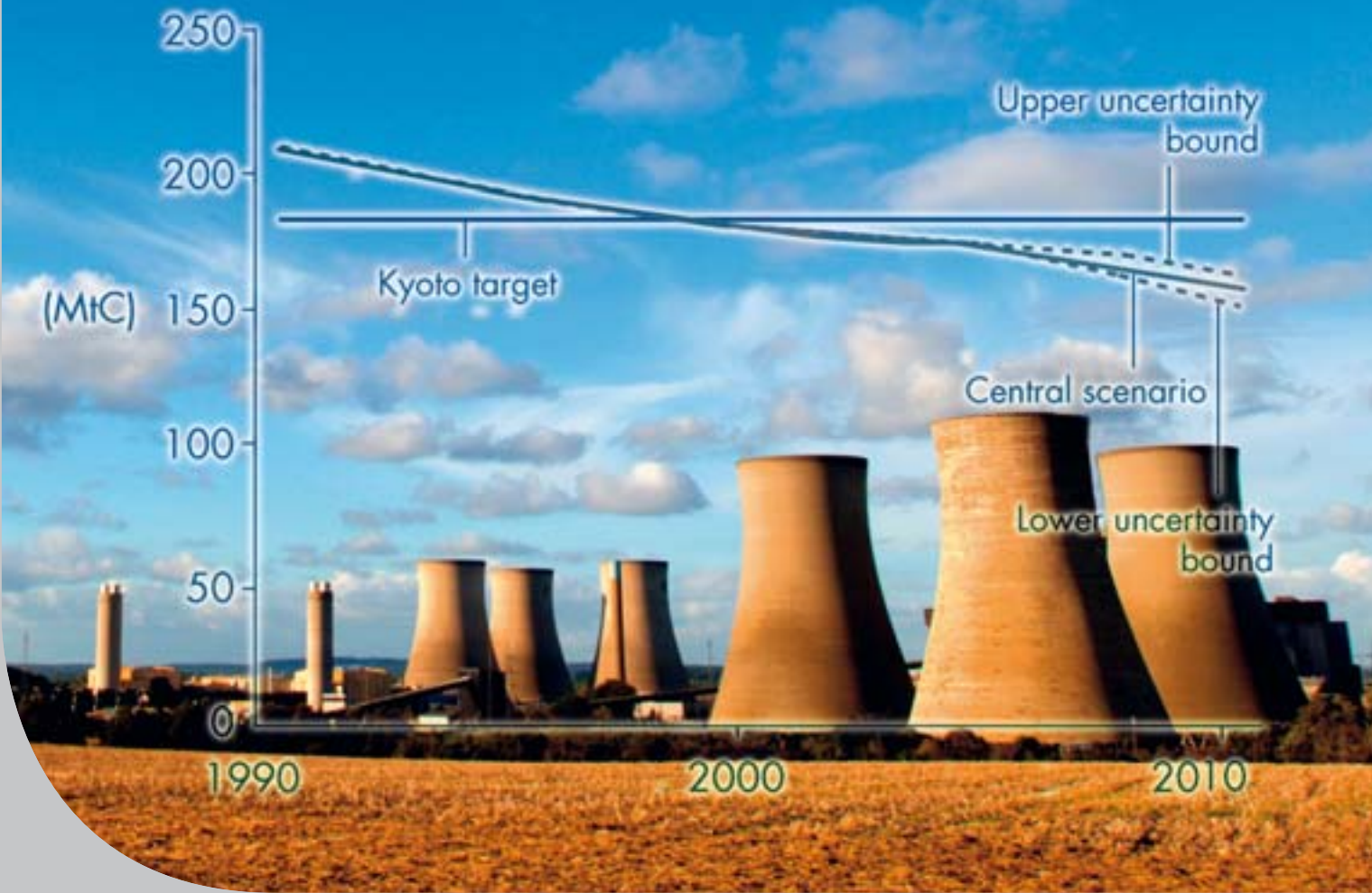




National Audit Office



EMISSIONS PROJECTIONS IN THE 2006 CLIMATE CHANGE PROGRAMME REVIEW

This review was undertaken by:

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This review can be found on the National
Audit Office web site at www.nao.org.uk

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Emissions projections in the 2006 Climate Change Programme Review

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1 Recent events have raised the profile of climate change policy. In September 2006 the government established an Office of Climate Change to co-ordinate climate change activity across government; and in November 2006 the government announced in the Queen's speech its intention to bring forward a Climate Change Bill including a proposal to establish an independent "Carbon Committee" to help government deliver its targets.

2 This briefing responds to a request from the Environmental Audit Committee. It examines the emissions forecasts (hereafter referred to as "projections") that informed the Climate Change Programme Review carried out between September 2004 and March 2006 (referred to here as the 2006 Review).

3 Why does forecasting matter? Because projections aim to tell us whether the UK is on course to meet its international and national targets; and because any gaps between target and projected outcome invite or require a policy response which could entail significant costs to taxpayers, industry and consumers. Emissions projections played a key role in the 2006 Review by identifying the extent to which the UK was likely to achieve its Kyoto and 2010 domestic targets for emissions reductions; highlighting the need to identify new or additional measures to meet the UK's domestic target; and informing decisions about the emissions reductions required from the EU Emissions Trading Scheme.

4 But forecasting is not straightforward. Projections of UK progress towards its 2010 domestic target, made at the time of the first Climate Change Policy in 2000, proved to be optimistic. In 2000, government predicted a 19 per cent reduction in carbon dioxide (CO₂) emissions by 2010, but by the time of the 2006 Review, this figure had been almost halved. After the 2006 Review, and the introduction of new measures, projected 2010 reductions were back up to a range of 15-18 per cent depending on the level of emissions reductions to be required under the EU Emissions Trading Scheme; the most stringent level of emissions reductions under consideration for this Scheme was later chosen, which would have corresponded to the 18 per cent reduction. Yet three months later, the projections had been reduced again to 16 per cent (see Figure 1).

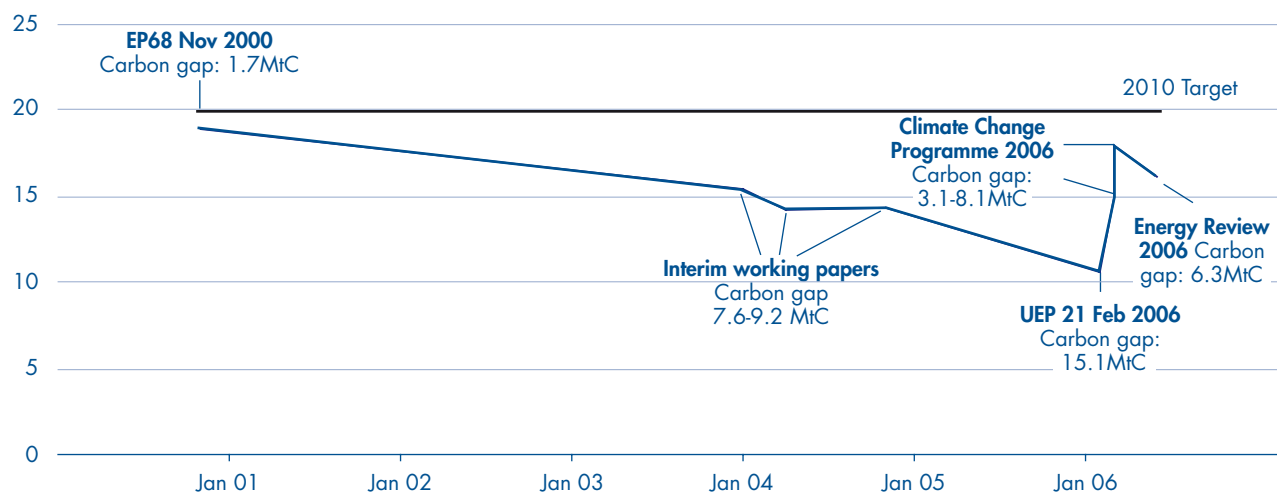
5 So why have projections been revised to this extent? How much more robust are the latest projections? And how has government responded to the projections in the 2006 Review and any uncertainty attaching to them? This briefing seeks to answer these and other questions.

6 The main points from our examination are:

- Projections made in 2000 have been revised to reflect a reduction in the expected savings from individual policy measures, changes in fossil fuel price assumptions, and gradual refinements to DTI's energy demand model and adjustments to the 1990 baseline. A degree of change in projections is to be expected; the Government recognised that the 2000 estimates were subject to considerable uncertainty. However, the extent of change in projections is greater than modelling teams anticipated.

1 How headline projections against the UK 2010 domestic target have changed

Carbon dioxide emissions — percentage reduction from 1990 levels



Source: National Audit Office analysis of data of published DTI papers

NOTE

DTI produced an additional working paper in July 2003, which gave a similar projection to the January 2004 projection. This is not shown here because it was not given on the same basis as the other projections shown (the effects of land use change for example, were not incorporated).

- The projections are based on sophisticated modelling approaches. The UK's approach to projections received a largely positive assessment in 2003 from a team acting on behalf of the United Nations. The UK models are subject to expert review and other quality assurance processes.
- Government has taken steps to make the 2006 projections more robust than those in 2000. The review of projected policy impacts that took place in 2006 involved a more sceptical scrutiny of the emission reductions to be expected from policy measures. Our review of minutes showed that peer review was more comprehensive than in 2000. There was also more detailed analysis of uncertainty. Key assumptions used in the 2006 Review were broadly in line with those used by other relevant organisations.
- There was little detailed peer review of the workings of the DTI model – the main model that the 2006 projections are based on. More could be done to learn from comparing outturn data against previous projections, although there has been some recent effort on this.
- There is considerable inherent uncertainty in modelling the UK energy market and emissions projections. A key assumption in the model is fossil fuel prices. In the past the relative price of gas and coal has had a significant effect on emissions projections, although the impact of further fuel price changes in the short to medium term is expected to be limited.

- The 2006 Review analysed and acknowledged uncertainty but might have done more to explain its implications. However, analysis of uncertainty does not alter the main messages of the 2006 Review – that the UK will meet or exceed its Kyoto target on all but the most pessimistic assumptions, and will fall short of its 2010 domestic target on all but the most optimistic assumptions.
- The 2006 Review was too late to allow a full and cost-effective response to the realisation that the UK would fall well short of its 2010 domestic target. New policies take time to introduce, and there are time lags before they have an effect. Earlier and more regular reviews of progress against targets, and trajectories towards them, would allow more cost-effective course corrections.
- The evaluation and appraisal of measures took longer than expected but was not the only cause of delays to the 2006 Review timetable. To date, UK projections have been produced in response to particular needs, but the government expects to move to annual reviews and publications of emissions performance.
- Projections against the 2020 and 2050 domestic targets to reduce CO₂ are less well developed and necessarily more speculative. As the 2010 target approaches, it is important to switch attention to the realism and delivery of these future targets. Government already acknowledges that significant change will be needed to meet these future targets.
- Projections to date have not included international aviation or shipping, reflecting the coverage of Kyoto targets, and thus do not give a complete picture of current emissions or future trends. These sources of emissions will become increasingly important to the overall UK picture.

Issues for Committee scrutiny

- 7 On the basis of our findings, the Committee may wish to pursue the following lines of inquiry:
- What further steps (if any) should government take to ensure that future projections of the impact of policy measures are robust?
 - Can steps be taken to increase the degree to which projections are subject to independent assurance?
 - How should government report and respond to the considerable, and unavoidable, uncertainties in forecasting?
 - What improvements are planned in the production and use of projections towards the 2050 (and associated 2020) domestic target?
 - Should future domestic targets and reporting include international aviation and shipping, and how might this treatment be reconciled with international reporting requirements?

INTRODUCTION

This briefing responds to a request from the Environmental Audit Committee

1 In April 2006 the National Audit Office published a briefing for the Environmental Audit Committee on UK climate change policy. This work was produced to inform and assist the Committee's further work on climate change, and set out options for further Committee scrutiny. After discussion of the briefing in June and July 2006, the Committee signalled that it wished to follow up in more detail the emissions forecasts (hereafter referred to as "projections") that informed the Climate Change Programme Review carried out between September 2004 and March 2006 referred to here as the 2006 Review.

2 The Committee has had a longstanding concern about the accuracy of greenhouse gas emissions projections and the need to update them on a timely basis. In the Committee's report, published in April 2006 "Keeping the Lights on: nuclear, renewables and climate change", the Committee made the following conclusions and recommendations:

"We have serious concerns about the ability of the Government to model reliably and in a timely fashion, future energy and emission forecasts. This is reflected in the fact that the updated energy projections are two years late, the unwillingness to accept earlier that the Climate Change Strategy was seriously off course, and the difficulties which the Government experienced in setting an emissions cap for Phase 1 of the EU Emissions Trading System. As a first step, the Government should ensure that it puts in place a transparent and credible system for updating these forecasts regularly every two years. Ultimately, it would be more appropriate for some form of sustainable energy agency – clearly independent of government – to perform this role."¹
Environmental Audit Committee, Sixth Report of Session 2005-06, Keeping the lights on: nuclear, renewables, and climate change, HC 584

3 This briefing responds to the Committee's request and earlier interest. It focuses on the reliability of the projections and their sensitivity to key assumptions. A separate briefing being prepared for the Committee examines the use of data on costs and cost effectiveness in the 2006 Review. At a detailed technical level, the preparation of projections and data on cost-effectiveness are closely connected (see Figure 2), but for the purposes of these two briefings we can treat projections and cost-effectiveness as two distinct topics for Committee scrutiny.

Climate change policy is a priority for the UK government

4 In the foreword to the 2006 UK Climate Change Programme, the Prime Minister stated that 'climate change is probably the greatest long-term challenge facing the human race'.² It is, for example, one of the five priority areas for action in the UK Sustainable Development Strategy.³ Majority scientific opinion is that climate change is predominantly driven by anthropogenic (man made) emissions, and that the resulting rising global temperatures will bring changes in weather patterns, rising sea levels and increased frequency and intensity of extreme weather events.

2 How projections and cost-effectiveness are linked

Emissions projections and data on cost-effectiveness both draw on the work of a cross-departmental group of analysts (the Interdepartmental Analysts Group, IAG). The IAG assessed all existing and proposed policy instruments as part of the 2006 Review, to determine both the expected carbon reduction they would deliver, and the related costs and benefits.

Although assessments could in theory examine alternative scenarios, with interventions of different scales, in practice the assessments done for the 2006 Review largely focused on a central or preferred scenario together with some uncertainty analysis around that central scenario. The resultant central estimates for expected impact, and cost-effectiveness, were taken into the 2006 Review's aggregate modelling and consideration of costs.

¹ http://www.parliament.uk/parliamentary_committees/environmental_audit_committee/eac_18_04_06.cfm.

² Defra, Climate Change Programme 2006 – <http://www.defra.gov.uk/ENVIRONMENT/climatechange/uk/ukccp/index.htm>.

³ UK Sustainable Development Strategy, March 2005 – <http://www.sustainable-development.gov.uk/publications/uk-strategy/index.htm>.

5 Mitigating or reducing climate change requires long-term reductions in greenhouse gases. The Stern Review, a major review of the economics of climate change commissioned by the government and published in October 2006, investigated the costs of stabilising greenhouse gas concentrations in the atmosphere at 450-550 parts per million (ppm) CO₂ equivalent. This compares to pre-industrial levels of around 270ppm, and current levels of 430ppm. Even at a stabilisation level in this range, the available scientific evidence suggests the global temperature increase could still range from 1 to 4.5°C with associated impacts on crop yields, extreme weather conditions and water availability in some parts of the world. The expected impacts become increasingly severe towards the top of this range of temperature increases, with an increased risk of abrupt, large scale changes to the climate system.⁴

6 The UK contributes only two percent of global carbon dioxide emissions, and thus a global effort is needed to reach these stabilisation levels. Nonetheless the UK government recognises that the UK can and should play a leading role. The UK is subject to international and national targets for emissions reductions:

- As part of the Kyoto protocol, developed countries agreed to cut their overall emissions of greenhouse gases by 5.2 per cent below 1990 levels by 2008-2012. These targets are legally binding. Countries have different targets to reflect their circumstances. The UK has a Kyoto target of 12.5 per cent reduction below 1990 levels by 2008-2012.
- The UK also has domestic targets for CO₂ that go beyond Kyoto.
 - The first is a 20 per cent reduction in carbon dioxide by 2010, which together with the Kyoto target, is detailed in a PSA target (2005-2008) shared by Defra, DTI, and DfT.⁵

- The second is a long-term goal to reduce the UK's carbon dioxide emissions by some 60 per cent by about 2050, with real progress towards this goal by 2020. This latter target was announced in the Energy White Paper (2003) and was intended to bring the UK in line with a 550ppm stabilisation target.

Figure 3 shows how UK emissions have changed since 1990, against international and domestic targets.

7 In September 2006 the government established an Office of Climate Change to co-ordinate climate change activity across government and to provide a shared resource for analysis and development of climate change policy and strategy. The government also proposes to introduce new legislation, through a Climate Change Bill, announced in the Queen's speech November 2006. This legislation would comprise the following four elements:

- establish an independent "Carbon Committee" to help government deliver its targets;
- make the target of a 60 per cent reduction in carbon emissions from 1990 levels by 2050 legally binding;
- create new powers to ensure the 2050 target is achieved; and
- improve the way CO₂ reductions are monitored and reported, including how government reports to Parliament.

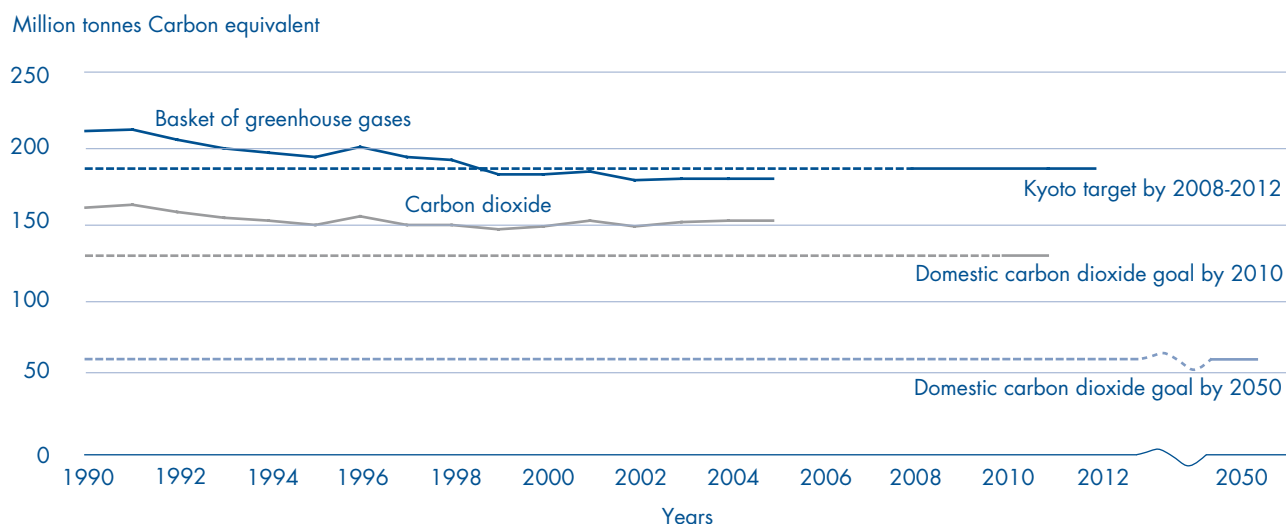
Emissions projections played a key role in informing the 2006 Review

8 Projections at the time of the Climate Change Programme 2000 predicted that the UK's domestic and international targets for 2010 were within reach. The Government expected that the UK would exceed its Kyoto target; central scenarios showed greenhouse gas emissions in 2010 down 23 per cent, considerably below the 12.5 per cent target. The domestic target was expected to be just within reach, with CO₂ emissions expected to be 19 per cent below 1990 levels.

⁴ http://www.hm-treasury.gov.uk/media/8AC/F7/Executive_Summary.pdf

⁵ HM Treasury, Public Service Agreements 2005-2008, July 2004 - http://www.hm-treasury.gov.uk/spending_review/spend_sr04/psa/spend_sr04_psaindex.cfm

3 UK emissions of greenhouse gases 1990-2005 and targets to 2050



Source: Netcen, Defra

NOTES

- 1 For clarity the graph is discontinued between 2012 and 2050, indicated by a wavy line.
- 2 In addition to the three targets pictured here, the UK also has a goal of 'real progress' towards the 2050 target by 2020.
- 3 Estimates for 2005 are provisional. Based on data updated August 2006.

8 Projections in the run up to the 2006 Review showed that the UK was still on track to exceed its Kyoto target, a good performance compared to a number of other major countries. A report by the European Environment Agency published October 2006, showed that seven member states – Austria, Belgium, Denmark, Ireland, Italy, Portugal and Spain – are predicted to miss their individual targets.⁶

9 Projections in the run up to the Climate Change Programme 2006 also revealed, however, that the UK would fall well short of its domestic target to reduce CO₂ emissions by 20 per cent by 2010. These projections therefore informed the conduct of the 2006 Review, highlighting the need to develop new or additional measures. The 2006 Review resulted in new policies and also informed discussions about the national emissions reductions to be achieved through the EU Emissions

Trading Scheme, which were finalised in summer 2006. The new policies were expected to save some 4MtC (million tonnes of carbon), with a further 3-8MtC from the EU Scheme, but nonetheless CO₂ emissions in 2010 were still expected to be 15-18 per cent below 1990 levels, leaving a "carbon gap" of some 3-8 MtC.

10 The projections were revisited again during the Energy Review of June 2006. Revised modelling, based in part on changed assumptions about energy supply, predicted that CO₂ emissions in 2010, before allowing for the expected savings from the EU Emissions Trading Scheme, would be 11 per cent below 1990 levels. With the level of savings for the EU Emissions Trading Scheme agreed finalised in 2006, the projection was 16.2 per cent below 1990, a carbon gap of just over 6 MtC. This represents the latest position.

⁶ <http://www.endsreport.com/index.cfm?action=bulletin.article&articleid=16461>

There may be political, economic and environmental costs if projections are misleading

11 If the future is significantly different from projections, there could be environmental, economic and political costs.

- If the UK does not meet its Kyoto target, there could be real costs in addition to the national and international political embarrassment. Kyoto targets are legally binding and carry a penalty. Undershooting the target will lead to higher targets in the next round of Kyoto reductions (which would be increased by the shortfall plus 30 per cent of that shortfall).
- Kyoto targets were agreed to reflect an achievable level of progress towards reducing environmental damage. Failing to meet them implies some environmental costs that were considered important to avoid.
- If actual emissions are different from projections, and a course correction is needed, additional measures may need to be introduced. Depending on the measure, and time period, this might impose higher transitional costs than if measures had been introduced earlier.

12 There could also be costs if projections overestimate emissions. For example, if the projections have overestimated the gap to the domestic target and policy instruments have been introduced unnecessarily, this may have associated costs to UK industry, consumers and taxpayers. For example, firms may be required to cut emissions by more than was necessary.

We reviewed the modelling process behind UK projections, and the key assumptions used

13 In the rest of this briefing we seek to explain the modelling process, provide reassurance where appropriate and highlight areas that may warrant further investigation by the Committee. In particular, we examine:

- the steps taken to ensure the reliability of the modelling process;
- the reasonableness of key assumptions, and the sensitivity of projections to changes in these assumptions;
- the treatment of uncertainty in projections; and
- the timeliness of projections.

Our principal aim is to open up the topic for scrutiny by the Environmental Audit Committee. This is not therefore intended to be an exhaustive or science-led critique of the modelling process. It focuses instead on the matters and level of detail appropriate for Parliamentary scrutiny.

14 We have focused our attention on projections against the 2010 domestic CO₂ target, although we also describe briefly what work has been done on longer term projections to 2020 and 2050 – these projections are necessarily more speculative and uncertain. Our briefing is based on a review of the published literature, as well as interviews with stakeholders and the main government departments involved in the modelling process and the 2006 Review. We also reviewed the evaluations and appraisals of the ten existing and new policies in the Climate Change Programme 2006 that were expected to deliver the most greenhouse gas emissions savings. We were assisted in this task by Michael Ridge, Matthew Bell and Catherine Howell, of Frontier Economics.

RELIABILITY OF MODELLING TECHNIQUES AND QUALITY OF DATA

The modelling process is complex

15 The UK's modelling and projection is a complex process, involving four main strands of analytical/modelling work, two main departments and several independent contractors (Figure 4).

16 The CO₂ projections that informed the 2006 Review supported or corroborated by several other models across government, which are used for different purposes. The National Transport Model, for example, is used for very detailed transport projections and in the detailed design and appraisal of transport policies.

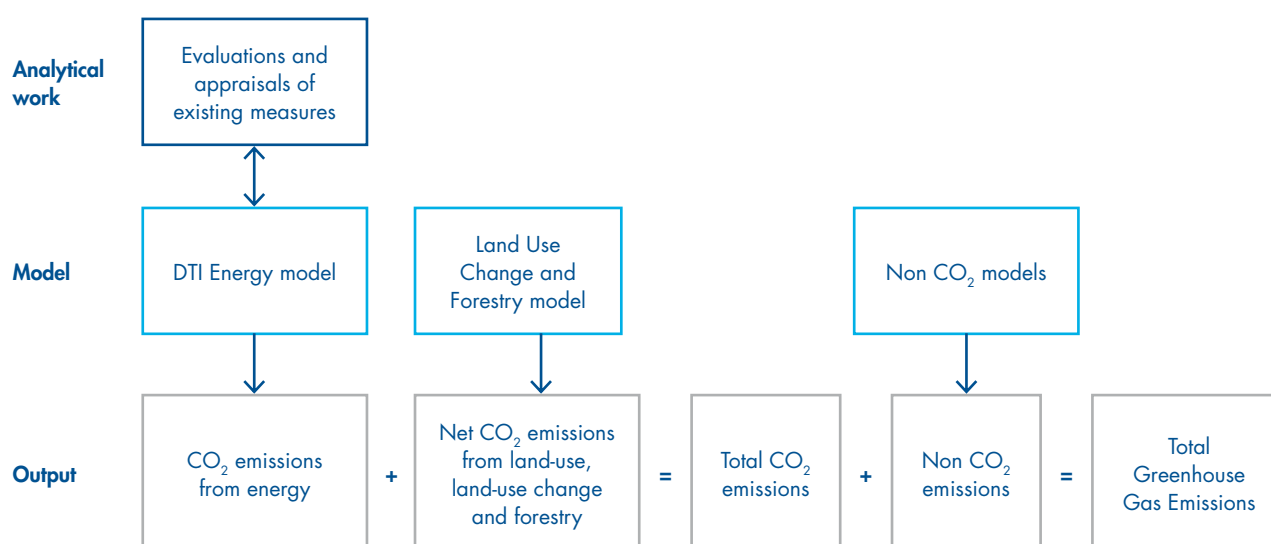
17 The DTI model projects energy supply and demand based on a set of equations that are estimated from historical data. The model itself can be run in a matter of minutes, being based on computerised information, but it can take months to gather the data that is needed to revise assumptions, consult on provisional projections with other government departments and industry stakeholders, and

refine the outputs. The model output is given in terms of energy demand, and this is converted into emissions using emission factors relating to different fuels.

18 Climate change policy measures are incorporated in the DTI model in three main ways.

- Some are included by changing inputs in the model directly. The climate change levy for example, is essentially a tax, so can be modelled by changing fuel prices in the model.
- In other cases the analytical work is independent of the DTI model and led by the Department responsible for the policy. For example, the effect of a policy to replace household boilers with more efficient ones is calculated from the 'bottom-up' analysis based on the number of existing boilers and the estimated numbers that would be replaced. The overall amount of energy saved is then subtracted from the forecast energy demand within the DTI model. Steps are taken to ensure such analytical work is consistent with the key assumptions in the DTI model.

4 An overview of the UK's modelling of emissions projections



Source: National Audit Office

NOTES

- 1 Net emissions from Land-use, Land-use change and forestry may be positive or negative, since Land-use can act as a "sink" for carbon emissions, carbon dioxide being stored in vegetation and soils.
- 2 Net emissions from Land-use, Land-use change and forestry are modelled by the Centre for Ecology and Hydrology under contract to Defra.
- 3 Non-CO₂ emissions are modelled by Entec, again under contract to Defra.
- 4 Other consultants are also involved in aspects of the analytical work.

■ Finally, if the policy analysis is not sufficiently developed, an initial or provisional estimate of the amount of carbon that is estimated to be saved is subtracted from the appropriate final emission output and where possible adjustments made to energy outputs. Such estimates formed a very small proportion of the emissions reductions now expected through to 2010.

19 Two further pieces of modelling are then factored into the DTI projection:

■ The effect of **changes in land-use and forestry** is modelled by the Centre for Ecology and Hydrology, under contract to Defra. Land and forests can act as a 'source' or 'sink' for carbon dioxide. Planting trees, preserving forests, and some cultivation practices increase soil carbon, and thus increase the size of carbon sinks; while the opposite leads to more emissions. The land-use model projects the effect of these changes based on information from the Countryside Survey, which provides a record of land-use changes over time. Projections are produced largely by assuming trends in land-use continue as before, although off-model adjustments are made to account for changes such as the increased rate of house building planned for the South East. The latest mid-range projection is for this sector to be a net sink for CO₂ emissions by 2010, though by less than 1 MtC. The underlying trend is expected to be for removals to increase more quickly than sources, so that by 2015, land-use change is a net contributor to greenhouse gas emissions.

■ **Non-CO₂ emissions** are modelled by consultants (Entec) working for Defra, using a methodology similar to that used to compile the Greenhouse Gas Inventory of historic and current emissions and based on the DTI model output for consistency. Emissions are estimated by applying emissions factors to statistical information and trends on industrial and other processes producing emissions, because it would be largely infeasible to project and then measure emissions at source or in the atmosphere.

20 Finally, the effect of the European Union Emissions Trading Scheme (EU ETS) is incorporated. The Government has decided that all emissions savings attributable to the UK's national allocation plan under the EU ETS will count towards the domestic target, whether or not they are actually achieved in this country. For the purposes of monitoring progress against the domestic target, therefore, the projections incorporate a reduction in greenhouse gas emissions equal to the full level of saving attributable to the EU ETS; this is modelled as the difference between the national cap and business-as-usual projections without the cap. At the time of the 2006 Review, the Government was considering a range of levels for the national allocation plan for the second phase of the EU ETS, corresponding to a saving of 3-8MtC below business-as-usual emissions. This range of reductions was incorporated in the headline projections that informed the 2006 Review.⁷

The UK's emissions projections received a largely positive assessment in 2003 from a team acting on behalf of the United Nations

21 An international team of experts reviewed the UK's projections in 2002-2003. The assessment was part of a wider review of the UK's report to the United Nations on its progress against Kyoto targets. Each signatory to the Kyoto Protocol is required to submit these reports to the UN on a periodic basis.

22 Reviews are co-ordinated by a secretariat at the United Nations and primarily assess whether the national communications follow reporting guidelines. They can include an assessment of the robustness of the projections methodology, though teams do not necessarily have access to the details of the methodologies used. Each review typically involves a desk-based study and an in-country visit.

⁷ The DTI model itself does not incorporate the effect of the European Emissions Trading Scheme, though DTI has explored the impact of different carbon prices on the projections.

23 The review team concluded that the UK's report met all of the reporting guidelines on projections, and drew particular attention to the "early and continuous involvement of various parties in the development of greenhouse gas emissions projections", considering that this process had given excellent results. The team concluded that the UK models were "quite robust" although the Communication did not give as much information as it could about the strengths and weaknesses of the model approach.

24 Although many other signatories to the Kyoto protocol received similar positive assessments from the in-depth review process, some assessments were more critical. The presentation of projections in Germany's Communication, for example, was considered to "deviate considerably from the requirements set out in the UNFCCC reporting guidelines" though the review team noted that there were plans to improve the projection methodology. It is also clear that projections from some of the smaller countries (for example, Belarus) were basing projections on much more simplistic models than those used in the UK. **Figure 5** sets out comments made in in-depth reviews about the robustness of the projections in the Russian Federation, Japan, Germany, Canada. These countries are the four most significant signatories to the Kyoto protocol in terms of greenhouse emissions.

5 Summary of comments on robustness of the emissions projections from United Nations in-depth reviews, for four countries

Country	Overall assessment of the robustness of the projections	Assessment against United Nations reporting guidelines
Russian Federation	No overall assessment of the robustness of the projections made The review team criticised the report for giving little information on how projections were prepared.	Reporting of the information on projections considered to be incomplete, and not strictly in accord with the United Nations requirements.
Japan	Some omissions identified Overall assessment was that the projection approaches were 'rigorous and sophisticated'.	Omissions were noted, such as for example, the fact that there was no concrete description of details on major assumptions and methodologies, and no sensitivity analyses presented.
Germany	It was noted that the communication had little information about how the projections were prepared. On the basis of a follow-up meeting, during which the review team saw more recent projections, it was concluded that 'German experts have state of the art knowledge of how to develop consistent and credible greenhouse gas projections'. Also suggested a number of areas for possible future national communications. These included presentational issues, as well as more technical points, for example about the method for modelling emissions from transport.	The overall conclusion was that the communication deviated considerably from the reporting guidelines. Major deviations highlighted included that the projections were not consistent with the latest greenhouse gas inventory and projections for 2015 and 2020 were not available.
Canada	Certain omissions highlighted but in spite of these, the team concluded that the 'methodology for preparing the forecast is rigorous and comprehensive'.	The review team gave no overall assessment against the guidelines. A number of omissions were noted such as: the projections were not entirely consistent with the inventory, and the fact that projections for certain sinks/sources (namely land use, land use change and forestry sinks and emissions from international air and marine bunkers) are not always included.

Source: In-depth reviews of the countries' third national communications, published 2004

The DTI model is subject to expert review though more could be done to evaluate against outturn data

25 The DTI model is a sophisticated energy demand model based on over 150 model equations. The model was first developed in the 1970s, and has been refined and updated on numerous occasions since. Independent experts are brought on board periodically to assist with these updates. Since May 2005, the projections have been subject to more detailed peer review:

- DTI established a Projections Advisory Group, with representatives from a range of industry groups,⁸ together with the DTI modelling team, a representative of the environmental NGO community, and representatives from other government departments (Defra, the Department for Transport and Treasury). Representatives from industry were chosen on the basis of their personal modelling expertise and asked to offer neutral advice rather than be a forum for lobbying. This group met periodically from May 2005 until May 2006. DTI expects the group to continue its work and it met again in September 2006.
- To improve the accuracy of the sector projections that informed the UK National Allocation Plan (NAP) under the EU ETS, DTI also set up a second independent panel. This group comprised academics and consultants. It had the task of reviewing responses to the consultation on the national allocation plan. The group considered recommendations from the DTI about refining the sectoral projections in the light of comments received and was asked on the robustness of those proposals. Having completed its task, the group is no longer active.

Because of the nature and timing available to these groups there has been limited opportunity to date for them to review the workings of the model in detail, though both groups were briefed on the broad approaches.

26 A key part of the modelling process is the evaluation of existing policies and the appraisal of new ones. In each case the analytical work was carried out primarily by the lead analysts in the responsible departments. The results of this work were brought together for peer review and to ensure consistency of approach by the Interdepartmental Analysts Group (IAG). This is a cross-departmental group of around fifty analysts that includes department officials as well as representatives from the Energy Saving Trust, Carbon Trust and Environment Agency. The IAG worked throughout the whole course of the 2006 Review – from September 2004 to March 2006. Some of the analysis was based on work that had been ongoing, but much was new, instigated and co-ordinated by the IAG. All evaluations and appraisals had to follow guidelines and pro-forma produced by the IAG. While this guidance did not specify the exact methodology to be used, it did set criteria based on the principles in Treasury guidance (“Evaluation and Appraisal in Central Government”, more commonly referred to as the Green Book).

27 All evaluations and appraisals were peer reviewed. Each policy had two peer reviewers, selected from IAG members, usually a policy official and an analyst or economist with no connection with the policy work strand, though consultants were asked to perform the peer review of many of the new policy appraisals. Peer reviewers used the guidelines and pro-forma to assess issues such as the completeness of data, and appropriateness of technique. Our review of the minutes of the IAG meetings suggests that peer reviewers were active in questioning work strand owners. External economic consultants Oxera also provided another level of review when they produced a synthesis of these evaluations. As part of this exercise, Oxera checked that the evaluation criteria had been complied with and ran a simple sense check of the figures. In certain sectors projections were verified by comparing the results of two types of model. Our review of minutes showed there was greater consistency and peer review was more comprehensive than in 2000.

⁸ External experts were represented from: UK Emissions Trading Group, Confederation of British Industries, Association of Electricity Producers, Renewable Energy Association, UK Business Council for Sustainable Energy, Energy Intensive Users Group, UK Offshore Operators Association and UK Petroleum Industry Association.

28 Part of the peer review process was to ensure that overlaps between policies were accounted for. Our review of the ten most significant policies (in terms of expected greenhouse gas emissions savings in 2010) showed that the most important policy overlaps were identified and taken into account in the analysis to prevent double-counting. (See Appendix 2).

29 DTI are working with industry to improve the quality of data provided on which their model is based. Now that projections are used to inform the allocation for the EU ETS, the assumptions about industry growth and the historic data on which these assumptions build, have come under increasing scrutiny from companies concerned to make sure their growth is not underestimated. DTI has therefore set up a project to improve the sector by sector data.

30 The modelling of non-CO₂ and land use changes is not subject to similar level of external or independent quality assurance, although both models are produced for Defra by contractors and are prepared to be consistent with UNFCCC guidelines.

31 An important component of modelling is to review how actual emissions (outturn) compare against forecasts, understand the reasons for any difference, and adjust the model accordingly. DTI currently do not report explicitly on how forecasts have compared against outturn, and why there may have been differences. This analysis is partly carried out implicitly, through updating model assumptions and refining model equations, and the effects of these changes on successive projections have been listed in the Updated Energy Projection publications. Analysis of this kind is also made more difficult by the fact that the model is based on an 'optimisation' method, which means it does not give projections year by year, but rather point estimates at five yearly intervals (2010, 2015 and 2020).

32 However, more could be done to make explicit how and why projections have changed and to explain how projections compare with outcome data. A good example of how to do this, albeit in a very different context, is the approach used by the Bank of England to support the decision making of the Monetary Policy Committee. Included in the reports of the modelling exercise are an explicit consideration of 'MPC's forecasting record' which compares outturn against forecasts 'to assess how well the MPC's projections have served as a guide to outturns'. There is scope for DTI to include similar analysis in its Updated Energy Projection reports.

Projections produced to date have not included international aviation or shipping

33 Projections produced for the 2006 Review do not give a complete picture of the UK's emissions because they do not include international aviation or shipping. This omission is legitimate in terms of assessing progress against Kyoto targets, since Kyoto does not include aviation or shipping because of the difficulties of allocating emissions to individual countries. Government has also set the 2010 and 2050 domestic targets as not including aviation or shipping. This approach has been criticised as giving a misleading picture, however, since the inclusion of these sectors paints a different picture of the UK's progress to date and future. A recent report by the Tyndall Centre, for example, highlighted that while the Government's inventory data show emissions to have fallen since 1990, emissions have stayed level if aviation and shipping are included. The Tyndall report argued that the 2050 target should include aviation and shipping. There are ways to measure and attribute emissions from international aviation and shipping, and the UK could adopt these for national purposes pending international agreement for Kyoto purposes.

REASONABLENESS OF ASSUMPTIONS

There have been significant changes in projections against the 2010 domestic target

34 We said above that projections made in 2000 about likely progress against the 2010 domestic target were optimistic and had to be revised. In this section, we examine the reasons for these revisions. In 2000 the government expected the UK was largely on track for its 2010 domestic target, with CO₂ emissions expected to be around 19 per cent below 1990 levels in 2010, a “carbon gap” of only 1.68 MtC. **Figure 6** shows how the 2000 emissions projections changed: by February 2006 projected emissions in 2010 had fallen to just 10.6 per cent below 1990 levels, a carbon gap of 15.1 MtC.

35 The figures for the carbon gap shown in **Figure 6** reflect three main changes over time, above and beyond modelling refinements:

- changes in the 1990 baseline, reflecting changes in definitions and measurement conventions;⁹

- revised ‘without measures’ projections from the model largely due to changes in fossil fuel price assumptions; and
- revised assumptions about the impact of policy measures introduced in the CCP 2000, which had to be revisited in the light of experience.

36 A degree of change in projections is to be expected, and modelling teams recognised in 2000 that their estimates were subject to considerable uncertainty. However, the extent of change in projections is greater than the uncertainty range that modelling teams anticipated in 2000. The level of uncertainty around the estimates made in 2000 was estimated as around plus or minus 8 per cent for 2010 projections. As **Figure 7** shows, the central projection that informed the 2006 Review was outside this range of feasible scenarios anticipated in 2000.

6 Changes in 2010 emissions projections between 2000 and 2006 (Before the new measures introduced by the 2006 Review)

DTI model ID	EP68	Jan 2004	May Working Paper	UEP12	UEP21
Date published	Nov 2000	Jan 2004	May 2004	Nov 2004	Feb 2006
A: 1990 Baseline (MtC)	168.0	164.9	164.9	165.1	161.4
B: 2010 target (80% of row A) (MtC)	134.4	131.9	131.9	132.1	129.1
C: 2010 Projection (MtC)	136.1	139.5	141.4	141.3	144.3
D: 2010 projection (% reduction)	19%	15.4%	14.3%	14.4%	10.6%
E: Carbon gap (row C minus row B) (MtC)	1.7	7.6	9.5	9.2	15.1

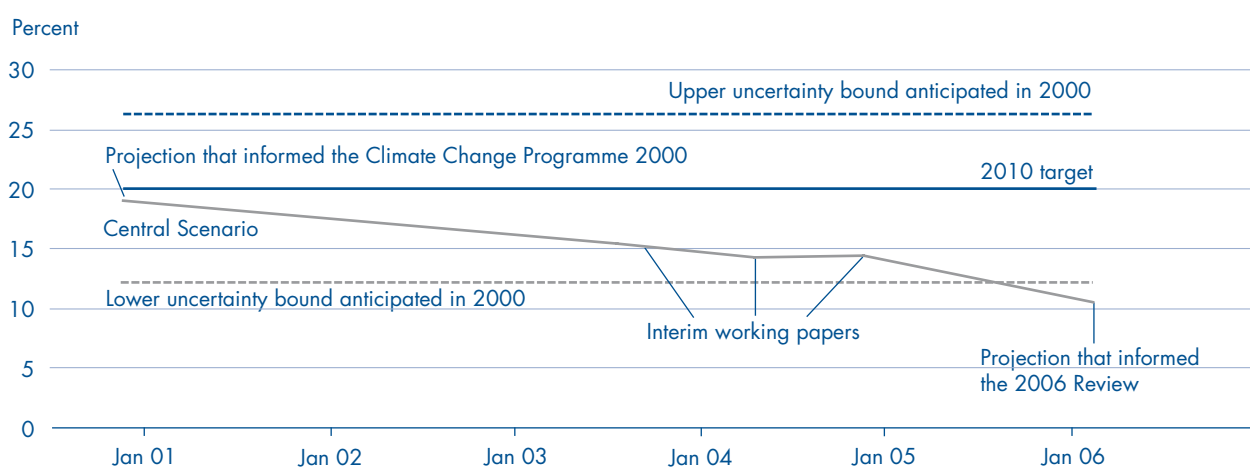
Source: National Audit Office based on information in DTI energy projection paper: EP68, May Working Paper, UEP12 and UEP21

NOTES

- 1 UEP 21 is the DTI model run which the projections in the Climate Change Programme 2006 were based on.
- 2 Numbers do not sum due to rounding.
- 3 All figures include estimates for emissions or removals from land-use, land-use change and forestry.
- 4 Projection quoted for EP68, UEP12, and UEP21 are the average of the two central scenarios presented.
- 5 Figures do not include estimated savings from new measures introduced in the Climate Change Programme 2006 and the EU ETS.

⁹ The main difference in the 1990 baseline between UEP 12 (Nov 2004) and UEP 21 (Feb 2006) is mostly because the latter takes account of estimates of the effects of forest sinks as well as emissions from land use change, in accordance with revised UNFCCC guidelines. This change was applied throughout the time series.

7 The central projection that informed the 2006 Review was outside the range of feasible scenarios anticipated in 2000



Source: National Audit Office analysis of DTI emissions projections papers

NOTE

The uncertainty bounds represented here correspond to a range of plus or minus 8 per cent around the central projection (in MtC). This is the range given in the Climate Change Programme 2000 as representing the range arising from the combination of uncertainties corresponding to the full range of emissions scenarios produced by DTI, sensitivities in key assumptions, an estimate of the uncertainty introduced by the energy modelling process plus the uncertainties due to the range in land use change emissions. The uncertainty bounds do not therefore take into account uncertainty around the estimated savings from policies; this uncertainty was not analysed at the time.

37 Outturn for 2005 however, is expected to be well within the uncertainty bounds made by DTI in 2000. The estimates made in 2000 about emissions in 2005, have not been subject to as much revision as 2010 projections. In 2000, the average of DTI's central estimates for emissions in 2005 was 151.7 MtC with an uncertainty range of more than ± 7 MtC. By November 2004 this was revised down slightly to 151.4 MtC, while the most recent estimate of actual emissions in 2005 is some 153 MtC.¹⁰

38 We discuss below the processes used in the 2006 Review to quality assure the model and its key assumptions, and the steps taken to counter the optimism which characterised the projections which informed the 2000 review.

Key assumptions used in the 2006 Review were broadly in line with those used by other relevant organisations

- 39** The key assumptions in the DTI model are:
- fossil fuel prices – energy prices affect both the demand for energy but also the mix of energy supply;
 - economic growth – in part this is because higher incomes lead to more consumption and production as well as more travel, all of which increase emissions. The relative growth of different sectors of the economy is also important. Emissions are likely to increase, for example, if the manufacturing sector grows more quickly than service industries; and

¹⁰ Actual and historic emissions (the "Greenhouse Gas Inventory") are calculated by Netcen, a division of AEA technology, under contract to Defra. Emissions are largely estimated by applying emissions factors to statistical data on processes releasing emissions, because it would be largely unfeasible to measure emissions at source. For example, emissions may be based on data on information such as fuel consumption in power stations, average number of journeys taken and number of landfill sites. The methods used are in line with UNFCCC guidelines. http://www.airquality.co.uk/archive/data_and_statistics.php?action=exceedence_pre_step&go=Go

- demographics – increases in population and household growth similarly lead to more consumption, production and travel, and thus higher emissions.

The lead for pulling together these assumptions is taken by DTI, and other models and analytical work are updated to be consistent.

Fossil fuel assumptions

40 DTI's fossil fuel price assumptions have been consistently revised upwards since 2000, but at the time of the 2006 Review were broadly in line with those predicted by other organisations:

- In the central case DTI assumed that the real oil price would fall from the then current levels of \$50–60 per barrel to \$35 per barrel¹¹ in 2010 and then be constant to 2020. The rationale was that oil prices would ease as new production capacity is built and demand growth moderates. The 2010-2020 level was higher than the historic average, on the basis that oil is increasingly produced from more expensive sources.
- The gas prices in Europe and the US were assumed to remain oil linked, meaning that gas prices would also fall over the period.
- Investment in coal production capacity, as a result of recent high prices, would also lead to coal prices falling to long-run marginal costs.

41 The 2006 Review also considered scenarios with higher and lower prices for oil. The former was based on strong global economic growth and low demand elasticity for oil and scarce spare capacity, leading to oil prices of \$50 per barrel in 2010 which would be maintained to 2020. A low price scenario, on the other hand, anticipated new production capacity and further technological development, bringing oil prices to \$20 per barrel in 2010.

42 The central 2010 oil price projection was lower than assumed by Cambridge Econometrics (an organisation that also provides economy-wide forecast of greenhouse gas emissions) but higher than the previous World Energy Outlook produced by the International Energy Agency. But oil prices are notoriously difficult to predict: many experts failed to foresee the increase in prices over the past few years, and there is disagreement about whether they will remain at these levels, rise further or fall. The central case coal price assumption in 2010 was also broadly mid-range in terms of the basket of available comparators. Both oil and coal price assumptions were also subject to public consultation.

Economic growth assumptions

43 Economic growth assumptions were consistent with the December 2005 Pre-Budget Report (up until 2008), in forecasting 2.25 per cent GDP growth for 2006, rising to 3 per cent over 2007 and 2008.¹² Longer term growth (after 2008) was assumed to be 2.5 per cent – close to the long term UK average. The NAO carries out a rolling review of the assumptions in Budget Reports. The NAO audited the Treasury's assumptions about the underlying trend rate of growth, in 2002 and 2006.¹³ On the basis of comparison with forecasts carried out by external organisations, the NAO considered the assumptions adopted by the Treasury to be reasonable and cautious.

44 The growth in output from the manufacturing sector of the economy is informed by work by Oxford Economic Forecasting. At an aggregate level, these sector projections are consistent with the Government's economic and manufacturing growth assumptions in the December 2005 Pre-Budget report. The sector by sector projections were used to inform the setting of the National Allocation Plan for Phase 2 of the EU ETS. As part of this process, the sectoral projections were subject to public consultation and review by an independent expert panel.

¹¹ Quoted in UEP 21 as real 2004 prices.

¹² This represents middle of the range forecast by Treasury in the Pre-Budget Report 2005, which were for 2–2.5 per cent for 2005 and 2.75–3.25 per cent in 2007 and 2008. – http://www.hm-treasury.gov.uk/pre_budget_report/prebud_pbr05/prebud_pbr05_index.cfm.

¹³ http://www.hm-treasury.gov.uk/media/20C/27/bud06_ao_258.pdf.

Demographic assumptions

45 On demographics, the main assumption was that the total number of households would grow by 2.3 per cent from 2005 to 2010 and a further 4.6 per cent between 2010 and 2020. These assumptions were based on work by the Office of National Statistics, and discussed with the former Office of the Deputy Prime Minister, the Government Actuarial Service and the Department for Transport.

Assumptions in 2006 about the effectiveness of policies were less optimistic than in 2000

46 The 2006 projections involved a more sceptical scrutiny of the expected savings from existing policy measures than the 2000 projections. Government figures given in the Climate Change Programme 2006 report indicate that the estimated savings in 2010 from existing measures fell from a range of around 20 to 23 MtC in the 2000 appraisal, to 17 MtC by the end of the 2006 Review, a decrease of some 3 to 6 MtC (16 to 26 per cent). The full extent of the reduction is slightly higher than these numbers would suggest because of the way these figures are compiled.¹⁴ Appendix 1 shows how the evaluation of existing measures changed between 2000 and 2006. The most significant downward revisions were to the UK ETS, Energy Efficiency Commitment and the voluntary agreement package.

47 Key assumptions underlying the analyses for each of the policies are shown in the table in Appendix 2. Although many of the appraisals and evaluations we reviewed professed a cautious approach in making assumptions, none explicitly adjusted for optimism bias.

Projections at the time of the 2006 Review were slightly less optimistic than independent forecasts

48 Cambridge Econometrics is generally accepted to be the only other organisation to provide an economy-wide projection of UK emissions. Their model is based on different assumptions, classifications and modelling approach than the DTI, but provides a useful comparison. Comparisons carried out by DTI in August 2005 indicated that Cambridge Econometrics were predicting that 2010 emissions would be around 2.6 MtC lower than the then current (internal) DTI projections; Cambridge Econometrics were forecasting that projections would be 12.24 per cent below 1990 levels by 2010, while DTI internal projections showed projections would be around 8.9 to 10.3 per cent below 1990 levels. (This was of course, significantly different from the latest published DTI figures at the time, which had taken a much more optimistic view, expecting 2010 projections to be around 14 per cent, see Figure 6). DTI's analysis carried out at the time indicated that the differences were explicable in terms of differences in assumptions.¹⁵

¹⁴ These figures do not represent the full extent of reduction in the expected savings from existing measures because they do not include the Climate Change Levy, and because of the different way the savings from the Renewables Obligation were modelled. The figures do not therefore reflect the fact that the level of savings from these two policies in the projections that informed the Review decreased between 2000 and 2006.

¹⁵ The most significant differences identified were that Cambridge Econometrics assumed that the renewables obligation, transport voluntary agreements and ten year plans would deliver the full target of savings, (DTI projections had taken on the less optimistic assessments that informed the projections in the Climate Change Programme 2006); and that Cambridge Econometrics fossil fuel price assumptions were more favourable to gas use in generation.

THE TREATMENT OF UNCERTAINTY IN PROJECTIONS

There are considerable uncertainties associated with any modelling of future emissions

49 Any modelling approach involves a number of judgements, each of which introduces some uncertainty into the projection. Modelling is inherently uncertain because it involves reducing a complex market based system into a simplified set of relationships based on economic and behavioural theory. There are two main approaches to the modelling of greenhouse gas emissions. The UK approach to modelling the UK energy market uses a combination of the two:

- The first approach is known as “top-down”. This is based on estimating the relationship between aggregate energy demand and hence emissions and a number of variables related to price and output. These relationships are usually determined by analysing the historic data to establish the relationships between particular drivers (like prices, output) and the variable of interest (such as fuel demand). The relationships are then assumed to continue into the future, though adjustments may be made if there are specific reasons to believe the future may differ from the past (e.g. new government policies come into effect). Determining the extent to which the past can be used as a reasonable representation of the future, and the formulation of the relationship usually requires expert opinion, for example from academics or industry experts.
- The second type of modelling is “bottom-up”. This models the behaviour of participants in the market (e.g. companies or individuals). The decisions of each participant are modelled (for example, corporate decisions about how much output to produce given the cost of inputs). The emissions from each are then added together to determine total emissions. The behaviour of participants is often modelled using a combination of industry specific data, expert opinion and what is known more generally from economic theory.

50 Uncertainty in modelling arises from three main areas:

- The choice of drivers or key variables included in the model. For example, a model that forecasts fuel demand and hence emissions from cars might identify economic growth as one of the primary driving factors, but would also likely need to consider, for example, the availability of alternatives such as rail.
- The estimated relationship between the drivers (e.g. steel production) and the outcome of interest (in this case, emissions). For example, for every unit change in steel production, by how much do CO₂ emissions increase?
- How the drivers will change in the future. For example, in the DTI model, fossil fuel prices are a significant driving factor and a judgement has to be made about how these will change in the future.

51 These estimated relationships and evidence-based judgements cannot be made with complete certainty. The level of uncertainty associated will depend on factors such as the quality of the data that informs the analysis, the complexity of the relationship between variables and the availability of impartial experts.

The 2006 Review analysed and acknowledged uncertainty but might have done more to explain its implications in the final report

52 The report of the Climate Change Programme 2006, which summarised the results of the 2006 Review, acknowledged that projections were uncertain, and provided a quantified estimate of this uncertainty. However, the degree of uncertainty (which is judged to be of the order of 6 per cent either side of central projection) is only mentioned in an annex to the report. On the one hand, this could be seen as a minor omission because the results of the uncertainty analysis do not contradict the main messages – that the UK is very likely to meet its Kyoto target even on the most pessimistic outlook but only likely to meet its 2010 domestic target on the most

optimistic outlook (see Figure 8). On the other hand, giving greater prominence to the uncertainty ranges would have helped give a more complete picture of likely progress against the targets.

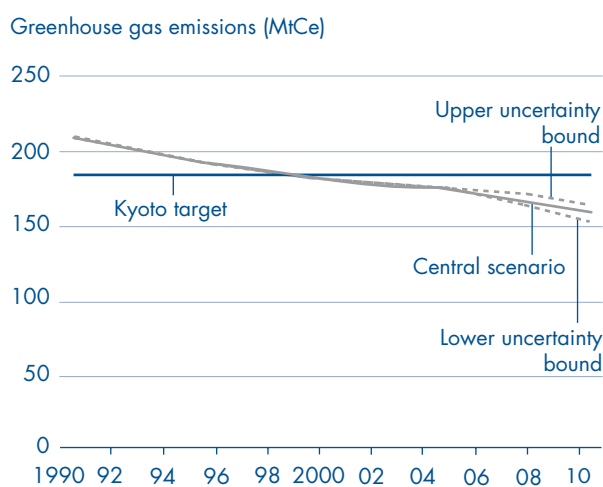
There is considerable inherent uncertainty in modelling the UK energy market and emissions projections

53 Government analysts considered five sources of uncertainty to inform the uncertainty ranges given in the 2006 Review:

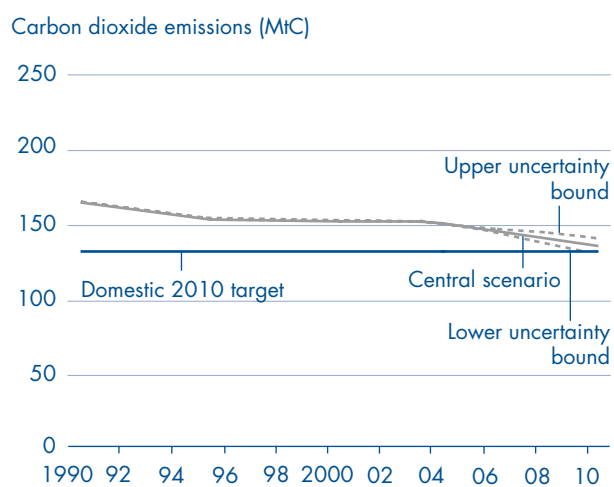
- The inherent uncertainty in the DTI model that arises in any attempt to estimate a system of relationships based on analysis of past trends. This uncertainty can be reduced but never eliminated. It is generally true that the greater the complexity of a system being modelled the higher the associated uncertainty.
- Sensitivity of the DTI model to fossil fuel price assumptions.
- A range of outcomes for emissions reductions from proposed policy measures.
- The range of outcomes for land use, land use change and forestry emissions/removals.
- The range of outcomes for non-CO₂ emissions.

8 Uncertainty around projected greenhouse gas and carbon dioxide emissions

Greenhouse gas emissions against the Kyoto target



Carbon dioxide emissions against the domestic 2010 target



Source: Paper presented to Interdepartmental Analysts Group, March 2006

NOTES

- 1 The central scenarios presented represent the average of the two central cases suggested by DTI modelling published in February 2006, and assuming an 8 MtC cap for the second phase of the European ETS. This is the level of the cap that Ministers eventually agreed, though at the time of the 2006 Review they were considering a cap in the range of 3-8 MtC.
- 2 The uncertainty bounds presented represent 95 per cent confidence intervals. These are based on Monte-Carlo analysis carried out by Defra to inform the 2006 Review. This uncertainty analysis considered uncertainty in the DTI model projections, uncertainty in land use, land use change and forestry projections, and uncertainty in the level of savings from the new measures announced in the Climate Change Programme 2006. It does not account for uncertainty in savings from existing measures.
- 3 The analysis pre-dates final decisions on the new measures to be introduced in the 2006 Climate Change Programme so average savings from new measures (excluding the level of ambition for the UK cap under EU ETS stage II) are slightly lower than in the final report (3.2 MtC as opposed to 4 MtC).

54 Analytical teams, estimating the impacts of policy measures, were asked to give a central estimate (the most likely outcome) and an upper and lower bound of probable outcomes¹⁶ for each component of the modelling. Each team used slightly different approaches to determine the range of probable outcomes, appropriate to the different components of the model. Sensitivity to fossil fuel prices, for example, was not analysed probabilistically – the upper and lower bounds do not therefore correspond to the same level of confidence level as the others. The individual probabilistic ranges were combined¹⁷ to develop an overall uncertainty range.

55 Although some uncertainty analysis was carried out for individual existing policy measures, this was not incorporated in the overall assessment of uncertainty. The analysis also did not take into account the uncertainty in the historic time series of methane and nitrous oxide (the emissions estimation methodology for the historical time series was assumed to be correct); this uncertainty arises because the estimates of historic emissions are themselves an estimate, calculated by applying emissions factors to statistical information on processes producing emissions.

The overall calculation of uncertainty carried out for the 2006 Review is therefore likely to be an under-, rather than an over-estimate.

56 Figure 9 shows the results of this work. It reveals that the sum of the inherent uncertainty arising from modelling the UK energy market is considerable. Other components (land use, and non-CO₂) also have relatively minor effects, because they represent a small proportion of overall energy demand. The uncertainty around the new measures introduced in the 2006 programme is also shown.

57 Figure 9 also gives an indication of the level of sensitivity to fossil fuel prices expected in the projections that informed the 2006 Review. Since 2000, relatively small changes in fossil fuel prices have had a significant effect on emissions projections, because of the effect on the mix of coal and gas used in electricity generation. The levels of coal and gas in electricity generation have changed because as fossil fuel prices have increased, coal has become cheaper than gas. The mix of coal and gas in generation affects emissions because coal is a more carbon intensive fuel. However, DTI expects that further increases in the price of gas relative to coal will

9 Sources of uncertainty in the 2010 projections produced for the 2006 Review

	Uncertainty inherent in the DTI model	Fossil fuel price assumptions in DTI model	Existing policy measures	New policy measures	Land-use change and forestry	Non CO ₂ emissions
Lower bound (MtCe)	137.1	144.7	Not analysed	1.9	0.5	22.8
Central estimate (MtCe)	144.7	144.3	Not analysed	3.2	-0.5	24.9
Upper bound (MtCe)	152.8	145.1	Not analysed	5.1	-1.3	28.0
Range (MtCe)	15.7	0.8	Not analysed	3.2	1.7	5.2

Source: Updated Energy Projections 21 and Summary Paper to the Interdepartmental Analysts Group "Monte Carlo Analysis for the Climate Change Programme Review", March 2006

NOTES

DTI did not attempt to assign probabilities to the fossil fuel price scenarios. The upper and lower bounds given in this table therefore correspond to the 'high fossil fuel price' and 'low fossil fuel price' scenarios respectively, and the central estimate to the average of the central cases explored (one favouring gas, the other favouring coal). The relationship between fossil fuel prices and overall emissions in the DTI model is not linear, because fossil fuel prices have a number of often counter-acting effects on energy demand. Emissions in both the low and the high fossil fuel price scenario are therefore higher than those in the central cases.

Figures quoted to 1 significant figure.

The analysis pre-dates final decisions on the new measures to be introduced in the 2006 Climate Change Programme so average savings from new measures (excluding the level of ambition for the UK cap under EU ETS stage II) are slightly lower than in the final report (3.2 MtC as opposed to 4 MtC)

¹⁶ Analysts were asked to give a 95 per cent confidence interval, a statistical concept that identifies a range within which the outcome will fall in 95 out of 100 occasions.

¹⁷ Using the Monte Carlo method, in which many scenarios are generated using random variations in assumptions – the results then reveal a distribution around a central estimate, from which uncertainty ranges can be derived.

not have such a significant effect on emissions projections in the short to medium term, because the level of coal in generation is reaching the capacity of existing stations.

58 DTI has explored sensitivity to changes in other key assumptions, such as household growth, car ownership levels and nuclear output (see **Figure 10**). These indicate a relatively narrow range of sensitivity, though this is partly because the analysis considered a narrow range of scenarios. For example, the scenario that examines higher electricity demand looks at a change of 1 TWh, which represents less than 0.3 per cent of total electricity generation in 2005. Annual growth has ranged between about 1 and 2.3 per cent suggesting that, in practice, electricity demand may vary by more than 1TWh with reasonable probability.

Long-term projections available at the time of the 2006 Review showed a significant gap to future targets

59 While the final 2006 Climate Change Programme report makes little reference to the 2020 target, projections from the DTI model available at the time showed that the UK was not expected to meet this goal. The target is

expressed as the aim of ‘real progress’ by 2020 towards the 2050 goal of a 60 per cent reduction in carbon dioxide emissions. DTI’s projections, however, showed carbon dioxide emissions increasing slightly between 2010 and 2020. This is because the effect of existing measures would be more than outweighed by higher energy use from economic growth and the closure of nuclear power stations. Emissions were projected to fall once more after 2015, even without additional measures, because of the closure of a significant number of coal-fired power stations, though this would not bring emissions below the 2010 level.

60 There is similarly little discussion in the final report of progress against the 2050 target. The latest published projections at the time, which had been produced for the Energy White Paper in 2003, showed that without further measures, total carbon emissions would likely be around 145 MtC in 2050, 80 MtC higher than the target. Updated long-term projections for the Energy Review (July 2006) painted a similar picture, showing that even on a ‘low growth’ scenario, emissions would be significantly higher than the target, as **Figure 11 overleaf** shows.

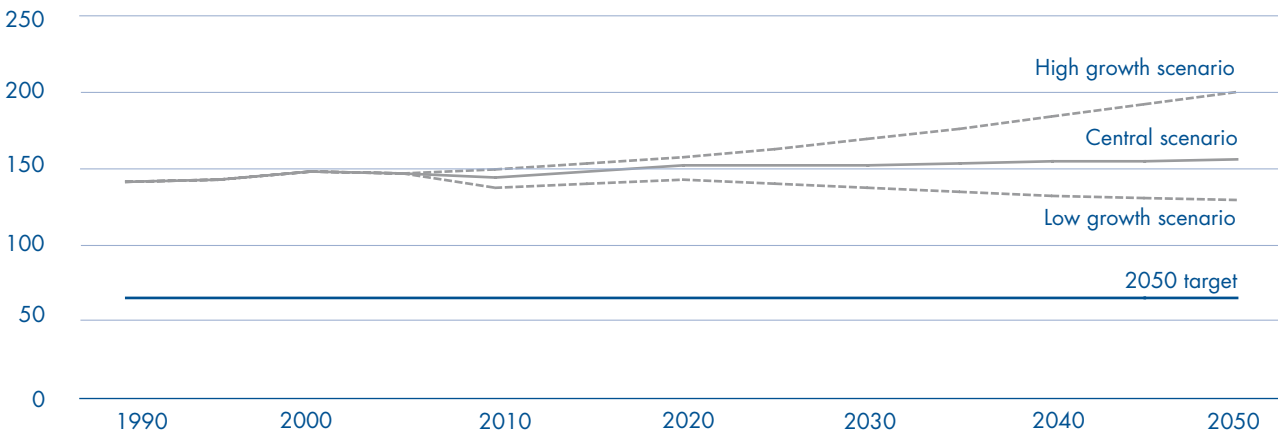
10 Sensitivity analysis to some key assumptions in the DTI model

Key assumptions	Alternative	Emissions in 2010 (MtC)
Further Voluntary Agreements and other measures		-0.1
Number of households	Higher growth in number of households	+1.2
Car ownership levels	Higher growth in number of households	+1.0
High coal generation	5TWh higher	+0.7
Nuclear Output	1TWh higher	-0.1
	1TWh lower	+0.1
Different electricity demand	1TWh higher	+0.1
Higher electricity import	1TWh higher	-0.1
Renewables at various levels of generation	7% of generation	+0.3
	9% of generation	-0.3
Temperature	Level Trend	+0.7

Source: DTI, Updated Energy Projections, 2006

11 Progress against the 2050 target

Carbon dioxide emissions (MtC)



Source: Energy Review, 2006

The importance of responding to uncertainty

61 Recognising uncertainty is important. But once recognised, there remains the question of how policy makers should respond to it. Given a point target for emissions reductions, like the domestic and Kyoto targets, responses to uncertainty can include:

- Provide for regular and timely monitoring and review. The limited flexibility and responsiveness of policies for reducing emissions, in response to being off-course, puts a premium on early and more regular review of progress against targets and trajectories towards them.
- Establish contingency plans. When emissions are sensitive to changes in assumptions such as fossil fuel prices, which are outside the government's control, policies need to be flexible. One way to build in this flexibility is to adjust the level of funding or implementation of different policies, according to outcomes. Another way is to develop a list of policies that can be implemented as needed.
- A final way to account for uncertainty is to err on the side of caution and aim to exceed the target, leaving a margin of error.

62 The 2006 Review showed that the Kyoto target would be exceeded with some margin for error. However, it also revealed a much greater gap to the 2010 domestic target than had been expected in 2000. But at this late stage it was difficult to introduce enough cost-effective policy measures to close the gap. More regular review and monitoring would have allowed the Government to pick up on these problems earlier. Uncertainty analysis carried out for the 2000 projections had anticipated that there were feasible scenarios in which we would not meet the 2010 target, yet a margin of error was not built in, nor contingency plans established in case the future did not turn out as expected.

63 As the 2010 target approaches, therefore, it will be important to switch attention to the realism and delivery of future targets. Current projections suggest that significant change will be needed to meet these future targets. Yet there was little discussion in the 2006 Review of how 2020 or 2050 targets would be met.

TIMELINESS

64 The Committee has previously raised concerns about the timeliness of projections that were produced to inform the UK's National Allocation Plan for Phase 1 of the EU ETS. The 2006 Review was also considerably delayed. The initial timeframe expected a publication date of March 2005, but the review was not eventually published until 2006.

The evaluation and appraisal of measures took longer than expected but was not the only cause of delays to the 2006 Review

65 The evaluation and appraisal of individual policy measures took more than twice as long to complete than initially expected. Project initiation documents for the 2006 Review anticipated that evaluation and appraisal work would be complete by February 2005, with a publication date of March 2005. This was highly ambitious given the scale of the task (in the end, some seventy policies were evaluated or appraised) and the amount of resources available. The majority of the evaluation and appraisal work for individual policies was not complete until September 2005, and as late as January 2006, further work was being carried out on savings from renewables, heat and the DTI's assumptions on waste. Thereafter, final publication was delayed until March 2006 as extra analysis was carried out at the request of Ministers.

66 DTI published two sets of updated emissions projections in the course of the 2006 Review. The first, at the beginning of the 2006 Review, in November 2004 and the second at the end, in February 2006. As Figure 6 shows, the emissions projections changed considerably over this period, from a carbon gap of around 9 MtC at the start of the 2006 Review to one of 15 MtC just before publication. However, by May 2005 the Interdepartmental Analysts Group was aware of unpublished estimates from the DTI that the carbon gap in 2010 would be of the order of 15 MtC.

67 The most significant reason for the delay was therefore that by May 2005, unpublished estimates from the DTI were showing that the carbon gap was much larger than expected in projections published at the beginning of the 2006 Review, while the estimates of savings that could be delivered by proposed new measures would not fill the gap. When Ministers met in summer 2005 they requested further analysis to try to find measures that might bring the UK closer to the target.

To date, UK projections have been produced in response to particular need but the government expects to move to annual publications

68 UK projections of greenhouse gases are required on a biannual basis for reporting to the EU's monitoring mechanisms, the body run by the European Commission responsible for ensuring EU-15 meets its Kyoto commitments; projections are also required for reporting national communications to the United Nations on a 'periodic' basis, which in practice means every three to five years. A projection may also be compiled and published for the purposes of a policy review, for example, to inform the 2006 Review or the Energy Review, or to inform decisions on the EU ETS.

69 The government expects to move to updating projections annually, with flexibility to compile additional projections to inform policy initiatives.

APPENDIX ONE

HOW THE EXPECTED SAVINGS FROM MEASURES IN THE CLIMATE CHANGE PROGRAMME 2000 CHANGED BETWEEN 2000 AND 2006¹

	Evaluation in 2000		Evaluation in 2006	
	Policy	Sector total	Policy	Sector total
Carbon dioxide emissions savings in 2010 (MtC)				
UK Emissions Trading Scheme	2.0		0.3	
Carbon Trust	0.5		1.1	
Building Regulations 2002	1.3		0.4	
Building Regulations 2005			0.2	
Climate Change Agreements	2.5		2.9	
Business total²		6.3		4.9
EEC 2002-11 (including Decent Homes)	2.6–3.7		1.6	
Building Regulations 2002			0.7	
Building Regulations 2006 including 2005 condensing boilers update			0.8	
Warm Front and fuel poverty programmes	0.2		0.4	
Market Transformation including appliance standards and labelling	0.2–0.4		0.2	
Action to encourage replacement of community heating systems	0.9		0.0	
Domestic total		3.9–5.2		3.7
Renewables Obligation	2.5		2.5	
Energy supply total		2.5		2.5
Agriculture and forestry total		0.6		0.7
Public sector (including NHS and schools) total		0.5		0.2
Scottish Executive total		0.1		
Voluntary Agreement package (including reform of company car tax and graduated vehicle excise duty)	4.0		2.3	
Wider Transport measures	1.6		0.8	
Sustainable distribution (Scotland)	0.1		0.1	
Fuel duty escalator	1–2.5		1.9	
Transport total		6.7–8.2		5.1
Waste management total				0.2
Total		20.6–23.4³		17.3³

NOTES

1 Drawn from Synthesis of Climate Change Policy Evaluations, April 2006, Department for Environment, Food and Rural Affairs.

2 The totals shown here do not include the estimated carbon savings from the Climate Change Levy (CCL). This is because DTI incorporate the CCL into their model baseline and do not publish a separate analysis of the effect of this individual policy measure in their 2006 projections. The estimated savings from the CCL given in the Synthesis of Climate Change Policy Evaluations document are taken from an evaluation carried out by Cambridge Econometrics. This estimate is higher than that included in DTI's projections because it assumes an "announcement effect" not replicated in the DTI model. The totals shown here do not include the estimated effects of policies on non-CO₂ emissions, because this was not assessed on a policy basis in 2000.

3 Numbers do not sum due to rounding.

TREATMENT OF OVERLAPS AND KEY ASSUMPTIONS IN A SAMPLE OF POLICY MEASURES¹

Policy	Lead department	Estimated saving in 2010 (from 2006 Review) (MtC/MtCe)	Examples of overlapping policies considered	Some key assumptions in the analysis
EU Emissions Trading Scheme	DTI	3.8MtC ²	Carbon Trust Energy Efficiency measures	The estimated savings were based on the government's position that all emissions savings attributable to the UK's national allocation plan under the EU ETS will count towards the domestic target, whether or not they are actually achieved in this country.
Climate Change Levy	Treasury	{3.7} ³	Climate Change Agreements	Analysis carried out by Cambridge Econometrics assumed an "announcement effect" would have a lasting effect on energy demand. DTI have not been able to replicate this effect in their model and did not include it in the projections that informed the 2006 Review, though DTI continue to review the evidence.
Climate Change Agreements	Defra	2.9	Climate Change Levy Carbon Trust	Key assumptions include: just over a quarter of emissions savings are assumed to be due to business as usual improvements; the impact of the Climate Change Levy is assumed to remain constant over time.
Waste Strategy 2000	Defra	2.7	Renewables Obligation	A key assumption was that 75 per cent gas collection efficiency would be achieved over the lifetime of a landfill site. A number of assumptions on the proportion of different types of waste that go to landfill were also made.
Renewables Obligation	DTI	2.5	Additional Renewable Obligation measures in the new programme	The analysis estimated that between 7.8 per cent and 9.3 per cent of renewable energy would be delivered by eligible renewable sources in 2010.
Voluntary Agreement Package including reform of company car tax and graduated vehicle excise duty	DFT	2.3	Fuel Duty Escalator	Key assumptions included the number of new cars bought each year and forecast changes in average fuel economy. The analysis assumed that the policies would lead to a larger up-take of diesel cars than would otherwise have been the case.

Policy	Lead department	Estimated saving in 2010 (from 2006 Review) (MtC/MtCe)	Examples of overlapping policies considered	Some key assumptions in the analysis
Fuel Duty Escalator	Treasury	1.9	Assumptions about price elasticities of fuel demand were based on the Department for Transport's National Transport model which takes into account the impact of other transport policies currently underway.	The evaluation assumed that price elasticity of demand for petrol and diesel would fall between 2006 and 2020. These elasticities were based on the National Transport Model, which takes into account a number of different influences and impacts on the demand for road travel.
Renewable Transport Fuels Obligation	DFT	1.6	Current Voluntary Agreement package	Key assumptions included the quantity of fuel demanded each year, carbon savings from biofuels relative to conventional fuels and the price elasticity of demand for motor fuel
Energy Efficiency Commitment/ Decent Homes	Defra	1.6	Overlaps between the two policies (Energy Efficiency Commitment and Decent Homes)	Data on the effectiveness of installed measures was scaled up to give the long term forecasts. A number of assumptions were involved in doing so. Estimates were adjusted "for a degree of comfort taking".
IPPC (EU f-gas directive)	Defra	1.4	UK ETS Climate Change Agreements Voluntary Agreements on f-gas use	11 technologies were considered and a number of assumptions made in estimating the effect of the directive on the emissions from each technology.

NOTES

1 The analysis is based on a review of the appraisals and evaluations for ten policies, carried out with the assistance of Frontier Economics. We chose the sample to include those that the 2006 Review identified as the ten most significant implemented policies in terms of carbon saved in 2010. Data on estimated savings in 2010 is taken from Synthesis of Climate Change Policy Evaluations, Defra, April 2006, unless footnotes explain otherwise.

2 A range is given corresponding to the level of the cap imposed by the national allocation plan.

3 The estimated savings from the Climate Change Levy (CCL) in 2010 is shown in brackets because although this is the figure quoted in the Climate Change Programme 2006 and Synthesis of Climate Change Policy Evaluations (based on analysis carried out by Cambridge Econometrics), the actual projections that informed the 2006 Review assumed a lower level of saving from this policy measure. This was because the Cambridge Econometrics analysis included an announcement effect, which is not replicated in the DTI model. The absence of an announcement effect in the DTI model is acknowledged in the Evaluation Synthesis report, and Cambridge Econometrics' estimate for the CCL is not included in the total given in the Synthesis report or 2006 Programme for expected savings from the business sector. Overlaps with the Climate Change Agreements were taken into account in the way this measure was incorporated in the projections that informed the 2006 Review.