CHAPTER 10

Impact of our Measures

This chapter sets out how our proposals contribute to progress against our long-term energy policy goals and explores the wider economic implications of reducing carbon emissions in the short and the long-term.

10.1 Together with the effect of the EU Emissions Trading Scheme, we estimate that our proposals will result in annual carbon savings of between 23-33 million tonnes of carbon (MtC) by 2020. This means that, if all our measures are fully implemented and achieve the upper end of the range of savings we have estimated, we shall be on track to achieve real progress by 2020 towards our goal of reducing carbon dioxide emissions by 60% by 2050.

10.2 Our policies improve the security and reliability of our energy supplies by reducing our dependence on imported energy, supporting the economic recovery of indigenous energy supplies and strengthening our competitive market framework.

10.3 Increases in global energy prices mean that fuel poverty in the UK remains a significant challenge. We estimate that the measures specifically designed to combat fuel poverty will reduce the number of UK households in fuel poverty by around 200,000 by 2010.

Progress towards our energy policy goals

Impact on carbon emissions

10.4 The Government has a goal to achieve a 60% reduction in carbon emissions by 2050, and to make real progress towards this target by 2020, defined as UK emissions falling to within a range of 110-120 million tonnes of carbon (MtC) by 2020[327].

10.5 The draft Climate Change Bill creates a new legal framework for the UK achieving, through domestic and international action, at least a 60% reduction in carbon dioxide emissions by 2050, and a 26-32% reduction by 2020, against a 1990 baseline. The Government will be required to set five-year carbon budgets, placing binding limits on aggregate carbon dioxide emissions. There is provision in the draft Bill for the targets to be amended in light of significant developments in climate science or in international law or policy.

10.6 The measures in this White Paper build on existing policies introduced to tackle carbon emissions. The continuation of these policies is expected to deliver an annual saving of around 25MtC in 2020[328].

327 This carbon goal was set out in the Energy White Paper 2003: Our Energy Future, Creating a Low Carbon Economy

328 Table D1, *Updated Energy and Carbon Emissions Projections, May 2007.* www.dti.gov.uk/energy/whitepaper

10.7 Depending on the assumptions made about future fossil-fuel prices,[329] and not taking into account any of the policies in this White Paper, carbon emissions in the UK are projected to be 149 to 151MtC in 2020, 3 to 5MtC higher than our central projections in the Energy Review Report published in July 2006[330].

10.8 Table 10.1 and Figure 10.1 below describe the carbon impact in 2020 of the measures included in this White Paper, measures announced since publication of the Energy Review Report and the potential impact of future phases of the EU ETS. The estimates are presented as a range to reflect uncertainty about the timing and impact of the measures. Box 10.1 describes the abatement potential and cost effectiveness of some of these measures (and of technologies) in 2020.

10.9 Beyond Phase II (2008-2012) of the EU ETS, caps and hence the future carbon savings to be delivered through the scheme, will be decided in line with future national allocation plans. Table 10.1 therefore presents an illustrative projection for carbon savings from the EU ETS in 2020 based on the assumption that the cap on emissions applied to EU ETS sectors in the UK in 2020 is equal to that agreed for Phase II. On the basis of our latest baseline emissions projections, this would achieve annual carbon savings of 13.7MtC in 2020[331].

10.10 Policies introduced as part of this White Paper represent a commitment to deliver additional carbon savings beyond those to be achieved through the EU ETS. In setting future EU ETS caps, we will first take into account how these White Paper measures impact on projected emissions, to ensure a sufficient level of effort from the EU ETS is maintained. It is our view that the carbon constraint imposed by the EU ETS should tighten over time.

10.11 We estimate that, together with the impact of the EU ETS, our proposals will result in carbon savings of between 23MtC – 33MtC in 2020. This means that, if all our measures are fully implemented and achieve the upper end of the range of savings we estimate in Table 10.1, we shall be on track to achieve real progress by 2020 towards our goal of reducing carbon emissions by at least 60% by 2050 (Chart 10.1).

10.12 The target set out in the draft Climate Change Bill to reduce UK carbon emissions by 26-32% in 2020 on 1990 levels, corresponds to the "real progress" aim in the 2003 Energy White Paper of reducing carbon emissions to within 110-120MtC by 2020. The targets in the draft Climate Change Bill are expressed in terms of carbon dioxide. Expressed in these terms[332], a 26-32% reduction on 1990 levels is equivalent to reducing emissions to around 438-402 million tonnes of carbon dioxide ($MtCO_2$) in 2020. We estimate that the measures in Table 10.1 will reduce carbon dioxide emissions in 2020 by 86-121$MtCO_2$, so that UK carbon dioxide emissions will be 469-433$MtCO_2$ in 2020. If we take the upper end of the range of savings we have estimated, we would be on course to achieve emissions savings just within the range set out in the draft Climate Change Bill (i.e. achieving just over a 26% reduction on 1990 levels).

329 These assumptions are published alongside this White Paper, and reflect the uncertainty over the outturn of future prices in the modelling. They are consistent with the latest assumptions from the International Energy Agency and the US Energy Information Administration.

330 See Annex B, DTI Updated Energy and carbon Emissions Projections. Part of the reason for the increase in projected emissions is the additional new coal capacity projected by 2020 (up to 8GW), due to the improved relative price of coal under the revised fossil-fuel price assumptions.

331 See Annex B for further explanation of EU ETS savings and implications for projected UK emissions.

332 In future, the Government will work in units of carbon dioxide, in line with the draft Climate Change Bill. Figures in this document are quoted mainly in million tonnes of carbon for consistency with the Energy Review Report. To convert carbon (C) into carbon dioxide (CO_2) multiply carbon by (44/12).

TABLE 10.1: ESTIMATED CARBON IMPACT OF OUR MEASURES, AND MEASURES ANNOUNCED SINCE THE PUBLICATION OF THE ENERGY REVIEW REPORT.

	MtC abated in 2020		
Energy Efficiency			
Better Billing	0.0	–	0.2
Real Time Displays in Households	0.0	–	0.3
Energy Performance of Buildings Directive (EPBD)[1]	0.6	–	1.6
Zero Carbon Homes[2]	1.1	–	1.2
More Energy Efficient Products[3]	1.0	–	3.0
Continued obligation on energy suppliers to make carbon reductions in the household sector[4]	3.0	–	4.0
Business Smart Metering[5]	0.1	–	0.2
New measure for achieving carbon savings from large non-energy intensive organisations (Carbon Reduction Commitment (CRC))[6]	1.0		
Energy Supply			
Changes to Renewables Obligation[7]	0.4	–	1.1
CCS demonstration project[8]	0.3	–	1.0
Transport			
Successor to EU voluntary agreements on new car fuel efficiency[9]	1.8	–	4.1
Renewable Transport Fuel Obligation[10]	0.0	–	1.0
EU ETS and offsetting measures			
EU Emissions Trading Scheme[11]	13.7		
Aviation in EU ETS (domestic)[12]	0.2	–	0.4
Carbon Neutral Government[13]	0.2		
Total	**23.4**	–	**33.0**

NOTE: Savings expressed in terms of million tonnes of carbon (MtC) under central fossil fuel price assumptions and rounded to the nearest decimal point.

[1] Excluding 0.2MtC included in the baseline. EPBD also supports 0.5-0.7MtC of the savings from the continued obligation on energy suppliers to 2020, to make carbon reductions in the household sector.

[2] Savings as estimated in the *Building a Greener Future* Consultation. These savings include the savings of the "Carbon neutral developments" policy as shown in the Energy Review Report Table 8.1.

[3] The range of carbon savings for products policy has been updated since the Energy Review Report as part of an annual process. This also includes a larger coverage of product groups and is net of overlaps with other policies.

[4] The level of ambition from 2011 is committed to be equal to that under CERT, delivering 3-4MtC of savings in 2020.

[5] This estimate excludes 0.1-0.2MtC accounted for within the EPBD and CRC estimate.

TABLE 10.1 CONTINUED

[6] The Government is committed to achieving a 1.2MtC saving from this sector – this estimate excludes 0.2 MtC accounted for in the EPBD estimate.

[7] This estimate assumes a range based on different technology assumptions – the low figure is based on high technology cost assumptions, and the high figure on low technology cost assumptions.

[8] This is based on around 0.3 GW to 1.9 GW of demonstration plant(s) displacing equivalent gas fired generation without CCS.

[9] Illustrative estimate reflecting annual improvements in new car fuel efficiency of 1.5%-3.6% p.a. Actual efficiency improvements will depend on the level of target set at EU level and application in the UK.

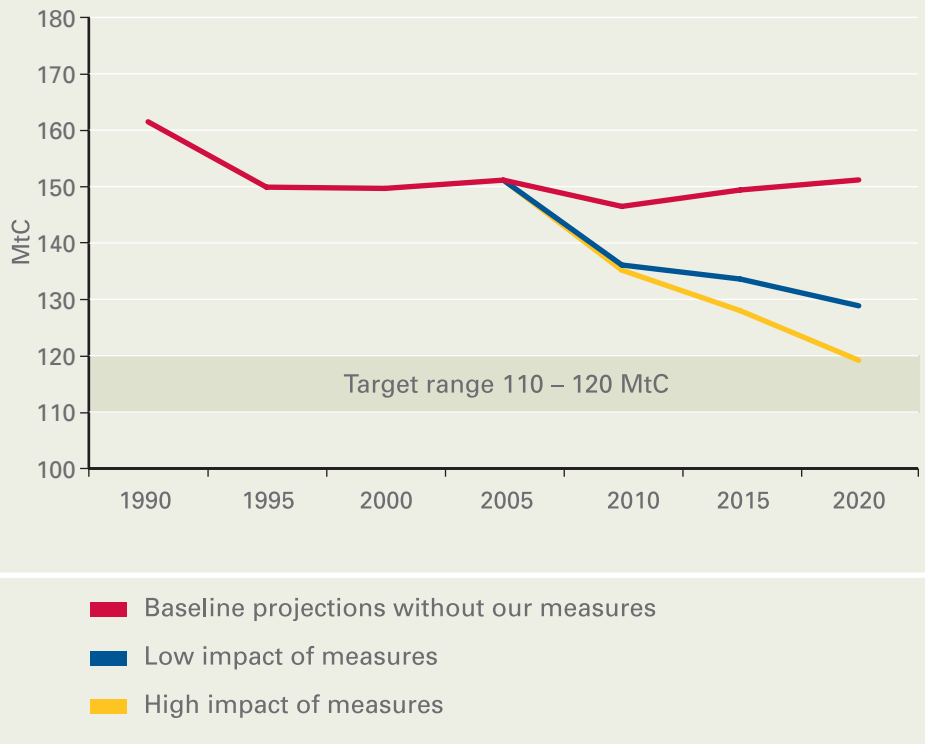
[10] Illustrative estimate of additional carbon savings that would occur were we to extend the RTFO beyond 5%. Upper estimate assumes Obligation rising to 10% by 2015. Lower estimate reflects RTFO remaining at 5% from 2010. Carbon savings from a 5% RTFO are included in the baseline.

[11] This estimate reflects the assumption that the cap for Phase II of the scheme is unchanged in future phases. On the basis of our latest baseline projections, this would require 13.7MtC of savings in 2020. The actual level of savings to be achieved through EU ETS beyond Phase II (2008-2012) will be decided in line with future national allocation plans.

[12] Illustrative saving from UK domestic aviation, assuming a cap at 2005 emissions on projected 2020 levels, in line with the current Commission proposal. Carbon savings from international aviation have not been estimated in the absence of agreement on how to allocate emissions.

[13] Savings from central government office estate, whose emissions constitute around one quarter of the total from the wider central government estate.

FIGURE 10.1. PROJECTED UK CARBON EMISSIONS AND CARBON IMPACT OF OUR MEASURES[#]



Source: DTI Energy Model, Updated Energy and Carbon Emissions Projections May 2007. See Annex B.

[#] UK carbon emissions, inclusive of carbon savings achieved through the EU ETS and other offsetting measures. High and low policy measure projections based on estimates presented in Table 10.1.

10.13 In accordance with the requirements set out in the draft Climate Change Bill, having set the five-year carbon budgets, it will be the duty of the Government to lay before Parliament a report, setting out the proposals and policies for meeting the budgets. As part of this process, the Government intends to keep under review options for additional measures that will further contribute to achieving our carbon goals.

10.14 For example, including road transport in the EU ETS could save in the region of 1-2MtC in 2020, depending on the cap on emissions set for the sector. This is on the basis of an illustrative assumption of a cap set to achieve emissions of between 2-5% below projected road transport emissions. As smart meters are rolled out to households, we might expect further carbon savings, as households act in response to the improved information and because improved metering would facilitate the transformation to an energy services market.

10.15 Furthermore, we are consulting on the issue of nuclear power. Following the consultation, should we conclude it is in the public interest for new nuclear power stations to be an option available to companies making investments in new generation capacity, it would be for the private sector to come forward with proposals should they choose to do so. One new nuclear plant could save up to 1.1MtC [333].

10.16 The UK is set to deliver savings beyond those in its Kyoto target of a 12.5% reduction in greenhouse gas emissions by 2008-2012. Based on the latest projections UK greenhouse gas emissions are set to be around 23% lower than 1990 levels in 2010 [334]. The EU has committed to cut total greenhouse gas emissions by 20% on 1990 levels by 2020, or by 30% if in conjunction with action by other countries. We estimate that the reduction in domestic carbon emissions from our White Paper measures (and inclusive of the estimated domestic abatement through the EU ETS) will result in UK greenhouse gas emissions of between 147-159 million tonnes of carbon equivalent (MtCe) in 2020, i.e. 25-31% lower than 1990 levels [335].

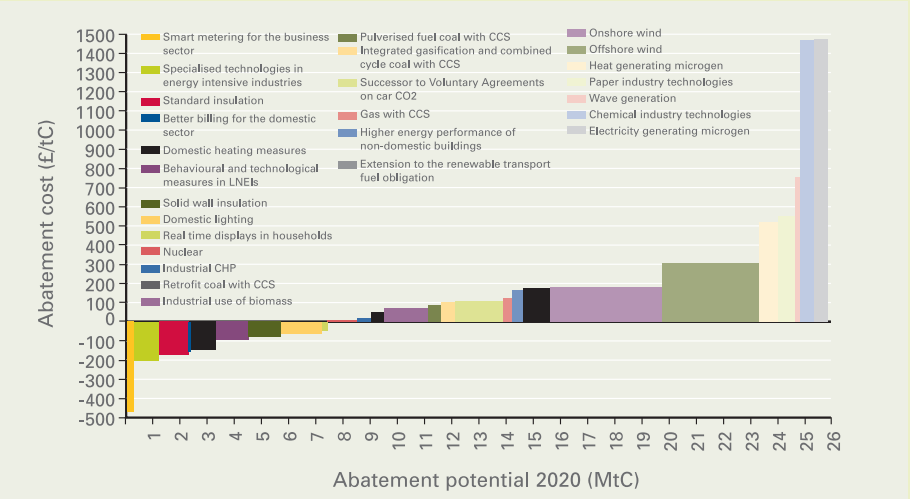
10.17 By reducing emissions of harmful greenhouse gases such as Sulphur Dioxide (SO_2) and Oxides of Nitrogen (NO_x), as well as particulate matter (PM10), our measures will also bring significant ancillary benefits, e.g. the benefits to public health associated with improved air quality. These are important to consider as the effects can be sizeable[336]. We estimate [337] that, as a result of the additional measures in this White Paper and inclusive of domestic abatement through the EU ETS, the improvements in local air pollution and subsequent benefits in terms of public health could be between £500 million and £740 million in cumulative terms up to 2020, with the annual benefit in 2020 ranging between £80 million to £120 million [338].

333 This assumes building of a new plant with a capacity of 1.6GW displacing an equivalent gas-fired plant.
334 Defra, Provisional 2006 UK Climate Change Sustainable Development Indicator. Savings are inclusive of expected UK effort through domestic and international action.
335 See Chart B1 in Annex B. This estimate is based on the latest DTI CO_2 emissions projections and Defra provisional non-CO_2 emissions projections (reference as above). The 25-31% range incorporates an estimate of UK domestic abatement through the EU ETS, but excludes UK effort achieved through international action.
336 The Stern Review finds that ancillary benefits could lower the overall cost of mitigation by 1% of GDP. In the IPCC 3rd assessment report, ancillary benefits were found to be in the order of 30-100% of abatement costs.
337 This analysis takes into account the reduction in energy demand and the ancillary benefits that accrue from this. It does not, however, take into account changes in the electricity generation mix.
338 2007 Energy White Paper Cost-Benefit Analysis Synthesis www.dti.gov.uk/energy/whitepaper. Benefits are presented in £2005 prices, discounted in line with HM Treasury guidelines. These estimates are a first approximation and depend heavily on the final implementation approaches and "whole sector" emissions profiles. Air quality impacts will require further evaluation when detailed options are considered for each policy.

BOX 10.1. UK MARGINAL ABATEMENT CURVE.

A marginal abatement curve shows, for a given year, the incremental cost of reducing additional units of carbon, and shows where the most cost-effective abatement opportunities lie. The shape of the curve changes over time, and as part of this White Paper we have constructed a curve for the UK showing the domestic abatement potential of a range of measures and technologies in 2020.

FIGURE 10.2. MARGINAL ABATEMENT COST CURVE 2020



Under the central fossil fuel price assumptions published alongside this White Paper, each technology or policy option was compared against a counterfactual in order to calculate its carbon abatement potential – for example, in the case of electricity generation, the alternative source of generation was assumed to be a new combined cycle gas turbine (CCGT) station. For energy efficiency and transport options, assumptions were made about the fuel displaced and their associated emissions.

The curve should not be taken as a prediction of the exact volume of carbon abated from each technology or policy, since the precise impact of policies, and the timing of the entry and cost of a new technology, are both subject to some uncertainty. This is particularly true for emerging technologies, such as Carbon Capture and Storage (CCS), which is yet to be developed on a commercial scale. The potential for nuclear power by 2020 is only indicative and depends on whether the Government decides to allow private sector companies the option of investing in new nuclear power stations.

Some of the measures in Figure 10.2 abate carbon at negative cost by encouraging more efficient use of energy – for example, smart metering in the business sector. The aim of the policies in this White Paper is to create the conditions necessary for producers and consumers of energy to pursue the most cost-effective ways of lowering carbon emissions. Not all measures are cost-effective (i.e achieve carbon savings at negative cost), particularly since the financial implications of carbon emissions for the environment and public health (i.e. the "social costs of carbon") are not factored into this analysis. However, given the scale of the challenge we face, we must act to innovate a number of technologies and implement a wide range of measures if we are to meet our carbon goals.

Impact on security of supply

Efficient use of fossil-fuels

10.18 Using energy and therefore fossil fuels more efficiently is a cost-effective method of both tackling emissions and increasing energy security. By reducing our demand for gas and oil, we reduce our exposure to security of supply risks, including the risks associated with imported energy. While the interactions of producers and consumers in energy markets determines future levels of oil and gas demand, we can evaluate the impact of our policies in terms of our reduced demand for gas or increased UK gas production and therefore reduced need for gas imports [339].

10.19 Our proposals can reduce gas consumption directly by reducing demand for gas i.e. in heating our homes; but also indirectly by reducing demand for electricity so reducing the need for new gas-fired power stations. We estimate that our measures will reduce electricity demand by between 8% to 15% of projected demand. In total, therefore, our measures could lead to up to 15 billion cubic metres of gas savings in 2020, equivalent to gas demand being 13% lower than it would otherwise be. This would reduce our projected gas imports by up to around 17%, which, combined with the possible increase in domestic gas production outlined in chapter 4, could bring our gas import dependence down to around 60% of projected gas demand in 2020, compared to around 80% if we did not implement our measures. Overall, we estimate that our measures will improve the energy efficiency of the UK economy by around 10% by 2020. This would be over and above the 25% improvement we already expect over that period.

Indigenous energy supplies

10.20 Our proposals to improve the framework for investment in the UK Continental Shelf (UKCS) aim to maintain the competitiveness of the UKCS as it becomes increasingly mature, in order to maximise economic recovery. If a high level of investment is maintained, this could potentially deliver substantially higher oil and gas production – up to an extra 0.6 million barrels of oil equivalent (boe) a day from 2020 to 2030. About half or slightly more of this extra production would be oil and the remainder would be gas.

Strengthening the market framework

10.21 A diverse mix of supply sources and routes is also fundamental in the management of our import risks. Strengthening our market based approach will improve the flexibility and responsiveness of the market, and help to manage the risks of supply disruptions. Changes to the planning regime and new and better market information arrangements will help market players to bring forward timely investments in infrastructure and provide sufficient supply capacity.

10.22 Providing incentives for low carbon generation, including through a carbon price, should also help our generation mix become more diverse. Our projections for the electricity generation mix, without taking account of the measures in this White Paper, show a trend towards higher levels of gas fired generation (see Annex B), which would reduce the diversity of our electricity

339 Here we assume a one-for-one relationship between reductions in gas demand, and reductions in gas imports.

generation mix. To encourage diversity whilst also tackling climate change we need to enable other cleaner technologies to play a role. In the short-term this means increasing renewables generation. Our changes to the Renewables Obligation, including the proposals to band the Obligation, are expected to increase the deployment of renewable generation up to 15% of electricity supplied and support a wider range of technologies. For the longer term, we are taking action: through continued support for renewable generation, through demonstration to promote the development of CCS power generation and, subject to consultation, deciding whether it is in the public interest for the private sector to have the option to invest in new nuclear power stations.

10.23 Beyond 2020 if CCS is successfully demonstrated, and if, following consultation, the Government decides it is in the public interest for new nuclear power stations to be an option for investment in new generation capacity, the share of gas fired plant in the mix is likely to be lower. By 2025, for example, if (in addition to the increased renewable generation delivered through the Renewables Obligation) we had 3 to 5 Giga Watt (GW) of coal-fired CCS plants, the share of gas in the mix could be between 6% to 10% lower[340].

10.24 The EU recently agreed to a binding target of reducing its greenhouse gas emissions by 20% by 2020 and by 30% in the context of international action and set a target for 20% of the EU's energy to be from renewable sources by 2020. The renewables target covers the energy we use in heat and transport as well as electricity. After a decision has been reached on each Member State's contribution to the EU agreement, we will bring forward the appropriate measures, beyond those set out in this White Paper, to make our contribution to meeting these targets, and in particular to increase the share of renewable electricity, heat and transport in our mix by 2020. In the meantime, the measures and market framework set out in this White Paper allow us to make significant progress on this important agenda.

Impact on competitive markets

10.25 According to a recent report, the UK has the most competitive energy market in the EU[341]. Recognising our increased reliance on global energy markets, we are committed to a strong international agenda to promote more open and competitive markets overseas. We will work towards realising fully liberalised European markets by 2010 and work with the European Union to extend the application of market principles beyond its boundaries, as set out in chapter 1.

10.26 At home we are establishing a clear, stable framework for investment: by clarifying our position on the Renewables Obligation and carbon policy; improving the planning framework for large energy projects; and setting out a clear process for deciding on whether it is in the public interest that the private sector should have the option to invest in new nuclear power stations. We will improve energy market transparency by providing accurate, timely data through our new and improved market information arrangements. We therefore believe our proposals within this White Paper will help to maintain the UK's position as one of the most competitive energy markets in Europe.

340 This is based on CCS replacing equivalent existing gas-fired generation capacity.
341 The Oxera report, *Energy market competition in the EU and G7: preliminary 2005 rankings*, shows that the UK leads the EU rankings in both electricity and gas markets http://www.dti.gov.uk/files/file35324.pdf

Impact on prices and fuel poverty

Impact on energy prices

10.27 Together with other countries, the UK has experienced increases in energy prices in recent years. Our existing policies to reduce carbon emissions are also having an impact on energy prices: the commitment to increase the share of renewable electricity under the Renewables Obligation by 15% by 2015, for example, is expected to increase electricity prices by around 5% by 2020, compared to what otherwise would have been. The existence of the EU ETS also affects UK electricity prices as electricity generators pass on the market value of carbon allowances. Assuming an EU ETS carbon price in 2020 of around €15-25t/CO_2, the impact on retail electricity prices could be between a 14-23% increase for industrial, and a 10-15% increase for household consumers, compared to if there were no carbon price [342].

10.28 It is therefore important that the policies in this White Paper do not greatly add to energy prices. Individually our measures on the demand side are unlikely to have a large effect on consumer prices. We have analysed the full impact of our measures, including the impact on energy prices, on an individual basis. While some measures could contribute to increases in energy prices, our analysis shows that they will also help to reduce energy bills by targeting improved energy efficiency [343]. For example, the cost of better billing, household real time displays and business smart metering will modestly increase energy prices, but will also lead to reduced energy bills if consumers act to realise energy efficiency savings. The continued obligation up to 2020 on energy suppliers to make carbon reductions in the household sector could increase household energy bills by approximately 1.5%-2% relative to today's energy bills, if all the costs are passed through to customers. But over time, we expect these costs will be outweighed by the benefits of a permanent reduction in energy demand.

10.29 Our proposals for changes to the Renewables Obligation, including banding, could add extra costs to final consumer bills. Based on our preferred banding regime described in chapter 5.3 the impact of the proposed changes to the Obligation could increase electricity prices by around 2% in 2020, compared to the existing regime.

10.30 Based on our analysis of individual measures, and given improvements in energy efficiency as a result of our proposals, we expect the overall impact on energy prices of our package of measures (excluding the EU ETS) to be equivalent of up to an additional 4% and 3% on the average annual household electricity and gas bill respectively in 2020 [344]. Some of these costs will be offset by energy savings through improved efficiency. We place a strong emphasis on a market-based approach, so that we can achieve carbon savings in the most cost-effective way as possible.

342 DTI analysis based on the Defra RIA on Phase II EU ETS. http://www.defra.gov.uk/environment/climatechange/trading/eu/phase2/pdf/overarching-ria.pdf.
343 2007 Energy White Paper Cost-Benefit Analysis Synthesis www.dti.gov.uk/energy/whitepaper
344 2007 Energy White Paper Cost-Benefit Analysis Synthesis. This is an illustrative figure based on the estimated impact of the policies when implemented on an individual basis. The final impact on prices of the proposals may be higher or lower than this, but this estimate does provide a broad indication of the expected impact.

Impact on fuel poverty

10.31 The Government has a target of eliminating fuel poverty in England by 2016, as far as reasonably practicable, with an interim target to eliminate it among vulnerable households by 2010. As described in chapter 2, we face challenges in meeting our fuel poverty targets, in part because of rising global energy prices. Recent rises in energy prices have resulted in an additional 1.2 million households in fuel poverty in the UK in 2006 compared to 2004, though price cuts taking effect during 2007 should reverse some of this increase.

10.32 Our projections (before the measures in this White Paper) of the number of households in fuel poverty between 1996 and 2016 are illustrated in Figure 2.1.1 in chapter 2, which shows that, under the central fuel price and income assumptions, 1.5 million households in England will be in fuel poverty in 2010. As incomes are assumed to rise faster than fuel prices, our projections show this number will fall to around 700,000 in 2016.

10.33 Specific measures in this White Paper have been designed to help reduce the number of households in fuel poverty. For example, a more joined up Government communication strategy to raise awareness of the support available, and more benefit entitlement checks to identify those eligible for the available support schemes. In total, we estimate that our proposals will lead to a reduction of around 200,000 UK households in fuel poverty by 2010.

10.34 It is possible that our package of measures may add to the challenges we face in combating fuel poverty, through their impact on energy prices. Our package of measures have been designed to improve the efficiency with which energy is used and, in some cases, will be specifically targeted at the fuel poor (for example, the priority group targeted under the Carbon Emission Reduction Target (CERT)). By encouraging the uptake of measures (such as domestic heat insulation for example), our proposals will not only reduce carbon emissions; but in doing so will also reduce consumer energy bills by reducing the amount of energy needed to heat households adequately.

10.35 We are midway through a full examination of our policies that tackle fuel poverty, looking at the ways in which they might be improved. We will set out our progress against our fuel poverty targets, and the next steps for our strategy, in the UK Fuel Poverty Strategy Fifth Annual Progress report, due to be published this summer.

Impact on the economy

10.36 The Stern Review highlighted the fact that climate change is a serious global threat that requires an urgent global response. It stated that the benefits of taking action far outweigh the economic costs of inaction. The dangers of unabated climate change will be equivalent to at least 5% of GDP each year and could possibly rise to 20% of GDP or more if a wider range of risks and impacts are taken into account. In contrast, the costs of action to avoid the worst impacts could be limited to around 1% of global GDP if the world pursues optimal policies.

10.37 Building on the Stern Review, which focuses on the global picture, we have used two models to explore the impact on the UK economy of reducing carbon emissions (see Box 10.2). The newly developed MARKAL-Macro model of the UK energy system is used to explore the potential long-term costs to the UK of achieving a 60% cut in domestic carbon emissions by 2050[345]. In addition, we have commissioned modelling work to explore the potential short to medium-term costs that might arise during the transition to a low carbon economy[346].

Long-term impacts to 2050

10.38 We have used the UK MARKAL-Macro model (M-M) to analyse over the long-term the optimal combinations of technology options consistent with achieving our 2050 goal of a 60% reduction in carbon emissions at least cost (see Box.10.2). The UK MARKAL-Macro model is a purely domestic model, which, unlike our policy framework, does not allow for international carbon trading[347].

10.39 Analysis using the UK M-M model suggests the annual cost of reducing UK carbon emissions by 60% by 2050 could be between 0.3% and 1.5% of UK GDP in 2050. The range reflects uncertainty over future fossil fuel prices and technological innovation – costs are higher when low carbon technologies do not develop as rapidly or efficiently as currently envisaged; conversely, higher fossil-fuel prices, or more enhanced development and take-up of energy efficiency reduce the cost of carbon abatement in the long-term.

10.40 The MARKAL modelling indicates that the costs of carbon abatement in the long-term could be significant, yet manageable. At the same time, they demonstrate that to achieve our carbon goals at least cost, a considerable change in our energy resources is required, including a concerted effort to reduce the amount of energy we use[348].

10.41 As in the Stern Review, these cost estimates are dependent on a concerted level of effort by the international community to reduce carbon emissions, so that the UK benefits from global economies of scale in developing low carbon technologies. The modelling reflects a market in which the costs of technologies come down so that they are harnessed at their full efficient potential, and there are no barriers to their take-up. In reality, these developments are not guaranteed. The Stern Review highlights the role of Governments in developing low carbon technologies; for example, by ensuring a strong carbon price signal, and by supporting the research, development and demonstration of early stage technologies. The costs of achieving our carbon goal may be higher if the UK does not benefit from the lower technology costs associated with global efforts to reduce carbon

345 DTI *The UK MARKAL Model in the 2007 Energy White Paper* www.dti.gov.uk/energy/whitepaper; Strachan N., R. Kannan and S. Pye (2007), *Final Report on DTI-DEFRA Scenarios and Sensitivities using the UK MARKAL and MARKAL-Macro Energy System Models*, http://www.ukerc.ac.uk/content/view/142/112

346 Oxford Economics – *Report on Modelling the Macroeconomic Impacts of Achieving the UK's Carbon Emission Reduction Goal* www.dti.gov.uk/energy/whitepaper

347 Whilst this could imply that abatement costs could be cheaper than those estimated by the MARKAL- Macro model, the opportunities available in an international carbon market in 2050 are, at the moment, uncertain; and by then, the majority of cheaper abatement options abroad may have been exhausted.

348 The M-M model shows that substantial changes in behaviour – affecting the amount of energy we use and constraining economic activity – are necessary to deliver a 60% reduction in carbon emissions by 2050. Such substantial changes could imply reductions in the welfare of energy users, which are difficult to quantify (at least in financial terms) and are not captured in the cost estimates from the model.

emissions, or suffered adverse trade and competitiveness implications as a result of acting unilaterally[349].

10.42 The long-term costs estimated by the M-M model are within the range indicated by Stern for global costs, and also within the range estimated for the 2003 Energy White Paper.

BOX 10.2. MODELLING THE IMPACT OF CARBON ABATEMENT

There are a number of models that can be used to estimate the impact of carbon abatement. The UK MARKAL-Macro model (M-M), developed from the earlier MARKAL model used as part of the 2003 Energy White Paper, is a "bottom up" technology model, covering the entire energy system. In the M-M model, a quantity constraint can be imposed on the level of carbon emissions to reflect government policy goals. The model then optimises available technological options to meet the target at least cost.

Since 2003, the M-M model has been developed to better calculate the macroeconomic impacts of carbon abatement, such as impacts on energy demand and GDP. The M-M model is particularly useful for exploring our energy system in the long-term, i.e. up to 2050, though it may be expected to produce lower-bound estimates of the costs of carbon abatement. This is because it is limited in its ability to capture the obstacles (such as information barriers) that, in reality, can slow the uptake of cost-effective abatement. Therefore, it does not capture the costs of implementing policies designed to overcome these obstacles. In addition, as a UK only model, it does not capture the potential trade or competitiveness impacts arising as a result of differences in climate change policy across countries.

Other models are more suitable for capturing the short-term dynamics of reducing carbon emissions. They explicitly model the short-run path as the UK makes the transition to a low carbon economy. When firms are forced to pay a price for each tonne of carbon they emit, they take time to move to a new "equilibrium" by reducing their demand for energy, or by using it more efficiently (through investment in new technologies, for example). Models that capture the short run dynamics do not necessarily have the technological detail of "bottom up" models such as the M-M model, and so do not fully capture the expected technological development as a result of carbon policy, which can help lower abatement costs. Therefore, to some extent, they will produce higher impact estimates.

We have commissioned Oxford Economics to explore the costs to the UK of carbon abatement in the short to medium-term. As part of the study for this White Paper, they have updated their model of the UK energy system to take better account of induced technological change as a result of climate change policy.

349 The M-M model is a UK-only model. Because it does not capture the effects of other countries' actions, the cost estimates for UK imply a degree of coordinated action, which would mitigate any trade and competitiveness impacts. Furthermore, the cost and availability of technologies in the M-M model are dependent on the development, demonstration and deployment of technology that might be expected under global action.

Short to medium-term transition costs

10.43 By 2050, the economy will have had a long period of time to adjust to government policy to mitigate climate change, imposed, for example, through carbon emissions constraints and/or changes in energy prices. However, in the short to medium-term, i.e. between now and 2020, the economy might find it more difficult to adjust. Therefore, to supplement the MARKAL-Macro analysis, we have commissioned further modelling to explore the potential short to medium-term adjustment costs of reducing carbon emissions between now and 2020.

10.44 Under a hypothetical scenario, in which all UK sectors face a unilateral carbon price, sufficient to achieve a 30% reduction in UK domestic emissions by 2020, UK GDP in 2020 is reduced by 1.3-2%, depending on prevailing fossil fuel prices[350]. This is equivalent to the economy growing by 40-41% between now and 2020, compared with 43% if no further effort were made to reduce carbon emissions.

10.45 The short to medium-term macroeconomic impacts vary according to the approach and level of ambition. For example, imposing an immediate carbon price on all sectors to achieve early, dramatic reductions would be more costly than under a phased approach or one where the target was less ambitious. For example, we have compared the imposition of a carbon price of €60 t/CO_2 to achieve early, dramatic reductions with a more phased approach (where a carbon price is introduced at a relatively low level but increases gradually). In the former, the cumulative loss of GDP over the period could be twice as much[351]. On the other hand the total cumulative reduction in carbon emissions over the period is higher than under a phased approach, i.e. 243MtC compared with 117MtC.

10.46 These scenarios reflect the UK acting unilaterally. However, the UK is actively pursuing a co-ordinated international effort in tackling climate change: commitments under the Kyoto Protocol, and the recent EU commitment to reduce EU greenhouse gas emissions by 20% by 2020 below 1990 levels, and by 30% as part of an international agreement, are encouraging. Looking ahead, our efforts to secure co-operation from large and fast growing economies such as the US, China and India will be of crucial importance in ensuring a truly global effort.

10.47 Acting unilaterally would mean the price of UK goods and services would increase, relative to those produced in other countries (because UK firms would incur a cost for the carbon emitted in their production and operation, whereas other countries would not). However, the modelling suggests that in the very short-term (i.e. up to five years), under a scenario of coordinated global action, the UK could also suffer a negative impact on the demand for its exports and therefore GDP, as other countries' economic output and demand for UK goods and services is depressed by similar policies affecting their energy use. But over the medium-term, UK competitiveness

350 "Business as usual" emissions in the short to medium-term analysis by 2020 are 17% below 1990 levels, therefore cost estimates reflect implications of reducing emissions by an additional 13% from the business as usual; and a 30% reduction on 1990 levels overall.

351 1.6% of GDP in 2020 compared to 0.8% under central fossil fuel price assumptions.

would be better maintained if there is multilateral action, as the UK's competitors would face the same penalty for carbon emissions associated with the production of goods and operation of services. If we act unilaterally, the analysis suggests our GDP will be lower by 1.7% in 2020 compared with no action; but acting to reduce emissions multilaterally reduces this impact to 1.3% of UK GDP in 2020[352].

10.48 International emissions trading reduces the overall global cost of abatement by allowing emissions reductions to take place where they are cheapest. Our policy framework allows for international action to reduce carbon emissions through the purchase of emissions credits, provided this is consistent with our international obligations. Through trading schemes such as the EU ETS or the Clean Development Mechanism, the UK could achieve significant carbon emissions reductions in a more cost-effective way and at a lower cost to GDP than if all emissions reductions were achieved domestically.

10.49 We have explored scenarios in which the UK achieves a 30% reduction in emissions by 2020, in part domestically but also through the purchase of international allowances. If we assume that the UK purchases two-thirds of the required level of abatement abroad, (at an allowance price equal to 80% of the cost of domestic abatement), achieving a 30% reduction in carbon emissions would cost 0.6% of GDP in 2020, compared with a GDP cost of 1.7% in 2020 if all reductions were achieved through domestic action[353]. Although there is uncertainty about the price and availability of emissions allowances in international markets, particularly after 2012, it is a useful illustration of how our market framework allows the UK economy to benefit from the most efficient, low cost abatement opportunities at home and abroad.

BOX 10.3. SECTORAL IMPACTS

The Stern Review recognised that if some countries move more quickly than others in implementing carbon reduction policies, some energy-intensive industries will locate in countries without such policies in place. A relatively small number of industries, particularly those which are most energy intensive, could suffer significant impacts as a consequence of pricing the cost of carbon emissions.

In the transition cost modelling we have conducted, output from sectors such as basic metals, paper, and wood and wood products have been highlighted to be particularly sensitive to achieving a significant reduction in carbon emissions by 2020.

However, the design of instruments to tackle climate change is of key importance and has the potential to mitigate some of the potential adverse effects in some sectors. For example, our analysis shows that if the UK invests in more cost-effective abatement options abroad through trading schemes such as the EU ETS and the Clean Development Mechanism, the effects on output are reduced by up to a half in basic metals and paper sector, and around a third in wood and wood products.

352 Under central fossil fuel price assumptions.
353 Under central fossil fuel price assumptions.

10.50 The estimates of the short to medium-term costs should not be taken as analysis of the effects of the Energy White Paper measures, but rather an estimate of the macroeconomic costs of achieving our carbon goals. The measures in this White Paper are intended to harness the most cost-effective ways of making carbon savings (See Box 10.1).

10.51 By putting in place measures that create the conditions necessary for producers and consumers of energy to pursue the most efficient and least cost ways of reducing carbon emissions; and by encouraging multi lateral effort and allowing for international trading this White Paper could significantly improve the trade-off between carbon abatement and economic growth, and by doing so, should deliver carbon reductions at lower cost.