12203 | 0 | 0 | | | | | | | 0.0 | 0.0 | | |
| 5B Cropland | | 15842 | 0 | 0 | | | | | | | 0.0 | 0.0 | | |
| 5C Grassland | | -6195 | 0.15 | 0.001 | | | | | | | 0.04 | 1.3 | | |
| 5D Wetland | | 0 | 0 | 0 | | | | | | | 0.0 | 0.0 | | |
| 5E Settlements | | 6925 | 0.51 | 0.004 | | | | | | | 0.1 | 4.5 | | |
| 5F Other Land | | 0 | 0 | 0 | | | | | | | 0.0 | 0.0 | | |
| 5G Other Activities | | -1456 | 0 | 0 | | | | | | | 0.0 | 0.0 | | |
| **6. Waste** | | **1201** | **1858** | **3** | **0** | **0** | **0** | **0** | **0** | **0** | **6** | **23** | **25** | **7** |
| A. Solid Waste Disposal on Land | | 0 | 1818 | 0 | | | | | | | 0.0 | 0.0 | 18.2 | 0.0 |
| B. Wastewater Handling | d | 0 | 34 | 3 | | | | | | | 0.0 | 0.0 | 0.0 | 0.0 |
| C. Waste Incineration | | 1201 | 6 | 0 | | | | | | | 6.1 | 23.3 | 6.5 | 7.3 |
| D. Other | | 0 | 0 | 0 | | | | | | | 0.0 | 0.0 | 0.0 | 0.0 |
| **7. Other (please specify)** | | **1844** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **Memo Items: (7)** | | | | | | | | | | | | | | |
| **International Bunkers** | e | **22345** | **1** | **1** | **0** | **0** | **0** | **0** | **0** | **0** | **195** | **28** | **9** | **95** |
| Aviation | e | 15668 | 0 | 0 | | | | | | | 75.6 | 12.8 | 5.1 | 3.9 |
| Marine | e | 6677 | 1 | 0 | | | | | | | 119.6 | 15.5 | 4.4 | 92.3 |
| **Multilateral Operations** | | | | | | | | | | | | | | |
| **CO2 Emissions from Biomass** | f | 2878 | | | | | | | | | | | | |

a Naval vessels and military aircraft

b Emissions arise from refrigeration, electronics applications, electrical insulation, foams, aerosols and training shoes

c Field burning ceased in 1994

d Emissions from own wastewater treatment by industry are not estimated

e Emissions are for information only and are not totalled

f Emissions arise from wood, straw, bagasse and poultry litter combustion for energy production

## SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (IPCC TABLE 7A)

Submission 2006

2004

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | | CO2 net | CH4 | N2O | HFCs | | PFCs | | SF6 | | NOx | CO | NMVOC | SO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | A | P | A | P | A | | | | |
| | | (Gg) | | | CO2 equivalent (Gg) | | | | | | (Gg) | | | |
| Total National Emissions and Removals | | 599092 | 2385 | 13 | 9799 | 8858 | 149 | 352 | 0.83 | 0.85 | 1621 | 2919 | 1022 | 833 |
| 1. Energy | | 547121 | 583 | 29 | | | | | | | 1616 | 2757 | 465 | 801 |
| A. Fuel Combustion | Reference Approach | 547567 | | | | | | | | | | | | |
| | Sectoral Approach | 541853 | 82 | 29 | | | | | | | 161.5 | 2738 | 237 | 795 |
| 1. Energy Industries | | 207149 | 7 | 4 | | | | | | | 484.7 | 84.0 | 5.9 | 565.1 |
| 2. Manufacturing Industries and Construction | | 87857 | 14 | 4 | | | | | | | 263.0 | 660.3 | 35.1 | 140.7 |
| 3. Transport | | 128487 | 9 | 18 | | | | | | | 491.7 | 1435.1 | 138.8 | 38.7 |
| 4. Other Sectors | | 115457 | 32 | 2 | | | | | | | 193.1 | 551.5 | 84.3 | 41.0 |
| 5. Other | a | 2903 | 0 | 0 | | | | | | | 20.2 | 7.3 | 1.3 | 5.4 |
| B. Fugitive Emissions from Fuels | | 5268 | 527 | 0 | | | | | | | 5 | 19 | 228 | 10 |
| 1. Solid Fuels | | 168 | 238 | 0 | | | | | | | 0.4 | 6.6 | 0.1 | 8.8 |
| 2. Oil and Natural Gas | | 5100 | 288 | 0 | | | | | | | 3.8 | 12.8 | 207.9 | 1.3 |
| 2. Industrial Processes | | 11368 | 3 | 13 | 9799 | 8858 | 149 | 352 | 0.83 | 0.85 | 2.66 | 131.67 | 145.74 | 31.20 |
| A. Mineral Products | | 7950 | 1 | 0 | | 0.00 | | 0.00 | | 0.00 | 0.0 | 2.6 | 9.5 | 16.6 |
| B. Chemical Industry | | 1529 | 2 | 13 | | 0.00 | | 0.00 | | 0.00 | 1.1 | 28.9 | 53.7 | 7.4 |
| C. Metal Production | | 2089 | 1 | 0 | 0.00 | 1.18 | 0.00 | 152.36 | 0.00 | 0.02 | 1.6 | 100.1 | 1.6 | 7.4 |
| D. Other Production | | 0 | 0 | 0 | | 0.00 | | 0.00 | | 0.00 | 0.0 | 0.0 | 80.9 | 0.0 |
| E. Production of Halocarbons and SF6 | | 0 | 0 | 0 | 0.00 | 288 | 0.00 | 106.34 | | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 |
| F. Consumption of Halocarbons and SF6 | b | 0 | 0 | 0 | 9799 | 8571 | 148.52 | 93.53 | 0.83 | 0.83 | 0.0 | 0.0 | 0.0 | 0.0 |
| G. Other | | 0 | 0 | 0 | | 0.00 | | 0.00 | | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3. Solvent and Other Product Use | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 | 0.0 | 307.3 | 0.0 |
| 4. Agriculture | | 0 | 893 | 86 | | | | | | | 0 | 0 | 0 | 0 |
| A. Enteric Fermentation | | 0 | 771 | 0 | | | | | | | 0.0 | 0.0 | 0.0 | |
| B. Manure Management | | 0 | 122 | 4 | | | | | | | 0.0 | 0.0 | 0.0 | |
| C. Rice Cultivation | | 0 | 0 | 0 | | | | | | | 0.0 | 0.0 | 0.0 | |
| D. Agricultural Soils | | 0 | 0 | 82 | | | | | | | 0.0 | 0.0 | 0.0 | |
| E. Prescribed Burning of Savannas | | 0 | 0 | 0 | | | | | | | 0.0 | 0.0 | 0.0 | |
| F. Field Burning of Agricultural Residues | c | 0 | 0 | 0 | | | | | | | 0.0 | 0.0 | 0.0 | |
| G. Other | | 0 | 0 | 0 | | | | | | | 0.0 | 0.0 | 0.0 | |
| 5. Land-Use Change and Forestry | | -1942 | 1 | 0.005 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 | 7.0 | 0 | 0 |
| 5A Forest Land | | -16403 | 0 | 0 | | | | | | | 0.0 | 0.0 | | |
| 5B Cropland | | 15329 | 0 | 0 | | | | | | | 0.0 | 0.0 | | |
| 5C Grassland | | -7036 | 0.57 | 0.004 | | | | | | | 0.14 | 4.9 | | |
| 5D Wetland | | 0 | 0 | 0 | | | | | | | 0.0 | 0.0 | | |
| 5E Settlements | | 6248 | 0.29 | 0.002 | | | | | | | 0.1 | 2.0 | | |
| 5F Other Land | | 0 | 0 | 0 | | | | | | | 0.0 | 0.0 | | |
| 5G Other Activities | | 619 | 0 | 0 | | | | | | | 0.0 | 0.0 | | |
| 6. Waste | | 452 | 705 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 24 | 13 | 1 |
| A. Solid Waste Disposal on Land | | 0 | 667 | 0 | | | | | | | 0.0 | 0.0 | 6.7 | 0.0 |
| B. Wastewater Handling | d | 0 | 38 | 4 | | | | | | | 0.0 | 0.0 | 0.0 | 0.0 |
| C. Waste Incineration | | 452 | 0 | 0 | | | | | | | 1.8 | 23.5 | 6.7 | 0.9 |
| D. Other | | 0 | 0 | 0 | | | | | | | 0.0 | 0.0 | 0.0 | 0.0 |
| 7. Other (please specify) | | 2893 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Memo Items: (7) | | | | | | | | | | | | | | |
| International Bunkers | e | 38997 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 254 | 32 | 10 | 82 |
| Aviation | e | 13125 | 0 | 1 | | | | | | | 149.6 | 18.5 | 6.0 | 8.6 |
| Marine | e | 5872 | 1 | 0 | | | | | | | 104.5 | 13.5 | 3.9 | 73.0 |
| Multilateral Operations | | | | | | | | | | | | | | |
| CO2 Emissions from Biomass | f | 9373 | | | | | | | | | | | | |

a Naval vessels and military aircraft

b Emissions arise from refrigeration, electronics applications, electrical insulation, foams, aerosols and training shoes

c Field burning ceased in 1991

d Emissions from own wastewater treatment by industry are not estimated

e Emissions are for information only and are not totalled

f Emissions arise from wood, straw, biogases and poultry litter combustion for energy production

## Summary Report for $CO_2$ equivalent emissions 1990

| 1990 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **GREENHOUSE GAS SOURCE AND SINK CATEGORIES** | $CO_2$ | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Total |
| | $CO_2$ equivalent (Gg) | | | | | | |
| **Total (Net Emissions)** | **592,117.50** | **91,905.79** | **68,330.94** | **11,375.39** | **1,401.46** | **1,029.95** | **766,161.04** |
| **1. Energy** | **573,056.00** | **31,225.06** | **5,938.70** | | | | **610,219.76** |
| A. Fuel Combustion | 566,439.41 | 2,630.66 | 5,894.22 | | | | **574,964.29** |
| 1. Energy Industries | 235,828.65 | 140.82 | 1,882.08 | | | | **237,851.57** |
| 2. Manufacturing Industries and Construction | 99,022.54 | 320.97 | 1,616.83 | | | | **100,960.34** |
| 3. Transport | 117,227.27 | 625.19 | 1,374.92 | | | | **119,227.38** |
| 4. Other Sectors | 109,036.10 | 1,538.36 | 954.95 | | | | **111,569.41** |
| 5. Other | 5,284.82 | 5.33 | 65.45 | | | | **5,355.59** |
| B. Fugitive Emissions from Fuels | 6,616.59 | 28,594.40 | 44.48 | | | | **35,255.47** |
| 1. Solid Fuels | 856.42 | 18,289.71 | 2.08 | | | | **19,148.21** |
| 2. Oil and Natural Gas | 5,760.18 | 10,304.69 | 42.40 | | | | **16,107.26** |
| **2. Industrial Processes** | **13,101.69** | **174.95** | **29,281.15** | **11,375.39** | **1,401.46** | **1,029.95** | **56,364.59** |
| A. Mineral Products | 9,470.15 | 22.43 | 0.00 | 0.00 | 0.00 | 0.00 | **9,492.62** |
| B. Chemical Industry | 1,321.67 | 136.17 | 29,270.04 | 0.00 | 0.00 | 0.00 | **30,727.88** |
| C. Metal Production | 2,309.85 | 16.36 | 11.11 | 0.00 | 1,332.75 | 426.03 | **4,096.07** |
| D. Other Production | | | | | | | **0.00** |
| E. Production of Halocarbons and SF 6 | | | | 11,373.73 | 10.90 | 0.00 | **11,384.63** |
| F. Consumption of Halocarbons and SF 6 | | | | 1.66 | 57.81 | 603.92 | **663.39** |
| G. Other | | | | | | | **0.00** |
| **3. Solvent and Other Product Use** | **0.00** | | **0.00** | | | | **0.00** |
| **4. Agriculture** | **0.00** | **21,479.21** | **32,030.20** | | | | **53,509.41** |
| A. Enteric Fermentation | | 18,289.97 | 0.00 | | | | **18,289.97** |
| B. Manure Management | | 2,923.21 | 1,545.31 | | | | **4,468.51** |
| C. Rice Cultivation | | | | | | | **0.00** |
| D. Agricultural Soils | | 0.00 | 30,407.12 | | | | **30,407.12** |
| E. Prescribed Burning of Savannas | | | | | | | **0.00** |
| F. Field Burning of Agricultural Residues | | 266.04 | 77.76 | | | | **343.81** |
| G. Other | | | | | | | **0.00** |
| **5. Land-Use Change and Forestry** | **2,915.43** | **13.84** | **1.40** | | | | **2,930.67** |
| **6. Waste** | **1,200.68** | **39,012.73** | **1,079.49** | | | | **41,292.90** |
| A. Solid Waste Disposal on Land | 0.00 | 38,175.47 | 0.00 | | | | **38,175.47** |
| B. Wastewater Handling | 0.00 | 703.82 | 1,031.79 | | | | **1,735.61** |
| C. Waste Incineration | 1,200.68 | 133.43 | 47.71 | | | | **1,381.82** |
| D. Other | | | | | | | **0.00** |
| **7. Other** *(please specify)* | **1,843.69** | | | | | | **1,843.69** |
| **Memo Items:** | **25324.33** | **18.48** | **284.29** | | | | **25,627.11** |
| **International Bunkers** | **22,344.93** | **18.48** | **284.29** | | | | **22,647.70** |
| Aviation | 15,668.14 | 5.79 | 154.18 | | | | **15,828.10** |
| Marine | 6,676.79 | 12.69 | 130.12 | | | | **6,819.60** |
| **Multilateral Operations** | **NO** | **NO** | **NO** | | | | **0.00** |
| **$CO_2$ Emissions from Biomass** | **2,979.41** | | | | | | **2,979.41** |

| **5. Land-Use Change and Forestry** | $CO_2$ | $CH_4$ | $N_2O$ | Total |
|---|---|---|---|---|
| A. Forest Land | -12,202.57 | | | **-12,202.57** |
| B. Cropland | 15,841.67 | | | **15,841.67** |
| C. Grassland | -6,192.80 | 3.08 | 0.31 | **-6,189.41** |
| D. Wetland | | | | **0.00** |
| E. Settlements | 6,925.01 | 10.76 | 1.09 | **6,936.87** |
| F. Other Land | | | | **0.00** |
| G. Other Activities | -1,455.88 | | | **-1,455.88** |
| **Total** | **2,915.43** | **13.84** | **1.40** | **2,930.67** |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$ | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | Total |
|---|---|---|---|---|---|---|---|
| | $CO_2$ equivalent (Gg) | | | | | | |
| **Total (Net Emissions)** | **559,092.21** | **45,884.97** | **40,746.06** | **8,857.79** | **352.23** | **1,127.29** | **656,060.55** |
| **1. Energy** | **547,121.32** | **12,248.53** | **8,896.74** | | | | **568,266.58** |
| A. Fuel Combustion | 541,853.28 | 1,308.36 | 8,855.75 | | | | **552,017.39** |
| 1. Energy Industries | 207,148.67 | 156.14 | 1,277.09 | | | | **208,581.91** |
| 2. Manufacturing Industries and Construction | 87,857.30 | 286.09 | 1,385.19 | | | | **89,528.58** |
| 3. Transport | 128,486.85 | 196.86 | 5,470.67 | | | | **134,154.38** |
| 4. Other Sectors | 115,457.23 | 666.29 | 686.43 | | | | **116,809.95** |
| 5. Other | 2,903.23 | 2.98 | 36.37 | | | | **2,942.58** |
| B. Fugitive Emissions from Fuels | 5,268.04 | 10,940.17 | 40.98 | | | | **16,249.20** |
| 1. Solid Fuels | 168.09 | 4,933.13 | 1.75 | | | | **5,102.97** |
| 2. Oil and Natural Gas | 5,099.95 | 6,007.04 | 39.24 | | | | **11,146.23** |
| **2. Industrial Processes** | **11,367.99** | **59.60** | **4,034.25** | **8,857.79** | **352.23** | **1,127.29** | **25,799.15** |
| A. Mineral Products | 7,949.92 | 12.80 | 0.00 | 0.00 | 0.00 | 0.00 | **7,962.72** |
| B. Chemical Industry | 1,329.20 | 32.95 | 4,025.97 | 0.00 | 0.00 | 0.00 | **5,388.14** |
| C. Metal Production | 2,088.87 | 13.85 | 8.28 | 1.15 | 152.36 | 388.02 | **2,652.54** |
| D. Other Production | | | | | | | **0.00** |
| E. Production of Halocarbons and $SF_6$ | | | | 283.41 | 106.34 | 0.00 | **389.75** |
| F. Consumption of Halocarbons and $SF_6$ | | | | 8,573.23 | 93.53 | 739.27 | **9,406.00** |
| G. Other | | | | | | | **0.00** |
| **3. Solvent and Other Product Use** | **0.00** | | **0.00** | | | | **0.00** |
| **4. Agriculture** | **0.00** | **18,762.98** | **26,557.65** | | | | **45,320.63** |
| A. Enteric Fermentation | | 16,195.47 | 0.00 | | | | **16,195.47** |
| B. Manure Management | | 2,567.51 | 1,276.31 | | | | **3,843.82** |
| C. Rice Cultivation | | | | | | | **0.00** |
| D. Agricultural Soils | | 0.00 | 25,281.34 | | | | **25,281.34** |
| E. Prescribed Burning of Savannas | | | | | | | **0.00** |
| F. Field Burning of Agricultural Residues | | 0.00 | 0.00 | | | | **0.00** |
| G. Other | | | | | | | **0.00** |
| **5. Land-Use Change and Forestry** | **-1,941.56** | **16.76** | **1.70** | | | | **-1,923.10** |
| **6. Waste** | **451.74** | **14,797.10** | **1,255.73** | | | | **16,504.58** |
| A. Solid Waste Disposal on Land | 0.00 | 14,000.78 | 0.00 | | | | **14,000.78** |
| B. Wastewater Handling | 0.00 | 793.04 | 1,207.43 | | | | **2,000.48** |
| C. Waste Incineration | 451.74 | 3.28 | 48.30 | | | | **503.32** |
| D. Other | | | | | | | **0.00** |
| **7. Other *(please specify)*** | 2,092.72 | | | | | | **2,092.72** |
| **Memo Items:** | **48368.76** | **13.22** | **439.48** | | | | **48,821.46** |
| **International Bunkers** | **38,996.95** | **13.22** | **439.48** | | | | **39,449.65** |
| Aviation | 33,124.88 | 2.15 | 326.01 | | | | **33,453.03** |
| Marine | 5,872.07 | 11.07 | 113.48 | | | | **5,996.62** |
| **Multilateral Operations** | **NO** | **NO** | **NO** | | | | **0.00** |
| **$CO_2$ Emissions from Biomass** | **9,371.81** | | | | | | **9,371.81** |

| 5. Land-Use Change and Forestry | $CO_2$ | $CH_4$ | $N_2O$ | Total |
|---|---|---|---|---|
| A. Forest Land | -16,302.00 | | | **-16,302.00** |
| B. Cropland | 15,329.12 | | | **15,329.12** |
| C. Grassland | -7,835.52 | 11.87 | 1.21 | **-7,822.44** |
| D. Wetland | | | | **0.00** |
| E. Settlements | 6,248.02 | 4.88 | 0.50 | **6,253.40** |
| F. Other Land | | | | **0.00** |
| G. Other Activities | 618.82 | | | **618.82** |
| **Total** | **-1,941.56** | **16.76** | **1.70** | **-1,923.10** |

**Emissions Trends (carbon dioxide)**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total net emissions** | 592,117.50 | 598,891.45 | 581,924.89 | 567,022.97 | 559,145.52 | 549,659.11 | 571,367.48 | 548,417.47 | 550,163.11 | 540,814.73 | 546,343.00 | 561,490.10 | 544,924.46 | 556,468.86 | 559,092.21 |
| **1. Energy** | 573,056.00 | 581,951.23 | 566,234.25 | 552,639.34 | 543,895.87 | 533,876.90 | 555,130.02 | 532,819.53 | 535,157.90 | 526,241.70 | 532,179.26 | 548,865.76 | 533,435.78 | 544,216.57 | 547,121.32 |
| A. Fuel Combustion (Sectoral Approach) | 566,439.41 | 575,735.80 | 559,664.21 | 545,751.27 | 536,789.47 | 525,237.98 | 545,866.65 | 525,828.28 | 528,568.07 | 519,977.25 | 526,705.55 | 543,284.97 | 527,806.04 | 538,854.14 | 541,853.28 |
| 1. Energy Industries | 235,828.68 | 235,329.71 | 224,203.23 | 206,454.79 | 201,784.74 | 198,775.56 | 200,231.53 | 187,392.71 | 190,954.03 | 180,531.42 | 191,114.64 | 201,002.23 | 199,262.73 | 207,545.92 | 207,148.67 |
| 2. Manufacturing Industries and Construction | 99,022.54 | 99,090.63 | 96,112.48 | 95,242.80 | 95,904.11 | 92,664.54 | 93,836.82 | 94,666.66 | 93,189.26 | 94,476.69 | 92,075.49 | 95,250.81 | 84,710.00 | 86,150.24 | 87,857.30 |
| 3. Transport | 117,227.27 | 116,548.44 | 117,868.32 | 119,080.54 | 119,234.17 | 118,242.78 | 123,073.87 | 124,543.99 | 123,810.81 | 124,674.05 | 123,993.74 | 123,331.04 | 125,634.90 | 127,020.36 | 128,486.85 |
| 4. Other Sectors | 109,076.10 | 120,474.58 | 117,393.40 | 120,832.22 | 115,906.65 | 111,668.93 | 124,919.45 | 115,594.21 | 117,419.97 | 117,145.46 | 116,605.37 | 120,778.98 | 115,141.78 | 115,322.50 | 115,457.23 |
| 5. Other | 5,284.82 | 4,292.42 | 4,086.79 | 4,140.93 | 3,959.80 | 3,886.18 | 3,804.99 | 3,630.71 | 3,194.00 | 3,149.63 | 2,916.31 | 2,921.90 | 3,056.63 | 2,815.12 | 2,903.23 |
| B. Fugitive Emissions from Fuels | 6,616.59 | 6,215.43 | 6,570.04 | 6,888.07 | 7,106.39 | 8,638.92 | 9,263.36 | 6,991.25 | 6,589.83 | 6,264.45 | 5,473.72 | 5,580.80 | 5,629.74 | 5,362.43 | 5,268.04 |
| 1. Solid Fuels | 856.42 | 519.42 | 650.00 | 344.83 | 163.25 | 225.84 | 366.77 | 459.63 | 158.41 | 112.08 | 102.36 | 101.68 | 110.85 | 111.87 | 168.09 |
| 2. Oil and Natural Gas | 5,760.18 | 5,696.02 | 6,120.04 | 6,543.24 | 6,943.14 | 8,413.09 | 8,896.60 | 6,531.63 | 6,431.42 | 6,152.37 | 5,371.35 | 5,479.12 | 5,518.89 | 5,250.56 | 5,099.95 |
| **2. Industrial Processes** | **13,101.69** | **11,085.93** | **10,334.93** | **10,277.50** | **11,455.79** | **11,890.13** | **12,455.97** | **12,547.01** | **12,524.20** | **12,341.58** | **11,938.24** | **10,706.32** | **10,060.51** | **10,864.63** | **11,367.99** |
| A. Mineral Products | 9,470.19 | 8,078.13 | 7,538.00 | 7,563.79 | 8,465.68 | 8,598.79 | 8,875.35 | 9,696.22 | 9,626.40 | 9,137.42 | 8,654.63 | 7,848.62 | 7,655.09 | 7,852.11 | 7,949.92 |
| B. Chemical Industry | 1,321.67 | 1,323.66 | 1,346.07 | 1,348.36 | 1,350.36 | 1,352.71 | 1,354.75 | 888.48 | 1,110.52 | 1,112.92 | 1,300.55 | 1,373.03 | 1,233.46 | 1,164.46 | 1,329.20 |
| C. Metal Production | 2,309.83 | 1,684.15 | 1,450.85 | 1,365.35 | 1,639.75 | 1,938.64 | 2,225.86 | 1,962.32 | 1,787.28 | 2,091.23 | 1,983.07 | 1,484.67 | 1,171.96 | 1,848.06 | 2,088.87 |
| D. Other Production | | | | | | | | | | | | | | | |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E. Production of Halocarbons and $SF_6$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| F. Consumption of Halocarbons and $SF_6$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| G. Other | | | | | | | | | | | | | | | |
| **3. Solvent and Other Product Use** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| **4. Agriculture** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| A. Enteric Fermentation | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| B. Manure Management | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| C. Rice Cultivation | | | | | | | | | | | | | | | |
| D. Agricultural Soils | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| E. Prescribed Burning of Savannas | | | | | | | | | | | | | | | |
| F. Field Burning of Agricultural Residues | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| G. Other | | | | | | | | | | | | | | | |
| **5. Land-Use Change and Forestry** | **2,915.43** | **2,782.03** | **2,289.51** | **1,082.19** | **889.22** | **1,033.53** | **901.90** | **552.15** | **-0.06** | **-234.35** | **-440.31** | **-596.49** | **-1,119.83** | **-1,179.63** | **-1,941.56** |
| A. Forest Land | -12,202.57 | -12,714.63 | -13,340.09 | -13,714.07 | -14,192.63 | -13,948.21 | -13,720.06 | -13,511.59 | -13,406.21 | -13,504.35 | -13,804.83 | -14,347.95 | -15,045.12 | -15,645.78 | -16,302.00 |
| B. Cropland | 15,841.67 | 16,001.32 | 16,004.23 | 15,578.64 | 15,631.57 | 15,771.11 | 15,802.36 | 15,542.40 | 15,427.30 | 15,327.95 | 15,338.88 | 15,287.31 | 15,314.06 | 15,380.23 | 15,329.12 |
| C. Grassland | -6,192.80 | -6,145.61 | -6,253.83 | -6,659.69 | -6,604.75 | -6,536.31 | -6,786.45 | -6,889.04 | -7,288.13 | -7,274.65 | -7,426.56 | -7,448.85 | -7,742.00 | -7,525.58 | -7,835.52 |
| D. Wetland | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| E. Settlements | 6,925.01 | 6,851.14 | 6,798.80 | 6,719.31 | 6,687.80 | 6,646.81 | 6,627.15 | 6,607.31 | 6,572.86 | 6,484.71 | 6,402.29 | 6,358.24 | 6,305.81 | 6,274.23 | 6,248.02 |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F. Other Land | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| G. Other Activities | -1,455.88 | -1,210.20 | -919.60 | -841.99 | -632.78 | -899.87 | -1,021.09 | -1,196.92 | -1,305.87 | -1,268.01 | -950.08 | -445.23 | 47.42 | 337.28 | 618.82 |
| **6. Waste** | **1,200.68** | **1,194.62** | **1,153.42** | **1,070.04** | **915.03** | **865.20** | **880.05** | **494.10** | **498.42** | **451.39** | **456.74** | **489.62** | **480.78** | **459.64** | **451.74** |
| A. Solid Waste Disposal on Land | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| B. Waste-water Handling | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| C. Waste Incineration | 1,200.68 | 1,194.62 | 1,153.42 | 1,070.04 | 915.03 | 865.20 | 880.05 | 494.10 | 498.42 | 451.39 | 456.74 | 489.62 | 480.78 | 459.64 | 451.74 |
| D. Other | | | | | | | | | | | | | | | |
| **7. Other *(please specify)*** | **1,843.69** | **1,877.63** | **1,912.78** | **1,953.90** | **1,989.61** | **1,993.34** | **1,999.53** | **2,004.68** | **1,982.66** | **2,014.41** | **2,009.06** | **2,024.88** | **2,067.22** | **2,087.64** | **2,092.72** |
| **Memo Items:** | **25,324.33** | **9,610.28** | **10,317.97** | **10,403.11** | **10,594.79** | **11,370.69** | **12,235.75** | **13,410.33** | **14,819.60** | **12,939.49** | **12,615.34** | **13,669.62** | **12,905.41** | **13,445.75** | **15,277.01** |
| **International Bunkers** | **22,344.93** | **6,472.70** | **6,764.90** | **6,698.52** | **6,267.65** | **6,726.88** | **7,351.75** | **8,243.32** | **8,996.53** | **6,528.54** | **5,742.13** | **6,446.51** | **5,374.27** | **5,162.60** | **5,905.20** |
| Aviation | 15,668.14 | 15.44 | 17.08 | 18.18 | 18.93 | 20.13 | 21.34 | 22.69 | 25.25 | 27.44 | 30.24 | 29.48 | 28.93 | 29.64 | 33.12 |
| Marine | 6,676.79 | 6,457.26 | 6,747.82 | 6,680.34 | 6,248.73 | 6,706.75 | 7,330.41 | 8,220.62 | 8,971.27 | 6,501.10 | 5,711.89 | 6,417.02 | 5,345.34 | 5,132.95 | 5,872.07 |
| **Multilateral Operations** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** |
| **$CO_2$ Emissions from Biomass** | **2,979.41** | **3,137.58** | **3,553.07** | **3,704.59** | **4,327.14** | **4,643.81** | **4,883.99** | **5,167.01** | **5,823.07** | **6,410.95** | **6,873.21** | **7,223.12** | **7,531.13** | **8,283.15** | **9,371.81** |

## Emissions Trends (methane)

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total net emissions** | **4,376.47** | **4,342.23** | **4,283.05** | **4,148.45** | **3,831.48** | **3,804.32** | **3,708.76** | **3,520.05** | **3,331.75** | **3,008.15** | **2,850.55** | **2,585.66** | **2,483.41** | **2,247.81** | **2,185.00** |
| **1. Energy** | **1,486.91** | **1,503.54** | **1,482.91** | **1,405.02** | **1,108.27** | **1,149.03** | **1,095.10** | **1,041.63** | **953.88** | **865.84** | **787.44** | **759.84** | **742.47** | **595.93** | **583.26** |
| A. Fuel Combustion (Sectoral Approach) | 125.27 | 127.67 | 119.52 | 117.11 | 102.30 | 87.12 | 89.76 | 85.30 | 84.73 | 86.79 | 75.27 | 76.88 | 68.92 | 61.08 | 62.30 |
| 1. Energy Industries | 6.71 | 6.40 | 6.15 | 5.89 | 6.08 | 5.50 | 5.74 | 6.12 | 6.11 | 7.25 | 7.88 | 8.02 | 7.25 | 7.18 | 7.44 |
| 2. Manufacturing Industries and Construction | 15.28 | 15.07 | 14.37 | 14.40 | 14.93 | 15.21 | 15.72 | 16.34 | 15.99 | 15.70 | 15.40 | 14.35 | 13.30 | 13.95 | 13.62 |
| 3. Transport | 29.77 | 29.34 | 28.12 | 26.74 | 25.14 | 23.14 | 21.93 | 20.16 | 18.47 | 16.84 | 15.04 | 13.24 | 11.74 | 10.51 | 9.37 |
| 4. Other Sectors | 73.26 | 76.64 | 70.66 | 69.89 | 55.96 | 43.08 | 46.18 | 42.48 | 43.99 | 46.83 | 36.81 | 41.13 | 36.49 | 29.32 | 31.73 |
| 5. Other | 0.25 | 0.22 | 0.21 | 0.20 | 0.19 | 0.19 | 0.19 | 0.19 | 0.15 | 0.16 | 0.15 | 0.14 | 0.14 | 0.12 | 0.14 |
| B. Fugitive Emissions from Fuels | 1,361.64 | 1,375.87 | 1,363.39 | 1,287.90 | 1,005.97 | 1,061.90 | 1,005.34 | 956.33 | 869.15 | 779.05 | 712.17 | 682.96 | 673.55 | 534.85 | 520.96 |
| 1. Solid Fuels | 870.94 | 895.22 | 887.17 | 825.64 | 547.72 | 599.65 | 556.22 | 532.68 | 454.48 | 380.84 | 333.42 | 301.87 | 301.96 | 259.87 | 234.91 |
| 2. Oil and Natural Gas | 490.70 | 480.66 | 476.22 | 462.26 | 458.25 | 462.26 | 449.11 | 423.65 | 414.67 | 398.21 | 378.75 | 381.09 | 371.59 | 274.98 | 286.05 |
| **2. Industrial Processes** | **8.33** | **7.85** | **8.29** | **7.10** | **8.65** | **6.69** | **7.89** | **6.40** | **4.56** | **3.76** | **3.46** | **2.87** | **2.76** | **2.84** | **2.84** |
| A. Mineral Products | 1.07 | 0.87 | 0.78 | 0.65 | 0.73 | 0.73 | 0.68 | 0.67 | 0.71 | 0.59 | 0.59 | 0.58 | 0.59 | 0.62 | 0.61 |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B. Chemical Industry | 6.48 | 6.45 | 7.06 | 6.01 | 7.36 | 5.26 | 6.41 | 5.04 | 3.22 | 2.44 | 2.20 | 1.87 | 1.88 | 1.64 | 1.57 |
| C. Metal Production | 0.78 | 0.53 | 0.46 | 0.44 | 0.56 | 0.70 | 0.79 | 0.69 | 0.63 | 0.73 | 0.68 | 0.42 | 0.29 | 0.59 | 0.66 |
| D. Other Production | | | | | | | | | | | | | | | |
| E. Production of Halocarbons and $SF_6$ | | | | | | | | | | | | | | | |
| F. Consumption of Halocarbons and $SF_6$ | | | | | | | | | | | | | | | |
| G. Other | | | | | | | | | | | | | | | |
| **3. Solvent and Other Product Use** | | | | | | | | | | | | | | | |
| **4. Agriculture** | **1,022.82** | **1,006.08** | **1,009.43** | **1,001.13** | **1,006.37** | **994.16** | **1,002.69** | **990.61** | **988.60** | **986.10** | **953.04** | **898.10** | **889.36** | **892.16** | **893.48** |
| A. Enteric Fermentation | 870.95 | 857.87 | 864.23 | 862.94 | 867.35 | 857.91 | 865.59 | 853.90 | 851.74 | 851.30 | 823.24 | 773.14 | 765.68 | 769.09 | 771.21 |
| B. Manure Management | 139.20 | 137.36 | 137.34 | 138.03 | 139.02 | 136.25 | 137.10 | 136.71 | 136.86 | 134.80 | 129.79 | 124.96 | 123.68 | 123.07 | 122.26 |
| C. Rice Cultivation | | | | | | | | | | | | | | | |
| D. Agricultural Soils | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| E. Prescribed Burning of Savannas | | | | | | | | | | | | | | | |
| F. Field Burning of Agricultural Residues | 12.67 | 10.85 | 7.87 | 0.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| G. Other | | | | | | | | | | | | | | | |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **5. Land-Use Change and Forestry** | **0.66** | **0.60** | **0.62** | **0.45** | **0.52** | **0.55** | **0.66** | **0.68** | **0.69** | **0.83** | **0.93** | **1.11** | **0.93** | **0.88** | **0.80** |
| A. Forest Land | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| B. Cropland | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| C. Grassland | 0.15 | 0.16 | 0.17 | 0.13 | 0.14 | 0.16 | 0.18 | 0.15 | 0.16 | 0.39 | 0.59 | 0.77 | 0.67 | 0.63 | 0.57 |
| D. Wetland | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| E. Settlements | 0.51 | 0.44 | 0.45 | 0.32 | 0.38 | 0.39 | 0.48 | 0.53 | 0.53 | 0.44 | 0.34 | 0.33 | 0.25 | 0.24 | 0.23 |
| F. Other Land | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| G. Other Activities | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **6. Waste** | **1,857.75** | **1,824.16** | **1,781.80** | **1,734.75** | **1,707.68** | **1,653.90** | **1,602.42** | **1,480.73** | **1,384.02** | **1,151.62** | **1,105.68** | **923.74** | **847.89** | **755.99** | **704.62** |
| A. Solid Waste Disposal on Land | 1,817.88 | 1,786.47 | 1,740.86 | 1,694.80 | 1,667.66 | 1,615.84 | 1,563.08 | 1,444.28 | 1,346.58 | 1,115.31 | 1,068.50 | 886.31 | 810.24 | 717.94 | 666.70 |
| B. Waste-water Handling | 33.52 | 31.40 | 34.89 | 34.59 | 36.10 | 34.47 | 35.41 | 36.35 | 37.29 | 36.15 | 37.03 | 37.27 | 37.49 | 37.89 | 37.76 |
| C. Waste Incineration | 6.35 | 6.30 | 6.05 | 5.36 | 3.92 | 3.59 | 3.93 | 0.11 | 0.15 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 |
| D. Other | | | | | | | | | | | | | | | |
| **7. Other *(please specify)*** | | | | | | | | | | | | | | | |
| **Memo Items:** | **0.88** | **0.81** | **0.82** | **0.82** | **0.76** | **0.79** | **0.85** | **0.92** | **0.99** | **0.75** | **0.65** | **0.69** | **0.59** | **0.57** | **0.63** |
| **International Bunkers** | **0.88** | **0.81** | **0.82** | **0.82** | **0.76** | **0.79** | **0.85** | **0.92** | **0.99** | **0.75** | **0.65** | **0.69** | **0.59** | **0.57** | **0.63** |
| Aviation | 0.28 | 0.22 | 0.21 | 0.21 | 0.20 | 0.18 | 0.18 | 0.18 | 0.18 | 0.16 | 0.14 | 0.12 | 0.11 | 0.11 | 0.10 |
| Marine | 0.60 | 0.58 | 0.61 | 0.61 | 0.57 | 0.61 | 0.66 | 0.74 | 0.81 | 0.59 | 0.51 | 0.58 | 0.48 | 0.46 | 0.53 |
| **Multilateral Operations** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** |
| **$CO_2$ Emissions from Biomass** | | | | | | | | | | | | | | | |

## Emissions Trends (nitrous oxide)

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total net emissions** | **220.42** | **213.84** | **191.79** | **179.42** | **189.10** | **183.90** | **189.73** | **195.19** | **185.83** | **143.30** | **142.62** | **135.72** | **130.39** | **129.22** | **131.44** |
| **1. Energy** | **19.16** | **19.17** | **19.12** | **19.15** | **19.99** | **20.77** | **21.75** | **22.42** | **23.66** | **24.46** | **25.40** | **26.92** | **27.41** | **28.07** | **28.70** |
| A. Fuel Combustion (Sectoral Approach) | 19.01 | 19.03 | 18.98 | 18.99 | 19.82 | 20.58 | 21.55 | 22.24 | 23.47 | 24.29 | 25.23 | 26.77 | 27.27 | 27.94 | 28.57 |
| 1. Energy Industries | 6.07 | 6.04 | 5.74 | 4.97 | 4.75 | 4.62 | 4.36 | 3.87 | 3.95 | 3.50 | 3.91 | 4.14 | 3.99 | 4.23 | 4.12 |
| 2. Manufacturing Industries and Construction | 5.22 | 5.10 | 5.13 | 4.91 | 4.94 | 4.80 | 4.68 | 4.63 | 4.61 | 4.67 | 4.38 | 4.71 | 4.46 | 4.35 | 4.47 |
| 3. Transport | 4.44 | 4.55 | 4.90 | 5.85 | 7.04 | 8.28 | 9.56 | 10.84 | 12.13 | 13.38 | 14.36 | 15.32 | 16.30 | 16.98 | 17.65 |
| 4. Other Sectors | 3.08 | 3.16 | 3.03 | 3.09 | 2.94 | 2.72 | 2.79 | 2.74 | 2.65 | 2.60 | 2.46 | 2.49 | 2.39 | 2.28 | 2.21 |
| 5. Other | 0.21 | 0.18 | 0.17 | 0.17 | 0.16 | 0.16 | 0.16 | 0.15 | 0.13 | 0.13 | 0.12 | 0.12 | 0.12 | 0.11 | 0.12 |
| B. Fugitive Emissions from Fuels | 0.14 | 0.14 | 0.15 | 0.16 | 0.17 | 0.20 | 0.20 | 0.18 | 0.18 | 0.17 | 0.16 | 0.15 | 0.15 | 0.13 | 0.13 |
| 1. Solid Fuels | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| 2. Oil and Natural Gas | 0.14 | 0.14 | 0.15 | 0.16 | 0.16 | 0.20 | 0.20 | 0.18 | 0.18 | 0.17 | 0.16 | 0.15 | 0.14 | 0.12 | 0.13 |
| **2. Industrial Processes** | **94.46** | **88.51** | **71.61** | **61.07** | **67.73** | **61.30** | **65.49** | **67.02** | **59.45** | **18.16** | **20.20** | **17.40** | **9.91** | **10.31** | **13.01** |
| A. Mineral Products | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| B. Chemical Industry | 94.42 | 88.48 | 71.58 | 61.04 | 67.70 | 61.27 | 65.45 | 66.99 | 59.42 | 18.13 | 20.17 | 17.37 | 9.90 | 10.28 | 12.99 |
| C. Metal Production | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.03 |
| D. Other Production | | | | | | | | | | | | | | | |
| E. Production of Halocarbons and $SF_6$ | | | | | | | | | | | | | | | |
| F. Consumption of | | | | | | | | | | | | | | | |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Halocarbons and $SF_6$ | | | | | | | | | | | | | | | |
| G. Other | | | | | | | | | | | | | | | |
| **3. Solvent and Other Product Use** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **4. Agriculture** | **103.32** | **102.71** | **97.57** | **95.75** | **97.94** | **98.34** | **98.89** | **101.81** | **98.75** | **96.71** | **93.06** | **87.32** | **89.01** | **86.76** | **85.67** |
| A. Enteric Fermentation | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| B. Manure Management | 4.98 | 4.96 | 4.90 | 4.92 | 4.97 | 4.90 | 4.95 | 4.94 | 4.98 | 4.97 | 4.68 | 4.50 | 4.38 | 4.28 | 4.12 |
| C. Rice Cultivation | | | | | | | | | | | | | | | |
| D. Agricultural Soils | 98.09 | 97.53 | 92.51 | 90.82 | 92.97 | 93.44 | 93.94 | 96.86 | 93.77 | 91.74 | 88.37 | 82.81 | 84.63 | 82.48 | 81.55 |
| E. Prescribed Burning of Savannas | | | | | | | | | | | | | | | |
| F. Field Burning of Agricultural Residues | 0.25 | 0.21 | 0.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| G. Other | | | | | | | | | | | | | | | |
| **5. Land-Use Change and Forestry** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** |
| A. Forest Land | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| B. Cropland | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| C. Grassland | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| D. Wetland | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| E. Settlements | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| F. Other Land | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| G. Other Activities | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **6. Waste** | **3.48** | **3.45** | **3.48** | **3.46** | **3.45** | **3.48** | **3.61** | **3.93** | **3.97** | **3.97** | **3.96** | **4.08** | **4.05** | **4.09** | **4.05** |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 200 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Halocarbons and $SF_6$ | | | | | | | | | | | | | | |
| G. Other | | | | | | | | | | | | | | |
| **3. Solvent and Other Product Use** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 |
| **4. Agriculture** | **103.32** | **102.71** | **97.57** | **95.75** | **97.94** | **98.34** | **98.89** | **101.81** | **98.75** | **96.71** | **93.06** | **87.32** | **89.01** | **86.7** |
| A. Enteric Fermentation | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 |
| B. Manure Management | 4.98 | 4.96 | 4.90 | 4.92 | 4.97 | 4.90 | 4.95 | 4.94 | 4.98 | 4.97 | 4.68 | 4.50 | 4.38 | 4.2 |
| C. Rice Cultivation | | | | | | | | | | | | | | |
| D. Agricultural Soils | 98.09 | 97.53 | 92.51 | 90.82 | 92.97 | 93.44 | 93.94 | 96.86 | 93.77 | 91.74 | 88.37 | 82.81 | 84.63 | 82.4 |
| E. Prescribed Burning of Savannas | | | | | | | | | | | | | | |
| F. Field Burning of Agricultural Residues | 0.25 | 0.21 | 0.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 |
| G. Other | | | | | | | | | | | | | | |
| **5. Land-Use Change and Forestry** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.01** | **0.01** | **0.01** | **0.01** | **0.0** |
| A. Forest Land | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| B. Cropland | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| C. Grassland | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.0 |
| D. Wetland | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| E. Settlements | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0 |
| F. Other Land | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| G. Other Activities | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **6. Waste** | **3.48** | **3.45** | **3.48** | **3.46** | **3.45** | **3.48** | **3.61** | **3.93** | **3.97** | **3.97** | **3.96** | **4.08** | **4.05** | **4.0** |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A. Solid Waste Disposal on Land | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| B. Waste-water Handling | 3.33 | 3.30 | 3.33 | 3.31 | 3.33 | 3.36 | 3.48 | 3.86 | 3.82 | 3.81 | 3.80 | 3.92 | 3.90 | 3.93 | 3.89 |
| C. Waste Incineration | 0.15 | 0.15 | 0.15 | 0.15 | 0.12 | 0.12 | 0.13 | 0.07 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 |
| D. Other | | | | | | | | | | | | | | | |
| **7. Other *(please specify)*** | | | | | | | | | | | | | | | |
| **Memo Items:** | **0.92** | **0.90** | **0.97** | **1.00** | **0.99** | **1.06** | **1.14** | **1.24** | **1.36** | **1.28** | **1.32** | **1.34** | **1.25** | **1.26** | **1.42** |
| **International Bunkers** | **0.92** | **0.90** | **0.97** | **1.00** | **0.99** | **1.06** | **1.14** | **1.24** | **1.36** | **1.28** | **1.32** | **1.34** | **1.25** | **1.26** | **1.42** |
| Aviation | 0.50 | 0.49 | 0.54 | 0.58 | 0.60 | 0.64 | 0.68 | 0.72 | 0.80 | 0.87 | 0.96 | 0.94 | 0.92 | 0.94 | 1.05 |
| Marine | 0.42 | 0.41 | 0.42 | 0.42 | 0.39 | 0.42 | 0.46 | 0.52 | 0.56 | 0.41 | 0.36 | 0.40 | 0.33 | 0.32 | 0.37 |
| **Multilateral Operations** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** |
| **$CO_2$ Emissions from Biomass** | | | | | | | | | | | | | | | |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Emissions of HFCs $CO_2$ equivalent (Gg) | 11,375.39 | 11,854.03 | 12,323.50 | 12,999.90 | 14,009.69 | 15,490.85 | 16,720.06 | 19,181.42 | 17,267.98 | 10,829.87 | 9,881.27 | 9,674.38 | 9,893.99 | 10,187.34 | 8,857.79 |
| HFC-23 | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| HFC-32 | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| HFC-41 | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| HFC-43-10mee | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| HFC-125 | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| HFC-134 | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| HFC-134a | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| HFC-152a | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| HFC-143 | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| HFC-143a | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| HFC-227ea | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| HFC-236fa | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| HFC-245ca | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| Emissions of PFCs $CO_2$ equivalent (Gg) | 1,481.46 | 1,170.78 | 573.48 | 490.68 | 490.51 | 476.67 | 493.23 | 416.79 | 420.89 | 398.61 | 498.20 | 425.30 | 322.72 | 296.81 | 352.23 |
| $CF_4$ | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| $C_2F_6$ | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| $C_3F_8$ | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| $C_4F_{10}$ | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| c-$C_4F_8$ | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| $C_5F_{12}$ | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| $C_6F_{14}$ | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| Emissions of $SF_6$ $CO_2$ equivalent (Gg) | 1,029.95 | 1,078.44 | 1,124.18 | 1,167.19 | 1,183.06 | 1,239.30 | 1,266.63 | 1,225.55 | 1,262.23 | 1,425.68 | 1,798.12 | 1,424.68 | 1,508.81 | 1,323.55 | 1,127.29 |
| $SF_6$ | 0.043 | 0.045 | 0.047 | 0.049 | 0.050 | 0.052 | 0.053 | 0.051 | 0.053 | 0.060 | 0.075 | 0.060 | 0.063 | 0.055 | 0.047 |

## Emissions Trends (Summary)

| GREENHOUSE GAS EMISSIONS | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Net $CO_2$ emissions/removals | 592,117.50 | 598,891.45 | 581,924.89 | 567,022.97 | 559,145.52 | 549,659.11 | 571,367.48 | 548,417.47 | 550,163.11 | 540,814.73 | 546,343.00 | 561,490.10 | 544,924.46 | 556,448.86 | 559,092.21 |
| $CO_2$ emissions (without LUCF) | 589,202.07 | 596,109.42 | 579,635.38 | 565,940.78 | 558,256.30 | 548,625.58 | 570,465.57 | 547,865.32 | 550,163.17 | 541,049.08 | 546,783.30 | 562,086.59 | 546,044.29 | 557,628.48 | 561,033.77 |
| $CH_4$ | 91,905.79 | 91,186.77 | 89,944.00 | 87,117.52 | 80,461.18 | 79,890.73 | 77,884.05 | 73,920.97 | 69,966.83 | 63,171.23 | 59,861.51 | 54,298.92 | 52,151.53 | 47,203.98 | 45,884.97 |
| $N_2O$ | 68,330.94 | 66,290.90 | 59,454.75 | 55,620.59 | 58,622.30 | 57,008.60 | 58,817.18 | 60,507.49 | 57,608.59 | 44,423.98 | 44,211.10 | 42,071.88 | 40,422.26 | 40,059.62 | 40,746.06 |
| HFCs | 11,375.39 | 11,854.03 | 12,323.50 | 12,999.90 | 14,009.69 | 15,490.85 | 16,720.06 | 19,181.42 | 17,267.98 | 10,829.87 | 9,081.27 | 9,674.38 | 9,893.99 | 10,187.34 | 8,857.79 |
| PFCs | 1,401.46 | 1,170.78 | 573.48 | 490.60 | 490.51 | 470.67 | 493.23 | 416.79 | 420.89 | 398.61 | 498.20 | 425.30 | 322.72 | 296.81 | 352.23 |
| $SF_6$ | 1,029.95 | 1,078.44 | 1,124.18 | 1,167.19 | 1,183.06 | 1,239.30 | 1,266.63 | 1,225.55 | 1,262.23 | 1,425.68 | 1,798.12 | 1,424.68 | 1,508.81 | 1,323.55 | 1,127.29 |
| **Total (with net $CO_2$ emissions/removals)** | **766,161.04** | **770,472.37** | **745,344.81** | **724,418.77** | **713,912.27** | **703,759.26** | **726,548.62** | **703,669.70** | **696,689.63** | **661,864.10** | **661,793.19** | **669,385.25** | **649,223.78** | **655,520.15** | **656,060.55** |
| **Total (without $CO_2$ from LUCF)** | **763,245.61** | **767,690.34** | **743,055.30** | **723,336.58** | **713,023.05** | **702,725.73** | **725,646.72** | **703,117.54** | **696,689.70** | **661,298.45** | **662,233.50** | **669,981.74** | **650,343.61** | **656,699.78** | **658,002.11** |

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Energy | 610,219.76 | 619,468.30 | 603,303.56 | 588,080.34 | 573,366.03 | 564,446.23 | 584,869.62 | 561,643.97 | 562,522.44 | 552,006.85 | 556,788.42 | 573,166.39 | 557,525.06 | 565,432.59 | 568,266.58 |
| 2. Industrial Processes | 56,364.59 | 52,791.80 | 46,729.33 | 44,014.64 | 48,316.96 | 48,234.60 | 51,402.19 | 54,281.08 | 50,000.10 | 30,703.05 | 29,649.39 | 27,684.29 | 24,917.53 | 25,927.05 | 25,799.15 |
| 3. Solvent and Other Product Use | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4. Agriculture | 53,509.41 | 52,968.38 | 51,445.94 | 50,705.47 | 51,493.86 | 51,361.94 | 51,711.47 | 52,362.83 | 51,373.83 | 50,688.96 | 48,862.01 | 45,928.80 | 46,269.85 | 45,630.20 | 45,320.63 |
| 5. Land-Use Change and Forestry | 2,930.67 | 2,795.86 | 2,303.84 | 1,092.66 | 901.22 | 1,046.24 | 917.25 | 567.91 | 15.93 | -215.07 | -418.90 | -570.90 | -1,098.36 | -1,159.36 | -1,923.10 |
| 6. Waste | 41,292.90 | 40,570.39 | 39,649.35 | 38,571.77 | 37,844.59 | 36,676.91 | 35,648.56 | 32,809.23 | 30,794.68 | 25,865.89 | 24,903.21 | 21,151.80 | 19,542.48 | 17,602.03 | 16,504.58 |
| 7. Other | 1,843.69 | 1,877.63 | 1,912.78 | 1,953.90 | 1,989.61 | 1,993.34 | 1,999.53 | 2,004.68 | 1,982.66 | 2,014.41 | 2,009.06 | 2,024.88 | 2,067.22 | 2,087.64 | 2,092.72 |

**Key**

NO: Not occuring
NA: Not applicable
NE: Not estimated
C: Confidential

# Annex B

**Summary of Policies and Measures**[149]

| Name of policy or measure | Objective and/or activity affected | GHG | Type of instrument | Status | Implementing entity or entities | Carbon savings (MtC) | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 2010 | 2015 | 2020 |
| **With measures** | | | | | | | | |
| **Energy Supply** | | | | | | | | |
| Renewables obligation | Electricity supply | $CO_2$ | Regulatory | Implemented | Industry regulator | 2.5 | | |
| **Business** | | | | | | | | |
| Climate Change Levy[150] | Non domestic energy use | $CO_2$ | Fiscal | Implemented | Government | 3.7 | | |
| UK emissions trading scheme | All UK companies | all | Economic | Implemented | Government | 0.3 | | |
| Carbon Trust | Buildings energy use | $CO_2$ | Fiscal (ECA, grant) Information, R&D | Implemented | Independent company funded by Government | 1.1 | | |
| Building regulations 2002[151] | Buildings energy use | $CO_2$ | Regulatory | Implemented | Government | 0.4 | | |
| Building regulations 2005 | Buildings energy use | $CO_2$ | Regulatory | Implemented | Government | 0.2 | | |
| Climate change agreements | Industrial energy use | $CO_2$ | Negotiated agreements | Implemented | Government | 2.9 | | |
| **Transport** | | | | | | | | |
| Voluntary agreements, package including reform of company car taxation and graduated VED | Transport emissions | $CO_2$ | Negotiated agreements and fiscal | Implemented | Government | 2.3 | | |
| Wider transport measures | Transport emissions | $CO_2$ | Fiscal | Implemented | Government | 0.8 | | |
| Sustainable distribution in Scotland and Wales | Transport emissions | $CO_2$ | Information | Implemented | Devolved administration | 0.1 | | |
| Fuel duty escalator | Transport emissions | $CO_2$ | Fiscal | Implemented | Government | 1.9 | | |

149 For supporting material on the quantification of policies see Synthesis of Climate Change Policy Evaluations, Defra April 2006, available at **http://www.defra.gov.uk/environment/climatechange/uk/ukccp/pdf/synthesisccpolicy-evaluations.pdf.** This covers evaluation of currently implemented policies. Appraisal of additional policies will be published in Synthesis of Climate Change Policy Appraisals, to be available at **www.defra.gov.uk** The methodological approach set out in Greenhouse Gas Policy Evaluation and Appraisal in Government Departments, available at: **http://www.defra.gov.uk/environment/climatGreenhouse Gas policyechange/uk/ukccp/pdf/greengas-policyevaluation.pdf**

150 An independent evaluation by Cambridge Econometrics concluded that CCL would deliver annual carbon savings of 3.7MtC by 2010, from an announcement effect and the price effect of the levy. This figure assumes CCL rates increase in line with inflation from 2005 to 2010. The impact of CCL in the projections is incorporated through the price elasticity of demand for different fuels and there is no separately identified announcement effect.

151 The building standards system and Scottish building regulations are devolved to the executive. Refer section 3.7.6.(Non-Domestic) and 3.9.3 (Domestic)

**Summary of Policies and Measures**

| Name of policy or measure | Objective and/or activity affected | GHG | Type of instrument | Status | Implementing entity or entities | Carbon savings (MtC) | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 2010 | 2015 | 2020 |
| **With measures** | | | | | | | | |
| **Domestic** | | | | | | | | |
| Energy efficiency commitment (EEC) (2002–2005) | Energy use in homes | $CO_2$ | Regulatory | Implemented | Government, the electricity industry regulator and energy supply companies | 0.4 | | |
| Energy efficiency commitment (EEC) (2005–2008) | Energy use in homes | $CO_2$ | Regulatory | Implemented | Government, the electricity industry regulator and energy supply companies | 0.6 | | |
| Energy efficiency commitment (EEC) (2008–2011) | Energy use in homes | $CO_2$ | Regulatory | Implemented | Government, the electricity industry regulator and energy supply companies | 0.6 | | |
| Building regulations 2002 | Energy use in domestic buildings | $CO_2$ | Regulatory | Implemented | Government | 0.7 | | |
| Building regulations 2006 including 2005 condensing boiler update | Energy use in domestic buildings | $CO_2$ | Regulatory | Implemented | Government | 0.8 | | |
| Warm front and fuel poverty programmes | Energy use in domestic buildings and the fuel poor | $CO_2$ | Fiscal (grant) | Implemented | Government | 0.4 | | |
| Market transformation including appliance standards and labelling | Energy use in appliances | $CO_2$ | Labelling and information | Implemented | Government | 0.2 | | |

**Summary of Policies and Measures continued**

| Name of policy or measure | Objective and/or activity affected | GHG | Type of instrument | Status | Implementing entity or entities | Carbon savings (MtC) | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 2010 | 2015 | 2020 |
| **With measures** | | | | | | | | |
| **Agriculture** | | | | | | | | |
| Woodland grants scheme (England) | Reforestation and sustainable management of woods | $CO_2$ | Fiscal (grant) | Implemented | Government | 0.2 | | |
| Woodland planting since 1990 (Scotland) | Reforestation | $CO_2$ | Fiscal (grant) | Implemented | Government | 0.5 | | |
| **Public Sector** | | | | | | | | |
| Central Government, NHS, UK universities and English schools including Carbon Trust activities | Energy use in public sector buildings | $CO_2$ | Fiscal (grant) and information | Implemented | Government | 0.2 | | |
| **Total** | | | | | | **17.1** | | |
| **With additional measures** | | | | | | | | |
| **Energy Supply** | | | | | | | | |
| Subsidy for biomass heat | Heat production | $CO_2$ | Fiscal | Planned | Government | 0.1 | 0.4 | 0.8 |
| Second phase of EU emissions trading scheme | Industrial energy use | $CO_2$ | Economic | Planned | Government | 3 to 8 | 3 to 8 | 3 to 8 |
| **Business** | | | | | | | | |
| Carbon Trust support for investment in energy efficiency in SMEs | Energy use in SMEs | $CO_2$ | Fiscal (loans) | Adopted | Government | 0.1 | 0.1 | 0.1 |
| Measures to encourage of assist SMEs to take up energy saving opportunities | Energy use in SMEs | $CO_2$ | Not defined | Planned | Government and Carbon Trust | 0.1 | 0.1 | 0.2 |
| **Transport** | | | | | | | | |
| Renewable Transport Fuel Obligation (RTFO) | Reducing carbon content of transport fuels | $CO_2$ | Regulatory | Adopted | Government and transport fuel suppliers | 1.6 | 1.6 | 1.6 |
| Future voluntary agreement with car manufacturers to reduce $CO_2$ emissions | Fuel efficiency of cars | $CO_2$ | Voluntary agreement | Planned | Government (through EC) | 0.1 | 0.8 | 2 |

**Summary of Policies and Measures continued**

| Name of policy or measure | Objective and/or activity affected | GHG | Type of instrument | Status | Implementing entity or entities | Carbon savings (MtC) | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 2010 | 2015 | 2020 |
| **With additional measures** | | | | | | | | |
| **Domestic** | | | | | | | | |
| Increased activity in Energy Efficiency Commitment (EEC) (2008–2011) | Energy use in homes | $CO_2$ | Regulatory | Planned | Government, the electricity industry regulator and energy supply companies | 0.5 | 0.5 | 0.5 |
| Provision of advice to stimulate early replacement of inefficient boilers and implementation of the Energy Performance of Buildings Directive | Energy use in buildings | $CO_2$ | Regulatory and infor-mation | Planned | Government | 0.2 | 0.2 | 0.2 |
| Package of measures to improve energy efficiency in buildings | Energy use in homes | $CO_2$ | Regulatory, fiscal and information | Planned | Government and local authorities | 0.1 | 0.2 | 0.1 |
| Better billing and metering | Energy use in homes | $CO_2$ | Information, fiscal | Planned | Government and the electricity industry regulator | 0.2 | 0.5 | 0.5 |
| Products Policy: Consumer information and standards for lights and other energy using products (EUPs) | Energy use in appliances | $CO_2$ | Voluntary agreement and labelliing | Planned | Government and the Energy Savings Trust | 0.2 | 0.2 | 0.2 |

**Summary of Policies and Measures continued**

| Name of policy or measure | Objective and/or activity affected | GHG | Type of instrument | Status | Implementing entity or entities | Carbon savings (MtC) | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 2010 | 2015 | 2020 |
| **With additional measures** | | | | | | | | |
| **Agriculture** | | | | | | | | |
| Strategy for non food crops | Energy crops and renewable raw materials | $CO_2$ | Fiscal (grants) | Adopted | Government | 0.1 | 0.1 | 0.1 |
| **Public Sector** | | | | | | | | |
| Additional effort by local authorities | Emissions from public sector and domestic buildings | $CO_2$ | Fiscal (grants), planning | Planned | Government, local authorities | 0.2 | 0.2 | 0.2 |
| Revolving loan fund for the public sector | Energy efficiency in public sector buildings | $CO_2$ | Fiscal (loans) | Adopted | Government and Carbon Trust | 0.1 | 0.1 | 0.5 |
| **Actions by devolved administrations** | | | | | | 0.3 | 0.3 | 0.3 |
| Other measures | All energy use | $CO_2$ | Fiscal, regulatory and information | Adopted/ Planned | Government | 0.1 | 0.1 | 0.1 |
| **Total** | | | | | | **7 to 12** | **8 to 13** | **10 to 17** |

# Appendix C

## Reconciliation of UNFCCC and KP Reporting bases

| | Base Year | 1990 | 1995 | 2000 | 2004 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|
| **A: UNFCCC reporting basis (Total GHG sources minus total sinks)** | 209.9 | 209.0 | 191.9 | 180.5 | 178.9 | 169.2 | 173.1 | 170.0 |
| B: Total LULUCF sources and sinks | 0.8 | 0.8 | 0.3 | -0.1 | -0.5 | -0.5 | 0.1 | 0.7 |
| C: Total without any LULUCF (A minus B) | 209.1 | 208.2 | 191.6 | 180.6 | 179.5 | 169.6 | 172.9 | 169.4 |
| D: Article 3.3 LULUCF (all three gases)* | | 1.0 | 0.0 | -0.3 | -0.5 | -0.7 | -0.9 | -1.1 |
| E: Article 3.4 Forest Management* | | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.4 | -0.2 |
| F: Overseas Territories** | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| G: Article 3.7 Deforestation estimate in 1990*** | 0.1 | | | | | | | |
| **Kyoto Protocol reporting basis (Total of C:G above)** | 209.5 | 208.2 | 191.6 | 180.3 | 179.0 | 168.9 | 172.1 | 168.5 |

*Note: Estimates may not sum due to rounding*

**Notes**
* Articles 3.3 and 3.4 LULUCF not added to the base year
** OTS: Cayman Islands, Falkland Islands, Bermuda, Monstserrat
***Article 3.7 'D' estimate only added to base year

## Bilateral and regional financial contributions related to the implementation of the Convention (£ million)

| Recipient Country/ Region | Mitigation | | | | | | Adaptation | | | | Year of financing | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Energy | Transport | Forestry | Agriculture | Waste management | Industry | Capacity-building | Coastal zone management | Other vulnerability assessment | Organisation through which project funded | | |
| Africa | | | | | | | | | 0.099 | DFID | 2005 | Mapping climate, vulnerability and poverty. |
| Africa | | | | | | | | | 5.0 | DFID | 2005–2010 | Support to the integration of climate risk information in decision making processes and increase availability of climate observations. |
| Asia/ Africa | | | | | | | | | 0.99 | DFID | 2004–2006 | Linking local adaptation needs to policy and institutional structures. |
| Bangladesh | | | | | | | | | 6.0 | DFID Bangladesh | 2005–2010 | Comprehensive disaster management programme |
| China | 3.5 | | | | | | | | | Defra/DTI | 2005 | Support for nZEC |
| China | | | | 0.15 | | | | | | Defra/DFID | 2005 | Impacts of climate change on agriculture |
| East and West Africa | 0.19 | | | | | | | | | DFID | 2001–2003 | |
| Global | | | | | | | | | 0.14 | DFID | DFID 2004 | Climate change and development |
| Global | | | | | | | 0.14 | | | DETR/UNDP | 2001–2003 | Regional climate change prediction |

| Recipient Country/ Region | Mitigation | | | | | | Adaptation | | | | Year of financing | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Energy | Trans-port | Forestry | Agriculture | Waste man-agement | Industry | Capacity-building | Coastal zone management | Other vul-nerability assessment | Organisation through which proj-ect funded | | |
| Global | | | | | | | | | 0.48 | DFID | 2001–2003 | Impact of climate change on achievements of International development targets |
| South Eastern Asia | 0.076 | | | | | | | | 5.0 | DFID | 2002 | CDM pilot project to stimulate the market for family hydro for low income households |

*"Note: General contrbutions to adaptation in addition to those shown in this Table amount to a further £62 million via the Special Climate Change Fund, the Least Developed Countries Find, Disaster Risk Reduction and Adaptation Research."*

# Annex E

## Reporting of information under Article 7 Paragraph 2

| National systems (i.e. emissions inventories) under article 5 para 1 | Reported |
|---|---|
| • Contact details of organisation with responsibility for inventory | National Inventory Report (NIR) 2006[152] |
| • Roles/responsibilities of those involved with development of inventory as well as associated institutional/legal/procedural arrangements | NIR |
| • Methodology of inventory – e.g. collection of activity data, choice of emission factors, development of estimates. | NIR |
| • Process/results of key source identification | NIR |
| • Process to reassess previously submitted data | NIR |
| • Description of QA/QC plans, internal/external review procedures etc | NIR |
| • Description of procedures for approval of inventory | NIR |
| • An explanation if above incomplete/ partially completed | NIR |

| Mechanisms – related to Articles 6, 12 & 17 (JI, CDM & Emission Trading respectively) | |
|---|---|
| • Provide details of how the use of such mechanisms is supplemental to 'domestic' action | UK Report on demonstrable progress (DP) paragraph 3.9 and 4th NC Chapter 3 |

152 UK Greenhouse Gas Inventory , 1990–2004, Annual report for submission under the Framework Convention on Climate Change, April 2006, will be available from http://www.airquality.co.uk/archive/reports/reports.php?report_id=400

| National systems (i.e. emissions inventories) under article 5 para 1 | Reported |
|---|---|
| **P&Ms – related to article 2** | |
| • Reporting of all P&Ms linked to emissions reduction including co-operation with other parties | DP Chapter 4 and 4th NC Chapter 6 |
| • Steps taken to implement decisions by ICAO and IMO to reduce GHG emissions from aviation/marine bunker fuels not controlled by the Montreal Protocol. | 4th NC Chapter 3 |
| • Provide information (not reported elsewhere) on how party aims to implement P&Ms whilst minimising adverse affect on international trade and social/econ/env impacts on other parties – in particular developing countries. | DP 4.11 and 4th NC Chapter 3 |

| Legislative arrangements and enforcement and admin procedures | |
|---|---|
| • Description of regional/domestic legislative arrangements and enforcement and administrative procedures the party has – to meet its commitments under the KP. Legal authority for such programmes, procedures for non-compliance etc. | DP report Chapter 3 |
| • Provision to make info on above procedures publicly accessible. | DP report |
| • Description of institutional arrangements and decision-making procedures in place to coordinate activities under articles 6,12 & 17. | DP report Chapter 3 |
| • Description of legislative/admin procedures for implementation LULUCF activities, and also any elected activities under these that contribute to conservation of biodiversity, sustainable use of natural resources etc. | DP Report Chapter 3. |

| Info under article 10 | |
|---|---|
| • Steps taken to promote/facilitate/finance tech transfer to developing countries. | Chapter 6 4th NC |

| Financial resources | |
|---|---|
| • Report on any financial contributions made to the 'adaptation fund' (established in accordance with decision 10/CP.7) | Chapter 5 4th NC |

# Glossary of terms

| | |
|---|---|
| ACEA | European Automobile Manufacturers Association |
| $CO_2$ | Carbon Dioxide |
| CAP | Common Agricultural Policy |
| CAT | Carbon Abatement Technology |
| CCA | Climate Change Agreements |
| CCS | Carbon Capture and Storage |
| CDM | Clean Development Mechanism |
| CFC | Chlorofluorocarbon |
| CHP | Combined Heat and Power |
| CH4 | Methane |
| CCL | Climate Change Levy |
| CT | Carbon Trust |
| Defra | Department for Environment, Food and Rural Affairs |
| DfT | Department for Transport |
| Dfid | Department for International Development |
| DTI | Department of Trade and Industry |
| ECA | Enhanced Capital Allowances |
| EEC | Energy Efficiency Commitment |
| EPBD | Energy Performance of Buildings Directive |
| EST | Energy Savings Trust |
| ETS | Emissions Trading Scheme |
| EU | European Union |
| FCO | Foreign and Commonwealth Office |
| G8 | Group of 8 |
| GDP | Gross Domestic Product |
| GEF | Global Environment Fund |
| GVA | Gross Value Added |
| HFC | Hydroflurocarbon |
| HMT | Her Majesty's Treasury |
| ICAO | International Civil Aviation Organisation |
| IPCC | Intergovernmental Panel on Climate Change |
| IPPC | Industrial Pollution Prevention and Control |
| JI | Joint Implementation |
| LULUCF | Land Use and Land Use Change and Forestry |
| MtC | Million tonnes of carbon equivalent |
| MTP | Market Transformation Programme |
| $N_2O$ | Nitrous Oxide |
| NAP | National Allocation Plan (for the ETS) |
| NERC | National Environmental Research Council |
| Ofgem | Office for Gas and Electricity Markets |
| Ofreg | Northern Ireland Office for Regulation of Electricity and Gas |
| PFC | Perfluorocarbon |
| REEEP | Renewable Energy and Energy Efficiency Partnership |
| ROC | Renewables Obligation Certificate |
| ROS | Renewables Obligation Scotland |
| SF6 | Sulphur hexafluoride |
| SME | Small and medium sized enterprise |
| UEP | Updated Energy Projections |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UNDP | United Nations Development Programme |
| UKCIP | UK Climate Impacts Programme |
| VED | Vehicle Excise Duty |

Product code PB 11862

Department for Environment, Food and Rural Affairs
Nobel House
17 Smith Square
London SW1P 3JR

www.defra.gov.uk