© OECD 2011

Chapter 4

Climate-change policy in the United Kingdom

The United Kingdom started to pursue policies to reduce greenhouse gas emissions at a relatively early date and now has a comprehensive set of measures in place. It has set clear targets for emission reductions consistent with international goals of limiting global warming and has pioneered statutory underpinning of target-setting. On the international stage, it has been an active protagonist of a global deal to limit human-induced climate change. The new government has endorsed the direction of previous policies in this area and is introducing further measures, despite heavy fiscal pressures. The United Kingdom is likely to reduce emissions by more than its near-term domestic targets and its target under the Kyoto Protocol, outperforming many OECD countries in the latter respect. But some of the success has been due to "one-off" factors such as the "dash for gas", reductions in non-CO_2 greenhouse gases in the 1990s and the recent recession, rather than explicit climate-change policies. The pace of decarbonisation of the power sector has been slow and the spread of renewable energy technologies limited. Implicit carbon prices vary across sectors, and should be harmonised and thus more efficient. The unevenness partly reflects the way in which policies have proliferated and overlap and a simplified structure would be desirable. A step-change in the pace of emission reductions is required to put the UK on the path towards its ambitious 2050 target. Given the central role of the EU emissions trading scheme, a key element of the UK strategy should be to seek tighter quotas within the EU scheme. Preparations to adapt to climate impacts also need to be stepped up, focusing on the provision of more information, better risk-assessment frameworks and more advanced metrics for monitoring and evaluation of adaptation planning.

Rising to the climate challenge

This chapter analyses the UK climate-change policy framework. It first examines the United Kingdom's performance according to various outcomes relevant to climate change, such as greenhouse gas emissions (GHG) reductions and the market penetration of renewable energy. It then discusses UK policies and how well they are designed to reduce greenhouse gas emissions in a cost-effective way. Particular attention is paid to carbon pricing and in the light of the market failures that afflict innovation the promotion of renewable energy. Examining policies piecemeal can lead to neglect of significant interactions among them when, for example, quantity-based instruments co-exist with price-based instruments or policies are applied at different stages in the supply chain. Hence the chapter also addresses the issue of overlapping policy instruments. The variety of policies across different sectors of the economy is also noted. The chapter then moves from climate-change mitigation to discuss adaptation policies. Finally, the chapter concludes with some suggestions for how policies could be improved.

Recent progress on emissions has been significant but a step change is needed to achieve ambitious targets

Emissions have fallen rapidly

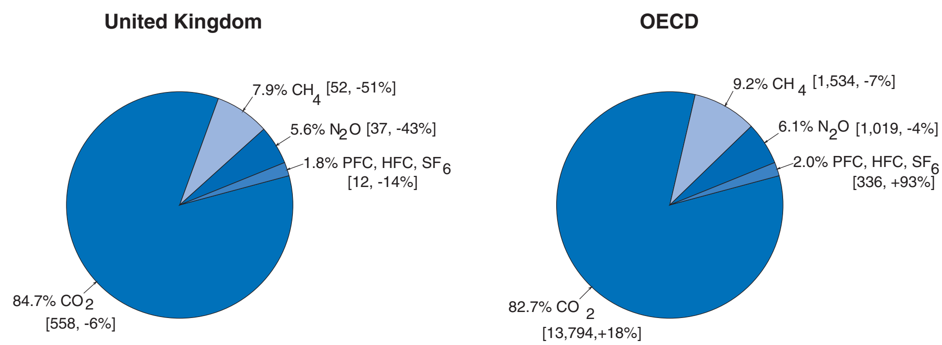
The United Kingdom did better than OECD countries on average in achieving emission reductions (Figure 4.1). Performance was most striking in the non-carbon dioxide (non-CO_2) gases. Much of the decrease in methane (CH_4) was due to improved landfill and waste management, encouraged by UK policies such as the 1996 landfill tax and the Landfill Allowance Trading Scheme. A small number of industrial installations accounted for nearly all industrial non-CO_2 emissions and reduced them sharply, responding to policy and new technological opportunities. The OECD as a whole has been much less successful in this area. Progress in reducing carbon dioxide (CO_2) emissions has also been better than in the OECD as a whole (Figure 4.1), although since 2007, there has been a major decline in both OECD and UK CO_2 emissions, primarily due to the recession (Figure 4.2).

Considering the full range of targets covered by the Kyoto Protocol, the United Kingdom, in 1990, had higher emissions per head than the EU15 as a whole. Emissions were lower than the OECD average though (Table 4.1).[1] By 2005, the United Kingdom had reached the EU15 average, which itself had dropped, while emissions per capita increased slightly in the OECD as a whole. Similarly, UK emissions per unit of GDP dropped faster than the OECD average, falling to around the EU15 average.

UK energy CO_2 emissions[2] are the main focus of climate change mitigation policies as they account for around four-fifths of total emissions (the same proportion as in the OECD as a whole).[3] The Kaya decomposition (Table 4.1) decomposes energy CO_2 emissions into its components using the "Kaya identity", which expresses energy CO_2 emissions per head (column A) as equivalent to the product of GDP per head (B), the carbon intensity of energy (C), and the energy intensity of output (D). The relatively low energy CO_2 emissions in the

Figure 4.1. **Total GHG emissions by gas in 2005**[1]

Total GHG's and percentage change from 1990



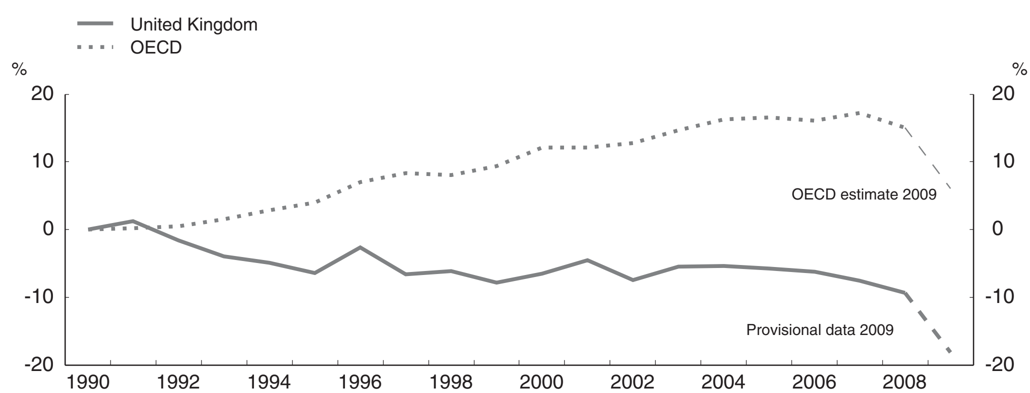
1. Share based on million tonnes CO_2 equivalent. Excludes land use change. Carbon dioxide (CO_2); Methane (CH_4); Nitrous oxide (N_2O); Perfluorocarbons (PFCs), Hydrofluorocarbons (HFCs); Sulphur hexafluoride (SF_6). In brackets: emissions in million tonnes CO_2 equivalent and percentage change from 1990.

Source: Climate Analysis Indicators Tool (CAIT) World Resources Institute (2010) and UK UNFCCC submission (2008).

StatLink http://dx.doi.org/10.1787/888932376991

Figure 4.2. **Change in total CO_2 emissions in the United Kingdom and the OECD**[1]

Percentage change from 1990



1. Excludes land use change.

Source: IEA database, *CO_2 Emissions from Fuel Combustion* (OECD estimate in 2009 extrapolated from Friedlingstein, *et al.*, [2010]); UK Department for Energy and Climate Change (DECC) (2010), *UK Emissions Statistics*, with 2009 Provisional data.

StatLink http://dx.doi.org/10.1787/888932377010

United Kingdom and European countries, compared with Canada and the USA, are driven by lower energy intensity (column D) and to a lesser extent by lower GDP (column B). Energy emissions decreased on average by 0.7% per year per head between 1990 and 2005, which is more than the OECD, EU15 and world averages. The reductions in carbon and energy intensities outweighed the impact of strong economic growth between 1990 and 2005. These reductions, strongest in the period 1990-2000 (Table 4.2), were influenced by the privatisation of the electricity industry in the early 1990s. Privatisation was accompanied by reduced gas prices and improvements in electricity generation technology, which led to greater use of cleaner energy sources, especially gas (the so-called "dash for gas"), which replaced coal and oil. At the end of the 1990s, the "dash for gas" and

Table 4.1. **Decomposition of energy CO_2 emissions**

Panel 1: Emissions 1990

Country/region (%)	GHG emissions/head (tCO_{2e})	A Energy CO_2 emissions/head (tCO_2)	B GDP per head ('000 Intl$ppp 2005)	C Energy CO_2 emissions/energy use (tCO_2/toe)	D Energy use/GDP (toe/Intl$ppp 2005) x 10^3
USA	24.5	19.6	31.9	2.5	0.24
Canada	21.1	15.7	27.0	2.1	0.28
Germany	15.3	12.0	25.7	2.7	0.17
UK	**12.8**	**10.0**	**23.6**	**2.7**	**0.16**
Japan	9.9	8.7	26.0	2.4	0.14
France	9.8	6.2	24.9	1.5	0.16
Italy	9.1	7.0	23.8	2.7	0.11
OECD	14.0	10.7	22.9	2.5	0.19
EU15	11.7	8.5	23.7	2.3	0.15
World	5.8	3.9	6.7	2.4	0.25

Panel 2: Emissions 2005

Country/region (%)	GHG emissions/head (tCO_{2e})	Energy CO_2 emissions/head (tCO_2)	GDP per head ('000 Intl$ppp 2005)	Energy CO_2 emissions/energy use (tCO_2/toe)	Energy use/GDP (toe/Intl$ppp 2005) x 10^3
USA	23.9	19.7	41.9	2.5	0.19
Canada	23.0	17.3	35.1	2.0	0.24
Germany	12.2	9.8	31.4	2.3	0.13
UK	**11.4**	**9.0**	**32.2**	**2.3**	**0.12**
Japan	10.9	9.6	30.3	2.3	0.14
France	9.4	6.4	30.7	1.4	0.15
Italy	9.9	7.7	28.1	2.4	0.11
OECD	14.3	11.1	29.6	2.3	0.16
EU15	11.4	8.5	30.4	2.1	0.13
World	6.0	4.1	8.8	2.3	0.20

Panel 3: Average annual growth in emissions 1990-2005

Country/region (%)	GHG emissions/head (tCO_{2e})	Energy CO_2 emissions/head (tCO_2)	GDP per head ('000 Intl$ppp 2005)	Energy CO_2 emissions/energy use (tCO_2/toe)	Energy use/GDP (toe/Intl$ppp 2005) x 10^3
USA	–0.2	0.0	1.8	–0.1	–1.6
Canada	0.6	0.7	1.8	–0.1	–1.0
Germany	–1.5	–1.3	1.3	–0.9	–1.8
UK	**–0.8**	**–0.7**	**2.1**	**–1.0**	**–1.7**
Japan	0.6	0.7	1.0	–0.3	–0.1
France	–0.3	0.2	1.4	–0.7	–0.6
Italy	0.6	0.7	1.1	–0.6	0.2
OECD	0.1	0.3	1.7	–0.3	–1.1
EU15	–0.2	0.0	1.7	–0.7	–1.0
World	0.2	0.3	1.8	–0.1	–1.4

Source: Climate Analysis Indicators Tool (CAIT): World Resources Institute, 2010; and *UN World Population Prospects database*: 2008 Revision.

the impact of privatisation lessened, and the United Kingdom began to implement a new set of climate-change policies directly targeted at energy efficiency and emission reductions. This coincided with a continued but slower decline in energy CO_2 emissions per head post-2000. The carbon intensity of energy stopped falling despite the new policies, although this was partly offset by a faster rate of reduction of the energy intensity of GDP. The United Kingdom's rank within the OECD improved on the latter measure, in contrast to its ranking with respect to growth in GDP per head and reductions in carbon intensity.

The economic downturn brought some temporary respite. The latest data suggest a faster annual average rate of decline in energy emissions per head between 2005 and 2009, driven by a fall in the annual rate of change in GDP per head (the early impact of the recession), a fall in carbon intensity, and a further fall in the energy intensity of output. Once allowance is made for the downturn, which has had a disproportionally large impact on several energy-intensive sectors, policies to reduce carbon emissions appear to have contributed less to reductions than did the "dash for gas". Stronger measures are therefore required to accelerate the transition from fossil-fuel-based electricity generation towards cleaner energy supplies to sustain the trend.

Table 4.2. **Average annual growth in energy CO_2 emissions, 1990-2000 and 2000-2005**

%	Period	Energy CO_2 emissions/head	GDP per head	Carbon Intensity	Energy Intensity
UK	**1990-2000**	**–0.9**	**2.1**	**–1.6**	**–1.4**
	2000-2005	**–0.3**	**2.0**	**0.1**	**–2.3**
	2005-2009[1]	**–3.4**	**–0.3**	**–0.5**	**–2.6**
	1990-2009[1]	**–1.4**	**1.6**	**–0.7**	**–2.4**
OECD	1990-2000	0.5	1.9	–0.4	–1.0
	2000-2005	0.0	1.4	–0.2	–1.3
World	1990-2000	–0.4	1.6	–0.3	–1.7
	2000-2005	1.6	2.3	0.2	–0.9
UK rank /all OECD countries	1990-2000	7	11	4	13
	2000-2005	7	14	23	4

1. These estimates for the United Kingdom are sourced from World Bank Development indicators, the UK Office of National Statistics (ONS), DECC (2010) *UK Emissions Statistics*, with 2009 Provisional UK figures, UK UNFCCC submission (2008), and IEA Energy, *Balances of OECD countries*, 2010. Provisional estimates for 2009 from various sources.

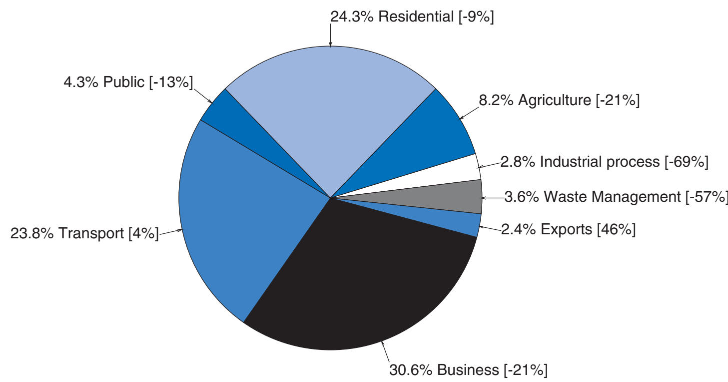
Source: Climate Analysis Indicators Tool (CAIT): World Resources Institute, 2010; *World Bank World Development Indicators; UN World Population Prospects database:* 2008 Revision; UK emissions data are from the UK UNFCCC National Inventory Submission, 2008.

The sectoral distribution of emissions reductions has been uneven. Emissions in UK waste management decreased 57% over 1990-2008 and those from industrial processes fell 69% (Figure 4.3). The United Kingdom has not, however, achieved significant reductions in the transport and residential sectors, which account for around 48% of total emissions, despite some relatively inexpensive mitigation options in these sectors. A range of market failures and behavioural barriers are preventing greater progress.

Emission reduction targets are ambitious

The United Kingdom, along with the EU15 as a whole, is on track to outperform its Kyoto target significantly by means of domestic emission reductions (Figure 4.4), unlike some individual EU members such as Spain, Austria and Luxemburg, and some other Kyoto signatories such as Canada and Japan. At the inception of the Kyoto Protocol, the EU15 committed to reducing emissions by 8%, on average, over the 2008-12 commitment period, compared with base-year emissions.[4] Under the EU's burden-sharing agreement the

Figure 4.3. **UK GHG emissions by end-user in 2008**[1]



1. Share based on million tonnes CO_2 equivalent. Percentage change since 1990 in brackets.

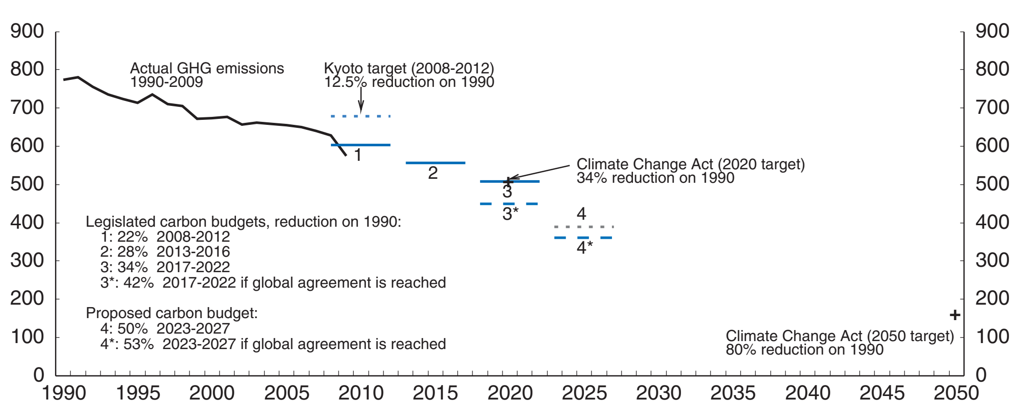
Source: DECC (2010). UK Climate Change Sustainable Development Indicator: 2009 Greenhouse Gas Emissions, Provisional Figures and 2008 Greenhouse Gas Emissions, Final Figures by Fuel Type and End-User. *www.decc.gov.uk/en/content/cms/statistics/climate_change/gg_emissions/uk_emissions/2009_prov/2009_prov.aspx.*

StatLink http://dx.doi.org/10.1787/888932377029

United Kingdom accepted a national target of a 12.5% reduction. In 2009, total UK emissions were around a fourth below 1990 levels (Figure 4.4). The EU15 as a group should also exceed its collective target; the European Environment Agency estimates that EU emissions were 13% below 1990 levels in 2009. In addition to the Kyoto commitment, in 1997 the incoming UK government set a 20% target for CO_2 reductions between 1990 and 2010. Prior to the recent downturn, the United Kingdom was not widely expected to meet this target, but success now appears likely. More recently the UK has introduced a system of carbon budgets setting legally binding emissions limits over five year periods. The first three carbon budgets, covering the periods 2008-12, 2013-17 and 2018-22 respectively, require a 34% reduction in emissions with respect to 1990 levels by 2020.

Figure 4.4. **United Kingdom GHG emissions 1990-2009 and targets to 2050**

Million tonnes CO_2 equivalent



Source: DECC (2010), *UK Emissions Statistics*, with 2009 provisional data; Committee on Climate Change.

StatLink http://dx.doi.org/10.1787/888932377048

However, further improvements in the rate of emission reductions are required over the coming decades if the UK (and the world) is to achieve reductions on the scale required to have a 50/50 chance of limiting the temperature increase from pre-industrial times to 2 °C. According to Stern (2009a, 2009b), that objective will require that countries will need to be, on average, at two tonnes CO_2 equivalent (CO_2e) per head by 2050. That is consistent with the UK national commitment of at least 80% cuts in total emissions from 1990 to 2050 (Figure 4.4). As energy is the largest contributor, energy CO_2 emissions will also need to be around two tonnes per head by 2050 if targets are to be achieved. This requires raising the annual average rate of emission reductions in energy CO_2 per head from 0.9% over the past decades (Table 4.2) to around 3.2% per year between 2008 and 2050. Over a shorter time horizon, the UK Committee on Climate Change (CCC) in its second progress report argued that the rate of emission reductions needs roughly to double from its mid-2000 level to meet near-term UK carbon budgets, even after taking into account the effect of the recession (CCC, 2010a).[5] Early and effective policy action is required to discourage new high-carbon investments, to redirect innovation towards low-carbon growth and to avoid the need for sharper changes in carbon prices and investment flows closer to the target dates. The current government is taking forward action in a number of areas to accelerate rates of decarbonisation, including through the Electricity Market Reform project, support for the carbon price and the introduction of a "Green Deal" to drive improvements in domestic energy efficiency.

Renewable and nuclear energy plays a less prominent role in the United Kingdom

Government policy in the United Kingdom over the past decade has promoted renewable energy to reduce the carbon intensity of energy and diversify supply. The contribution from renewable energy to Total Primary Energy Supply (TPES) and electricity generation has risen since the introduction of renewable energy policy in the early 2000s, by around 2 and 4 percentage points respectively (Table 4.3, Panels 1 and 2). The share of nuclear energy has declined since 2000, reversing an upward trend during the 1990s (Table 4.3, panel 3). The contribution of renewables to energy supply and electricity generation remains low, both in absolute terms and relative to other OECD countries. Fossil fuels continue to account for the major share of supply (Figure 4.5).

Table 4.3. **Non-fossil energy contributions**

Panel 1: Contribution of renewable energy sources to TPES[1]

%	1990	2000	2009	Absolute % change 1990-2009	Average annual % change 1990-2000	Average annual % change 2000-2009
USA	5	4.5	5.4	8.0	–1.0	2.0
Canada	16.2	16.9	16.9	4.3	0.4	0.0
Germany	1.5	2.7	9.1	506.7	6.1	14.5
UK	**0.5**	**1**	**3.1**	**520.0**	**7.2**	**13.4**
Japan	3.5	3.2	3.2	–8.6	–0.9	0.0
France	6.8	6.3	7.6	11.8	–0.8	2.1
Italy	4.4	5.9	9.3	111.4	3.0	5.2
OECD Total	5.8	5.9	7.3	25.9	0.2	2.4
OECD Europe	5.7	6.8	9.9	73.7	1.8	4.3
World	12.7	12.9	–	–	–	–

Panel 2: Share of electricity generation from renewable sources[1]

%	1990	2000	2009	Absolute % change 1990-2009	Average annual % change 1990-2000	Average annual % change 2000-2009
USA	11.5	8.2	10.2	–11.3	–3.3	2.5
Canada	62.4	60.6	60.8	–2.6	–0.3	0.04
Germany	3.5	6.2	16.1	360.0	5.9	11.2
UK	**1.8**	**2.7**	**6.7**	**272.2**	**4.1**	**10.6**
Japan	12	9.9	9.5	–20.8	–1.9	–0.5
France	13.4	13.1	12.9	–3.7	–0.2	–0.2
Italy	16.4	18.8	23.1	40.9	1.4	2.3
OECD Total	17.3	15.6	17.2	–0.6	–1.0	1.1
OECD Europe	17.6	18.9	22.5	27.8	0.7	2.0
World	19.5	18.4	–	–	–	–

Panel 3: Share of electricity generation from nuclear energy

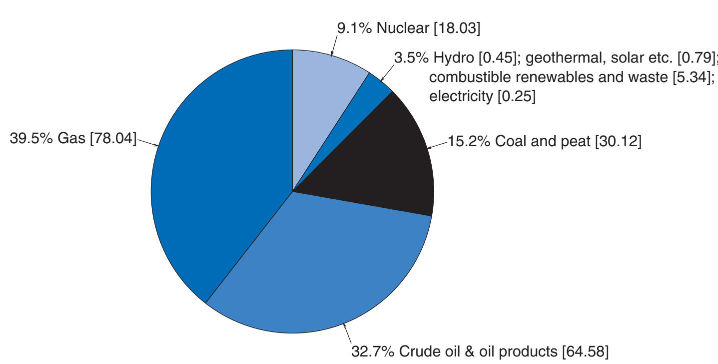
%	1990	2000	2009	Absolute % change 1990-2009	Average annual % change 1990-2000	Average annual % change 2000-2009
USA	19.1	19.8	20.0	4.7	0.4	0.1
Canada	15.1	15.1	14.5	–4.0	0.0	–0.4
Germany	27.8	29.6	22.8	–18.0	0.6	–2.9
UK	**20.7**	**22.7**	**18.8**	**–9.2**	**0.9**	**–2.1**
Japan	24.2	30.7	26.9	11.2	2.4	–1.5
France	75.3	77.5	76.5	1.6	0.3	–0.1
Italy	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
OECD Total	22.8	23.3	21.8	–4.4	0.2	–0.7
OECD Europe	29.7	29.2	25.6	–13.8	–0.2	–1.5

1. Renewable energy sources include hydroelectricity, geothermal, solar thermal, solar PV, tide, wind, renewable municipal waste, solid biomass, liquid biomass and biogas.

Source: Panels A and B: IEA Renewable Information 2010; Panel C: IEA Energy Balances of OECD countries, 2010.

Figure 4.5. **Estimated energy supply balance for the United Kingdom in 2009**[1]

Total primary energy supply



1. Share based on million tonnes of oil equivalent. Million tonnes of oil equivalent in brackets. Includes imports and deducts exports, including international aviation and marine bunkers.

Source: IEA (2010), *Energy Balances of OECD countries*.

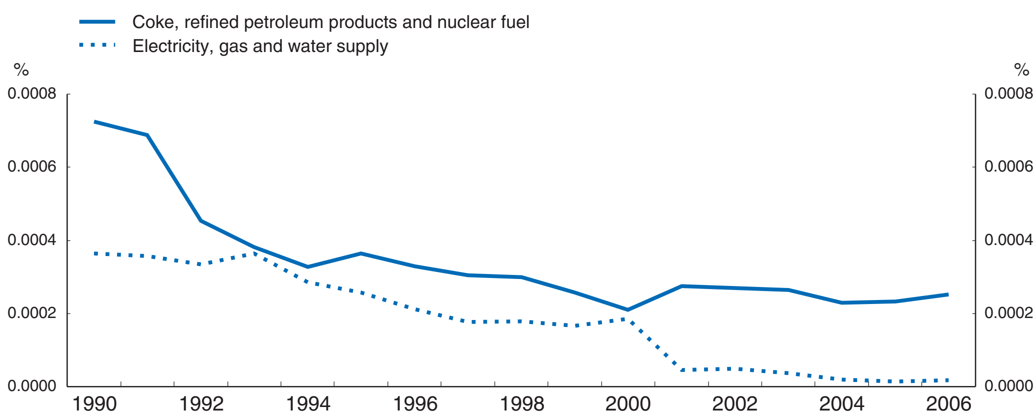
StatLink http://dx.doi.org/10.1787/888932377067

Research, development and technological innovation

Technological innovation over the long term is essential to ensure that the step-change in emission reductions required is delivered at a reasonable cost. While it may be technically possible to achieve the required emission reductions using current technologies, this is likely to be increasingly costly as cheaper options are exhausted and more fundamental structural changes, such as the replacement of fossil-fuel-powered transport, are required. Hence it is worrying that R&D spending in energy-related industries has declined substantially over the past 20 years in relation to GDP (Figure 4.6). The United Kingdom has lagged other major OECD countries in government energy R&D spending (Figure 4.7). A sharp decline in both public and private nuclear R&D post-1990 can be attributed to countries' experiences with cost over-runs, construction delays, and public concerns over reactor safety and waste disposal. The more recent resurgence of UK government R&D is largely due to spending on renewable

Figure 4.6. **Industry R&D expenditure**

Per cent of GDP – nominal current prices

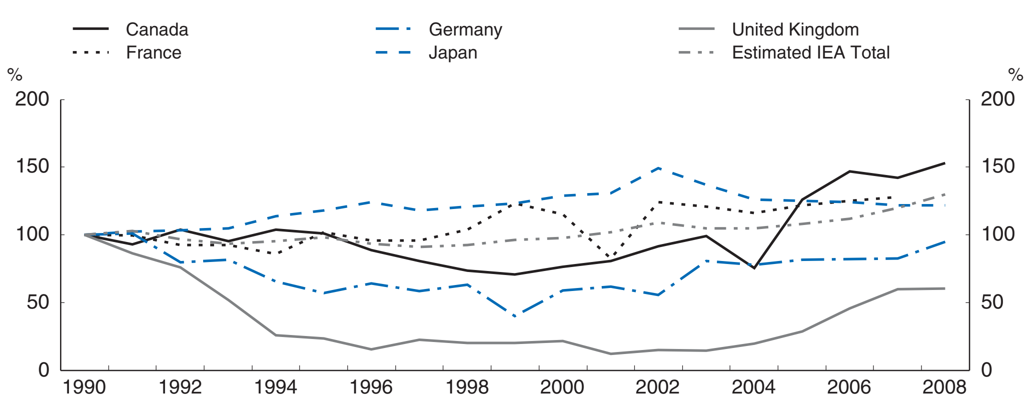


Source: IEA database, Energy Technology R&D Statistics.

StatLink http://dx.doi.org/10.1787/888932377086

Figure 4.7. **Index of government "green" energy R&D budgets**[1]

Index: 1990 = 100 – 2008 prices USD and PPP



1. "Green" energy R&D budgets include: energy efficiency, renewables, nuclear, hydrogen and fuel cells, other power and storage technologies, and other technology or research. Excludes fossil fuels.

Source: IEA database, Energy Technology R&D Statistics.

StatLink http://dx.doi.org/10.1787/888932377105

energy R&D, reflecting climate-change and energy-security objectives. However, the recent review of innovation policy by the Committee on Climate Change suggests that current government funding for clean energy R&D is at its minimum acceptable level and increases are warranted in certain areas (CCC, 2010b).

Although the United Kingdom ranked highly on global patent submission in "clean" innovation over the period 1980-2007 and 2002-2007, its position slipped slightly in the latter period (Table 4.4). While the United Kingdom remains a leader in marine energy innovations, its ranking declined in batteries, electric and hybrid vehicles, nuclear, methane, heating, solar, fuel injection and waste. However, the falls appear to be due to higher growth in patenting activity in emerging economies such as Korea, rather than a major decline in the UK.

Table 4.4. **Top 15 nations by share of the world's climate-related inventions**

Country Rank	1980-2007		2002-2007	
	Average % of world's inventions	Rank	Average % of world's inventions	Rank
Japan	20.2	1	20.8	1
Germany	19.8	2	17.8	2
USA	15.4	3	14.1	3
France	5.1	4	4.4	5
UK	**4.5**	**5**	**4.3**	**6**
Australia	3.8	6	2.9	9
Sweden	3.3	7	1.7	14
South Korea	3.1	8	5.6	4
Canada	2.2	9	3.0	8
Netherlands	2.1	10	1.8	13
Austria	2.0	11	2.1	11
Italy	1.9	12	2.3	10
Switzerland	1.9	13	1.3	16
China	1.9	14	3.9	7
Denmark	1.4	15	1.4	15
Total	**88.6**		**87.4**	

Source: Dechezleprêtre and Martin (2010).

Major policy instruments

The overall policy framework is complex, encompassing several different instruments and objectives

The UK has developed a complex set of measures to reduce emissions since the late 1980s. The aim has been to price emissions, stimulate the development and deployment of clean energy and improve energy efficiency. Policies to promote efficient adaptation to the uncertain impacts of climate change are underdeveloped. The United Kingdom has recognised the importance of international collaboration on mitigation and adaptation, given the global nature of the climate-change problem (Box 4.1).

Most domestic UK policies are designed to be "market friendly", using price signals to encourage firms and households most able to adjust their behaviour cost effectively (Box 4.2). Policies rely heavily on tradable quota markets, a form of quantity-based

Box 4.1. **Contributions to international climate-change policies**

The United Kingdom has a proven track record in international action on climate change, which, together with a cross-party commitment to a strong domestic policy framework, is setting a useful international example. The United Kingdom has consistently been in the vanguard of developed nations in promoting international action on climate change. It has strongly supported international climate-change negotiations through the United Nations Framework Convention on Climate Change (UNFCCC) and EU channels, along with considerable unilateral efforts to support adaptation and mitigation in developing countries. At the G8 Summit at Gleneagles in July 2005, the United Kingdom proposed a focus on poverty reduction and climate change. Soon after, the then Labour government commissioned the Stern Review on the economics of climate change, which helped to push climate change to the centre of the policy debate in the United Kingdom and many other OECD countries. The United Kingdom offered strong support for a global climate change agreement at the UNFCCC Conference of Parties in Copenhagen in 2009 (COP15) and Cancun in 2010 (COP16).

Although COP15 fell short of expectations and COP16 made only modest progress on outstanding issues, the United Kingdom continues to push for strong and co-ordinated action on climate change. In July 2010, the environment ministers of the United Kingdom, Germany and France published joint articles in three leading newspapers emphasising the economic benefits of unilaterally increasing the EU emission-reduction target for 1990 to 2020 from 20% to 30%, a proposal that is now official UK policy. Despite the environment of fiscal austerity, the new government is also committed to providing finance to assist developing countries manage climate change, including £1.5 billion as its share of fast-start financing of USD 30 billion in 2010-2012 promised in the Copenhagen Accord. The United Kingdom's total commitment to international climate-change finance over the spending review period is £2.9 billion.

The United Kingdom is active in the international arena in other ways, too. The Foreign and Commonwealth Office's three strategic priorities include promoting sustainable growth. The Department for International Development (DFID) supports adaptation in developing countries and, through the International Forestry Group, participates in international forestry negotiations.*

* A list of recent and ongoing programmes and initiatives is available at *www.dfid.gov.uk/About–DFID/Finance-and-performance/Structural-reform-plan/Climate-change/About–DFID/Finance-and-performance/Structural-reform-plan/Climate-change.*

instrument (such as the Renewables Obligation [RO]), although there are also primarily price-based instruments (such as the Climate-Change Levy [CCL]). In practice, several schemes are hybrids. There are also regulations mandating specific actions, such as labelling requirements for energy efficiency. One unusual aspect of the UK policy framework is that, since 2008, it has been underpinned by a Climate Change Act, which gave statutory force to domestic carbon-reduction budgets. The Act also set up an independent body, the Committee on Climate Change, with statutory responsibilities to propose appropriate carbon budgets, assess progress towards the government's long-term emission reduction targets and give advice to the government on climate-change policies in general, covering both mitigation of and adaptation to climate change.

Box 4.2. **A timeline of UK climate-change policies**

1989: The Non Fossil Fuel Obligation (NFFO) and the Scottish Renewables Obligation (SRO) were established under the Electricity Act 1989. Originally intended to support nuclear electricity generation, the NFFO and SRO were expanded in 1990 to include renewables. The NFFO and SRO were funded by a **Fossil Fuel Levy** paid by suppliers of electricity from fossil fuels.

2000: Climate Change Programme. This report set out policies and priorities for action both in the United Kingdom and internationally. Updated in 2006, the policies are supposed to reduce CO_2 emissions by 15-18% below 1990 levels by 2010 and overall GHG emissions by 23-25%.

2001: The Climate Change Levy (CCL) was introduced on 1 April 2001, effectively replacing the Fossil Fuel Levy. It is a downstream tax on non-domestic energy use by industry and the public sector, designed to incentivise energy efficiency and emission reductions, with part of the revenue being used to reduce National Insurance contributions. Energy-intensive firms can receive up to an 80% discount if they join a ***Climate Change Agreement (CCA)***, which requires meeting energy efficiency or carbon-saving targets. Renewable electricity suppliers are exempt from the CCL.

2002: The Renewables Obligation (RO) replaced the NFFO and SRO as the primary renewable energy policy instrument. The RO requires electricity end-suppliers to purchase a certain fraction of their annual electricity supply from producers using specific renewable technologies, and they receive tradable Renewables Obligation Certificates (ROCs) for doing so. The supplier can also "buy out" the obligation by paying a set price per MWh. The buy-out revenue is recycled to participating suppliers in proportion to their ROCs.

2002: The Energy Efficiency Commitment (EEC) was introduced, requiring energy suppliers to achieve 62TWh of savings over the period to 2005 through assisting the implementation of home energy efficiency improvements, equivalent to a reduction in domestic emissions of approximately 1%. The second phase of EEC (2005-2008) raised the total savings required to 130TWh.

2005: European Union Emissions Trading System (EU ETS). The UK Emissions Trading Scheme closed in 2006 and was replaced by the EU's that aims at ensuring compliance with the Kyoto obligations. Under the EU system, member states proposed National Allocation Plans (NAPs) to the European Commission, allocating a set proportion of a country's total 2008-2012 emission budget to sectors covered by the scheme; tradable quotas were then divided among firms (*www.eea.europa.eu/pressroom/newsreleases/questions-and-answers-on-key*).

2008: Climate Change Act. This Act set a legally binding target of 80% reductions in emissions from 1990 to 2050. A medium-term target of a 34% reduction by 2020 was also adopted, with the promise of a further tightening in the event of a global deal on climate change. To achieve these targets, the Act established the principle of five-year carbon budgets. The first three budgets were set in 2009 and cover 2008-12, 2013-17 and 2018-22. The fourth budget, 2023-2027, was recently proposed by the UK Committee on Climate Change. The government must submit its policies to meet these budgets to Parliament, as it did in the **Low-Carbon Transition Plan** of July 2009, which set out policies to cut emissions across the power and heavy industry sector; the transport sector; in homes and communities, workplaces and jobs; in agriculture; and in land use and waste management. The Act also requires the government to include aviation and shipping emissions, or provide an explanation why not, by the end of 2012.

Box 4.2. **A timeline of UK climate-change policies** *(cont.)*

2008: Carbon Emission Reduction Target (CERT). This scheme follows on from the Energy Efficiency Commitment, with a greater focus on more substantial and robust household energy saving measures such as insulation, and a component targeted at those most vulnerable to fuel poverty. The total lifetime savings required from energy suppliers over the duration of the scheme until 2012 is 293 million tonnes CO_2.

2008: Renewable Transport Fuel Obligation (RTFO). This is administered by the Renewable Fuels Agency and requires suppliers of fossil fuels to ensure that a specified percentage of UK road fuel supply is from renewable fuels. The target for 2009-2010 is 3.25% of fuels by volume. Suppliers may buy out their obligation for 30 pence/litre. The obligation also requires companies to submit reports on the carbon content and sustainability of the biofuels used.

2009 Community Energy Saving Programme (CESP) established to complement CERT. The scheme achieves aims of both carbon reduction and addressing fuel poverty by requiring energy suppliers to achieve 19.25 million tonnes CO_2 lifetime savings in the most deprived areas of England, Scotland and Wales, promoting area-based and whole-house approaches to energy efficiency improvements.

2010: Carbon Reduction Commitment Energy Efficiency Scheme (CRC EES). Established under the Climate Change Act 2008, the scheme covers emissions by firms and public bodies not already subject to the EU system or substantially covered by other agreements. It comprises reporting requirements and a carbon levy. There are also several policies to promote energy efficiency in residential buildings.

2010: Feed-In Tariffs (FITs). From April 2010, the government has offered FITs for small-scale low-carbon electricity generated by households, businesses and communities. Additional payment is provided for electricity fed into the grid. FIT rates vary according to technology, will last from 10 to 25 years, and are adjusted for inflation. A pilot scheme for micro Combined Heat and Power plants has also been launched.

Proposed: Green Investment Bank (GIB). The new government plans to introduce a GIB to unlock finance for the transition to low-carbon growth. The autumn 2010 Spending Review committed £1 billion funding and promised additional future proceeds from asset sales to capitalise the Bank.

Proposed: Renewable Heat Incentive (RHI). Details of this policy, to provide incentives for the use of renewables for heating, will be announced during 2011.

Proposed: The Energy Bill. Currently before the House of Lords, this bill includes provisions for a "Green Deal" on energy efficiency, greater security of energy supplies and more low-carbon electricity. More detailed secondary legislation will be prepared during 2011 and there will be a formal consultation process (*www.decc.gov.uk/en/content/cms/what_we_do/consumers/green_deal/green_deal.aspx*). The business Plan 2011-2015 outlines plans for future policies (*www.decc.gov.uk/assets/decc/About%20us/decc-business-plan-2011-2015.pdf-2015.pdf*).

Related: Taxes on hydrocarbon oils (*e.g.* petrol, diesel, biodiesel) were first introduced in 1909. In 1993, the government introduced an annual Fuel Price Escalator (FPE), initially at 3% above the rate of inflation, then at 6% after the election of the Labour government in 1997. The escalator was abolished in 2000, although rates have been adjusted since. Other transport taxes include the vehicle excise duty on road vehicles, now differentiated by emissions. Other environmental taxes include the Landfill Tax and the Aggregates Levy, a tax designed to price externalities from quarrying, while taxes such as Air Passenger Duty have potential environmental impacts. The VAT rate charged on domestic energy consumption is 5% in contrast to the standard rate of 20% (IFS 2010).

Carbon pricing is complex, with numerous overlapping instruments

The central pillar of any set of policies to combat climate change must be a method of pricing the externalities caused by emissions. Each tonne of CO_2 or CO_2-equivalent can be expected to do the same amount of damage wherever it is emitted, because emissions mix in the atmosphere quickly. Its price should therefore be the same regardless of location or sector, reflecting the social cost of carbon and giving an incentive to equalise the marginal cost of abatement across technologies, countries and firms.[6] The United Kingdom's main pricing instrument is the EU trading scheme, which covered about 48% of UK CO_2 emissions in 2009 (but not other GHGs) with aviation to be covered from 2012 onwards. From 2013, CO_2 emissions from a wider range of industrial processes will be included, as will some industrial nitrous oxide (N_2O) and perfluorocarbon emissions.

The EU system is a cap-and-trade scheme that sets quantitative limits for emissions by firms within its scope. The carbon price is set by trading emissions quotas, in contrast to a carbon tax that directly sets a carbon price. A quantitative limit delivers a greater degree of confidence about the amount of emissions reduction in the face of economic shocks, and hence can ensure that a long-run emissions reduction target and milestones along the way can be met. However, it may do so at the cost of deviations of the carbon price from the social cost of carbon and large variations in the price signal over time, distorting investment incentives and increasing uncertainty at the firm level.

In practice, the price of European Emission Allowances (EUAs) has been volatile, and has been highly correlated with the wholesale prices of natural gas (one of the most volatile commodity prices), oil and coal, reflecting variations in energy demand and the scope for switching commercial energy supplies among sources (Mansanet-Bataller, Pardo and Valor, 2007; Geman, 2005). The price dropped some 70% between July 2008 and February 2009 with the onset of the global recession. As the downturn could not have had such a large impact on the social costs, or marginal damage costs, of CO_2, which the price should reflect, the fall was excessive.[7] Volatility is not unusual in cap-and-trade schemes, because shifts in demand translate into price changes due to inelastic supply of quotas (Metcalf, 2009). The high volatility may in turn discourage investment, especially in risky and long-term abatement options.

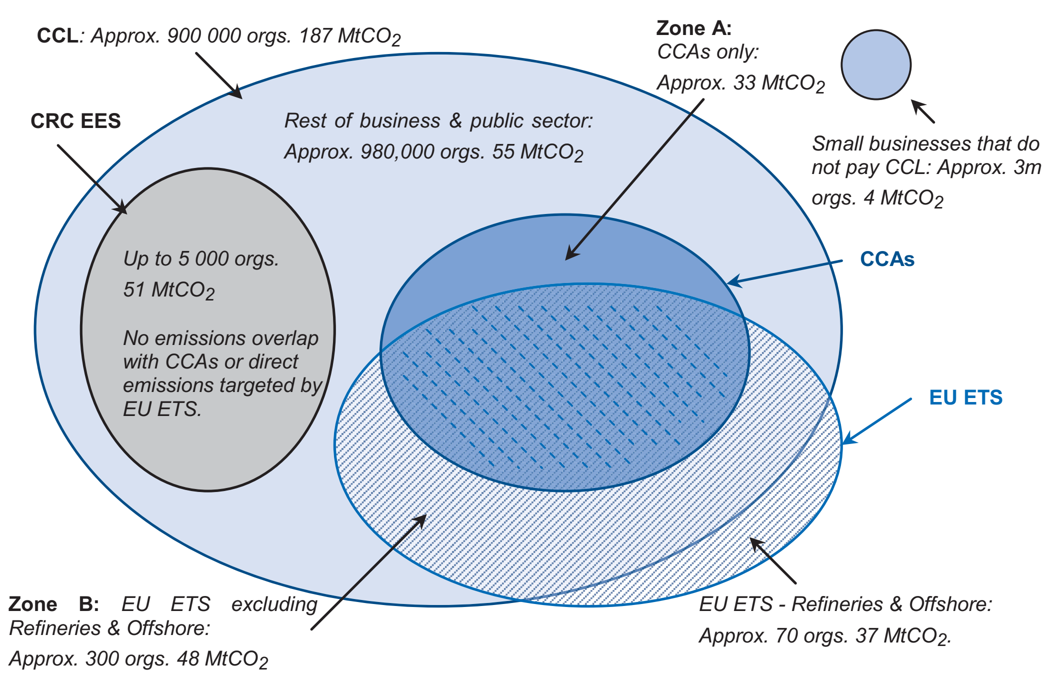
The price of EUAs may also be too low to achieve the UK 2050 target. In 2009, the UK Climate Committee revised its projection for the carbon price in 2020 from € 55/tCO_2 to € 20/tCO_2, and commented that such a price might not be sufficient to support the required investments in low-carbon power generation. This fear is corroborated by model-based projections of the carbon price trajectory needed to keep the global temperature increase from pre-industrial times below 2°C.[8] The uncertainty about the long-run emissions reduction goal of the EU, and the low and volatile price at which allowances have recently been trading, have served to reduce the incentive for covered firms to cut emissions. The most transparent route to ensure carbon prices that are consistent with the 2050 target would be to work for firmer and earlier commitments about the stringency of quota allocations under the EU scheme in the future. An early decision about whether the EU will adopt unilaterally the currently conditional target for more aggressive emissions reductions by 2020 would be helpful in this respect.

Domestic policy instruments should also be used to accomplish the higher, more consistent and less volatile carbon prices that are needed to achieve the transformation of the capital stock needed to meet the UK's 2050 emissions target.[9] The UK Climate

Committee has argued that there is a case for government underpinning of the carbon price. The government already does this to some extent, as described below. A further step could be taken by shifting part of the burden of uncertainty about the carbon price from firms to the government, on the grounds that carbon price volatility is partly due to policy uncertainty. Policy uncertainty relates to potential time inconsistency problems, whereby governments will be tempted not to deliver the high carbon prices that are needed to reach future targets. This discourages investment in low-carbon technologies predicated upon future carbon price increases. This time inconsistency problem reflects uncertainty about future policy, a risk that may be appropriate for policy makers to mitigate, unlike the normal commercial risks arising from fossil-fuel price volatility and uncertainties about the success of new technologies. An example of such a policy would be for the government to offer, for a fee, contracts to pay firms if the carbon price at a future date was below some reference level (thereby threatening to make investments in low-carbon capital unprofitable), while firms would pay the government if the carbon price was above that level. The UK is considering options for market reform to encourage more investment in low-carbon power, including support for the carbon price through the imposition of Climate Change Levy (CCL, henceforth the Levy) and oils carbon price support rates on the fossil-fuel inputs to electricity production (see *www.hm-treasury.gov.uk/consult_carbon_price_support.htm*).

In practice, effective carbon prices in the UK economy have been higher and more pervasive than the EU Allowance price would suggest. For example, the Levy (an energy tax) and the Carbon Reduction Commitment Energy Efficiency Scheme (CRC EES) in effect apply additional carbon prices and these policies overlap each other (Figure 4.8). Firms not covered by a Climate Change Agreement (CCA) (see Box 4.2) could be paying a form of

Figure 4.8. **Climate policy overlap**[1]



1. Million tonnes of Carbon Dioxide ($MtCO_2$)

Source: Based on a figure from Defra presented in CBI evidence to the House of Commons Environmental Audit Committee report, *The role of carbon markets in preventing dangerous climate change, Fourth Report of Session 2009-10.*

carbon tax three times over: first, through higher payments for electricity produced by generators subject to the EU scheme and sold by suppliers subject to the Renewables Obligation; second, through the Levy; and, third, through the Energy Efficiency Scheme. That could result in an effective carbon price more than triple the EU price. In contrast, energy-intensive firms outside the EU scheme but covered by a Climate Change Agreement would have to pay only 20% of the Levy (35% from April 2011)[10] and would not be affected by the implicit carbon tax in the electricity price if they used fossil fuels directly (although they would then be paying fuel duties).

Outside the sectors subject to the EU scheme, other measures such as Vehicle Excise Duty and graduated company car taxation are based on emissions and hence provide an incentive to promote more environmentally efficient behaviour, although that is not their prime objective. Air Passenger Duty also provides environmental signals. Hydrocarbon fuel duties can be thought of as a form of carbon tax, too, although there is no rebate for biofuels (the Renewable Obligation, a quantity-based instrument, is the main tool to achieve greater market penetration of biofuels). If the entire fuel duty were treated as a carbon tax, the implicit rate on unleaded petrol would be in the region of € 250/tCO_2. But such a treatment would be inappropriate, because the tax can also be regarded as a road user charge, congestion charge, tax on local pollution and means of raising revenue from a commodity for which demand is relatively inelastic. A more explicit assignment of taxes to specific purposes, or the introduction of instruments targeted at specific externalities such as road pricing schemes, would help to clarify whether the implicit tax rates are set at appropriate levels. At the retail level, energy for domestic use is only subject to a VAT rate of 5%, much lower than the standard rate of 20%, thus reducing the incentive for households to increase energy efficiency and cut energy use. As a result the effective carbon price can vary widely across the economy because of the interaction of these different ways of pricing carbon, leading to inefficient (and therefore unnecessarily costly) allocation of abatement activity across sectors and distorting relative prices of final goods and services. The extra cost burden and perceptions of unfairness risk undermining the popular acceptability of climate-change policies.

The Climate Change Levy provides an example. It is a tax levied "downstream" on energy use in the business sector (rather than "upstream" on primary energy providers), which now adds around 3-6% to business energy bills. The implicit rates of taxation on energy from different sources differ; the rate charged for electricity use does not depend on the primary energy mix used by the electricity suppliers (Table 4.5). Given its carbon content, coal is relatively lightly taxed, which some commentators have ascribed to the desire of the previous government to put less of a burden on the coal industry than other energy providers (Pearce, 2005; Helm, 2010). The carbon input to electricity production is taxed relatively heavily (and will be more so as lower carbon generation technologies are deployed, unless the tax rate per kWh is reduced *pari passu*). Hence implicit carbon prices vary across firms and sources in a way that makes abatement less effective and more costly.

The Climate Change Agreements have been controversial. One review claimed that there had been a substantial announcement effect from the introduction of the Climate Change Levy (Cambridge Econometrics, 2005) and that the Agreements strengthened the effectiveness of the Levy (Ekins and Etheridge, 2006). Firms themselves have claimed that the Agreements were effective in winning managerial attention to energy efficiency (EAC, 2008). However, others have argued that they have not been very demanding, given the way in which targets were negotiated and the underlying trend in energy efficiency

Table 4.5. **Implicit rates of carbon taxation, 2001**

Fuel type	Tax rate	Fuel price	Implicit carbon tax
	[Pence/kWh]		[£/tCO_2]
Electricity	0.43	4.25	8.45
Coal	0.15	2.46	4.36
Gas	0.15	0.91	8.17
LPG	0.07	0.85	5.99

Source: Martin, de Preux and Wagner, 2009.

improvements. Martin and Wagner (2009a, 2009b), utilising more detailed micro-level data allowing better identification of the impact of the Agreements, have cast serious doubt on their efficacy; participation in an agreement had a strong *positive* impact on both energy intensity and energy expenditures relative to firms having to pay the full Levy. The case for the Agreements on competitiveness grounds, protecting energy-intensive industries particularly vulnerable to foreign competition, is weak, as there was no sign of an impact of the full Levy on output, jobs or productivity. The studies also showed that the full Levy, but not the Agreement, was successful in promoting energy efficiency and innovation. Negotiating and monitoring the Agreements was also a resource-intensive process. Their research provides persuasive evidence of the effectiveness of the full Levy, its lack of adverse side effects and the inadequacy of the Agreements, suggesting that there is a case for the abolition of the latter. Along with a rise in the VAT rate on domestic energy use, this would also raise revenue at a time of fiscal retrenchment. However, any rise in VAT would impose significant new cost burdens on households at a time of slow real income growth, and may need to be accompanied by targeted support for the most exposed groups (See Chapter 1). The timing of any rise in VAT on energy use would need to be carefully considered to avoid undermining public support for climate policies.

The new Energy Efficiency Scheme also applies a carbon price downstream, to businesses that are not subject directly to the EU trading scheme and for which less than a quarter of emissions are covered by an Agreement. It covers emissions from energy use (electricity and heat) in large but not particularly energy-intensive public and private organisations. In the introductory phase, tradable allowances will be sold at a price of £12 per tonne of CO_2. The government has stressed the scheme's role in promoting energy efficiency. The registration and monitoring requirements placed on organisations, and the publication of league tables, should help to tackle the lack of managerial focus on energy efficiency, bringing down the very high implicit discount rates reported for investments in this area. The Climate Change Committee (2010c) offered recommendations to simplify the scheme. A further simplification, reducing compliance costs and risks from policy overlap, would be to develop a single downstream carbon tax to supplement the inadequate signal given by the EU price, merging the Levy and the levy component of the Efficiency Scheme. The downstream layer could be justified on two grounds. First, it would push up the overall carbon price while the EU scheme was giving an insufficiently strong signal. Second, it would help to focus the attention of energy users on the need to improve energy efficiency, as would the new reporting requirements on energy use brought in by the Efficiency Scheme, which could be maintained. For the household sector, the carbon subsidy implicit in the reduced rate of VAT on domestic energy should be removed, as there are more narrowly focused tools with which to tackle energy poverty. Upstream carbon pricing could also be simplified, by relating hydrocarbon fuel duties outside the EU scheme more closely to their carbon content. The guiding principle would be to simplify the structure of carbon pricing to one upstream and one downstream layer. Remaining anomalies in the overall incidence of the carbon price could be reduced extending the coverage of both layers.

In the event of such changes, two issues would remain about the interaction of the downstream layer of taxation with the quantity constraint imposed by the EU scheme. First, the layering would be designed to reduce UK emissions further than would the EU scheme alone. However, in so far as it succeeded in reducing demand for the output of plants and establishments subject to the EU scheme, their demand for the allowances would be reduced and they would sell more of them to the rest of the EU, reducing their price. Hence greater stringency of UK policies would tend to weaken abatement incentives elsewhere in the EU, unless the overall cap was tightened or the UK government bought up the allowances. And if other countries were to pursue a similar approach to the United Kingdom, the allowance price could fall significantly. This is why economists have stressed the need to co-ordinate multiple interventions by administrations at different levels carefully (Boemare *et al*, 2003). Second, the layering would result in a higher implicit carbon price for energy downstream than for other carbon-intensive products such as steel. For that reason, layering is very much a second-best option as a means of raising the carbon price. Strengthening and extending the EU scheme (and applying upstream carbon taxes in sectors not subject to the cap-and-trade scheme) would be a more attractive approach.

However, some downstream policy intervention is warranted to focus attention on opportunities to improve energy efficiency where information is currently scarce or energy accounts for only a small proportion of total costs. One option is to create a UK carbon reduction certification agency that could help to address the latter concern (Martin and Wagner, 2009b). It could take on the monitoring, verification and reporting requirements in the Efficiency Scheme, Levy and possibly EU schemes, and promote public and shareholder interest in firms' success in cutting emissions and energy use. Standards-setting and obligations to provide information, for example by labelling, may also have a role to play, although care needs to be taken to avoid imposing less cost-effective energy efficiency improvements than market incentives would encourage.

As long as the EU allowance price remains an inadequate price signal to achieve UK emission-reduction objectives in a cost-effective way, domestic measures to move towards higher and more uniform carbon pricing across the economy are desirable. They should preferably be introduced in the context of the more wide-ranging reforms of environmental and energy taxes that have been proposed (Newbery, 2005; IFS, 2010):

- adjusting Climate Change Levy rates and hydrocarbon fuel duties to reflect carbon content (and the content of other pollutants) more closely;
- merging the Levy and Efficiency Scheme to a single levy related to carbon content (while keeping new reporting requirements);
- stopping making Climate Change Agreements that effectively reduce the implied carbon tax rate;
- raising the VAT rate on domestic energy use from 5% to the standard rate of 20%, while using more focused payments to help those deemed to be in "energy poverty"; and
- considering ways of giving firms greater certainty about the trajectory of the carbon price.

Promoting clean energy

Efforts to promote clean low-carbon energy have focused on the promotion of renewable energy, although nuclear power and "carbon capture and storage" equipped fossil fuel plants are also low-emissions energy sources. The EU has adopted a target of deriving 20% of final energy demand from renewables by 2020 and has agreed on country targets to achieve this; the United Kingdom's target is 15%.[11] Carbon pricing via the EU scheme provides an incentive to switch to renewables (and nuclear). However, further incentives might be justified. Market failures afflict technology development as a result of the public good nature of much knowledge, including some of that acquired by learning-by-doing. Support now for a range of the most promising renewables technologies is one means of building credibility of climate policies over the long term, as long as that support is seen to be designed to correct market failures rather than supplement an inadequate carbon price.[12] There may be other social objectives apart from mitigating climate change served by promoting renewables, such as greater energy security and lower local pollution.

Unlike the EU's emissions reduction target, the EU-wide renewables target is not accompanied by an EU-wide policy instrument. As a result, the extent, strength and form of support differ considerably across Europe, with no assurance of a cost-effective distribution of resources across countries or technologies. In the United Kingdom, the main additional instrument has been the Renewables Obligation (Obligation), a quantitative requirement on electricity end-suppliers to increase the proportion of wholesale electricity purchased from producers using renewable energy, with the costs reflected in higher retail electricity prices. There is also a Road Transport Fuel Obligation designed to increase the proportion of transport fuel comprising biofuels. Both these measures are primarily quantity-based instruments mandating that a certain proportion of energy consumption is provided by renewable energy. Certificates are issued for verified renewables use and can be traded. Such quantity-based instruments differ from those that guarantee a price for renewable energy (such as feed-in tariffs) or a premium over the price charged for energy from non-renewable sources, although there are certain similarities with the latter in practice given the fixed buy-out price in the UK Renewables Obligation scheme (see Box 4.3 for a discussion of different forms of renewables support).[13] However, the revenue from the penalty or "buy-out" price that has to be paid by users who do not meet their Renewables Obligation is recycled to suppliers that over-achieve their targets, providing an additional incentive to hold or acquire certificates, driving up their price. In 2010-2011, the target for renewables penetration of the power generation market is 11%, compared with the achievement of 6.7% in 2009 (Table 4.3, panel B).

The Renewables Obligation has evolved since it was launched in 2002, in response to some of the criticisms to which it has been subjected (Box 4.3). The most significant change was in April 2009, with the introduction of varying rates of certificate allocation across technologies to provide a greater incentive to technologies further from the market but with potential to deploy on a large scale. For example, landfill gas now earns only 0.25 certificates for every MWh produced, onshore wind 1.0, offshore wind 1.5 (although it is temporarily receiving an uplift to two for projects accredited by March 2014), geothermal and solar photovoltaic (PV) 2.0. In April 2010, there were further changes, including the extension of the Obligation's end date from 2027 to 2037 for new projects, to provide greater long-term certainty for investors and an increase in support for offshore wind projects. The market penetration target is now set in such a way that there is less risk of the success of the policy leading to a collapse in the Obligation certificate price. In 2010, a feed-in tariff system for household and other micro-power-generation (under 5 MW) was launched to complement the Obligation system, with the rate paid per kWh varying by technology and size of installation.

Notwithstanding the welcome evolution of the Obligation system, the Committee has warned that "meeting the 2020 renewable energy target requires a step change in the rate of progress and entails significant delivery risk" (CCC, 2010d). It pointed out, for example, that the capacity of electricity generation from wind power needed to increase at an annual average rate of 3 GW from 2010 to 2020, yet only 1 GW was added in 2008. Also, the subsidiary targets for biofuels and heat generation from renewables appeared to be difficult to achieve sustainably (in the former case) or cost-effectively (in the latter). The recent Energy Market Assessment (DECC, 2010) also acknowledged that current electricity market arrangements were unlikely to result in the required electricity-sector decarbonisation by 2030 and that long-term incentives to invest in low-carbon energy needed to be improved. Pollitt (2010) has suggested that the element of the Obligation system by which the payments from suppliers "buying out" their obligations are recycled to suppliers in proportion to their certificates should be dropped, because it contributes to the high cost per kWh of power from renewables in the UK scheme (Box 4.3). In December 2010, the UK government announced a programme of market reforms to support additional low-carbon power investment and ensure continued energy security. The proposals are focused on introducing a floor for the carbon price in the UK electricity generation sector, a system of feed-in tariffs for low-carbon generation, an emissions performance standard to prevent the construction and operation of new unabated coal-fired power stations, and measures to ensure sufficient generating capacity is available to maintain security of supply.

While the emphasis on rewarding output of renewable energy helps to compensate for lower than-desirable and uncertain carbon prices and rewards learning-by-doing, it is unlikely to correct fully for underinvestment in R&D arising from difficulties in appropriating returns to new ideas. Capacity support mechanisms encourage picking winners by government, deliver subsidies to incumbents, weaken the focus on providing a stronger, less volatile, carbon price signal and benefit large foreign utilities and offshore equipment manufacturers disproportionately (Jamasb *et al.*, 2008). Privatisation and increased competition in the early 1990s saw a decline in private energy R&D (Figure 4.6) and utilities reduced their spending in this area after privatisation, consistent with the "public good" nature of much R&D. In the energy sector, the scope for capturing returns to R&D through product differentiation, charging more for the most innovative products (as many consumer goods manufacturers do), is limited.

One option for achieving carbon emissions reductions is the expansion of nuclear power, the generation of which does not produce emissions. However, challenges remain in managing nuclear waste and ensuring operational safety. Policy makers also face the problem of assessing and managing the small risk of catastrophic outcomes over a very long time horizon. Anti-nuclear sentiment has contributed to a widespread desire to phase out aging capital stock in the nuclear industry. UK nuclear operator British Energy (bought by EDF Energy in 2009) has extended the operating lives of many of its plants in recent years but all plants but one are due to shut by 2023 (BERR, 2008), which will place additional pressure on energy and emission reduction policies. However, official UK policy has been changing. Nuclear energy is increasingly seen as a relatively clean technology likely to make an important contribution to long-term decarbonisation of the power sector. The new government has voiced support for nuclear power as long as it does not need subsidies beyond those for low-carbon generation generally. New nuclear plants are planned, but the private sector developer of the first does not expect it to be operational until at least 2018.

The UK policy framework could be more effective if there were more support for energy R&D, where the existence of externalities is well-known. More deployment options would be maintained as technologies developed and information about climate change improved. A greater emphasis on R&D relative to the output of renewable energy would also promote the creation of skills enabling firms to respond more readily to shifts in the direction of innovation. Investment in human capital would have a substantial advantage over technology-specific support mechanisms because skills are more transferable (Jamasb *et al.*, 2008). It may be possible to identify areas in which the United Kingdom has a comparative advantage at the margin in innovation (*e.g.* using marine technologies) and to co-ordinate the distribution of international research across technologies to avoid excessive duplication of effort. Recent increases in government-financed R&D have been helpful, including the announcement in the October 2010 Spending Review of a commitment to spend up to £1 billion on a commercial-scale carbon capture and storage demonstration project (one of the first in the world on power generation). However, since 1990 UK public spending has fallen relative to other major countries (Figure 4.7).

The potential interaction of policy instruments aimed at market failures associated with the development of clean energy and those directed at the emissions externality needs to be considered (Braathen, 2007; Fischer and Preonas, 2010). An appropriate combination of instruments can achieve the emissions reduction objective more cost effectively by tackling the two sets of market failures simultaneously (Fischer, 2008; Fischer and Newell, 2008).

However, instrument interaction can also be inefficient. Renewables policies may affect the carbon objective through their indirect impact on the carbon price. By gradually switching electricity generation away from fossil fuels (if successful), renewables policies reduce the power generation sector's overall CO_2 emissions. If a cap on emissions is already in place, this reduces the sectoral demand for allowances and thus the carbon price, so electricity producers' costs are offset to some extent, the marginal cost curve shifts, and wholesale electricity prices are lower than they would be if the carbon price were constant (Rathmann, 2007; De Jonghe *et al*, 2009; Stankeviciute and Criqui, 2008). That contributes to a "rebound" effect, tending to increase energy demand relative to what it would have been with a constant carbon price. If renewables policies are introduced without revising down the emissions cap, their impact on emissions is very likely to be entirely offset by this and other induced increases in demand. Carbon markets can then appear more and more inadequate on their own, apparently justifying more and more direct, technology-specific, support (Blyth *et al.*, 2009). The weakened carbon price signal can then point path-dependent technological development and investment away from low-carbon technologies, especially outside the sectors covered by the renewables policies. The weakness of the EU allowance price suggests that the EU has not adequately taken into consideration the impact of renewable energy policies on carbon reduction objectives.[14]

Other market failures may warrant government intervention. At the current conjuncture, the malfunctioning of financial intermediation is a major issue in the developed world. The 2010 Spending Review announced the setting up of a Green Investment Bank (GIB), funded initially by a £1 billion commitment, to encourage investment in green infrastructure. The consultants Ernst and Young have estimated that the United Kingdom needs capital investment of £450 billion from now to 2025 if it is to meet its green energy goals, but that there will only be some £50-80 billion of capital available from current project finance and infrastructure funds. Hence the Bank alone will not be sufficiently large even if it is allowed to function as a true bank, borrowing to apply leverage to the capital provided by the government. However, it could play an important role together with more robust carbon pricing and stronger incentives for renewable energy in reassuring potential private-sector investors that the United Kingdom is committed to a low-carbon growth path. The main arguments for a public-sector institution focused on green objectives are:

- Investments with intergenerational implications, including many low-carbon investments, should be appraised using a discount rate lower than the market interest rate, for reasons of equity across generations that are not internalised by markets. If they are to be undertaken at an adequate scale, they may require an interest rate subsidy.
- Many low-carbon projects entail large-scale investments that pay off over very long time horizons. Such investments have often required syndicated project finance, which has become more difficult because of heightened risk aversion among financial intermediaries in the wake of the financial crisis.
- Financial markets may not be prepared to take on all the risks associated with new low-carbon technologies, given their novelty and the dependence of their success on future policies and provision of infrastructure, so that in the absence of further government intervention insufficient finance would be available at the scale and pace needed to meet decarbonisation goals. Private investment in this area is contingent on the credibility of the government's long-term commitment to carbon pricing and other climate-change policies; subscription of government capital helps build that credibility. This will help to redirect saving flows to low-carbon investments more generally.

The consequences of the Bank for the balance sheet of the government also need to be considered. Government interest rate subsidies and public guarantees to those lending to the Bank would increase public sector liabilities, particularly if the Bank were to focus its lending on riskier products.

In summary, the government needs to speed up the development and deployment of low-carbon technologies, focusing on correcting inadequate private market incentives for innovation. Its proposal to reform the regulation of the electricity market provides an opportunity to reduce the risks faced by renewable-energy power generators, for example, by encouraging long-term contracts for the supply of renewable energy and making grid connection easier (without removing all the commercial risks, many of which firms are better placed than government to manage). Given the "public good" nature of basic research, it is also desirable to increase public spending on R&D for low-carbon technologies, preferably focusing on areas in which the United Kingdom has a comparative advantage at the margin and (to avoid free-riding) in the context of international co-ordination of research efforts across technologies. Such spending would need to be consistent with overall fiscal consolidation plans.

Box 4.3. **Price *versus* quantity instruments to promote renewable energy**

Several empirical studies have investigated the relative merits of price- and quantity-based instruments (such as feed-in tariffs (FITs) and the UK Renewables Obligation respectively) as means of promoting renewable energy for electricity generation. On the whole, they have found that price-based instruments have been the more effective. For example, the European Commission (2005, 2008) compared the costs of renewable energy support schemes with the proportion of the potential renewable energy supply share achieved, concluding in both years that "well-adapted feed-in tariff regimes are generally the most efficient and effective support schemes for promoting renewable electricity." Despite the United Kingdom being below the EU27 average on the Commission measures of both the effectiveness of its support for onshore wind power over 1998-2006 and the trend in effectiveness in 2006, the expected profit per kWh for UK generators using renewable energy was one of the highest.* Ragwitz *et al.,* (2007) also found that in 2004 and 2006, the Spanish and German FITs were the most effective and the UK quota system was much less so. Lipp (2007) compared UK experience unfavourably with that of Denmark and Germany, writing that "not only has the United Kingdom avoided picking winners, but it would also seem it has not chosen a policy winner either." Ofgem (2007) argued that the price of electricity including the cost of the Renewable Obligation was above that necessary to make renewable energy technologies viable. Similarly, Jacobsson *et al.* (2009) concluded that UK renewables support had generated excess profits for the wind power sector (primarily owned by the established utilities).

The evidence is not, however, entirely in favour of price-based over tradable-certificate systems. For example, Jamasb *et al.* (2008) noted that German FITs had encouraged inefficient wind generation in low-wind areas. Newbery (2010) observed that FITs had originally been set too high for solar PV power in Spain and Germany, raising prices excessively high; the solar PV industry was then undermined when the pricing regime was amended. The two key issues are the incidence of risk and the generation of intramarginal rents on more mature renewables technologies, rather than the debate over price-based *versus* tradable-certificate systems.

Potential renewable-energy suppliers face several types of risk. Mitchell *et al.*, (2006) compared the Renewable Obligation in England and Wales with the FIT system in Germany, showing how in the former renewables generators have faced considerably more risks. But many of those risks reflected the absence of long-term contracts and the way in which the electricity grid has been regulated, and are not intrinsic to tradable-certificate schemes. Tradable certificate systems have tended to be more effective in promoting renewable energy where long-term contracts have been used (Agnolucci, 2007). That has reduced the risks associated with the short-run volatility of certificate prices, which have been easier for large incumbent firms than new market entrants to manage. In the United Kingdom, long-term contracting has been uncommon. Introducing compulsory long-term certificates would help encourage new entrants (Mitchell, 2006). It would be unwise in any case to try to remove all sources of risk facing renewables suppliers. Klessman *et al.* (2008) drew attention to how risks facing renewables suppliers have often been reduced at the cost of reducing incentives for them to respond to long-run relative cost developments and shorter-run fluctuations in market demand and grid balancing requirements.

Box 4.3. Price *versus* quantity instruments to promote renewable energy *(cont.)*

Among the reasons suggested for the superiority of some price-based systems has been that they have allowed the differentiation of price according to the renewables technology used. However, it is possible to differentiate among technologies under certificate trading schemes where this is deemed appropriate to reduce rents, as recent revisions to the UK Renewables Obligation system illustrate. The point of differentiation has been to prevent excessive profits being made by the users of more mature technologies, while ensuring that an appropriately broad portfolio of technologies are initially encouraged (Kramer and Haigh, 2009; Foxon and Pearson, 2007). There is, however, a danger of setting prices so that even technologies with very poor prospects are profitable at the margin. That can be avoided if the premium for any particular technology starts at broadly the same level and declines after initial commercial deployment at the same rate.

* However, it is not clear that all the costs of the FIT schemes (*e.g.* those falling on national grids) were taken into consideration.

Adaptation to climate change

Climate-change policy in the United Kingdom should increasingly consider adaptation in addition to mitigation. The world is already committed to some climate change due to past emissions, and emissions over the coming decades, which will lead to further increases of concentrations of greenhouse gases in the atmosphere, will contribute to further changes in climate. Failure to reach agreement to restrain emissions across nations may also lead to high emissions in the future. Therefore the United Kingdom must prepare to adapt.

Adaptation requires a very different set of policy responses from mitigation. The UK Climate Change Act 2008 encouraged a step change in adaptation activities required, proposing:

- the introduction of Climate Change Risk Assessments (CCRAs), at five-yearly intervals from 2012, to provide assessments about the risks faced by the UK from climate change;
- a National Adaptation Programme, to be produced following the first risk assessment in 2012 and reviewed every five years, which will address the most important opportunities and risks;
- an Adaptation Sub-Committee (ASC) to provide advice to government on the risk assessments, to assess progress towards the implementation of the government's National Adaptation Programme, and to provide advice when requested on adaptation; and
- the Adaptation Reporting Power, which enables the Secretary of State to direct authorities with public or statutory functions to prepare reports on their proposed adaptation actions.

Other measures outside the Act include the requirement for government departments to prepare Departmental Adaptation Plans and local authorities to report their progress on adaptation.

A review by the Environmental Audit Committee (EAC, 2010) concludes that "The UK's adaptation policy framework compares well with arrangements put in place in other countries. The Climate Change Act 2008 has, however, introduced a complicated assessment and reporting regime. Its complexity has been increased by the introduction of Departmental Adaptation Plans." Furthermore, while action on adaptation has increased in recent years, especially since the 2008 Act, the UK Committee on Climate Change has reported that the United Kingdom remains inadequately prepared for the changes in climate that may occur over the coming decades. Current action involves building adaptation capacity through the provision of advice. But there is little evidence that climate impacts are being incorporated into local decision-making and actions that reduce risks (CCC 2010e).

The Environmental Audit Committee review (EAC, 2010) recommended that the new government should review the regime if it fails to deliver the necessary step-change in adaptation planning and action. The government has responded, arguing that the framework is robust and that it is committed to reducing any unnecessary complexity and bureaucracy should it arise.

The United Kingdom has made strong progress in overcoming barriers to adaptation in recent years.[15] Insufficient climate risk information, undeveloped risk-assessment frameworks, little incorporation of adaptation across government policy, and poorly developed metrics for monitoring and evaluation have hampered progress; Pidgeon and Butler (2009) provide a detailed review of the benefits and limitations of risk-based approaches to climate-change adaptation. The forthcoming risk assessments should provide high-quality risk information, and the quality of risk-assessment frameworks, such as the guidance offered by the Supplementary Green Book, has also increased. While there is more work to be done on measuring and monitoring adaptation, progress is being made on many fronts.[16] It will be important to resolve tensions between the use of process-based tools and outcome-based metrics for monitoring and evaluation. The United Kingdom has also started incorporating adaptation into policy, for example, in the building regulations and in heat-wave plans that will assist preparations for more frequent heat-waves.[17]

Going forward, the government should establish a process for defining what level of risk is acceptable, assist in the delivery of adaptation outcomes, and consider adaptation measures in policy reform (CCC, 2010e). The sub-Committee also recommends that the United Kingdom should focus early adaptation efforts where further adaptation to present-day climate variability is desirable and where decisions have long-lasting consequences. The latter include investment in long-lived assets (for example, buildings and infrastructure), decisions that may cause irreversible changes (for example loss of biodiversity), and decisions that may have systemic and far-reaching effects (for example development in one part of the floodplain with knock-on effects downstream). Five adaptation priorities are proposed, including a strategic approach to land-use planning, provision of national infrastructure, design and renovation of buildings, management of natural resource sustainability, and effective emergency planning. Focus on these areas will provide "low-regrets" investment options that provide immediate benefits and reduce risks.

The UK government is already active in these five areas. For example, the United Kingdom committed more than £2 billion over the 2010 Spending Review period to flood and coastal erosion adaptation. This funding should remain a priority as recent events suggest that the United Kingdom is not adequately equipped to cope with extreme local flooding, despite better information about risks in this area. In addition, various government departments are undertaking work to build capacity and move adaptation planning and action forward.[18] The authorities should take incremental actions to protect against near-term climate threats that are better understood, allowing flexibility and retaining options as risks and the knowledge base evolve over coming decades. They should continue to focus on the appropriate provision of public goods, including information, better risk-assessment frameworks, and more advanced metrics for monitoring and evaluation.

The challenge of decision-making under uncertainty at the local level remains, as does the need to maintain flexibility and options as new information becomes available. Much of the adaptation decision-making will be carried out at the local and regional levels and this will increasingly be the case as responsibility for many central government policies is decentralised. The implications of the recent government decision to abolish the Regional Development Agencies and Government Offices for the Regions need to be carefully considered to avoid the loss of critical regional information. However, the Environment Agency, the body responsible for much adaptation planning and oversight, operates on a regional basis, with implementation largely falling on local government. It should be possible, therefore, to maintain progress on adaptation despite the administrative changes. Flexibility implies focusing on mitigation before large-scale spending on adaptation, long-lived infrastructure investments excepted. Defra, the relevant government department, recommends this approach for government appraisals, emphasising the need to maintain flexibility as risks evolve.[19]

Box 4.4. **Recommendations on climate change and adaptation policies**

- Given the government's ambitious emission-reduction targets, it should seek a higher carbon price at the international level through tighter quotas within the EU emission trading system (EU ETS) and the adoption of a 30% EU emissions reduction target by 2020. The EU ETS should also aim at strengthening the long-term carbon price signal and extending its scope to reduce distortions in carbon pricing across the economy.
- EU emission allowances may not provide sufficient price signals to achieve the UK's major emission-reduction objectives. Higher and more uniform domestic carbon prices across the economy should therefore be sought in a cost-effective way. The government should also assess more thoroughly how policy instruments overlap and interact so that the effective carbon price becomes more uniform across industry sectors and different stages of production. Specifically:
  - Adjust the Climate Change Levy (CCL) and hydrocarbon fuel duties to reflect more closely carbon content and the content of other pollutants.
  - Merge the CCL and the Carbon Reduction Commitment Energy Efficiency Scheme and stop making Climate Change Agreements which reduce the implied carbon tax rate.
  - Raise the VAT rate on domestic energy use over time from 5% to the standard rate of 20% to promote consistency in climate change policies and enhance efficiency of taxation. Relevant distributional concerns could be more efficiently addressed through targeted support.
  - Consider ways of giving firms greater certainty about the trajectory of the carbon price they face (*e.g.* by means of long-term contracts that transfer some risk around EU ETS carbon prices from firms to the government), including by implementing proposals in the current carbon price support and energy market reform consultations.

Box 4.4. **Recommendations on climate change and adaptation policies** *(cont.)*

- Speed up the development and deployment of low-carbon technologies, focusing on correcting the inadequate private market incentives for innovation. Increased public spending on R&D for new low-carbon technologies could be warranted taking account of fiscal constraints.
- The government plans to reform the regulation of the electricity market, which should be used to review support for renewable-energy power generators. The review should focus on ways to facilitate longer-term renewable-energy contracts; reducing the burdens placed on renewable-energy power generators by grid connection rules; and simplifying and accelerating planning procedures.
- The proposed Green Investment Bank should be used to subsidise projects where a low social discount rate is appropriate. To increase leverage, it should also be allowed to borrow in debt markets taking into account fiscal constraints.
- The government should continue to build adaptive capacity across the UK economy, with a focus on reducing market failures such as the appropriate provision of public goods, including information, better risk-assessment frameworks and more advanced metrics for monitoring and evaluation. Immediate action should focus on near-term climate threats that are better understood.

Notes

1. Based on CAIT data, which exclude emissions from changes in land use. The Kyoto gases comprise CO_2, N_2O, CH_4, HFCs, PFCs, and SF6. The EU15 comprise Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom.
2. Energy CO_2 emissions are produced from fuel combustion in electricity and heat generation, transport, manufacturing and construction and include "fugitive" emissions, as defined by the United Nations Framework Convention on Climate Change (UNFCCC) Reporting Framework. Electricity production, heat generation and transport account for over 80% of energy CO_2 emissions in the United Kingdom.
3. The Kaya decomposition (Table 4.1) decomposes energy CO_2 emissions into its components using the "Kaya identity", Kaya (1990), which expresses energy CO_2 emissions per head (column A) as equivalent to the product of GDP per head (B), the carbon intensity of energy (C), and the energy intensity of output (D). The relatively low energy CO_2 emissions in the United Kingdom and European countries, compared with Canada and the USA, are driven by lower energy intensity (column D) and to a lesser extent by lower GDP (column B).
4. Base year emissions are generally 1990. However, most EU15 countries, including the United Kingdom, have chosen 1995 as the base year for fluorinated gases (HFCs, PFCs and sulphur hexafluoride).
5. Analysis in this chapter focuses on the United Kingdom's prospects of meeting 2050 targets, under certain simplifying assumptions. CCC (2010a) examines the prospect of meeting the 2018-2022 UK carbon budget.
6. Strictly speaking, this is a requirement for efficiency; whether it is desirable depends also on whether the distributional impacts of carbon pricing are acceptable and, if not, whether appropriate redistributive transfers are made.
7. The marginal damage costs depend on the marginal climate change brought about over a long time period in the future, which is unlikely to be much affected by a transient recession.
8. See, for example, the reports of the RECIPE and ADAM projects (Edenhofer *et al.*, 2009; Knopf *et al.*, 2009).
9. This problem illustrates one reason why many economists prefer a carbon tax to a cap-and-trade system, as long as the tax rate is regularly reviewed in the light of its impact on cumulative

emissions. See Weitzman (1974), Pizer (1998) and Hepburn (2006). It could also be argued that a global recession warrants revising quantitative emission targets downwards to reflect the reduced costs of meeting any given target.

10. Firms in certain energy-intensive industry sectors are offered an 80% discount if they join a negotiated CCA, adopting a specific target for energy consumption or carbon emissions. The discount will decrease to 65% in April 2011.
11. The adoption of these targets implies a judgement about the desirable contributions of renewables, gas and nuclear energy to lower-carbon energy supply by 2020, a judgement that could have been left to the interaction of markets and broader energy-sector regulation. The UK emissions target for 2020 might be hit more cheaply if gas were substituted for coal more rapidly and renewable energy were adopted more gradually (Grubb *et al.*, 2008).
12. It would not be sensible for all governments to support the entire range of potential technologies indefinitely. International agreements on some burden-sharing and collaboration would be desirable, together with public guidelines about what would trigger the winding down of support of individual technologies.
13. Lipp (2007) counted 38 countries and five sub-national entities with FIT systems, compared with eight countries and 30 sub-national entities with tradable renewables certificate systems.
14. It can be argued that the EU ETS quotas are consistent with the current EU target for GHG emissions in 2020, so that renewables policies are not undermining the main climate-change policy. But the concern is about the incentives for the R&D and investment in low-carbon plant, equipment and buildings that will determine the capacity to decarbonise beyond 2020.
15. See *www.ukclimateprojections.defra.gov.uk/content/view/12/689/*.
16. See, for example, *www.defra.gov.uk/environment/climate/documents/adaptation-guidance.pdf*.
17. See *www.environment-agency.gov.uk/research/library/consultations/106100.aspx*.
18. For a summary of government adaptation action, see *www.2.defra.gov.uk/environment/climate/government/*.
19. See *www.environment-agency.gov.uk/research/library/consultations/106100.aspx*.

Bibliography

Agnolucci, P. (2007), "The effect of financial constraints, technological progress and long-term contracts on tradable green certificates", *Energy Policy*, Vol. 35, pp. 3347-3359.

Barker, *et al.* (2009), "The macroeconomic rebound effect and the world economy", *Energy Efficiency*, Vol. 2, pp. 411-427.

Department for Business, Enterprise and Regulatory Reform (BERR) (2008), "Meeting the Energy Challenge, A White Paper on Nuclear Power", UK government.

Blyth, W., D. Bunn, J. Kettunen and T. Wilson (2009), "Policy interactions, risk and price formation in carbon markets", *Energy Policy*, Vol. 37, Issue 12, pp. 5192-5207.

Boemare, C., P. Quirion and S. Sorrell (2003), "The evolution of emissions trading in the EU: tensions between national trading schemes and the proposed EU directive", *Climate Policy*, Vol. 3S2, pp. S105-S124.

Braathen, N.A. (2007), "Instrument mixes for environmental policy: how many stones should be used to kill a bird?" *International Review of Environmental and Resource Economics*, Vol. 1, Issue 2, pp. 185-235.

Pidgeon, N.F. and C. Butler (2009), "Risk analysis and climate change", *Environmental Politics*, Vol. 18, pp. 670-688.

Cambridge Econometrics (2005), "Modelling the initial effects of the Climate Change Levy", Technical report, *Cambridge Econometrics*, Cambridge, UK.

De Jonghe, C., E. Delarue, R. Belmans and W. D'haeseleer (2009), "Interactions between measures for the support of electricity from renewable energy sources and CO_2 mitigation", *Energy Policy*, Vol. 37, pp. 4743-4752.

Dechezleprêtre, A. and R. Martin (2010), "Low carbon innovation in the UK: Evidence from patent data", Report for the UK Committee on Climate Change, Centre for Climate Change Economics and Policy, Grantham Research Institute on Climate Change and the Environment.

Department for Environment Food and Rural Affairs (2007), "Consultation on the recommendations of the Climate Change Simplification Project: Climate Change Instruments – areas of overlap and options for simplification", December.

Department for Environment Food and Rural Affairs (2010), "Defra's Climate Change Plan 2010".

Department for Transport (2009), "Low Carbon Transport: A Greener Future, A Carbon Reduction Strategy for Transport".

Department for Transport (2010), "Transport Carbon Reduction Delivery Plan".

Department of Energy and Climate Change (2010), "Energy Market Assessment", March.

Environmental Audit Committee (EAC) (2008), "Reducing carbon emissions from UK business: the role of the Climate Change Levy and Agreements", House of Commons Environmental Audit Committee, Second Report of Session 2007-2008, London.

EAC (2010), "Adapting to Climate Change", House of Commons Environmental Audit Committee, Sixth report of session 2009-2010, London.

Edenhofer, O., C. Carraro, J-C. Hourcade, *et al.*, (2009), "The Economics of Decarbonization", Report of the RECIPE project, Potsdam Institute for Climate Impact Research, Potsdam.

Ekins, P., and B. Etheridge (2006), "The environmental and economic impacts of the UK Climate Change Agreements", *Energy Policy*, Vol. 34, pp. 2071-2086.

European Commission (2005), "The support of electricity from renewable energy sources", Communication from the Commission SEC(2005) 1571.

European Commission (2008), "The support of electricity from renewable energy sources", Commission Staff Working Document accompanying the proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources, COM(2008)19 final.

Fischer, C. (2008), "Emissions pricing, spillovers, and public investment in environmentally friendly technologies", *Energy Economics*, Vol. 30, Issue 2, pp. 487-502.

Fischer, C. and L. Preonas (2010), "Combining Policies for Renewable Energy Is the Whole Less than the Sum of Its Parts?", *Resources for the Future Discussion Paper*, pp. 10-19, March.

Fischer, C. and R.G. Newell (2008), "Environmental and technology policies for climate mitigation", *Journal of Environmental Economics and Management*, Vol. 55, pp. 142-162.

Foxon, T. and P. Pearson (2007), "Towards improved policy processes for promoting innovation in renewable electricity technologies in the UK", *Energy Policy*, Vol. 35, pp. 1539-1550.

Friedlingstein, P., *R.A. Houghton*, *G. Marland*, *et al.* (2010), "Update on CO_2 emissions", Correspondence, *Nature Geoscience*, Vol. 3, November.

Garnaut, R. (2008), "The Garnaut Climate Change Review", Cambridge University Press, Chapter 21, pp. 510.

Geman, H. (2005), "Commodities and commodity derivatives", John Wiley and Sons Ltd, Chichester.

Grubb, M., T. Jamasb and M. Pollitt (2008): "A low-carbon electricity sector for the UK: what can be done and how much will it cost?" in Grubb, M., T. Jamasb and M. Pollitt (eds.): "Delivering a low carbon electricity system", Cambridge University Press, Cambridge.

Helm, D. (2010), "Government failure, rent-seeking, and capture: the design of climate-change policy", *Oxford Review of Economic Policy*, Vol. 26, Issue 2, pp. 182-196.

Hepburn, C. (2006), "Regulation by prices, quantities, or both: A review of instrument choice", *Oxford Review of Economic Policy*, Vol. 22, Issue 2, pp. 226-247.

IEA (2010), "CO_2 Emissions from Fuel Combustion", IEA Statistics.

IEA (2010a), "Renewables Information", IEA Statistics.

IEA (2010b), "Energy Balances of OECD countries".

Jacobsson S., A. Bergek, D. Finon, *et al.* (2009), "EU energy support policy: faith or facts?"*Energy Policy*, Vol. 37, pp. 2143-2146.

Jamasb, T., W. Nutall and M. Pollitt (2008), "The case for a new energy research, development and promotion policy for the UK", *Energy Policy*, Vol. 36, pp. 4610-4614.

Kaya, Y. (1990), "Impact of carbon dioxide emission control on GNP growth: interpretation of proposed scenarios", paper presented to IPCC Energy and Industry Sub-Group, Response Strategies Working Group.

Knopf, B., O. Edenhofer, *et al.* (2009), "The economics of low stabilisation: implications for technological change and policy", in M. Hulme and H. Neufeldt (Eds): *Making climate change work for us – ADAM synthesis book*, Chapter 11, Cambridge University Press, Cambridge.

Kramer, G., and M. Haigh (2009), "No quick switch to low-carbon energy", *Nature*, Vol. 462, December.

Lipp, J. (2007), "Lessons for effective renewable electricity policy from Denmark, Germany and the United Kingdom", *Energy Policy*, Vol. 35, pp. 5481-5495.

Mansanet-Bataller, M., A. Pardo and E. Valor (2007), "CO_2 prices, energy and weather", *The Energy Journal*, Vol. 28, Issue 3, pp. 67-86.

Martin, R. and U. Wagner (2009a), "Econometric analysis of the impacts of the UK climate change levy and climate change agreements on firms' fuel use and innovation activity", Contribution to the OECD project on *Taxation, Innovation and the Environment*, COM/ENV/EPOC/CTPA/CFA(2008)33/FINAL.

Martin, R., and U. Wagner (2009b), "Surveys of firms' responses to public incentives for energy innovation including the UK Climate Change levy and Climate Change Agreements", Contribution to the OECD project on *Taxation, Innovation and the Environment*, COM/ENV/EPOC/CTPA/CFA(2008)34/FINAL.

Martin, R, L. de Preux and U. Wagner (2009), "The impacts of the Climate Change Levy on business: evidence from microdata", Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science, Working Paper No. 6, August.

Metcalf, G. (2009), "Cost containment in climate change policy: alternative approaches to mitigating price volatility", *NBER Working Paper,* No. 15125, July.

Mirrlees, J. *et al.* (2010), "Tax by Design: The Mirrlees Review", Institute for Fiscal Studies, *www.ifs.org.uk/mirrleesReview/design*.

Mitchell, C. (2006), "How to increase installed renewable energy capacity in the UK", Paper submitted in response to Question 1 in the 2006 UK Government Energy Review, Warwick Business School (referred to in Agnolucci, 2007).

Mitchell, C., D. Banknecht and P. Connor (2006), "Effectiveness through risk reduction: a comparison of the Renewable Obligation in England and Wales and the Feed-In System in Germany", *Energy Policy*, Vol. 34, pp. 297-305.

NERA (2007), "Market Mechanisms for Reducing GHG Emissions from Agriculture, Forestry and Land Management", Department for Environment, Food and Rural Affairs, September.

Newbery, D. (2005), "Why tax energy? Towards a more rational energy policy", *Cambridge Working Papers in Economics*, No. 0508, Cambridge University.

Newbery, D. (2010), "A nuclear future? UK government policy and the role of the market?", *Cambridge Working Paper in Economics*, No. 1019, Cambridge university, March.

OECD (2009a), "Integrating Climate Change Adaptation into Development Co-operation", Policy Guidance, Paris.

OECD (2009b), "The Economics of Climate Change Mitigation: Policies and Options for Global Action Beyond 2012", OECD Publishing, Paris.

Ofgem (2007), "Ofgem puts forward new approach to funding green generation", *Press release*, 22 January.

Parry, I.W.H., M. Walls and W. Harrington (2007), "Automobile externalities and policies", *Journal of Economic Literature*, Vol. 45(2), pp. 373-399.

Pearce, D. (2005), "The United Kingdom Climate Change Levy: a study in political economy", report for the Joint Meetings of Tax and Environment Experts under the OECD's Fiscal Affairs Committee and Environment Policy Committee, COM/ENV/EPOC/CTPA/CFA(2004)66/FINAL.

Pizer, W.A. (1998), "Prices vs. quantities revisited: the case of climate change", *Resources for the Future Discussion Paper*, No. 98-02 (revised), Washington.

Pollitt, M.G. (2010), "UK renewable energy policy since privatisation", *EPRG Working Paper*, No. 1002, Electricity Policy Research Group, Cambridge University, January.

Ragwitz, M., A. Held, G. Resch, *et al.* (2007), "Assessment and optimisation of renewable energy support schemes in the European electricity market", OPTRES, Final Report, Karlsruhe.

Rathmann, M. (2007), "Do support systems for RES-E reduce EU-ETS-driven electricity prices?", *Energy Policy*, Vol. 35, pp. 342-349.

Stankeviciute, L., and P. Criqui (2008), "Energy and climate policies to 2020: the impacts of the European "20/20/20" approach", *International Journal of Energy Sector Management*, Vol. 2, Issue 2, pp. 252-273.

Stern, N. (2007), "The Economics of Climate Change, The Stern Review", Cambridge University Press, pp. 400-401.

Stern, N. (2009a), "A Blueprint for a Safer Planet: How to Manage Climate Change and Create a New Era of Progress and Prosperity", The Bodley Head, London.

Stern, N. (2009b), "Deciding our future in Copenhagen: will the world rise to the challenge of climate change?", Policy Brief, Centre for Climate Change Economics and Policy and Grantham Research Institute on Climate Change and the Environment, December.

UK Committee on Climate Change (2008), "Building a low-carbon economy – the UK's contribution to tackling climate change", The First Report of the Committee on Climate Change.

UK Committee on Climate Change (2010a), "Meeting Carbon Budgets – ensuring a low-carbon recovery", 2nd Progress Report to Parliament, June.

UK Committee on Climate Change (2010b), "Building a low-carbon economy – the UK's innovation challenge", July.

UK Committee on Climate Change (2010c), "The CRC Energy Efficiency Scheme – advice to Government on the second phase", September.

UK Committee on Climate Change (2010d), "The level of renewable energy ambition to 2020", Letter from the Chair of the Committee on Climate Change to the Secretary of State, DECC, September.

UK Committee on Climate Change (2010e), "How well prepared is the UK for climate change?" Adaptation Sub-Committee, September.

UK Energy Research Centre (2007), "The Rebound Effect: an assessment of the evidence for economy-wide energy savings from improved energy efficiency", October.

Weitzman, M. (1974), "Prices vs. quantities", *Review of Economic Studies*, Vol. 41, Issue 4, pp. 477-491.

From:
OECD Economic Surveys: United Kingdom 2011

Access the complete publication at:
https://doi.org/10.1787/eco_surveys-gbr-2011-en

Please cite this chapter as:

OECD (2011), “Climate-change policy in the United Kingdom”, in *OECD Economic Surveys: United Kingdom 2011*, OECD Publishing, Paris.

DOI: https://doi.org/10.1787/eco_surveys-gbr-2011-7-en

This work is published under the responsibility of the Secretary-General of the OECD. The opinions expressed and arguments employed herein do not necessarily reflect the official views of OECD member countries.

This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

You can copy, download or print OECD content for your own use, and you can include excerpts from OECD publications, databases and multimedia products in your own documents, presentations, blogs, websites and teaching materials, provided that suitable acknowledgment of OECD as source and copyright owner is given. All requests for public or commercial use and translation rights should be submitted to rights@oecd.org. Requests for permission to photocopy portions of this material for public or commercial use shall be addressed directly to the Copyright Clearance Center (CCC) at info@copyright.com or the Centre français d’exploitation du droit de copie (CFC) at contact@cfcopies.com.